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INSECTICIDES AND THEIR APPLICATION IN MEDICAL PRACTICE

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INSECTICIDES AND THEIR APPLICATION IN MEDICAL PRACTICE

By: V. I. Vashkov, M. N. Sukhova, et al.

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* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

ANNOTATION

This book is intended for those interested in the questions of disinfestation [Translator's Note: disinfestation = extermination of insects]. The book describes the contemporary insecticides from different groups of chemical compounds: chlorinated hydrocarbons, including those obtained by diene synthesis, chlorinated terpenes, organophosphorus insecticides, carbamates, vegetable insecticides, including synthetic pyrethrins, fumigants and various other compounds utilized for the destruction of arthropods; also described are the forms of application of insecticides, their synergism and antagonism.

The biological methods for controlling insects, including attractonts, repellents, physical and chemical methods of sterilization, are also covered.

There are also described the epidemiological significance of certain insects (fleas, lice, gnats [Translator's Note: gnats = blood-sucking flies collectively], mites, bugs, mosquitoes, moths, ants, flies, and cockroaches) and the measures for controlling them.

FOREWORD

/Text pages 5-6/ [JPRS 37684]

The period of the elimination of some infectious diseases and the decrease of others is accompanied by the expanded use of insecticides for the purpose of exterminating arthropods -- vectors of infectious diseases, including parasites of man and his quarters.

The number of insecticides has substantially risen during the past ten years, but there is no manual describing modern insecticides and methods of their application in the control of vectors of infectious diseases. This text deals with theoretical and practical problems of disinfection. In addition, a description is given of new effective preparations studied in the last decade.

Of the enormous number of synthesized insecticides suggested for practical use, only those which to some extent can be used for the purpose of exterminating arthropods affecting human health are described. Also presented are methods of controlling these species of arthropods.

Much attention has been paid to biological methods of control of arthropods; in recent years they have been more commonly applied.

The handbook is intended for physicians at disinfection and sanitary-epidemiological stations, and also for other specialists working in these establishments. It can also be used by workers of veterinary establishments engaged in the prevention of animal diseases. It can prove useful to instructors in epidemiology in the higher and secondary medical schools, and also to instructors of several other teaching institutions where problems of the biology of arthropods, the methods, and agents for their extermination are studied.

Individual chapters of the book have been written by the following persons: Doctor of Biological Sciences M. N. Sukhova ("Flies and Their Control"); Candidate of Medical Sciences E. B. Kerbabayev ("Malarial Mosquitoes, Sand Flies, Buffalo Gnats, Biting Midges, Ticks, and Their Control"); Candidate of Medical Sciences Ye. V. Shnayder (Acetion, Acetoxon, Diazinon, Rogor, and Carbophos). Doctor of Medical Sciences, Professor V. I. Vashkov prepared the plan for arrangement of the material, wrote the remaining chapters and sections of the book, and carried out the general supervision and editing of all chapters and sections.

Much assistance was provided by laboratory assistant V. P. Kretova.

The text was edited by Candidate of Biological Sciences V. P. Dremova, Candidate of Biological Sciences A. P. Volkova, Candidate of Biological Sciences L. I. Brikman, Candidate of Chemical Sciences Yu. P. Volkov, biologist I. V. Bessonova, and biologist G. M. Zubova, for which deep gratitude is extended.

Critical remarks will be thankfully received by the authors and given due consideration in preparation of similar editions. We request that all comments be sent to the Central Scientific Research Disinfection Institute, at: Moscow, Miusskaya Ploshchad', d. 3/8.

The Authors

Chapter I [JPRS 37684]

CHEMICAL METHOD AND CHEMICAL AGENTS FOR INSECT EXTERMINATION

Poisons are classified according to the objectives against which they are applied: poisons used in exterminating insects are called insecticides (from the Latin words insectum -- insect, and caedo -- I kill), for extermination of ticks -- acaricides, larvae -- larvicides, eggs of insects and ticks -- ovicides, and for extermination of mollusks (slugs, etc.) -- limacides. Agents used simultaneously for control of insects and causative factors of fungal diseases of plants are called insectofungicides. Sometimes, this term is employed to designate all chemicals used in agriculture. Preparations used to exterminate weed vegetation are called herbicides, against bacteria -- bactericides, against spores -- sporicides, against viruses -- virulicides, etc. In audition, at present the term "pesticides" is used, including insecticides, raticides (against rodents), limacides (against mollusks), and herbicides.

Chemical agents -- insecticides -- are widely used to exterminate arthropods in general and vectors of causative agents of infectious diseases in particular. These compounds exhibit high toxic properties for insects and warmblooded animals, and some are just as toxic for the former as for the latter, while others are highly toxic for arthropods and of low toxicity for warmblooded animals.

Insecticides are widely used in controlling human parasites, including vectors of infections of man, animals, and birds. They are widely used in controlling pests of agricultural plants and grain stores, produce, etc.

All preparations used in disinfection (solid, liquid, gaseous) are poisons for insect life. Usually, poisons are taken to refer to those compounds which in minimal amounts act on the living organism and induces death or serious disturbances of its physiological functions, leading ultimately to the death of the organism.

Insecticides are classified by the mode of penetration into the insect organism, from the objects of use, from the method of preparation, and from the chemical composition.

Depending on the modes of penetration into the insect organism, poisons used in controlling them are divided into three groups:

1) contact insecticides -- preparations penetrating into the organism upon contact with the cuticula, including through the thin sections of the integuments found at the base of the sensory hairs, especially at the proboscis and on the chela of the legs in contact with a surface on which

the insecticide is present;

2) intestinal insecticides -- preparations penetrating the organism through the intestines with poisoned food;

3) fumigants -- preparations penetrating the organism through the tracheal system together with air.

Some insecticides can be related in their action directly to two or even to all three groups. An example can be found in solvent [naphtha - ?], hexachlorane, chlorophos, DDVP, and other preparations which can be at one and the same time contact insecticides and fumigants, DDT -- a contact insecticide, but it can be used in the form of vapors, and for certain insects it can be used also as an intestinal poison (locust).

In the chemical classification, poisons are combined into groups closely related in chemical composition, method of preparation, and chemical properties, for example, chlorinated hydrocarbons, preparations of diene synthesis, organophosphorus compounds, carbamates, etc.

Some insecticides have their own characteristics differing in extent of action on various insect species: for some they are highly toxic, and for others little toxicity or none at all. A detailed knowledge of preparations permits the use not only of harmless, but also high-toxicity insecticides, free of danger to persons and warmblooded animals. By way of example we can refer to the fact that in the practice of disinfection use is made of such high toxicity compounds as prussic acid, ethylene oxide, methyl bromide, etc.

In treating quarters and grounds, insecticides often are used in the presence of people and animals. This increases the possibility of their penetration into the human and animal organisms. When insecticides are used, first of all, care must be taken so as not to inflict harm on others, and also to animals and plants.

The latest data on the physiology, pharmacology, and pharmacodynamics of insecticides has shown that some of their general properties are accounted for by their chemical structure. This makes it possible to more deeply and correctly engage in a search for new insecticides.

In searching for new insecticides, special attention is paid to efforts to find such compounds that exhibit high toxicity for insects and would be harmless or of low toxicity for people and animals.

In connection with extensive scientific research in the synthesis of effective preparations, we present those requirements to which newly synthesized insecticides must correspond. They must:

1) exhibit selective action, that is, devastingly act on insects and at the same time have no harmful effect on animals and man;

2) promote extermination of insects or induce their deep paralysis in as short a time as possible with a small dosage (a gram per kilogram of insect bodyweight);

3) exhibit a sizable resistance to the effect of environmental factors (humidity, temperature, light);

4) not cause the rotting of articles in the immediate environment and materials (do not change their stability and color);

5) exhibit prolonged residual action, that is, pass on to the treated surfaces insecticidal properties retained for a long time;

6) not repel insects, but rather attract them if possible;

7) manifest their action both at room temperature, as well as at the lowest temperatures possible;

8) not exhibit an unpleasant odor;

9) be used easily and safely, that is, nonflammable and explosion-free;

10) be accessible in price.

However, not all insecticides meet these requirements. Among numerous agents proposed for control of insects, although not all, still most of these requirements are met by the preparations DDT, chlorophos, hexachlorane, carbophos, etc.

When insecticides are used both within as well as outside quarters, allowance must always be made for the effect of environmental factors. A change in the humidity does not have a marked effect on insecticidal action. The presence of wind, rain, fluctuations in temperature, and other factors lead to decreased effectiveness of insecticides. It has been established that hexachlorane, heptachlor, and aldrin become completely ineffective on surfaces after rain for 24 hours; toxaphen and dieldrin retain their effectiveness under these conditions. Upon an exposure of 24 hours outside quarters, in the shade, at high temperatures on plants, the effectiveness of hexachlorane, heptachlor, and aldrin is considerably reduced. Under the effect of solar light, dieldrin wholly loses its effectiveness; at the same time, diffuse and direct rays of solar light have no strong effect on toxaphen. An increase in dosage does not prolong the residual effect.

Air temperature is of major importance. Fluctuation in temperature is reflected in the sensitivity of insects to insecticides. Thus, with an increase in temperature of maintenance of insects after application of insecticides from 20 to 30°, the toxicity of DDT is reduced and the activity of dieldrin and diazinone is intensified, but this has no effect on hexachlorane, although the death of flies is increased with increase in temperature.

Insecticides can have a local or general, immediate or remote effect. The immediate or direct effect is characterized by the fact that signs of the action of insecticides on an insect is observed in a short time. When remote action is operative, changes develop slowly and set in after a longer period of time. For example, in the action of several poisons on fly larvae they do not succumb and proceed to pupate, however, later the pupae succumb.

Preparations differ from each other in extent of toxicity, which is measured by the quantity called the minimum lethal dose, that is, the smallest amount of poison causing the death of the insect.

In establishing the toxicity of poisons for insects (insecticidal properties) six methods are used: 1) application of the insecticide on a specific part of the insect body (topical application); 2) immersion of insects in a solution of the insecticide; 3) contact of the insecticide with a test-object coated with the insecticide, or spraying of the insect with an insecticidal solution; 4) administration of the insecticide with food (study of intestinal action); 5) administration of the insecticide with inhaled air; 6) administration of the insecticide in the hemolymph of the insect (with the aid of a syringe).

In topical application, the minimal lethal dose -- LD -- is expressed usually in grams (micrograms -- mcg) per insect (gram/insect), but in comparing the toxicity of a poison for different insects the lethal dose is given in micrograms or sometimes in milligrams per gram of bodyweight for insects (mg/gm), or per kilogram of live weight for warmblooded animals (mg/kg).

Lethal doses inducing death of half of the insects are designated by LD_{50} (in micrograms or grams), doses inducing total death of insects are denoted by LD_{100}.

Upon immersion in a solution, by spraying, or contact, the following commonly accepted conventional designations are employed: LC -- lethal concentration, LC_{50} -- lethal concentration inducing the death of half of the insects, LC_{100} -- concentration inducing total death of insects.

When an insecticide penetrates into the organism of an insect or higher animal, it is degraded and partially detoxified. The term "detoxification" relates to reactions as a result of which the toxicity of the absorbed substances is reduced; this does not always occur, on the contrary, in several cases as a result of the degradation of the poison entering the organism, extremely toxic metabolites are formed. Nonetheless, in most cases such reactions are accompanied by the formation of nontoxic substances.

The mechanism of activation usually includes the reaction of oxidation (conversion of heptachlor into its epoxide, aldrin into dieldrin; conversion of the thionophosphates into phosphates; oxidation of thiolic esters into sulfoxides and sulfones; oxidation of phosphoramides into more stronger inhibitors of cholinesterase). The type of change depends on the chemical structure of the compound and the insect species -- DDT is metabolized by flies, lice, certain species of mosquitoes, American cockroaches, Mexican beetles, cotton pests, fruit flies, and other insects, but this process follows four or five different routes.

Several processes of the degradation of insecticides in the insect organism occur as they do in warmblooded animals.

Study of the toxicity of insecticides of the chlorine-containing hydrocarbon group has shown that given the same concentrations of preparations the tissues of insects and animals react similarly, in spite of differences in the structure physiological features. It is wholly probable that the principal metabolic processes in the cells of insects and mammals are essentially the same. Therefore, any compound affecting the respiration of cells is identically toxic for arthropods and mammals under identical routes of penetration into the site of action. However, in actually this looks differently. For man the danger begins only when insecticides enter his organism in concentrations 1000 and more times greater than the doses needed to kill insects. This refers to the entire group of chlorinated hydrocarbons; they are insoluble in water and are slowly adsorbed from the intestine or through the skin of the person. In intravenous administration in experiments, the toxicity of chlorinated lies within the limits of 1.5 - 250 mg/kg of bodyweight.

Insecticides act much more strongly on arthropods than on vertebrate animals, which obviously is accounted for by differences in the ratio of bodyweight to body surface area. In arthropods the vital centers are several microns from the surface, while in man they are at a distance of several centimeters from the corresponding surface. Thus, for example, hexachlorane or DDT are highly toxic for insects, since they rapidly reach their vitally important centers. Similar concentrations cannot be induced in the vital centers of man simultaneously subjected to the action of this preparation (G. K. Kovalev).

Preparations obviously have a monotypical effect on organs and tissues both of man and insects sensitive to the given compounds; moreover, the results of the action differ due to the fact that physiological and biochemical processes occurring in organs and tissues of mammals differ from those occurring in insects. In addition, insects and mammals differ in content of enzymes. For example, mammals have enzymes capable of rapidly detoxifying the gamma-isomer of hexachlorocyclohexane and methoxychlor, while these enzymes are lacking in insects, which absence has an effect on the degree of toxicity. In mammals enzymes capable of detoxifying an insecticide usually fulfill some other role in fact.

Insects differ from vertebrates in the character of their reaction to insecticides. In the neuromuscular system of insects, it would seem to be that no pathological changes are noted after the action of insecticides; thus, phenols are converted in insects into beta-glucosides. In this respect, reactions occurring in insects are akin to reactions occurring in plants in which phenols are detoxified by condensation with glucuronic acid. Reactions of the conversion of phenols into ether sulfates, the acetylation of aromatic amino-groups, and condensation of aromatic acids with glycine, and the methylation of the heterocyclic nitrogen ring -- all this has been observed both in vertebrates as well as in insects. In connection with the lack of sufficient data on the oxidation of extraneous organic compounds penetrating into the insect organism, it is impossible to establish whether the same mechanism participates as in the case of vertebrates. However, what is known with respect to the intermediate metabolite -- tryptophan and tyrosine compels the assumption that in this case there is a common "reaction pathway." The products of the metabolic oxidation of thiophosphates and phosphoramide insecticides in vertebrates and insects are the same, and these products are considerably more toxic than the initial compound. Detoxification in organophosphorus compounds in most cases occurs in the form of hydrolytic reactions.

The toxic action of chemical preparations on insects is based, apparently, on the fact that each of them is alien to the organism and, acting on the latter, alters the structure of protein or disrupts enzymatic processes occurringin the insect organism, as a result of which its normal functions are upset. The action of poisons on living plasma, highly complex in its compical composition, consists of a combination of physical, physico-chemical, and chemical phenomena.

Among insecticides, a high proportion is represented by contact insecticides, which at present have become widespread and are the principal insecticides used in practice. The first effective synthetic preparation introduced into practice -- bisethylxanthogen (preparation K) -- was obtained in 1938 (F. S. Khanenya and S. V. Zhuravlev); then, several other preparations appeared: in 1944 -- DDT (V. I. Vashkov, L. N. Pogodina, N. A. Sazonova, A. V. Molchanov, etc.); in 1945 -- hexachlorocyclohexane and its isomer (I. S. Travkin, V. N. Polikarpov, N. N. Mel'nikov, L. N. Pogodina, V. I. Vashkov, N. A. Sazonova, Yu. N. Bezobrazov, etc.). Diene preparations were introduced into practice in 1950, and organophosphorus compounds (chlorophos)

-- in 1960; in 1961, several highly effective organophosphorus preparations appeared (acetoxone, acetion, etc.).

Some contact compounds act searingly, destroying the external soft and thin integumenta of the body; they include kerosene, mazut, sodium arsenite, phenol, and carbolineum. Among compounds penetrating through the external integumenta into the body and slowly disintegrating the tissues are alkalis, sodium fluoride, and several other compounds. Other contact insecticides act mechanically, plugging the tracheas of insects and inducing death from suffocation; these are the mineral-oil emulsions, etc. Some of the contact insecticides also exhibit intestinal action, but those of them which more rapidly and more reliably act on the insect organism through external integumenta in further exposition will be classed by us as contact poisons.

The toxic action depends on the properties of the preparation, the quantity used, the insect species, its individual characteristics, and length of contact with the insecticide.

Contact insecticides are used to poison insects in all stages of their development. These insecticides are used in the form of dusts, solutions, emulsions, suspensions, aerosols, etc. For man and domestic animals the greater part of contact insecticides is less poisonous than insecticides of intestinal action, owing to which contact insecticides under otherwise equal conditions are preferred above other insecticides.

Contact insecticides penetrate through the external integumenta of insects, which consist of several protective membranes passing different preparations to differing degrees. The penetration of an insecticide through insect integumenta (cuticula) is based not on simple diffusion, but on phenomena of penetrability through living membranes.

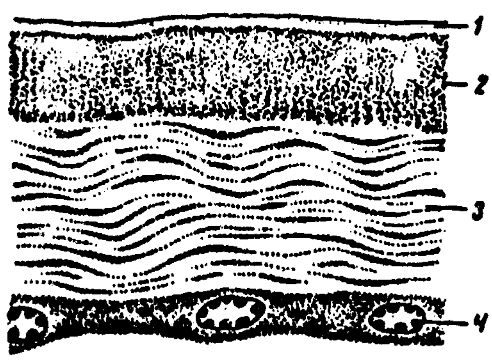

Figure 1. Longitudinal section through the cuticula of a larva of the flour-beetle, according to the data of L. M. Semenova. 1 -- epicuticula; 2 -- exocuticula; 3 -- endocuticula; 4 -- hypodermis.

Insect integumenta consist of two membranes: the hypodermis and the cuticula (Figure 1). The hypodermis -- the inner membrane -- consists of a single layer. The cuticula -- the outer membrane -- consists of three layers: the epicuticula, exocuticula, and the endocuticula. The epicuticula -- the outermost layer -- is 0.2 - 0.3 micron thick and comprises two layers: the lipoidal and the protein. The epicuticula can be regarded as the first barrier on the path of penetration of contact insecticides into the insect organism. The exocuticula -- the rigid layer of varying thickness

-- contains chitin and protein, and in some insects lipoids as well, these latter are usually in the upper layer of the cuticula.

In some insects the epicuticula consists of several layers. Thus, for example, in meat fly larvae the epicuticula has two layers, but in the caterpillar of the silkworm moth -- five layers. The endocuticula, as true also of the exocuticula, consists mainly of chitin and protein. The endocuticula of cockroaches and fly larvae consists of up to 60 % chitin. The exocuticula and the endocuticula serves mainly for mechanical protection of the insect organism.

The cuticula protects the internal organs from injury; some of its sections serve as insertion sites for musculature. It lines several internal organs, for example, some of the intestine, respiratory system, and serves as a barrier retarding evaporation of water by the organism. The mode of life of insects to a large extent depends on the permeability of the cuticula. The external integumenta are relatively impermeable for water; this fact accounts for the possibility of life for insects. The endocuticula and the exocuticula are permeated by numerous canals not extending into the epicuticula. The ducts of skin glands run through the entire cutciula, including through the epicuticula. The hypodermis lies under three layers of the cuticula. From the cells forming the hypodermis run cytoplasmatic filaments, which penetrate the endocuticula and exocuticula, but do not permeate the epicuticula.

Investigations by several authors on the problem of the permeability of the cuticula can be summed up as follows: the penetration of compounds into the insect organism occurs through their integumenta and depends on the permeability of the cuticula. At the base of the pores from which hairs and chelae emerge, covering the entire body of the insect, and also between segments forming the insect body, the cuticula is thinner and here penetration of the insecticide proceeds more rapidly. Lipoids present in the cuticula andthe cuticula upon contact with several preparations are dissolved, and the toxic compound finds access to the hypodermis and to the nerve endings and lymph ducts. The undamaged layer of the of the cuticula protects the penetration through the latter of various compounds in solutions. Thus, for example, according to the data of A. A. Skvortsov, a saturated solution of cupric sulfate penetrates through the cuticula of fly larvae in 4 - 4.5 hours, but through the cuticula previously treated with ether dissolving lipoids, in 4 - 5 minutes. Substantial variations in the rate of penetration of the same compound can depend on the species of the insect, its age, and its nutrition. Major significance for the rate of penetration of poisons attaches also to individual characteristics of the structure of the insect cuticula. Even for the same insect species in the same developmental stage, some variations are observed in the rate of penetration of the same compound. In the stretched cuticula, the rate of penetration increases compared with wrinkled, which depends both on the fatigue of the membrane protecting the insect, and on the dilation of the duct pores.

A principal role is played by the epicuticula, in the makeup of which a wax layer protecting the organism from dessication is always found. It is advantageous to destroy it or even to damage it, since then water losses of the insect rise rapidly. This is markedly apparent in damage to the cuticula by small sharp particles of various nonpoisonous powders. Thus, cockroaches and bugs succumb when sprayed with silica gel. Disruption of the integrity of the epicuticula by neutral powders is especially important when using contact preparations, since even partial disintegration of the wax layer somewhat facilitates the penetration of poisons through the integumenta.

It is not at all obligatory that the poison cover the entire surface of the external integuments of the insect. We have succeeded in tracing the penetration of DDT through strictly limited sections of the cuticula on the dorsum of bugs; the insect succumbs also in those cases when the preparation is applied only on one of its tarsi (for example, the rear).

In all modes of penetration into the insect organism, insecticides enter the hemolymph, which carries them throughout the entire body.

In using poisons acting on the nervous system, to the fore emerge phenomena related to the attack on the latter; externally, this is expressed in seizures, trembling, and complete or partial paralysis of various groups of muscles due to the fact that nerve tissue is highly susceptible to the action of an insecticide.

The process of poisoning an insect with poisons acting on the nervous system after contact with the latter consists of the following stages: 1) the latent period; 2) the period of excitation; 3) the toxic action period, lasting from several minutes to several days, depending on the insecticide, dose, insect species, time of contact, temperature, etc.; 4) the period of recovery, if the insect has not succumbed. In this last period, the disrupted functions of individual organs gradually return to normal, while the anatomical disturbances setting in after the action of the poison are restored. As a result of the action of several poisons (chlorophos and pyrethrum) sometime the recovery period is followed by the period of remote action of the poison on insects.

It is sufficient for an insect to reside on a treated surface for a short time in order for poisoning to take effect. A fly or a mosquito sitting on a surface treated with DDT contacts it with its tarsal claws, which become covered with crystallites of the preparation. In addition, the insects probe the object on which they sit with their proboscis, which assures adequate intake of the poison into the insect organism through the labellar surface rich in sensory endings.

Contact insecticides are used in controlling parasites of domestic animals.

Several contact insecticides can be used as intestinal poisons and fumigants.

Synthetic contact insecticides -- DDT, hexachlorane, its gamma-isomer, methoxychlor, thiophos, etc. -- are widely used in agriculture and veterinary practice. The main incentive promoting the synthesis and setting up of production of such insecticides in enormous quantities lies in the effort to protect harvests, agricultural plants, processed products, and also products of animal origin.

Not only insects damaging agricultural plants but also insects of enormous benefit are highly susceptible to insecticides. Of the large number of contact insecticides in existence, the highest toxicity is shown by thiophos. For example, 90 % of bees (LD_{90}) succumb when 0.15 mcg of the preparation is applied on a single individual.

Recently, industry has begun manufacturing preparations exhibitint systemic action, that is, when applied to the soil, they enter through plant roots and are carried by plant juices throughout the entire plant. Upon ingesting the juices of such a plant, the insect succumbs. Several compounds, when ingested into the organism of mammals, give their blood insecticidal properties. Such insecticides can also be called systemic insecticides. They include:

Butylchlorophenylmethylmethylphosphoramidate -- a systemic insecticide for internal use against gadflies and other cattle parasites. The LD_{50} for rats in oral administration is 1000 mg/kg.

Dimeton -- a contact insecticide with several fungicidal properties with strong systemic activity for plants. The LD_{50} for rats is 1.7 - 7.5 mg/kg.

Dimethyldiaminotriazineylmethyldithiophosphate -- a persistent systemic insecticide for plants. The LD_{50} for rabbits is 200 - 500 mg/kg.

Dimethyldibromodichloroethylphosphate -- an effective contact and systemic insecticide and acaricide with several fumigational properties. The LD_{50} for rats is 430 mg/kg.

Dimethylethylthionylethylthiophosphate -- a contact and systemic insecticide. It is recommended in controlling aphids and ticks on decorative plants. The LD_{50} for rats is 65 mg/kg.

Diethylmethylcoumarinylthiophosphate -- a systemic (for plants) and contact insecticide. The LD_{50} for rats is 15 mg/kg.

Diethylisopropylthiomethyldithiophosphate -- a systemic (for plants) and contact insecticide, a promising agent in extermination of bloodsuckers. The LD_{50} for rats is 50 mg/kg.

2-Methyl-4,6-dinitrophenol -- a powerful systemic poison (for plants) and contact insecticide. The LD_{50} for rats is 40 - 65 mg/kg.

Cryolite, or sodium aluminofluoride -- a systemic (for plants) and contact insecticide, weakly toxic for warmblooded animals.

Methyldimethone-0,0-dimethyl-0-2(ethylthiophosphate -- a contact insecticide with substantial systemic action. The LD_{50} for rats is 40 - 180 mg/kg.

Methylacetamidedithiophosphate (rogor) -- promising as a systemic insecticide.

Thiodemethone, or 0,0-diethyl-S-2(ethylthio)ethyldithiophosphate -- a systemic insecticide for plants. The LD_{50} for rats is 2.6 - 12.5 mg/kg.

Phorate, or 0,0-diethyl-S-(ethylthiomethyl)dithiophosphate -- systemic insecticide for plants. The LD_{50} for rats is 3.7 mg/kg.

Phosphamidon, or dimethyl-2-chloro-2-diethylcarbamyl-1-methylvinylphosphate -- an insecticide systemic for plants. The LD_{50} for rats is 16 mg/kg.

Fluoracetanilide -- a poison systemic for plants. The LD_{50} for rats is 10 mg/kg.

Insecticides applied in soil have no strong effect on soil microflora either positively or negatively. Thus, heptachlor and DDT inhibit the population of molds in various types of soil; hexachlorancyclohexane in some cases promotes an increase in mold population; aldrin retards the growth of molds, but dieldrin increase their numbers; when parathion is present in the soil, the number of bacteria changes only slightly.

Lindane, DDT, and aldrin are absorbed by plants to a considerable extent; carrots absorbs the greatest amount of the preparation, but when lindane is present it is also accumulated; the latter is readily absorbed by potatoes, etc. The insecticide is more readily absorbed from sandy soil than from loamy.

When sizable amounts of hexachlorane are applied to soil, vegetables acquire a specific odor and become unsuitable for human nutrition. Plants grown in soils treated with aldrin contain both aldrin and dieldrin in their tissues.

After chlordane is applied to soil, 15 % of it can be detected over a period of 12 years; hexachlorane is detected to the extent of 41 % in 11 years; heptachlor can be isolated for approximately 9 years, while with the aid of biodeterminations, the presence of 4 - 5 % of the poison can be established in the form of heptachlorepoxide; aldrin disappears from soil in 4 years, part of it converting into dieldrin, which can be isolated to the level of 8 - 10 % of the dose used.

In controlling grain pests, insecticides are used in treating both empty and filled warehouse bins. In particular, contact insecticides are used also for the purpose of impregnating sacks intended to store grain products. In storing grain in cotton bags, the inner surfaces of which have been sprayed with a 1 % solution of one of the following preparations: aldrin, hexachlorane, chlordane, dieldrin, endrin, heptachlor, isodrin, lindane, malathion (carbophos), parathion (thiophos), and piperonylbutoxide, no grain spoilage is noted for a period of 6 months. There is also no marked increase in pest population; only stroban does not assure prolonged protection.

We have dwelt on the use of contact insecticides in agriculture in very brief fashion, since this book is concerned in the main with the use of insecticides in controlling causative agents of infectious diseases and parasites of man and his quarters.

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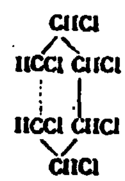
CHAPTER II

CHLORINATED HYDROCARBONS[1]

Hexachlorocyclohexane

Hexachlorocyclohexane – $C_6H_6Cl_6$ (1, 2, 3, 4, 5, 6-hexachlorocyclohexane):



Synonyms – [VNS] (BHC), Gammexane, benzene hexachloride, 666 and others. Most frequently in the Soviet Union hexachlorocyclohexane is abbreviated to hexachlorane and [HCCH] (ГХЦГ). Its molecular weight is 290.85. Technical hexachlorane is a slightly oily, crystalline substance, white with a brownish tint or brown, comprising 8 isomers; the pure isomers are crystalline substances, achromatic (white), which sublimate upon heating; the individual isomers have different physical and chemical properties (Table 1).

Hexachlorane was first made by Faraday in 1825 by chlorination of benzene in sunlight. In the Soviet Union hexachlorane was tested in 1940-1941 (I. S. Travkin). In 1941 hexachlorane was patented in France under the name of "avtariya" as an agent for controlling mange. In the period 1942-1943 in England the insecticidal properties of hexachlorane was studied. In the Soviet Union

[1]For purposes of reducing the size of the structural formulas we do not indicate the chemical designation of carbon and hydrogen in a number of compounds.

the insecticidal properties of hexachlorane were studied. In the Soviet Union for public-health purposes this preparation was introduced into broad practice in 1945 by the Central Scientific-Research Disinfectional Institute (V. I. Vashkov, N. N. Mel'nikov, V. N. Polikarpov, N. D. Sikharev and others). Special monographs have been dedicated to the study of hexachlorane, including the monograph of Yu. N. Bezobrazov, A. V. Molchanov and K. A. Gar ("Hexachlorane").

Table 1. Isomers of hexachlorane (alpha, beta, gamma, delta, episilon, zeta, eta, theta) (Yu. N. Bezobrazov, A. V. Molchanov, K. A. Gar).

Isomers	Year of discov-ery	Discoverer
Alpha	1884	Men'ye
Beta	1884	The same
Gamma	1912	Van der Linden
Delta	1912	The same
Epsilon	1946	Kauer
Zeta	1953	Rimschneider
Eta	1952	Kolka and Orlov
Theta	1954	The same

Hexachlorane is a product of the addition of 6 atoms of chlorine to benzene. This reaction takes place under the effect of ultraviolet rays and can be expressed by the following equation:

$$C_6H_6 + 3Cl_2 = C_6H_6Cl_6.$$

Hexachlorane starts to melt, as a rule, at a temperature lower than 100°. The composition of the technical product is not standard and depends on the method of derivation. In connection with the heterogeneity of hexachlorane the melting point and the other physical properties of its various forms are also different and due to this in literature definite data on the physical properties of the technical product are absent.

The composition of hexachlorane can vary, depending on the conditions and the method of its derivation. As an insecticide hexachlorane is extremely versatile. The active compound of this substance is the gamma-isomer. There are means for increasing the gamma-isomer content in the mixture. These methods are based on the various solubilities of the isomers of hexachlorane in organic solvents (see Tables 2 and 3).

Table 2. A number of isomers of technical hexachlorane and their melting points.

	Alpha	Beta	Gamma	Delta	Epsilon	Note
Contained in technical hexachlorane	5%	70%	12%	7%	3%	The mixture is decomposed 288°
Melting point	159—160°	309—310°	112—113°	138—139°	219—220°	
Average	158°	312°	112,5°	138°	219°	

Table 3. Vapor pressures of the basic isomers, (alpha, beta, gamma, delta) of hexachlorane in mm Hg.

Temperature	Alpha	Beta	Gamma	Delta
+40°	0,06	0,17	0,14	0,09
+20°	0,02	0,005	0,03	0,02
−20°	$2{,}5\cdot10^{-5}$	$2{,}8\cdot10^{-7}$	$9{,}4\cdot10^{-6}$	$1{,}7\cdot10^{-5}$
+60°	0,33	0,58	0,48	0,34

All the isomers hardly differ from each other in their chemical properties. The physical, chemical, and toxic properties of the isomers of hexachlorane depend on the spatial arrangement of the chlorine atom with respect to the carbon atoms. The isomers are resistant to the action of oxidizing agents and strong acids. Under the effect of alkalis the isomers are decomposed by the splitting of hydrogen chloride and the formation of trichlorobenzene. The reaction takes place in the following manner:

$$C_6H_6Cl_6 + 3NaOH = C_6H_3Cl_3 + 3NaCl + 3H_2O.$$

Dehydrochlorination by alkalis at normal temperatures yields 3 moles of HCl per mole and 1, 2, 4-trichlorobenzene (65-85%), 1, 2, 3-trichlorobenzene (5-15%) and 1, 3, 5-trichlorobenzene (6-15%).

Both the technical mixture, and also the individual isomers hexachlorane are almost insoluble in water. Thus, for example, at 20° the alpha- and delta-isomers dissolve in distilled water approximately at a rate of 10 mg per ℓ, the gamma-isomer at 2-7 mg and the beta-isomer within the limits of 5 mg per ℓ.

The aphla-isomer is steam distilled; the beta-isomer is not steam distilled but sublimates.

Hexachlorane and its isomers dissolve readily in organic solvents – acetone, ethyl acetate, benzene, dichlorethane, in which the greatest solubility in such solvents belongs to the delta-isomer, then the gamma-, epsilon- and beta-isomers (Table 4).

Table 4. Physical properties of the components of hexachlorane.

Name	Empirical formula	Melting point	Crystal forms	Vapor pressure in mm Hg at a temperature of 20°	40°	60°	Dipole moment
Alpha-hexachlorocyclohexane	$C_6H_6Cl_6$	159-160°	Monoclinic prisms	0.02	0.06	0.33	2.2
Beta-hexachlorocyclohexane	$C_6H_6Cl_6$	309-310°	Octahedrons	0.005	0.17	0.58	0
Gamma-hexachlorocyclohexane	$C_6H_6Cl_6$	112-113°	Needles from acetic acid or rhombs from chloroform	0.03	0.14	0.48	3.6
Delta-hexachlorocyclohexane	$C_6H_6Cl_6$	138-139°	–	0.02	0.09	0.34	0
Epsilon-hexachlorocyclohexane	$C_6H_6Cl_6$	218.5-219.3°[1]	Prisms[2]	–	–	–	–
Alpha-chlorobenzene hexachloride	$C_6H_5Cl_7$	146°	–	–	–	–	–
Beta-chlorobenzene hexachloride	$C_6H_5Cl_7$	260°	Prisms[2]	–	–	–	–

Table 4 (Cont'd)

Name	Empirical formula	Melting point	Crystal forms	Vapor pressure in mm Hg at a temperature of			Dipole moment
				20°	40°	60°	
o-dichloro-benzene hexachloride	$C_6H_4Cl_8$	149°	–	–	–	–	–
m-dichloro-benzene hexachloride	$C_6H_4Cl_8$	81.8°	Leaflets[2]	–	–	–	–
alpha-п-dichloro-benzene hexachloride	$C_6H_4Cl_8$	89.6°	Needles[2]	–	–	–	–
beta-п-dichloro-benzene hexachloride	$C_6H_4Cl_8$	262°	Rhombs[2]	–	–	–	–

[1]At a temperature close to the melting point there is noticeable sublimation.

[2]From ethyl alcohol.

In accordance with the requirement of the Committee on Insecticides of the Universal Organization of Public Health, Technical hexachlorane must consist mainly of a mixture of isomers and be in the form of grains, flakes (or a white, light-brown colored powder), free from impurities or introduced modifying agents:

	Minimum	Maximum
Technical hexachlorane, content of the gamma-isomer in weight per cent......................	12	16
Purified hexachlorane, content of the gamma-isomer in weight per cent......................	16.1	93
Acidity in weight per cent based on HCl...........	–	0.1
Solids insoluble in acetone, in weight, per cent..	–	1.0
Water content in weight per cent.................	–	1.0

Hexachlorane is stable with respect to light, humidity and strong acids. At the same time high temperatures considerably lower its residual effectiveness, and increasing the dosages insignificantly increases the residual effectiveness.

Hexachlorane has contact, fumigant and intestinal actions. At ordinary temperatures (20°) it is slightly volatile; with a temperature increase, for example up to 60°, the volatility of the gamma-isomer and the other isomers increases by 11-17 times. Thus, hexachlorane acts on insects not only upon contact, but also by means of its vapors.

The odor and taste of hexachlorane, remaining on the food products treated with it, are the main deficiencies limiting its application.

Preparations made from hexachlorane. In the manufacture of various preparations calculation of the active agent is made according to the total isomers, assuming that hexachlorane contains 10-13% of the gamma-isomer.

Hexachlorane solutions manufactured with highly inflammable solvents are not used in treating lodgings, inasmuch as they can be a fire hazard. Solutions in organic solvents are employed only for the selective treatment of locations where insects reproduce or infest. The solvent has a considerable influence on the effectiveness of the preparation.

For practical purposes hexachlorane paste of the following composition is recommended: isomers of hexachlorane 30%; [OP-7] (ОП-7) 26%; technical gelatin 0.5% and water 43.5%.

In controlling everyday parasites a 15% emulsion of technical hexachlorane is utilized in the manufacture of which terpentine, white spirit and chlorobenzene are used. It is possible to obtain a concentrate of mineral oil emulsion with a 25% gamma-isomer content. Water-soap emulsions of kerosene contain 2% active agent (according to the total number of isomers), a solvent (kerosene), an emulsifier (household soap) and water.

In certain cases insecticidal pencil-cylinders with a diameter of 1.5 cm are used. The method of their manufacture was developed by Yu. N. Bezobrazov, A. V. Molchanov and V. P. Pivovarov (see "Insecticidal Pencils"); the pencils contain 70% hexachlorane and 30% paraffin. Hexachlorane is also put in floor-polish to control insects, especially fleas.

Hexachlorane soap contains 3% hexachlorane and 2-5% organic solvent (turpentine, white spirit, liquid petroleum, and so forth).

Hexachlorane ointment has approximately the following composition: hexachlorane (with a 10% gamma-isomer content) 1.5% liquid petroleum 10%, vaseline 88.5%.

Disinfecting powders are prepared with a different percentage of hexachlorane. In agricultural practice it is recommended that disinfecting powders be applied at a 6-12% concentration, and in sanitation practice – at a 6% concentration (of technical hexachlorane). The fineness of the ground product should correspond to the passability of the disinfecting powders through a No. 90 screen, the residue on such a screen should not exceed 3%.

According to K. A. Gar and V. I. Chernetsova, during the storage of the disinfecting powder for 70 days it loses 25% of its activity. In studying the influence of the filler the authors determined that after 47 days the disinfecting powders with Shiberov and Ilmen talc lose 35% of their activity, with Miass talc 22%, with kaolin 80% and with ash 5%. The disinfecting powders of hexachlorane lose their effectiveness at least 2 times faster than DDT disinfecting powders.

Under the influence of the rays of a mercury-vapor lamp for a period of 10 hours at a temperature of 24-25° on a surface covered with hexachlorane (150 mg/m^2), the toxicity of the preparation after 3 hours decreases by 70%. The effectiveness hexachlorane also decreases under the influence of sunlight.

Aqueous suspensions, as has been shown by mean years of observation of the use of hexachlorane, have a greater effect than application in the form of disinfecting powders. Suspensions hold better on a surface than dry disinfecting powder. For intensifying the adhesion of solid particles to surfaces wettable powders, stable suspensions, etc., are being manufactures. Suspensions acquire such properties with the introduction into their composition of emulsifiers and wetting agents (OP, sulfanole-alkalyaryl, sulfonate, and others).

The aerosols of hexachlorane possess high effectiveness. They are obtained by atomization of solutions, by the combustion of thermal mixtures containing hexachlorane, and other ways. Insecticides in the form of aerosols obtained in the combustion of thermal mixtures are employed in controlling arthropods (flies, mosquitoes, gnats, mites, bugs, fleas, and others).

In the sublimation of hexachlorane vapors will form, possessing potent insecticidal properties. For sublimation the preparation is poured into any metal cup, porcelain crucible or simply onto a piece of sheet metal and heated on an electric hot plate, kerosene burner, alcohol lamp, or other heating device. In sublimating it is necessary to consider that too strong heating of hexachlorane (above 200°) causes noticeable decomposition. It is sufficient to vaporize 50 mg of the substance per 1 m^3 of space, so that after 2 hours paralysis is induced in the flies with their subsequent death (90%). Increasing the dose to 75 mg/m^2 causes paralysis in the insects in an hour and their subsequent complete destruction. Aerosols can also be obtained by burning hexachlorane impregnated materials at a rate of 0.1-0.15 g of preparation per 1 m^3 of space.

Aerosols of hexachlorane are also obtained by atomizing solutions of enriched hexachlorane in highly volatile solvents (freon, ethyl chloride and methyl chloride), contained in various special vessels – bombs, gas cylinders, and so forth. It is also possible to obtain aerosol possessing high insecticidal properties by atomizing various mineral-oil solutions of hexachlorane. Such aerosols are employed in locations where people do not stay for long periods of time (outbuildings, warehouses, and other locations).

In the Federal Republic of Germany they are turning out preparation xylamon, which consists of a mixture of mono- and dichloronapthalene with hexachlorane. It is a yellow- noninflammable liquid with a strong odor reminiscent of napthalene, which boils at 230° and is insoluble in water, but mixes with the usual organic solvents; xylamon is also broadly utilized in Italy.

Insecticidal properties of hexachlorane. Hexachlorane preparations are valuable as a means of controlling everyday insects and carriers of human diseases – malarial mosquitoes, flies, buffalo gnats, biting midges, fleas, bugs, cockroaches, mites, moths, pharoah's ants and others. These preparations are very important as a means of controlling animal parasites – gadflies, mites, and others. They are widely used in agriculture for controlling agricultural plant pests.

Hexachlorane is several times more toxic to insects than DDT. It, like DDT, acts selectively on insects. Thus, for example, for cockroaches its toxicity is 4.6 mg/kg for the adult stages of flies – 0.8 mg/kg, and for flies in the breeding stage – 0.4 mg/kg. For warm-blooded animals it is less toxic – complete destruction of white mice is observed from a dose of 1 g/kg. Thus, as compared to warm-blooded animals hexachlorane is 200 times more toxic for cockroaches, 1200 times for the adult stages of flies and 2500 times for breeding flies. These data show that the preparation acts selectively on insects and is especially toxic for flies. Hexachlorane has no effect on insect eggs.

With the addition of octachloropropyl ester the insecticidal properties of hexachlorane are increased by 24 times.

The preparation is used to treat of places where insects reproduce, living quarters, and also outdoor buildings and stagnant anophelogenic reservoirs.

Its specific, persistent odor reminiscent of the odor of a cellar covered with mold, and also its volatility (fumigant) do not make it possible to recommend this preparation for impregnation of tissues and the continuous treatment of the internal walls of living and working areas, all the more so because the people located in the treated areas complain of headaches; in individual cases vomiting is even observed. The application of this preparation is also not recommended in food outlets [Translator's Note: wholesale and retail grocery establishments] odor, apparently, is caused by the presence of an insignificant amount of still undetermined compounds forming in the process of hexachlorane derivation. The pure, repeatedly recrystallized isomers of hexachlorane are practically devoid of odor.

The isomers of hexachlorane in their insecticidal properties to a considerable extent differ from each other. The most potent insecticidal properties are possessed by the gamma-isomer, the insecticidal properties of which with respect to mosquitoes are 250 times greater than the activity of the alpha- and delta-isomers and 10,000 times greater than the insecticidal properties of the beta-isomer.

With respect to flies the insecticidal properties of the isomers to a considerable degree also differ from each other.

With the application of 2 g/m^2 of hexachlorane on a surface the latter acquires considerable insecticidal properties, which are preserved for a long time. Thus, for example, if a day after the application of hexachlorane about 90% of the flies coming into contact with the surface die, then in a week their mortality rate is 63%, and after 4 weeks – 13%. Aedes aegypti mosquitoes coming in contact a week after the application of the preparation have a mortality rate of about 100%, and after 2 weeks 49%. Complete destruction of Anopheles mosquitoes is observed in the presence of 0.1 mg/ℓ of hexachlorane in water (L. P. Blakitnaya, S. G. Grebel'skiy, A. M. Klechetova, P. Ya. Leviyev, L. N. Pogodina, A. G. Radchenko, M. L. Fedder, B. L. Shura-Bura).

With an increase in the amount of the preparation applied to a surface up to 3.3-4.3 g/m^2 it completely disappears in 50-60 days. With the addition of polyphenols the evaporation intensity sharply decreases, in connection with which the insecticidal properties are preserved considerably longer.

After application to a surface of a suspension of hexachlorane in a 0.3% concentration at a rate of 75 mg/m^2 of active substance at a temperature of 25-30° the effectiveness of the latter is halved after a period of 24 hours.

The effectiveness of hexachlorane and its gamma-isomer, when applied out of doors, depends on the climate, especially on air temperature and humidity (A. M. Lunova, Ye. A. Pokrovskiy). For hexachlorane there is absent a sharply expressed negative temperature coefficient, usually noted in DDT poisoning. At a temperature of 24° and above preparations of hexachlorane are less effective than at low temperatures. High temperatures cause an almost complete loss of insecticidal toxicity and sunlight does not play a significant role in the (Mitrin). At lower temperatures surfaces treated with hexachlorane lose their toxicity after 2-$3\frac{1}{2}$ months. Aqueous suspensions or emulsions with a 2% hexachlorane concentration are applied to surfaces at a rate of 100 mℓ of solutions per 1 m^2. Hexachlorane at a rate of 8 mg/kg, added in the form of an acetone solution to substrate, inhibits fly breeding by 50%. There exist data about the fact that hexachlorane does not have any larvicidal action; larvae, it appears, avoid hexachlorane by migrating into manure or other waste materials. The use of this preparation on manure is justified only by the fact that it promotes the destruction of the hatching flies and the females, which are laying eggs here.

House flies with topical application of 2-3 μg, and flow flies with 0.6 μg/g (kerosene solution) die within the limits of 50%

[LD_{50}] (ЛД$_{50}$) for lice LD_{50} is 0.03 μg per insect; for oriental cockroaches it is 5 μg/g by injection, and for the common cockroaches 0.2 μg per insect.

Smokes containing hexachlorane are highly effective (G. K. Kal'bergenov and others). Thus, for example, with the combustion of a thermal mixture at a rate of 0.51 and 1.2 g/m^3 in a chamber with a volume of 4 ℓ complete destruction of cockroaches was observed in the first case after 70, in the second after 60 hours. Blood-sucking flies (buffalo gnats, biting midges and gadflies) are very sensitive to the preparation. It is equally effective when used for the destruction of mosquitoes (K. P Andreyev and others).

Vapors of the gamma-isomer penetrate readily through various packing materials, into cracks, wrapping paper, and others. It has been established that packing materials (cardboard, kraft paper, cellophane, glass, or aluminum foil) do not completely protect food products from the penetration of parasites. With the presence in 1 m^3 of air of 220 mg of hexachlorane with an exposure of 24 hours the quality of the packing noticeably affects the permeability of the preparation vapors. In descending order of vapor penetration through the packing materials it is possible to arrange the latter in the following sequence: cardboard, kraft paper, cellulose (2 layers), aluminum foil (paper), cardboard with paper lining, and carboard with glass lining.

In insect control hexachlorane is sometimes sublimated from heated surfaces (pans, etc.), and aerosol bombs, etc., are used. The low residual action of smoke aerosols on treated surfaces is explained, apparently, by the fact that a very small amount of aerosols settles on vertical surfaces. After the combination of DDT smoke-pots in premises with a dimension of 70 m^3 in one case with a charge of 110 g of technical preparation, and another containing 120 g of technical hexachlorane (10-12% gamma-isomer), determinations were made of the amount of deposition of preparations on horizontal, vertical, and inverted surfaces. The greatest amount of deposition was on the horizontal surfaces, and the least – on the inverted surfaces (ceiling).

In a chamber during fumigation filter paper was placed on the horizontal, vertical, and inverted surfaces. The gamma-isomer settled on all the surfaces, irrespective of position, to a considerably greater degree than the DDT (see "Aerosols"). The greatest insecticidal properties were obtained by the horizontal surfaces, and the least – by the inverted surfaces.

Surfaces covered with insecticidal varnish containing 1.5-2% hexachlorane acquire insecticidal properties for common and oriental cockroaches and true bugs. Toxicity was observed as long as 820 days after application of the varnish (see "Varnishes and Paints").

In the insect organism hexachlorane is decomposed by enzymes. Its decomposition and the character of the metalolites depend to a certain degree on the species of insect.

As was already indicated above, hexachlorane is very effective in controlling pests of agricultural crops. It is equally toxic and to useful insects, especially bees.

Hexachlorane is utilized to control insects, which sting and cause injury to animals (gadflies and mites) (Zh. V. Vranchan, N. N. Gorchakovskaya, S. A. Shilov).

Phytotoxicity. When employed in the recommended doses hexachlorane does not present a danger to plants, but in higher doses it has an effect on seed germination, plant growth and lowers the grain productivity and can cause root deformation and cytogenetic mutations. At a dose of 0.112-0.672 g per 1 m^2 there is a noticeable effect on seed germination; a dose of 5.6-8.96 g/m^2 does not harm cotton and tobacco, but a dose of 11.2-22.4 g/m^2 causes plant necrosis. Certain strains of potatoes could endure 8.96 g/m^2, and certain strains perished from 2.24 g/m^2.

The gamma-isomer penetrating into plants through the root system is lethal to certain agricultural plant pests, for example aphids and mites. The systemic insecticidal properties of hexachlorane are minor, and therefore it is not used in practice for these purposes.

A deficiency of the preparation is that after its application fruits and vegetables acquire an unpleasant aftertaste, therefore it is not recommended for application in orchards after blossoming. Such cultures, as cabbage, can be dusted with 12% hexachlorane disinfecting powder at a rate of 10-12 kg/ha during early growth (seedlings). Dusting should not be carried out on beets, carrots, lettuce, strawberries, and other vegetables and berries, which are used in their raw form. The application of up to 40 kg/ha of 25% powder in to the soil of sugar beet fields is not reflected in the taste qualities of the sugar.

After the introduction of 12% disinfecting powder or 25% powder with phosphorite mean at a rate of 1-2.5 kg/ha into the soil for extermination of wire worms the potatoes cultivated during the next 3-5 years on this soil become unfit for food; the potatoes can only be used for technical purposes or as feed for cattle. Analogicous soil treatment unfavorably affects the taste qualitites of onions and turnip.

Damage to the taste of fruits, vegetables and berries also occurs without the direct contact of hexachlorane with plants. The introduction of the preparation to soil under cabbage causes a change in the taste of the head (especially the stump). Excess application of the preparation to soil under currants gives the berries an unpleasant aftertaste, which is more strongly discerned in preserves and jam than in fresh berries.

The effect of hexachlorane on soil microorganisms is insignificant. With a dose of 1 g of the gamma-isomer per 1 kg of soil there is a slight increase in the processes of ammonification and nitrification and minor suppression of the development of mold fungi irrespective of the soil type. Of all the isomers the most active in this respect is the gamma-isomer, which with the application of small doses of hexachlorane to cotton, wheat, cabbage, and certain other cultures leads to an improvement in the development of the plants.

After the application of 11.2-56 g/m^2 of hexachlorane the fungi in the soil and the nitrogen-resistant bacteria are suppressed in their reproduction for several months. Hexachlorane is less stable in the soil than DDT: large doses are decomposed at a rate of 10% per year. The toxic effect lasts for 5 years with treatment at a rate of 11.2-22.4 g/m^2.

Toxicity for vertebrates. For vertebrates hexachlorane poisoning can occur by inhalation, ingestion and in the case of absorption of the preparation through the skin. In the organism hexachlorane is deposited most of all in the fatty tissue, it is retained in the liver and kidneys in considerable quantities. The beta-isomer is retained in larger quantities than the other isomers.

The toxicity of hexachlorane for animals and man fluctuate depending upon the presence in it of the gamma-isomer and the ways it gets into the organism of the animals. The average toxic dose of the gamma-isomer is equal to 125 mg/kg. Of the four most studied isomers the greatest toxicity belongs to the gamma-isomer: the alpha-isomer is 2-3 times, the beta-isomer is 30-40 times, and the delta-isomer is 4-7 times less toxic for white rats than the gamma-isomer (Table 5).

Table 5. Toxicity (LD_{50}) of the hexachlorane isomers for warm-blooded animals in mg/kg when ingested through the mouth.

Species of animal	Alpha	Beta	Gamma	Delta
White rats	500	6000	125-200	900

Technical hexachlorane (12% gamma-isomer) is approximately 4-5 times less toxic than the pure gamma-isomer. In the presence of other isomers of hexachlorane the gamma-isomer is less toxic for animals than in its pure form.

The rats can stand (without any symptoms of poisoning and lesion to the tissues of the organism) food containing 10 mg/kg over a period of 104 weeks. Great changes are observed in the tissues of the rat with an increase of the dose of the preparation in the food up to 100 mm/kg (N. M. Rusin, G. P. Andronova, A. P. Volkova, M. S. Levinskiy, K. Morozovskiy, V. . Mustaov).

With the application of 2.5 mg of hexachlorane per 100 g of weight to the white rats for 250 days symptoms of intoxication and death were observed in the animals. Hystological examinations showed that considerable cytoplasmic and nuclear lesions take place, particularly granular degeneration or homogenization of the cytoplasma. Mice can endure 40 mg/kg with oral administration of this dose for a period of 40 days.

The daily, oral administration to cats of 0.5 mg/kg of hexachlorane for a year is nontoxic.

The beta-isomer is most persistently retained in the tissues of the organism. The gamma-isomer appears in the tissues of rats (fatty tissue) soon after the application of feed containing 20-100 mg/kg. However, its accumulation is not observed. The gamma-isomer is rapidly metabolized. Experimental data do not confirm the theory that hexachlorane serves as an antimetabolite replacing C-inositol in cell metabolism.

After the administration of 2 g/kg of hexachlorane (10% gamma-isomer) to a sheep with a weight of 86 kg severe symptoms of poisoning, breathing spasms, and blindness appeared after 6 hours; the condition of the animal returned to normal on the 5th day. With a decrease in the preparation dose to 1 g/kg mild nervous symptoms were observed.

In horned cattle no symptoms of intoxication were observed after the introduction of hexachlorane within the limits 125-300 mg/kg, with the exception of calves, in which severe symptoms of poisoning were observed; after increasing the dose to 0.5 g/kg mild nervous symptoms were observed.

Hexachlorane possesses expressed cumulative properties; it appears in 11 days in the blood of rabbits after a single administration of 0.6 g/kg (V. I. Vashkov). It is eliminated from the organism of animals with excrement, urine, and the milk of lactating animals; thus, for example, after a single feeding of the gamma-isomer at the dose of 10-20 mg/kg cows' milk acquires toxic properties for flies after 12 hours. The toxicity of the milk increases for a period of 12 days and only after 2 weeks does it again become nontoxic for flies.

When hexachlorane gets into the organism through the skin or orally with the feed of animals or birds it is deposited in the fat in nontoxic quantities; maximum accumulation is noted after 6 weeks.

The fat and fatty meat of animals treated with the preparation acquire an unpleasant aftertaste and odor, which do not disappear for several weeks after the termination of feeding with feed containing the insecticide.

Cattle bear up without clinical symptoms after a 10-fold application of 0.2% wettable powder, carrying out each subsequent treatment at 2 week intervals. The application of the preparation to the hide of young animals for the purpose of eliminating ectoparasites is dangerous; especially dangerous is the application hexachlorane for treating calves aged less than 3 months. As for birds, hexachlorane can be used only for treating their perches. The preparation also penetrates into the white and yolk of hen's eggs.

Hexachlorane imparts an odor to the meat and eggs of hens not only after they have eaten the preparation with their feed, but also in the case of painting or treating soils, bedding, perches, or the birds themselves with solutions.

According to V. I. Vashkov and A. P. Volkova, a sojourn of white rats for a month in a chamber treated with hexachlorane at a rate of from 0.5 to 10 g per m^2 does not cause in the animals any external symptoms of poisoning. Nevertheless, in regard to the conditioned reflex activity of the brain of these same rats there appear characteristic changes, associated with the intensification of the inhibitory processes and the weakening of the processes of excitation. Apparently, the intoxication of the organism of experimental rats with vapors of hexachlorane causes attenuation of the activity of cerebral cortex and lowers the level of efficiency of the cortical region and in parts of the subcortical regions. Therefore, the delayed and numerous occurrences of conditioned reactions, mainly to strong stimulus the disinhibition of differentiation and the appearance of paradoxical and ultraparadoxical phases intensified in proportion to the increase of the concentration of the preparation, indicate that the excitation induced by normal conditioned stimuli exceeds the attenuated limit of efficiency of the cortical cells and transliminal protective inhibition develops in them. The latter also spreads to the subcortical regions (the region of the unconditioned food reflex).

Such oppressing action of the hexachlorane vapors occurs to certain extent due to the presence of the alpha-isomer in it.

Subsequent investigations by the same method showed that the application of the gamma-isomer on the walls of toxicological chambers at concentrations up to 1300 mg/m^2 did not cause essential changes in the functional state the cerebral cortex of rats during their continuous stay in the treated chamber for a period of 3 weeks. The alpha-isomer applied to the walls of the same chamber at a rate of 7 g/m^2 causes intensification of the inhibition processes and attenuation of the excitation processes.

Thus, it is possible with a certain degree of probability to consider that the oppressing effect of hexachlorane on the conditioned reflex activity of the cerebral cortex depends to a great extent on the presence in it of the alpha-isomer.

Hexachlorane causes the greatest damage to the liver and the other parenchymal organs by its oral administration to an animal, and also in the inhalation of the vapors of the preparation by the latter.

Hexachlorane vapors reduce the resistance of warm-blooded animals to the unfavorable factors of the environment, which was confirmed by our experimental data on white mice. For a period of 50 days 25 mice were situated in a box in a cage, which was placed in another cage; the walls of the latter cage were treated weekly with a solution of hexachlorane in acetone. During the time of treatment and drying of the cage the mice were removed from it. After 27 days the mice were each administered 0.5 mℓ of 0.1% agar. As a result after the 50 days of the experiment only 3 mice remained alive (all were pregnant); in the control 4 of the 25 mice died. In a repetition of the experiment analogous results were obtained. This indicates that continuous inhalation of hexachlorane vapors weakens the organism and in the presence of unfavorable circumstances (the administration of agar) the mortality rate was approximately 8 times greater than among those, which were not subjected to the effect of hexachlorane (V. I. Vashkov, F. D. Mazhbits).

The toxic effect of hexachlorane depends on the concentration, exposure and temperature.

In working with hexachlorane it in most cases in one or another amount gets into the human organism. According to Wasserman and others, during an 8-hour working day a man inhales 0.49 mg/kg of the preparation; during this period the deposition on the arms, hands, nasopharynx and the neck of persons occupied in spraying the preparation reaches 1.17 mg/kg. Consequently, the deposition of hexachlorane on the skin exceeds by 2 times the inhaled amount.

Dusting with disinfecting powder in the amounts used in practice is toxic, therefore in working with it is necessary to strictly observe all measures of precaution provided for in the instructions for the application of hexachlorane.

In working with hexachlorane disinfecting powders reddening of the skin is noted especially of moist skin. There are data to the fact that working with hexachlorane can cause dermatitis. The cases of people dying from poisoning by the preparation are rare. There have been cases when after continuous treatment of living and working quarters with preparations of hexachlorane there were observed headache, nausea, vomiting, irritation of the mucous membranes of the eyes and respiratory tract, asthenia, and sometimes insomnia. Thus, for example, at one factory during the hot summer time after the treatment of working areas for the purpose of exterminating cockroaches, work was recommenced without airing out the areas, and mass poisoning of the workers (10 men) occurred; the injured were taken to a hospital, where medical help was given to them.

In using hexachlorane to control scabies no harmful effect was observed on an adult human after the application of a 1% mixture in the form of a paste or ointment at a dosage of 15-20 g of ointment on the surface of an affected section of the body and letting it remain there for 24 hours. After two-three applications at weekly intervals toxic symptoms or irritation of the skin were also not observed. Furthermore, the result of the therapy for scabies was positive. According to estimations made in the USA in 1950, the average concentration in the fat of humans was within the limits of 0.6-1.64 mg/kg. In inhabitants of France the concentration of the preparations in the fat of humans was even higher.

After the application of 200-500 mg of hexachlorane in acetone and an exposure of $1\frac{1}{2}$ hours there is observed in man barely perceptible sensation of burning and mild rapidly passing hyperemia at the site of application (Behrbohm).

Like DDT, hexachlorane, although it is broadly used, no severe cases of occupational poisoning have been reported. There are data with respect to the high sensitivity of individual persons and mild intoxication during its application as a spray or dust. Accidental poisonings have taken place under various circumstances, including the taking of hexachlorane as a vermifuge. Cases have been described of severe poisoning of humans by a single accidental dose of 60-40 mg of a gamma-isomer preparation. On the other hand, Klosa reported that after a daily administration of 40 mg for a period of 10 days only weak symptoms were observed in a human. Seventy-nine cases of poisoning occurred as a result of the incorrect use of hexachlorane powder, of which 6 were fatal. The symptoms of poisonings in certain cases were prolonged and manifested themselves as fatigue, spasms, pareses, ataxia, tremors, memory disturbance and others.

There are data about the death of a $2\frac{1}{2}$ year old child, who took (probably, a small quantity) a mixture containing 6% lindame and 30% malathion. This is explained, apparently, by the fact that the toxicity of these preparations increases, when they are used in combination.

For man a lethal dose of technical hexachlorane is approximately 0.2-0.4 g/kg. In man the initial symptoms of poisoning are observed after 1-2 hours, death occurs within 24 hours. The minimum permissible concentration of technical hexachlorane (12% gamma-isomer) in the air of working areas is considered to be 0.0013 mg or 0.01 mg of 12% disinfecting powder per ℓ of air in observing the necessary precautionary measures.

These data indicate that the danger of chronic poisoning of animals and man by hexachlcrane is small. In working with the preparation and the skin becomes contaminated it is necessary to immediately wash it off, and to remove the contaminated clothing. It is necessary to avoid inhaling the vapors, and disinfecting powders, and also using in human food and animal feed products contaminated with the preparation. In the event of hexachlorane poisoning it is also recommended that the use of butter and other fats be avoided.

The Gamma-Isomer of Hexachlcrane

Synonyms: lindane (contains 98% of the isomer), gamma-HCCH, gamma benzene hexachloride, 666, gammexane, ben-hex, gamhex, gamoxo, gamtox, hexadow, isotox, gexane, and others. The molecul ır weight is 290.85. In its pure form it exists as colorless crystals of monoclinic shape; the melting point is 112.5°; at 20° the vapor pressure is 0.03 mm, at 40° - 0.14 mm Hg; at 60° the vapor pressure increases to 0.48 mm Hg. At 25° saturated air contains 1.15 μg/ℓ of the vapors of the preparation, at 30° - 1.8 μg/ℓ. When applied to a surface at 50° it loses 51.5% of its weight in 3 days, and after 7 days 92%. It is insoluble in water (at 20° 10 mg/ℓ); dissolves it is soluble in organic solvents.

According to the requirements of the Committee on Insecticides of the Universal Organization of Public Health, the product should be in the form of grains, flakes, powder (wh... or almost white in color) and contain mainly the gamma-isomer of 1, 2, 3, 4, 5, 6-hexachlorocyclohexane free from impurities or introduced modifying agents. A sample taken from any part of a batch of the product should conform to the following requirements.

	Minimum	Maximum
Content of the gamma-isomer in weight percent..	99	–
Melting point....................................	112°	–
Acidity in percent based on HCl.................	–	0.1
The solid matter ...es not dissolve in acetone...	–	0.1
Water content in percent.........	–	0.1

The gamma-isomer of hexachlorane is manufactured in the form of disinfecting powders, wettable powders, concentrates, emulsions, creams, preparations specially designed for evaporation from electrical and heating devices. The gamma-isomer is added to disinfecting powders containing other insecticides. The combination of DDT powder and the gamma-isomer of hexachlorane is a mixture containing 5% DDT, 1.5% gamma-isomer and the remainder - kaolin or another filler.

The lindane manufactured abroad (gamma-isomer 1, 2, 3, 4, 5, 6-HCCH) contains 98% gamma-isomer, melts at a temperature lower than

112°. The preparation does not have an odor, is resistant to light, air, heating, strong acids, to carbon monoxide; is nonresistant to alkalis (is dechlorinated by them to trichlorobenzene) is decomposed by 10% solutions of lime and other alkalis. It is less corrosive to metals than hexachlorane.

Insecticidal properties. It is a highly effective contact and intestinal poison. All insects are sensitive to the gamma-isomer. Depending upon the species of insect the LD_{50} varies within the limits of from 0.4 up to 57 mg/kg (application of the preparation of the body surface). In connection with its vapor pressure it is a good fumigant.

Among the chlorinated hydrocarbons the gamma-isomer (lindane) occupies a primary place in its application for the extermination of various insects; according to their effectiveness in destroying arthropods the preparations are arranged in the following manner:

for bugs – lindane, dieldrin, aldrin, HCCH, DDT, methoxychlor, chlordane, [DDD] (ДДД), toraphene;

for lice – dieldrine, lindane, aldrin, HCCH, chlordane, DDT, toxaphene, methoxychlor, DDD;

for flies – dieldrin, lindane, HCCH, aldrin, chlordane, DDT, toxaphene, methoxychlor, DDD;

for mosquitoes – lindane, dieldrin, aldrin, HCCH, DDT, chlordane, toxaphene;

for fleas – lindane, dieldrin, aldrin, DDT, toxaphene;

for mites – dieldrin, lindane, aldrin, toxaphene, chlordane, DDT.

The gamma-isomer is a selectively acting insecticide, it is highly toxic to insects and slightly toxic to warm-blooded animals. Thus, for example, the LD_{50} when applied on the skin of warm-blooded animals is 300-500 mg/kg and when applied on the cuticle of insects – 0.4-7.5 mg/kg; thus, with respect to insects, depending on the species, lindane is 66-750 times more toxic than to warm-blooded animals.

According to its insecticidal properties the gamma-isomer is approximately 2-20 times more effective than DDT depending upon the species of insect, and with respect to stability it is inferior to it by $1\frac{1}{2}$ times.

The average lethal concentrations of oil solutions of the gamma-isomer with respect to insects are: for bed bugs 0.2%, for lice 0.025%, for fleas, 0.018%, for flies 0.006%, for Aëdes mosquitoes 0.018%, and for Ornithodorus ticks 0.024%. The gamma-isomer is 20 times more active for adult fleas and 36 times more effective for larvae; probably, its fumigation action is conducive to more intimate contact with the pre-imaginal stages of fleas on the substrate and, possibly, also with the imagoes situated on a host during treatment of the latter with this preparation. The same insecticidal properties are also pertinent to the gamma-isomer with respect to lice.

The gamma-isomer is highly toxic to honeybees; when introduced through the mouth the LD_{50} is equal to 0.08 mg/insect. Other insects are highly sensitive to it; thus, for example, the house fly dies within the limits of 50% with a topical application at a rate of 0.25 μg/insect, and mosquitoes (Aëdes aegypti) at a rate of 2 mg/kg.

In studying the duration of the residual action of the gamma-isomer with respect to bugs on filter paper impregnated with 0.1 mg of the preparation per cm^2, it was established that 100% extermination of the insects is observed during the first 10 days, after a month the mortality rate is 94%, after 3 months 58% and after 6 months 51%; when the dose was increased to 0.5 mg/cm^2 the preparation was effective for 3 months and provided complete destruction of the insects; towards the end of the 3rd month the mortality rate decreased to 66%. If to wood or to plaster there is applied 3.3 and 4.3 g/m^2 on the gamma-isomer, then at room temperature it will have completely evaporated after 50-60 days.

The utilization of the gamma-isomer to control maggots showed that when they are submerged in a suspension for 10 seconds their complete destruction was observed from a 0.1% concentration of the solution; the application to a substrate of 44 mg/kg of the gamma-isomer caused destruction of third stage larvae.

The vapors of the gamma-isomer possess high insecticidal properties. Thus, for example, the presence of only 1.19 of the γ-preparation per ℓ of air ensures the destruction of mosquitoes, flies, and other insects.

In fumigating a chamber by the combustion of filter paper on surfaces located horizontally, vertically, and in an inverted position, the gamma-isomer is deposited on them in considerably greater quantities than DDT. The greatest insecticidal properties are acquired by the surfaces situated horizontally, and the least – by the inverted surfaces (ceiling). With respect to taiga mites disinfecting powders are highly effective, which contain 2% of the gamma-isomer, with a normal expenditure 0.05 g/m^2, whereas aldrin is effective at a dose rate of 0.3 g/m^2 (S. A. Shilova and others).

The gamma-isomer is widely used in controlling insects – pests of agricultural plants. It is considered to be a nonphytotoxic preparation, of course, when the rules of application are observed. The deposits on the surfaces of plants are retained for 4 days; the gamma-isomer is a danger to bees, when the preparation is used in treating of flowering plants visited by bees.

When introduced into a block soil the gamma-isomer tends to become equally distributed. From the soil the hexachlorane is sucked up by the roots of plants. Mushrooms collected from beds treated with the gamma-isomer acquire an indistinct, strange, aftertaste, and mushrooms collected 7 days after treatment, have a strong aftertaste, which is reflected not only in the taste qualities of the mushrooms themselves, but also the quality of soup prepared with them. After the grinding of grain, which have been treated with the gamma-isomer, the majority of the preparation remains in the flour.

The preparation rapidly penetrates through the cuticle of insects. The mortality rate from applied [Translator's Note: dusted or sprayed] and injected doses is almost identical. The gamma-isomer penetrates through the integuments of insects more rapidly than the other isomers of hexachlorane. The amount of preparation picked up by the insect (from deposits when it is in direct contact with them depends upon the solubility of the hexachlorane isomers in particular hydrocarbon solvents. The dissolving of the gamma-isomer in the wax of the epicuticle is the first stage in the death of insects in contact with it.

For producing insecticidal aerosols are being manufactured tablets consisting of the gamma-isomer and camphor, which are placed in special electrical lamps. These lamps in contrast to ordinary lamps have an additional glass shell. In the shell two holes are made, in which tablets of the hexachlorane gamma-isomer are placed. Through these same holes when the lamp is burning exit the vapors of the gamma-isomer. A biological appraisal has showed that the heating and light rays of the lamp do not lower the effectiveness of the preparation.

The mechanism of its effect on the insect organism is still not totally known. This preparation belongs to the neurotoxid insecticidal group. In the insect organism it is circulated with lymph and branches out along the cords of nerve tissue. The gamma-isomer affects the ganglia, where for the appearance of tremors and spasms an unimpaired reflex arc is necessary.

The effect of the gamma-isomer on insects has much in common with the action of DDT, but there are also distinctions. A sharply expressed negative temperature coefficient is absent, which is usually noted in insects with DDT poisoning; there are no data concerning any direct effect on the peripheral nerves and the sensory receptors. The symptoms of poisoning in cockroaches, visible to the naked eye after the penetration of the preparation into the body are basically as follow. The initial excitation is replaced in common cockroaches by paralysis after 20-40 minutes; death ensues in several hours; in American cockroaches there is observed the rapid advent of tremors, then atoxia, spasms, loss of equilibrium and, finally, paralysis. With the application of the preparation within the limits of LD_{50} death occurs in common cockroaches after $2\frac{1}{2}$ hours. Both when applied to the body surface, and also when administered internally to an insect (common cockroach) with the advent of convulsions the oxygen consumption increases approximately by 5 times, and then in proportion to the degree of exhaustion of the insect it decreases; just before death oxygen consumption is approximately 2 times less in comparison with the normal.

During the prolonged, systematic application of hexachlorane and its gamma-isomer over a period of 2-6 years insects develop resistance to it. Thus, for example, in breeding a strain of house flies, which had spent a period of 28 generations in a laboratory contaminated with hexachlorane, only 6% of the flies died from a dose which killed 40% of sensitive strains, which had not been subjected to breeding. Analogous data have also been obtained with respect to the gamma-isomer. The development of resistance is also observed in other species of insects. Insects, which are resistant to the gamma-isomer, are also resistant to diene preparations, despite the considerable distinction in the mechanism of their toxic action (V. I. Vashkov, P. Ya. Leviyev). Strains of flies, which are resistant to the gamma-isomer, metabolize the preparation more rapidly than sensitive strains. The gamma-isomer is adsorbed by the surface of the insect body to an identical degree both by the sensitive strain, and also by the resistant strain of flies.

The DDT-dehydrochlorinose does not participate in the metabolism of the gamma-isomer. Pentachlorocyclohexane is, apparently, one of the metabolites of the disintegration of the gamma-isomer; 30 minutes-2 hours after treatment it is possible to detect measurable amounts of it plus pentachlorocyclohexane and other compounds. Inasmuch as after the indicated period the content of pentachlorocyclohexane does not increase although the amount of gamma-isomer continues to decrease, it is assumed that pentachlorocyclohexane is an intermediate metabolite. Both the strain resistant to the preparation, and also the sentitive strain easily metabolize pentachlorocyclohexane into other products.

Toxicity to vertebrate animals. Most of the data available on the toxicity of lindane is for warm-blooded animals, which we will present in this division. The latter is completely justified, since lindane mainly contains the gamma-isomer of hexachlorane (98%) (A. P. Volkova). The absorption of the gamma-isomer takes place through the gastro-intestinal tract, the skin and the respiratory tracts. The gamma-isomer administered orally is more toxic to the higher animals than the other isomers. Thus, for example, when orally administered LD_{100} is equal in milligrams per kilogram: for the alpha-isomer – 1500, for the beta-isomer – 2000, for the gamma-isomer – 225, for the delta-isomer – 250, for epsilon-isomer – 1000 and a mixture of the isomers – 1250. The toxicity of the gamma-isomer depends on species of animal. Thus, it is less toxic to laboratory animals than DDT and dieldrin (Table 6).

Table 6. Doses of preparations in milligrams per kilogram, which cause death to 50% of the vertebrates and insects when the insecticides are injected or applied by spraying a dusting on external integuments (according to Layg, Bodenstlin, Lehman).

Preparation	Vertebrate animals		Insects	
	sprayed or dusted	injected	sprayed or dusted	injected
Lindane.........	300-500	50-75	0.4-7.5	3-17
DDT.............	300-300	12-75	5-30	5-60

Note: Among verterates – the frog, rat, rabbit, guinea pig, dog; among insects – Musca domestica flies, cockroaches, Aëdes mosquitoes.

For the higher animals the LD_{50} is 125 mg/kg (acute perocal dose). In guinea pigs with the daily application of 10 mg/kg loss in weight was observed. The application of 50 mg/kg to the skin is dangerous. Of 10 rats, on whose skin there was daily applied 25 mg/kg, 2 died by the 6-7th day.

The maximum dose in food products or feed, which causes chronic intoxication is 400 mg/kg of the product.

For all species of cattle a single spraying with a 1.5% solution of lindane is lethal; a 0.25% dilution is tolerated without complications. The daily bathing of sheep and goats for 2 weeks in a 0.025% solution of lindane (prepared from 25% wettable powder) led to the accumulation in the fat of the sheep of 4.22 mg/kg, in the fat of goats of 2.62 mg/kg of the gamma-isomer. After cessation of the bathing these deposits gradually decreased and after 12 weeks they were not detectable by chemical methods.

In a number of states of the USA for controlling itch mites on dairy and meat cattle lindane is applied in a single spraying of 0.09% suspension or in double application of 0.0045% suspension with an interval of 15 days. With a single application of 5.7 ℓ of suspension per animal (to protect the udder and head) the maximum amount of gamma-isomer detected in the milk was within the limits of 0.4 mg/kg one day after spraying. After 17 days the amount of preparation in the milk was 0.02 mg/kg.

The gamma-isomer has a local irritating effect on healthy skin; it can penetrate through the skin into the organism and cause its general poisoning. With the chronic effect by the gamma-isomer in the experimental animals (cats) there is observed a rather rapid decrease in the immunobiological reactivity, which manifests itself in a lowering of the agglutination titer after immunization with typhoid vaccine. The toxicity of the gamma-isomer to a considerable degree depends on the way it is introduced and on the solvent; thus, for example, for rats the LD_{50} in paraffin oil is 35 mg/kg, in linseed oil – 75 mg/kg, in fish oil – 80 mg/kg (Ye. N. Burkatskaya, V. I. Vashkov).

During the prolonged introduction into the stomach of rats of small doses of various isomers the gamma-isomer is least toxic, the most toxic – the alpha- and the beta-isomers. All the isomers are mainly stored in fatty tissue, however, the alpha- and beta-isomers are retained in the organism in larger amounts than the gamms-isomers.

The gamma-isomer is chiefly a neurotropic poison rendering a toxic effect on warm-blooded animals when getting into the organism through the mouth and respiratory tract; when entering through the mouth it is 4-10 times more toxic than hexachlorane. The gamma-isomer can accumulate in the organism when repeatedly administered in hypotoxic doses. Therefore, the presence of gamma-isomer residues in food products cannot be permitted, inasmuch as 5-10 mg of it per kg of the product during prolonged use can cause degenerative changes in the liver of animals, pathological changes in the blood and death to individual animals, and also the intoxication and death of the offspring. This indicates that when the gamma-isomer gets into food products it is dangerous to the health of humans (Ye. A. Antonovich).

The latter is especially dangerous to pregnant women and nursing mothers, since residues of the insecticide can cause not only acute poisoning in the mother, but the secretion of the gamma-isomer with the milk can be dangerous for the child. From the point of view consumption by milk cows of feed treated with gamma-isomer is contraindicated. Milk containing even the slightest residue of the preparation should not be allowed to be put in children's food.

The symptoms of poisoning in warm-blooded animals are the following: there are observed increased sensitivity, excitability, loss of equilibrium, ataxia, tremors, spasms, fits, increased arterial pressure, decrease of cardiac activity, the encephalogram is of the epileptic type, frequent urination, deep, rapid breathing, and death due to an acute decline in strength or after respiratory paralysis. In dogs after intramuscular administration of the preparation in oil there are noted typical profound apathy, anorexia, loss in weight, and convulsion before death. In acute poisoning nervous symptoms predominate: in dogs after the oral administration of 100 mg/kg convulsions appear in 10-15 minutes. Barbiturates of curare and section of the neck segment of the spine prevent the appearance of the spasms.

The greatest deposits are noted in the fat, brain, kidneys, and muscles. The gamma-isomer and the products of its metabolism are mainly excreted with the urine (more rapidly in males) The symptoms in man are reminiscent of the symptoms of poisoning in animals.

In rats eating feed containing 100 mg/kg of the preparation, changes were detected in the liver, and kidneys by hystological sections; enlargement of the liver, inflammation, variation in color, focal necroses, atrophy, fatty degeneration.

The vapors of lindane possess considerable toxicity. When inhaled it can cause considerable irritations of the mucous membrane of the nose, eye, nasopharynx, vomiting, headache. Overheated lindane is especially irritating to mucous membranes. The maximum permissible concentration of vapors in the air for safe work during an 8-hour working day is 0.5 γ per ℓ of air. The vapors of the gamma-isomer forming after the application of oil solutions on the surfaces of premises contaminate exposed and packed products. The permissible amounts of the gamma-isomer in products is 0.5 mg/kg.

There are data about the fact that with the accidental introduction into a river of large quantities of the gamma-isomer over a length of 10 km of a river course all species of fish died. In stagnant water in the presence of 0.05 mg/ℓ of the preparation 70-80% of the trout died within 6 days.

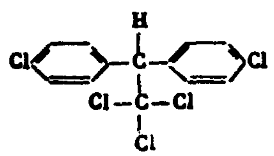
Among fish (11 tropical species) located in an aquarium aerated with the air of a room, which contained vapors from a constantly acting gamma-isomer evaporator a high mortality rate was observed among them. The deposits in the aquarium were toxic for house flies.

In controlling scabies among people it is permissible to apply the gamma-isomer in a concentration of 0.03-0.05% not more than 2 times per year. Human sensitivity to the gamma-isomer oscillates to a considerable degree. Its lethal dose for man is approximately 1.5 g, i.e., about 20-30 mg/kg. A dose of the insecticide of 17 mg/kg is on the border between toxic and lethal. L. I. Medved' (1956) considers that a lethal outcome can occur when the human organism is exposed to 15-18 mg/kg of this preparation.

According to Greaves, of 15 persons, who received a single oral dose of 40 mg of lindane in the form of an emulsion, 11 survived the dose without aftereffects, in the others there were observed dizziness, spasms, epileptic seizures, nausea, and pains in the intestine. Severe sickness with spasms was noted in a young man after a dose of 45 mg of the preparation as a vermifuge. Adults survived without injury after 3 daily doses of the preparation of 90 mg each; with a subsequent dose after 5 days there appeared heachaches, dizziness, and diarrhea. After a daily single dose during a period 6 days of a 100 mg of a preparation containing 60-85% of the gamma-isomer diarrhea was observed. A dangerous, acute toxic dose for humans is 7-15 g.

DDT

The DDT - $C_{14}H_9Cl_5$ - 4.4'-dichloro-diphenyl-trichloromethylmethane



Synonyms: 1, 1, 1-trichlor-2, 2-di-(п-chlorophenyl)-ethane; 4, 4'-DDT; п, п'-DDT 2, 2-bis-(4-chlorophenyl)-1, 1, 1-trichlorethane; trichloro-para-(4-chlorophenyl)-ethane; d, d'-para-(p-chlorophenyl)-β, β, β-trichlorethane; chlorophenothane; dikaphen; gezarol'; neocide; pentachlozine and others. The molecular weight is 354.5.

To abbreviate the name this compound is designated by three letters - DDT or п, п'-DDT.

The melting point of DDT is 92.5-93° (at 1 mm Hg); the specific gravity at 25° is 1.556 (1.6-1.52); the vapor pressure $5 \cdot 10^{-7}$ mm Hg at 20°. The indices of refraction - alpha - 1.618; beta - 1.628, and gamma - 1.755.

Technical DDT, from which the different insecticidal preparations are prepared (disinfecting powders for dusting and spraying, emulsions, solutions), is made up of flakes or fragments with a dimension of up to 3 cm. The color is from white and gray to brown with a solidification point not lower than 80°. The preparation possesses a clearly perceptible characteristic odor. It contains, besides 4, 4'-dichloro-diphenyl-trichloromethylmethane 11 or more other compounds, including a considerable amount of the 2, 4-isomer and a small amount of the 2, 2-isomer.

The acidity of the technical preparation should be, when scaled to sulfuric acid, not more than 0.06, and the moisture content not more than 9.4%. In water it is almost insoluble – approximately 0.00001%.

The specifications set forth by the Committee on Insecticides of the Universal Organization of Public Health for DDT produced by industry are the following:

	Minimum	Maximum
Solidification point.............................	89°	–
Total content of organic chlorine in weight percents..	49	51
Content of hydrolyzing chlorine in weight percents..	9.6	11.5
Content of the п, п'-isomer in weight percents...	70	–
Melting point of the п, п'-isomer................	104°	–
Content of hydrochloride in weight percents......	–	0.025
Acidity based on H_2SO_4 in weight percents........	–	0.3
Solid substance insoluble in acetone in weight percents..	–	1.0
Water content in weight percents................	–	1.0

According to Bowman, who conducted experiments with DDT tagged with carbon (C^{14}), its solubility in water is 1.2 parts per billion, and according to other authors – 10 μg per ℓ of water. The DDT is much more soluble in the majority of organic solvents. Pure DDT has a neutral reaction and is stabler than the technical preparation (S. F. Bezuglyy).

In a highly alkaline medium, including lime, DDT is decomposed with the formation of the poorly insecticidal compound, dichloro-diphenylethane. It decomposes at 100°, rapid decomposition occurs at temperature of 195°; the technical preparation of less resistant to heating. Iron and its salts in the form of trivalent iron, especially ferric chloride and aluminum chloride during heating decompose DDT.

After evaporation of the solvent DDT crystallizes in the form of small, thin needle-shaped crystals. Depending upon the type of solvent, the concentration of the solution and the rate of evaporation the same size and shape of the crystals can vary somewhat (Table 7).

Table 7. The composition of technical DDT.

Name of compound	Content in percents in samples with the solidification point			
	91.4°	91.2°	83.6°	oil
4, 4'-dichlorodiphenyltrichloromethylmethane	72,7	72,9	70,5	—
2, 4-dichlorodiphenyltrichloromethylmethane	11,9	19,9	20,3	74,8
2, 2'-dichlorodiphenyltrichloromethylmethane	0,011	—	—	—
4, 4'-dichlorodiphenyltrichloromethylmethane	0,17	0,3	4,0	—
4-chlorophenyltrichloromethylcarbinol	—	0,2	—	—
Bis-(4-chlorophenyl)-sulfone	0,034	0,6	0,1	—
2-trichlor-1-o-chlorophenylethylchlorobenzosulfonate	0,57	0,4	1,85	0,11
2-chlorophenylchloroacetamide	—	—	0,007	—
4-chlorophenylchloroacetamide	0,006	—	0,01	—
4-sodium chlorobenzenesulfonate	—	0,02	—	—
4-ammonium chlorobenzenesulfonate	0,005	—	—	—
Chlorobenzene	—	—	—	2,44
П-dichlorobenzene	—	—	—	0,73
Inorganic compounds	0,01	0,1	0,04	—
Unidentified compounds	14.504	5,38	2,303	21,92

The DDT was synthesized in 1874. Its insecticidal properties were determined in 1939. It was proposed as an insecticide in Switzerland in 1942. In the Soviet Union DDT was investigated in 1944 in the Chemical-Pharmaceutical and Disinfectional Institutes of the Ministry of Public Health of the USSR.

Possessing good insecticidal properties and mild toxicity for man and animals and being free from a number of deficiencies peculiar to pyrethrum and preparation-K applied at that time in the Soviet Union, DDT very rapidly occupied a leading place in controlling everyday parasites and agricultural pests. Especially important are the properties, which favorably distinguish this preparation from the vegetable insecticides, its resistance to the external factors of the environment and its high activity.

The DDT possesses selective toxicity – for insects it is highly toxic while for warm-blooded animals its toxicity is low.

The introduction of DDT into practice for controlling insects created a revolution in the field of disinfestation, since it opened great possibilities for destroying harmful insects. An especially great role was played by DDT in eliminating malaria and other parasitic infections on the earth. Furthermore, the introduction of this preparation stimulated further research for new insecticides. In connection with the broad application of synthetic insecticides in control practice and especially in agriculture the necessity of a detailed study of the toxicity of insecticides to humans, animals, and vegetation has arisen.

The interest induced by DDT has stimulated the study of pharmacology and the pharmacodynamics of insecticides, which has considerably increased our knowledge in this field. The introduction of DDT has opened a new path for the creation of synthetic preparations possessing valuable properties including such as the combination of high insecticidal properties with relatively low toxicity to person, domestic and wild animals.

The determination of the fact, that with prolonged application of DDT there develops a resistance to it among arthropods, has somewhat decreased its distribution and the analogs close to it.

The positive qualities of DDT are well-known. Among them there belong: 1) its universality of application (against everyday and agricultural parasites), 2) its resistance to oxidation, 3) its low volatility, 4) the absence of an unpleasant odor, 6) the preservation of its activity for a long period of time, 7) its use for the purposes of treating fabrics (impregnation), 8) it does soil or stain.

The study of DDT there has been dedicated a great number of scientific works, reports, treatises, monographs, and dissertations (N. N. Mel'nikov, V. A. Nabokov, Ye. A. Pokrovskiy, 1954; V. I. Vashkov, L. N. Pogodina, N. A. Sazonova, 1955; N. B. Il'inskaya, 1961;

G. M. Meyerson, 1962), and also special instructions have been worked out.

The DDT, when applied to surfaces, retains its insecticidal properties for a long time. Thus, for example, walls inside habitations, treated with DDT preparations at a rate of 1-2 g per m^2, preserve their insecticidal properties for about 6 months in the central belt of the Soviet Union, and the outside walls of structures - more than a month.

Chemical analysis shows that the DDT is rapidly absorbed by wooden surfaces, and then slowly migrates from the inside outwards, crystallizing on the surface of the wood (forms a patina). The factors affecting this process are the composition, solvent and time factor. There are data about the fact that after treatment of the bark of an elm tree with DDT preparations the latter retains its insecticidal effectiveness in the upper layer of the bark for a period of 14 years.

When applied to the soil DDT can retain its insecticidal properties for a number of years. According to Fleming and others, who studied 84 samples of soils and manure, the average amount of DDT in the soil after dusting at a rate of 3-6 g per m^2 was equal to 97% after a year, 90% after 2 years, 79% after 3 years, 64% after 4 years, 56% after 6 years, 44% after 8 years. In soils treated with 50 kg of DDT per hectare, the pattern of preparation loss was the same. When the DDT was mixed with earth, the losses were less in comparison to those when the preparation was applied with peat. The duration of DDT retention was affected by various factors, and not only by the method of applying the preparation. In 2/3 of the soils 50% of the DDT was retained after 8 years, and in 9/10 of the soils it was possible to detect more than 25% of it after a prolonged period of time.

The tendency towards more prolonged retention of DDT in soil in proportion to the transition from north on south indicates that there is some connection with the organic composition of the soil. The DDT is retained longer in sand and least of all in manure; in various types of clay the duration of preservation was identical. A pH index within the limits of from 4 to 7.5 does not play a role. The more organic substances in the soil, the shorter the period of time DDT is retained in the soil.

The DDT has an insignificant action on the soil forms of microorganisms.

Upon getting into the soil the relative humidity has a strong effect on the toxicity of the insecticide; with an increase in humidity of 10% the effectiveness is doubled. The movement of the insecticide tagged with C^{14} in the soil is blocked both by high, and also by low humidity. The migration of water in the soil causes movement of the preparation in the same direction.

The DDT preparations are widely used to protect agricultural plants and green plantings including gardens (Ye. N. Burkatskaya, M. Z. Lur'yev, S. G. Ped'ko, M. G. Khatin). In treating rice fields for the purpose of controlling mosquito larvae there is detected after the gathering of the harvest in rice straw 4.3 mg/kg of DDT, in the rice husk [palea] 3.2 mg/kg, in refined rice 0.7 mg/kg of DDT. According to F. P. Vayntraub, after the spraying of winter wheat in the Stavropol' Region with a DDT suspension (400 ℓ/ha) at a rate of 3 kg/ha of technical preparation, in the ears, which appeared after the treatment, protected by paper caps from possible DDT drift by the wind from neighboring plants 10 days after spraying there was detected 1.78 μg/g of DDT. Analogous data were obtained in treating wheat during earing, when the ears were also protected by caps.

Into the whorls and sheaths of corn leaves there were introduced granules of DDT (with a diameter of 0.5-1 mm) with 0.5 g on each plant (20 kg/ha). In a vegetational experiment in treating with 2.5% or 6% granules after 5 days there was found in the leaves 0.5-1.4 g of DDT. In an experiment on plots (Moldavia) 10 days after the application of 5% or 7.5% granules there was detected corn in the stems 0.17-0.45 μg/g of DDT. The DDT content in the plants depended upon the initial concentration of DDT in the granules. In using granules with a superphosphate filler in the stems more DDT was detected than in those variants, in which the filler was clay and kaolin.

Beginning with 1961 the limited application of DDT was introduced into agriculture, the essence of which reduces to the following: the treating of agricultural plants used in human food is prohibited; the treating of the pastures of dairy cows and animals intended for slaughter is prohibited; the treating of orchards is permitted up to the time of their blossoming.

The DDT penetrates through the leaves, rhizomes into vegetables and fruits, including oranges, apples; the degree of penetration depends on the type of preparation. Immediately after treating forests and fields the DDT content in the grass is 21-348 μg/g, and on the 60th day it decreases to 2.2-17.6 μg/g; in hay on the 120th day the DDT content is 1.8-43.2 μg/g, on the 325th day - 0.05-0.4 μg/g. In hens' eggs the DDT content on the day after the treatment reached 0.57 μg per egg, and after a month - 0.12 μg per egg.

When it is necessary to simultaneously conduct disinfection and disinfestation chloramine is added to the DDT emulsion (V. T. Osipyan, N. D. Uspenskiyy).

Technical DDT is used in the industrial manufacturing of disinfecting powders, solutions, emulsions, soap, and other preparations applied for the destruction of many forms of insects (lice, bed bugs, cockroaches, fleas, house flies, and mites); this compound does not act in insect eggs. The DDT belongs among preparations of contact action (M. L. Fedder, V. I. Vashkov, A. M. Klechetova, R. B. Kosminskiy, and others).

Preparations prepared from DDT. Disinfecting powders are prepared with various percentages of the preparation - 5.5% DDT disinfecting powder contains the technical preparation and filler; in accordance with technical conditions the disinfecting powder should contain 4.5-5% pure DDT, 94.5% filler (talc with chalk added) and not more than 1.5% moisture; the fineness of the grind is measured by the residuum on the screen (No. 170/69 with the size of the mesh gap 84 μ), which should not exceed 2.5%. The preparation is manufactured for controlling agricultural pests. It can be used for destroying the parasites of man and of his dwellings. It is also applied as a 10% disinfecting powder in those cases, when the latter is absent.

Ten-percent DDT disinfecting powder contains 10% technical DDT (6.7-8% pure DDT) and 90% kaolin or a mixture of kaolin with talc (up to 20%). In accordance with the technical specifications, it should contain not more than 1.5% moisture. It is used against all species of insects and mites by application on a surface at a rate of 2-4 g per m^2 (of the technical preparation), and also by dusting vegetation to control mites at a rate of 0.25 g/m^2.

For controlling arthropods they also manufacture disinfecting powders containing 30-75% DDT.

Both disinfecting powders containing 30-75% DDT and also others are used for dusting surfaces or from it they make a suspension (suspended powder in water) various concentrations. The DDT preparation is also used in the manufacture of 50-75% wettable powders, which are used in the form of suspensions. The heating of DDT for an hour to a temperature of 70° causes an increase in its ability to form suspensions (probably, as a result of the drying effect); heating it to temperature above 70° for a similar time period causes a decrease in the suspension qualities.

In 20% concentrated mineral-oil DDT emulsion there is contained 20% technical preparation, 40% spindle oil, 5% sulfite liquor and 35% water. The liquid has the consistency of sour cream from a light-gray to brown color. The concentrate is stable and can be kept for a long time at temperatures down to -35°. The dilute concentrate (emulsion) is unstable and can be stored for not more than twenty-four hours. It is used against fleas, bugs, mosquitoes, gnats, cockroaches, and other arthropods.

A concentrate of DDT emulsion with synergist contains 20% technical preparation, 5% sulfoanilide, 60% green oil, 15% OP-7. It is used for controlling flies, bugs, and oriental cockroaches. When used the concentrate is diluted with 5-10 parts water (to 2-4% DDT) and applied at a rate of 2 g of DDT per m^2 of surface. In using a hand sprayer and other sprayers giving large-drop atomization certain contamination of the surfaces can occur.

A 50% emulsion-paste of DDT contains 50% technical DDT (not less than 34.5% pure DDT), 10% grade "2" spindle oil, 15% sulfite waste liquor and 25% water. In external appearance this thick mass has a consistency of a gray-colored paste. When mixed with water it forms an emulsion, the drops of which contain DDT; furthermore, a small portion crystallizes out and settles to the bottom; a 1% concentration emulsion should be stable for 4 hours. The preparation is used for destroying gnats, mosquitoes, flies, cockroaches, bugs, lice, mites, and others.

An emulsified suspension of DDT (a paste of the [TsNIDI] (ЦНИДИ)) contains 60% DDT, 8-9% OP-7 or OP-10, 5-6% talc and 25-27% water. The DDT is in the emulsified suspension in crystalline form and only an insignificant portion of it is in solution. The preparation is a white semisolid mass, easily cut by knife. It is applied in the same concentrations (by active substance), an emulsion against mites and insects – bugs, flies, cockroaches, mosquitoes, inside and outside living quarters (A. N. Tregubov, N. A. Fuks, and others).

Dezinsektal' – 5-7% DDT solution in kerosene. The preparation possesses high insecticidal properties in connection with the fact that one insecticide (DDT) is dissolved in another insecticide (kerosene). For the purpose of decreasing the kerosene odor the latter is chlorinated, in which chlorinated lime is added to it (25 g/l) thoroughly mixed and precipitated. After twenty-four hours the chlorinated kerosene is run off from the precipitate. Besides DDT, in individual cases to the chlorinated kerosene there are added 3-10% turpentine and 1-3% hexachlorane. Such a preparation possesses higher insecticidal properties than kerosene containing only DDT. Dezinsektal' can be used for controlling cockroaches and other crawling insects, but the greatest effect is attained in controlling bugs, wherein preparation acts not only on the bugs, but also on their eggs.

Detoyl' - the composition of this preparation includes 25% DDT (not less than 13% pure DDT), 40% chlorobenzene, 10% spindle oil, 25% neutral sulfonated fish oil and ammonium naphthenic soap. Detoyl' - an emulsion concentrate consisting of an oil-like thick gray to dark-brown colored liquid.

Sublimating aerosol thermal mixtures or DDT smoke pots contain DDT, thiourea, Berthollet's salt [potassium chlorate] and others (see Chapter XI "Aerosols, obtained with the help of thermal mixtures"). The DDT is heat-resistant; noticeable decomposition begins at 195° in smoke-pots, with flameless combustion (350-400°) it is decomposed by approximately 10-30%; the remaining portion evaporates, and then condenses in the air, form solid, insecticidal, aerosol particles. Strong alkalis, and also lime rapidly decompose DDT.

DDT soap contains 5% preparation 2-3% solvent (diphenyl oxide, liquid petrolatum), 92-93% household soap. When pediculosis occurs it is used for washing the head and washing the garments and bed-clothing. The DDT soap can be used in controlling lice and fleas (see "Lice and Their Control").

Insecticidal properties of DDT. The sensitivity of insects to DDT is determined, apparently, by a number of factors having greater or lesser significance. According to I. V. Kozhanchikov, sensitivity depends on the stage of development of the insect; thus, diapausing eggs and pupae are less sensitive to insecticides than the imago, which, probably, is explained by the lowered metabolism.

When growth and development of the insect starts, which are accompanied by the formation of cellular structures and the intense absorption of oxygen, then oxidase (the cytochrome system), enters in action, in connection with which the sensitivity to DDT increases. Adult flies, in which oxidation is basically of the oxidase type, are least sensitive in the case, when they possess high activity of cytochrome oxidase; due to this the partial oppression of cytochrome oxidase, caused by DDT, is not so strongly reflected on the insect organism.

The earliest criteria of the influence of DDT are the increase in the sensitivity of the labella. With the topical application of a dose 300 times less than LD_{50}, there is noted after $1\frac{1}{2}$ minutes a six-fold increase in the sensitivity of the hairs of the labella to a saccharose solution. The chemoreceptors do not react to the saccharose 10-11 minutes after the treatment. This time coincided with the stage of paralysis. Thiophos in contrast to DDT did not have stronger effect on the hairs of the labella in comparison with its effect on the whole fly.

Another symptom of the effect of DDT on flies is also the fact that they begin to periodically stretch out their legs; such a phenomenon does not occur earlier than 4 minutes after the treatment.

Lethal doses of DDT for insects vary to a great degree depending on the species and sex of the insect, the stage of development, and the age, how well nourished the insect is, season, temperature, age, rate of expenditure of the preparation. In some cases 50% of the bugs, house flies and body lice die with the application per insect of 0.05 µg, in others – this dose is far from sufficient. Usually the females are more resistant than the males, which to a considerable degree depends on the weight of the insect. Insects captured under natural conditions are approximately 5-10 times more resistant to the preparation than the specimens of a laboratory sensitive strain.

The insecticidal properties, in applying the preparation with various fillers, depend on a number of factors, including the type of filler, the genus and species of the insects, and also on the configuration of the preparation.

On clay surfaces DDT rapidly loses its insecticidal properties and completely vanishes after 4 weeks. The rate of this disappearance is identical whether emulsions or suspensions are used; however, the degree of decomposition, when suspensions are applied, depends on the preparation dose applied to the surface. The loss of DDT effectiveness on clay bars depends on adsorption; in removing several layers from such bars (0.5 mm each) to a depth up to 2 mm the amount of DDT and dichlorodiphenylethylene [DDE] (ДДЕ) in each layer corresponded to the total amount applied. Twenty-four hours after the application the preparation was almost completely still situated in the upper layer (0-0.5 mm). The losses of insecticidal properties by the preparation on the surface depend on the atmospheric humidity: the lower the humidity, the more rapidly DDT loses its insecticidal properties and conversely (L. V. Yaguzhinskaya). On cement DDT effectiveness is preserved up to 6 months.

The treating of surfaces with DDT preparations causes death to insects coming in contact with these surfaces. In such cases it is not always possible to indicate that the poisoning of the insects occurs only through the extremities, since frequently the insects also touch the substrate with their abdomen and oral parts. For mosquitoes, especially the Anopheles, the toxic effect of DDT applied to the substrate, in view of the peculiarities of the landing process of these insects occurs, probably, only through the extremities.

The dispersion of DDT in a reservoir influences its effectiveness on it was possible to determine that, besides the tendency to evaporate, DDT also manifests the following: it is somewhat hydrophobic, and it concentrates in the upper layers of the water, and also on the sides and bottom of the reservoir. Two minutes after application of one part of DDT per 100 million parts of water 1/3 of the DDT courses toward the walls and the bottom of the container regardless of whether they are made out of paper, glass, or aluminum; after 24 hours more than half of the DDT has evaporated from the reservoir. When topically applied LD-50 for mosquitoes is 0.015 μg/insect, for flies 0.22 μg/insect.

The preparation in crystalline form possesses higher insecticidal properties than in the amorphous state. Crystals with a size of approximately 400 μ of needle-shaped form possess higher insecticidal properties than the crystals of the other forms; as the width of the crystals increase the effectiveness of the preparation decreases. A study of insecticidal properties of DDT depending on crystal form with respect to the rust-red flour beetle (Tribolium castaneum) showed that a suspension consisting of needle-shaped crystals is considerably more effective than a suspension consisting of plane crystals. With the brief contact (by submersion) of the insect DDT is less effective in colloid form than in the suspension form containing suspended crystals. A study of insecticidal properties of DDT in emulsion form at 20-30° (in the case of contact with the insect) and in suspension form showed that a suspension containing crystals of a size up to 400 μ is more effective than an emulsion.

The application of ultraviolet rays leads to a lowering of the effectiveness of DDT.

When the preparation is introduced under the integuments of insects differences in the toxicity of DDT in the crystal and colloidal state are not noted. Thus, for example, injections of the common milkweed bug (Oncopeltus fasciatus) with crystalline and colloidal suspensions showed equal toxicity at 27°. When insects are cooled (10°) the colloidal suspension acts more rapidly (the advent of paralysis) than the crystalline one; however, death arrived for both in about the same period of time, after 10 days of observation at that same temperature.

The amount of the preparation penetrating into the insect organism, and also its accumulation depend to a considerable degree on the application site. The preparations penetrate with greater facility where the insect cuticle is the thinnest; this is also connected the proximity and the number of sensitive nerves. The amount of preparation penetrating through the cuticle, depends not only on the site of its application, but also on the area of contact. Increasing the area of treated surface of the insect body intensifies

DDT penetration. The passage of the latter through the integument debilitates by disturbing the normal activity of the insect. The applied preparation into the insect organism as long as its concentration on the surface is higher than that inside the organism.

According to P. G. Kalmykov, one minute after the application of DDT tagged with radioactive carbon to Protoformia terrae novae flies there was recorded in the chitinous integument of the insects (10 individuals) 68 impulses per minute; after 10 minutes – 72, after 30 minutes – 80, after an hour – 88, after 10 hours – 92, and after twenty-four hours – 144 impulses per minute.

The diffusion and the accumulation of DDT in the epicuticle have great significance. Most frequently the insecticide penetrates through the lower parts of the tarsi of the insect. The contact of the tarsi of the house fly with residual deposits for 2 seconds leads to poisoning.

The penetration of DDT through insect integuments is favored by the fact that DDT absorption is a specific peculiarity of chitin. The intensity of penetration increases with the increase of the amount and the concentration of DDT solution on the surface. The amount of DDT adsorption is usually in conformity with the sensitivity of the insect species and it also depends on the temperature. When the DDT on the surface of an object has reached a specific limit increasing the preparation dose does not increase the intensity of its penetration into the insect organism when the latter is in contact with that object.

After DDT tagged with radioactive carbon has been applied to the labella of an insect there occurs rapid absorption and distribution of it throughout the organism via the hemolymph (although the hemolymph itself does not accumulate DDT). In the American cockroach 24 hours after the application of 40 μg of DDT preparation 95% of the preparation is distributed throughout the whole body. After 24 more hours approximately 75% of the DDT has been converted into the metabolite DDE and has been eliminated from the organism with the excretions. Thus, from the site of application the preparation is distributed throughout the whole organism and this distribution continues right up to the death of the insect. To kill an insect sometimes the absorption and distribution throughout the organism of a total of 10-20% of the applied dose is sufficient.

The accumulation and the degree of toxicity of DDT depend on the site of application of the preparation. The DDT also easily penetrates into the insect organism from the gastrointestinal tract. The DDT – an effective intestinal poison for many insect pests of agriculture. Bait containing 1% sugar or molasses and 1% DDT, ensures in 30 minutes the death of 30% of the flies, in an hour 40%, and in 24 hours 98% of the flies. Various species of flies differ in their sensitivity to DDT. Thus, the toxicity of DDT to flies to a considerable extent depends on their species.

With respect to its activity rate among insecticides DDT occupies an intermediate position. Thus, for example, if the rate of action of DDT on mosquito larvae, Culex pipiens pallens, is taken as unity (LD_{50}), then for the pyrethrins it will be 27.2, allethrin – 20.5, dimetrol – 8.63, lindane – 4.69, barthrin – 4.61, Sevin – 4.4, [TEPP] (ТЭПФ) – 2.88, nicotine – 2.85, [DDVP] (ДДВФ) – 1.73, metaphos – 1.14, malathion – 1.1, Diazinon – 0.8, [EPN] (ЕПН) – 0.71, sumathion – 0.7, endrin – 0.68, dieldrin – 0.5, Dipterex – 0.51, parathion – 0.48, rotenone - 0.21, aldrin – 0.21. The symptoms of insect poisoning are expressed in the following order of their sequential appearance: 1) increased sensitivity of the feet (pedicels), difficulty in maintaining normal insect position; 2) increased intensity in the tremors of the head, body, and appendages; 3) ataxia (disturbance of motor coordination), hyperreflection; 4) inability to maintain vertical position on the legs, inability to regain standing position when placed on the back; 5) disappearance of overall tremors, isolated residual movement, for example, of the mouth parts; 6) when placed on the back continuous movement of the legs, high frequency tremors with overlapping slow flexion and extension of the legs; 7) before death general paralysis appears, only the heartbeat is preserved.

The typical symptoms of DDT poisoning indicate that this preparation acts on the neuromuscular system. The evidence of the existence of precisely this character of DDT action on the insects is seen in a number of symptoms when insects are poisoned with this preparation. Thus, for example, when the tarsi of flies are wet with a DDT solution there is observed the propagation of the action of the poison, which is expressed in tremors of the legs; the latter appears at first on the poisoned extremity, then on the paired torsus on the opposite side of the body. Subsequently, the symptoms of DDT poisoning appear on the other tarsi, then on the mouth parts, and, finally, complete paralysis of the insect occurs. In butterflies poisoned with DDT there was observed autotomy of legs, i.e., the poisoned extremities are rejected by an arbitrary act of the insect. The autotomy of the legs occurs in a definite order, spreading from the poisoned extremities to others.

The neurocidal action of DDT is also substantiated by the fact that autotomized or several extremity of the insect, first poisoned by the preparation, continues to manifest typical tremors and spasms for several hours after its detachment from the body. In exactly the same way an amputated extremity of a healthy fly, being moistened by a DDT solution (in paraffin or acetone) at the site of amputation, reacts with typical tremors and spasms. The nervous nature of these phenomena is also confirmed by the fact that the tremor and spasms of the insect extremity poisoned with DDT, can be halted by narcosis, for example by ether and chloroform vapors or by smearing the amputated extremity with atropine.

The DDT has a strong effect on the peripheral nerves and on nervous ganglions in the late stages of poisoning. The removal of the mesothorocic ganglion, the removal of the lateral nerves of the extremities, and the application of nicotine to the mesothorocic ganglion sharply decrease the typical symptoms of hyperreactivity in the extremities of a Drosophila fly.

The administration of phenobarbiturates before applying DDT prevents the appearance of symptoms of DDT poisoning. With the use of large doses of the preparation it has a direct influence on the fibers of the nervous system. The direct action on the neural-muscular junctions is proved by the response reactions of the amputated extremities. The injection of DDT at a rate of 0.01 mg/ℓ into the haunch of the American cockroach causes acute, frequently recurrent tremors (approximately 300-400 movements per second). When the DDT doses are increased the insect manifests increased excitability and death appears in the end from exhaustion and the severe loss of moisture. Anatomical and hystological changes in the insects as a result of the effect of DDT were not observed.

In spite of the characteristic pattern of DDT action on the nervous system of insects, there were no direct proofs of the neurocidal effect of DDT. For specific nerve poisons the disturbance of the structures and functions of nerve tissue is characteristic, whereas no characteristic morphological changes in the nervous system of insects, from DDT poisoning could be found.

V. I. Zakolodkin ascertained certain morphological changes in the wing muscle of the house fly and histochemical changes in the nerve ganglia. According to I. S. Yakobson, after the effect of DDT individual dark disks disappear, in the muscle fibers there is observed a fusion of the nuclear chromatin into coarse clumps and the coalescence of fibrin of the muscle fibers into bands. In lice poisoned with DDT almost all tissues are injured, with the exception of the transversostriated musculature.

The DDT stimulates insect respiration. The degree of increase and decrease in the intensity of respiration depends on the amount of preparation applied. In flies resistant to the preparation the intensification of respiration is considerably weaker than in sensitive flies. The DDT has an irritating effect on mosquitoes, therefore after their blood-sucking they tend to leave a site treated with this preparation.

In cockroaches 24 hours after the administration of DDT tagged with radiocarbon, the radioactivity concentrated in the application sites on in foregut and hindgut, the fat of the insect and the malpighian vessels. After injecting DDT into the blood stream it was detected in the digestive tract, the gonads, fat, malpighian vessels, pectoral muscles it is found in larger quantities than in the remaining tissues. The greatest amount of DDT was ascertained in the fat of the insect.

In house flies DDT metabolized into DDE, but detoxification occurs rather slowly.

Among the secondary phenomena connected with the action of DDT it is necessary to place the sharp increase in the intensity of metabolism appearing in the period of intense motor activity of the insect and also the water loss; at the same time the reserve carbohydrates are expended, resulting in the exhaustion of the organism to the same degree, as is normally observed in starvation. The death of the insect is the result of the totality of significant disturbances in metabolism.

The DDT inhibits the activity of a number of enzymes, and it also affects the iron-containing cyctochrome system, which is instrumental in the aerobic respiration of the tissue cells; it also inhibits the action of anhydrose, esterose, and cholinesterose. In its ability to oppress tissue respiration DDT has features in common with prussic acid.

As a result of prolonged contact with DDT flies appear to be producing special enzymes (dehydrochlorinase), which decompose DDT and its analogs. For the purpose of increasing the effect of DDT on resistant insects a number of preparations-synergests have been proposed, addition of which considerably increases DDT effectiveness. Among these preparations there belong pepronyl cyclone, piperonyl butaxide, the dialkyamides (R) п-chlorobenzene sulfo acid, where R is п-alkyl group containing from 2 to 7 carbon atoms. The compounds 1, 1-bis-(п-chlorophenyl)-ehtanol [DMS] (ДМС), 4-chlorobenzene sulfo-4-chloroanilide and 4-chlorobenzene sulfanilide, N, N-dibutyl-п-chlorobenzene sulfamide [DA] (ДА) are also synergists; in combination with them DDT effectiveness increases by 2-3 times with resistant flies.

The DDT preparations containing synergists, are highly effective in controlling not only sensitive, but also resistant insects. The presence of piperonyl cyclonene in DDT preparations lowers the excretion rate of DDT metabolites. In the presence of synergists certain low-activity DDT analogs become more effective than DDT with respect to resistant strains of flies. Individual compounds belonging to the synergist group inhibit in vitro the action of dehydrochlorinose of DDT resistant strains of insects on DDT (A. M. Klechetova, M. N. Titova, and others). Thus, for example, when di(п-chlorophenyl) methylcarbinal (DMC) is added to DDT the insecticidal properties of the latter increase to such a degree that it also becomes effective when used to control resistant flies. This is explained by the fact that DMC oppresses dehydrochlorinose; the latter has been confirmed by experimental data.

The insecticidal properties of a mixture of DDT with hexachlorane or with chlorophos are considerably higher than each of these preparations used separately.

As a result of prolonged and systematic application of DDT approximately 137 different species of insects have acquired resistance to this compound, including human parasites, pests in his dwellings, and also mites -- carriers of causal organisms of infectious diseases. The degree of resistance depends on how frequently and how long DDT is applied to control these species of insects. The greatest resistance has been acquired by house flies.

Under laboratory conditions resistant strains can be obtained the sensitivity of which to the preparation is 100-1000 times lower than the sensitivity of the common of house flies, mosquitoes, bugs, and other insects (V. I. Vashkov, T. V. Yerofeyeva, M. L. Fedder).

Under natural conditions resistance develops considerably more slowly and it is not so high as that obtained under laboratory conditions. Strains of flies resistant to DDT are also resistant to its analogs. Furthermore, they are also somewhat more resistant than common strains to other insecticides, also including organophosphorus compounds.

A special role in the development of resistance to DDT is played by the enzyme systems arising in insects (the DDT-enzyme - dehydrochlorinose), under the effect of which there occurs the cleavage of hydrochloric acid from the DDT molecule with the formation of nontoxic ethylene derivative DDE. This is the basic pathway for the detoxification of DDT.

Soviet and foreign authors have shown that increasing the ambient temperature has a positive effect on insects poisoned by DDT. With an increase in temperature the metabolism of insects increases, and absorption decreases; thus, when the temperature is high the possibility of insect survival is increased. The switching of the insect from heat to cold causes the return of the symptoms of poisoning. This phenomenon is characteristic for both sensitive, and also for resistant individuals. With respect to mosquito larvae the temperature coefficient is positive. In the opinion of L. V. Yaguzhinskiy, increasing the temperature stimulates in sensitive individuals the same mechanisms, which in resistant individuals are innately highly developed and which accomplish their mission under ordinary temperature conditions (with a temperature increase the insecticidal properties of DDT decrease).

Thermophilic diptera possess the ability to develop resistance at high temperatures, whereas in psychrophilic forms a temperature increase in practice does not bring about an increase in resistance. There also exist data about the fact that fish, in reservoirs completely surrounded by cotton fields treated with DDT to control mosquitoes or their larvae, become 2-4 times more resistant to DDT than fish not subjected to the effect of preparation.

The DDT toxicity to birds. The DDT is highly toxic to chickens. Thus, for example, when they are fed feed containing 1000 mg of DDT per 1 kg they die in 3-10 days; chicks receiving 40 mg of preparation per kg with their feed died in 4-16 days. The hatching rate of eggs laid by hens fed with feed containing 0.02% DDT and the viability of their chicks are reduced. The mortality rate of birds becomes marked, when the amount of the preparation reaches approximately 30-35 mg/kg. When birds are fed until their appetites are completely satiated with insects killed by DDT (by dusting), a considerable portion of the birds die.

Quail are very sensitive to DDT; with the use of feed with 0.025%, 50% of the birds die. After consuming feed with an analogous content of the preparation intoxication in ducks is observed.

In dusting a thick forest with DDT at a rate of 1360 g/ha amphibians die in reservoirs, but the number of birds remains unchanged. Dusting a forest with a dose rate of 2.75 kg/ha also does not affect the number of birds. When 5 kg/ha is employed the number of birds diminishes. After five applications of DDT at a dose rate of 2 kg/ha a decrease of approximately 26% of the wild birds is noted in the treated area.

The dusting of a forest with DDT disinfecting powder at a dose rate of 1 kg/ha causes death to birds feeding on the buds of spruce trees, containing worms; the number of insects in such a forest decreases by approximately 25-50%.

The DDT can be detected in the organisms of many wild birds.

The DDT toxicity to fish. Experiments under natural conditions have shown that this preparation is very toxic not only to insects, but also to fish. The danger in proportional to the dose, individual sensitivity and the presence of vegetation. The toxicity varies depending on the species and age of fish.

The DDT is detected in the fat of fish living far out in the sea. The concentrations of the preparation in fish fat vary from one to 300 parts per million.

It is characteristic that in one lake in California (USA), the water of which contained 0.2 parts of DDT [2, 2-bis (п-chlorophenyl)-1, 1-dichlorethane] per million parts of water, plankton grew with a content of 5 parts of this insecticide per million parts, and fish feeding on this plankton yielded fat containing hundreds and thousands of parts of DDT per million. Great created grebes feeding on these fish died although their fat contained somewhat less residual amounts of the insecticide than in the fish fat.

An experimental study of the effect of various insecticides on the fish, Micropterus dolomien, when they were orally administered food containing large quantities of DDT in capsules at a dose rate of 50, 100, and 200 mg/kg, showed that these amounts are fatal to these fish; they all died within 24-29 hours. The dusting of ponds with wettable DDT powders at a rate of 0.04; 0.065; 0.1 mg/ℓ (0.37; 0.5 and 1 kg/ha) caused the complete destruction of the fish, Micropterus dolomien and M. salmoides.

The spraying of DDT solutions in oil at a rate of 0.08 and 0.09 mg/ℓ (approximately 0.5 kg/ha) led to the complete destruction of the fish. When the concentration was decreased to 0.07 mg/ℓ (0.5 kg/ha) destruction of 87-88.5% of the fish was observed. In all cases 81.5-95% of the control individuals survived. After the dusting of a reservoir the fish start dying on the first day and continue to die for about a month.

According to Premdas, when DDT is added to a reservoir in an amount of 1 mg/ℓ, 5.87 mg/kg is detected in dead salmon. The greatest amounts of DDT are found in the gills, liver, spleen, heart, kidneys, sex glands, and the swim bladder. The author considers that the DDT gets into the organism mainly through the gills, and then is transported by the circulatory system. However, a certain part of the preparation enters through the integuments. Biological tests on mosquito larvae showed that 63% of the absorbed DDT was converted into a nontoxic compound.

In the case when the quantity of preparation applied causes the death of 70-80% of the insects in the reservoir, there is observed a considerable destruction of fish (for example, trout) as a result of their eating these insects. Great destruction of fish in lakes is also noted not only from direct dusting of the reservoirs, but also from the preparation being carried by the wind.

The DDT dusting (2 kg/ha) of deep swamps leads to the destruction of certain species of crustaceans in them, and only individual snails and bivalve mussels survive.

The DDT toxicity to warm-blooded animals. When working with DDT its aerosols, solutions, emulsions and suspensions penetrate into the animal and human organism in three ways: through the skin, lungs, and intestines. The rate of the passage of DDT through the intestines is affected by the presence of fat in the food consumed.

A toxic dose for animals, when administered orally, on the average of 250 mg/kg. When the effect is prolonged the minimum lethal dose [MLD] (МЛД) is equal to 100 mg/kg. In comparison with other insecticides DDT occupies an intermediate position. Thus, for example, for rats on LD_{50} of DDT is equal 2500 mg/kg, methocyclor – 5000 mg/kg, the gamma-isomer – 125 mg/kg, chlordane – 250 mg/kg, toxaphene – 60 mg/kg, nicotine – 10-60 mg/kg. The toxicity depends on the species and the state of the animal.

A study on dogs showed that a 2.5-5 mg/kg dose of DDT administered orally 4 times a day for 7 weeks causes mild intoxication. The administration of 50-80 mg/kg in corn oil causes the animal to die. When 10% DDT disinfecting powder was sprayed into the air at a rate of 12.44 mg/ℓ for 3 hours daily over a period of 4 weeks, no toxic symptoms were noted (A. N. Alekseyev, S. A. Kukavskaya, Ye. P. Krasnyuk).

The daily oral administration of 0.2 mg/kg of DDT to cats over a period of a year does not cause toxic symptoms; a dose of 0.5 mg/kg is toxic. The milk of a cat, which has repeatedly received DDT at a dose rate of 0.2 mg per kg, is toxic for kittens, which die within 2-3 weeks.

Four-ten inhalations of air containing 100 mg/ℓ of DDT leads to the death of the animals within 4-10 days. The spraying of DDT solutions in oil at a dose rate of 0.5 g/m^3 causes the death of the animals after 30-minute stay in a chamber treated in such a manner.

Aerosols obtained by burning paper containing DDT at a dose rate of 0.12 g of pure preparation per m^3 of air (the concentration recommended for practical application) do not cause death among animals even with 100- and 40-fold applications. Aerosols with a concentration of 0.5 g of pure DDT per m^3 of air after 19 applications cause the death of 52% of mice (V. I. Vashkov and N. A. Sazonova).

With the spraying of oil solutions (0.2 g/m^3 of air) after 22 treatments death is observed in 56% of the mice; death was not observed among rabbits. The same concentrations of aerosols applied under field conditions caused the death of mice and individual complaints from people who had gotten into the aerosol billow (S. G. Ped'ko).

The spraying of 10% DDT disinfecting powder with a concentration of 6 g of pure DDT per m^3 of air does not cause toxic symptoms in rabbits after 10 treatments over a period 10 days; treatment with the same concentration 11 times per day over a period of 10 days causes a severe condition and even death in rabbits.

When up to 100 mg/kg of DDT is administered in food to rats (during prolonged feeding) mild symptoms of poisoning were noted; increasing the amount of preparation up to 400-800 mg/kg had a severe effect on the central nervous system, which manifested itself in the form of tremors. When food is used, which contains 1000 mg/kg, toxic symptoms appear after 6-13 days, and death ensues within 14-18 days. Food containing 25 mg/kg and administered to rats over a period of 2 years did not increase the death rate among them in comparison to control rats.

Mice are more sensitive to DDT than rats; thus, for example, the administering to them of a preparation containing 125 mg/kg and higher along with their food causes them to die within 1-6 days.

No carcinogenic effect was noted during the prolonged action of DDT on the skin of mice of a well studied strain.

When guinea pigs were administered food containing 1000 mg/kg of DDT for a long period of time their death is observed after 8-10 exposures.

The daily rubbing into the skin of 1, 2, 3 mℓ/kg of 30% DDT solution in demethyl phthalates results in the death of rabbits, and when the amount is decreased to 0.5 mℓ/kg it causes symptoms of poisoning; the rubbing in of 0.25 mℓ per kg of weight over a period of 13 weeks is not fatal. With the application of a 10% DDT solution in kerosene at a rate of 100 mg/kg death of the animals is noted after 6 days. The application of pure DDT or 5% disinfecting powder to the skin for a period of 2 hours at a quantity of 15 mg/kg does not cause illness.

Daily oral administration of 100 mg/kg of DDT for a period of a week to cows, horses, sheep, and then of 150 mg/kg during the 2nd week and 200 mg/kg during the 3rd week causes symptoms of sickness in the animals, especially in the cows. In certain animals poisoning appears as a disorder of the central nervous system, and symptoms of illness are not noted in horses and sheep eating this feed.

After the oral administration of DDT in oil the latter is detected in the blood man hour and reaches its maximum in 6-8 hours; the preparation circulates in it for 14-16 days. The DDT can be detected for 14-20 days in all the organs, especially in the brain, kidneys, the tongue muscle, and the rectum. The formation of п, п'-dichlorodiphenyl acetic acid (a product of the decomposition of DDT) has been ascertained in the organism of man and the rabbit.

When DDT gets into animal organisms with feed the preparation is discharged with excrement, urine, and milk. In individual milk samples the amount of DDT or its related compounds (methoxychlor) comprised 0.00015%. Most frequently the source of milk contamination comes from the fodder, the treating of cows to control mites and gadflies and the treating of dairy barns and other premises.

Milk contamination is of especially great importance for humans, who use the milk from these cows in their food. As is known, milk and its by-products are consumed by people in large quantities and makes up approximately 25% of their total diet in many countries. When milk is being processed large quantities of DDT and hexachlorane are detected in butter, sour cream, and cheese.

In human urine after poisoning with DDT there has been detected 75% unaltered preparation and 25% п, п'-dichlorodyphenyl acetic acid. After 11 mg/kg of DDT has been taken internally the greatest amount is noted to be excreted with the urine on the 2nd day with a gradual decrease during the ensuing 10 days. The preparation is not retained by the kidneys.

The administration to volunteers of 3.5-5.5 mg of DDT per person over a period of 18 months (in the USA) did not cause any symptoms. The DDT level in the fat was raised above 270 mg/kg in people receiving the highest doses (Hayes and others), which exceeds by 20 times the average level of the DDT contents in the organism of adults in the USA.

The DDT in the animal and human organism is converted into DDE (dichlorodiphenylethylene), a compound nontoxic to them.

In a disinfector, who mixed DDT with talc and petrolatum in a hot room two times a week with unprotected hands, there were observed during the first week intestinal disorders, loss of appetite, mild diarrhea, dizziness, numbness in the fingers and toes (in certain cases dermatitis and eczema are observed). During the first 2 weeks in the disinfector symptoms of gastritis and disturbance of the liver function continued to become intensified; herpes on the lips and spots on the chest appeared; numbness of the extremities and muscular debility continued to become intensified. In the course of the subsequent 3 weeks neuralgic symptoms became even more noticeable; the man could not move without assistance.

In all cases of acute DDT poisoning the same symptoms are observed: early nausea and vomiting are usual in these cases; headache, debility, dizziness, torpor, paresthesia, loss of motor coordination and tremor after several hours. All these symptoms can last for several days and complete recovery takes a long time.

Spasms appear in people with the administration of 16 mg/kg; small doses may cause vomiting. Death ensues from a dose of approximately 285 mg/kg. It is difficult to state an exact and precise toxic dose, because it depends on age, how well nourished the man is, individual sensitivity and on the method of administering the DDT.

It is known that after an oral dose of 500 mg/kg the death of the man ensues in 2-24 hours. A lethal dose of DDT dissolved in kerosene is approximately 150 mg/kg.

There is no danger to people from a city water supply where the city water line takes water from reservoirs treated at a rate of 0.2-2.5 kg/ha, because with normal water treatment the greater part of the preparation (0.1-10 mg/ℓ) is removed.

In mice, which have exclusively received water containing 10 mg/ℓ of DDT for a period of 75 days, harmful aftereffects were not observed; also toxic symptoms in mice were not noted, which received water containing 50 mg/ℓ for 58 days.

As a result of the broad application of DDT the latter gets into the human organism in numerous ways and is partially deposited in the fat. To determine the DDT in the fat from 100 volunteers (USA) fat samples were taken. As it turned out, in human fat on the average there is stored 4.9 mg of DDT per kg. Analogous data were obtained in the Federal Republic of Germany (up to 10 mg/kg) and in Canada; the amount of DDT in the fat of 62 examined persons was within the limits of 2-14.3 mg/kg. In Southern England Hunter and others determined the amount of DDT in the fat humans (samples were taken from corpses) according to the data received the amount of DDT constituted 2.21 parts per million. The portion of dichlorodiphenylehtylene was 28-90% (on the average 67%). Ye. N. Burkatskaya considers that in the insecticide industry and in insecticide storehouses the maximum permissible concentration of DDT in the air is 0.0001 mg/ℓ. Under the conditions of short-term work in the open air this concentration must not exceed 0.0005 mg/ℓ. A toxic DDT dose for man when taken orally is about 10-20 mg/kg, whereas LD_{50} for animals is about 250 mg/kg.

In spite of the broad application of DDT, its analogs and hexachlorane for a period of 15 years without any kind of precaution, there has not been reported in literature one case of industrial poisoning with a fatal outcome both among workers at enterprises manufacturing these preparations, and also among disinfectors. An examination has been carried out of restricted groups of people, who by the character their occupation are subjected to the effect of insecticides. Among them symptoms of nervous diseases have been detected, which usually bear a reversible character. basically in persons subjected to the severe effect of certain chlorinated hydrocarbons and organic phosphates. The Committee of Experts on Insecticides of the Universal Organization of Public Health, which convened in October of 1961 to examine the question of the toxicity of insecticides to men, passed the following resolution (the 12th report of the Committee of Experts on Insecticides of the Universal Organization of Public Health, Geneva, 1962).

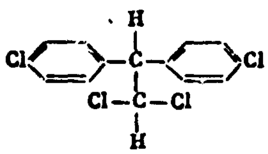
"Considering the unexcelled role of DDT in the successful elimination of malaria in various parts of the world, and also the preservation by it at the present time of its effectiveness in carrying out of the majority of measures for the elimination of infection, it is necessary to recognize that this insecticide is best preparation from the point of view of safety in application. It should be replaced by other insecticides only in the case of extreme necessity."

Analogs of DDT

In diphenylethane compounds chlorine can exist structurely in the ortho-, meta- and para positions, moreover the number of chlorine atoms can vary greatly as in the benzene ring, and also for the ethane group; for example, in the latter case this number can oscillate from 1 to 4 chlorine atoms; analogous compounds can also be obtained, not containing chlorine, but iodine, bromine, fluorine or several of the halogens in a single molecule. Over 200 analogs and homologues of DDT have been described, but of all the compounds of this group the best is the compound dichloro-diphenyl-trichloroethane or 4.4'-dichlorodiphenylchloromethylmethane.

A study of the insecticidal properties DDT analogs showed that only three of them approximate DDT in effectiveness: dichloro-diphenyl-dichloro-ethane - [TDE] (ТДЕ), or DDD, difluorodephenyltrichloroethane - [DFDT] (ДФДТ) (fluorine-DDT) and methoxychlor, or methory-DDT.

DDD - $C_{14}H_{10}Cl_4$ - 2, 2-bis (п-chlorophenyl)-1, 1-dichlorethane:



Synonyms: TDE, dichlordiphenyldichloroethane, tetrachloro-diphenylethane, and others. The molecular weight is 320.05. In contrast to the DDT molecule the DDD molecule contains one atom of chlorine less and one atom of hydrogen more.

Pure DDD - composed of solid colorless crystals. The technical preparation contains, besides п, п'-DDD, a mixture of various isomers, among which the о, п'-isomer predominates. The quantity of the latter in the mixture is equal to approximately 7.8%; the melting point is 76°. The melting point of pure DDD is 109-110°, the boiling point is 185-193°. The specific weight is 1.385. The preparation does not have an odor or taste, does not burn, the cleavage of chlorine occurs more slowly than DDT. Under the influence of alkalis DDD decomposes and converts to 2, 2-bis-(п-chlorophenyl)-1-chloro-ehtylene (the melting point is 68°).

The DDD is less corrosive to metals than DDT; it is insoluble in water, but dissolves in organic solvents; the degree of solubility depends on the solvent used; for example, in 100 ml of olive oil at 37° 10 g dissolve in acetone and methylethylmethane 10 g also dissolve in 100 g of benzene 70 g of DDD dissolve, in 100 g of chlorobenzene 92 g of 000 dissolve, in other solvents its solubility is higher than in acetone.

Ultraviolet rays decompose DDD just as they do DDT. When heated up to 300° in the presence of ferric chloride DDD is decomposed by the cleavage of hydrochloric acid. In the cleavage of chlorine two molecules of hydrochloric acid are formed.

The technical product (solidifies at 86°) makes it possible to manufacture water-wettable powders, 5-10% disinfecting powders and 25-30% emulsion concentrates. Disinfecting powders are usually applied in agriculture at a rate of 10-15 kg/ha; the wettable powders are used in a 3% concentration.

According to the number of insects, which can be controlled by DDD, it is considerably inferior to DDT. In its insecticidal properties it is approximately 2 times weaker than DDT. Nevertheless, with respect to certain insects it possesses high insecticidal properties, including with respect to mosquitoes and their larvae, and also with respect to individual species of agricultural crop pests. The DDD has a considerable insecticidal effect on bed bugs, lice, and other insects. In its effectiveness it is weaker than methorychlor.

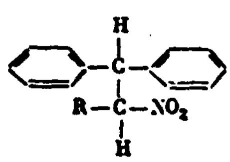
The DDD, just like DDT and methoxychlor, has a negative temperature coefficient; for example with the same dose of DDD at 36° fewer flies die than at 28°.

With respect to bees DDD is approximately 4 times less toxic than DDT, 70-80 times less toxic than the gamma-isomer of hexachlorane, and 15 times weaker than chlordane.

The DDD is slightly toxic to the higher animals. For rats LD_{50} is approximately equal to 3400 mg/kg, for rabbits – 4000 mg/kg, for fish (gold fish) – 0.9 mg/kg.

With the systematic application of 80 mg/kg of DDD per day to animals it causes atrophy of the suprarenal glands and death. The isomer, п, п'-DDD even at a dose rate of 200 mg/kg per day does not cause changes to the suprarenal glands after a 60-day action; the о, п'-DDD isomer even at a dose rate 4 of mg/kg per day causes loss of appetite and atrophy of the suprarenal glands. The DDD concentrates more intensively in the fatty tissue and in the tissue of the suprarenal glands.

Dilan – a mixture of two compounds containing the nitroalkyl group, 2-nitro-1, 1-bis-(п-chlorophenyl)-butane [1, 1-bis-(п-chlorophenyl)-2-nitrobutane and 2-nitro-1, 1-bis-(п-chlorophenyl-propane [(1, 1-bis)-(п-chlorophenyl-2-nitropropane]; these compounds are called bulan and prolan. The mixture contains 52.2% bulan and 26.2% prolan and 19.6% related compounds (by weight):

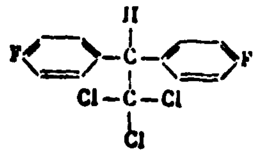


where R = CH_3 (prolan); R = $CH_3 - CH_2$ (bulan).

Dilan according to its insecticidal properties with regard to flies and other insects is considerably inferior to DDT; for example, when topically applied at a rate of 100 μg to flies 50% of the individuals die within 24 hours.

In its toxicity to warm-blooded animals it is approximately equal to DDT.

The DFDT – $C_{14}H_9Cl_3F_2$ – 2, 2- -(4-fluorophenyl-1, 1, 1-trichlorethane:

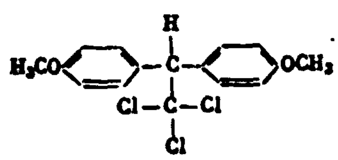


Synonyms: 1, 1, 1-trichloro-2, 2-п-(п-fluorophenyl)-ethane, difluorodiphenyl-trichloroethane, fluorine-DDT, fluorogezarol', Gix and others. The molecular weight is 321.6.

The pure compound - solid colorless crystals; the technical preparation is a viscous, colorless liquid; it contains about 10% of this substance. The boiling point is 135-136° at a pressure of 9 mm Hg. The melting point is 45.5°. The vapor pressure is 2.2 × × 10^{-6} at 20°. The odor of the preparation is reminiscent of the odor of ripe apples. It is almost insoluble in water, but is soluble in the majority of organic solvents.

The preparation is used to control agricultural plant pests and human parasites. In its insecticidal properties with respect to all insects, with the exception of cockroaches, it is inferior to DDT. To the higher animals it is 3-4 times less toxic than DDT.

<u>Methoxychlor</u> - $C_{16}H_{15}O_2Cl_3$ - 1, 1, 1-trichloro-2, 2- di-(п-methoryphenyl)-ethane:



Synonyms: 2, 2-bis-(4-methoryphenyl)-1, 1, 1-trichloroethane; [DMDT] (ДМДТ); methoxy-DDT; marlate and others. The molecular weight is 345.7.

An analog of DDT, in which the two atoms of chlorine located in para position are replaced by the methoxy-group. A colorless powder of crystal form. The melting point of the crystals is 78 and 86-88°

depending on its form. The specific weight at 25° – 1.41. It possesses an odor reminiscent of the odor of fruit.

The specifications set forth by the Committee on Insecticides of the Universal Organization of Public Health for technical methorychlor are the following:

	Minimum	Maximum
General content of chlorine in weight percent....	29.5	31.5
Content of hydrolyzing chlorine in weight percent	9.7	11.7
Content of hydrochloride in weight percent.......	–	0.025
Acidity based on H_2SO_4 in weight percent..........	–	0.3
Solid substance insoluble in isotol in weight percent......................................	–	1.0
Content of water in weight percent..............	–	1.0

The para, para-isomer of methorychlor solidifies at 69°; at normal temperatures it does not melt.

Methorychlor is insoluble in water, but readily dissolves in certain organic solvents (in particular, in the aromatic ones), for example it dissolves in trichlorethane to 70 g per 100 mℓ at 20°, in methylene chloride up to 133 g per 100 mℓ at 15°, it also dissolves (moderately) in kerosene and olive oil. It does not decompose with heating, it is resistant to oxidation, is less sensitive to alkalis than DDT, it is stable with respect to ultraviolet rays, it slowly dehydrochlorinates into 2, 2-bis-(п-methoxyphenyl)-1, 1-dichlorethylene; heavy metals accelerate the dehydrochlorination just as with DDT.

The insecticidal properties of methoxychlor depend on the content of the п, п-isomer.

From technical methoxychlor the emulsion concentrate is manufactured (24% technical preparation); the emulsion is used to treat gardens and useful vegetation; the wettable powder (50%) is used in suspension form for spraying animals or to submerge them in it; the suspension is also used to spray structures, fruit gardens, grain cultures, and others.

Methorychlor preparations are also highly effective with respect to everyday parasites and carriers of causal organisms of infectious diseases. They possess a somewhat more prolonged residual action than DDT. Methoxychlor is highly toxic to the same insects, to which DDT is toxic. At the same time its toxicity to warm-blooded animals is 25-30 times lower than DDT.

Methoxychlor is of special value for its use in destroying ecto-parasites of domestic animals. It possesses high residual toxicity to insects, as does also DDT, but it is less dangerous to man. Abroad the preparation is widely applied in agriculture, it is recommended to be applied up to 7 days before the gathering of the harvest. It possesses high insecticidal properties with respect to garden pests, human parasites and pests in his dwellings, ecto-parasites of animals and pests of agricultural plants.

Methoxychlor is inferior to DDT in its effectiveness with respect to all insects: LD_{50} of methoxychlor has approximately 3/5 the index of the insecticidal properties of DDT; if the insecticidal capability of the latter is taken as unit, then with respect to house flies its acitivity is equal to 0.35-0.92, for bed bugs – 0.97, for clothes lice – 0.38, for Anopheles mosquitoes – 0.10, for Aëdes mosquitoes – 0.09.

To fly larvae methoxychlor in emulsion form is mildly toxic at a dose of 320 parts per million parts of substrate.

According to Ye. V. Shnayder and V. V. Shavyrina, and also to our observations, the insecticidal properties of methoxychlor with respect to flies, fleas, cockroaches, bugs, and satiated mite larvae are insignificantly inferior to DDT, and precisely: methoxychlor in disinfecting powder form, just as DDT, when applied to horizontal surfaces at a quantity of 1 g of active substance per 1 m^2 after 15-minute contact with the flies and 5-minute contact with fleas causes their complete destruction after 24 hours. These same doses with a 15-minute exposure ensure the complete destruction of bugs and cockroaches after 48 hours.

In treating surfaces by spraying a 1% solution of methoxychlor at a rate of 0.5 g/m^2 after 15-minute exposure there is observed complete destruction of hungry larvae of fleas and mites after 48 hours.

Lice on fabric impregnated with a 1% solution of the preparation are completely destroyed after 3-5 hours of contact. On vertical surfaces (wooden or plastered covered with oil paint) in the case of the application of methoxychlor suspension at a rate of 1 g/m^2 flies die within the limits of 86-90% after 5 minutes of contact.

With the application of the preparation in the form of disinfecting powder on wood and plastering covered with oil paint at a rate of 1 g of technical preparation on m^2 it retains its activity for 60 days (the mortality rate reaches 80-90%). In treating the same surfaces with a 1% methoxychlor suspension at a rate of 1 g/m^2 even after 2 weeks the death rate of insects on wood colored with oil paint is 50%, and on plastering colored with oil paint - 30%.

The insecticidal properties of methoxychlor to a considerable degree depend on the resistance of the insects. Thus, for example, house flies of a sensitive strain die from a topical application of 0.07 μg, and flies of a strain resistant to this preparation die from 100 μg; flies resistant to DDT die after an application of 1 μg of methoxychlor per individual.

To bed bugs, mosquitoes and their larvae methoxychlor is highly toxic but in effectiveness it is somewhat inferior to DDT.

For dusting vegetable cultures wettable powders of methoxychlor are used at a rate of 2-4 kg/ha.

In toxicity to bees methorychlor is somewhat inferior to DDT. Its effect on insects is close to the action of DDT; similar to DDT, methorychlor has a high coefficient of solubility in lipoids in comparison with water; it has the same negative temperature coefficient as DDT. Thus, in its effect on flies the death rate of the latter is higher when the preparation is applied at 28°, than at 36°.

In insects poisoned with methoxychlor (red cockroaches) by the injection of a toxic dose, the oxygen demand is immediately increased (muscular activity, tremor, etc., characteristic nervous impulses without a latent period). The oxygen consumption rises within 30 minutes-1 hour from 0.6 to 3 mm^3 per minute before the advent of paralysis, with the beginning of which the oxygen consumption sharply decreases until complete cessation.

To methorychlor, the same as to DDT, resistance develops with its continuous effect on flies (21-80 generations).

The toxicity of methoxychlor to warm-blooded animals. With the oral administration the toxicity of the preparation to animals is lower than the toxicity of DDT: for rabbits and rats it is 4 times lower, when applied on the skin - 8 times lower.

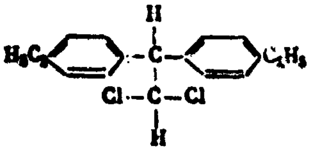
The administration in the food of young rats of a 0.01% preparation does not have an effect on their growth; increasing the dose to 0.1% insignificantly inhibits the growth of young rats. Of 10 rats (males and females) 8 perished when fed a diet containing 3% methoxychlor (50% died within 45 days). Dogs survive a diet containing 10 g/kg over a period of 6 months. In cows' milk treated with 10 g of 50% wettable powder it is possible to detect not less than 0.1 mg/kg of methoxychlor.

Methoxychlor accumulates slightly in the fat of animals and is secreted from their organism with milk.

Olney and other fed brood-hens and large chicks a standard feed with the addition to it of 2; 4; 8; 10; 100 and 1000 parts of methoxychlor per million parts of feed; the duration of the feeding of hens reached 85 days, and the chicks - 56 days. No harmful effect was noted on egg laying nor on feed consumption nor on the addition of weight nor on the death rate of the birds. It was impossible to detect the insecticide in eggs during the use of low doses, but during the feeding of birds doses of 100 and 1000 parts per million parts of feed, the preparation was easily detected starting with the 8th day from the beginning the experiment. After doing away with the methoxychlor it was impossible to detect it at the indicated doses in the birds on the 14th and 28th day respectively. The preparation was detected in the fat and skin when administered in low doses in the feed, and with the use of high doses it was possible to detect it in the heart, paws, liver, chest, and throat. After the cessation of the administration of the insecticide with the feed it rapidly disappeared from the tissues, with the exception of the skin and fat; in these tissues the level of preparation content after 63 days was determined at an amount lower than 0.05 parts per million. The content methoxychlor in the various organs and tissues of the brood hens reached the following values: with a dose of 1000 parts per million from 1.4 to 4.4 parts per million were detected in the eggs, in the chest - 0.18, in the liver - 0.68, in the paws - 0.98, in the throat - 1.7, in the heart - 4.5, in the skin - 18.9 and in the fat - 54.1 parts per million. In chicks all these values were somewhat lower.

In human toxic symptoms are noted after a single application of 169 g or with the multiple application in the course of a day 36 g on the skin. When orally administered a lethal dose for man is 7.5 g/kg of the preparation.

Pertan - $C_{19}H_{20}Cl_2$ - 1, 1-dichloro-2, 2-bis-(п-ethylphenyl)-ethane:



Synonyms: di-(п-ethylphenyl)-dichloroethane; 2, 2-bis-(4-ethylphenyl)-1, 1-dichloroethane.

The compound is analogous to DDT. The molecular weight is 307,254, solid crystals, the melting point is 56-57°. In its insecticidal properties it is considerably inferior to DDT. The LD_{50} for flies is approximately 0.4). g per insect. Its oil solutions of 2-5% concentration are used for controlling American, common, and black cockroaches, moths and skin beetles [khapra beetles]. It is widely used for controlling agricultural culture pests.

Pertan is slightly toxic for warm-blooded animals. The LD_{50} for mice when orally administered is equal to 9340 mg/kg, when intravenously administered it is 175 mg/kg. For rabbits when orally administered LD_{50} is equal to 8170 mg/kg, and when intravenously administered – 75 mg/kg. Death ensues after 1-4 days. When fed food containing 5000 mg of pertan per kg, dogs die.

CHAPTER III

INSECTICIDES OBTAINED FROM THE DIENE SYNTHESIS REACTION

This group of chlorine-containing preparations, just like [DDT] (ДДТ) [HCCH] (ГХЦГ) and others, belongs to the chlorinated hydrocarbons. They possess higher insecticidal properties than DDT. Among these preparations belong chlordane, heptachlor, aldrin, dieldrin and isomers of these last two preparations – isodrin and endrin. All these substances are obtained by diene synthesis from hexachlorocyclopentadiene, which is the basic intermediate for the synthesis of this whole group of named compounds. The most importa... reactions described for hexachlorocyclopentadiene belong to the diene synthesis type of reactions; it is obtained by the chlorination under various conditions of cyclopentane, amylenes and cyclopentadiene (S. D. Volodkovich).[1]

Chlordane, heptachlor, aldrin, dieldrin and others possess high insecticidal properties. All the preparations – contact poisons, and chlordane and aldrin, furthermore, possess considerable effectiveness in the vapor form. The preparations are highly effective in oil solutions and emulsions, similar to DDT; aldrin and dieldrin are also used in powder form. According to their insecticidal effectiveness these preparations can be arranged in the following descending order: dieldrin > gamma-HCCH > aldrin > chlordane > DDT.

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[1] In a number of structural formulas of diene synthesis (for the purpose of reducing the space of formulas) carbon is not shown.

From the point of view of residual action dieldrin is equal to DDT, since it is extraordinarily stable; the remaining compounds are somewhat volatile and evaporate slowly. According to the degree of the length of their residual action the preparations are arranged in the following manner: aldrin > chlordane > gamma-HCCH according to some authors, and gamma-HCCH > chlordane > aldrin according to other researchers.

Aldrin, DDT, dieldrin, endrin, isodrin and toxaphene are effective against the larvae of Aedes dorsalis mosquitoes at a concentration of mg/ℓ. When the concentration is decreased by 10 times good results are also obtained.

Chlordane is less stable than DDT and less insecticidal than HCCH; there is not one insect, with respect to which it would not exceed the other insecticides, especially DDT.

The most expedient method of applying diene synthesis preparations is to use them in the form of residual films on surfaces. Under these conditions dieldrin is the best, because it combines the stability of DDT with the high insecticidal capacity of gamma-HCCH. When it is used by qualified workers, it produces good results in controlling flies. Aldrin and dieldrin – effective mosquito larvacides. Both the compounds are stable with respect to alkalis. Insects resistant to DDT are more resistant to these preparations. Furthermore, such insects develop resistance to preparations obtained by diene synthesis reaction more rapidly than do ordinary strains.

According to the experimental works of L. N. Pogodina, I. N. Savel'yev, M. V. Skibinskaya, and A. L. Englin, aldrin, dieldrin and stereoisomers – endrin and isodrin – are highly effective in controlling certain species of insects – human parasites and pests in his dwellings.

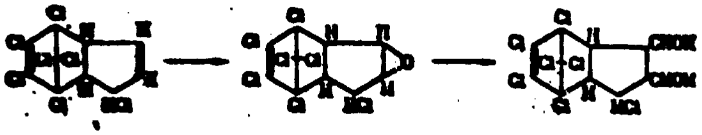
The preparations, dieldrin and endrin, in the form of 1-5% disinfecting powders with talc in one-minute contact with fleas cause their complete paralysis in the first 5 minutes. Lengthening the contact of the fleas with the disinfecting powders to 3 minutes provides analogous results even when the concentration of the disinfecting powders is decreased to 0.5%. Lower effectiveness with respect to fleas is possessed of the disinfecting powders, aldrin and isodrin.

Alcohol solutions (0.05-1%) of aldrin, dieldrin and their isomers when impregnating fabrics are less effective than disinfecting powders. The toxic properties with regard to lice situated in fabrics impregnated with dieldrin and endrin solutions at low concentrations (0.000075-0.00001%) exceed the toxicity of fabrics impregnated with isodrin by 3-4 times, and fabrics impregnated with DDT by 44-52 times.

The disinfecting powders, aldrin and dieldrin, used to treat a substrate (middlings) at a rate of 0.5 active substance per kg cause within 48 hours the death of 65% of the fly larvae.

Insecticides obtained by diene synthesis reaction, penetrating into the animal organism, can accumulate in it. This phenomenon has been studied in sufficient detail for warm-blooded animals. Insecticides obtained by diene synthesis reaction usually concentrate in the fatty tissue. These poisons are detected in considerably smaller quantities in the muscles, tissues of the internal organs, in the peripheral and central nervous systems. In the animal organism the insecticides of this group undergo a number of biochemical transformations, of which the best studied is oxidation.

Such a case of oxidation can be illustrated by heptachlor. In the organism of warm-blooded and invertebrate animals heptachlor is converted into epoxide of heptachlor with a melting point of 159-160°, which then changes into diol:



It is also known that aldrin in an organism changes into dieldrin, the epoxides of α- and β-chlordane have been described. The epoxides are considerably more toxic than the corresponding parent substances. For example, [LD_{100}] ($ЛД_{100}$) of heptachlor is 40 mg for mice when introduced intravenously, and of the corresponding epoxide – 10 mg/kg. If cows are administered with their feed heptachlor at a rate of 3 mg/kg in twenty-four hours, then the epoxide begins to appear in the milk on the 9th day and its content increases up to 1.8 mg per kg of milk. Based on the butter fat the content of heptachlor epoxide will be 44 mg/kg. After the cessation of feeding heptachlor to cows its epoxide disappears from the milk after approximately 50 days.

Thus, as a result of the oxidation of heptachlor or aldrin in the animal organism highly toxic compounds will be formed.

In interacting with glucuronic acid diol is detoxified, forming water-soluble metabolites, which are excreted by kidneys.

The details of the metabolism of cyclodiene compounds, especially their individual representatives, are very little known. Certain observations and experiments have shown that with a single feeding to animals of heptachlor at a dose rate of 35 mg per kg of living body weight there is retained in females 8 times more epoxide than in the body of males.

The general pattern of insect poisoning with cyclodiene insecticides and also many physiological indices are similar to the described symptoms noted during the administration of DDT and hexachlorane. In the insect organism analogous processess (fly) were distinguished.

An injection of 80 μg of chlordane or toxaphene into an Americal cockroach leads to the disturbance of cardiac pulsation, an increase in respiratory intensity, etc.

Aldrin

Aldrin – $C_{12}H_8Cl_6$ – 1, 2, 3, 4, 10, 10-hexachloro-1, 4, 5, 8-di-endomethyloene-1, 4, 4a, 5, 8, 8a-hexahydronaphthalene:

Synonyms: 1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4-endo, exo-5, 8-dimethanonaphthalene. The molecular weight is 365. It is a white solid. The melting point of the pure preparation is 104-104.5°; of the technical – about 90°. The vapor pressure is 6.10^{-6} mm Hg at 25°. At room temperature it has an odor. The technical products is a wax-like substance; it contains not less than 11% aldrin.

Aldrin – an effective insecticide widely applied abroad is controlling various insects. It is somewhat more volatile than gamma-hexachlorane. It only slightly dissolves in water – 0.07 mg/ℓ, it readily dissolves in organic solvents.

The manufacturing enterprises of certain countries prepare wetable powders from aldrin, containing 20-40% aldrin, and disinfecting powders containing up to 75% of the preparation. The preparation is also manufactured in granulated form with an aldrin content of 25%; aldrin emulsions are also produced containing the same percentage.

Aldrin is used to control various arthropods. Thus, for example, when 25 mg/kg is applied to a substrate is provides 97-100% destruction of fly larvae. It is highly toxic to adult flies.

The use of the preparation in the form of oil solutions showed that it is effective at the following concentrations: for bed bugs – 0.28%, for fleas – 0.48%, for lice – 0.038%, for adult flies – 0.009%, for Aedes mosquitoes – 0.36% and for Ornithodorus mites – 0.08%. It is also effective in controlling Trombicula mites. The preparation is superior to DDT in its insecticidal properties with respect to flies by 5 times, fleas – by 8 times and lice – by 15.7 times. Aldrin is 3 times more toxic than chlordane to cockroaches and 70 times more effective than DDT. When the preparation was applied at a rate of 1% in food baits under laboratory conditions complete destruction of flies was observed within 24 hours; under practical conditions the baits containing aldrin were completely ineffective.

The residual action of aldrin is slight: with filter paper impregnated at a rate of 0.1 mg/cm^2 the bugs died in 100% of the cases only during the first 3 days; after 10 days their mortality rate decreased to 95%, after a month it was equal to 65%, and toward the end of the 6th month it was only 23%. When the preparation dose was increased to 0.5 mg/cm^2 a mortality rate of 95% was observed for a period of a month, but toward the end of the 6th month it descended to 51%. When the preparation is employed on a surface for the purpose of controlling mosquitoes 1-2% solutions are applied. Such a treatment is effective for a period of 4 weeks. Anopheles mosquito larval die at a rate of up to 50% when 0.025 mg/ℓ of aldrin is applied; LD_{50} for honeybees is 0.025 μg/insect, LD_{50} for house flies is 0.032 μg/insect.

With the injection of aldrin into a cockroach and after a 2-3 hour latent period there appears a considerable increase in oxygen intake, from 0.5 to 3 mm per minute. The greatest amount of oxygen intake is reached 5 hours after the injection. The insect remains active during the latent period.

In the insect organism, and also in the organism of higher animals aldrin is oxidized and is converted into dieldrin. When aldrin is employed to combat cockroaches and flies its effectiveness, in contrast to DDT, lindane and pyrethrin increases with an increase in temperature.

With the presence of up to 0.01 mg/ℓ of the preparation in water 95-100% of Anopheles quadrimaculatus larvae due; Aedes aegyrti larvae are more resistant as compared to Anopheles larvae — their complete destruction is accomplished with the presence of 1 mg/ℓ in water.

Cattle infested with fleas are freed from them with a subcutaneous injection of 50 mg/kg of aldrin. It has been shown that after treating wool on sheep with a 0.05% solution of aldrin for the purpose of combating flies the preparation retains its effectiveness for a period of 12-14 weeks. When dieldrin is employed at an analogous concentration its effectiveness was maintained for 40 weeks. The wool removed from sheep maintains its anti-moth properties for a considerable period of time.

The preparation has found its greatest application in agriculture. Locust are killed when it is employed at a rate of 150 g/ha; to destroy the Colorado beetle a 0.01% emulsion is used at a rate of 130 ℓ/ha. Aldrin, according to its insecticidal properties, is twice as weak as dieldrin; inasmuch as the residual action of aldrin is shorter than dieldrin, it is better to apply it for treating fruit and vegetable crops, in particular beets. Aldrin is used to combat pests of cotton, tobacco, grain crops and others. It can be used at a concentration of 0.12-0.24% to combat ants, causing damage to citrus trees.

In moist clayey soil aldrin changes more rapidly into dieldrin then in soil to which manure has been added. Aldrin which has been applied to soil at a rate of 3 kg/ha is not detected in it after 4 years, but it was possible to detect traces of dildren — 0.03 mg/kg. In soils containing a small quantity microorganisms (autocloved clays and sand), or in dry soils the amount of dieldrin formed is insignificant.

It has been established that such cultures, as wheat, corn, rye, sugar cane and others grown in soil treated with 0.14-6.78 kg/ha of aldrin do not absorb the preparation.

According to Fletcher the doses of aldrin recommended to control insects do not affect soil microorganisms to a significant degree and cannot cause serious changes in the fertility of such soil. In the United States aldrin and other preparations are applied in mixture with fertilizers.

In the organism of cows and other lactating animals - in pigs, sheep, rats, apparently, in all other animals, and also birds aldrin is rapidly converted to dieldrin. This conversion of aldrin occurs independently of the method of its application. The rapid rate of the epoxidation of aldrin into dieldrin in the animal organism is proved by the fact that dieldrin can be detected in milk 24 hours after the introduction of aldrin.

Thus, it has been established that the toxicity of aldrin depends on its transformation into dieldrin. The analogous transformation is also observed and in soybeans and grain cultures.

There was observed in animals after the introduction of 20-100 mg/kg of aldrin to their feed an increase in the amount of aldrin in their fat (by 5%), an increase in the amount in their liver (by 15%) and simultaneously there was noted an increase of serum esterose; this increase reached 149% on the 54th day in an experiment with aldrin and 111% in experiments with dieldrin. Aldrin has a definite effect on the central nervous system but does not affect the peripheral system.

The toxicity level of aldrin to warm-blooded animals is: for white rats 40-50 mg/kg, for sheep and pigs - about 50 mg/kg. The action mechanism is similar to the action of the chlorinated hydrocarbons. The clinical pattern of aldrin and dieldrin poisoning is indicative of central nervous system damage.

According to N. A. Sazonova and A. P. Volkova, the preparations possess cumulative properties and cause chronic poisoning. With a single oral administration of aldrin dissolved in oil a 100% mortality rate of white mice, white rats and rabbits is realized from a dose of 50 mg/kg; in the case of the administration of dieldrin a 100% mortality rate of white mice and white rats is realized from a dose 64 mg/kg and of rabbits -- from a dose of 125 mg/kg.

Aldrin and dieldrin cause changes in the leucocytes and an acceleration of [ESR] (РОЭ). The preparations are readily absorbed through the skin. The toxicity obtained by this method of introduction is less than the toxicity observed with oral administration; a 5% oil solution does not have a local effect on the skin of white mice and rats.

During multiple dusting with 1-0.5% aldrin disinfecting powder at a rate of 10 mg per cm^2 of surface pathological changes develop in the lungs of rabbits, which are less expressed during the action of dieldrin disinfecting powder under the same conditions. The prolonged action of aldrin vapors (evaporating from the walls of a chamber, to which the preparation has been applied at a rate of 1-2 g of active substance per m^2) causes pathological changes in the lungs of white mice and then death. Aldrin vapors are somewhat more toxic than dieldrin vapors (N. A. Sazonova and A. P. Volkova).

When aldrin is added to the feed of young bull-calves, sheep, pigs over a period of 12 months there is detected in their tissues only small amounts of this preparation even with the presence of 10 mg per kg in the feed. Moreover, in the fat of bull-calves there was 39.2 mg/kg, in the liver - 3.84 mg/kg, in the kidneys - 3.5 mg/kg and in the muscles - 0.72 mg/kg, in the sheep there was respectively 42.3; 3.14; 1.36 and 0.73 mg/kg, in pigs - 17.4; 0.77; 0.69 and 0.49 mg/kg respectively.

When aldrin is injected under the skin it is less toxic than when it is orally administered; in the first place aldrin is detected in the fat of animals up to 4 months.

Aldrin is extremely toxic to gold fish: one part of aldrin per billion parts of water is fatal.

The acute toxicity of aldrin to people is relatively high. The preparation can get into the human organism through the digestive tract, the respiratory tract and the skin. When it gets into the organism it causes severe illness in man. Thus, for example, in an adult man aged 23 years, who drank 170 ml of a solution containing 1.8 g of aldrin (25.5 mg/kg) there appeared spasms within 20 minutes. Changes were recorded on electroencephalograms for a period of 5 months.

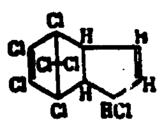
There are data available about 30 cases of poisoning in people, who manufactures aldrin disinfecting powder; of these 5 cases were among factory workers working with empty aldrin packing. The symptoms of poisoning are diverse: nausea, vomiting, general lethargy, headache, cough; more rarely there were observed dizziness, loss of weight, in individual cases spasms and bronchial irritation. The therapy in individual cases (with spasms) consisted of gastric lavage, the internal administration magnesium sulfate, oxygen therapy and the intravenous infusion of glucose, and also symptomatic therapy.

It is characteristic that aldrin in the human organism and in the environment is converted into dieldrin. In inhabitants of England, where aldrin is broadly applied, dieldrin was detected in fatty tissue at a rate of 0.2 parts per million. This same index was also characteristic for the population of the United States.

For the purpose of preventing of accidents it is recommended that people, who plan to apply aldrin, be given preliminary training, that they wear protective clothing, rubber gloves and respirators, and that they immediately wash off any preparation which has gotten onto the skin.

Heptachlor

Heptachlor – $C_{10}H_5Cl_7$ – 1, 4, 5, 6, 7, 8, 8-heptachloro-3a. 4, 7, 7a-tetrahydro-4, 7-endomethanoindene:



Synonyms: 3, 4, 5, 6, 7, 8, 8a-heptachlorcyclopentadiene; heptachlorotetrahydro-4, 7-methanoindene; Velsicol-104; E-3314. Its molecular weight is 373.239.

Heptachlor – a chloroorganic preparation obtained by a diene synthesis reaction. In its pure form it is a crystalline substance with a melting point of 95-96°. Technical heptachlor melts at 46-47°; the boiling point of pure heptachlor is 135-145° at 1-1.5 mm Hg. The density of the technical preparation is 1.57-1.59. The vapor pressure is 0.0003 mm Hg at 25°. The technical product contains 67% heptachlor and 33% related compounds. Technical heptachlor at room temperature – a soft, wax-like substance with a camphor odor and a melting point of 46.1-73°; its color is reddish-brown; it dissolve readily in organic solvents.

It is used in the form of disinfecting powders containing 1-10% of this compound, in the form of oil solutions up to 10% and in concentrated emulsion form. Wettable powders of heptachlor contain 20-30% active substance, 76-66% filler, 2% wetting agent (sulfite liquor) and 2% [OP-7] (ОП-7).

Heptachlor was first isolated from chlordane (a related compound). It is highly toxic to insects in the imaginal and preimaginal stages. Its insecticidal properties are considerably higher than (by 4-5 times) chlordane. It is 30-40 times more toxic to common cockroaches than DDT; its insecticidal properties with respect to house flies are equal to the gamma-isomer of hexachlorane (lindane). It belongs to the contact insecticides and in certain cases it can be used as a fumigant and as an intestinal poison.

Heptachlor is injurious to both sucking, and knawing insects; it possesses a less prolonged residual action than DDT.

Heptachlor has been successfully used to destroy grasshoppers, caterpillars, root crop parasites, fly larvae, cockroaches and mosquitoes. The two latter insect forms rapidly develop resistance not only to this preparation, but also to all preparations of diene synthesis.

With respect to fly larvae it is effective at a dose of 25 mg/kg of substrate, which kills 90-100% of the larvae. The insecticidal activity of heptachlor is 2-10 times less than DDT depending on the species of insects, and its stability is $2\frac{1}{2}$ times less than DDT; it does not possess ovicidal properties, but hatching larvae can die as a result of being in contact with a surface treated with this preparation.

Heptachlor is highly toxic to mosquito larvae: in the presence 0.025 mg/ℓ of this preparation destruction of Anopheles quadrimaculatus larvae is observed within 24 hours; Aedes aegypti larvae under these conditions are completely destroyed by heptachlor when present at a rate of 0.016 mg/ℓ.

According to A. A. Ivannikova, lice die at a rate of 80-100% on fabrics treated with a 0.5-1% emulsion after 5 minutes of contact; 10% heptachlor disinfecting powder provides the same lice mortality rate; bugs die at a rate of 78.5-100%, and cockroaches at 66.6-100% after the same duration of contact; the bugs die on the 2-3rd day, cockroaches – on the 4-5th day. The preparation is very toxic to fleas.

The fumigational properties of heptachlor are somewhat lower than chlordane; fabric treated with a 0.25% emulsion of the preparation and then wrapped twice in clean fabric cause of the death of 88.8% of the lice situated on the surface; with a temperature increase the fumigational properties of the preparation are increased.

Insects poisoned with heptachlor or dieldrin do not die immediately after contact with the poison, but after several hours and even after several days (cockroaches). When this preparation is applied, they are at first observed to experience excitation, then loss of motor coordination, paralysis and death.

To destroy cockroaches application is recommended of a 0.3% (V. N. Plyater-Plokhotskaya), and to destroy bugs – of a 0.5% suspension of heptachlor or a 1-3% emulsion of it.

Sunlight has a less noticeable effect on heptachlor than on chlordane; fabric, subjected to the effect of solar rays over a period of 48 hours 2 months after being treated kills 72% of the lice present after 3 hours of contact. Chlordane under these same conditions ensures the death of only 52% of the lice, whereas freshly impregnated fabric (with heptachlor or chlordane) causes complete destruction of the insects.

The residual action on fabrics treated with heptachlor is retained without change for 3 months (period of observation), when they are stored at a temperature of 5° and -1°.

According to source material, when heptachlor was employed in California (the United States) under practical conditions to combat fleas on susliks – carriers of plague – good results were obtained, a flea index equal before dusting to 111-318 fleas per suslik decreased to 2 fleas per suslik and even less, i.e., the mortality rate of the insects constituted more than 98%.

Heptachlor is widely used to destroy insects, which damage useful vegetation. It is employed mainly to control the same groups of pests, against which DDT and hexachlorane are applied. Heptachlor is effective in combating ants in citrus orchards. When applied at a rate of 1.5 kg/ha the preparation ensured effective results within 3 months. When treating field crops the heptachlor expenditure was equal to 2-2.5 kg/ha, when treating grain crops it was applied at a rate of 1.2 kg/ha; under these conditions the amount of heptachlor on the grain was after 1-4 days 1.44-0.55 mg/kg, and after 8-120 days it decreased to 0.01 mg/kg; its epoxide content was 0.03-0.15 mg/kg.

According to Barthed and Young, 6 months after the application of the preparation the epoxide content in the soil is approximately 20% of the original content. Chlordane belongs to the poisons possessing intermediate toxicity to warm-blooded animals.

When orally administered dogs and rats heptachlor is rapidly converted into epoxide, which accumulates in the fat of animals. An analogous phenomenon is also observed in house flies.

Heptachlor is secreted from the organism of lactating animals along with the milk. According to Gannon, insecticides are distributed in the following manner in the decreasing order of deposition accumulation: aldrin (is liberated as dieldrin), DDT, methoxychlor; heptachlor is liberated in the form of epoxide (Ye. I. Spynu, V. I. Osetrov). The epoxide of heptachlor is considerably more toxic than heptachlor.

The observation of Bell and others showed that in 1-2 week old calves the oral administration of heptachlor epoxide is 10 times more toxic than heptachlor. When both these preparations are administered several times they accumulate and cause poisoning in the animals. When 0.2 mg/kg of heptachlor epoxide is administered over a period of 100 days (a total of 20 mg/kg) no injurious effects were noted in the calves. The symptoms and lesions of poisoning with heptachlor and its epoxide are identical to those, which are observed in poisoning with other cyclic chlorinated hydrocarbons (V. I. Osetrov). Deposits heptachlor epoxide were detected in the fat of calves, treated both with heptachlor epoxide and also with heptachlor. Bunn and others gave to cows 0.5 and 1 mg/kg of heptachlor epoxide with their feed; an analysis of the fat showed that the deposits amount respectively to 0.38 and 1.94 mg/kg. When heptachlor was fed to animals with their feed at a dose rate of 5-25 parts per million with the subsequent gradual decrease of the dose rate to zero within a period of 16 weeks no noticeable deposits of the preparation or its epoxide were detected in the fat of the animals. When the dose was increased to 30 parts per million over a period of 15 weeks only the deposition of its epoxide was noted in the fat. At a dose rate of 60 parts per million insignificant deposits of the epoxide were noted (less than 2 parts per million) in the liver and thymus and a greater deposition in the fat; heptachlor itself was not detected in any of the specimens taken regardless of the size of the dose.

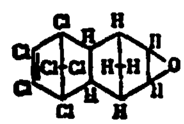
Feeding two dogs for 13-21 days their daily food containing 5 mg/kg of heptachlor caused death. When the amount of the preparation was decreased to 1 mg/kg of heptachlor the dogs died in 265-424 days. When 20 mg/kg was applied to the skin of rabbits each day for 14 days a cumulative effect was noted, which resulted in the death of the animals.

After feeding cows forage containing 3 mg/kg of heptachlor for 14 days heptachlor epoxide was secreted with their milk at a rate of up to 1.8 mg/ℓ; it was also detected in the butter in an amount approximately equal to 44 mg/kg. The secretion continued for a period of 50 days after stopping the administration of the preparation.

It is necessary to note that the toxicity of heptachlor to higher animals has been insufficiently studied. The precautionary measures are the same, as when working with other insecticides.

Dieldrin

Dieldrin $C_{12}H_8OCl_6$ - 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 5, 8-diendomethylene-1, 4, 4a, 5, 6, 7, 8 8a-octahydronaphthalene:



Synonyms: 1, 2, 3, 4, 10, 10-hexachloroexo-6, 7-epoxy-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4-endo-5, 8-dimenthanonaphthalene, compound-497; octachlor and others. Its molecular weight is 380.926.

It is a solid, white, crystalline substance without odor.

The pure preparation (recrystallized) contains 99% dieldrin. The melting point is 176-177°. Dieldrin contains 1, 2, 3, 5, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octachloro-1, 4, 5, 8-dimenthylenenaphthalene (85%) and its isomer 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 7, 8, 8a-octahydro-1, 4, 5, 8-ecto-exo-dimethylenenaphthalene; the melting point of the mixture of isomers is 150°.

Technical dieldrin – flakes of soft consistency, brownish in color with a specific odor, insoluble in water, but soluble in various organic solvents. It was first synthesized in the United States in 1949, in Europe it began to be applied in 1953.

According to the specifications of the Committee on insecticides of the Universal Organization of Public Health, technical dieldrin should contain not less than 76.5% active substance; the acidity based on acetic acid should be a maximum of 0.4%; the solids are not soluble in xylene, the maximum is 0.5%, the water content maximum is 0.3%.

From dieldrin there are manufactured emulsion concentrates, 50% wettable powders, 1.5% disinfecting powders and 0.5% solutions.

The specific gravity is 1.75. The vapor pressure is $1.8 \cdot 10^{-7}$ mm Hg at 25°. The solidification point is 112.77°. It is alkali-resistant.

Dieldrin – a contact and intestinal poison, possessing high insecticidal properties with respect to house flies and other arthropods.

The preparation can be used both as a contact insecticide and as a fumigant. Adult flies and other insects are very sensitive to dieldrin; thus, for example, when 0.85-1.1 μg/g of dieldrin is topically applied to house flies a 5 % mortality rate is observed.

In using dieldrin at a concentration of 1% in food baits under laboratory conditions complete decimation is achieved within 24 hours; under practical conditions it is ineffective as an intestinal poison with respect to flies. According to source material, it is effective in controlling fly larvae at a dose rate of 2 mg/kg of subtrate, which kills 94% of the larvae. In the form of an oil solution dieldrin causes the death of insects at the following concentrations: bed bugs — 0.17%, lice — 0.015%, fleas — 0.032%, flies — 0.005% and mites — 0.016%.

Dieldrin solutions applied to glass, plywood and wallpaper surfaces at a rate of 2, 1 and 0.5% dieldrin per m^2 possess greater insecticidal effectiveness with respect to house fly images than aldrin solutions. A higher fly mortality rate is observed on glass and plywood, a smaller rate — on wallpaper (L. N. Pogodina). It has no effect on insect eggs, but hatching larvae can die after coming in contact with a surface covered with the insecticide.

For controlling cockroaches, fleas and moths it is recommended that a 0.2%, and for controlling bugs — a 0.5% suspension of wettable powders be employed.

Oil solutions of dieldrin destroy mosquitoes at a 0.2% concentration. An aqueous suspension is more effective when used on porous surfaces. Under practical conditions with the application to a surface of 0.5-1 g/m^2 the destruction of mosquitoes was observed for 7 months. Under dry climatic conditions dieldrin is used in a mixture with a resin called Arochlor [Translator's Note: English spelling two ways: Aroclor]; normal expenditure is 0.2 g/m^2; the mortality rate of Aedes mosquitoes reaches 100%. When 9-25 mg/m^2 was applied to smooth surfaces the mosquitoes died within 6 hours. Humidity is of great importance. It was determined that with 90% relative humidity mosquitoes die after 10 minutes, and with 30% humidity — after 10 hours.

In the case when dieldrin is used in the form of granules to kill mosquitoes the minimum lethal dose of granules with 1% preparation, when applied by hand, is 375 g/ha. Under practical conditions 1% granulated dieldrin was employed weekly for a period of 8 weeks at a rate of 725 g/ha. As a result of such treatment

Anopheles larvae vanished after the second application, but the Culex larvae were somewhat more resistant.

Dieldrin on paper retains its insecticidal properties for a considerable period of time; even when filter paper was impregnated with only 0.1 mg/cm^2 the preparation ensured the complete destruction of bugs for a period of 6 months. Dieldrin is 70-80 times more toxic than DDT to cockroaches and 40 times more effective with respect to flies; to fleas it is 11 times more toxic than DDT, and to lice – 40 times (in an oil solution).

Under practical conditions for the purpose of destroying of Trombicula mites a single treatment with technical dieldrin at a rate of 2.8 kg/ha ensured a considerable reduction in their number, and after 5 weeks on the experimental section there was in 75 times fewer mites than on the control section; thick vegetation and rains did not reduce the effectiveness of the preparation and the residual action was preserved for 8 weeks. Apparently, the insecticide was effective with respect to all stages of mite development, inasmuch as their number remained at a low level.

When dieldrin was used to control floors on susliks it appeared that the preparation was more effective in solution form than in the form of disinfecting powder, and it ensured the death of 98% and more of the insects; the index decreased to 2.04 fleas per suslik as compared to 111-318 before the treatment.

In Venezuela dwellings were treated with only a suspension of dieldrin disinfecting powder at a rate of 0.5 and 1 g/m^2 to combat mosquitoes; the results were very good – the insects were seen to be dying even toward the end of the 7th month. It was noted that the suspension was the most effective on absorbent surfaces.

When dieldrin was used in living quarters it was applied to surfaces, like DDT and other cyclical insecticides.

When insects come into contact with the insecticide they manifest symptoms of agitation after a latent period point just as they do after contact with chlordane, toxaphene, aldrin, chlorinated terpenes, etc. After being poisoned the oxygen intake sharply increases, almost like after being poisoned with DDT, methorychlor, lindane, pyrethrin and nicotine.

In Blattella germanica cockroaches the latent period lasts several hours, and then the oxygen intake starts to increase approximately by 5-6 times, the oxygen intake especially increases with the appearance of increased sensitivity. When paralysis begins the oxygen intake returns to normal.

A noticeable difference in the action of dieldrin as compared to DDT, [DDD] (ДДД) and methoxychlor can be observed when the preparation is applied to flies; when the temperature is increased the insects die in greater numbers; an analogous phenomenon is also noted in cockroaches (common).

After the action of dieldrin stimulation with an electrical current of low voltage of the femoral nerve of an American cockroach causes a severe reaction, and the latent period is reduced by up to 2 hours. The mechanism of the action of dieldrin is still unclear. The resistance of insects to this preparation develops as a result of breeding. Flies which are resistant to DDT are somewhat more resistant to dieldrin.

Dieldrin is used to control insects, which infest animals. A treatment with a 1% disinfecting powder of the preparation at a normal expenditure of 12-19 g per animal (cat, dog and others) is effective for 15 days. For the purpose of preventing fly bites to sheep preparations containing 0.025-0.05% dieldrin are used. When wool on sheep is treated with 0.05% dieldrin the effectiveness is retained for a period of 40 weeks.

To combat to skin gadfly 25 mg/kg of dieldrin is administered subcutaneously in the form of a 5% suspension in oil. Two treatments with this preparation were sufficient to protect the animals for a whole season (Hypoderma lineatum).

Lipson and others have shown that 0.05% of dieldrin per weight of wool protects it from moths; the preparation, thus, is an effective anti-moth agent, and it retains its effectiveness both after washing, and also after dry cleaning (the activity does not disappear after a 1 1/2-hour washing and in one hour of dry cleaning).

The preparation has obtained wide application in agriculture: in controlling the locust and the Colorado beetle 0.01% emulsion applied at a rate of 67 ℓ/ha kills the larvae after 48 hours; to kill the beetles a somewhat higher expenditure of liquid per ha was required. The wireworm dies with the application of 2-3 kg/ha (treatment of the surface layer). To kill ants it is sufficient to apply several grams of 2% preparation to the anthill. Dieldrin was also effective in controlling rice water weevils when applied at a rate of 0.6-1.1 kg/ha; with the use of an emulsion at a rate of 0.5-1 kg/ha rice pests were completely destroyed for a period of 9-10 weeks. The preparation is also effective in combatting the cabbage fly, plum tree pests, the red locust and others.

Dieldrin is toxic to white rats at an amount of 50-75 mg/kg, and to sheep and pigs – at about 50 mg/kg.

Dieldrin can get into the organism of the higher animals through the skin, mouth and during respiration [inhalation]. The relative toxicity of dieldrin applied to the skin can be considerably higher than when orally administered. The greatest danger is presented by its penetration through the skin of animals. Its acute toxicity is approximately 3 times, and chronic (oral administration) is 4-100 times higher than DDT toxicity. When the preparation is repeatedly administered its toxicity is 30 times higher than DDT toxicity.

The administration to white rats for 18-24 months of dieldrin with their food containing 2.5, 12.5 and 25 mg/kg did not produce a noticeable difference in the mortality rate of the animals as compared to the control animals. The muscular vigor of the female and male rats was reduced as compared to the vigor of the control group of animals; a certain enlargement in the liver was observed.

When white rats were fed for a period of 2 years feed containing 12.5 mg/kg of dieldrin a great increase in the weight of the liver was noted as compared to the weight increase of the other tissues. Dogs are more sensitive to dieldrin than are rats; to kill them it is sufficient to feed them food containing 25 or 50 mg/kg; the majority of dogs die within several days, an individual animal dies after 45 days. When the dose rate of dieldrin is reduced to 10 mg/kg dogs live up to 9 months. In dogs dying as a result of eating dieldrin with their food, there are observed degenerative changes in the brain, liver and kidneys.

Chicks receiving feed containing 50 mg/kg of dieldrin die within 90 days; when the dose rate is decreased to 25 mg/kg the birds die within 6 months. Laying hens accumulate the greatest amount of dieldrin, however the dieldrin content in their eggs is insignificant.

Dieldrin causes poisoning when a 0.25% solution of the preparation is cutaneously applied to young calves, lambs – 3% solution, horned cattle – 2% solution, sheep and goats – 4%

solution. Lower concentrations do not cause toxic symptoms. When orally administered the preparation causes poisoning in young calves at a dose rate of 10 mg/kg, in pigs – 50 mg/kg, sheep and goats – 25 mg/kg and in horses at a dose rate of 25 mg/kg. When dieldrin gets into the animal organism 8-146 mg/kg of the preparation is detected in the fat and 4.9-8.3 mg/ℓ of the preparation is detected in the milk. Dieldrin deposits dissipate slowly; after 16-24 weeks the amount of preparation decreases in the fat to 1 mg/kg, and in the milk to decrease its content to 0.2 mg/ℓ 3 weeks are required.

After treating pastures at a rate of 0.5-3 kg/ha lactating cows are observed to secrete the preparation with their milk in the amount of 5-4 mg per ℓ; the maximum content of dieldrin in milk was noted between the 3rd and 7th day. Aldrin is secreted with milk for a period of more than 100 days after it has ceased entering into the animal organism. Certain researchers studied the possibility of administering the insecticide to mannals for the purpose of destroying parasites feeding upon their blood, but this has not found wide application.

In acute poisoning the most characteristic symptoms are increased excitability, nervousness, a low rate of salivation, spasms in various muscles (first in the neck and snout), which intensify until they change into convulsions at which time there is observed profuse salivation, and the animals emit loud sounds. The period, during which such symptoms come on, lasts from several hours to several days.

In experiments on animals it has been shown, that without therapy severe poisoning is always fatal, and the poisoning is characterized by convulsions, complete rejection of food and rapid loss of weight. After recovery the return of convulsions is sometimes observed. The resistance of animals increases with age, with the exception of sheep.

At the time of death the temperature of the animal can increase sharply. Dissection shows, that the mucous membranes are usually cyanotic, there are accumulations of saliva; the intestine is pale; the liver and kidneys are inflamed; sometimes hemorrhage is observed at the site of connection of the abomasum with the rest of the stomach; inflammation of the intestines is rarely encountered, these almost always hemorrhage in the lower segment of esophagus, dense hemorrhage is noted in the endocardium; the lungs are usually highly inflamed and edematous. Upon microscopic examination attention was attracted to the generalized turbid swelling of the majority of organs; the most severe action of dieldrin is noted in the renal tubulbs, where vacuoles and other degenerative processes appear. Frequently there is observed proliferation of the capular epithelium with exfoliation; in the liver cells there are vacuoles with subsequent necrosis, but after a longer period than in the kidneys.

Atropine is used in the treatment of the poisoned animals but its action rapidly passes and it does not protect the poisoned animals when it is administered 30 minutes before the introduction of dieldrin. The recommended dose of atropine for animals poisoned with dieldrin is about 0.005 g/kg; for the synthetic derivative paraverine -- 0.017 g/kg; both these doses are maximum.

Degree of poisoning depends on the concentration of the solution, the size of the openings in the skin, the duration of contact and absence of prophylactic measures. In humans symptoms of poisoning are observed from a dose of 10 mg/kg. There is a report about 20 cases of poisoning in humans, 19 of whom either prepared or sprayed a dieldrin suspension. Workers, who had previously become accustomed to working with DDT and hexachlorane, did not always take the necessary precautionary measures — they did not put on gloves when mixing suspensions or when pouring the powder from the package into the water (to combat mosquitoes), they did wear protective clothing or masks, after work they did not wash with water and soap and so forth.

From the human organism dieldrin is excreted with the urine in the form of two polar chlorinated metabolites (i.e., in modified form).

A definite sequence is noted in the symptomatology: poisoning starts with a headache, general lethargy, dizziness, tendency to sweat, loss of consciousness and muscle tremors; then the symptoms increase, convulsions appear several times each day with the loss of consciousness for up to 2 hours.

A case is known, where two men drank from a bucket, in which dieldrin had previously been stored; they drank only a few swallows, because they suddenly realized their mistake. Within a few hours they began to sweat, they had spasms with the loss of consciousness. There are data that the attacks can recur for a period of 3 months.

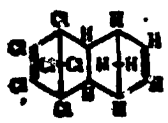
Source material cites a case where a 9-month old child was poisoned with dieldrin disinfecting powder; the child died 20 hours after being poisoned.

Poisoning has not been observed in people working with this preparation for less than 4 months, but mainly after 8 months or more. Those affected usually have disturbed sleep; in severe cases of poisoning spasms and loss of consciousness appear, epileptic-like attacks are also observed.

To prevent chronic poisoning it is recommended that prophylactic examinations be carried out on those people who work with this preparation.

Isodrin

Isodrin – $C_{12}H_8Cl_6$ – 1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4-endo, endo-5, 8-dimethanonapthalene:



Molecular weight is 364.94.

Isodrin – a stereoisomer of aldrin, one of the group of insecticides obtained by a diene synthesis reaction. Isodrin – a contact insecticide with properties close to aldrin, but its toxicity to insects and warm-blooded animals is higher than the toxicity of aldrin.

Isodrin is comprised of hard white crystals with a melting point of 240-242° (it begins to decompose at temperatures higher than 100°); it is virtually insoluble in water, is soluble in aromatic solvents, for example 17 g of isodrin dissolve in 100 mℓ of acetone at 25°, 138g – in 100 mℓ of benzene, 3.3 g of the preparation – in 100 mℓ of carbon tetrachloride, etc.

The preparation is produced in certain countries (Canada, England, the United States and others) in the form of a 19% emulsion concentrate of 25% wettable powder.

Isodrin is mainly utilized to protect agricultural plants. When applied as an intestinal poison against tobacco pests isodrin is 80 times more active then other preparations recommended for this purpose. Isodrin can be used to destroy everyday parasites and carriers of infectious diseases outside living and working areas. The death of 50% of house flies is attained with a topical application of 2 mg per insect. A quadrimaculatus mosquito larvae have 100% mortality rate in the presence of 1 mg/ℓ of the preparation and 70% in the presence of 0.1 mg/ℓ of isodrin.

L. I. Golokhov used isodrin in bronchial asthma therapy; 20 patients were treated 2 times a day by having them inhale (during attacks) a 0.5% solution of isodrin in the form of aerosols at a dose rate 0.5-1 g for 7-10 minutes; the duration of the therapy was 10-35 days. According to the author, isodrin has a rapid and prolonged inhibitory effect, improves the function of external respiration and decreases the symptoms of respiratory insufficiency, removes the pathological reflexes, improves the bronchial passages.

The following side effects were noted: moderate tachycordia, an increase in the pulse rate and increase in arterial pressure. In our opinion, this experiment should be repeated with great caution because isodrin is a highly toxic compound to man; only after a thorough check is it possible to resolve the question of the expendiency of its use for this goal.

Isodrin is very toxic to the higher animals. Thus, for example, when orally administered the minimum lethal dose for rats is 5-7 mg/kg, for rabbits - 3-4 mg/kg. When 94-250 mg/kg of the dry preparation is applied to the sheared skin of rabbits under a rubber dressing the death of the animals is observed within 1.5-11 days. When introduced with feed containing 12 mg/kg of isodrin, 90% of the chicks die within 42 days.

Kepone

Kepone - $C_{10}Cl_{10}O$ - 1, 2, 3, 5, 6, 7, 8, 9, 10, 10-decachloro-(5, 2, 1, $0^{2,6}$, $0^{3,9}$, $0^{5,8}$)-decano-4-OH - a chlororganic insecticide of unique construction being an assemblage of a chlorinated polycyclic ketone with a cage-type structure. It is a highly effective preparation in controlling cockroaches, ants and other insects; it is distinguished by its prolonged residual effect.

It differs considerably from the other chloroorganic insecticides in that it destroys insects like the Colorado beetle, which are actually resistant to all the hydrocarbons. Kepone possesses not only insecticidal, but also fungicidal properties.

The preparation is stable up to temperatures of 350° and is almost insoluble in water.

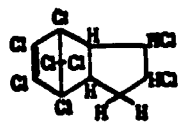
When a 5% solution of kepone in sunflower oil is administered orally the LD_{50} for male white rats is equal to 135 mg/kg, and for male dogs – about 250 mg/kg.

Kepone is manufactured in the form of pellets containing 0.125% active substance in combination with insect attractants. These baits are considerably less toxic than the broadly applied baits containing thallium sulfate, sodium arsenite and phosphorus. At the present time it is used in the United States against field ants and common cockroaches. The duration of its action against ants is 6 months after which it is necessary to conduct another treatment. The pellets are put in nests (1-2 tablespoons at a depth of 15-30 cm) and they are scattered around buildings. The dose against cockroaches is 2-3 tablespoons (40-60 g) for each infested site.

Kepone – a slow acting poison, therefore it is best to apply it as an additive to ordinary spray mixtures. Due to its prolonged action it has a great advantage over other pesticides and the possibility of the appearance of populations (developing from individuals remaining alive) resistant to it is almost excluded.

Chlordane

Chlordane – $C_{10}H_6Cl_8$ – 1, 2, 4, 5, 6, 7, 8, 8-octachloro-2, 3, 4a, 4, 7, 7a-hexahydro-4, 7-methanoindene:



Synonyms: Velsicol-1068, CD-68, octachlorodihydrodicyclopentadiene. Its molecular weight is 409.8.

It is a viscous, brown odorless liquid, containing 60-75% chlorine. Its boiling point is 175° at 2 mm Hg, 155-160° at 0.5-1 mm Hg. Its specific gravity at 25° is 1.59-1.63. Its refraction is 1.56-1.57. Its vapor pressure is 1.10^{-5} mm at 25°. It is insoluble in the water, but soluble in many organic solvents; the best of these are xylene and kerosene. Chlordane contains a considerable number of admixtures – 24-40% consisting of compounds related to it. Chlordane is unstable in an alkaline medium.

Chlordane – the simplest insecticidal preparation obtained from hexachlorocyclopentadiene. The active agent of this preparation is octachloro-endomethylene-tetrahydroindane. The technical product is a mixture of several related substances – the alpha-, beta-isomers of chlordane and other compounds related to it.

The alpha- and beta-isomers of chlordane and related compounds are white, crystalline, solid products; the first two can be chromatographically partitioned by alumina. Refined heptachlor is 2 times more toxic to higher animals than technical chlordane; it is 4-5 times more insecticidal than technical chlordane. Trans-chlordane (beta-chlordane) is 10 times more toxic than cis-chlordane (alpha-chlordane), but its insecticidal effectiveness is lower than heptachlor.

According to the rules established by the Committee on insecticides of the Universal Organization of Public Health, the product produced by industry must contain 60-75% 1, 2, 4, 5, 6, 7, 8, 8-octachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoidane and 25-40% other related compounds usually formed in the productive process. It must have the form of a viscous liquid, free from impurities or introduced modifying agents.

Technical chlordane should be stored only in aluminum or aluminum-coated steel containers, or containers from phenol plastics pressed at high temperature, or enameled metallic containers.

Chlordane can be used in the form of an oil solution, emulsion, concentrate, disinfecting powder or wettable powder. Suitable solvents are kerosene, fuel oil, mineral spirits, xylene and methyl-naphthalene (K. A. Gar, S. D. Volodkovich, L. G. Vol'fson). In preparing emulsions nonalkaline emulsifying agents dissolved in oil are used. It is highly toxic to flies, cockroaches and mosquitoes. When chlordane is topically applied the LD_{50} for house flies is 4 μg/g.

For combatting flying insects the following formula has been suggested: 0.2% (weight to volume) chlordane with 0.4% pyrethrin (to bring about fast paralysis in the insects) in kerosene; for crawling insects (bugs, cockroaches) – 2% solution in kerosene, this solution ensures a high mortality rate for insect and under appropriate conditions it possesses residual activity, preventing new infestation for at least 2 months.

In preparing insecticidal disinfecting powder either pyrophyllite or talc is used. The filler is mixed with chlordane at a rate of up to 50% of preparation by weight.

Chlordane possesses a positive temperature coefficient; for example, when it is applied against house flies its insecticidal properties increase according to the increase in temperature.

Chlordane is considerably more toxic than DDT to common cockroaches — to destroy 50% of the insects over a period of 120 hours 38 μg of DDT are required per g of weight, whereas chlordane provides analogous results at a dose rate of 14 μg/g; to kill 95% of the cockroaches within the same time period 40 μg of DDT or 25 μg of chlordane is required. When chlordane is applied to a wall at a rate of 1 g/m^2 oriental, common and American cockroaches continue to be killed for a period of 8 weeks after 20 minutes of contact. To approximately the same degree that chlordane is toxic to common cockroaches, it is toxic to house flies — to obtain a mortality rate of 95% a 0.2% solution of DDT or a 0.05% solution of chlordane is required. The median lethal dose bringing about the death of 50% of the flies, is equal for DDT to 0.05% and for chlordane — 0.02%.

When applied to a wall at a rate of 2 g/m^2 Aedes aegypti are observed to die for a period of 4 weeks. The fourth stage larvae of the Anopheles mosquito are equally sensitive to DDT, hexachlorane, chlordane; an application of 0.01 mg/ℓ leads to the death of 100% of the insects within a period of 48 hours.

According to source material, chlordane is effective in oil solutions at the following concentrations; for bed bugs — 0.95%, for lice — 0.11%, for fleas — 0.33%, for flies — 0.036%, for Aedes mosquitoes — 1.4%, for Ornithodorus mites — 0.22%. For house fly larvae it is one of the toxic preparations: the median lethal concentration for third stage larvae in the substrate is 23 mg/kg, when a 1% emulsion is used at a rate of 150 and 300 mg/m^2, 97% of the flies did not hatch; an analogous effect was obtained as a result of the application of 5% disinfecting powder at a rate of 300 mg/m^2.

The stability of chlordane is small — when filter paper was impregnated at a rate of 0.1 mg/cm^2, 100% of the bugs died only during the first 3 days and toward the end of the 6th month — a total of 26%. When the impregnation dose was increased to 0.5 mg/cm^2

the results improved and their complete destruction was observed for 10 days; after a month it had decreased to 98%, after 3 months – to 92%, and toward the end of the 6th month – to 59%. When applied to the surfaces of buildings with respect to mosquitoes DDT preparation has the most prolonged insecticidal properties, the least prolonged – hexachlorane, chlordane occupies an intermediate place. Thus, although chlordane also surpasses DDT with respect to lice, flies, cockroaches and mites in its effectiveness, with respect to stability it is considerably inferior to it. Chlordane upon reaction with alkalies gives up chlorine and loses its insecticidal properties.

According to A. A. Ivannikova, chlordane provides a mortality rate of 80-100% of the lice with the use of a 0.5-1% emulsion or 10% disinfecting powder after 5 minutes of contact; the preparation does not possess insecticidal properties; the death of 79-100% of the bugs ensues as a result of the application of 10% disinfecting powder after 5 minutes of contact; at this exposure 66.6-100% of the cockroaches die; the bugs die on the 2-3rd day after contact, and cockroaches – on the 4-5th day. Chlordane possesses considerable fumigational properties; fabric treated with a 0.25% emulsion of the preparation and wrapped in 4 layers of other clean fabric causes the death of 95% of the lice after 15 minutes of contact on the upper layer of fabric, where the fumigational properties are in direct dependence on the temperature.

Solar rays noticeably decrease the effectiveness of chlordane; so that, after the action of solar rays for a period of 48 hours the fabric (after 2 months of storage) provides the death of only 52% of the lice after 3 hours of exposure, whereas on freshly treated fabric the mortality rate at this exposure reached 100%. With the application to fabric of 0.25% emulsion the effectiveness was maintained (at a temperature of from 5° to -1°) for a period of 3 months (period observation).

Chlordane is highly toxic to bees; with the application of 1.7 μg of preparation per insect death is observed in 90% of the cases.

Chlordane is effective when it is used to protect soil from termites; the application 1-2% oil solutions or 2% aqueous emulsions at a rate of 3-6 ℓ per m^2 of soil provided protection for 4-5 years; an aqueous emulsion of the preparation does not damage plants, if it is applied at a distance of 30 cm from the roots.

The stability of chlordane in different soils is not the same: in some soils when 11.5 hg/ha is applied its content after a year is 84%, and after 2 years - 50%; in other soils even after a year only 23% remains, and after 2 years - 10%. According to Fleming and others, in soil after 3 years there is detected 12% of the chlordane and after 4 years - 5% of the applied amount. It was noted that the more organic matter there is in soils, the shorter is the period of retention of the preparation in the soils. No kind of relationship has been established between residual chlordane and the elements of the soil, with the exception of nitrogen, which is associated with the organic substances. After the application of chlordane and dieldrin to soil neither of these preparations were detected in potatoes taken from this plot. The penetration of these preparations into other plants was noted. In a study of the effect of chlordane on the microflora of soil it was established that it had no significant toxic effect neither on bacteria nor on mold.

Chlordane is widely applied against various pests of agricultural crops, but it is not recommended that it be sprayed on grasses while they are germinating and ripening or that it be used to treat forage, which is going to be fed to animals and birds.

In connection with its strong fumigational properties and toxicity it is not recommended that chlordane be widely applied in dwellings; it can be used to treat exterior surfaces of buildings and the territory around buildings.

Inasmuch as chlordane is absorbed by intact skin it is unsuitable for the treatment of scabies or for the extermination of head lice. Chlordane is also absorbed by the gastrointestinal tract and penetrates through the lungs.

In its toxicity to warm-blooded animals chlordane is 1 1/2-4 times more toxic than DDT to rats. According to source material, the median lethal dose for the acute poisoning of the latter is from 20 to 700 mg/kg.

According to N. A. Sazonova, with a single oral administration of the preparation in an oil solution a 100% mortality rate of the animals is caused for cats by 50 mg/kg, for white rats — by 700 mg/kg of the preparation. Chlordane in an oil or alcohol solution is readily absorbed through the skin and is toxic to the same degree, as when orally administered. Moreover, there is a definite danger of chronic intoxication, therefore chlordane must be used very carefully and it is necessary to refrain from using it to control ectoparasites of man and animals. The rubbing of it into the skin causes dermatosis. Repeated treatments at a dose rate of 40 mg/kg and a four-fold application of 6-8 drops of 1.5 and 2% emulsion and suspension of chlordane are dangerous and even lethal for large and small horned cattle; the preparation is more toxic to young animals than to adults. Chlordane is a nerve poison and affects the central nervous system.

Chlordane — one of the most dangerous chlorinated hydrocarbons. In the acute poisoning of experimental animals there are observed changes in the lungs, irritation of the gastrointestinal tract, increased excitability, muscular tremor, convulsions and death. The preparation possesses cumulative properties and induces chronic poisoning. The prolonged feeding of animals with food containing 1-5 mg/kg of chlordane inhibits growth, causes pathological changes in the liver and death among the offspring. It stimulates respiration, changes the morphological composition of the blood. The prolonged application to rabbits of dressings impregnated with a 1% aqueous emulsion of chlordane causes toxic symptoms and the death of the animals; the application of dressings impregnated with a 0.25% emulsion (aqueous) is harmless.

With the daily spraying of 2 g of active substance of an aqueous emulsion of chlordane per m^3 of air for 20 days into the respiratory organs of animals there are observed considerable lesions. With the dusting of 10% disinfecting powder of chlordane at a rate of 10-20 g/m^2 of the cage floor (practically recommended concentration) 12 times per day for 15 minutes each time for a period of 10 days in the respiratory organs of rabbit pathological changes were observed (N. A. Sazonova).

With the daily oral administration to rabbits of 25 mg/kg each day for 15 days no symptoms of intoxication were observed; increasing the dose caused the death of 60% of the animals. With the administration to dogs of 6 mg/kg daily for a period of 32-72 weeks death did not occur among them, but upon hystological examination changes in the liver were detected. Feeding the dogs food containing 600 mg/kg of chlordane caused the death of the animals in a week.

The four-fold spraying or the 6-8-fold submersion in 1.5-2% emulsion or suspension was fatal for goats, sheep and large horned cattle. Large cattle can endure 1-2-single bathings or sprayings with a 2% emulsion at 2-week intervals, but they can be killed by a third treatment. Freshening cows can also be killed when sprayed with a 1% emulsion.

Chlordane is more toxic to man than DDT, and when used it is necessary to take precautionary measures: to avoid inhalation of its vapors, letting the disinfecting powders get in contact with the skin, etc. With the combined effect of chlordane on the skin and on the respiratory organs the severity of the poisoning increases, the cumulative properties are increased, and the symptoms of poisoning appear later. Frequently the symptoms for an early determination of the developing poisoning are absent. Chlordane is readily absorbed by the skin, the mucous membrane of the gastrointestinal tract and the respiratory tract. It is more toxic than DDT when applied to the skin. The skin readily absorbs solutions and dusts. Chlordane can be desorbed from any form of mixtures containing it. The physical state and nature of the solvent has an effect on absorption. Dry preparations are not less dangerous for the skin than those dissolved in oils. The preparation causes skin irritation. Wettable powders have comparatively high toxicity and are dangerous when applied repeatedly. Chlordane is very dangerous when used to dust human clothing to destroy lice. It is also not recommended to use it to treat animals by submerging them in its solution to destroy ectoparasites, since the difference between a lethal dose for insects and warm-blooded animals is very small.

Chlordane stimulates the central nervous system, but the precise mechanism of its action is unknown. Poisoned animals lose their appetite simultaneously with the appearance of such neurological symptoms, as raised excitability and tremor. There are no exact data about its distribution in the tissues of animals; there are individual data about the fact that preparation is deposited in fatty tissue, where it rapidly vanishes after termination of its application. It can be deposited in the form of an epoxide. The acid, chlorine-containing products isolated from the urine of rabbits, obviously, are products of the detoxification of chlordane.

When rats are fed a diet containing 150 mg/kg of chlordane they secrete with their milk a substance toxic to baby-rats. The symptoms are similar to the symptoms induced by DDT, but chlordane acts for a longer time on the central nervous system. After it has been administered there appear increased excitability, salivation, tremor, and convulsions. The administration of Amytal Sodium partially reduces these symptoms.

In chronic poisoning there is observed disturbance of the activity of the central nerve system, especially of the optic nerve; besides these there occur initation of the skin, liver damage and loss of consciousness; before death albuminuria develops. There exist data about 15 cases of human poisoning of which 5 ended in the death of the patients. After using chlordane on factory premises to combat insects for a period of a week of 166 workers 55 became ill; the illnesses were a mild form.

The fatal cases due to chlordane poisoning have been described in detail. In one case the preparation was spilled on the clothes of a person (a young woman), who died within an hour. A second person attempted to commit suicide and took about 200 g of 5% chlordane powder. She died within 10 days. In the first case the dress drenched with chlordane was not removed and the large dose of chlordane was absorbed by the intact skin. In the autopsy nonspecific pathological changes were detected in the brain, lungs and kidneys. One more person died 9 days after taking internally 6 g of chlordane; vomiting began 2 1/2 hours after the introduction of the preparation and continued all night; the patient was taken to a hospital within 24 hours; her tongue was red and a gray exudate was observed, covering the mucous membrane of the oral cavity and the pharynx; the patient was excited, agitated and depressed; oliguria was observed. The patient at times lost consciousness and died within several hours with symptoms of tonic and clonic spasms at intervals. The basic clinical symptoms were burning of the buccal cavity, acute hemorrhagic gastritis, shock, anuria, after which there followed convulsions and death.

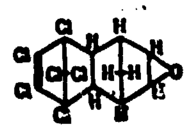
In the autopsy there were detected inflammatory symptoms in the brain, bronchopneumonia and burns in the buccal cavity and throat.

Also described was a case of the acute poisoning of a man situated in premises where disinfestation was being conducted with a 1-2% solution chlordane (the solvent is unknown). There were observed severe coughing, vomiting, disturbance of liver function, decrease in the number of erythrocytes and leucocytes, pneumonia. In literature there are also descriptions of a number of other cases of poisoning with the oral introduction to a man of a lethal dose of 5-60 g. A single cutaneous application of a dose of 113 g is dangerous to man, with multiple application – 2.4 g (daily).

The measures to observe in human poisoning consist in the following: stopping the absorption of the preparation by the skin (its purification), lavage of the stomach and the internal administration of a physiological solution; it is necessary to avoid the use of milk and fats, inasmuch as they facilitate the absorption of the preparation. To prevent convulsions it is possible to apply the intravenous administration of any fast acting barbiturate (thiopentane), and then the prolonged application phenobarbitol.

Endrin

Endrin -- $C_{12}H_8Cl_6O$ – 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5, 8-dimenthano-napthalene:



Its molecular weight is 380.926.

The stereoisomer of dieldrin is called endrin. Pure endrin – solid white crystals; technical endrin – hard brownish crystals. It possesses an insignificant odor.

At a temperature of about 200° it melts and decomposes. Its vapor pressure at 25° is $2 \cdot 10^{-7}$ mm Hg. It is soluble in the same solvents as dieldrin.

The preparation possesses considerable insecticidal and larvicidal properties. It is used mainly in agriculture to combat insects – pests of cotton, tobacco, sugar beet, the larvae of the Japanese beetle and others. In using endrin to combat the larval stages tobacco pests it has been established that it is 20 times more toxic than the preparations recommended earlier for this purpose.

Endrin is manufactured commercially in England and other countries in emulsion form, as 25% wettable powder, and as 1-1.5% granulated disinfecting powder.

Endrin can be used to destroy flies, mosquitoes and other insects; it is especially toxic for larvae and pupae.

When topically applied to flies (imago) 1.6 μg of the preparation causes the death of 50% of the insects. Endrin, like other compounds of this group, acts on the nervous system of the insects (similar to DDT). The preparation cannot be widely utilized in practice to control parasites of habitations because of its high toxicity to the higher animals. LD_{50} of a single oral administration of the preparation is approximately 5-43 mg/kg; the size of the lethal dose depends on the species of animal.

When endrin is administered to rats with food, containing 1; 5; 25; 50 and 100 mg/kg, the phosphatose of the index ser is increased. Rats recei in food containing 100 mg/kg of the preparation, died in the first 2 weeks. The mortalitity rate among males was considerably higher than among females; they were more susceptible to such doses as 1-5 mg/kg. The animals lost weight and the greatest loss was noted in those, which received the highest dose. The consumption by rats of food containing endrin was lower then the consumption of feed by the control animals. It was noticed that in all cases rats which received poisoned food were very sensitive to various stimuli. The preparation is very toxic to young animals. In the milk of cows with the use of hay containing 1.9-8.7 mg of endrin per kg it was possible to detect for a period of a week the presence of 0.05-0.15 mg/kg of the preparation. Toxic symptoms were noted in 2 cows, which received 1.5 mg of endrin in soybean oil per kg of weight.

The preparation is also deposited in the fat of animals; in milk it appears in the case, when the food contained more than 0.55 mg/kg. The endrin disappeared from the milk a month after the termination of the experiment.

Under manufacturing conditions the preparation readily penetrates into the human organism through the respiratory tract and the skin. In acute poisoning there are observed an increase in initiability, convulsions and coma. In chronic poisoning there are observed a loss in weight and disturbance of the activity of the nervous system.

A case was described in which 49 persons were poisoned as a result of eating bread made from flour, which had been in sacks, which had accidentally been treated with endrin. There was detected in the bread up to 150 mg of endrin per kg.

When the preparation gets into the gastrointestinal tract the immediate application of emetics is recommended or gastric lavage. The introduction into the stomach of fat or oil promotes the absorption of the preparation by the walls of the intestine. Good results in endrin poisoning are obtained with the use of barbiturates. In working with the preparation it is necessary to use special clothing and gloves.

CHAPTER IV

CHLORINATED TERPENES

This group of compounds, just like [DDT] (ДДТ), hexachlorane and the diene synthesis preparations, belongs to the chlorinated hydrocarbons or the terpene hydrocarbons. The latter are a basic component of turpentine. Ye. Ye. Vagner, B. A. Arbuzov, S. S. Nametkin and others defined the structure, studied the chemical properties of a large number of terpene hydrocarbons and their derivatives. Terpenes have found application as a raw material in the production of aromatic pharmaceutical preparations.

The bicyclic terpenes and their oxygen compounds – pinene, camphene, borneol and so forth – are used as initial products for the production of insecticides. These latter are obtained by the chlorination of turpentine and its fractions. To such preparations belong chlorinated turpentine, chlorten, polychloropirene, toxaphene and strobone.

Polychloropinene

Polychloropinene – $C_6H_{10}Cl_7$. Its specific gravity is 1.574-1.585. It is a product of the catalytical dark (i.e., without illumination) chlorination of the pinene fraction of turpentine (hydrochlorinated pinene). In its properties it is close to chlorten. It is manufactured in the form of a 65% concentrate, which is used in the preparation of the emulsion. The concentrate consists of the following components: 65% polychloropinene, 20% solvent (grade "3" diesel fuel, No. 2 spindle oil or transformer oil), 15% emulsifier (the auxiliary substance [OP-7] (ОП-7). The percent of organically combined chlorine is not less than 48.8%.

The concentrates of polychloropinene are dark-colored, oily, viscous liquids. The concentrates of polychloropinene and polychlorocamphene are emulsified with water, forming a white emulsion, a ... aqueous emulsion should not separate into layers within a period of 4 hours.

Polychloropinene and polychlorocamphene have a delayed contact and a mild fumigational action (see Table 46). They do not have a prolonged residual toxic action after they are applied to various surfaces.

According to T. V. Yerofeyeva, the addition of 50% naphthalysol and diesel fuel brings about an increase in the larvicidal properties of polychloropinene, which is especially defined with respect to cultures of house flies, which are resistant to the action [HCCH] (ГХЦГ). The addition of napthalysol to the emulsion concentrates of chlorinated terpenes along with OP-7 promotes the activation of their insecticidal effect.

Polychloropinene is used basically in agriculture to destroy sugar beet weevils (ground spraying with 0.5% emulsion and aerial spraying with 3.2-4% emulsion). It is also used in the form of emulsified concentrates in controlling the house fly and to destroy larvae and pupae in their breeding places.

To destroy fly larvae in liquid waste 5% aqueous emulsions of polychloropinene is used at a rate of 0.2 ℓ per m^2 of surface (once in 8-10 days). For solid waste material with a layer thickness of 20-30 cm 2% emulsions are used at a rate of 3-4 ℓ/m². To destroy fly larvae in soil 5% aqueous emulsions are applied at a dose rate of 2-6 ℓ/m² (M. N. Sukhova, I. I. Myalo).

Polychloropinene emulsions are used as repellents to protect animals from blood-sucking flies (K. P. Andreyev, Yu. I. Gadalin, M. G. Dem'yanov, I. A. Zakamyrdin, A. B. Levit). In 1959-1960 for the purpose of exterminating Ixodes persulcatus ticks in the Kuibyshev region aerial treatment of 11,000 hectare of broad-leaved forests was carried out with polychloropinene emulsion from an [AN-2] (AH-2) aircraft at a rate expenditure of 30 ℓ/ha (3 kg of 65% polychloropinene concentrate per 27 ℓ of water) The forest was treated two times: before leafing and after complete leafing. A high effect was obtained, not lower than with aerial dusting with DDT and HCCH preparations; and the cost of the treatments was 2-3 times cheaper than dusting with DDT. In the following year on the treated sections partial regeneration of the number of ticks was observed, which in individual areas increased to epidemically dangerous levels.

The toxicity of polychloropinene to man, if it should happen to be orally introduced, is approximately the same as DDT.

According to G. A. Voytenko, the absolutely lethal doses of chlorten and polychloropinene when introduced in a single dose into the stomachs of white mice are within the limits of 300-500 mg/kg; for white rats they are 400-600 mg/kg; when cutaneously applied to rabbits – 1000-1500 mg/kg. The absolutely fatal concentration of the insecticide in the aerosol state for cats is 0.07 mg/ℓ of air.

Consequently, when introduced into the stomach the chlorinated terpenes approach DDT in toxicity, and when applied to the skin they are somewhat more toxic then it. When inhaled chlorten and polychloropinene are considerably more toxic than DDT.

The zone of toxic action of polychloropinene is comparatively narrow: the threshold concentration is 0.006 mg/ℓ and a dose of 0.02 mg/ℓ causes the death of a portion of the animals.

The capacity of the preparation to accumulate in animal organisms has not been clearly expressed. With a daily oral administration of 1/10 of the [LD_{100}] ($ЛД_{100}$) of polychloropinene the death of the animals occurs with the total intake into the organism of 3.8 of the absolutely lethal doses, and when it enters through the respiratory tract 2.5 of the absolutely fatal doses as compared to a single effect. In animals, which died after the administration of this preparation, dystrophic changes and hemodynamic disorders were detected. In the central nervous system, chiefly in cerebellum, there was observed pyknomorphic swelling. karyolysis, karyocytolysis and sclerosis of the nervous elements. In the internal organs, especially in the liver and kidneys, there was detected parenchymatous and fatty dystrophia. During intoxication with polychloropinene in the early stages of its development changes in the higher nervous activity of the animals were noted and also disturbances of the acid-alkaline equilibrium. The change in the conditioned-reflex activity leads to the inhibition of the conditioned reflexes. On the part of the acid-alkaline equilibrium with the effect of polychloropinene in smaller doses there is noted an alkaline shift, and under the effect of large doses -- a shift in the direction of acidosis, to which attest the changes in the alkali reserves of the blood and the activity of carbonic anhydrose.

Industrial observations and the data experimental investigations indicate that at concentrations of thousands and especially of hundreds of parts of a milligram per liter polychloropinene can have an unfavorable effect on workers.

Some observed cases of human poisoning by polychloropine make it possible to consider that the chlorinated terpenes are a definite danger with respect to the possible appearance of acute poisoning. Taking into account that on industrial premises in contrast to agricultural ones workers are in contact with the preparation for a long period of time, in the air of the working premises its concentration should not exceed 0.0002 mg/ℓ.

Inasmuch as polychloropinene possesses upon entering through the gastrointestinal tract, the respiratory tract and the integument the same toxicity as chlorten, and is similar in the character of its effect on the organism, the recommended size of the maximum permissible concentrations of polychloropine should be the same as for chlorten.

Strobane

Strobane – $C_{10}H_{11}Cl_7$. Synonyms: polychloropinene-2; chlorpin, chlorpinak. It is a mixture of chlorinated terpene and camphere, containing 66% chlorine. It is a transparent, rather mobile liquid with a characteristic odor of turpentine. In external appearance it is from straw to amber color, and possesses an indefinite aromatic odor, similar to pinene. Its specific gravity is 1.630. At 25° its refractive index is 1.582. The boiling point is 155-157°. Vapor pressure is $3 \cdot 10^{-7}$ mm Hg at 20°. It is noninflammable, dissolves in water in trace amounts, is soluble in aromatic solvents. It is slightly soluble at 95° in ethyl alcohol (12-14%). At room temperature it is soluble up to 40% in deodorized kerosene. It decomposes slightly in boiling water. It hydrolyzes slowly at 100°; it is not stable in the presence of organic bases. It is corrosive to steel and tin. No labeling required. It is compatible with the majority of insecticides and fungicides. It is obtained by the dark chlorination of pinene dichloride. It does not keep long in an alkaline medium. Technical strobane and its liquid concentrate should be stored in acid-resistant vessels in a dry and cool place.

From strobane an emulsion concentrate, a wettable powder, a disinfecting powder, and oil solution are prepared.

It is toxic to many species of insects, including cockroaches, house flies and others. After spraying with a 2% solution 40-80% of the cockroaches (common, oriental, American) die within 48 hours. When the concentration is increased to 5% the mortality rate of the cockroaches reaches 100%. Flies are more sensitive to this preparation than cockroaches. With the use of a 1% solution of strobane the mortality rate of flies after 10 minutes reaches 95%. It is basically used to control pests of agricultural plants.

Strobane was studied in detail by V. N. Dyadechko, who recommend that it be used in 2-5% aqueous emulsions to combat ticks and mites.

Toxaphene

Toxaphene — a waxy, yellow preparation with a mild odor of pine. It contains 67-69% chlorine. The melting point is 65-90°. It is insoluble in water, and readily soluble in organic solvents. Its density at 27° is 1.65. The solutions of the preparation do not lose their effectiveness in storage for 14 months or more.

Abroad it is manufactured in the form of a 10-20% disinfecting powder, a 40% powder and emulsion concentrates. In the United States it is used in the form of a 0.5-0.75% emulsion for treating animals against ectoparasites by spraying or bathing. Its insecticidal properties are not high; the oil solution is effective at the following concentrations: for bed bugs — 3.9%; for lice — 0.6%, for fleas — 2%, for flies — 0.09% and for Ornithodorus ticks — 0.21%. With respect to clothes lice toxaphene is more toxic and stable than DDT. With respect to cockroaches the 10% disinfecting powder is ineffective. In testing the duration of its action with respect to bugs on filter paper impregnated with 0.1 mg/cm^2 it was established that the preparation does not lose its effectiveness for 6 months, a 1% emulsion of toxaphene, used on manure at a rate of 300-600 mℓ/m^2, was more effective than DDT (10 mg of toxaphene per kg of substrate destroys 100% of the fly larvae). When present in a reservoir at a rate of 1 mg/ℓ toxaphene kills 96% of the mosquito larvae; the purpae do not die at this concentration.

Thus, in its effectiveness toxaphene is inferior to DDT with respect to bugs and fleas; with respect to lice and flies the activity of both preparations is identical, and with respect to mites and ticks toxaphene is more effective. In an insect coming in contact with this preparation, paralysis occurs slowly, therefore to accelerate its action DDT is added. The impregnation of fabrics with an 0.8% solution of toxaphene protects them from moths.

In toxaphene's action on insects a latent period is noted; 3 hours after the application of the preparation tremor of the extremities appears. When the leg of a cockroach is isolated the tremor ceases. After the oral administration of 100 μg of the preparation to the common cockroach oxygen consumption increases by 3 times as compared to the normal. The increase of oxygen consumption occurs during the time of the tremor, after cessation of the tremor oxygen consumption decreases. The administration of toxaphene to an American cockroach stimulates the cardiac activity, in the death of the cockroach the heart stops during the systole. Toxaphene at a concentration of 0.01-0.001 mg/ℓ almost completely inhibits the activity of cytochrome oxidase. Increasing the temperature increases the capacity of the preparation to kill house flies.

Experiments of the Department of Agriculture of the United States show that cattle can be fed 25 parts of toxaphene per million parts of feed or less over a period of 10 consecutive weeks the level of permissible dose of deposition in the organism of the animals will not be exceeded. In connection with this it was recommended to farmers that they observe a 7-day interval between the treatment of grass with toxaphene and the putting out of the cattle to graze on this pasture. Permissible amounts of toxaphene deposition in the fat of slaughtered cattle were officially established, precisely 7 parts per million.

Under laboratory conditions it was established that toxaphene at 24° is 3 times more toxic at 10°.

Toxaphene is toxic to gold fish at concentrations of 0.0032 mg/ℓ.

The treating of cattle and horses with 0.5-0.75% emulsions is safe.

Toxaphene is more toxic to vertebrate animals and causes the death of 50% of the rats (LD_{50}) with a dose of 50 mg/kg, and in sheep and goats with 200 mg/kg. A dose of 20 mg/kg causes convulsions in dogs and cats, and of 60 mg/kg brings about their death within 3 hours. Dogs are approximately 10 times more sensitive to toxaphene than to DDT. The median lethal dose LD_{50} for animals in an acute experiment was equal to 60 mg/kg (LD_{50} of DDT is 250 mg/kg, of chlordane – 500, of [DDD] (ДДД) – 2500 and of methoxychlor – 7000 mg/kg). The preparation possesses cumulative properties and is deposited in the fat of animals (Lehman). The lethal dose for man, when administered orally, is equal to 60 mg/kg (2-7 g). Thus, to man toxaphene is 4 times more toxic than DDT. When applied on the skin it causes irritation; the daily contact of the preparation with the skin is very dangerous.

When cattle grazed on meadows treated with toxaphene approximately 0.5 mg/kg of deposition is detected in the animal organisms. In the fat of pigs treated 2 times with a 0.5% emulsion there was detected 0.36-4.6 mg/kg of toxaphene. Pig meat is safe for human consumption 6 weeks after treating them with an application of 0.5% toxaphene.

Chlorinated Turpentine (CT)

The use of turpentine for the extermination of insects has been known for a long time. Freshly impregnated fabric possesses pediculicidal properties, but due to the volatility of the preparation its effectiveness diminishes rapidly. To intensify its activity and to increase the duration of the action of this preparation a number of chlorinated turpentines was prepared at 100-110°, which in their chlorine content corresponded to the composition of from monochloroturpentine to hexachloroturpentine inclusively.

Preparation-CK [CT] is a clear, transparent, viscous, slightly mobile liquid with a mild odor reminiscent of the odor of coniferous needles. Its specific gravity at 50° fluctuates from 1.49 to 1.53. It is insoluble in water; it is slightly soluble in alcohol, but very soluble in ether, turpentine and other organic solvents. The products of chlorination are the main component of preparation-CT. They are obtained as a result of the interaction of chlorine with alpha-pinene, the content of which in turpentine is more than 70%. The products of chlorination possess very high insecticidal activity. They contain 58-60% chlorine (S. V. Zhuravlev).

For the treatment of linen the preparation has been produced by industry in the form of a concentrate with various emulsifiers under the name of antipediculin-CT and CT-9.

Antipediculin-CT is a thick, oily, dark-colored liquid which is readily emulsified by water (50% preparation CT, sulfonated naphthenic acids and oils). The emulsion at 2% concentration is used for treating underclothing and bed linen, for spraying bed appurtenances, and for treating other garments and living quarters. The linen is treated by soaking it in the emulsion. One ℓ of emulsion is used per each kg of clear linen. After 10-15 minutes of soaking the linen is wrung out to a certain extent and then dried. The dried linen is mangled, but not ironed with an iron. The linen can also be treated on ribbon machines. To exterminate insects the bed appurtenances (lice), and also the floor (fleas) are sprayed with 2% emulsion using an atomizer, pneumatic sprayer or hand sprayer. The approximate expenditure of emulsion per m^2 of floor is 0.3-0.4 ℓ.

The CT-ointment has a vaseline base. It contains 10% preparation-CT. The ointment is applied to the seams of underwear and outer garments and is used to treat hairy parts of the body. In the latter case the preparation expenditure is equal to 10-15 g per person.

Powder (disinfecting powder)-CT contains 10% preparation and 90% filler (talc, kaolin, bone meal, clay). The disinfecting powder is used to combat clothes lice and fleas.

Chlorten

Chlorten – $C_{10}H_{10}Cl_8$ – a mixture of high chlorinated terpenes. Technical chlorten is obtained by the photochemical chlorination of the alpha-pinene fraction of turpentine; in composition it is close to toxaphene. It has the form of an oily, dark-brown liquid; it is sticky and has a specific odor; it contains 64-66% chlorine. The density of technical chlorten is 1.5-1.6 g per cm^2. Chlorten is insoluble in water, is decomposed by alkalis, and evaporates faster than DDT. In its properties it is close to preparation-CT and possesses considerable insecticidal and acaricidal action. It was first obtained by the Scientific-Research Institute of Fertilizers and Insectofungicides in 1951.

A number of authors (Ye. . . Burkatskaya, S. F. Vyazkova, E. M. Bernadskaya, G. K. Kovalev and others) characterizes this preparation as a very active insectoacaricide.

To control pests of agricultural plants there is used a 65% concentrate of chlorten, which contains, besides chlorten, 20% mineral oil and 15% emulsifier. Furthermore, on the basis of this preparation it is possible to prepare disinfecting powders and composite chlorten-DDT preparations (K. A. Gar). The concentrate (65%) of chlorten is a transparent, yellow, viscous liquid, which, when mixed with water, forms a stable, milky emulsion. This concentrate is used to prepare emulsions, which are employed to spray plants (K. A. Gar, D. K. Nechinennyy, V. M. Romanov, Barber).

Methods of preparing working solutions: to prepare 100 ℓ of 0.5% emulsion there is weighed out 0.5 kg of the concentrate to which 3 spoons of water are added, as a result of which there is formed a white, pasty mass; to this mass there is added, while stirring, the remaining amount of water to bring it up to 100 ℓ.

Chlorten – a contact insecticide acting on the mobile stages of many forms of harmful insects. The fumigational action of chlorten is milder than hexachlorane. The preparation is highly toxic to bugs and can be used as a repellent to protect animals from insects (Ye. I. Pokrovskaya).

Chlorten is used to combat aphids, mites and ticks on various plants (0.5-1% emulsion), to exterminate in the instar periods caterpillars of the gypsy and lackey moths, and also ermine moth caterpillars (0.5-0.6% emulsion), for disinfestation of empty granaries (1-2% emulsion). In practice, when it is applied in the appropriate concentrations it does not burn plants.

Chlorten at 0.7% concentration is also employed to combat ectoparasites of animals (S. F. Vyazkova and others).

Chlorten does not have special significance for sanitary practice. It can be used when necessary against fleas mites and ticks, especially when mixed with DDT.

When chlorten is utilized in combination with a 15% emulsion of DDT for the purpose of killing fleas its insecticidal effect is after 5 minutes from 2-3% concentration.

Its acaricidal action is delayed. Thus, for example, when a 1.5 emulsion of chlorten is used and it is in contact with the mites and ticks for 30 minutes the death of the arthropods ensues within 48 hours.

The acaricidal action on mites and ticks of the 1.5% emulsion in combination with 1.5% DDT also requires prolonged exposure – 30-60 minutes.

The toxicity of chlorten with respect to higher animals and man is approximately the same as the toxicity of hexachlorane. Chlorten emulsion possesses an expressed therapeutic action on sheep scabies. The therapeutic effect is attained after a single bathing of the affected animals in 0.65% chlorten emulsion (active) substance) at a temperature of 20-25° and an exposure of 30-60 seconds.

According to G. K. Kovalev, chlorten in toxic and lethal doses when externally and internally administered causes disturbance of central nervous system activity (acute clonic-tonic spasms, tremor, retrogressions, a state of depression or prostration after violent neuromuscular symptoms, etc.), a decrease in body temperature, changes on the part of the cardiovascular system and respiration; albuminuria is also observed. Changes in the blood are characterized mainly by leukocytosis, neutrophilia with a shift to the right. During path-anatomical and hystological examinations there were detected pulomonary edema, dystrophic changes in the liver, kidneys, heart, brain; in the case of chronic poisoning, moreover, there was noted focal necrosis of the liver and necrosis of the convoluted tubules of the kidneys. The toxicity of chlorten to the higher animals and to man is approximately the same as hexachlorane. Chlorten possesses expressed cumulative properties. When orally administered a dose of 0.15 g/kg is minimumally toxic to rabbits, 0.3 g/kg – tolerable, and 0.4 mg/kg – lethal. For sheep a dose 1 g/kg, when orally administered, is fatal, a dose of 0.1-0.06 mg/kg is harmless. When externally applied in the form of an aqueous emulsion chlorten penetrates through intact skin. A general treatment of the integument of sheep with 0.5-3%, and rabbits with a 1% concentration of emulsion is practically harmless. The application of a 5% emulsion of chlorten causes toxic symptoms.

CHAPTER V

ORGANOPHOSPHORUS INSECTICIDES

The insecticides of the chlorinated hydrocarbon group have been widely employed in disinfestational practice for more than 20 years. The necessity of applying insecticides from other groups of chemical compounds was dictated by the appearance among arthropods of resistance to the chlorinated hydrocarbons. These and other deficiencies of the chlorinated hydrocarbons stimulated the quest for insecticides from various chemical groups including from the group of organophosphorus compounds. The great advantage of the latter insecticides from a hygienic point of view was their lesser stability to environmental conditions as compared to the chlorinated hydrocarbons, which is important for insecticides applied to combat pests of agricultural crops. The quality of these compounds to decompose rapidly decreases the danger of them getting into the human organism directly or along with food products. At the present time more than 500 preparations belonging to the group of organophosphorus compounds have been studied (N. N. Mel'nikov, P. V. Popov, Casida).

A number of these preparations is suitable for use in controlling the parasites of man and his dwellings, and also the carriers of organisms causing infectious diseases.

At the present time the number of preparations of this group being used in practice is as great as the number from the chlorinated hydrocarbon group being practically applied. Among those in practical use we find chlorophos (dipterex), carbophos (matathion), metaphos (wofatox), diazinon, thiophos (parathion), [DDVP] (ДДВФ) and others.

The toxicity of the organophosphorus compounds varies widely. Thus, for warm-blooded animals the [LD_{50}] ($ДД_{50}$) of thiophos is 3.6-13 mg/kg, and of carbophos more than 2000 mg/kg. The organophosphorus insecticides which have been introduced into practice conform to the specifications put forward by the sanitary service. They are highly toxic to arthropods and with certain exceptions are only slightly toxic to warm-blooded animals (L. P. Bocharova, Eddy).

In order to visualize the degree of toxicity of the organophosphous compounds to insects (as compared to the earlier applied preparations), we present the following calculated data: in order to kill insects, for example the fly, with the insecticides applied before 1940, it was necessary to apply to one individual several milligrams of preparation, whereas when using [DDT] (ДДТ) it was necessary to apply to one individual (a fly) 2 μg or a 1000 times lesser amount, i.e., as a result of the application of 1 mg of the preparation about 500 flies die. At the same time from 1 mg of chlorophos about 3000 flies are killed and from 1 mg of dimethyldichlorovinylphosphate (DDVP) - more than 30,000 flies die, approximately the same regularity is also observed with respect to bugs and other arthropods.

The other organophosphorus insecticides are also highly toxic to insects. Thus, for example, the median lethal doze in micrograms for the female mosquito is for baytex 0.002-0.003; malathion (carbophos) - 0.006; diazinon - 0.006-0.016; ronnel - 0.016-0.021; Co-Ral 0.002-0.012; dimethoate - 0.003-0.005; DDT - 0.018.

Especially toxic to flying insects in its vaporous form is DDVP. To kill mosquitoes 0.2 μg per ℓ is sufficient. According to calculated data, DDVP vapors are approximately 600 times more effective than DDT vapors, and 300 times more effective than hexachlorane vapors.

Another difference between the chlorinated hydrocarbons and the organophosphorus compounds is the decrease in effectiveness of certain chlorinated hydrocarbons during the hot season, in particular DDT, whereas the effectiveness of the organophosphorus compounds, for example chlorophos, increases. In comparing the sensitivity of flies to chlorophos in spring in summer and in autumn it was noted that the sensitivity of flies is higher to chlorophos than to DDT in a number of cities of the Soviet Union in spring by 17 times, in summer by 31 times, in autumn by 18 times, and in the southern cities it reaches 70-80 times. Therefore, it was recommended that DDT and hexachlorane be applied in spring and autumn, and chlorophos — in the summer period.

Another peculiarity of the organophosphorus compounds is the fact that certain of them have a more expressed selective effect on insects than do the chlorinated hydrocarbons, i.e., they are highly toxic to insects and less toxic to warm-blooded animals.

The organophosphorus insecticides are widely applied for the purpose of controlling pests of agricultural plants; they are especially applied in the form of aerosols and sprays. The best preparation in all the experiments was carbophos: its dosage when used in the form of aerosols was 77-193.6 g/ha, as a spray 291-347 g/ha. The least effective in aerosol form was ronnel.

When the organophosphorus insecticides were introduced into practice the assumption was advanced that arthropods would not develop resistance to these preparations. However, these hopes were not justified; in a number of countries fly populations have appeared, which are resistant to organophosphorus insecticides. The resistance to these insecticides is not as high, as to the chlorinated hydrocarbons; it is created over more prolonged periods and disappears more rapidly.

In the Soviet Union such phenomena have still not been observed, which, obviously, is connected with the brief period of their application here.

A great advantage of the organophosphorus compounds over the chlorinated hydrocarbons from a hygienic point of view is their low resistance to environmental conditions, which is very important for insecticides applied to control the pests of agricultural cultures (cotton, fruit trees, grain, vegetable and other cultures). The rapid decomposition of the organophosphorus compounds decreases the danger of the compounds getting into the human organism directly or along with food products.

A distinctive peculiarity of the organophosphorus compounds is their capacity even in small concentrations to obstruct cholinesterase.

Acetycholine is biologically a very active substance possessing many-sided action. Acetylcholine has been detected in all tissues of vertebrate and invertebrate animals, also including worms and certain plants.

At the basis of the toxic action of the organophosphorus compounds on vertebrate animals (as well as at the basis of the insecticidal action) is the mechanism of the suppression of enzymes which are widespread and which play a great role in the organism, i.e., enzymes belonging to the esterose group, especially cholinesterase. In the course of its normal function the latter [cholinesterase] catalyzes the hydrolysis of choline esters (the hydrolysis of acetylcholine into low-activity choline and acetic acid).

The presence of enzymes in the tissues of insects or mammals, which are able to hydrolyze an inhibitor while preserving their own activity, to a considerable extent lowers its toxicity. The toxicity of the organophosphorus compound depends on a number of factors, each of which in the organism of insects and mammals plays a relatively different role. Among these factors R. Metcalf includes: a) the transformation of an insecticide into an active inhibitor of cholinesterase, which usually occurs by oxidation; b) the relative affinity of a compound for various cholinesterases, hence its activity as an inhibitor; c) the rate of the reversibility of the suppressed enzyme; d) the hydrolysis of the inhibitor by the enzymes.

Frequently the relationship between the suppression of cholinesterase in vitro and the toxicity to insects is disproportionate. Thus, for example, phosphorothionates and phosphorodithionates (thiophos and carbophos) are usually weak inhibitors of cholinesterase in vitro, but possess high toxicity to insects (thiophos and carbophos, which are considered to be some of the strongest preparations). This is explained by the fact that such compounds in the animal organism are decomposed to their individual parts, which suppress cholinesterase.

In most cases in the poisoning of insects the suppression of other esterases (besides cholinesterase) has a secondary significance; in individual cases this plays the same role as the suppression of cholinesterase.

Among the organophosphorus compounds possessing insecticidal properties preparations are encountered, which also differ greatly from each other in their anticholinesterase properties, in their degree of toxicity to warm-blooded animals and others. But all them, to one extent or another possess the capacity to suppress cholinesterase.

Acetylcholine exists in large concentrations in the nervous tissues of both vertebrate and invertebrate animals; it is claimed that this substance transmits nerve impulses to the sites of the myoneural junctions. Its excessive accumulation in the animal organisms interrupts cholinergic transmission and leads to the death of the animals.

According to Dubois and others, the intra-abdominal introduction of malathion, chlorothion, tetrapropyldithiopyrophosphate leads to the suppression of cholinesterase in the brain, submaxillary gland and especially in the blood plasma.

This served as a basis for a study of the action of organophosphorus compounds on the central, and also on the vegetative nervous system, where acetylcholine fulfills important physiological functions as a mediator of nervous impulses.

According to Yu. S. Kagan, the introduction of organophosphorus compounds into the organism of warm-blooded animals causes changes in the conditioned and unconditioned reflex activity of the animals.

The basic action of the anticholinesterase compounds is their effect on the pathway, which the impulse follows along the nerve supplying the respiratory muscles.

A certain connection exists between the speed and degree of suppression of blood cholinesterase and the severity of the symptoms.

The duration of the symptoms of poisoning depends partially on the speed of the reactivation of cholinesterase and on the speed, at which the inhibitor is decomposed or is removed from the tissues of the animal organism. The suppression of cholinesterase is reversible.

The rate at which cholinesterase returns depends on the nature of alkyl groups combined with the phosphorus atom. In the case, when the alkyl groups belong to methoxy, the reversibility of the intoxication is rapid in the early stages.

The speed of the restoration of cholinesterase suppressed by organophosphorus compounds is slower than the speed of the restoration of cholinesterase suppressed by other compounds. Thus, cholinesterase suppressed by carbamate returns to normal activity several hours after removing the surplus carbamate, whereas cholinesterase suppressed by organophosphorus compounds returns to normal only after several days.

The speed of reactivation depends not only on the character of the inhibitors, but also on the strength of the enzyme. The ability of organophosphorus compounds to suppress cholinesterase also depends on the stability of the preparation in the animal organism right up to and including its direct effect on cholinesterase.

The difference in the speed of restoration is explained by the fact that certain organophosphorus preparations introduced internally are not only absorbed on the surface of the enzyme, but are also stably combined, as a result of which an irreversible chemical reaction is obtained. Thus, the suppression by an organophosphorus compound occurs as a result of a chemical reaction between the insecticide and enzyme with the formation of a covalent type bond. The speed of this reaction depends on the reactivity of the organophosphorus compound. The strong inhibitors of cholinesterase are those compounds, which are most easily hydrolyzed in an alkaline medium.

Besides cholinesterase, organophosphorus compounds act on other esterases: trypsin, esterase of the human liver, lipase of milk and others.

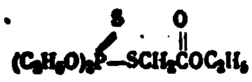
Besides these esterases, there also exist others, which are not suppressed and even possess the capacity to hydrolytically decompose certain organophosphorus compounds. Thus, para-oxon does not affect the ali-esterase of the serum of rabbits, rats, and horses, and this esterase actually causes the catalysis of its hydrolysis; the enzyme "tabunase" existing in the plasma and other tissues of rabbits, man, horses, and certain other animals enzymatically hydrolyzes dimethylophosphoramidocyanidate (tabun) into its appropriate acids; an aromatic esterase existing in the erythrocytes and plasma of man is able to hydrolyze a number of substituted phenylacetates and, apparently, is identical with ali-esterase. As yet there is little known about the true function of these esterases which are not susceptible to organic phosphates; it is possible that they participate in the mechanism of the detoxication of these poisons.

Of all the domestic animals with respect to acute and chronic poisoning the most sensitive to the effect of the organophosphorus compounds are pigs. Of their enzymes the most highly suppressed is cholinesterase (Ye. I. Spynu). The latter is restored to the normal level after 6-9 weeks, and subsequently the animals must not be subjected to the effects of organophosphorus insecticides for a period of 10 weeks.

According to Gershon and Show, in 16 subjects subjected to the chronic effect of organophosphorus insecticides, there was noted disturbance of the memory and attention, against the background of which 7 patients became depressed, 5 developed schizophernoid psychosis with notions and hallucinations of hearing things and one - a twilight state (fugue). The psychosis lasted not less than 6 months after the cessation of the effect of the organophosphorus insecticides; almost all the patients recovered within 12 months from the beginning of the psychosis. At the basis of the psychosis lies the inhibition or the decomposition of cholinesterase caused by these insecticides.

Acetione

Acetione – $C_8H_{17}O_4PS_2$ – 0,0-diethyl-S-carbethoxymethylphosphoro-



dithionate – a yellowish liquid with a mild ether odor. Its boiling point is 107-108° at 0.2 mm Hg; its specific gravity is 1.1796, its index of refraction is 1.5007; the preparation is insoluble in water, in connection with which a 30% emulsion concentrate is prepared.

It possesses considerable insecticidal properties; when the preparation is applied to flies the LD_{50} is 0.4 μg/g, for cockroaches – 100 μg/g, for lice – 0.63 μg per insect or 13 μg/g.

According to V. I. Vashkov and Ye. V. Shnayder, when the emulsion of the preparation is applied to glass at a rate of 0.05-0.1 g of active substance per m^2 it causes the death of 80-95% of the insects after 5 minutes of contact. With an increase of the dosage of the insecticide to 0.25 g/m^2 complete destruction of the insects was noted within 30-60 minutes.

When applied to other surfaces the effectiveness of the preparation is lower than on glass; thus, on wood when the preparation is applied at a rate of 2 g/m^2 from 17 to 28% of the flies die after 5 minutes of contact and 60% after 10 minutes of contact.

On wallpapers and surfaces painted with an oil-based paint the preparation is ineffective, on plywood the mortality rate of flies after 5 minutes of contact is on the average 35% with an expenditure of 1 g/m^2 and 57% at 2 g/m^2.

The residual insecticidal action of acetione on surfaces is in direct dependence on the rate of expenditure of the preparation per unit of area. Thus, for example, when the insecticide is applied to glass at a rate of 0.5 g/m^2 high destruction of flies was noted during the course of 2-3 days; when the dosage was increased to 1 g/m^2 the insecticidal action was preserved for 7-8 days.

The preparation possesses considerable larvicidal properties: with the addition of 50 mg of the preparation per kg of substrate the mortality rate of the larvae reaches 97% after 96 hours. Increasing the dose to 200 mg/kg does not accelerate its toxic action.

Satisfactory results were obtained with respect to common cockroaches: their complete destruction was noted 24 hours after 15 minutes of contact with surfaces, on which the preparation had been applied at a rate of 1 g/m^2; at 0.5 g/m^2 the mortality rate of the insects reached 45%. Acetione was more effective with respect to fleas and body lice; thus, the complete destruction of fleas occurred after 15 minutes of contact with a neutral surface (glass), on which there had been applied 0.25 g/m^2 of the preparation.

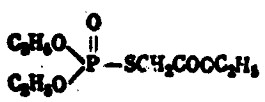
Body lice after contact with a treated glass surface are almost destroyed with a dose of 0.1 g/m^2 and an exposure of 15 minutes. Cotton fabric becomes toxic to lice when it is exposed for 3 hours and impregnated with a 0.5% emulsion; under certain conditions the mortality rate of the insects reaches 90%. Lengthening the time of contact of the lice with the impregnated fabric up to 24 hours makes it possible to decrease the concentration of the insecticide to 0.05%, and at this concentration complete destruction of the lice is also observed. Cotton fabric treated with a 0.5% emulsion of acetione (of active substance) with open storage under room conditions preserves its insecticidal properties for 25-30 days.

The preparation is volatile; its vapors are toxic to insects. A very important property of acetione is the fact that it is only slightly toxic to warm-blooded animals. According to O'Brien, the LD_{50} for mice is 1280 mg/kg.

In a study of the metabolism of the preparation in animals it was established that it is decomposed in the liver, as a result of which acetione acid is formed.

Acetophos

Acetophos — $C_7H_{17}O_5PS$ — 0,0-diethyl-S-carbethoxymethylthiophosphate.



Synonym — acetoxom.

Pure acetophos — a clear, yellowish liquid with a mildly unpleasant, but not a stable specific odor. Its molecular weight is 256; its boiling point is 120° at 0.15 mm Hg, 95° at 0.03 mm Hg, the index of refraction is 1.4624; the specific gravity is 1.1840.

The technical product is an oily liquid with a yellowish color. Its index of refraction is 1.461-1.464. Its specific gravity is 1.820-1.850. Acetophos mixes readily with water in any proportions. It has an acid reaction. It possesses contact, intestinal and fumigational action with a positive temperature coefficient. With an increase of temperature the coefficient of insecticidal action is increased by 1 1/2-3 1/2 times.

There is little in literature on acetophos. O'Brien notes that acetophos containing the carboxyester group is less selective than acetione, i.e., the selective action on insects in comparison with warm-blooded animals of acetophos is less expressed than acetione. The experimental data of the authors about the anticholinesterase activity of these preparations agree with the accepted view that phosphates (acetophos) are more active than the corresponding thionophosphates. The preparation was synthesized at the Scientific Research Institute of Fertilizers and insectofungicides (Ya. N. Mandel'baum, N. N. Mel'nikov and others).

In disinfestation acetrophos can be applied in different forms: in the form of aqueous solutions, disinfecting powders, suspensions, insecticidal ointment and oil. The latter contains 10% of the preparation. Into the composition of the insecticidal ointment there goes 3-5% acetophos, 69-70% liquid petrolatum, 18.5-18% ceresin, 3-5% paraffin and 3% odorant.

Acetophos possesses high insecticidal properties: with an increase in the temperature the insecticidal properties increase by 1 1/2-3 1/2 times. With respect to house flies and rat fleas it is almost 10 times more toxic than chlorophos; a dose of acetophos equal to 0.01 g per m^2 of glass surface causes the death of 93% of the flies after 5 minutes of contact and 10% of the fleas after 15 minutes of contact. With respect to bed bugs the insecticidal activity of acetophos is analogous to the action of chlorophos, i.e., the contact of bugs with a surface (glass) treated at a rate of 0.5-0.1 g per m^2 causes the death of a number of insects after 24 hours and their complete destruction within 48 hours. On the common cockroach the action of acetophos is in 2-3 times weaker than the action of chlorophos; the expenditure of 0.5 g of the preparation per m^2 of glass provides within 48 hours the destruction of up to 80% of the insects after 30 minutes of contact; complete destruction of cockroaches is noted within 72 hours after 15 minutes of contact on surfaces to which the preparation has been applied at a rate of 1 g/m^2.

The insecticidal activity of acetophos when applied to a surface to a considerable degree depends on its form and character. For example, on surfaces painted with oil based paint the aqueous solutions of the preparation with respect to flies and fleas are effective at a dose of 1 g of active substance per m^2 with an exposure of 15-30 minutes; with respect to bugs and cockroaches the effectiveness of the preparation is lower. In treating surfaces painted with an oil base paint with aqueous solutions of acetophos yellowish spots remain. On wood the effectiveness is considerably lower than on a surface covered with oil base paint. The destruction of 70% of the house flies is attained only when the preparation is applied at a rate of 3 g per m^2 with an exposure of 15 minutes.

The insecticidal activity of acetophos on such surfaces, as wallpaper, plywood and cotton fabric with brief exposures is very insignificant. After a 5-minute contact of flies with wallpaper and plywood, treated with aqueous solutions at a rate of 3 g of preparation per m^2 only from 20 to 50% of the insects die. Analogous data were obtained with the impregnation of cotton fabric with which body lice and bed bugs had come in contact.

The residual action of the preparation was determined on surfaces of glass and those painted with oil base paint for various intervals of time after treatment. As a result it was established that with an expenditure of 2 g per m^2 (glass surface) the insecticidal properties are retained for over 10 days, on a surface painted with oil base paint – 5-7 days.

It is necessary to note that the insecticidal properties of acetophos in summer at an air temperature of 25-27° are considerably higher than in autumn at a temperature of 17-18°. Thus, for example, on surfaces painted with oil base paint and treated with acetophos at a rate of 1 g/m^2 the mortality rate of flies after 5 minutes of contact in the first case reaches 74%, and in the second 50% in the case when 2 g of preparation per m^2 of surface was applied and after 5 minutes of exposure at a temperature of 22° 56% of the flies die, and at 18° the death rate of the flies is 15%.

With respect to body lice acetophos is distinguished by its high toxicity. The submersion of mature individuals in 0.5% aqueous solutions of the preparation for 5 minutes causes the death of 70-75% of the insects within 24 hours; increasing the concentration of the solution to 1% provides complete destruction of the lice with the same exposure. When topically applied the LD_{50} is within the limits of 0.02 μg per individual or 13 μg/g.

The insecticidal action of calico, satin, knitted fabric, repp and other fabrics impregnated with acetophos and its analog (2 g/m^2) decreases considerably after washing in warm water with soap. The destruction of lice after contact with washed fabrics is within the limits of 50% and lower. Wool fabrics also preserve their insecticidal properties after washing for a month.

One of the advantages of acetophos over other preparations is its ovicidal properties with respect to nits. According to V. D. Larionova, to combat head pediculosis the most promising are 3-5% vaseline ointments or shampoo containing the same amount of preparation. A single application of acetophos in ointment or shampoos causes the complete destruction of lice and nits; the latter are easily removed from the hair by combing with a fine comb. After the submersion of lice eggs in a 0.5% solution for 2 hours or in a 1% solution for 1 hour the lice do not hatch from the eggs.

Acetophos in its larvicidal action with respect to the larvae of house flies belongs to the highly effective preparations. Under laboratory conditions 50 mg of the preparation per kg of substrate provide complete destruction of the larvae after 3 days. In the same experiments, where after 72 hours the individual larvae did not die, the flies did not hatch.

If acetophos is compared with chlorophos, then in its larvicidal properties with respect to fly larvae acetophos is somewhat weaker than chlorophos, although its toxic doses are also very small.

Acetophos in its insecticidal action with respect to the larvae of mosquitoes is equal to chlorophos. The minimum effective dose of the preparation causing complete destruction of mosquito larvae is 0.5 g per m^3; in the case about 10% of the pupae die. Doses of 100 and 50 mg of acetophos per m^3 of water kill 66-80% of the larvae of mosquitoes and midges (A. N. Alekseyev, A. P. Ignat'yev).

To determine the insecticidal activity of acetophos in aerosol form the latter was tested in the laboratory by Ye. V. Shnayder by burning filter paper impregnated with the preparation, and aerosol tablets containing 22% acetophos (A. N. Sidorov). As a result it was established that aerosols obtained by the burning of tablets are more effective than by burning paper impregnated with the preparation. The optimum dose of the preparation, which, when sublimated, causes the complete destruction of flies after 24 hours is 0.1 g per m^3 when tablets are burned and 0.2 g - when aerosol paper is burned.

The death of 94-96% of the flies was obtained after 2-3 hours and of 100% of the flies - after 4-5 hours when tablets were used at a rate of 0.2 g of preparation per m^3. The preparation in large concentrations suppresses the cholinesterase of flies.

As a result of a single application of a 0.5% solution of acetophos complete destruction of the bugs was not achieved in connection with which a solution of the same concentration was applied repeatedly after 10 days. This provided the complete liberation of the quarters from bugs. In those quarters, where

1% aqueous solutions were applied, complete destruction of the bugs was achieved after a single treatment.

To combat flies a 1% aqueous solution of acetophos was used to treat the walls of basement quarters (70 m^2), next to which was a trash container from which many flies were seen flying into the basement. The walls of the premises plastered and whitewashed were treated at a rate of 100 $m\ell/m^2$. As a result there was noted the rapid destruction of the flies, flying into the area. The residual action was preserved for 7 days.

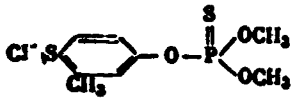
It is necessary to note that the odor of acetophos in well ventilated quarters disappears rapidly. The preparation is also used to combat the pests of agricultural plants (S. A. Roslavtseva).

In studying the fumigational action of acetophos it was established that the vapors of this preparation in their insecticidal activity with respect to house flies are considerably inferior to chlorophos. Placing entomological populations (in container) (with a dimension of 6 × 4 × 2 cm) of flies for 24 hours in half-liter glass jars, the walls of which on the inside were covered with filter paper impregnated with acetophos (1 g/m^2) did not result in the complete destruction of the insects.

With respect to warm-blooded animals acetophos is a comparatively nontoxic preparation. According to A. P. Volkova, when acetophos is orally administered to animals LD_{50} for mice is 700 mg/kg. In pure form it causes local irritation and has a general toxic action when applied at a dose of 0.1 mℓ on the skin of the back of white mice or on the mucous membrane of the eyes. Aqueous solutions of the preparation at a concentration of 1-2% when applied to the skin one time and repeatedly for a period of 5 days do not cause toxic symptoms and irritation of the skin. The pure preparation causes acute hyperemia, edema and necrosis of the skin, and also death to the animal within 2-24 hours. When applied to the mucous membrane of the eyes acetophos in its pure form causes acute irritation (conjunctivitis, edema, epiphora and acute stenocoriosis by 5-6 times); after 24-48 hours these symptoms disappear. A 1% aqueous solution causes mild contraction of the pupil and mild conjunctivitis; after 24 hours all the symptoms pass. In experiments involving the inhalation of the aerosols of acetophos by the burning of tablets at a rate of 0.2 g of active substance per m a single time and repeatedly for a period of 10 days toxic symptoms were not observed in rats and rabbits.

Baytex

Baytex – $C_{10}H_{15}O_3PS_2$ – 0,0 dimethyl-0-(4-methylthio-3-tolyl) phosphorothionate.



Synonyms: bayer-29493 or S-1752, entex and others. It belongs to the group of phosphoric acid esters.

Its molecular weight is 278.53, the index of refraction is 1.5698, the boiling point is 105° at 0.01 mm Hg. Its vapor pressure is $3 \cdot 10^{-5}$ mm Hg at 20°; it is heat-resistant up to 210°; it is resistant to alkalis up to pH 9; degree of purification is 95%. Baytex is soluble in the majority of organic solvents and practically insoluble in water. It does not decompose in light. The active substance – a brown liquid with a relatively weak odor reminiscent of the odor of garlic.

Baytex is effective with respect to a wide range of insects. Its insecticidal properties have been studied on 40 forms of arthropods. It can be considered a good substitute for DDT in those cases, when insects resistant to the latter are encountered.

Baytex is produced in the form of an emulsion concentrate, a 25% wettable powder, a 3% oil solution and 5% granules. The preparation is highly toxic to flies, mosquitoes, cockroaches, fleas and other arthropod carriers of infectious diseases when it is used at a rate of 1.7 g/m^2.

For house flies LD_{50}, when topically applied, is equal to 4.8 mg/kg. On filter paper (5 mg/m^2), on wood (1.2 g/m^2), on glass (1 g/m^2), on fired and unfired clay (1.5 and 1.7 g/m^2) complete destruction of flies is obtained.

The spraying of surfaces in dwellings, in cowbarns and other places where flies congregated with its emulsions or suspensions containing 0.5 g/m^2 of baytex, or its emulsions with the addition of 12.5% sugar decreased the number of flies for 13 weeks. The preparation is highly effective in all food baits.

According to Blasgues, in the laboratory on glass the effectiveness of baytex is retained for 12 weeks; on clay treated at a rate of 3 g/m^2 the mortality rate reach a total of 28% over a period of 4 days.

After applying the preparation at a rate of 1.1 g/m^2 to clay walls destruction of mosquitoes (Culex) was observed over a period of 30 days. Analogous results were obtained when it was applied to glass at a rate of 1-3 g/m^2. The duration of the residual action on glass was 155 days (Young). In living quarters at a temperature of 25° and humidity of 85% when it is used at a rate of 1 g/m^2 the duration of the residual action was 6 months. In the Congo after applying the preparation to surfaces at a rate of 0.4 g/m^2 the number of mosquitoes in the treated areas as compared to the control was 40 times less (Davis, Cerf).

In using granules to treat reservoirs, containing baytex, the latter retains its insecticidal properties for a week.

A study of baytex stability showed that in solar rays and in air it is completely converted into sulfoxide and sulfonic products of oxidation within 1-3 days; these products are rapidly decomposed into noninsecticidal compounds. Under the effect of heating baytex is rapidly converted into the S-methyl isomer.

Baytex possesses relatively low toxicity to fish, but high toxicity to mosquito larvae. Thus, for example, its concentration within the limits of 1:1,000,000 did not have a harmful effect of fries of Lebistes reticulatus peters fish after 48 hours of contact, whereas its concentration within the limits of 0.01 part per million during 24 hours of exposure is lethal for Aedes aegypti and Culex pipiens larvae in the stage before pupation. Baytex is highly toxic to imagoes, when it is used at a rate of 115 g/ha it results in the complete destruction of adult mosquitoes (Table 8).

Table 8. Comparative toxicity of certain insecticides to Culex mosquitoes, LD_{50}.

Name of preparation	Preparations (mg/ℓ)		Concentration (%)
	larvae	pupae	adults
Baytex	0.003	0.58	0.0009
Trithion	0.003	0.5	0.12
Diazinon	0.035	2.7	0.016
Malthion	0.031	3.1	0.009
Carbophos	0.021	2.8	—
DDT	0.23	—	—

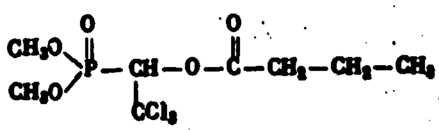
In houses treated with baytex there is complete destruction of cockroaches, bed bugs and fleas. American cockroaches die with the presence of 50 mg/m^2 of preparation on a surface. The preparation is not recommended for application in treating the interiors of living quarters, chicken coops, cow barns and those areas, where children or domestic animals come in direct contact with the treated surfaces. It is not necessary to wet asphalt surfaces, rubber, plastic materials very much with the emulsions and oil solutions of this compound. Baytex possesses considerable acaricidal properties.

In determining the systemic properties of baytex it was established that the administration to rabbits of 25 mg/kg and the planting of bugs, mites and ticks on them completely killed the former and only 59% of the two latter. When a dose of 10 mg/kg was used the arthropods did not die (Brady). Its toxicity to mammals is slight. It is highly toxic to birds.

The LD_{50} of the preparation when orally administered to hens and ducks is 15-30 mg/kg, for rats – 190-310 mg/kg, for guinea pigs – 260 mg/kg. When intra-abdominally administered to various animals the LD_{50} is from 125 to 325 mg/kg; when acting on the skin of rats – 330-500 mg/kg, when inhaled by rats – 2.4 mg/ℓ of air over a period of 60 minutes. Its toxicity is considerably lower than certain widely applied insecticides. Thus, for example, for rats the LD_{50} of lindane is 125 mg/kg for dieldrin it is 50 mg/kg, for diazinon it is 245 mg/kg, for baytex it is 310 mg/kg, for dipterex 450 mg/kg and carbophos 3140 mg/kg.

Butonate

Butonate – $C_8H_{14}PCl_3O_3$ – 0,0-dimethyl-2,2-trichloro-1-(n-butyryloxy)ethylphosphonate.



It is a colorless, somewhat oily liquid with a specific gravity of 1.3742. It has a slight ester odor. It is light-resistant and decomposes at 150°. It is not stable in an alkaline medium; it readily mixes with the majority of organic solvents: benzene, hexane, xylene, toluene, acetone, ethanol, methanol. In deodorized kerosene it dissolves within the limits of 2-3%. Butonate combines with the majority of the nonalkaline insecticides and fungicides. It is manufactured (abroad) in the form of oil solutions, emulsions, wettable powders and disinfecting powders. Butonate at concentrations of 0.8-2% is used to combat flies, mosquitoes, cockroaches and certain other insects.

When butonate is applied to glass at a dose rate of 0.6 g per m^2 its effectiveness with respect to flies is preserved for a week. When butonate is applied to plywood in the form of an emulsion, oil solution or wettable powder it provides complete destruction of cockroaches for 3 weeks. When it is used in the form of aerosols at a dose rate of 0.69 g/m^3 paralysis of flies occurs after 15 minutes (85%), and a mortality rate of 87% after 24 hours, in the composition of the aerosol there is 1.5% butonate, 0.2% pyrethrins, 0.5% piperonyl butoxide, 12.8% petroleum distillate and 5% methylene-chloride and propellant. When the solutions are sprayed at a dose rate of 0.4 mg/m^3, containing 1.2% butonate complete destruction of cockroaches was achieved. For practical application the following forms of the preparation are recommended: 1.5% butonate in aerosol form against flies and other flying insects; the solution for application to a surface is: 0.4-0.8% butonate by weight mixed with pyrenthrins and a synergist.

Butonate is only slightly toxic to mammals. When orally administered it is to a considerable extent removed from the organism of rats within several days; the preparation is decomposed primarily in the blood serum, liver and fatty tissue; it is a cholinesterase inhibitor — the suppression of this enzyme in the nerves of insects causes paralysis and death ensues. Atropine is used as an antidote. The LD_{50} for white rats is: when orally introduced 1100-1600 mg/kg, subcutaneously - 700 mg/kg, intraperiloneally - 700 mg/kg, on the skin - 7000 mg/kg; inhaling median doses 8 hours with 10-minute intervals does not have any effect, besides lowering the activity of cholinesterase by 73% in the erythrocytes and by 52% in the brain: with the presence in feed of 1% butonate a decrease in weight of 40-50% is noted as compared to the control.

Dow

The industry of the western countries manufactures two preparations: Dow-109 and Dow-105. Synonym O-(4-tert-butyl-2-chlorophenyl)-O-methyl-N-methylamidophosphate, ruelene.

Dow-105 - ethylamide-O-(4-tert-butyl-2-chlorophenyl)-O-methylthiophosphate. It belongs to the group of compounds called systemic preparations. It is used in controlling ectoparasites of birds and animals by dusting them, and also by introducing it internally with their feed.

When its 0.5-1% solutions are used on birds at a rate of 25 mℓ per bird complete destruction of mites and ticks is observed, whereas the destruction of lice and fleas did not exceed 50-60%.

To control animal ectoparasites Dow is used in the form of granules and solutions, which are administered to the animals with their feed, and also they are dusted with this preparation. With the oral administration of 10-15-25 mg/kg the destruction of the larvae of warble flies and lice on animals fluctuated from 76 to 100%.

After an oral administration to guinea pigs of 50-100 mg/kg of the preparation there was observed the destruction of 100% of the insects, feeding on the blood of these animals. An injection of the same preparation in the amount of 100 mg/kg causes the destruction of warble fly larvae.

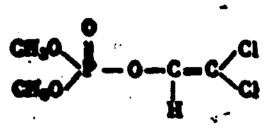
In combating the warble fly Dow is introduced into the animals subcutaneously and intramuscularly at a rate of 15 mg/kg. In certain animals after a subcutaneous introduction ataxia is observed, possible also as a result of the joint side effect: the disintegration of the preparation and the decomposition of the warble fly larvae. When animals are sprayed with a 0.5-0.75-1% Dow emulsion at a rate of 1-2 ℓ per animal 80-90% of the warble fly larvae died. Moreover, the residual effect of the insecticides was preserved for approximately 3-4 months.

Dow does not cause a noticeable suppression of the activity of blood cholinesterase and poisoning of animals. It was established that in 30-40% of the calves after the introduction of the preparation at a rate of 7.5 mg/kg poisoning symptoms were observed within 2 days – torpor, debility, poor appetite; with an increase of the dose to 15 mg/kg per day the symptoms were more expressed, but they disappeared after 24 hours.

Dow, like ronnel, promotes the development of immunity in animals treated with it, after destroying the warble fly larvae in one season in the following year a smaller quantity of them is observed on the animals.

DDVP

Dimethyldichlorovinylphosphate (DDVP) – $C_4H_7O_4PCl_2$.



Synonyms: dimethyl-2,2-dichlorovinylphosphate, 0,0-dimethyl-0-(2,2-dichlorovinyl)phosphate, vapona, dichlophos and others. Its molecular weight is 227.

The DDVP – a product of the dehydrochlorination of chlorophos (the latter abroad is called Bayer L-13/59 and dipterex). As a result of investigations it has been established that dimethyldichlorovinylphosphate is a highly toxic, volatile admixture of technical dipterex.

The DDVP is a clear, transparent liquid. Its boiling point is 57-60° at 0.3 mm Hg. Its vapor pressure 0.15 mm Hg at 20°.

The DDVP mixes completely with the aromatic hydrocarbon solvents, the chlorinated hydrocarbons, alcohols, freon No. 11; it dissolves poorly in diesel oil, kerosene, isoparaffin hydrocarbons, and mineral oils. The preparation is slightly soluble in water (about 1%), glycerine and freon No. 12. The DDVP corrodes black iron, soft steel, in the absence of humidity it does not corrode aluminum, nickel and stainless steel. Light polyethylene fabric is permeable to its vapors. It is hydrolyzed in the presence of water and is rapidly decomposed in the presence of strong acids.

In the Soviet Union DDVP was synthesized in the Scientific Research Institute of Fertilizers and insectofungicides in 1955. The preparation possesses high insecticidal properties, it is approximately equal thiophos, but in its toxicity to animals it is considerably inferior to it.

In its synthesis instead of the methyl radicals there can be introduced the ethyl radicals, but such a compound in its insecticidal properties is inferior to DDVP. From the preparation there are prepared 20% concentrates, oil solutions, water emulsions in petroleum solvents; the preparation is added to food baits (in solutions and granules). It is not recommended that the working solutions be prepared for storage, they should be applied immediately after preparation. The DDVP is highly effective when it is used to destroy a large number of insects, especially with respect to parasites in dwellings. It possesses systemic, contact, fumigational and intestinal action; its insecticidal properties vary depending upon the type of insects and the method of treatment.

The preparation possesses its highest insecticidal properties in the vaporous state.

Ye. V. Shanyder studied the insecticidal properties of this preparation with respect to 5 types of insect: house flies, rat fleas, body lice, bed bugs and common cockroaches.

As a result it was established that house flies were the most sensitive to the tested preparation (Table 9).

Table 9. Median lethal dose of dimethyldichlorovinylphosphate and chlorophos for insects when the preparations are applied in the form of alcohol solutions on the back of the thorax of each individual (according to Ye. V. Shnayder).

Type of insects	LD_{50} for each individual (μg)		LD_{50} per g of weight of the insects (μg)	
	dimethyldichlorovinylphosphate	chlorophos	dimethyldichlorovinylphosphate	chlorophos
House flies..........	0.015	0.4	0.75	20
Body lice............	0.09	3	45	1500
Bed bugs.............	0.022	0.05	5.13	11.65
Common cockroaches....	0.43	4	7.31	68

Kerosene considerably increases the toxicity of DDVP; its optimum insecticidal properties appear at a ratio of 1 part of insecticide to 10 parts kerosene. After such a mixture is applied to a surface at a rate of 1 $\mu g/cm^2$ of preparation after 3 hours there is detected in the air 0.534 μg and in the absence of kerosene – 0.360 μg.

Comparing the toxicity to insects of the tested preparation and chlorophos, it is necessary to note that the latter is considerably less toxic. Thus, to house flies the toxicity of DDVP exceeded by almost 27 times the toxicity of chlorophos, to body lice – by 33 times, to bed bugs – by 2.3 times and to common cockroaches – by 9.3 times.

The tests of the preparation, conducted on house flies, body lice, bed bugs and common cockroaches by the method of applying alcohol solutions to the back of the thorax of each individual, showed that after a year's storage the toxicity of the preparation decreased by approximately 2-2 1/2 times.

On neutral surfaces (glass) 100 mg/m^2 of the insecticide per m^2 when the amount of substance was decreased by one hald (50 mg) high lethal indices were also obtained (85-100%) after 3-5 minutes of contact.

The toxic effect of the preparation on flies appears very rapidly. Thus, for example, after 5 minutes of contact with surfaces (glass) treated with an emulsion at a rate of 0.1 g of substance per m^2 paralyses occur in 100% of the flies after 10 minutes, after contact with these surfaces for 1 minute complete destruction ensues within 10-15 minutes.

On absorbent surfaces (wood, wallpaper) the effectiveness of the preparation was somewhat lower. Moreover, on wood treated with an emulsion in the amount 0.1 and 1 g of substance per m^2 the mortality rate of the flies after 5 minutes of contact was respectively 87 and 100%, whereas on wallpaper at the same dosages unsatisfactory results were obtained – 38 and 59%.

With respect to other forms of insects (in particular, fleas) the insecticidal action of the preparation was considerably weaker.

The doses, which caused the complete destruction of bugs, cockroaches and fleas (after 30 minutes of contact) were 20 times higher than the doses, which completely destroyed flies after 5 minutes of contact. The available data showed that DDVP has a greater insecticidal action on house flies than on other insects, however it can also be used as an insecticide with respect to mosquitoes, fleas, cockroaches and wasps. For controlling cockroaches it is one of the best preparations.

Thus, for example, according to Keller, after the administration to the American cockroach of insecticides with a microinjector the LD_{50} after 24 hours was in mg/g: for DDVP – 0.74 mg/g, parathion – 1.29 mg/g, isoline – 6.4 mg/g, aldrin – 6.6 mg/g, dieldrin – 14.5 mg/g, heptachlor – 16.5 mg/g, endrin – 42.5 mg/g, carbophos – 40 mg/g, thiodan – 45.5 mg/g, DDT – 63 mg/g, chlordane – 130 mg/g, toxaphene – 134 mg/g. Inasmuch as DDVP possesses not only contact, but also fumigational properties, it is one of the best insecticides in controlling fleas in dwellings.

A test of the duration of the residual action of the preparation applied on a surface showed that it very rapidly loses its insecticidal properties. Thus, 2 hours after applying the emulsion to glass plate at a rate of 0.05 and 0.5 g of substance per m^2 85-100% of the flies died, when this same surfaces were stored under room conditions for 48 hours the effectiveness of the preparation decreased by 50% and after 72 hours the mortality rate of flies after 5 minutes of contact was 14-20%.

To reduce the rate of evaporation of the preparation and to increase the duration of its insecticidal effect on the surfaces we tested mixtures of this preparation with polychloropinene, which is a thick, viscous mass; it is manufactured by industry and is used to combat fly larvae, and it possesses a weak and rapidly disappearing effect on winged house flies. As a result it was found that a mixture of DDVP and polychloropine with the addition of the emulsifier [OP-10]·(ОП-10) (1:1:1) when applied on glass and surfaces painted with an oil base paint at a rate of 0.5 g of the tested preparation per m^2 killed 95-100% of the flies within 7-10 days. The addition of 0.3% dieldrin to the DDVP solutions prolonged the residual effect up to 30 days.

According to L. N. Pogodina, V. D. Larionova, O. M. Glozman, an application of the preparation in bait containing 10% sugar and 1% of the preparation in water is effective in combating flies for a period of 48 hours. To ensure a permanently low level of the fly population the authors recommend repeating the application of the bait every 2-5 days.

The best insecticide in dry baits for house flies is dibrome (in bait 0.25-0.5%). The basic attracting substance in the bait can be sugar, ground grain and so forth. Coloring the bait yellow, brown or pink improves, and coloring it black, dark-blue, orange or red decreases the attracting properties of the bait.

The DDVP can be used to destroy the larvae of house flies in the third instar. The action of the preparation was determined by the method of submerging the larvae in working emulsions (0.01, 0.03, and 0.1% concentration) for 5, 10, 20, and 30 minutes, after which the larvae were placed in a pure substrate (wheat middlings moistened by water), and by a method of treating the substrate where the larvae were situated for 48 hours.

The DDVP has a comparatively high larvicidal action, however its effectiveness with respect to the larvae of flies is inferior to the effectiveness of chlorophos, which provides complete destruction of the larvae after 48 hours when it is applied to the substrate at a rate of 10 mg per kg (at a humidity of 70%). Furthermore, there was noted its delayed toxic action on fly larvae.

It was estimated that in case of the free fall of drops with a size of 100 μ at 30° the evaporation of the active substance equalled 1% per m of fall. Drops of a DDVP solution in dioctyl phthalate lost their active ingredient even faster. The toxicity of the vapors has little significance as compared to the toxicity of the solutions.

The preparation possesses considerable volatility; its vapors are injurious to insects. Thus, in fly vivariums placed in glass jars the interior walls of which are covered with filter paper treated with an alcohol solution of DDVP at a rate of 1 g of substance per m^2, complete destruction of the flies was observed 1 1/2 hour from the beginning of the exposure. When technical chlorophos is used in analogous experiments the flies died within 3-4 hours.

In experiments with fly larvae the high fumigational action of DDVP was confirmed. However, in the rate of its toxic action on larvae this preparation did not differ from cholorphos vapors. When the larvae were exposed in a vapor zone of the tested preparation for 30 minutes the complete destruction of the insects ensued after 40-60 minutes. These data show that the accumulation of the insecticide vapors in a closed space (desiccator) up to a toxic concentration occurred considerably faster when the pure preparation was used than when the emulsion concentrate was utilized. If in the first case the effect of the vapors on the fly larvae for 30 minutes ensured their complete destruction after 40-60 minutes of exposure, with the use of the emulsion concentrate (under the given conditions of the experiment) there was only noted the accelerated pupating of the larvae, and the mortality rate was 3-5%.

Flune, studying the analogs and homologs of Bayer L-13/59 with respect to insects resistant to the chlorinated hydrocarbons, reported that DDVP was effective against the larvae of fourth instar mosquitoes in water at a concentration of 0.05 parts per million (this dose of the preparation is 20 times less than the dose of chlorophos, providing complete destruction of the larvae).

As a result of the application of the preparation as a larvicide in combating mosquito larvae by treating the water before flooding rice fields good results were obtained when the preparation was used in the amount of 0.05-0.1 part per million. Its residual action, however, did not exceed one week.

The peculiarities of DDVP can be (but not scientifically) well expressed by the following words: when DDVP is applied on the floor the flies die on the ceiling. Thus, for example, it was noted that in stables after the application of DDVP to the floor at a rate of 15 mg/m^3 house flies, stable flies and other diptera died within 2 1/2 hours, whereas common cockroaches and tobacco pests were unaffected. With an increase of the dose to 30 mg/m^3 after 4-5 hours 50% of the cockroaches died; at an expenditure rate of 60 mg/m^3 of preparation not only flies, but also cockroaches, and tobacco pests died within 18 hours. At 30° the volatility of DDVP is such that about 2-9% of the total dose was determined to be in the air several hours after spraying. Thus, for example, after spraying an aqueous suspension at a rate of 18 mg/m^3 8.4% of this preparation was ascertained to be in the air after 2 hours (Tracy). In connection with the volatility of DDVP when treating closed premises the volume of the letter should be taken into consideration.

When DDVP vapors get into the spiracles of flying insects including house flies and mosquitoes, their effectiveness is very high. It was determined that the LD_{50} for Anopheles quadrimaculatus mosquitoes was 0.007-0.02 γ per ℓ of air; under analogous conditions 95-100% of the flies (females) die in the presence of 0.05 μg/ℓ and more after 30 minutes of exposure. According to L. I. Brikman and L. N. Pogodina, when DDVP is sprayed in a chamber at a rate of 16 mg/ℓ the flies die after 15 minutes. The greatest effectiveness of DDVP is observed at a temperature of 31-36° and 58-90% relative humidity (Matson and Sedlak).

Inasmuch the concentration of DDVP in the air when exterminating mosquitoes and flies is low as compared to the concentration of DDVP causing toxic symptoms in people, the Committe on Insecticides of the Universal Organization of Public Health agreed with the fact that it is possible to combat mosquitoes in aircraft by vaporizing DDVP with special equipment in the presence of passengers. The Committe recommends that the vapors be applied in the cabin of aircraft during flight for 30 minutes.

The DDVP vapors, from an experimental vaporizer, passed through the ventilation system of an aircraft, provide effective results. About 50% of the house flies die after 18 minutes in the presence of 0.3 μg per ℓ of air. At these concentrations the presence of the preparation is not sensed by the passengers in the aircraft. The vapors leave rapidly disappearing deposits. With normal ventilation the preparation introduced into the air is gradually removed.

Analogous methods of combating flying insects can be used when exterminating them in living quarters and other premises. In Africa in houses with a volume of 30 m^3 and with a door and two windows cylinders (38 × 127 mm) containing 40 g of technical DDVP and 120 g of inert filler are hung up. With the door of the house closed and in the presence of one cylinder the destruction of 70% of the mosquitoes was observed for a period of 12 weeks. With the door open 4 such cylinders were required.

In England the Shell firm manufactures resinous cylinders impregnated with 30% DDVP, which in use give off the latter in the form of vapors. Such cylinders are called "vapona"; the weight of the cylinder is 100 g. The cylinder retains its effectiveness for 3 months.

Such cylinders, when placed in greenhouse with one cylinder per 30 m^3, after 15 hours cause the death of the imaginal stages of all greenhouse pests. The eggs and pupae of the latter remain viable. When the insects hatch from the pupae the treatment is repeated. During the time the greenhouse is being treated all the people working in it leave. It has been established that fumigating for nights in succession at a rate of 1 cylinder per 34 m^3 of botanical greenhouse with 2000 different plants does not have a phytotoxic effect.

The DDVP is also used for filling aerosol cylinders; it is put in the cylinders at concentrations of from 0.45 to 4%.

The aerosol mixtures are used in dwellings, restaurants, theaters, food plants, industrial enterprises and storehouses in the form of a 0.5% solution for combatting flies, fruit flies, cockroaches, ants and others. The DDVP is a unique preparation (a semi-volatile organic compound), which imparts to objects residual fumigational properties. Therefore, it is used basically in a mixture with plastic or waxy materials, which ensure its slow uniform emonation. When DDVP evaporates in this manner its concentration within the premises is at all times maintained at a level ensuring the destruction within 1-2 hours of all flying mosquitoes (at the same time this concentration in toxicity when inhaled by people is 100 times lower than the danger limits). The DDVP is used to heat rubber, which is used as a fumigational device for exterminating flies and mosquitoes in restaurants (manufactured by the Shell firm).

In treating restaurants, apartments, and also small premises it is not necessary to remove the people, but when treating large premises, factories, storehouses it is recommended that the people be removed. In storehouses and premises for animals, where the air is in a motionless state, the results were also good. Its application in a gaseous state outside a building was not effective (Asperen).

The DDVP is not a true fumigant like hydrogen cyanide or methyl bromide. Its molecule is relatively large. Probably for this reason DDVP vapors do not penetrate well into objects. Its vapors do not penetrate into grain stored in bulk, or into piles of bags with spices, beans, etc., even when the preparation is sprayed at a rate of 280 mg/m^3 with an exposure of 48 hours. Thus, for example, after treating coffee beans in bags with the indicated amount of DDVP a total of 50-86% of the insects there died.

The DDVP is readily adsorbed and is slowly desorbed by surfaces (as compared to gases). Usually with a singly spraying the effectiveness will be retained for 1-5 days after application. Porous materials, which readily absorb, retain the insecticidal properties for 3-4 weeks.

It can be used in combating the sheep botfly.

An insecticidal effect of DDVP aerosols outside chambers is observed close to the aerosol generator.

The DDVP is a direct inhibitor of cholinesterase; a survey of the extensive research on this question showed that it does not possess another mechanism of action and does not cause side effects.

The mechanism of DDVP action in insects and higher animals basically reduces to the fact that this preparation blocks cholinesterase; as a result of its effect on this enzyme an inert compound is formed — dimethylphosphoryl enzyme. Pure DDVP is a stronger anticholinesterase substance than chlorophos.

The toxicity of DDVP to vertebrate animals. It has been established that insecticidal doses of DDVP both under laboratory and also under practical conditions do not cause toxic symptoms in people or animals.

The DDVP to rats when orally administered is 10 times more toxic than chlorophos; the LD_{50} for male rats is 62-104 mg per kg, whereas after the administration of chlorophos it is 630 mg/kg. When the preparation is applied on the skin in the form of a solution in xylene the LD_{50} was equal to 75 mg/kg for female rats, for males it was 107 mg/kg.

The investigations of Durhhman and Hayes also show a median toxicity of the preparation to warm-blooded animals. Its LD_{50} for chicks administered subcutaneously in an oil solution was equal to 20 mg/kg and when orally administered in doses of 10-160 mg/kg the birds died after a day and paralytic symptoms were not observed in them. According to Durham, the LD_{50} of DDVP for female rats was equal to 60-80 mg/kg, whereas, according to other data, when intrabdominally administered the LD_{50} was 6 mg/kg. Treece established that the LD_{50}, when the preparation was introduced into the intact conjunctional sacs of rats was equal to 10 mg/kg.

Female rats with offspring were administered various doses of DDVP with a stomach probe. Doses of 10 and 20 mg/kg caused suppression of the cholinesterase of the erythrocytes (about 50%) without any clinical symptoms of poisoning. However, 30 mg/kg cause cholinergic shocks with subsequent recovery from it after 1-2 hours; in female rats receiving 40 mg/kg the shock was very severe, nonetheless in the experiment one animal survived 23 consecutive doses before its death.

On the other hand, the offspring of these animals did not manifest cholinesterase suppression in the erythrocytes or plasma, although they were fed the milk of their mothers during the whole period of the experiment (18-38 days). The average weight of the individual baby rats and the rate of their growth did not differ from the same indices in the control animals, where the offspring were fed the milk of mothers not subjected to the effect of DDVP.

After the oral administration of 1 mg/kg of DDVP to two dairy cows there was observed mild suppression of the cholinesterase in the erythrocytes, and when the dose was increased to 4.5 mg/kg there was noted considerable suppression of cholinesterase. With a subsequent increase of the preparation to 18 mg/kg considerable changes in the suppression were not noted. After the administration of 27 mg/kg of the preparation the cows manifested cholinergic shock, which lasted for 5 hours. When capsules with 1.8-27 mg/kg of DDVP were administered to cows 2 times per day for 30-60 days the death of the animals also was not observed, but with the administration of 40 mg/kg the animals died. When lethal dosages were administered to cows and sheep excessive salivation, labored breathing and rigidity of the legs are observed. In poisoned horses the predominant symptoms were pain in the stomach and general muscular weakness. It was noted that when the DDVP was administered with the feed the suppression of cholinesterase was less expressed than when it was introduced with the help of a probe. Thus, for example, with introduction through a probe symptoms of poisoning were observed from doses of 25 and 50 mg per kg whereas with the administration of these same doses with the feed toxic symptoms were not noted. Possibly, this depends on the action binding the feed to the preparation which causes its slower absorption into the organism from the stomach.

It is established that when orally introduced DDVP partially accumulates in the animal organism, in connection with which the LD_{50} increases by approximately 1/3. The toxicity of the vapors to animals is of little importance as compared to the toxicity of solutions.

In 5 horses subjected in a closed stable to the constant effect of 18 mg/m^3 of DDVP vapors for 22 days mild suppression of erythrocytic cholinesterase was noted; after 7 days of staying in such an atmosphere the activity of cholinesterase was restored between the 11th and 22nd days; the activity of plasma cholinesterase for the whole period of the experiment was normal. The toxicity of the preparation is almost identical both when applied to the skin and also when orally introduced. The appearance of symptoms of poisoning and their progressive development up until death proceeds rapidly in animals receiving a lethal dose; the animals surviving after taking DDVP recover very rapidly. A large difference was noted between the doses suppressing cholinesterase, and the dose causing illness. Thus, a concentration of DDVP at a rate of 50 mg/kg causes a definite decrease in the activity of plasma and erythrocytic cholinesterase in rats; however, these animals endure 1000 mg/kg in feed for 90 days without symptoms of intoxication. The LD_{50} for rats, when orally administered is 56 mg/kg.

The data presented with respect to the toxicity of DDVP to cows and rats show that DDVP itself does not penetrate into the milk of lactating animals even when the administered dose of the preparation exceeds the LD_{50} by 2-3 times. This attests to the fact that DDVP is rapidly detoxicated in mammals subjected repeatedly to oral administrations of sublethal doses.

The DDVP in the animal organism decomposes into 0,0-dimethylphosphate and 0-methyl-2-dichlorovinylphosphate, containing phosphorus, they are only slightly toxic and are rapidly eliminated or are subjected to further disintegration. With the urine there is excreted from 40 to 89% of the DDVP (from the administered dose) and with the feces - from 11 to 53%. The deposits in various tissues are 0.46-0.39 part per billion with the introduction of 1 mg/kg and 21.1-7.3 parts per billion with the introduction of 20 mg/kg.

During a study of the organs of rats, which died from multiple oral doses of DDVP and with the landing of house flies on these organs, under the conditions of the biological experiment, it turned out that the parenchymatous organs, with the exception of the stomach, were not toxic to the flies. The brains of rats, which had died 12-16 hours after the administration of DDVP, were also toxic to the flies; the death of the animals occurred 20 hours after the introduction of the preparation, then the brain also lost its toxicity.

Biological experiments on house flies have shown that DDVP mixed with the pulverized livers of rats (500 μg/g) after 18-20 hours of incubation at 37° was inactivated. This quantitative detoxification was also identical for the livers of pigs, cattle, cats and chicks.

No other tissue of rats, cats and chicks approached the rate of detoxification of the liver.

These data clearly show that the liver is an important center of DDVP detoxification in the organisms of mammals. Furthermore, on the basis of the data presented it is possible to draw the conclusion that DDVP does not accumulate in animal tissues and does not form toxic metabolites.

On the basis of the data obtained it is possible to draw the conclusions that the danger of DDVP poisoning is connected with the amount of dose taken, and not with the cumulation of the preparation in the body tissues after repeated exposures or with the metabolic changes of the DDVP molecule in the animal organism.

When a 0.5% solution of DDVP is used a concentration of 0.5 mℓ/ℓ of the insecticide is created in the air during the time of treatment. Such a concentration does not present a danger to people. Even in the case when the concentration is increased by 5 times as compared to the normal a dangerous situation is not created, because the amount of preparation in the air immediately after the treatment will be only 3.6 mg/ℓ, after 2 hours this concentration decreases to 1.5 mg/ℓ, and after a long interval of time - to 0.43-0.47 mg/ℓ.

The DDVP can be recommended for disinfesting aircraft at a concentration of 0.05-0.25 γ/ℓ with an exposure of 30 minutes. It has been established that DDVP concentrations of 0.9-3.5 μg/ℓ caused mild suppression of the activity of cholinesterase in the plasma both in people, and also in monkeys. At a DDVP concentration of 7.5-17.9 μg/ℓ of air there was noted in monkeys a marked suppression of the activity of cholinesterase in the erythrocytes and plasma, and also myosis; other symptoms of poisoning were not noted. According to Hays, man can endure concentrations of 6.9 μg/ℓ daily in short exposures and daily with 8 hours of exposure in the presence of 0.5 μg/ℓ of air without any symptoms of poisoning, with slight suppression of blood cholinesterase or even in a number of cases without noticeable suppression of its activity. In apes, subjected to the effect of DDVP vapors for 24 hours in storehouses treated at a rate of 20 mg/m^3 no expressed decrease in cholinesterase activity was noted.

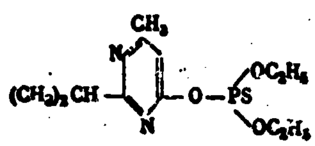
After people had stayed 39 times for 30 minute periods over a period of 14 days in quarters the air of which contained DDVP at a concentration of 140-330 mg/m^3 no measurable changes of cholinesterase in the plasma or erythrocytes were recorded.

According to the same author, doses of DDVP in the air of quarters within the limits of 56 mg/m^3 did not affect the activity of cholinesterase in the erythrocytes and plasma of humans. With an increase of the dose to 112 mg/m^3 an insignificant lowering of cholinesterase activity was noted. Also there were no changes in the level of erythrocytic cholinesterase in the plasma of 18 persons from 6 families subjected to the prolonged effect of vapors with 15 mg/m^3 of DDVP used for insecticidal purposes in their dwellings. The periods of daily exposure fluctuated from 3 to 18 hours and varied in duration from 4 days to 2 weeks during the period of the 4-month test. To analyze the cholinesterase periodically blood was taken from each person 2 times before the exposure to DDVP and 3-5 times during exposure.

In not one case was there noted any significant suppression of cholinesterase either in the erythrocytes or in plasma of the people in spite of the fact that the analyses of the cholinesterase in the drawn specimens were conducted in 3 different laboratories. And only after increasing the concentration of DDVP to 350 mg/m^3 did the effectiveness of cholinesterase begin to drop, although no toxic symptoms developed in the volunteers.

Diazinon

Diazinon – $C_{12}H_{21}N_2O_3PS$ – 0-0-diethyl-0-(2-isopropyl-4-methyl-6-pyrimidinyl)thiophosphate.



Synonyms: 0,0-dimethyl-(2-isopropyl-6-methyl-4-pyrimidylphosphorothionate); 0,0-diethyl-0-4-methyl-3-isopropylpyrimid-6-phosphate and others. Its molecular weight is 303,337.

Technical diazinon co[illegible]ins about 95% active substance; it is a dark-brown liquid with a mild ester-like odor. The pure substance – colorless liquid with almost no odor. The boiling point is 83-84° at 0.002 mm Hg. The vapor pressure at 20, 40, and 80° is equal respectively to 1.5×10^{-4}; 1.1×10^{-3} and 3.3×10^{-2} mm Hg.

The vapor pressure of diazinon is 5 times greater than that of thiophos. For the pure preparation the index of refraction is equal to 1.4978-1.4981. The specific gravity is 1.116-1.118 at 20°, for technical diazinon the index of refraction is equal to 1.4975-1.4985, the specific gravity is 1.11-1.12.

Diazinon is practically insoluble in water (0.004%); it is readily soluble in the majority of organic solvents and petroleum products; it readily mixes with alcohol and many other organic solvents. In an alkaline medium this substance is more stable than in acid. It is decomposed by lime, strong bases and acids.

The insecticidal properties of diazinon. Reports in literature about tests of the insecticidal properties of diazinon began to appear in 1951. As a result of the investigations it was established that diazinon possesses high insecticidal properties with respect to a number of erthropods. However the greatest number of works was conducted on house flies.

Diazinon has received broad propagation in combating flies. It possesses strong insecticidal properties. Basically it is a preparation of contact action, also possessing fumigational properties. An investigation of the insecticidal action of diazinon with respect to house flies, individually treating them with an acetone solution of the preparation on the anterior back showed its considerable superiority as compared to the chlorinated hydrocarbons (Ye. V. Shnayder).

According to March, the toxicity of diazinon to house flies of a natural population is equal to 0.06 μg per insect, whereas the chlorinated hydrocarbons were effective in the amounts: methoxychlor - 2.33 μg, heptachlor and chlordane - 2.9 μg. When diazinon is used not only the house flies die, but also stable flies, mosquitoes and their larvae. According to Ye. V. Shnayder, toxic doses causing the complete extermination of insects with the local application of the insecticide on each individual are as follows: for house flies - 0.35 μg, for body lice - 0.05 μg, for bed bugs 0.15 μg.

Under practical conditions diazinon like other organophosphorus insecticides began to be applied mainly to combat flies, particularly where, when the chlorinated hydrocarbons were used, there was not observed any decrease in the number of flies in connection with the appearance in them of a specific resistance to these preparations.

Diazinon — one of the most effective insecticides; when a 1% concentration was used to combat flies, applied at a rate of 0.4-0.5 g per m^2, good results were ensured for the whole season on dairy farms; when combined with methoxychlor diazinon ensured the extermination of flies for a month in the "peak" season. In horse stables its effectiveness was retained for 3-4 weeks.

In the Soviet Union in 1955 tests were carried out by Ye. V. Shnayder, V. A. Nabokov, M. A. Laryukhin and others on combating house flies which were resistant to DDT. According to their data, when an aqueous emulsion of diazinon was used to treat walls at a rate of 1-2 g of active substance/m^2 effective results were attained; the insecticidal properties were retained on the surfaces for 30-45 days. Diazinon, when applied to surfaces at a rate of 0.1 g per m^2, continued to remain effective with respect to house flies for a week.

Its insecticidal effect with respect to normal strains of insects which were resistant to DDT was not uniform. Insects, which were resistant to DDT (house flies, cockroaches), also manifested a somewhat increased resistance to diazinon.

In combating house flies diazinon has obtained broad recognition as an insecticide in food baits.

Ye. V. Shnayder showed that diazinon in baits containing 0.008% of the insecticide, exterminated 88% of the flies within 24 hours; complete extermination of the flies was observed when its concentration was 0.063%. Under practical conditions when the preparation was used to destroy DDT-resistant flies by applying liquid baits containing 10% sugar and 0.1-0.5% diazinon there was observed on the surfaces a decrease in the number of insects by 99% within 24 hours; during 3 subsequent weeks the mortality rate of the flies was on the average 96%. However, in places, where there was great production of flies, frequent treatments were necessary. Other authors have also arrived at analogous conclusions. Sweetened baits containing from 0.2 to 2% diazinon are used for combating flies on rubbish piles by spraying the latter every 3-4 days, however the best results are obtained with daily treatment. Also being used are baits in the form of granulated sugar containing 1% diazinon for controlling flies on dung heaps; a sharp decrease was noted here in the number of insects even after only 10 minutes. However, after the fifth application of the baits stable results are observed (the extermination of 61% of the flies). For combating house flies in places containing animals most effective are dry baits with diazinon, which are scattered on the floor. With the simultaneous application of diazinon in baits and as a contact insecticide more house flies die than with only the application of the baits.

In controlling house flies on premises used for public dining (kitchens, dining rooms), and also in animal quartering areas diazinon is applied by hanging up "antenna" cords treated with it. The cords (0.23 cm in diameter) are impregnated with a 25% solution of diazinon in xylene at a rate of 450-1800 mg of preparation per linear meter, and then hung up at a rate of 3 m per 10 m^2 of floor; the cords preserve their effectiveness for 2 weeks. Cotton strips treated with 10% sugar bait containing from 5 to 25% diazinone are also hung up; they have the same degree of effectiveness as the cords which are moistened daily.

According to Hansens, the application of diazinon to a surface in the form of a 1% emulsion exterminates flies in cow barns for 5-12 weeks, whereas a 0.5% emulsion retains its action for 7 weeks.

With respect to DDT-resistant flies diazinon preparations (powder, suspension) applied on surfaces, preserve their insecticidal action for 30-40 days. The effectiveness of diazinon and the duration of the preservation of its residual action depend on the physical properties of the surfaces; diazinon retains its insecticidal properties longer on porous surfaces (wallpaper, wood, paint), but it rapidly loses its effectiveness on nonporous surfaces (glass, stainless steel).

The duration of the preservation of the residual action also depends on the form of application of the preparation. According to some authors 1 g/m^2 of diazinon when used in the form of a wettable powder ensures complete destruction of the flies for 14 days. Toward the 21st day the effectiveness decreases and provides the destruction of only 45-54% of the insects. Emulsion at a dose rate of 0.5 g/m^2 toward the 21st day becomes completely ineffective.

According to other authors, the acute action of diazinon when used in the form of a wettable powder and emulsion essentially does not differ in the degree of effectiveness; the residual action of the emulsion is considerably better; on the average diazinon provides protection from flies for 30-60 days (Garcial, Granett).

Diazinon vapors possess a very strong insecticidal action. For example, if vivariums with house flies are placed for 30 minutes in a chamber, then 5 hours after its treatment with a 1% wettable powder of diazinon their complete extermination is noted, after 6 days 96% of the flies die, and after 21 days only 9.5%.

Diazinon possesses larvicidal and ovicidal properties. When eggs are placed on a substrate treated with a 25% wettable powder at a rate of 5 mg of diazinon per kg of substrate, the larvae did not hatch. When acting on third instar larvae of house flies an effective dose of the preparation is equal to 30 mg per kg of substrate, moreover all the pupating larvae do not develop to the imaginal phase. At the same time when DDT is used in the same quantities only 2% of the larvae die and 91% of the adult flies emerge.

The larvicidal effectiveness of diazinon depends on the form of application of the preparation, the most effective are oil solutions; complete destruction of larvae in laboratory experiments came after the addition to 1 kg of substrate of 25% emulsion – 3.9 mg and 25% wettable powder – 7.81 mg of preparation, whereas hexachlorane containing 35% gamma-isomer was effective only at an amount of 125 mg/kg.

For delarvating manure diazinon emulsions are also more effective than powders and suspensions. After spraying 100-200 $m\ell/m^2$ of diazinon emulsion from a sprayer (0.5-1 g of active substance per m^2 more) 99-100% of the house flies in chicken excrement died; when the dose was lowered to 0.25 g/m^2 the mortality rate was 60%. When 1 g/m^2 of preparation was used the fly larvae were observed to have reinvaded after 5-6 days.

The presence of ovicidal and larvicidal properties of diazinon was also established with respect to body lice, mosquitoes, flesh flies and others.

With respect to mosquitoes when 21.5 mg/m^2 of diazinon are applied on a surface 51% of the insects were exterminated. In combating Anopheles mosquitoes mixtures are used, consisting of DDT paste and diazinon at a rate of 0.17 g of diazinon per m^2; the residual action on surfaces is retained for 40 days. Diazinon is also effective in combating bugs and cockroaches.

When individual treating cockroach females the LD_{50} of diazinon is 0.33 μg, of chlordane – 2.3 μg, of dieldrin – 0.5 μg and of DDT – 13.5 μg. Diazinon is a completely effective preparation for combating not only cockroach populations which are sensitive to the chlorinated hydrocarbons but also those which are resistant to chlorinated hydrocarbons.

In combating oriental cockroaches diazinon can be used in the form of an oil solution of the preparation for treating their infestation sites. Atkins reports on the considerable sensitivity of bees to diazinon. The latter is highly toxic to gadflies and horseflies. It can also be used in combating orchard and garden pests.

For increasing diazinon effectiveness, especially in combating resistant insects, methods have been developed for increasing its insecticidal capacity and its preservation on surfaces by the addition of synergists (piperonyl butoxide, sulfoxide, butoxy-polypropylene-glycol and others). However, all these synergists have not found wide application, because they are expensive. Furthermore, mixtures containing diazinon and aldrin or carbophos can be used.

Resistance builds up to diazinon, just as to the other phosphorous preparations (ronnel, carbophos, dimethoate and others) after prolonged application. When diazinon is applied to the soil it is sucked in by the plants through the roots, spreads rapidly in them along with the juices and causes the death of pests eating the leaves or fruits.

To an equal extent the systemic action of diazinon manifests itself with respect to arthropod ectoparasites of animals. Getting into the organism of warm-blooded animals through the intestines or integuments, preparation is distributed in it with the blood and causes the death of bloodsucking ectoparasites. According to McGregor, a subcutaneous administration to guinea pigs of up to 5 m/kg of diazinon dissolved in peanut oil provides the complete destruction of larvae for 2 weeks.

With the oral introduction of 10 and 25 mg/kg of diazinon emulsion there was also observed the complete destruction of the larvae of this parasite for a week.

Diazinon, when sprayed on mowed grass at a rate of 10 and 100 parts per million, disappears rapidly when it is stored as ensilage as a result of fermentation; after 22 days of fermentation only 3% of the preparation remains. With the preparation present at such an amount in the feed of animals it was not detected in the fat of the latter.

<u>The toxicity of diazinon to vertebrates</u>. Diazinon was synthesized in the period, when the main attention of researchers was focused on obtaining organophosphorus compounds possessing along with high insecticidal activity a minimum of toxicity to warm-blooded animals. Nevertheless, it is not nontoxic to animals and man. When the preparation is to animals in gum Arabic with a stomach tube the LD_{50} is for mice 96 mℓ/kg, for rats 100 mℓ/kg, for guinea pigs 240 mℓ/kg, for rabbits 130 mℓ/kg, for hens 10-50 mℓ/kg, and for pigs 100 mℓ/kg. A certain dependence is observed between the form of application of diazinon and the degree of its toxicity; when emulsifying solutions were used the LD_{50} was equal for mice to 70 mm^3/mg, for rats to 220 mm^3/kg, when disinfecting powders were used – 122.5 mg/kg and 712.5 mg/kg respectively (Ofifi, Apte).

It is not more poisonous to warm-blooded animals than DDT, the LD_{50} of which is approximately 200-300 mg/kg. Diazinon is 10 times less toxic with respect to animals than thiophos, being at the same time equal in most cases in degree of toxicity to this latter with respect to insects, mites and ticks.

Certain data also exist about the toxicity of diazinon to man, when orally administered a toxic dose is 50 mg/kg (20-30 g).

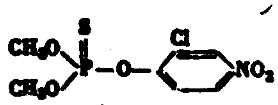
The daily (for 42 days) feeding of 6.5 mg/kg of 25% wettable powder of diazinon to dogs does not produce strong intoxication, but causes inhibition of cholinesterase formation. When 10, 100 and 1000 mg per kg of feed were employed they did not cause in rats symptoms of intoxication during a period of 72 weeks. The data of the experiment attest to the fact that diazinon does not accumulate in the organism.

Diazinon, when administered to a cow in a dose of 20 mg/kg, decomposes rapidly and is excreted with the urine. In the blood and milk there is detected only an insignificant amount of the unchanged preparation. After animals are sprayed only insignificant amounts of diazinon are detected in their fat for 12-14 days.

The comparatively low toxicity of diazinon to warm-blooded animals and also the absence of cumulative properties make it possible to apply it to combat the ectoparasites of domestic animals by spraying the animals, or by oral or subcutaneous introduction (Rodriguer, Grefor). Thus, diazinon is a very valuable insecticide and acaricide due to its high toxic properties with respect to arthropods and its comparatively low toxicity to warm-blooded animals.

Dicaptone

Dicaptone – $C_8H_9O_5PSNCl$ – 0,0-dimethyl-0-(2-chloro-4-nitrophenyl)-thiophosphate.



It is a white, solid, crystalline substance, unstable when heated (at temperatures above 100°). Its melting point is 51°. It dissolves poorly in water, it is slightly soluble at room temperature in methanol, ethanole, hexane and others. It is soluble (up to 25%) in xylene, cyclohexane, toluene and others. It is very soluble in acetone.

The insecticidal properties of dicaptone. Dicaptone is used to combat mosquitoes, flies, fleas, cockroaches, and ectoparasites of birds and animals. The preparation possesses a number of deficiencies: it has an unpleasant odor, colors certain surfaces a yellow color. Dicaptone is used to exterminate flies in the form of a 0.5-1-2% emulsion with the addition of attractant substances (liquid bait). In treating chicken coops with dicaptone emulsion at a rate of 10-15 g/m^2 the extermination of 93-95% of the insects was attained. When dicaptone is topically applied the LD_{50} for house flies is 0.08 μg/insect, and for the larvae of Anopheles mosquitoes the LD_{50} is 0.029 mg/ℓ.

The addition of sugar to the emulsion (10-12%, or 2.5-4.5 g/m^2) ensures the complete extermination of flies with the duration of the residual action, according to some authors, 11 days, and according to others – 6-8 weeks.

In combating cockroaches using a 1-2% emulsion their complete extermination is observed for 60 days. It is also effective with respect to resistant common cockroaches.

When the preparation was used in the form of a 2% emulsion at a rate of 4 ℓ per 100 m^2 the complete extermination of the flies was observed and the duration of the residual action was 24 days.

When it was used to destroy fruit flies at a concentration of 0.1% their mortality rate in their breeding places reached 97-100%, its residual action was preserved for 37 days.

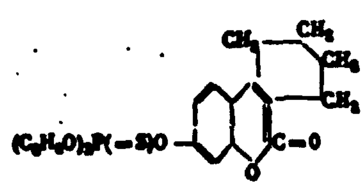
To destroy ectoparasites of birds and animals the 0.5% suspension, 0.25% solution and the 4% disinfecting powder of dicaptone were used, 25 mℓ was applied to each bird, and manure was treated at a rate of 50 g/m^2 of surface. Lice, mites and ticks were completely destroyed; the residual action was preserved for 105 days. After treating sheep with a 0.1% emulsion the mortality rate of the ectoparasites reached 100% and the duration of the residual effect was 6 weeks, moreover dicaptone colored the wool of the animals.

The toxicity of dicaptone to warm-blooded animals is low: when orally administered the LD_{50} is equal for mice and rats to from 400 to 1350 mg/kg with the introduction of 10% oil solutions and 171 mg/kg with the introduction of the 10-20% aqueous suspension. In dogs with a single oral dose of 200 mg/kg (in vegetable oil) the suppression of cholinesterase activity is observed; the application on the skin of guinea pigs for 18 hours of a dry dressing containing the preparation at a rate of 200 mg/kg did not cause harmful symptoms and the suppression of cholinesterase. After the administration to rabbits in the conjunctival sac of 0.1 mℓ of a 50% oil solution only mild irritation was observed. When it was introduced with the feed for 4 days at a rate of 200 mg/kg (oil solution) all the animals died; with the daily introduction of 100 mg/kg the animals died within a week.

When dogs were fed feed for 3-6 weeks (6 times a week) containing 10, 50, and 100 mg/kg of dicaptone they developed a progressive lowering of cholinesterase activity in the plasma and erythrocytes and symptoms of poisoning, the severity of which depended on the dose. These symptoms included salivation, ataxia, shortness of breath, depression, stomach disorder, and loss of weight. After the administration of the preparation was stopped all the symptoms disappeared and the condition of the animals returned to normal (W. Negherbon, 1959).

Dithione

Dithione - $C_{17}H_{21}O_5PS$ - O,O-diethylthiophosphoric acid ester of 3,4-tetramethyleneumbelliferone.



Synonym: O,O-diethylthiophosphate-7-hydroxy-3,4-tetramethylene-coumarin. Its molecular weight is 368. It is a white, crystalline substance with a melting point of 88-88.5°. The technical product contains 94-96% active substance; it is a large-granular powder of grayish color with a melting point of 85-87°. It is insoluble in water and partially soluble in organic solvents. The pure preparation is soluble in absolute alcohol, and upon the dissolution of the technical product at a 1% concentration a slight precipitate is formed. It dissolves in acetone with the limits of 21%, in benzene up to 40%: it is stable in an alkaline medium. Dithione possesses very low volatility. For example, in an experiment at 35° the loss in weight was barely 3% after 60 days. From dithione pastes are prepared. In Italy they prepare special preparations for combating flies, in the composition of which there is 18% technical dithione (approximately 17% pure compound), 5% technical rogor, 4.75% N-monomethylamide-O,O-dimethyldithiophosphoryl acetic acid, 48% technical DDT, 6.5% S 150 (synergist of DDT 4-chlorobenzylsulfone-N-methyl-4-chloroanilide), 22.5% dissolving and dispersive substances. This mixture received the name dithione-18. The latter is not used to treat agricultural cultures. It is especially recommended for the disinfestation of dwellings, industrial and agricultural installations for the extermination of flies (sensitive and resistant to chlorinated hydrocarbons), mosquitoes, spiders and other arthropods.

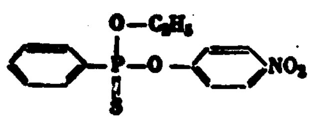
It is more effective than the other insecticides, when used for these purposes. In most cases it is possible to provide protection against flies for a whole year with a single treatment.

In preparing working solutions 1 kg of dithione-18 is dissolved in 15 ℓ of water. This is done in the following manner: first 1 kg of paste is diluted with a small amount of water (fresh) until a thick homogeneous suspension is obtained, then the remaining amount of water is gradually added with continuous mixing until the desired dilution of mixture is obtained. The liquid is applied on a surface at a rate of 2.9 g/m^2 (of preparation). This insecticide is not recommended for use in the disinfestation of bedrooms, school rooms, hospital wards and in general, premises, where people remain for a long period of time. Technical dithione possesses insignificant toxicity to warm-blooded animals. Thus, for example, when orally administered the LD_{50} for mice is 1820-1850 mg/kg, for rabbits – 450 mg/kg, for dogs – 400 mg/kg; when intravenously administered to mice 150 mg/kg of solution (in dimethylamide) kills 10% of the animals.

The toxicity of dithione-18 is somewhat different from the toxicity of technical dithione: when an aqueous suspension is orally administered the LD_{50} for mice is 615 mg/kg, for rats – 210 mg/kg, and when 2 g/kg are applied to the skin 20% of the animals are killed.

EPN

EPN – (ethylparanitrophenylbenzenethiophosphonate) – $C_{14}H_{14}O_4PSN$.



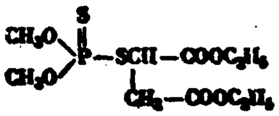
Synonym: ethyl-n-nitrophenylthiobenzenephosphonate. Its molecular weight is 301-303. In pure form it is white crystals, technical – dark transparent liquid. The boiling point of the pure preparation is 36°. The specific gravity (technical) is 1.268; refraction (technical) is 1.5978; at 20° the vapor pressure is $3 \cdot 10^{-4}$ mm Hg, at 100° – 0.03 mm Hg. It is completely insoluble in water, it dissolves in the majority of organic solvents, it is stable at normal temperatures in an acid medium, it is hydrolyzed in an alkaline medium.

Abroad it is manufactured in the form of wettable powder and emulsion concentrate, it possesses high insecticidal properties.

The preparation in its toxicity to mosquitoes is approximately 100 times higher than carbophos, it is also highly toxic to flies. It is used to exterminate pests of agricultural plants, in particular to combat the spider mite. Ethyl-n-paranitrophenylbenzenethiophosphate is highly toxic to animals. When orally administered the LD_{50} is equal for mice to 45 mg/kg, for rats – 5-40 mg/kg, for guinea pigs – 10-30 mg/kg, for dogs – 20-45 mg/kg. The larvae of Culex and Aedes mosquitoes die within 24 hours within the limits of 50% when 0.00064-0.00086 mg/ℓ of it is present in water. When EPN is topically applied the LD_{50} for the house fly is 1.9-2.0 μg/g (of the weight of the insect).

Carbophos

Carbophos – $C_{10}H_{19}O_6PS_2$ – 0,0-dimethyl-S-(1,2-dicarboethoxyethyl) dithiophosphate



Synonyms: malathion; S-(1,2-dicarbethoxyethyl-0,0-dimethylphosphorodethionate; 1,2-bis-(ethoxycarbonyl)-ethyl-0,0-dimethylthiophosphate; 0,0-dimethylthiophosphate of diethyl mercaptosuccinate; experimental insecticide 4049 (American Cyanamide Co.). Its molecular weight is 330.

In pure form it is a yellowish oily liquid; the technical preparation – a dark-brown liquid with a strong garlic odor; it contains 95-98% pure preparation; its melting point is 2.85° (purity 99%); its boiling point is 156-157° with insignificant decomposition upon boiling. Its specific gravity at 4-20° (technical) is 1.23; its index of refraction at 25° (purity 99%) is 1.495. Its vapor pressure is 4×10^{-5} mm Hg at a temperature of 30°; the saturated atmosphere holds 0.5 part per million; it is slightly soluble in water (up to 145 mg per ℓ); it mixes with the majority of utilized organic solvents; it is somewhat soluble in petroleum oils; it is rapidly hydrolyzed at pH greater than 7 and less than 5; it is stable in an aqueous buffer solution (pH 5.26); in the presence of alkaline compounds the acute action of carbophos almost does not diminish, but its residual toxicity considerably decreases. It is soluble in alcohol, ether, ketone, aromatic substances, alkylated aromatic hydrocarbons, vegetable oils, and in light petroleum oil (30-60°). Carbophos decomposes at 270°. A study of the stability of the preparations in light packing by the spectrophotometric method showed that of 100 different preparations containing carbophos more than half lose their activity after a year's storage. The compatibility of carbophos with fungicides and insecticides varies; it is stable when mixed with the majority of chlorinated hydrocarbons with the exception of toxaphene, but it is incompatible with calcium hydroxide and Bordeaux mixture.

Insecticidal properties. Carbophos combines low toxicity to mammals with extremely high activity with respect to phytophagous mites, lice, mammals and birds, aphidae, various insects, flies, sucking and gnawing insects, pests of fruits, vegetables and plants. At the present time it is one of the few organophosphorus insecticides recognized as sufficiently safe for broad sale to the population for the purpose of combating insects (Clark). Carbophos is toxic to insect with its contact action, through the intestine and by its fumigational action. It penetrates into plant tissues (through one side of the leaf surface).

Carbophos is produced in the form of a concentrate containing 35% technical preparation and 65% auxiliary emulsifier substance ([OP-7] (ОП-7)). The concentrate is a dark-brown liquid; it readily emulsifies with water. A 5% moisture content in the disinfecting powder does not have a negative effect.

A 5-15% water content in the emulsion concentrate has a negative action after 5 weeks of storage at 50° (it is decomposed by 40-78%). All emulsion concentrates not containing water under those same conditions for that same period decreased in effectiveness by 12%. Carbophos is also used in the form of a disinfecting powder containing 24% of the preparation (Rai). The addition of powdered metals to the disinfecting powder leads the considerable decomposition of carbophos. The most active effect is rendered by copper, lead, to a lesser degree by tin, zinc, iron. Many salts and oxides also considerably decrease the effectiveness of the carbophos in the disinfecting powder. After 2 weeks of storage of the disinfecting powders with the addition of $Hg(NO_3)_2$, $FeCl_3$, $Fe(NO_3)_2$, HgO, Cu_2O 96-100% of the carbophos decomposed, with the addition of $CuCO_3$, $CuCl_2$, CuO, $SuCl_2$, $(C_2H_6Hg)_2HPO_4$ its effectiveness was diminished by 71-78%. With the presence of $HgCl_2$ and $CuCl_2$ its effectiveness was diminished by 67-70%.

With the presence of $HgSO_4$, $CuSo_4$, $CH_3OC_2N_4$, HgCl carbophos after 2 weeks was decomposed by 52-56%. Without the addition of the indicated compounds the effectiveness of the disinfecting powder after 2 weeks had decreased by 5.2% (Mack, Simmons).

When the temperature increases the insecticidal properties of carbophos increase. Thus, for example, the [LD_{50}] ($ЛД_{50}$) for house flies at 26° was equal to 13 μg/g and at 17° LD_{50} – 19 μg/g.

Piperonyl butoxide is an antagonist of carbophos; when they are administered jointly to animals the degree of cholinesterase suppression decreases; this is not observed in common cockroaches.

When piperonyl butoxide is added to carbophos its effectiveness in combating insects is diminished, while with the addition of this synergist to chlorophos and diazinon their insecticidal properties are increased. When pyrethrins are added to carbophos their effectiveness is augmented (Johnson, Ouye, Rai, Sundershan).

The most effective synergists of carbophos turned out to be [DEF] (TBTΦ) (SSS-tributyl-phosphorotrithioate) and triphenyl phosphate: the former increases the toxicity of carbophos to resistant flies by approximately 50 times, and the second by 2-3 times (Plapp). Tritolyl phosphates intensify carbophos with respect to mosquitoes, but they do not intensify it with respect to flies. Triisopropyl phosphorotetrathioates conversely, intensify carbophos against flies, but do not intensify it against mosquitoes. The intensification of the activity of carbophos probably occurs as a result of the blocking of the insects' ability to detoxicate the oxygen analog of carbophos by the synergist.

The residual toxic effect of carbophos emulsion when treating wooden, plastered surfaces is brief - not more than 2-3 days in the summer season. It is not recommended that carbophos be applied in dwellings; it must not be applied on freshly whitewashed surfaces; this can only be done 14 days after whitewashing. Carbophos is a fast acting poison with respect to winged flies and their larvae. Irreversible paralyses manifest themselves in flies 5-10 minutes after, and in larvae 15-20 minutes after contact with the preparation emulsions. In regard to the toxicity of carbophos to house flies when topically applied the LD_{50}, according to some data, is 0.56 μg per fly, or 27 μg/g, according to other data, the LD_{50} is 2 μg per insect (Table 10); when sprayed the LD_{50} is 0.48 mg/mℓ calculating the mortality rate after 24 hours. For Fannia flies the LD_{50} with topical application is 0.06-0.1 μg per fly. When diazinon is applied the LD_{50} for house flies is 0.092 μg per fly.

Table 10. The toxicity of carbophos to insects when applied on the anterior back in the form of alcohol solutions (according to Ye. V. Shnayder)

Concentration (%)	Dose of active substance μg per insect	Destruction (%)			
		flies	lice	bugs	cockroaches
1	5	100	100	100	100
0.8	4	100	90	100	100
0.6	3	100	80	100	80
0.5	2.5	80	100	100	60
0.4	2	80	100	100	50
0.01	0.05		100	100	

In combating flies carbophos is mainly applied in places containing animals (dairy farms, pigsties and so forth). However, some authors do not recommend the application of carbophos on dairy farms and in other places, where food products are present, because of its unpleasant odor. When carbophos is used in treating surfaces the duration of the insecticidal action is retained for from 2 to 3 weeks.

In exterminating fly larvae in liquid waste materials (discharge from toilets and sinks) 1% (of technical preparation) water emulsions of carbophos are recommended at doses of 0.1-0.2 ℓ/m^2 of treated surface (1-2 g/m^2 of technical carbophos). Treatment is carried out once in 10-15 days depending upon the season and meterological conditions.

In exterminating flies in solid waste material (everyday rubbish, manure), when the waste material is 20-30 cm thick the carbophos emulsion is applied at 0.3-0.5% (by technical preparation) at a dose rate of 1-2 ℓ/m^2, 3-10 g of technical preparation per m^2.

In treating large amounts of solid waste material 10-12 ℓ/m^3 0.03-0.5% emulsion (30-50 g of technical preparation per m^3) are applied. The delarvation of solid waste material in receptacles of various types is carried out with emulsions of carbophos once in 5-10 days depending on the meteorological conditions, the periods of decontamination and the rate at which the receptacles fill up.

Good results were obtained with the use of a 2% water emulsion of carbophos in combating fly larvae in poultry droppings. Treating of soil with a carbophos emulsion is ineffective, because in its interaction with the soil carbophos is hydrolyzed and loses its insecticidal properties. Carbophos has not been observed to possess properties, which attract or repel insects.

Carbophos is widely applied as an intestinal poison for flies in the form of baits containing sugar or other attracting food substances. When applied to a surface the odor rapidly disappears. Baits containing a 0.5-5% carbophos emulsion and 12% sugar, when applied to the walls of cow barns and pigsties, retain their effectiveness for 3-4 weeks. Baits placed in various vessels preserve their effectiveness considerably longer.

Effective results are noted when carbophos is used mixed with molasses (carbophos 0.5-1%, molasses 1-5%).

A number of authors indicates that molasses, and also sugar causing the crystallization of the preparation, increase the toxicity of carbophos and increase the duration of its action. In combating house flies carbophos is also applied in the form of granulated baits. As carriers of the insecticide it is possible to use sugar, corn grains, various admixtures, etc. According to Kilpatrick, baits containing 2% carbophos do not attract and even repel flies. Carbophos possesses considerable larvicidal effects. According to Baker carbophos at a concentration of 0.25-0.95% is effective in combating fly larvae in animal corpses. For combating mosquitoes the Universal Organization of Public Health sanctioned the application of carbophos at an expenditure rate of 1.5-2 g/m^2. Such a treatment provides the protection of premises for 5 weeks. Guillin showed that carbophos as compared to lindane works 30 times more effective with respect to Aedes mosquitoes and 40-100 times more effective with respect to Culex mosquitoes. The absorption and subsequent inactivation of carbophos by clay walls limits its use in combating malaria on porous surfaces. Outside quarters the preparation can also be sprayed from aircraft.

For exterminating mosquitoes in the larval stages an emulsion or the insecticide in granulated form is applied at a rate of 600-800 g/ha.

Carbophos is highly effective in aerosol form (0.11-0.17 kg/ha), when used to exterminate A. taeniarhynchus mosquitoes. Its effectiveness in this case is higher than the effectiveness of diazinon, ronnel and dichlophos. When carbophos is topically applied for Anopheles mosquitoes the LD_{50} is equal to 0.0087 μg per insect.

According to Brown and others, when carbophos is used mosquito larvae rapidly develop resistance. Thus, for example, according to his data, by the 8th generation the resistance had increased by 6 times as compared to the initial generation. Cross resistance developed simultaneously for the following preparations (there is indicated in parentheses by how many times as compared to a susceptible strain): lindane (2-3), methoxychlor (3), sevin (5) [DDT] (ДДТ) (30). The resistance to DDT developed in an imago strain subjected to selection [breeding] malathion was analogous to the resistance of the larvae.

In connection with the fact that certain strains of body lice became resistant to DDT and gamma-hexachlorane, the need arose to seek a new effective preparation. Carbophos, as is known, is active with respect to lice at a 1% concentration; after the preparation is applied to linen it does have a toxic effect on people, who wear this linen. According to Barens, in the Seoul prison no toxic symptoms were noted for 200 persons, who were treated with carbophos to kill lice. The duration of the action of the disinfecting powder was retained for 4 weeks. After dusting the bodies and clothing of 89 persons 5 times a week for 8-16 weeks with 0.1, 5 and 10% carbophos disinfecting powder with talc filler no toxic symptoms were reported. The experiments showed that after two treatments of 30-40 g each per man of carbophos disinfecting powder with a 2-week interval between them the number of lice is reduced to such a level that the typhus cannot be transmitted from one person to other. Two such treatments are effective for the period of a year.

A method of treating vol[illegible]eers consisted of the following. Each given 90 g of disinfecting powder; they dusted one another after taking showers and after blood samples had been taken the dust covered the whole body, except the head, neck and genitalia, for which 25-30 g were required, the remaining amount was used to treat the clothing. After the treatment each washed his hands and forearms. In the urine on the average 1.8-3.3% of carbophos was detected (Heyes).

The complaints of people about the odor and skin irritation were approximately proportional to the employed dose of the preparation. Changes were not registered in the activity of blood cholinesterase with the exception of cases where the 10% disinfecting powder was used. The excretion of formed derivatives of carbophos with the urine was proportional to the preparation dose. Other changes were not noted, which could be ascribed to the effect of carbophos.

Carbophos can be used to combat the (Kantack) moth. Carbophos is highly effective in combatting animal ectoparasites, in particular of pigs and birds. It can be used to combat ectoparasites of chicks at the age of 9 weeks; turkeys at the age of 12-15 weeks can endure being immersed in a 1% solution of carbophos. When the concentration was increased to 2%, 25% of the birds died; all the others manifested symptoms of poisoning. Submersion in a 4% emulsion of the preparation kills all the birds. When bedding was treated with 4% carbophos disinfecting powder at a rate of 125-60 g/m^2 good results were observed in combating lice on hens for 5 weeks. It has been determined that when carbophos is used to treat bedding it does not diminish the hatching of chicks from eggs and no traces whatsoever of the preparation were detected in the eggs of the birds. Solutions containing 1% carbophos completely exterminate the ectoparasites of birds for a period of 49 days after the treatment. When 0.25-0.5% solutions were used worse results were observed (Rodriguez).

Carbophos differs from the organophosphorus insecticides in that arthropods die after a considerably extended phase of ataxia. Thus, for example, in cockroaches ataxia began to manifest itself rather rapidly, approximately after 30-60 minutes, but it was drawn out for a prolonged period of time. After the administration of 1 μg/g of the preparation the insects remained half alive for a period of 5 days. Insect resistant to the chlorinated hydrocarbons, retain their sensitivity to carbophos.

In agriculture it is used to combat pests of vegetables and grain as a contact poison and as a systemic poison. As a result of the application of carbophos more than 75 species of insects die on 30 species of plants or more. It is highely effective in combating flies, and pests of fruit trees and agricultural cultures.

Carbophos is effective with respect to small or intermediate citrus infestations at a dose rate of 1 kg of 25% wettable powder per 378 ℓ of water (the application is carried out after blossoming); it can be mixed with thiophos or various petroleum oils. It is relatively nonphytotoxic.

A positive property of this insecticide for agriculture is the fact that its residues on plants very rapidly decompose. When applied to vegetation it disappears within 3-4 days. The interval between the last application and the gathering of the harvest should be 7 days; for certain species harvested products 72 hours is sufficient. The amount of the preparation in the gathered harvest should not exceed 8 mg/kg. The application of carbophos has a noticeable negative influence.

N. M. Rusin, O. N. Vasil'yeva and V. G. Kharchenko conducted a hygienic appraisal of food crops treated with carbophos. The authors came to the conclusion that the application of carbophos to protect agricultural food crops is completely permissible under the conditions, that the products obtained from these cultures will not have an unpleasant taste and odor not characteristic of these species of products, and that the amount of residual carbophos will not exceed 5 mg/kg. Carbophos is widely used to combat insects – pests of stored products. When 8 mg of carbophos are present per kg of wheat its effectiveness is retained for 5 months; under the same conditions the effectiveness of the gamma-isomer of hexachlorcyclohexane is retained for a period of 15 months; with the presence of 4 mg/kg of the gamma-isomers of hexachlorane its effectiveness is preserved for 10 months. It has been determined that with the presence of carbophos in wheat in the amount of 8 mg/kg an unpleasant odor was not perceived; with the addition of 100 mg of carbophos per kg of grain the latter acquires an unpleasant odor. The wheat moisture has great significance; it has been established that 12% – the maximum permissible humidity. Carbophos rapidly decomposes on fruits and vegetables; 14 days after treatment the preparation is detected on apples, pears, and cabbages in only trace amounts. In the treatment of empty storehouses it is recommended that it be applied to surfaces within the limits of 1.5 g/m^2.

The mechanism of the action of carbophos reduces to the fact, that the metabolite in vivo suppress the activity of cholinesterase. Acetylcholine and acetylcholinesterase exist in the nervous systems of insects; the role of acetylcholine in the transmission of stimulation along the nerves has still been only studied to a minor degree in insects and in mammals, but the presence of cholinesterase in excess in the brain and nervous trunk makes it necessary to assume that it plays a large role in the nervous physiology of insects, although as yet there is no data about the role of acetylcholine as a neural synaptic mediator in insects, in connection with which there was advanced the assumption that not the choline, but some other esters can be in insects these synaptic mediators, which are decomposed by an enzyme capable of hydrolyzing acetylcholine. In suppressing cholinesterase carbophos is less active in vivo than many other organic phosphates. The death of an insect is observed, when the level of cholinesterase suppression reaches 57%. Ali-esterase is also rapidly suppressed in flies.

When an amount of the preparation is used, ensuring the survival of several individuals, the level of ali-esterase activity returns to normal within 24 hours (Plapp). Carbophos metabolism in higher animals, probably, to some degree is similar to its metabolism in insects.

The metabolic inactivation and elimination of carbophos in insects is less intensive than in mammals, which is explained by the great difference in toxicity in insects and higher animals. For example, when the preparation is administered intra-abdominally to chickens definite initial symptoms of intoxication are observed, but even 200 mg/kg do not kill them, which, obviously, can be explained by the elimination of the preparation by its intense inactivation (possibly, low absorption at the basic site of its effect).

According to data obtained in determining oxygen consumption in a Warburg's apparatus, the presence of organophosphorus preparations ([TEPP] (ТЭПП)) at a molar concentration of 1:100-1:10,000 stimulates the cytochrome oxidase of the coxal muscles of the American cockroach. However, carbophos and thiophos completely suppress cytochrome oxidase with the presence in dilution of 1:1000. The symptoms of the poisoning of cockroaches by carbophos are: hyperexcitability, after which there ensues complete ataxia (the beginning of ataxia occurs 30 minutes – 1 hour after the application of the preparation) with noticeable tremor at first of the whole body, and then only of the extremities. After the injection of 10 μg of the cockroaches remain in a moribund state for 5 days and respond to stimulation with tremor.

The respiration of cockroaches after an injection of a dose of 17-96 μg/g of carbophos is intensified in the beginning and subsequently marked reductions are noted in oxygen consumption.

This compound has attracted attention because its low toxicity to mammals and its rapid disappearance; however, it has turned out to be very toxic to certain wild animals, and also to fish.

Regarding the toxicity of carbophos to higher animals, it is one of the least toxic of the organophosphorus compounds - it is 100 times less toxic than thiophos, while its insecticidal properties are lower than the insecticidal properties of thiophos by 3-4 times.

The preparation does not possess cumulative properties. The toxicity of carbophos to warm-blooded animals when orally administered to a considerable extent depends upon its degree of purity, and also on the form and quality of the solvent. The LD_{50} of pure undiluted carbophos for male rats is 1850 mg/kg, while the LD_{50} of a solution of 65% carbophos in propylene glycol for male rats is equal to 369 mg/kg.

When cows are fed hay containing 800 parts of carbophos per million parts of hay, the latter is not detected in the milk.

In the animal organism carbophos is oxidized and converted into malaxon, which is a considerably more toxic compound than carbophos. The formation of malaxon in warm-blooded animals occurs mainly in the liver, to a lesser degree in the heart and, possibly, in the testicles; in cockroaches - in the fat bodies and midgut.

Along with the activation of carbophos in the organisms of warm-blooded animals and insects there occurs the hydrolytic decomposition of carbophos and malaxon with the separation of an ester of carboxylic acid. In mice malaxon is hydrolyzed in the liver, kidneys and lungs; in the cockroach hydrolysis occurs in the fat bodies. The lower toxicity of carbophos to warm-blooded animals as compared to insects is explained by difference in the rate of hydrolytic decomposition of malaxon. This hydrolysis in mice occurs faster than the process of the accumulation of malaxon obtained by the oxidation of carbophos. In the cockroach activation occurs more rapidly than hydrolysis, and therefore it accumulates in the organism up to the lethal level.

Carbophos aerosols are only slightly toxic to vertebrates. Thus, for example, in rats toxic symptoms are not noted with a one-time or two-time stay in premises, where carbophos exists in the aerosol state at a concentration of 60 mg/ℓ, with the exception of local irritation. A single administration of 95% technical carbophos in an amount of 0.05 mℓ into the conjunctival sac of a rabbit caused mild conjunctivitis. When the preparation is administered to rabbits for 2 years with their food containing 5000 μg/kg the animals remain healthy; these amounts do not inhibit growth etc. Males withstood food containing 1:10,000 for one year, and some withstood 1:20,000 for 2 years. In a microscopic examination of the organs of sacrificed animals no pathological changes were detected in them. When dogs ate food for 5 weeks, containing 100 mg/kg, no symptoms of poisoning were observed. Analogous data are also available with respect to cats. When dogs are administered a single dose of [EPN] (ЭПН) and carbophos a 50-fold increase in the toxicity of these preparations was noted. The increase in toxicity was somewhat less expressed with respect to rats.

The carbophos absorbed by the tissues is eliminated from the organism within a week. Certain organophosphorus compounds, including carbophos, are used against parasitic skin disease in sheep. After a double treatment with a 1% solution of the preparation with weekly intervals of 2 pigs, 3 sheep and 3 goats symptoms of intoxication were not observed. A week after the second treatment the animals were sacrificed. No deposits of the preparation were detected in the organs and tissues of the pigs; in the tissues of the other animals there were small deposits: in the flesh of the sheep there was 0.1-0.08 mg/kg, in the flesh of the goats there was 0.02-0.05 mg/kg; in the omentum of the sheep the amount of preparation was 0.07-0.41 mg/kg, and in the omentum of the goats — 3.2 mg/kg; in the kidney fat of the animals no deposits were detected (Roberts and Mattson).

After 26 treatments with a 0.5% solution of carbophos at weekly intervals the fat taken for cows a week after the last treatment did not contain noticeable amounts of the insecticide. After treating dairy cows with 0.5-1% carbophos there was detected in the milk 5 hours after the treatment 0.08-0.36 mg/kg of the insecticide, after 24 hours - only traces, and after 7 days the preparation was not detected at all.

Symptoms of poisoning also were not observed after dusting with 25% disinfecting powder for a period of 14 days. The pharmacological action of carbophos manifests itself in the suppression of cholinesterase with explicit toxic symptoms after the administration of large doses. Dipping cats in a liquid containing 0.3% carbophos did not harm them. A lethal outcome occurred in one case, when a 4-month old kitten was immersed in a 50% emulsion of the insecticide.

Laboratory animals after an administration of the preparation manifested excessive salivation, depression and tremor. With the administration of lethal doses these symptoms were accompanied by coma and death. With lethal [sic] doses the symptoms were observed for a brief period, and complete recovery ensued rapidly. The return of cholinesterase to the normal level requires considerable time even after the disappearance of the evident symptoms of poisoning. When chickens and mice were administered radioactive-phosphorus labled carbophos 60% of the carbophos was excreted with the feces within 2-4 days; 75% within 5-6 days; 97% of the excreted radioactivity was in the form of water-soluble metabolites - products of decomposition. The maximum amount was less than 3% of the swallowed amount.

When working with carbophos the basic danger is the absorption of the compound through the skin, therefore it is obligatory that workers' hands be protected and, when the work is done, washed thoroughly. The early symptoms of poisoning are headache, nausea and fatigue; later myosis, vomiting, diarrhea and convulsions appear.

During prolonged work with it there is observed a decrease in cholinesterase by up to 30%, which can cause poisoning. Wolter cites a case of the poisoning of a 35 year old housewife, who drank about 450 ml of 3% carbophos (in tolune + xylene). After 3 hours she was admitted to a hospital: on the way she lost consciousness; her pupils constricted and did not react to light; poisoning was also noted in the cardiovascular and nervous systems; her leg muscles were flaccid and without deep reflexes; her breathing was normal; there was vomiting; the patient was administered 1.2 mg of atropine subcutaneously and 0.4 mg of atropine through a stomach tube. The patient regained consciousness 3 hours later. She was released from the hospital after 13 days.

Healy cites a case of the poisoning of an 18-month old boy, who had been kept for 6 weeks in a yard which had been treated with carbophos. Besides the amount of poison which had been absorbed through the skin and which had gotten in through the respiratory tract, a certain amount of the preparation had been absorbed by eating the buds of plants which had been subjected to treatment.

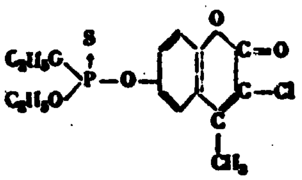
Soon after the beginning of the application of carbophos the boy became irritable and his appetite fell off. After a week he developed a fever. After 6 weeks he had lost 3 kg in weight; he developed polydyspepsia; he began to drag his feet and fell down frequently. Several days after entering the hospital complete paralysis of the legs set in, which then spread to the trunk and arms. His systolic blood pressure increased up to 210 mm Hg station. The subcutaneous administration of atropine every 3 hours (1.2-2.4 mm/day) was prescribed; then for a period of several weeks he was administered 1.2 mg of atropine per day without exhibiting any side effects. The reaction manifested itself almost immediately, and movement was finally restored.

The preparation is excreted from the organism with the urine in the form of products of decomposition mainly in the first 3 days after it has gotten into the organism and on the 3rd day in the form of traces. Investigations have shown that the daily application of 10% carbophos disinfecting powder on the skin of a man for several weeks only causes minor irritation. Data of other authors are also available on the toxicity of carbophos to people.

The following maximum permissible concentration of the preparation in food products were established in the United States: in eggs and milk - zero parts per million, in meta and meat products - 4 parts per million, in fruits and vegetables - 8 parts per million, in air - 15 mg/m^3.

Co-Ral

Co-Ral - $C_{14}H_{16}ClO_5PS$ - 0,0-diethyl-0-(3-chloro-4-methylumbelliferome)-thiophosphate.



Synonyms: Bayer 21/199.

Co-Ral is used in the form of disinfecting powders, emulsions and solutions. It is employed to combat the ectoparasites of animals. It is also utilized to exterminate flies, mosquito larvae and fleas. In a study done on co-ral in the laboratory with a test on small wooden boards, on which 1 g/m^2 was applied, complete destruction of the insects was observed for a period of 56 days. In treating animals with a 1% solution of co-ral at a rate of 2 g/m^2 with the addition of 3-4.5 g of sugar per square a mortality rate of 88-93% is attained for flies; the effective action lasts for about a week. An attempt to treat cow barns by a patch method, and not completely, with a co-ral emulsion at a rate of 0.5 g/m^2 did not yield satisfactory results.

In a case of treating manure in poultry yards at a rate of 1-5 g/m^2 complete extermination of flies was observed for 52 days. The addition of synergists to the bait did not increase the effectiveness. As a result of the application of radioactive co-ral to the larvae of Anopheles and Aedes mosquitoes it was established that with the presence of 0.03 mg/ℓ on the substrate and with the absorption by each larva of 0.0033 μg complete extermination of all mosquito larvae is attained for 48 hours. For combating fleas in yards and infested premises (kennels) 1% solutions are used at a rate of 4 ℓ on 100 m^2. Under such conditions complete extermination of the fleas was noted; the duration of the effect was 63 days.

In treating birds to combat their ectoparasites with 0.1-0.25% co-ral solutions (25 mℓ per each bird) complete destruction of the lice and ticks is observed. Co-ral is also used to exterminate ectoparasites of animals. The basic method of employment - the treating of animals with solutions of the preparation. Under laboratory conditions the possibility of oral and subcutaneous administration of co-ral was studied; guinea pigs were each given 25 mg/kg in the form of a suspension or solution, after which bugs and ticks were planted on them. The former were completely exterminated but the ticks did not die.

Co-ral possesses considerably systemic action. According to Viskery and Arthur, after co-ral was administered to rabbits at a rate of 50 mg/kg the bugs and ticks feeding on the blood of the rabbits died. When 200 mg/kg was applied on the skin the ticks remained alive, and the bugs died. The highest percentage of tagged radioactive phosphorus in the blood of rabbits and the maximum systemic toxicity to bugs were observed during the first day. When orally administered the maximum amount of the preparation in the blood was observed after an hour, and when cutaneously applied - after 24-30 hours.

This preparation is also used in combating warble flies, for which a device exists, with which the animals are rubbed every 2 weeks in treating them with a 0.25% oil solution of co-ral. And favorable results were obtained with this method; the duration of the action was approximately 30 days. Small sacks with disinfecting powder are also used; in each of them there is poured 0.5 kg of the preparation, and then they are attached (14 pieces) to a wire, stretched along a narrow passage for the animals; a herd passing along this passage brushed against the sacks and is "self-dusted." The duration of the action of such treatment can be as much as 5 weeks.

For spraying animals suspension of co-ral are mainly used at concentrations of 0.1-0.25-0.5-1%. The normal expenditure fluctuates from 2 to 8 ℓ per animal. The mortality rate of the ectoparasites can be as much as 94-100%. Thus, in treating cows with a 1% suspension of co-ral at a rate of 8 ℓ per animal complete extermination of the ticks was obtained, after which the number of ticks was held at a low level for 2-3 months. In spraying animals a 0.75% suspension with a nonionic surface-active substance is also used. Such a mixture is applied on the sides and backs of animals at a rate of 4 ℓ per animal, as a result the destruction of 90-99% of the warble flies (Hypoderma) was observed. In treating sheep at a rate of 2 ℓ per animal (0.1% co-ral) complete extermination of the parasites was attained; the duration of the effectiveness lasted 6 weeks. Positive results were also obtained when it was used in combating gadflies.

The same results without deposits were obtained after bathing the animals (a herd) in a suspension containing 0.25% of the preparation (prepared from 25% wettable powder). The effectiveness was retained for 3 weeks, but if it rained within 5 days the effectiveness of the preparation was retained for not more than 7 days. Hann and others cite a description of 6 cases of calves dying after they were treated with a 0.5% wettable pow...

Co-ral is also used to protect calves from warble flies and lice. According to Drummond, the topical application and the intramuscular administration of small doses of co-ral provide better results in controlling warble flies than the normal method of application.

The duration of the protection of sheep from Phormia regina fly larvae (0.5% suspension, 1.1 ℓ per animal) was 2-3 weeks. With any method of treatment the animals did not manifest toxic symptoms. A study of the sensitivity of house flies to various insecticides showed that under laboratory conditions and with selection the resistance to co-ral by the 50th generation was 90 times greater than the normal resistance. In determining the LD_{50} for a normal strain of flies it was established that for susceptible individuals it was equal to 0.096 μg per fly (when the preparation was topically applied on the back of the insect), while for a resistant strain it was 0.23 μg.

A study of the mechanism of the action of co-ral with respect to house flies and warble flies of cattle showed that in the insect organism the preparation is activated as a result of decomposition. In warble flies this is connected with the fat bodies and intestines. The activating system is less expressed in fly larvae than in the imago. The LD_{50} for flies is 1.5 mg/kg. When co-ral is orally administered to animals to combat warble flies it does not yield positive results, obviously, because the liver playing the basic role in the metabolism of the preparation in the animal organism decomposes the preparation before it reaches the larvae; when co-ral is applied on the skin it is effective and the larvae die before they get into the liver.

The feeding of animals (for 6 weeks) with grain and grass dusted with co-ral containing 0.5 mg/kg causes the death of Musca autumnalis, which bite animals. The excrement of the latter was toxic to house flies.

The addition of a synergist (piperonyl butoxide) in a 1:5 ratio (synergist co-ral) increases the toxicity of the preparation by 4-6 times with respect to mice, but in connection with the fact that piperonyl butoxide promotes better distribution of the poison in the tissues of the organism, this points to the fact that the synergist blocks the metabolites of co-ral and increases its toxicity, which was established by using the preparation tagged with radioactive phosphorus.

Toxicity. With the oral administration to warm-blooded animals of 10-20 mg/kg of the preparation for a period of 7 days approximately 38% of it is excreted with the urine and about 35% with the feces (Hopkins). After the oral administration to white rats of 20 mg/kg of preparation tagged with radioactive phosphorus about 78% of the dose was excreted with the urine within 24 hours; the preparation was also detected in the feces, bile, lymph and blood; a small amount was detected in the bones, liver and kidneys. The meat of pigs killed after being treated with a 0.5% co-ral emulsion does not have an odor. The odor of the meat from the ribs and the odor of the kidneys are also not changed. However the odor of the liver of animals treated with the preparation differs considerably from the odor of the control animals.

In chickens the greatest deposition of the preparation was noted in the liver, kidneys and eggs. When co-ral is applied to the skin of rats, cows and goats at a rate of 30-45 mg/kg it is detected in amounts of from 0.2 to 0.5 mg/l in the brain, gallbladder, heart, lymph nodes, spleen, etc.; more than 0.5 mg/l in the ribs, mammary glands, kidneys, liver, urinary bladder (Krueger). The cholinesterase level in cows decreases up to the 7th day, and toward the end of the 2nd week returns to normal, whereas in goats such a phenomenon was not observed. O'Brien showed that in mammals the preparation is mainly decomposed in the liver. In mice, which are sensitive to this preparation, its disintegration was delayed; in animals resistant to this preparation (bulls and rats), its disintegration occurs considerably faster than in mice. The LD_{50}

for an intra-abdominal administration of this preparation for mice is 23.5 mg/kg, for rats when it is orally administered the LD_{50} is 41 mg/kg for males and 15.5 mg/kg for females, and when cutaneously applied – 160 mg/kg.

The ability of rats to decompose co-ral into water-soluble products more rapidly and more completely than this is done by insects is, probably, an important factor in the selective toxicity of co-ral. The calorimetric method is used to determine the amount of co-ral in animal tissues.

Mercaptophos

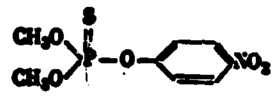
Mercaptophos – $(C_2H_5O)_2 \cdot PO \cdot SC_2H_4SC_2H_5$ – thiol isomer; a thione isomer – $(C_2H_5O)_2PS \cdot OC_2H_4SC_2H_5$, diethyl-β-ethylmercaptoethyl thiophosphate.

Synonyms: vnuran, systox, demeton, E-1059 and others. Both the thione and also the thiol isomer of diethyl-β-ethylmercaptoethyl thiophosphate are achromatic or slightly yellowish liquids with unpleasant odors. They are manufactured in the form of a 30% concentrate. It is designed mainly for application as a systemic acaricide and insecticide to destroy pests of agricultural plants. Due to its high toxicity to warm-blooded animals it is not used to combat parasites of man or pests in his dwellings (S. A. Zhuravskaya, N. I. Mel'nikov and others, P. Ye. Radkevich, M. A. Trotsenko). The lethal dose of the thione isomer for rats when orally administered is 7.5 mg/kg, and of the thiol isomer – 1-2.5 mg/kg. Source materials describe a large number of cases of poisoning in man and animals with this preparation.

Metaphos

Metaphos – $C_8H_{10}O_5PSN$. Metaphos is conventionally called 0,0-dimethyl-0-(4-nitrophenyl) thiophosphate, or 0,0-dimethyl-0-p-nitrophenyl-thiophosphate. It is the methyl analog of thiophos

(0,0-diethyl-0-p-nitrophenylthiophosphate).



Synonyms: wofatox, methylparathion, E-605, dimethylparathion, methyl homolog of thiophos, metacide (which is a mixture of 24.5% methylparathion, 6.2% parathion, 66.6% emulsifiers and others).

The technical preparation has the form of an oily liquid, from yellow to dark-brown in color, a sharp odor similar to garlic. In its pure form metaphos is a white crystalline substance with a melting point of 35-36.5°, a boiling point of 158° (at 2 mm Hg); it crystallized at 29°, its density at room temperature is 1.358, the index of refraction is 1.5515, the vapor pressure is 109° at 0.5 mm Hg; its volatility at 20° is 0.14 mg/m^3. It is readily soluble in the halogen derivatives of the aromatic series (dichlorethane, carbon tetrachloride, chlorobenzene and so forth) and the auxiliary substances OP-7, OP-10. It is only slightly corrosive to metals. The aqueous suspensions with neutral reaction in storage are stable for several days.

Metaphos is compatible with arsenites, rotenone, pyrethrins, nicotine sulfate, in its toxicity and insecticidal properties it has a close similarity to thiophos (parathion).

From metaphos liquid concentrates, wettable powders and disinfecting powders are prepared. A suspension of disinfecting powders in water preserves its stability for several days. Metaphos in the form of 2.5% disinfecting powder is conventionally called wofatox.

Metaphos is rather widely used abroad to combat pests of agricultural plants. According to source material, the toxicity of metaphos to certain insects exceeds the toxicity of thiophos; thus, to weevils metaphos (Malbrunot) is 10 times more toxic than thiophos (Metcalf). Honey bees and locusts are very sensitive to this preparation. Metaphos also possesses considerably insecticidal properties with respect to such insects, as house flies, mosquitoes and others.

In the Soviet Union metaphos is mainly used to combat pests of agricultural plants. The preparation is especially effective in combating aphids, boll weevils, plant mites, etc. The preparation in the form of disinfecting powder (wofatox) is also employed in combating harmful shield bugs – on wheat crops (30 kg/ha). V. A. Babenkov recommends the use of wofatox is poisoned bait form for controlling these insects. The preparation is also successfully utilized to control pests of vegetable cultures.

To house flies metaphos is 20 times more toxic than carbophos. With local application an an insect the LD_{50} of metaphos is 1.3 μg/g of flies, and of carbophos – 27 μg/g. A. quadrimaculatus larvae (4th stage) die with the presence in water of 0.005 mg/ℓ of metaphos. This dosage is almost half the dosage of diazinon necessary for the complete destruction of these larvae. It can also be used for the destruction of mosquito larvae at a rate of 120 g of technical preparation per hectare.

A characteristic peculiarity of metaphos is its high toxicity with respect to parasites of man and pests in his dwellings. Minimum doses of the preparation causing complete destruction of flies, mosquitoes, fleas, bugs, cockroaches and lice on various surfaces are within the limits of 0.01-0.7 g of insecticide per m^2.

The effectiveness of metaphos to a considerable degree depends on the properties of the treated surface. Its greatest toxicity is noted on glass: doses of 0.01-0.03 g of active substance per 1 m^2 provide the complete extermination of all insects. To obtain an analogous effect on such surfaces, wood and plywood, covered with oil base paint, and others, it is necessary to increase the rate of expenditure of the preparation by 5-30 times. The greatest amount of metaphos aqueous suspension is required for application on porous and plastered surfaces; the rate of expenditure of the preparation, causing complete destruction of the insects, in this case must be increased by 20-60 times as compared to the rate of expenditure on glass.

The residual effect of metaphos (when treating at a rate of 0.5 g/m^2 of active substance) is retained for more than 3 weeks. After 15 minutes of exposure body are completely exterminated on fabric impregnated in a 0.085% solution. When a 0.0017% solution is used to impregnate fabric 93% of the lice die.

Metaphos possesses low ovicidal properties. The immersion of pieces of fabric with lice eggs in a 0.1% aqueous suspension of the preparation for 5 minutes causes the death of 30% of the eggs; increasing the concentration of the preparation to 0.5% increases the mortality rate of the eggs to 40%.

House fly larvae have been found to be very sensitive to metaphos. When it is added to a substrate at a dose rate of 7.5 mg/kg (wheat middlings with a moisture content of 66%) third-instar larvae were completely wiped out after 48 hours; as a result of the application of a dose of 2.5 mg/kg the same mortality rate was provided after 96 hours (Bordas and others).

According to S. F. Suz'ko, metaphos possesses significant acaricidal properties. It has been demonstrated that a 0.05% emulsion, a 0.075% suspension and 2.5% disinfecting powder possess well-defined contact acaricidal properties with respect to Ix. ricinus in the imaginal stage. The mortality rate of mites and ticks depends on the degree of their saturation. Five days after an application of metaphos grass, according to certain authors, was not toxic to large animals.

In comparing the insecticidal properties of metaphos and chlorophos it is noted that the activity of metaphos with respect to insects exceeds the toxicity of chlorophos by 2-10 times depending upon the species of insects. An advantage of metaphos as compared to chlorophos is high effectiveness of its aqueous suspensions on porous (absorbent) surfaces (wood, wallpaper, plastering), on which chlorophos in an analogous form provides the complete destruction of insects with doses 4-6 times higher than metaphos. Metaphos is employed to combat bugs at a rate of 3 g/m^2.

Metaphos is recommended for exterminating insects in granaries. Before carrying out the extermination process necessary repair work and thorough cleaning of the granaries should be conducted and also the adjacent territory should be rid of the rubbish, dust, straw, and remnants of grain and forage. For a distance of 2-3 m around the storehouse the grass should be removed.

The cleaning of the storehouse is one of the main preparatory operations for the successful application of the insecticide. Furthermore, the sub-floor space should be cleaned of spilled grain, after which the sub-floor space is covered with 2 cm of freshly slaked lime or dusted with metaphos disinfecting powder DDT or hexachlorane at a rate of 50-100 g of disinfecting powder per m^2.

The extermination of insects in empty granaries with an emulsion or suspension of metaphos is carried out 2-4 weeks before they are refilled.

When using an emulsion the concentrate of the latter is diluted to 0.1% (100 g of 20% concentrate per 100 ℓ of water). In preparing large quantities of metaphos emulsion 100 g of the concentrate are first well mixed with 3-5 ℓ of water; lacking the emulsion concentrate disinfestation is carried out with a 3% metaphos suspension (3 kg of 2.5% disinfecting powder per 97 ℓ of water).

The working liquid at a rate of 0.1-0.5 l/m^2 is used to thoroughly treat the surfaces of shelves, posts, floor, etc., at such an expenditure so that puddles will not form on the floor. The exterior walls are also sprayed (especially near the doors and windows). In the course of the spraying operation the windows and doors are kept open. After completing the spraying the doors and windows are closed for 24 hours; they are then opened again and the premises are dried out for 3 days.

In exterminating insects in a granary it is possible to use 2.5% metaphos disinfecting powder at a rate of 15-20 g on m^2 of floor or 5 g per m^3 of space.

After completing the extermination process the premises are again picked up or tidied up and the rubbish and remnants of grain and forage are burned or buried in the ground at a depth of not less than 1 m.

In order to neutralize the metaphos it is desirable to whitewash the storehouse, to accomplish this the walls and ceiling are sprayed with a 15% solution of lime, after which the storehouse is allowed to dry.

Before filling with grain the floors are cleaned of lime and are washed with a solution of soda ash (200 g of soda ash per bucket of water) or ash lye.

Disinfestation and whitewashing are carried out with a ["DUK"] ("ДУК") disinfectional device which is utilized in veterinary practices or garden sprayers ([OPM-A] (ОПМ-А), [OSSH-15] (ОСШ-15) and others) or with a barrel plunger [OPB] (ОПБ) (the former "Pamona") or a knapsack [ORP] (ОРП) (the former "Automaks"). After using the apparatuses and hoses are washed well with water and dried.

The dusting of storehouses is carried out with the help of tractor or motor vehicle dusters or sprayers on motorcycles or motorscooters.

Technical metaphos is highly toxic to warm-blooded animals.

As compared to chlorophos metaphos is 5-10 times more toxic to mice; for rats the difference in toxicity is even greater — metaphos is 10-30 times more toxic than chlorophos. With respect to rabbits the toxicity of metaphos is equal to the toxicity of chlorophos (N. A. Sazonova, V. I. Kurchatov, F. A. Petunin).

N. M. Rusin, G. P. Andronova and O. I. Vasil'yev conducting a hygienic appraisal of food crops treated with metaphos (technical) showed that it is highly toxic to animals. A dose of 5 mg/kg, when introduced into the stomach, caused disturbance of conditioned reflex activity in rats for 1-3 days of the experiment. Metaphos does not have cumulative properties when introduced into the stomach.

As compared to thiophos metaphos is approximately 2 times less toxic. When the respiratory organs and the eyes are protected it does not present any great danger to people working with it (M. K. Vinokurova).

In a study by A. P. Volkava of the toxicity of wofatox disinfecting powder on white mice it was established that a suspension prepared only from the disinfecting powder is less toxic upon getting into the stomach than a solution of the preparation in water. Thus, when 10-20% disinfecting powder suspension is administered immediately after its preparation the LD_{100} for mice is 200 mg/kg, and the LD_{50} is 125 mg/kg (by active substance). The introduction of a more liquid (12-8%) suspension of wofatox 30-60 minutes after its preparation causes a very great toxic effect — LD_{100} is equal to 75 mg/kg, and LD_{50} — 50 mg/kg of weight; the latter depends, apparently, on the rate of desorption of the preparation from the disinfecting powder in the water and gastric juices.

The clinical picture of the poisoning with the introduction of the preparation into the stomach is the following: after 15-30 minutes motor coordination is disturbed, tremor develops which has an intermittent character; each attack of clonic-tonic spasms lasts 30-40 seconds alternating with a period of relative calm. Gradually complete atonia develops. Breathing is heavy the whole time. Death ensues 15-60 minutes after the introduction of the preparation, but it can also come 1-2 days later.

The effect of inhaling 2.5% wofatox disinfecting powder was studied in toxicological chambers with the static positioning of the animals. A. P. Volkova established that a single dusting with 2.5% disinfecting powder at a rate of 500 mg of active substance per m^2 (20 g of disinfecting powder per m^2) was nontoxic to white mice and rats. With repeated dusting using the same amount of disinfecting powder daily at a rate of 4 times per day (for 3 hours of the experiment) the animals developed toxic symptoms very similar to the symptoms of poisoning, which appear with the introduction of the preparation into the stomach.

The first symptoms of poisoning – depression, disturbance of motor coordination – appear after 2 days of the experiment (8 dustings) intensify in proportion to the duration of the experiment, causing the death of 70% of the mice and 100% of the rats after 4 day experimentation. Death comes to the animals slowly, sometimes 1-2 days after the discontinuance of the experiment. When autopsies were performed on the animals stagnant plethora and pulmonary edema were noted.

Thus, it is obvious that wofatox disinfecting powder is toxic when acting on the respiratory tract and that it possesses expressed cumulative properties when it is inhaled at its working concentration.

When wofatox disinfecting powder got on the exposed skin of mice during the course of dusting a local, irritating effect of the preparation was observed – dermatitis developed. Simultaneously irritation of the mucous membrane of the eyes was observed.

According to M. K. Vinokurova, when 2.5% wofatox disinfecting powder was applied to the skin of rabbits at a rate of 4 mg/kg for 2 hours daily during a period of 2 months no effect was noted on body weight, temperature or number of formed elements in the blood, the amount of hemoglobin decreased by up to 13% and the activity cholinesterase was suppressed by 43.6-50.6%. Seventeen-forty days after cessation of the application of disinfecting powder a gradual increase in cholinesterase activity occurred.

Consequently, when dusting with wofatox disinfecting powder it is necessary to strictly observe measures of personal safety, protecting oneself from the preparation getting into the eyes, onto the skin or into the respiratory tracts (by using protective spectacles, gloves, a respirator or cotton-gauze dressing on the nose and mouth).

Bordas, Kanyo, Nagy note that in the dusting fields its concentration in the air reached 0.75-1.35 mg/m^3 in the proximity of the worker. After working for one work week (48 hours) the workers were not observed to be intoxicated nor was suppression of pseudocholinesterase activity in the blood serum observed. Dusting was carried out using protective clothes, gloves and gasmasks.

R. Grigor'yev, describing the manufacture and packing of wofatox disinfecting powder, reports on workers' complaints; examination showed that in winter in 18 (38.3%) of 47 persons, and in summer in 29 (82.9%) of 35 workers the following symptoms were observed: loss of appetite, stomach pains, disturbance of vision and sleep, fatigue, nervousness and headaches. These symptoms were mild in winter and considerably stronger in summer. It was established that in summer cholinesterase activity decreased; in 27 of 29 persons its variation fluctuated from 11 to 66.4%.

It is necessary to note that technical metaphos is considerably more toxic than the pure preparation. Of all the possible ways in which the insecticide can get into the organism of warm-blooded animals (mouth, skin, respiratory tract and others) the most dangerous is entrance through the eyes. In its pure form the preparation has almost no effect as a cholinesterase inhibitor; in the animal organism it is converted into a substance suppressing cholinesterase.

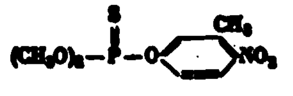
Methylacetophos

Methylacetophos - 0,0-dimethylcarbotoxymethylthiophosphate - $(CH_3O)_2POSCH_2COO\ C_2H_5$, an analog of acetophos, is obtained by the same methods as acetophos. In its external appearance it is very similar to the latter, but it differs from it in its more pungent odor. It is readily soluble in water. It is soluble in benzene, cholorbenzene, acetone and other organic solvents. The specific gravity of methylacetophos (at 4-20°) - 1.25; its index of refraction (at 20°) - 1.475; its boiling point is 116-124° at 0.35 mm Hg. The technical product contains 80% methylacetophos and 20% admixture not possessing insecticidal properties.

The preparation can be used for the same insects, as acetophos. In its insecticidal properties it is only slightly inferior to the latter. It is only slightly toxic to warm-blooded animals when introduced through the mouth; the LD_{50} for white mice is 250 mg/kg.

Methylnitrophos

Methylnitrophos - 0,0-dimethyl-0-(3-methyl-4-nitrophenyl)-thiophosphate



Synonyms: preparation 5660, sumithion and [MNP] (МНФ). This product was synthesized by the Scientific-Research Institute of Fertilizers and Insectofungicides in 1962. The pure preparation is a light-yellow colored liquid; its boiling point is 140-147° (0.15 mm Hg). Its specific gravity is 1.5475 and index of refraction at 20° is 1.538. It is insoluble in water. The MNP is obtained from a mixture of nitrocresol isomers.

The technical preparation is a thick, dark-brown colored, oily liquid with an indistinct odor. Industry manufactures a 25-30% concentrate; the concentrate is readily emulsified with water by OP-7, forming a stable emulsion. The preparation possesses high insecticidal properties both for pests of agricultural plants, and also for carriers of infectious diseases: fleas, lice, house flies and others (V. P. Dremova, V. I. Zakolodkina). The sensitivity of insects to the preparation depends on the species; the LD_{50} for female body lice and house flies is 0.055-0.050 μg per individual (for lice 20 μg/g; for flies 2.75 μg/g of insects); the LD_{50} for common female cockroaches is 1.15 μg per individual (18 μg/g). Bugs are highly sensitive to MNP (Table 11, 12).

Table 11. Minimum amount of methylnitrophos providing extermination of insects after contact.

Species of insects	Topical application for LD_{50}, μg	Minimum dosage (g/m^2) providing extermination of insects in contact with				
		glass	wood	wall-paper	wood painted with oil-base paint	plywood
House fly	0,05—0,1	0,02	1,0	1,0	0,5	0,5
Bed bug	0,02	0,1	0,5	1,0	1,0	0,5
Common cockroach	1,0	0,2	2,0	2,0	2,0	2,0
Mosquitoes (Culex)	—	0,01	1,0	1,0	—	0,5
Rat flea	—	0,2	0,01	0,3	0,5	0,1

The minimum dosage providing complete extermination of flies, mosquitoes and bugs on wooden surfaces (painted and not painted) — 0.5-1 g/m^2; for cockroaches — 2-3 g/m^2; for fleas — 0.1-0.3 g/m^2.

Table 12. LD_{50} with respect to flies and bugs; minimum dosages of MNP, chlorophos, trichlorometaphos-3, causing extermination of insects after contact.

Name of preparation	Topical application, LD_{50}		Type of surface	Minimum dosages causing extermination of the insects in contact with surfaces treated with solutions, g/m²			
	flies	bugs		flies	bugs	cockroaches	fleas
Chlorophos	0,2 0,5	0,2	glass wood	0,05 2,0	0,2 0,3	0,2 2,0	0,5
Trichlorometaphos-3 .	0,1	0,1	glass wood	0,02 2,0	0,1 3,0	0,5 2,0	0,2 0,03
MNP	0,1	0,02	glass wood	0,02 1,0	0,1 2,0	3,5 2	0,2 0,3

When used under practical conditions it is recommended that 100 ml of 2% emulsion be applied per m² of treated area. The minimum dosage of preparation on coarse calico, providing complete destruction of lice after 30 minutes of contact, is 1-1.5 g of active substance per m² of coarse calico.

The insecticidal properties of MNP for flies, bugs, cockroaches, fleas, and lice are higher than the insecticidal properties of chlorophos. The duration of MNP effect under laboratory conditions on glass is 25-30 days, on wood it is 15-18 days.

The MNP possesses considerable ovicidal and larvicidal properties (Table 13).

Table 13. Concentration of MNP in percents, causing destruction of fly and bug eggs.

Species of insects	Concentration of water emulsions %	Amount of preparation g/m²	Destruction of eggs %
Ovipositions of flies	0,1	0,5 1,0 2,0	[illegible]
Ovipositions of bugs	0,3 0,05	0,5 0,2 0,5	[illegible]

The LD_{100} of fly eggs is observed upon their submersion in 0.05-0.1% emulsion for 30 minutes, and when the ovipositions are sprayed with 0.3% emulsion at a rate of 0.5-1 ℓ with the addition of MNP at a rate of 15-20 mg/kg of substrate while mixing complete extermination of third instar fly larvae is provided within 24 hours. In treating the substrate without mixing complete destruction of the larvae is provided with 1-2 ℓ of 0.2-0.3% emulsion per m^2.

After treating the substrate (sand) 85-95% of the fly pupae die. Thus, MNP acts on flies in all stages of their development.

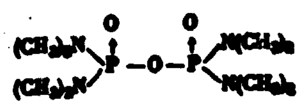
Bug eggs are completely exterminated 24 hours after spraying the surfaces with 0.2 $ℓ/m^2$ of 0.1% emulsion.

The fumigational properties of MNP are not too great; it is inferior to chlorophos in its fumigational properties.

The MNP is only slightly toxic to warm-blooded animals. According to N. A. Sazonova and the Kiev Scientific-Research Institute of occupational illnesses, the LD_{50} of MNP for white mice, when orally administered, is 470-1000 mg/kg. It is highly toxic in the aerosol state. The toxicity of the preparation to a considerable degree depends on the purity of the preparation. The pure preparation is less toxic than the nonrefined preparation.

Octamethyl

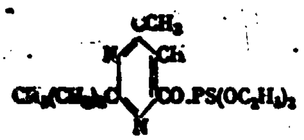
Ocetamethyl - octamthyl pyrophosphoramide - $C_8H_{24}N_4O_3P_2$.



Synonyms: schradan, pestox-III, [OMPA] (ОМПА). The molecular weight is 286.26. Pure octmethyltetramide of pyrophosphoric acid — a transparent liquid with a mild odor and light-yellow color. Its boiling point is 135-136° at 1.5 mm Hg. Its specific gravity 1.140. It dissolves in water in any proportions. The preparation acid and alkali resistant; it retains its properties in aqueous solutions for a long time. It possesses insecticidal and acaricidal action. The technical preparation contains about 65% octamethyltetramide of pyrophosphoric acid and several other compounds, the insecticidal effectiveness of which is low. Octamethyl is used in agriculture to combat pests of agricultural crops by spraying. The preparation in toxic amounts (for certain pests) penetrates into the plants through the roots, bark and leaves and is carried by the vessels throughout the plant bodies, therefore octamethyl is called a systemic insecticide. The duration of its protection is 3-6 weeks. It is not used in sanitary practice because of its high toxicity for man and animals. Attempts have been made to use it to combat field rodents by dusting the vegetation, which they eat. A single lethal dose causing the death of experimental animals is 5-20 mg/kg.

Pyrazinon

Pyrazinon — $C_{12}H_{21}N_2O_3PS$ — 0,0-diethyl-0-(2-n-prophyl-4-methyl-pyrimidinyl-6)-thiophosphate

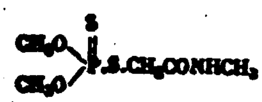


Pyrazinon — technical product (about 90% pure preparation); it is liquid with a pale- to dark-brown in color; it is relatively insoluble in water; it is readily soluble in petroleum solvents, alcohol, xylene and acetone. Pyraxinon has a close relationship to diazinon; possessing the normal prophyl group instead of the isopropyl group.

It is effective in combating flies, in particular in treating livestock barns. In such cases the walls, ceilings and partitions are sprayed; manuredepositories and sheds located close to the animal barns and also the entrance doors are treated. The preparation is sprayed with a mechanical sprayer, having an ordinary garden nozzle. The expenditure rate for the preparation (200-250 $m\ell/m^2$ of 0.5% solution) depends on the structure of the material. Surfaces are covered with the preparation up to the point of "runoff." Available data show that pyrazinon is not less effective in combating flies than diazinon -- it is 12 times more effective than pyrethrin preparations. The same conclusion was arrived at by a number of authors, who studied this preparation.

Rogor

Rogor - $C_5H_{12}PS_2NO_3$ - 0,0-dimethyl-S-(N-methylcarbamoil)-methyldithiophosphate or 0,0-dimethyl-N-methylcarbamidemethyldithiophosphate.



Synonyms: dimethoate, phosphomide, dithio, American cyanamide 12980, phosthion MM and others.

It consists of white crystals, with the odor of mercaptan. The melting point is 49-50°. Its specific gravity is 1.069. The preparation is relatively stable in neutral and slightly acid media; it is soluble in water up to 3%. The index of refraction at 50° is 1.5373. Vapor pressure at 25° is 0.025 mm Hg, at 35° it is 0.086 mm Hg, at 45° it is 0.300 mm Hg. The technical product contains 94-96% rogor. Its melting point is 43.5-45.8. The ignition point is 130-132°.

Rogor is recommended in England and Italy to combat a number of pests of grain, vegetable, technical and fruit cultures, and also of olive trees and vineyards. It is manufactured industrially in the form of a 40% emulsion concentrate with a yellow color and moderately unpleasant odor. Under laboratory conditions 17 derivatives of rogor have been obtained. In the USSR rogor was synthesized in the Scientific Research Institute of Fertilizers and Insectofungicides.

The most effective rogor preparations with respect to house flies have turned out to be the rogor derivatives from the dimethoxy-groups; their activity was higher than the diethoxy-compounds. It has been established that in proportion to the increase in the number of carbon atoms in the carbamide chain the toxicity of the preparations to films decreased. Monoalkyl-substituted amides turned out to be more effective than dialkyl-substituted amides.

Rogor is a contact and systemic insecticide and an acaricide. It is also employed to combat flies, mosquitoes, cockroaches, ectoparasites of birds, animals, etc.

It has been established that when the preparation is injected into a fly the LD_{50} is equal to 0.43 μg, and when topically applied to the insect body – 1 μg/g. Dorough and Arthur established that when it is applied to the body of a fly the LD_{50} is 1.3 mg/kg. For L. cuprina flies the LD_{50} was 0.027 μg per insect. According to V. P. Dremova, when rogor was topically applied to female house flies of an insect culture it killed 50% of the insects (LD_{50}) at a dose of 0.008 μg per insect or 0.056 μg/g; for female bed bugs these indices were 0.011 μg per individual. or 1.5 μg/g. The experiments were carried out at a temperature of 20-22°. For mosquitoes the LD_{50} equalled 6 mg/kg when they fed on treated lambs and calves.

Rogor is also used to combat the warble fly.

Larvae of Anopheles and Aedes mosquitoes die in the presence of 2.77-7.8 mg/ℓ of the preparation. It was established that the larvae during this time absorb 0.0041 and 0.0087 μg respectively. Their mortality rate was 56-67%. Rogor can also be used in preparing poisoned baits for flies.

Under laboratory conditions V. P. Dremova established that manufactured phosphamidized insecticidal flypaper is highly effective in combating flies. The authors prepared the flypaper in the following manner: cardboard sheets were treated for 24 hours in an aqueous solution (0.005-0.1%) of the preparation with the addition of 5% sugar. In treating 100 g of cardboard 220 mℓ of the solution were used. This paper was just as effective as chlorophos paper prepared in an analogous manner. Its attractant properties were inferior to chlorophos paper. It retained its insecticidal properties for 15-20 days, if after each time it dried out it was again moistened with water.

Rogor is effective as an intestinal poison in combating cockroaches. Baits made from rye grain consisting 1 g per 20-30 mg of rogor, are effective in exterminating cockroaches.

According to V. I. Vashkov, V. G. Dremova and Ye. V. Shnayder when insects come into contact with glass treated at a rate of 0.03-0.1 g/m^2 they are all killed. However, rogor is ineffective when it is applied to such absorbant surfaces, as wood, plywood, plaster, plywood painted with oil base paint, wallpaper and others. Complete destruction of flies was observed when 2.5 g of preparation is applied per m^2 of the indicated surfaces. For other insects (bugs, fleas, mosquitoes) the treating of absorbent surfaces with dosages higher than 4 g/m^2 was effective. The preparation is ineffective when it is used as a contact insecticide to exterminate cockroaches. Thus, upon coming in contact with plywood treated at a rate of 2 g/m^2 100% of the flies died, 77-66% of the bugs, mosquitoes, and fleas, but only 30% of the cockroaches.

Plaster treated with 2.5 g/m^2 of the preparation provided complete destruction of the flies, cockroaches and extermination of

75% of the bugs. Complete destruction of lice was observed after 15 minutes of contact with coarse calico treated with 1% rogor solution and after 30 minutes of contact with coarse calico treated with 0.5% rogor solution. One-hour's contact provided complete extermination of lice on coarse calico, treated with 0.125 g/m^2.

The preparation possesses high larvicidal properties. A dosage of 3 mg per g of substrate provides complete extermination of third-instar fly larvae after their stay in the treated substrate for 48 hours. In a substrate treated with 3 mg/kg of preparation after 48 hours 40% of the larvae died, after 96 hours – 95% of the larvae; only 3.5% pupated. Larvae added to middlings 5 days after treatment at a rate of 8 mg/kg died within 48 hours after being planted there. The hatching rate of flies from pupae located in a plant treated with a 1% aqueous solution of rogor was 10% with a 0.25 ℓ/m^2 rate of expenditure of the solution and 1% with an expenditure rate of 0.5-1 ℓ/m^2. Rogor possesses considerable fumigational properties. Filter paper treated at a rate of 2 g of preparation per m^2 retained its fumigational properties for 30 days. After treating cowbarns with 2% rogor (water emulsion) until drops ran and analyzing milk samples the content of the preparation was determined as being within the limits of 0.005 parts per million.

The effect of technical emulsified rogor at a concentration of 30 parts per million parts of water, given to brood-hens for 5 weeks, was studied. The daily expenditure of the preparation reached 0.1 g of the technical and 0.0092 g of the emulsified preparation. As a result of such an application of rogor high effectiveness was observed with respect to the larvae of house flies, small house flies, Chrysomyia megacephala and parasarcophaga argirostoma breeding in the excrement of the birds. The activity of plasma cholinesterase was rapidly suppressed and just as rapidly restored after cessation of the administration of rogor. A decrease in weight gain and in food consumption was noted; however egg laying remained normal when the technical preparation was used, and when the emulsified preparation was used an increase in egg laying was even observed compared to the control birds. The treatment did not affect the thickness of the shell or the weight of the eggs and considerably improved the quality of the eggs. No strange odor, nor strange taste, nor color was noted in the eggs.

Of the contemporary systemic insecticides rogor is of greatest interest. The available data provide the basis to assume that the preparation penetrates into seedlings in larger quantities than [HCCH] (ГХЦГ) and heptachlor; it is evenly distributed in the plants in proportion to their growth, and then within a period not exceeding 2 weeks it is completely decomposed. These qualities make its use possible for presowing treatment of seeds and also to treat vegetable cultures with a short period of vegetation, for example, radishes. However, the duration of the toxic action of rogor and hexachlorane is not shorter than that of heptachlor. Rogor reduces the germinability of barley (V. P. Vasil'yev, Ye. N. Kititsin).

It is noted that rogor is effective in granular form with respect to a large number of plant pests when used at 12, 24, and 48 kg/ha. The mortality rate approaches 97-100%. Rogor is ineffective as a systemic insecticide in combating cotton pests; when seeds are treated with the preparation their germinability is reduced (N. N. Mel'nikov).

When rogor is applied to vegetation it decomposes comparatively rapidly on plants. In England it was officially decided to use rogor on all crops with the condition that the last treatment be conducted not later than 7 days before the gathering of the harvest.

Rogor is used abroad as a systemic insecticide in combating animal ectoparasites. For this purpose it is introduced orally into animals in the form of solutions, pellets, etc. The preparation is also injected into animals. Thus, for example, after administering solutions orally and subcutaneously to animals at a rate of 10-25 mg/kg there was noted the complete destruction of stable flies (Stomoxyscalcitrans L) planted on these animals.

Under practical conditions after administering the preparation to sheep and goats analogous data were obtained (the complete extermination of these same arthropods). With the oral introduction of 6 mg/kg of preparation to mice there was observed the extermination of mosquitoes feeding on these animals. Increasing the dose by 7 times resulted in toxic symptoms in lambs and calves. The effectiveness of the solutions was studied with respect to exterminating warble flies; these solutions were introduced orally at a rate of 5-10 mg/kg. The mortality rate of the arthropods was 86-100% depending upon the dose. For third-instar warble fly larvae 10 mg/kg was the lowest dose. In animals which had been administered 20 mg/kg and more of the preparation symptoms of poisoning were noted.

Harvey used the preparation to exterminate rat fleas (Xenopsylla cheopis) by introducing it orally in the form of alcohol solutions to rats at a rate of 25 mg/kg. Rather favorable results were obtained: the mortality rate of the insects reached 80%. For exterminating bird ectoparasites (lice and ticks) 0.1-0.25% solutions of rogor were investigated with an expenditure of 25 mℓ per bird; it was established that complete extermination of the lice was provided with a 0.25% solution.

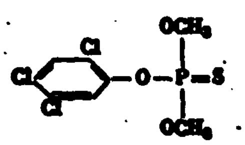
For calves and lambs a 40 mg/kg dose of rogor causes severe toxic symptoms; 80-100 mg/kg is a lethal dose. Doses of 15-20 mg/kg cause only mild symptoms of poisoning, and doses lower than 15 mg/kg are harmless.

A study of the metabolism of rogor tagged with radioactive phosphorus, after the oral and intramuscular administration to sheep, cows and others at a dose of 10 mg/kg showed that considerable radioactivity is noted in the blood with any method of administration: the preparation spreads throughout the tissues more rapidly with intramuscular administration. After about 24 hours approximately 87-90% of the orally administered dose had been excreted with the urine, the same amount was excreted, when intramuscularly administered, after 9 hours. A total of 3.7-5% of the preparation was excreted with the feces after oral administration and about 1.1% after intramuscular administration. In the brain, liver, ovaries, and lungs only insignificant amounts of rogor were present (0.02 γ/g).

The preparation is metabolized and excreted from the organism within 12 days. It is detected only in the form of traces. The hydrolysis of rogor mainly results in methylphosphate, sulfur phosphate, carbon disulfide and especially in carbonyl nitrate bonds. For rats with oral administration LD_{50} – 150–250 mg/kg, with subcutaneous injection – 275 mg/kg and with cutaneous application – 750 mg/kg. In experiments with rabbits a portion of the animals died from a dose of 50 mg/kg. The residues of the poison are rapidly decomposed in the plant, thus it can be applied shortly before gathering the harvest.

Ronnel

Ronnel – $C_8H_8O_3PSCl_3$ – 0,0-dimethyl-0-(2,4,5-trichlorophenyl)-thiophosphate.



Synonyms: trolene, Dow-ET-57.

It is a highly volatile liquid with a very unpleasant odor; it is almost insoluble in water. It dissolves in organic solvents. The vapor pressure is 0.0008 mm Hg at 25°.

Ronnel possesses contact, intestinal and fumigational action. From ronnel 25% disinfecting powders, wettable powder, and 25% emulsion concentrate are prepared. The preparation possesses considerable insecticidal properties. It is especially effective in combating flies. It is used to exterminate flies in animal barns. According to L. N. Pogodina, V. D. Larionova and O. M. Glozman, when the preparation is applied at a rate of 40 mg/m^2 on glass flies coming in contact with the latter are completely exterminated. It is also toxic to fly larvae.

According to other authors, there has been observed in animal farms the complete destruction of flies after the preparation is applied in the form of a 1% suspension or 1% emulsion on a surface at a rate of 1-2 g/m^2.

The duration of the residual effect is retained for 6-11 weeks. It has been determined that when ronnel is topically applied to the surface of flies' bodies the LD_{50} is equal to 1.5 μg/g. For the oxygen analog of ronnel this dose was equal to 2 μg. For combating Drosophilae in their breeding places (clusters of putrescent fruit) a 0.1% suspension of 25% wettable powder is used adding to the suspension 10% sugar, 1% vinegar or apple cider and 4% yeast. This treatment kills 97-100% of the Drosophilae for 33 days. Ronnel is highly toxic when it gets into the insect organism along with food. Thus, according to the laboratory data of L. N. Pogodina and others when 0.04% of the preparation is present in liquid bait containing sugar the complete destruction of flies is observed.

Cord treated with a 25% solution of ronnel in xylene turned out to be effective in combating flies. The cord is hung in animal quartering places at a rate of 1 m/m^2 of floor. Its effectiveness is preserved for 8-16 weeks depending upon the conditions of the quarters and the size of the fly population. In connection with the low toxicity of ronnel to warm-blooded animals the indicated method of application is promising, inasmuch as cord manufactured in this way can be recommended for sale to the general public. To exterminate larvae a 1% emulsion (25% concentrate) or a 1.25% suspension is recommended at an application of 1 g/m^2 of manure. The treatment was repeated in 2-7 days.

Ronnel is also effective in controlling cockroaches; it is used in the form of 1-2% oil solutions, and also in the form of oil aerosols. Surfaces and fissures treated with an emulsion of this preparation preserve their insecticide properties with respect to cockroaches for 30-50 days. Analogous results were also obtained using 40% disinfecting powder. Ronnel at a 1-2% concentration is also applied in the form of oil aerosols for treating restaurants, markets and other places where food is handled. This is the only organophosphorus insecticide recommended in the form of an oil aerosol for treating food enterprises.

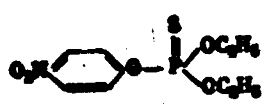
To exterminate fleas 1% solutions or suspensions of ronnel are used at a rate of 45 $m\ell/m^2$; they are effective for 9 weeks. Analogous results using a 1% solution were obtained in exterminating bugs. When treating mattresses and mattress covers it is recommended that precautions be taken not to wet them with the solutions. The treatment is repeated in 2 weeks; children's things should not be treated with it. Its 1% solutions are also employed in dealing with mosquitoes and ants. In the insect organism the detoxification of ronnel is achieved through hydrolysis. The basic role of hydrolysis is the bonding of phosphorus with oxygen and phenyl.

Ronnel is used as a systemic preparation in combating warble fly larvae by administering it to animals in doses 100-110 mg/kg. No harmful after effects are reported in treating 1-2 week-old calves, adult animals and sheep with 2.5% solutions or in immersing them in these solutions, or in treating them with 10% ronnel disinfecting powders. It is also used for spraying animals in the form of a 0.5-1% suspension or emulsion at a rate of 2-4 ℓ per animal. An attempt was made to orally administer to chicks 500-800 mg/kg nonlethal doses of the poison properties; the mortality rate of flies under these conditions reached 90%, but the excrement retained its insecticidal properties only for 3 days. The preparation has found its greatest application in combating ectoparasites of birds and animals. For these purposes a 1% disinfecting powder is used with a 3-4 g expenditure of each bird. Of the preparations possessing systemic action ronnel belongs among the best. It is used in the form of pellets at a rate of 100-110 mg/kg. Its protection lasts 6 months.

Toxicity. The preparation is only slightly toxic to warm-blooded animals; when orally administered the LD_{50} for rats is 1.74 g/kg, for mice – 2.14 g/kg, for dogs – about 0.5 g/kg, for ducks – 4 g/kg, for chicks – 5 g/kg, for turkeys – 0.5 g/kg. No morphological changes were noted after the prolonged feeding of rats with food containing 15 mg/kg of the preparation, for dogs it was 10-25 mg/kg of the preparation. When the preparation gains entry into the organism through the skin it is less toxic than when entry occurs through the mouth. When 125 mg/kg of preparation are administered to large animals there are observed only mild symptoms of poisoning which progress in proportion to the increase of the dose up to 400 mg/kg. It has been noted that animals treated with systemic insecticides to exterminate warble flies acquire resistance to repeat infestations by these ectoparasites.

Thiophos

Thiophos – $C_{10}H_{14}NO_5PS$ – 0,0-diethyl-0-n-nitrophenylthiophosphate.



Synonyms: parathion, [NIUIF-100] (НИУИФ-100), diethyl-p-nitrophenyl-monothiophosphate, E-605, compound 3422, niran, alkron, genithion, penphos, phos-kil, vapophos and others.

The pure preparation is a light-yellow, odorless liquid, which on cooling crystallizes into needle-like, almost colorless crystals having a melting point of 6°. The specific gravity is 1.2655 at 25°. The technical preparation is a thick, oily, dark-brown liquid, with a pungent garlic odor, which the inpurities impcrt to it. Its specific gravity is 1.26 at 20°. Its boiling point is 157-162° at 0.64 mm Hg; at 35° thiophos solidifies. The vapor pressure is $3.78 \cdot 10^{-5}$ mm Hg at 24°.

In the usual organic solvents it is very soluble; in mineral oils it is only slightly soluble; in water 0.015-0.024% of the preparation dissolves at 25°.

Thiophos is slowly hydrolyzed in distilled water, and slightly by sulfuric acid, but considerably more rapidly by alkalis. Thus, at pH 5-6 1% of the dissolved thiophos is hydrolyzed after 62 days, at pH 8-9 after 120 days 50% of the preparation is hydrolyzed. In a saturated aqueous solution of lime for hydrolysis of the indicated amount at 25° 8 hours is required.

The mechanism of its action is the same as the mechanism of action of the other organophosphorus compounds, i.e., it suppresses cholinesterase.

Thiophos is used under the name of preparation NIUIF-100 to manufacture preparations to combat pests of agricultural crops. In the manufacture of this preparation [NIUIF-100] thiophos is dissolved (at the plant) first in the auxiliary substance OP-7 or OP-10 and in this manner there is obtained a 30% thiophos concentrate or preparation NIUIF-100 (N. N. Mel'nikov).

For dusting a 1% talc or talc-kaolin disinfecting powder is prepared, which as a chemical poison received less application than the 30% concentrate. The preparation is effective in controlling shield bugs and other agricultural pests. In an analogous manner the stronger concentrates are prepared, which are 45-50% solutions of the preparation in a surface-active agent. Working emulsions are prepared from the concentrates by simple dilution in water (while mixing) to the desired concentration (it is possible to use hard water). Working emulsions are effective against the majority of insects within the limits of 0.02-0.07% of thiophos, i.e., within the limits of 0.04-0.14% of factory concentrate.

The preparation is highly toxic to lice, bugs, cockroaches, flies and red house ants. After 5 minutes of contact with a fabric treated with the disinfecting powder containing 0.0125% of this preparation, the enumerated insects die. The preparation is highly effective in combating flies by treating the exterior walls of buildings. It is also effective in treating rubbish containers and rubbish to exterminate the pupae and larvae of flies. The disinfecting powders containing 0.06% of the preparation are highly effective in combating red house ants. In a number of countries thiophos is used to control mosquito larvae at an expenditure of 120 g/ha. When used in these amounts the action of thiophos does not last long. Mosquito larvae (Anopheles and Aedes) die within the limits of 50% when it is present in the water in the amounts 0.00046-0.0006 mg/ℓ respectively. When thiophos is topically applied the LD_{50} for house flies is 0.015 μg/insect.

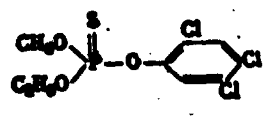
Thiophos possesses high toxicity to warm-blooded animals. When it is administered in a single oral dose or applied to the skin in a dose causing complete extermination [100% mortality] of the animals, this 100% lethal dose for cats and guinea pigs is 12.5 mg/kg, for white mice it is 15-20 mg/kg, for rabbits it is 50 mg/kg. The maximum permissible amount of thiophos vapors in the air of industrial premises is 0.00005 mg/ℓ. Because of its high toxicity and fumigational properties its application for treatment of objects inside living quarters is forbidden. The use of thiophos is also prohibited for dusting and spraying vegetable, fruit, berry, subtropical and other crops, except technical crops. Many cases of humans being poisoned with thiophos are encountered in literature (K. Gar and others, N. A. Sazonova, V. I. Vashkov, A. P. Volkova; F. P. Kalayanova).

The presented data indicate that in working with thiophos it is necessary to be careful and to observe all the rules of safety. Its application for the extermination of pests of dwellings is permissible only in extreme cases and furthermore only with great caution; it can be used for treating the exterior surfaces of structures. In combating flies in places containing animals, and also in dining rooms, cords are hung, which have been treated with a thiophos solution with sugar or without sugar at a rate of 1 m of cord per 3 m^2 of area. In Denmark in certain places after the prolonged application (1956-1958) of such cords flies increased their resistance to this preparation by approximately 5 times. When eaten by hens the preparation is deposited in the egg white.

In inhabited localities, where thiophos was used to combat parasites of dwellings numerous cases of human poisoning have arisen with a lethal outcome. When a thiophos aerosol is inhaled its toxicity for man is extraordinarily great — 1 mg/kg. Cases of poisoning of workers occupied in dusting with this preparation are frequent (V. F. Gusev). In literature hundreds of cases are cited of thiophos poisoning as a result of the preparation getting into the human organism along with food.

Trichlorometaphos-3

Trichlorometaphos-3 — $C_{12}H_8O_3Cl_3PS$ — O-methyl-O-ethyl-O-2, 4,5-trichlorophenylthiophosphate is a compound from the group of mixed aliphatic-aromatic esters of thiophosphoric acid.



The chemically pure preparation is an oily colorless liquid with a specific odor. Its specific gravity is 1.4345. The boiling point is 125-135° at 0.15 mm Hg. The index of refraction is 1.5541.

Technical trichlorometaphos-3 is also an oily liquid with a light- to dark-brown color. The percentage of the basic product is within the limits of from 70 to 84%. It is obtained from 2,4,5-trichlorophenyl with phosphorotrichloromethyl alcohol.

The preparation is insoluble in water, but soluble in organic solvents. Industry produces an emulsion concentrate containing from 30 to 50% active substance; when diluted with water it is readily emulsified, as a result of which a stable white emulsion will be formed. Trichlorometaphos-3 possesses a fumigational, contact and intestinal action.

It was synthesized in 1961 of the Scientific-Research Institute of Fertilizers and Insectofungicides. It was thoroughly studied by I. V. Gvodzdeva at the Central Scientific-Research Disinfection Institute. The preparation possesses high insecticidal properties (contact, intestinal and fumigational). This enzymatic poison is used to exterminate flies, mosquitoes, bugs and other insects.

The LD_{50} for female house flies for an insectary strain with the topical application of acetone solutions from a pipette is 0.15 mg per insect (calculation after 24 hours). When flies are individually fed sugar syrup containing the preparation the LD_{50} is 0.5 μg per insect.

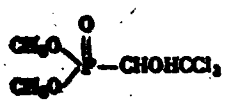
In connection with the fact that trichlorometaphos-3 does not possess prolonged residual action with respect to winged flies, it is used for these purposes in the absence of other preparations. When 100 $m\ell/m^2$ of the emulsion containing 0.5% trichlorometaphos-3 are applied to a surface its effectiveness is preserved for 2-3 days.

The preparation possesses larvicidal properties; complete destruction of house fly larvae is observed for 24 hours after its addition at a rate of 15 mg/kg to an air-dried substrate (middlings). Under practical conditions to destroy fly larvae in liquid waste material - cesspools, restrooms and others - a 0.2% concentration of the technical preparation is used in an amount of 0.2 ℓ/m^2. The rate of treatment in the moderate climatic belt is one time in 10-12 days. Under the conditions of a hot dry climate the recommended treatment is 0.1% water emulsion in the amount of 2-5 ℓ/m^2 once in 5-6 days. With respect to toxicity for warm-blooded animals it is approximately equal to chlorophos; the LD_{100} when subcutaneously administered to white mice is approximately 750 mg/kg.

According to A. N. Volkova and N. A. Sazonova, when applied on the skin the preparation is only slightly toxic; it does not cause irritation at a 0.5% concentration. The prolonged inhalational action of aerosols of the technical preparation when a 0.1% emulsion is sprayed does not cause changes in the respiratory organs of animals. Increasing the concentration of the emulsion to 0.5% caused symptoms of focal bronchitis in the lungs of rabbits. When the concentration was increased to 1% the toxicity of the preparation was considerably increased and in the respiratory organs of the animals expressed pathological changes developed.

Chlorophos

Chlorophos - $C_4H_8O_4PCl_3$ - 0,0-dimethyl-2,2,2-trichloro-1-hydroxyethyl phosphonate.



Synonyms: dipterex, Bayer-L-13/59. It is one of the most wide-spread representatives of the organophosphorus compounds.

The molecular weight is 257.5. The pure preparation is a white crystalline, odorless substance with a melting point of 82.5-83°; when recrystallized needle-like, transparent crystals are obtained.

The boiling point at 0.004 mm Hg is 91°; at 0.1 mm Hg it is 100°; at 0.2 mm Hg it is 109°; at 0.4 mm Hg it is 120°; the specific gravity at 4-20° is 1.73. The refraction (10% aqueous solution) is 1.3439; the volatility of technical chlorophos is great — at 20° it is equal to 0.01 mg/m^3, and at 40° — 2 mg/m^3. Its vapor tension is equal to $8 \cdot 10^{-5}$ mm Hg at 27.4°.

It is soluble in water up to 13-15% at 25°; it is soluble in alcohol, ethyl ether, benzene, toluene, ligroin and in the majority of chlorinated hydrocarbons, such as: ethylene chloride, chloroform; it is readily soluble in petroleum ether, carbon tetrachloride. It is stable at room temperature in a neutral or slightly acid medium; it slowly decomposes when it stands for a long time in the form of an aqueous solution; it is unstable in an alkaline medium. Alkalis turns it into water-insoluble, highly toxic [DDVP] (ДДВФ). With a weakly alkaline reaction at great dilution chlorophos is rapidly converted into DDVP. The half-periods of this transformation at pH 8.0, 7.0 and 6.0 are equal respectively to 63 minutes, 386 minutes and 89 hours. At pH 5.4 hydrolysis occurs very slowly.

The technical preparation can have a different form: from a hard, white substance reminiscent of paraffin to a liquid in the form of a thick honey of gray color with a sharp specific odor.

Domestic industry, besides the liquid preparation, manufactures technical chlorophos in the form of a white, friable powder. This preparation contains 97% 0,0-dimethyl-2,2,2-trichloro-1-hydroxyethyl phosphonate; the solidification point is 73.6°, the acidity based on H_2SO_4 in weight percents is not more than 0.7. The water content in weight percents is not more than 1%. The melting point is 50-70° depending upon the consistency and purity of the preparation. It is miscible in water in any proportions. The time of its half-life in an aqueous solution at 20° is equal to 526 days, 30° – 140 and at 40° – 41 days.

When a 10% aqueous solution of chlorophos is stored, its insecticidal properties decrease in a month by 5%, after 3 months – by 6%, after 6 months – by 8%, and after 13 months – by 39% (Table 14, 15, and 16).

Table 14. The half-life period at pH 1-5 depending upon temperature (in days).

Name of the preparation	0°	10°	20°	30°	40°	50°	60°	70°
Chlorophos	11 600	2 400	526	140	41	10,7	3,2	1.13
ДДВФ	1050	240	61	17	5,8	1,6	0,58	0,164

Table 15. The half-life period depending upon the pH of an aqueous solutions at 70° (in days).

Name of the preparation	1	2	3	4	5	6	7	8	9
Chlorophos	32	34	33	26	15	3	0,7	0,6	0,1
ДДВФ	2,3	3,4	3,4	3	2,8	1,4	0,45	—	—

Table 16. The conversion of 100 g of chlorophos into DDVP depending upon pH.

pH	Amount of chlorophos in %	Amount of DDVP in %	Amount of the products of hydrolysis in %
1	98,5	0,5	1
5	96,8	1,6	1,6
6	72,2	21,6	6,2
7	3,0	58,5	38,5
8	0	54,0	46,0

When a 0.1% solution is stored its effectiveness is reduced after a month by 6%, after 3 months - by 17%, after 6 months - by 43%, after a year - by 85%. The determination of chlorophos is carried out mainly by the chromatographic method (Chen Sen Haun and others).

Technical chlorophos is used to combat ecto- and endoparasites of domestic animals and birds, pests of agricultural cultures and household parasites.

Insecticidal properties of chlorophos. Chlorophos can penetrate into the organism of insects by various pathways. Its insecticidal activity manifests itself upon contact, upon getting into the intestine of insects with food, and also due to the penetration of chlorophos through the respiratory pathways mainly in a vaporous state.

Chlorophos is used in the form of an aqueous solution, solutions in organic solvents, a disinfecting powder, solution-suspensions, aerosols, food baits and screens impregnated with chlorophos, and others.

Chlorophos is not soluble in kerosene and is incompatible with Bordeaux mixture, lime or any substance, the pH of which is higher than 7.5.

In the Soviet Union it was first synthesized in 1954 in Scientific Research Institute of Insectofungicides. Certain data on its insecticidal properties were first published by V. A. Nabokov, A. V. Nikiforova. It was studied in detail at the Central Scientific Research Disinfectional Institute (V. I. Vashkov, Ye. V. Shnayder).

The insecticidal activity of chlorophos is in direct dependence on the purity of the preparation: the purer the preparation the more toxic it is to insects in its contact action.

Chlorophos belongs to the strong intestinal poisons.

A lethal dose of pure chlorophos when orally administered to house flies is approximately three times less than when applied to the cuticle. Thus, for example, in the introduction of chlorophos to a house fly through its mouth the LD_{50} is equal to 0.3 μg per insect, and when topically applied, according to I. V. Gvozdeva, it is 0.77 μg per insect and according to Ye. V. Shnayder, it is 0.4 μg per insect.

The speed of the advent of paralyses depends on a number of factors, including the physical state of the insect. Flies kept for 18 hours before the experiment in vivariums without food, died considerably faster than those, which were taken into the experiment without this corresponding starvation. In the first case they died after 30-60 seconds, in the second – after 3-5 minutes.

The fumigational effect of chlorophos is stronger the less purified the preparation is. This, obviously, is caused by those volatile impurities, which are constantly present in technical chlorophos (DDVP and others) and which possess high insecticidal properties.

Thus, for example, when freshly impregnated sheets of filter paper are used the toxic action of the vapors of the preparation appears considerably more rapidly than when sheets are used, which were stored for a long time after treatment. When sheets of filter paper were used 24 hours after impregnation the mortality rate of the flies located in a closed jar was complete toward the end of 3 hours, when these same type of sheets were used 48 hours after impregnation the mortality rate of the flies attained 77% with the same exposure.

According to their mechanism of action on arthropods the organophosphorus insecticides belong to the enzymatic poisons:

they caused significant inhibition in the formation of cholinesterase and pseudocholinesterase.

The organophosphorus compounds even in insignificant amounts ($1 \cdot 10^{-7}$ and $1 \cdot 10^{-9}$ mole) are able to suppress these enzymes.

As it is known, the function of cholinesterase consists in the prevention of the accumulation of acetylcholine, which normally vanishes as rapidly as it is formed. Organophosphorus compounds inhibiting the formation of cholinesterase promote the accumulation of acetycholine in the organism which causes poisoning.

The anticholinesterase action of the esters of phosphoric acid started to take on meaning during the Second World War, then the high toxicity of these compounds to people was ascertained.

Chlorophos also belongs to the enzymatic poison. Getting into the organism, it inhibits the formation of cholinesterase, forming with it stable complexes. This process is accompanied by the phosphorulation of cholinesterase and the cleavage of organophosphorus compounds. Spencer expresses the assumption that dipterex (chlorophos) in the organism is first dehydrochlorinated, then isomerized into 0,0-dimethyl-0-2,2-dichlorovinylphosphate (DDVP), which also, apparently, phosphorylates cholinesterase.

The effectiveness of chlorophos in an alkaline medium is higher than in an acid medium. Thus, for example, with pH of 5.4 and 8 the suppression of cholinesterase is 11 and 100% respectively. These data clearly illustrate that in the suppression of cholinesterase an essential role is played by DDVP, forming from chlorophos. The speed of the paralysis of house flies, which were fed sugar containing chlorophos increased with the increase of pH from 5.4 to 7.0. In flies poisoned with chlorophos tagged with radioactive phosphorus, the formation of DDVP was established for a portion of which was necessary for 5% of the total radioactivity. The latter, as is known, is 7-10 times more toxic to flies than chlorophos. With the addition to solutions of chlorophos of an equal amount of ammonium carbonate the effectiveness of the former in fly baits is increased by approximately 6-7 times.

In a study of the disintegration and excretion of the preparation Bayer-L-13/59 tagged with radioactive phosphorus in a lactating cow, and also of the penetration of the preparation into the organism of the larvae of the Hypoderma bovis ox warble fly it was established that the preparation is subjected to rapid metabolism in the organism and is excreted with the urine. The greatest quantity of the preparation is excreted 2 1/2-5 1/2 hours after its introduction into the organism. In the milk of the experimental cow 144 hours after the beginning of the experiment less than 0.2% of the radioactive preparation was detected of the total dose introduced and about 23% was inorganic phosphorus. In the blood the highest level of radioactivity was reached between the 1st and 3rd hour after the introduction of the preparation. In the exudate of warble fly larvae there was noted a somewhat slower dispersion of the radioactivity than in the blood of an animal. The maximum radioactivity per unit of weight was noted in those larvae, which were gathered between the 6th and 24th hour after the introduction of the preparation to the cow. In the blood, urine or milk of the animals DDVP was not detected. It was ascertained with the help of tagged radioactive phosphorus that Bayer-L-13/59 and DDVP administered in the form of a solution in absolute ethanol on the dorsal cervical membrane of first instar oriental cockroach nymphs were rapidly absorbed by the insects and excreted mainly through the intestinal tract, where the preparation Bayer-l-13/59 was spread all over the organism so that the hemolymph and all the tissues of the insects became radioactive, and the greatest amount of this preparation was found in the fat bodies and only an insignificant part in the intestines.

Analogous results in experiments with insects were also obtained using the tagged preparations Bayer-L-13/59 and DDVP. The absorbed preparation first got into the blood, then into the intestines of the insects, after which it was distributed all along the alimentory canal, appearing finally their posterior segment. This method of distribution, in the opinion of the authors, differs somewhat from the way phosphorus-containing insecticides are distributed, with respect to which their accumulation was noted in the anterior segment of the intestines.

They assume that organophosphorus compounds act suppressingly on the acetylcholinesterase of the nervous system thereby causing the death of the insects.

However, these compounds are also toxic to insect eggs treated before the time the differentatiation of the nervous system occurs. Eggs treated before the time cholinesterase activity appeared in them, developed normally, but larvae did not hatch from them.

The investigations of the histochemical changes in the organism of insects under the effect of chlorophos, conducted by V. I. Zakkolodkina, showed that 3-5 hours after the action of the organophosphorus insecticides on the flies changes were observed in the hemolymph: the number of basophilic cells sharply decreased, and in most cases they completely vanished; the number of oxyphilic cells changed slightly, but in certain of them pyknosis of the nuclei was observed; many were rather strongly compressed and decreased in size. After 5 hours only single oxyphilic cells were evident.

After treating flies with chlorophos for 30-60 minutes the weight of the hemolymph in paralyzed individuals decreased by 63%, and after 5 hours - by 90% as compared to the control flies; in the experimental nonparalyzed individuals sharp changes in the hemolymph were not noted.

These data show that chlorophos causes sharp changes in the hemolymph of house flies, and not only does it significantly decrease the weight of the hemolymph, but also the cellular elements degenerate.

Investigations by V. I. Zakolodkina in the region of the enzymes of the respiratory tissues of insects showed that 3 hours after the effect of chlorophos there was observed in the nerve cells a certain suppression of the activity of cytochrome oxidase and succinic dehydrogenase, which gradually intensifies and after 5 hours is rather pronounced.

In the muscles of the house fly 3 hours after the effect by chlorophos there is also observed a certain suppression of the activity of cytochrome oxidase, which after 5 hours is strongly expressed.

The activity of succinic dehydrogenase fluctuates somewhat differently. Three hours after the application of chlorophos the activity of this enzyme is increased, but after 5 hours it is considerably suppressed.

These changes in the activity of cytochrome oxidase and succinic dehydrogenase indicate great changes in the oxidative processes of the cells and tissues.

There also occurs disturbance of protein metabolism, as a result of which in the large and average nerve cells the amount of ribonucleic acid and arginine decreases. In the small nerve cells 5 hours after the influence of chlorophos ribonucleric acid and arginine cannot be detected by the histochemical method.

Chlorophos is very toxic to dipterous insects, and this is why it is also called dipterex. It is especially effective in combating flies, including those resistant to the chlorinated hydrocarbons. A mortality rate of 50% of the house flies occurs with the application of 0.2-0.4 μg of the preparation per each individual; 100% of the flies die with the application of 2 μg of the preparation.

After coming in contact with the preparation the flies rapidly develop paralyses and death ensues. Thus, for example, when 2.5 μg of the insecticide is applied to the dorsum of each fly paralysis ensues in the insects after 5-6 minutes, and 50% of the flies die after 8-10 minutes.

Chlorophos is highly toxic to house flies and at a concentration of 0.001% causes their death within 24 minutes. In comparing the concentrations required to bring about the death of 50% of the house flies, it was established that chlorophos is $4\frac{1}{2}$ times more toxic than the pyrethrins (T. A. Bolotova, L. N. Vasilenko).

Of great interest also is the fact, that chlorophos with respect to flies was 4-5 times more toxic than DDT; furthermore, in weak solutions (0.1-0.2%) it possesses the capacity to attract flies.

On glass and surfaces painted with oil base paint, with their solid covering with aqueous solutions of chlorophos, the preparation after evaporation of the moisture becomes distributed in the form of a nonuniform film. When the surfaces are treated with fine drops the preparation is deposited in each drop in the form of a ring with an uneven internal region [edge]. On cotton fabric after it has received a fine-drop, continuous [solid] treatment, and also after it is moistened the deposits of chlorophos have the form of individual, small scales; the remainder of the preparation is dispersed inside the fibers, where it becomes inaccessible for the insects. When test-objects of glass and those painted with oil paint are stored, there is observed after 8-10-12 days crystallization of the preparation, as a result of which there are formed long needle-shaped crystals, disposed in small clusters, which are rather firmly held on the surface.

When DDT is used the effectiveness of the preparation depends on the size of the crystals, however one should not always attach great significance to the crystals and consider the effectiveness of the treatment dependent on their presence and form. This especially pertains to chlorophos, which at first after evaporation of the solvent covers a surface in the form of a film formed by a substance of viscous consistency; nevertheless in the first days the effectiveness of the surfaces treated with chlorophos is the highest. The insecticidal effectiveness of surfaces treated with aqueous solutions of chlorophos is maintained for 15-20 days depending upon the temperature and meteorological conditions. It is necessary to note that the question concerning the physical-chemical state (amphoteric or crystalline) in which insecticides are effective has still not been resolved. Moreover, the higher vapor tension of chlorophos in the viscous state, in conformance with physical-chemical laws, ensures their best dissolubility in the cuticle of the insect.

Chlorophos readily dissolves in water; it is used to treat external surfaces of buildings in the warm season, when precipitation in the form of rain falls rarely; in places, where precipitation falls frequently, chlorophos is used to treat surfaces protected by roofs, the inside of premises, the inside of medical installations, etc.

Chlorophos solutions are unsuitable for impregnating soft objects, especially frequently washed fabrics because the preparation dissolves in the water and is washed out.

Aqueous solutions of chlorophos are best suited for treating surfaces which do not absorb or only slightly absorb water (glass, tile, linoleum, surfaces painted with oil paint, to a lesser extent those covered with whitewash, plastered surfaces) on which the preparation retains (up to 30 days) its residual toxic action for a long time. The addition of terphenyl or other prolongantors increases the period of action of chlorophos on surfaces (D. Ye. Genis, V. P. Dremova, I. V. Gvozdeva).

It is not expedient to treat with aqueous solutions of chlorophos water-absorbent surfaces – unpainted, wooden, adobe.

On all the enumerated surfaces chlorophos, when applied in a fine spray, does not leave spots. Depending on the character of the operations being carried out water solutions of chlorophos are applied at a 0.5-4% concentration. Chlorophos solutions in organic solvents (dichloroethane, technical oils and others) should contain from 0.2 to 2% chlorophos and from 99.8 to 98% solvent.

Disinfecting powders made from DDT and hexachlorane preparations have advantages over chlorophos disinfecting powders. If the former can be stored for a long time (several years), then chlorophos disinfecting powders (5-10% with talc as a filler) when stored in paper or fabric packing (sacks) lose in the course of 2 years insecticidal properties within the limits of 20-30%, but when stored in a glass jar for 3 years the insecticide properties do not vary.

Disinfecting powder is the most effective form for the application of chlorophos. Thanks to the fact that particles of the disinfecting powder lie freely on treated surfaces, they easily adhere to insects, as a result of which their destruction is ensured even after 30 seconds of contact with preparation deposits in an amount of 0.5 g/m^2. In those experiments in which the time contact of the flies was extended to 5-10 minutes, a high level of insect death (90-100%) was observed when chlorophos was used at a rate of 0.05 and 0.1 g/m^2.

On absorbent surfaces (wood, wallpaper) where aqueous solutions of chlorophos are ineffective the application of disinfecting powders is necessary and when the insecticide is expended at a rate of 0.1-0.3 g/m^2 it ensures the complete destruction of flies after 5 minutes of contact. The effectiveness of chlorophos disinfecting powder applied on wood and wallpapered surfaces is almost identical (K. D. Stepanov).

Moreover, on vertical, wallpapered surfaces, a sufficient amount of the preparation remains, which ensures complete destruction of the flies coming in contact with them for 5 minutes.

The insecticidal activity of chlorophos applied in the form of a solution-suspension on porous, absorbent surfaces is considerably greater than when aqueous solutions of the preparation are used.

When a solution-suspension is used it is necessary to stir or agitate it constantly since the powder rapidly settles to the bottom.

The results of observations showed that the insecticidal properties of chlorophos preparations applied on various surfaces are retained for a more or less prolonged period of time and depend on, besides the physico-chemical properties of the preparation, on the number of conditions under which it is applied.

Of great importance in preserving the residual action of the chlorophos is the amount of insecticide applied on a surface, and also its form of application. Thus, for example, in the form of a disinfecting powder the duration of the insecticidal action of chlorophos is greater than in the form of an aqueous solution and by increasing the preparation dose its action on surfaces is prolonged.

Considerable influence on the duration of residual action is rendered by air temperature and solar radiation. Under conditions of room temperature (19-20°) the insecticidal effect of chlorophos is retained for 2-3 weeks, at a temperature of 2-3° up to 3 months, and at a temperature of 28-30° - for 6-7 days. Thus, when the temperature of the ambient air is increased the duration of the residual action of chlorophos is decreased.

The effectiveness of the preparation with respect to insects increases with temperature increase. Thus, for example, the same dose of chlorophos (0.005 g/m^2), when experiments are conducted under room conditions with a temperature of 25-26°, kills 70% of the flies whereas at a temperature of 19-20° only 30-40% of the flies die.

The effect of ultraviolet rays on surfaces treated with chlorophos preparations is one of decreasing its effectiveness. Thus, for example, irradiation by an ultraviolet lamp of 15 W placed at a distance of 40 cm from surfaces, on which 0.4 g/m^2 of chlorophos disinfecting powder has been applied decreases its insecticidal action by 10-16% after 5 days and by 25% after 6 days of irradiation. By the 10th day of irradiation the effectiveness of chlorophos on given surfaces approaches zero, whereas the duration of the residual action of chlorophos disinfecting powder under the same conditions without the influence of ultraviolet rays is preserved for 20 days.

The application of aerosols is one of the effective methods of using insecticides to combat flies, gnats, mosquitoes, moths, and also agricultural pests.

A comparison of the results of testing chlorophos aerosols obtained by burning aerosol paper, tablets and pots, showed that their insecticidal activity was almost identical. In all cases a high level of house fly extermination (90-100%) is attained from aerosols with an expenditure of 0.05 g of preparation per m^3 of air.

Surfaces after chlorophos is applied to them in the form of aerosols retain their insecticidal properties for 24 hours. Thus, it is expedient to apply chlorophos aerosols for the production of an acute effect with respect to flying insects.

In combating flies food baits containing insecticides are widely applied.

Observations show that baits containing chlorophos are an effective method of controlling flies. All methods of applying baits (scattering granulated baits, treating surfaces with liquid bait, hanging up cords and gauze screens impregnated with bait, and also setting out vessels containing bait and others) are highly effective (V. I. Vashkov, Ye. V. Shnayder).

A study of the insecticidal activity of chlorophos with respect to the preimaginal stages of house fly development showed that this preparation has a toxic action on all the stages of their development (V. I. Vashkov, Ye. V. Shnayder, N. P. Kulkina).

Its insecticidal (larvicidal) action on fly larvae and pupae appears both as a result of direct contact with the cuticle insects, and also as a result of its getting into the respiratory tract in the form of vapors.

Chlorophos has an injurious effect (ovicidal) on fly eggs when they are submerged in a 0.1% aqueous solution for 30-60 minutes. On a humid substrate in the presence of chlorophos the hatching larvae also die rapidly (Ye. V. Shnayder).

When chicks drinking water with a pH < 7 and containing 130 mg/ℓ of chlorophos fly larvae did not develop in their feces. When the pH of the water was increased to 8 this effect was not observed (Sherman). Abroad after 3-5 years of continuous dipterex employment reports began to appear concerning the development of a specific resistance among insects, mainly among flies, ticks and mites. In Denmark after 3 years of application of dipterex the resistance of flies increased by 40 times, in the United States the resistance of larvae to this preparation after 4 years was increased by 5-20 times.

Chlorophos possesses high insecticidal activity with respect to fleas. After a single application of 3-24 g of 2.5% chlorophos disinfecting powder on dogs and cats the residual action was retained for 5-11 days, and with a double application - 14-19 days.

In combating rat fleas good results were obtained by treating surfaces with a 1% aqueous solution at a rate of 40 $m\ell/m^2$. With such treatment the effectiveness is preserved for 35 days. Disinfecting powders and aerosols are also highly effective in combating fleas.

Body lice are the least sensitive to chlorophos as compared to other arthropods (fly, fleas, bugs, cockroaches, ticks, mites and other). In combating pediculosis in practice chlorophos can be applied only with respect to the imago by dusting with 5% disinfecting powder the upper clothes or bed appurtenances (blankets, mattresses) and by beating out the powder after 1-2 hours.

Bed bugs are very sensitive to chlorophos. Thus, for example, they are 1.7 times more sensitive to chlorophos than flies. Cockroaches are also highly sensitive to this preparation. In its insecticidal effect on cockroaches chlorophos exceeds DDT.

Chlorophos preparations possess high insecticide activity with respect to winged mosquitoes. Thus, for example, after being in contact for 5 minutes with surfaces treated with the disinfecting powder at a rate of 0.025 g of preparation per m^2, the mortality rate of the insects on the average reaches 96%. A high effectiveness of chlorophos is also noted in combating mosquito larvae: at a concentration of 0.00005%/0.5 g/m^3 (in shallow reservoirs or irrigating ditches) it causes complete destruction of the larvae.

Chlorophos is as safe for fish as thiophos (parathion), at concentrations from 1 to 10 parts per million, therefore when this preparation is used to combat mosquitoes it does not present a danger to fish.

Chlorophos with respect to the sand flies Phlebotomus papatasii in its insecticidal properties is not inferior to DDT. The high acaricidal properties of chlorophos make it possible to recommend it for the extermination of various forms of ticks and mites.

In connection with the fact that chlorophos possesses bactericidal properties, 5% aqueous solutions of it along with its application to combat insects can also be used for the purpose of disinfecting surfaces and excretions. The application of chlorophos solutions to carry out prophylactic disinfection and disinfestation has great promise because coliform bacterium [Escherichia coli], dysentery bacillus, winged flies and their larvae die simultaneously. This circumstance acquires especially great significance in cases of carrying out of prophylactic disinfection of medical units in public places, in particular there, where outhouses are still employed. Chlorophos does not affect spore types of micro-organisms (V. I. Vashkov, T. S. Nekrasova).

<u>The application of chlorophos in combating animal ectoparasites</u>. Because the toxicity of chlorophos is not high, it is used to treat animals for the purpose of protecting them from insect infestation.

In experiments on cattle it has been shown that chlorophos is an effective agent for combating warble fly larvae both as a systemic and as a contact poison, and in doses of 10-20 mg/kg it is harmless for animals. Subcutaneous injections of a 10% aqueous solution of chlorophos at a rate of 10-15 mg/kg, and also the external application of a 5-10% solution for treating the animals killed 98-100% of the warble fly larvae. Moreover, the authors confined that milk obtained from cows treated with chlorophos was harmless to animals (mice).

A larger dose of chlorophos (50 mg/kg) when administered subcutaneously causes in bull-calves mild suppression of the general state for 1-2 days, and a dose of 70 mg/kg 1-3 hours after the injection causes severe excitation, alternating with suppression and debility, passing within 6 days without a trace.

Positive results have been obtained with the subcutaneous and external administration of chlorophos when it is used hypoder[illegible]osis. (V. A. Kolyakov, A. P. Komarin, D. F. Loginov).

One of the ways of secreting chlorophos from the organism of animals after the subcutaneous introduction of 20 mg/kg of the preparation is in the milk, which is toxic to flies, but clinically harmless to white mice. Furthermore, by a biological test (the feeding of flies with the blood of animals, which have obtained 0.02 g/kg of the preparation subcutaneously) it was established that chlorophos is retained in the blood of animals for a period of 10 days.

The investigations of D. V. Savel'yev on the most improved [perfected] of combating warble flies on reindeer showed the highly effective action of chlorophos for treating animals both for the imaginal and also for the preimaginal stages of this insect. On the basis of his own investigations the author indicates that after abundant wetting of the skin with 1-2% aqueous solutions of the preparation, placing drops in the eyes, and also after the atomization of disinfecting powder in the nose these injurious symptoms were no longer noted in the animals.

The experiments of N. V. Voblina on the larvae of the nose botfly of reindeer showed that a 1% aqueous solution of chlorophos in laboratory experiments kills the first stage larvae after 24-36 seconds. Analogous data were obtained by D. F. Loginov. Treating the nasal cavity with chlorophos solutions at test concentrations, according to the author, did not cause pathological aberrations. I. S. Ivashkov applied 15 mg/kg of chlorophos to treat parascaridosis of horses without harming them. Other authors also obtained good results in studying the possibility of using chlorophos to combat animal ectoparasites.

A cutaneous application of a 3% chlorophos solution is used to combat the warble fly by moistening the individual tumors, if there are only a few of them on the body of the animal (for example, up to five), or an affected surface of the animal body — back, chest, croup, neck, etc., if the tumors are numerous. After the wetting the solution is immediately rubbed into the skin with a stiff brush or (in treating an animal soon after shedding) with a wad of cloth.

The application of chlorophos to combat the warble fly by cutaneously treating animals does not have a prophylactic action, but yields a highly therapeutic effect.

According to A. I. Zotov and Sh. A. Mkrtchyan, who carried out measures against warble fly larvae, double treatment of the animals with a warm (37°) 4% aqueous solution of chlorophos (50-100 mℓ per animal) caused the disappearance of small tumors; the dried larvae were drawn out of the large tumors.

With hypodermatosis in cattle D. K. Polyakov, I. S. Ivashkov, K. P. Andreyev and others consider that for cutaneous treatment of the animals a 3% chlorophos solution is the most effective; in second place in effectiveness the authors place a 1.5% aqueous solution of chlorophos with the addition of 1% OP-7 emulsifier.

Chlorophos is used subcutaneously only for treating young steers up to 2 years, but only for severe warble fly infestation. For emaciated young steers injections are contraindicated and they are treated cutaneously.

For injection a 10% chlorophos solution is used. As a solvent distilled, snow or rain water is used. The snow or rain water is first filtered and then sterilized by boiling for 30 minutes.

With respect to ixodoid ticks the investigations of M. G. Khatin, I. V. Semenov, Sh. A. Mkrtchyan showed that the treating animals with 1-2% aqueous solution of chlorophos provides a good acaricidal effect. The addition OP-7 emulsifier to aqueous solutions of chlorophos helps increase its activity for treating animals. When 3-5% aqueous solutions are used the residual effectiveness after treating cows and horses is retained for 8-13 days (Yu. N. Pil'shchikov).

When the preparation is applied with a pipette to ticks taken from animals, paralyses in the majority of arthropods ensues within 20 minutes and death – within 30 minutes.

Abroad it was demonstrated that an application of a suspension or a 1% aqueous solution of the preparation Bayer-L-13/59 by rubbing it into the back of animals with a brush results in the death of all the larvae; when a 0.5% solution was used 91% of the larvae died. But it is necessary to note that these data were obtained by the authors in experiments on only two animals (Ye. I. Pokrovskaya).

With the introduction into food of 10 mg/kg of chlorophos in the form of soluble powder for a period of 10 days there was observed the death of 99% of the larvae of the hypodermis. Some of the animals refused to eat food containing chlorophos. The preparation did not evidence any toxic effect; there was noted however, a certain suppression of blood cholinesterase.

In a study of its systemic action for animals the mortality rate of bed bugs and ticks of genus Amblyomma was ascertained.

In treating birds to combat ectoparasites 3-4 g of 5% disinfecting powder of the preparation Bayer-L-13/59 were used per bird.

When 3-4 g of 1% chlorophos disinfecting powder were applied per bird to combat the northern bird tick Ornithonissus sylviarum good results were attained. A single application of chlorophos provided a positive effect for up to 28 days. Moreover in the chicken coop as a result of the treatment almost complete extermination of the ticks was obtained (Knapp, B. A. Frolov).

N. A. Kolotin showed that the spraying of a 0.5% aqueous solution of chlorophos was completely harmless to the hens located in the treated chicken coops at the same time it was an effective means of destroying of the fowl tick.

For the water fleas Daphnia magna LD_{50} is equal to gammas per ℓ: for chlorophos 0.4, for parathion 1.8, for diazinone 2.5, for malathion 3.0, for chlorothion 4.2, for DDT 15.0, for systox 20, for endrin 39, for toraphene 15.5, for heptachlor 200, for thiodane 220, for dieldrin 230, for aldrin 270, for metasystox 440, for lindane 720.

<u>The application of chlorophos to control pests of agricultural crops</u>. In the area of agriculture chlorophos was tested against pests of fruit trees, cotton, etc. It was determined that the preparation penetrates into the tissue of plants and acts on arthropods as an intestinal and contact poison.

Chlorophos solutions of 0.025 and 0.05% cause the complete destruction of 19 forms of harmful lepidopterous insects; application of solutions at that same concentration gives good results against 7 forms of aphidae and mites. The preparation possesses a contact and intestinal action, and the latter is 60 times stronger than the contact action.

For control Drosophila flies on tomato plantations spraying was carried out with bait containing 0.1% of the preparation Bayer-L-13/59, 10% molasses, 1% vinegar and 0.1% dry yeast, which provided good results for 8-14 days.

In combating pests of pear trees chlorophos as well as other preparations (diazinone separately and in a mixture with DDT, thinet), did not yield positive results.

Aqueous solutions of chlorophos can be used for treating vegetation. If instead of water other solvents are used, which frequently occurs in combating agricultural pests (mosquitoes, gnats and mites), then it is necessary to consider the phytocidal effect of the solvent.

Chlorophos in the form of the preparation tugon has found application against a number of harmful insects in the hothouse and forest economy, and also in cotton growing. The preparation, penetrating into the leaves, stems and fruits of plants, acts on sucking and gnawing insects: flies die within a minute of the poison getting into their organism; caterpillars and beetles upon consuming the poison also die within a very short time (N. M. Gamper, N. S. Vladimirskaya).

Chlorophos solutions at 1% concentration are toxic to poplar trees, black currant trees, rasberry bushes, apricot trees, beet and tomatoe plants; to apple trees, potatoe plants and carrots chlorophos is toxic in a 3% solution, and for cherry trees, plum, pear, oak trees, and corn – at 5% solution.

In contrast to other typical systemic insecticides (syptox and metasystox) chlorophos does not possess prolonged residual action which is very favorable for its application in agriculture.

Chlorophos is very effective in combating such leaf mining pests, such as Hyphantria cunca and Sparganotus pilleriana.

For control of fruit flies Steiner recommends bait sprayings; as an attractant for these baits enzymatic and acidic hydrolyzates of yeast protein are used. Besides, according to the author, malathion and parathion are more effective insecticides for these baits than is diazinone, chlorothion, and the preparations Bayer-L-13/59 and Bayer-17147.

After treatment chlorophos is retained on lettuce for 3 days, on spinach 2 1/2-3 days, on beans 1-5 days and on pears 2-2 1/2 days.

The toxicity of chlorophos to warm-blooded animals. By its mechanism of action on warm-blooded animals as well as on insects, chlorophos is an enzymatic poison. In the action of organophosphorus compounds on an animal organism there occurs hydrolysis of the phosphate group, however it still remains connected to the enzyme, thus preventing the interaction of acetylcholine with cholinesterase.

The pathoanatomical picture in the poisoning of animals and people by phosphorus-containing insecticides is expressed in the destruction of the myelin sheath around certain nerves in individual sections of the spinal cord. In the organism there occur three types of reactions: a) constriction of the respiratory tracts - bronchospasms; b) disturbance of the conduction of impulses from the motor nerves to the muscles carrying out breathing and others; c) disturbance of the genesis of impulses proceeding to the brain and back along the motor nerves innervating the breathing muscles.

These three reactions of the organism to organophosphorus compounds are expressed in the affection of the respiratory function and the animal dies from asphyxia. The disturbance of the junction between the motor nerves and the muscles occurs as a result of the constant presence of acetylcholine at the myoneural junctions (A. P. Volkov, Ye. V. Shnayder).

A favorable property of the preparation Bayer-L-13/59 is its comparatively low toxicity to warm-blooded animals.

Data about the toxicity of chlorophos to man, and also accounts of cases of human poisoning by this preparation do not appear frequently in literature. Certain authors affirm that a lethal dose of the preparation Bayer-L-13/59 for man is 5 times greater than a lethal dose of DDT.

Lebrun conducted experiments studying the toxicity of chlorophos to people - volunteers.

The latter were orally administered 7.5 mg/kg each day for several days (a total dose of 1050 mg per person with a weight of 70 kg); of the 15 men taking part in the experiment, only one manifested nausea and colic and for this he was given 1 mg of atropine, as a result of which these symptoms vanished.

We know of a case of poisoning of a 25-year old woman who took 100 g of chlorophos in attempting to commit suicide. After 5-6 minutes she began to vomit. Her state of being began to deteriorate. After about 3 hours she was taken to a hospital; she was admitted with complaints of stomach pain, nausea, vomiting and an unpleasant sensation in the cardiac region. The condition of the patient, according to the description of the attending physician, was severe; she was pale but conscious. The heart tones were good but somewhat muffled. The pulse rate was 84 beats per minute rhythmic with weak filling and satisfactory tension.

In the lungs the breathing vesicular. The stomach was soft, acutely painful upon palpation. Urination was not disturbed. In the hospital her stomach was pumped and she was given a saline purgative. Symptomatic treatment was conducted.

On the 3rd day spasms started; the condition of the patient was inhibited; she responded to questions hesitantly. After 5 days her condition began to improve and after 11 days she was sent home in satisfactory state.

After placing drops of a 1-3% chlorophos solution in the eyes of rabbits irritation of the mucous membrane was not observed; a temporary contraction of the pupil was noted. The application of a 5-10% solution caused inflammation of the eyes, which passed within a day.

D. V. Savel'yeva also noted that the placing of drops of a 1-2% aqueous solution of chlorophos in the eyes of reindeers did not cause noxious symptoms in the animals.

According to the data of N. A. Sazonova, A. P. Volkova and T. P. Kazakova, the application of chlorophos leads to a considerable reduction in cholinesterase activity.

Behey and his colleagues studied the toxicity of dipterex to people; in the experiments 37 volunteers participated in 7 of whom in the course of 2 days doses of 500 mg did not cause symptoms of poisoning. In 13 of 21 people, who each received 1 g of the preparation per day in the course of 2 days and in 9 who received 1.32 g daily for 2 days, more or less severe pains were noted in their intestines.

Clinical and biochemical investigations of the basic functions of the organism did not show any variations as a result of the effect of this preparation, with the exception of a significant reduction of the level of the activity of blood cholinesterase, which also was the cause of gastrointestinal symptoms. The authors emphasized that these symptoms although they were acute in certain cases, their severity was minor, and they did not leave aftereffects.

The cases of poisoning with organophosphorus compounds described in literature, as a rule, appeared as a result of the application without any measures of such highly toxic insecticides as thiophos and [TEPP] (ТЭПФ), (Chamberlain).

The specific antidote for poisoning with organophosphorus compounds is atropine. The administration of cholinolytic preparations (tropacine, penetaphene) prevents the subsequent development of poisoning. In mild cases of poisoning with phosphorus preparations the administration of 2 mg of atropine is recommended, and in severe cases 4-6 mg. For acute spasms the application of barbiturates, ether and chloropromazine is recommended. The administracion of morphine is categorically contraindicted because it has a suppressing effect on the breathing center.

In poisoning with alkyl phosphate insecticides atropine is only a symptomatic antidote. As a result of investigations by the author the best antidote turned out to be 2-pyridine aldoxime methiodide ([PAM] (ПАМ)). The most effective therapy for treating poisoning with phosphorus preparations, according to the author, is the carrying out of the following regimen: artificial respiration, inhalation of oxygen, the injection of atropine in complete and repeated doses according to the clinical indications, the administration of PAM symptomatic therapy.

Due to the considerably expanded application of organophosphorus insecticides for combating insects it is necessary when working with these preparations to observe precautionary measures, which include compulsory use of respirators, thorough washing of the hands with soapohm, correct handling of the preparations and storing them in a separate place.

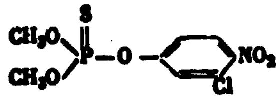
To protect the respiratory organs it is possible to use brand "A" gasmask cylinders and Ф-46 respirators, for protecting the integuments – rubberized and other fabrics with water-resistent properties. For decontaminating organophosphorus insecticides when they get on the skin and clothing the application of a 3-5% ammonia solution, and a 2-5% chloramine-B solution is recommended. Airing out the clothing is also considered very important. To decontaminate organophosphorus compounds spilled on a floor or on the ground, it is possible to use 20% chlorinated lime milk.

Although chlorophos possesses relatively mild acute toxicity its chronic toxicity to man is rather significant, therefore when working with it it is necessary to apply measures against poisoning. For this purpose it is necessary to determine the cholinesterase level quarterly for those people working with organophosphorus insecticides; workers whose choliensterase level is lower than 50% of the normal should be relieved from work.

Such regular examinations are not possible (for example, in carrying out disinfestational treatments in isolated regions of a rule district), then to prevent poisoning it is necessary not to permit too prolonged contact of the workers with organophosphorus compounds. In connection with this the alternation of work with insecticides is recommended: 2 months with organophosphorus and 2 months with other chemical groups or a 2 months shift to other work. However, it is also necessary to check the effect of other insecticides on the human organism. Thus, Bruce established that DDT, with which 39 men worked, caused a variation in their cholinesterase level by 23 units from the normal. Therefore, those people working with organophosphorus compounds should not be transferred to working with DDT and vice versa.

Chlorothion

Chlorothion – $C_8H_9ClNO_5PS$ – 0-(3-chloro-4-nitrophenyl)-0,0-dimethyl-thiophosphate



Synonyms: Bayer-22/190; 0,0-dimethyl-0-3-chloro-4-nitrophenylthiophosphate, p-nitro-m-chlorophenyl-dimethyl-thiophosphate.

The liquid is a yellowish-brown color with a characteristic ether-like odor. The boiling point is 112° at 0.04 mm Hg, 121° at 0.08 mm Hg. Its specific gravity is 1.437; the refractive index is 1.5661; the vapor pressure at 10° is 7×10^{-6} mm Hg, at 20° 22.10^{-6} mm Hg. Its volatility at 20° is 0.07 mg/m^3, at 30° 0.3 mg/m^3, at 40° 0.95 mg/m^3. It is slightly soluble in water (1 part per 25,000 parts); it dissolves readily in organic solvents, for example in benzene, alcohols, ether, fats, in olive oil, in peanut oil, it is slightly soluble in petroleum ether. In an alkaline medium it is rapidly hydrolyzed, it is unstable upon dilution in water with a pH of 7.5.

Like metaphos it is hydrolyzed under certain conditions; it is incompatible with Bordeaux liquid and sulfur preparations; it is compatible with DDT, lindane, dissolved sulfur. From chlorothion there are prepared a 25% wettable powder and a 3% disinfecting powder. According to L. Lewallen the LD_{50} for the house fly is 0.33 μg per insect for Fania canicularis 0.022 μg per insect. With respect to its insecticidal properties for the house fly it is approximately 100 times stronger than heptachlor 20 times stronger than methorychlor and somewhat weaker than diazinone. Its toxicity to larvae of the Anopheles quadrimasulatus mosquito is less than thiophos carbophos and DDT. In the presence of 0.005 mg/ℓ of chlorothion in water 44% of the Anopheles larvae die.

In combating flies 1-2% solutions of the preparation in sugar bait are used. To exterminate flies of suspension and emulsions of the preparation are applied on surfaces of various construction. Chlorothion at a rate of 250 g/ha is also used to destroy Anopheles and Aedes mosquitoes. It is used to destroy bed bugs, cockroaches and other arthropods at a concentration of 1-2%. Basically chlorothion is used in combating pests of agricultural plants. Its toxicity to warm-blooded animals is lower than chlorophos. Thus, according to source material, the LD_{50} for rats with oral administration for males is 880 mg/kg, for females - 980 mg/kg, and when applied on the skin - approximately 4000 mg/kg.

CHAPTER VI

CARBAMATES

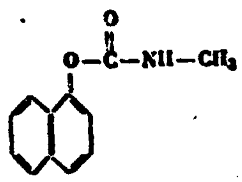
In 1951-1952 there was first synthesized in Switzerland a number of carbamates possessing insecticidal properties: dimetan, pyrolan, isolan. At the present time it has been established that approximately 70 carbamates possess insecticidal activity, and sevin enjoys the greatest popularity.

The insecticidal specificity of the carbamates depends on the nature of the aryl group — an approximately linear connection is noted between the logarithm of the toxicity of the preparations for flies and cholinesterase suppression. Carbamates have been studied as inhibitors of cholinesterase in the brain and poisons for fly imagoes and larvae of gnats and mosquitoes. The dimethyl carbamates are weaker inhibitors (4-40 times less) and less insecticidal than the methyl carbamates (Casida and others). Aliesterase and cholinesterase are sensitive to sevin, isolan and other compounds, but a dose causing inactivation of 50% these enzymes, for aliesterase is approximately 10 times greater than for cholinesterase (Plapp and others).

The relative insecticidal specificity of the carbamates almost completely depends on the nature of the phenol group. The addition of piperonyl butoxide, sesoxane and other synergists of pyrethrum to the carbamates to a considerable degree decrease the rate of detoxification in connection with which their toxicity is considerab strengthened, especially for room flies. It has been shown that the dimethylcarbamates are less reactive than the methylcarbamates. The carbamates have a contact and an intestinal action.

With prolonged use of the carbamates the house flies developed resistance to them. According to Georghious, after the effect for a period of 55 generations of methylisopropylphenyl-N-methylcarbamate and isolan (1-isopropyl-3-methyl-5-pyrazoline-dimethylcarbamate) there was observed in house flies cross resistance [DDT] (ДДТ), methoxychlor and simultaneously to the organophosphorus compounds. A strain subjected to breeding with m-isopropylmethylcarbamate showed the presence of cross resistance analogous to the aforementioned strains, and, furthermore, cross resistance to lindane and dieldrin. The pattern of cross resistance under the effect of breeding with the carbamates was very similar to the pattern obtained during breeding with organophosphorus compounds, but not with the chlorinated hydrocarbons. If for susceptible flies the [LD_{50}] ($ДД_{50}$) of m-isoprophylphenyl-N-methylcarbamate when topically applied was equal to 1.4-2 µg per insect, then for resistant ones this value was more than 100 µg per individual.

Sevin - $C_{12}H_{11}O_2N$-1-naphthyl-N-methylcarbamate.



Synonyms: N-methyl-alpha-naphthnaphthalcarbamate; carrolin and others. The preparation is an analog of the alkaloid physostigmine; it is a white crystalline substance with a melting point of 142°; its vapor pressure is less than 0.005 mm Hg at 26°; its density is 1.232 at 20°. The technical product is slightly colored; about 0.09% will dissolve in water or 99 parts per million parts of water;

it is soluble in the organic solvents (acetone, cyclohexanone and others), it is resistant to heating, light and acid medium, but hydrolyzes in a highly alkaline medium. Both the technical product, and also the prepared preparation are stable under normal conditions of storage, they do not have an odor. Sevin is a contact insecticide. Its mechanism of action is similar to mechanism of action of the organophosphorus insecticides. It suppresses cholinesterase and aliesterase; it quickly kills insects; it possesses a considerable residual action exceeding the residual toxicity of the chlorinated hydrocarbons and the phosphates (K. D. Shevtsova-Shilovskaya). This insecticide can be used to combat insects, which have developed resistance to the chlorinated hydrocarbons and phosphates. Its activity is increased by the addition of a number of synergists – piperonyl butoxide (1:5), sesoxane, sulfoxide, seasame oil and others; it is possible to use it in a mixture with DDT. The addition to sevin of piperonyl butoxide at a ratio of 1:1 strengthens its insecticidal properties by approximately 4 times. The preparation is produced in the form of a 38% concentrate, which is used for preparing disinfecting powders (from 1.75 to 10%) and solutions (in kerosene).

Sevin is effective in combating ants, cockroaches, moths, fleas, bed bugs, wasps and other insects. With respect to house flies it does not provide good results; in combating them it can be used with the addition of synergists, in particular 1 part of octachlorodipropyl ester [bis-(2,3,3,3-tetrachloropropyl)-ester] to 20 parts of carbamate.

The 50% water-soluble powder of sevin is highly toxic to mosquitoes; after treating roofs covered with grass, the insecticidal properties are preserved for 6 weeks (100% mortality rate after 5 minutes of exposure).

When using 2% aqueous or oil solutions to exterminate common cockroaches their mortality rate was noted to be from 50 to 100%; the best effect is provided by the oil solution – its effectiveness is retained for 15 days. It was determined that the duration of the residual action of suspension is greater than that of the oil solutions. After treating under practical conditions premises with a 5% suspension of sevin complete destruction of cockroaches was observed for a period of 60 days.

Of 66 derivatives of carbamic acid the highest insecticidal properties with respect to lice are possessed by sevin. Lice die (LD_{100}) on fabrics impregnated with 0.0025% acetone solutions or dusted with 1% disinfecting powder of sevin; such fabrics retain their insecticidal properties for 91 days. Lice resistant to DDT are less sensitive and to sevin than nonresistant varieties. With the addition of sulfoxide the toxicity of sevin to lice and their eggs is increased. With the addition piperonyl butoxide the ovicidal properties are increased.

Sevin is toxic to bees, to the same degree as DDT.

Sevin is effective when it is used to destroy pests of stored products. It is also effective with respect to garden and forest pests. When used to treat fruit trees sevin is absorbed by the fruits. Thus, for example, when the 50% wettable powder is used to treat lemon orchards there was detected on the surface of the lemons and inside the fruit 4.5 and 2.2 parts per million on the 12th day, and on oranges 2.5 and 1 part per million; the duration of the retention of the deposits of sevin on these citrus trees was 28 and 42 days respectively (mainly on the surface of the fruit).

After the spraying of kerosene solutions of sevin from aircraft to exterminate agricultural pests the preparation can be detected in the vegetation in considerable amounts. Thus, on the day of application there were detected 30-35 parts of sevin per million; toward the 8th day the deposits reached 1.97 parts per million; toward the 28th day — 0.1 and toward the 49th day 0.08-0.09 parts of the preparation per million. Thus, sevin possesses certain systemic properties.

Sevin in the form of disinfecting powder under laboratory conditions revealed high effectiveness when it was used to destroy snails and slugs.

The toxicity of sevin to fish and warm-blooded animals is approximately equal to the toxicity of DDT; the LD_{50} for gold fish when the pure preparation is used is 28 μg/ℓ of water, and of the technical solution is 14 μg/ℓ (Heines and others).

The addition to bird feed of 245 mg/kg of sevin provides the destruction of ectoparasites and no harmful effect is noted on birds. After a single administration of sevin at a rate of 150 mg/kg it is possible to detect it in the throat and blood of hens (Furman, Pipec). Sevin was not detected in the breast, legs, liver, and skin of 18-30 month-old hens after feeding them for 7 days feed containing 200 parts of the preparation per million (McCay, Arthur).

Sevin does not cause pathological neuromuscular changes; no cancerogenic activity or sensitizing ability was noted. The feeding of this to rats for 2 years showed that they withstand a total dose of 200 parts per million without significant deviations from the control animals. Dogs withstand the preparation administered in an analogous manner in an amount of 400 parts per million. Observations on rats showed that with the joint administration of sevin along with one of 24 other insecticides given in the experiment (including 10 preparations from the group of organophosphorus compounds), neither an antagonistic nor an intensifying action was observed for sevin or for the added preparation.

When the preparation was introduced in the feed of cattle at a rate of 150-450 mg/kg for a period of 2 weeks not more than 0.01 mg/kg was detected in the milk, and the milk did not manifest any side odor or aftertaste. The cows did not manifest changes in weight or any other symptoms of poisoning (Camp, Harrison, Roberts, Wiedenbach).

The LD_{50}, when orally administered to various warm-blooded animals, was as follows: for cats 0.25 g/kg; for guinea pigs 0.28 g/kg; for dogs 0.795 g/kg; for rabbits 0.71 g/kg; for rats 0.51-0.61 g/kg; when intravenously administered to rats the LD_{50} was 0.018-0.033 g/kg; when intrapenitoneally administered to rabbits the LD_{50} was 0.223 g/kg; when subcutaneously administered to rabbits – 2 g/kg, to rats – 1.4-2 g/kg, to chicks – 2-3 g/kg. Sevin penetrates through the integuments of rabbit in a dose exceeding 2000 mg/kg; with cutaneous application the LD_{50} is greater than 4000 g/kg. After 4-12 administrations of sevin to white mice at a rate of 50 mg/kg (within 3 months) in the internal organs of the animals there developed disturbance of blood circulation expressed in venous plethora, perivascular edema and acinous hemorrages. In the parenchymatous organs there were observed dystrophic changes expressed to a minor degree. When the number of administrations was increased (48-96) within a period of 12-24 months (the period of observation) there was noted proliferation and weakly expressed focal fibrosis in the liver, kidneys and spleen. Furthermore, in the liver, kidneys and myocardium there were detected areas of dystrophy, necrosis and necrocytosis.

Cases of human poisoning with sevin are not numerous.

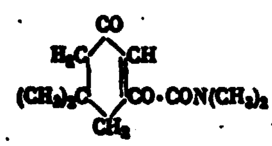
A $1\frac{1}{2}$ year old child who took internally an unknown quantity of sevin, in spite of the fact that his stomach was washed within 30 minutes after he swallowed the sevin, constriction of his pupils, salivation and weakened musculature were observed. A single dose of 0.3 mg of atropine was effective. The child recovered after 12 hours. In his urine the amount of alpha-naphthol increased to 31.4 mg/ℓ.

In an adult a single oral dose of 250 mg or 2.8 mg/kg (approximately) caused poisoning symptoms of average severity. When the same amount dose was repeatedly administered analogous symptoms were observed. Twenty (20) minutes after taking this dose there appeared pain in the stomach region and abundant perspiration; the person continued to work.

After taking 1 mg of atropine only minor relief was observed. Debility gradually appeared; the patient vomited twice. An hour after taking 3 mg of atropine relief began to appear, and within another hour had completely recovered and with gusto he ate his lunch. The level of blood cholinesterase dropped; in his urine there was detected 10 mg/ℓ of alpha-naphthol (the normal is 1.5-4 mg/ℓ). During therapy depending upon the severity of the illness it is possible to use all methods applicable for treating poisoning caused by organophosphorus compounds, with the exception of [2-PAM] (2-ПАМ) and other oximes.

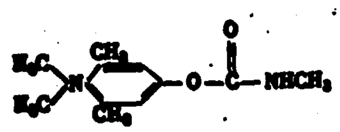
The experiments carried out on the animals show that the use of 2-PAM can be harmful.

Dimetan — $C_{11}H_{17}NO_3$ — 5,5-dimethyldihydroresorcinol-dimethylcarbamate.



This is a whitish crystalline substance with a melting point of 45-46° and insignificant solubility in organic solvents; it is soluble in water up to 3.15% at 20°. It possesses high insecticidal properties — is effective in combating flies (both house, and also other varieties).

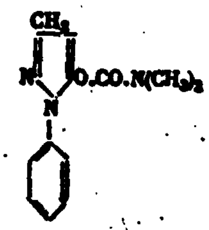
Zektran — $C_{12}H_{18}N_2O_2$ — 4-dimethylamine-3,5-xylene.



A crystalline solid with a melting point of 85°; it is insoluble in water, but soluble in the majority of organic solvents.

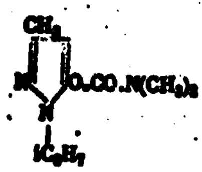
The preparation is especially effective with respect to cockroaches and butterflies: treatment with a 0.125% solution at a rate of 100 mℓ/m^2 provides complete destruction of insects – agricultural crop pests; in combating cockroaches effectiveness is attained by using the preparation at a rate of 7 mg/m^2, and their extermination ensues after 45 minutes, whereas diazinon under these conditions ensures death after 2 hours, and chlordane after 48 hours. However the duration of the residual effect of zektran is considerably shorter than that of sevin, and its toxicity to warm-blooded animals is higher than the toxicity of sevin. Thus, when orally administered the LD_{50} is equal to 15-63 mg/kg depending upon the type of animal.

<u>Pyrolan</u> – $C_{13}H_{15}N_3O_2$ – 3-methyl-1-phenylpyrazolyl-(5)-dimethylcarbamate.



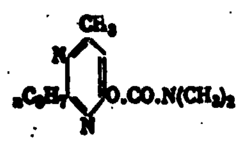
It consists of colorless crystals with a melting point of 50°; it is volatile when acted upon by steam. Its solubility in water is 2%, it is slightly soluble in petroleum oils, but possesses considerable solubility in alcohol, acetone and the aromatic hydrocarbons. It possesses high toxicity to flies. The LD_{50} for mice is 46 mg/kg, and for rats – 62 mg/kg.

<u>Isolan</u> – $C_{10}H_{17}N_3O_2$ – 1-isopropyl-3-methylpyrazolyl-(5)-dimethylcarbamate.



Its boiling point is 105-107° at 0.3 mm Hg; it is miscible with water, alcohol and xylene. The preparation possesses high contact properties with respect to house flies and aphidae; it acts weakly on mites and ticks; it possesses certain systemic properties when it is applied on plants. The LD_{50} for animals (mice) is 18 mg/kg.

Pyromat – $C_{11}H_{17}N_3O_2$ – 4-methyl-2-propylpyrimidyl-NN-dimethylcarbamate.



It is a very active preparation of the dimethylcarbamate group, it is inferior in its properties to the other carbamates. It is effective in combating flies.

Other carbamates. A number of other compounds of carbamic acid also possesses significant insecticidal properties. As insecticides there are proposed esters of NN-dimethylcarbamic acid: o-crysol, m-cresol, p-cresol, and also mixtures of the isomers 3,4-dylenol, 3,5-xylenol and 2,5-xylenol esters (solids). These preparations can be used in the form of aqueous emulsions, disinfecting powders or aerosols.

The effective preparations are: 2-isopropoxy-5-methyloxyphenyl-N-methyl (LD_{50} for flies is 6.5 μg/g), 3,5-dimethoxyphenyl-N-methyl

(LD_{50} 11 μg/g). For the naphthyls and phenyls (of the carbamate group) the value of LD_{50} is higher than 500 μg/g, just as it is for the quatenary butylphenyls.

The carbamates are highly toxic to mosquitoes. Hadaway, Barlow arrived at the conclusion that although the carbamates also give encouraging results as residual insecticides, their effectiveness on surfaces varies depending upon the properties of the construction materials. Sevin with respect to mosquitoes is less effective than 2-chloro-3-isopropyl-N-methylcarbamate (Hercules), 3-isopropylphenyl-N-methylcarbamate, 2-isopropoxyphenyl-N-methylcarbamate and 3-sec-butyl-N-methylcarbamate.

The average lethal doses, when topically applied, in micrograms per female mosquito are 0.0018-0.0043; 0.0013-0.0025; 0.0013-0.0053 and 0.0012-0.0023 respectively for the above-mentioned four preparations; the index for sevin is 0.0037-0.0145 μg per female; the first figure is the index of the value of the LD_{50} for Anopheles stephansi, the second for Aedes aegypti.

These insecticides can be used in combating cow stable flies. They are effective in combating insects, which have developed resistance to the chlorinated hydrocarbons and the organophosphorus compounds.

High insecticidal properties are possessed by zinc dimethylcarbamate – ziran; it is very effective with respect to mosquito larvae, complete destruction of the larvae of Culex fatigams of the I and II instar is observed from concentrations of 1-3 mg/ℓ; larvae of the third instar – from concentrations of 1-10 mg/ℓ. Ziram retains its activity in a reservoir for 30 days, but it is not ovicidal. The preparation is nontoxic to man and warm-blooded animals, but it is toxic to fish, therefore its permissible concentration in reservoirs is not more 5 mg/ℓ.

CHAPTER VII

VEGETABLE INSECTICIDES

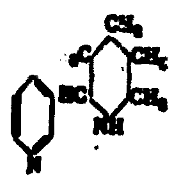
Vegetable insecticides from ancient times and at the present time are finding broad application in disinfestation practice. Research operations on new vegetable insecticides are continuing along with the quest for new synthetic compounds. With respect to insecticidal properties they are not inferior to the synthetic ones, and some of them act even faster on insects (anabasine, pyrethrum).

Poisonous substances are located in various parts of plants and belong to various chemical compounds – alkaloids, glucosides, saponins, essential oils and others.

Among the insecticidal plants having industrial significance are certain forms of camomiles (Caucasian, Salamation and Persian), the blackberry subshrub, the rotenoids and nicotine-containing plants. The insecticidal use of nicotine-containing plants is secondary (Bowingdon, Strong).

Anabasine

Anabasine – $C_{10}H_{14}N_2$,



alpha-piperidine-beta-pyridine is an isomer of nicotine — neonicotine (3-/2-piperidyl/-pyridine). Its molecular weight is 162,24. Anabasine contains 74.03% carbon, 8.7% hydrogen and 17.27% nitrogen. It is a colorless oil acquiring under the effect of light and air a yellowish color. The melting point is 97°, the boiling point 276°, its specific gravity is 1.04 at 20°. The index of refraction at 20° is 1.5443. The vapor pressure is 2.5 mm Hg.

Anabasine was discovered by A. P. Orekhov and G. P. Men'shikov in 1929, who extracted this compound from the perennial leafless blackberry subshrub (Anabasis aphylla) growing in many regions of the semiarid steppes of the Transcaucasus and Central Asia, in the southern regions of the Don, Volga and in the Caucasus. The plant is readily distinguished by its bright green verdure. It is most frequently encountered together with various types of white wormwood. The plant is highly branched, attaining a height of 30-75 cm, the root system is sturdy penetrating deeply into the earth; the leaves are not well-developed; they have the form of slightly projecting scales growing in pairs in short sheaths. All the above-ground parts of the plant are poisonous. In its fresh form the plant has an unpleasant odor and is not eaten by animals at all. It contains from 0.5 to 12% alkaloids, of which about 60% is anabasine. The latter is contained mainly in the small green twigs of plants; in the thick preroot parts, the woody stems and fruits there is very little of it. Therefore only the herbaceous, green branches with a thickness of 3 cm are gathered for anabasine. The gathering of these branches is conducted before the beginning of blossoming usually at the end of June — the beginning of July. The cut, above-ground parts are placed in small stacks at the collection place, then they are thrashed; in thrashing the branches are broken up into segments with a length of 30-40 cm. In the dry product there is not more than 5% of the woody parts and 1% of the fruit. The moisture should not exceed 12%. There should be not less than 1.2% anabasine.

In the Soviet Union anabasine is obtained by extraction from plants the obtained extract is evaporated and by treating with kerosene and sulfuric acid is converted into anabasine-sulfate (the sum of the alkaloids).

Anabasine can also be obtained synthetically.

Anabasine-Sulfate

Anabasine-sulfate $(C_{10}H_{14}N_2)_2H_2SO_4$. Its molecular weight is 422,56. It is a transparent oily liquid (specific gravity is 1.15-1.19) dark-brown in color with a characteristic odor, with a slight acid reaction; it is readily soluble in water and alcohol. Crude (unpurified) anabasine-sulfate is a mixture of alkaloids, among which are: aphyllidin $(C_{15}H_{22}ON_2)$, aphyllin $(C_{15}H_{24}ON_2)$, lupine $(C_{10}H_{19}ON_2)$ and others. The percentage of anabasine in the technical preparation is usually about 40%; on conversion to anabasine-base the amount of the latter should not be less than 30%.

From anabasine-sulfate 0.1-10% disinfecting powders and solutions are prepared. The liquid and powder-form preparations of anabasine possess high insecticidal properties with respect to fleas, lice, ticks, mites, bugs, butterflies, clothes moths and beetles, cockroaches and dog lice.

Anabasine-sulfate disinfecting powders prepared with vegetable ash fillers (saxaul, sunflower, corn, wood, coal), and also with fillers of sodium carbonate, slaked lime, sifted chalk, treated gypsum, possess higher insecticidal properties with respect to insects than disinfecting powders prepared with kaolin or talc fillers. Prolonged storage of anabasine-sulfate disinfecting powders with a saxaul ash filler lowers their insecticidal properties. The best adherence quality for insects is possessed by anabasine-sulfate disinfecting powders prepared with vegetable ash fillers, with the moisture content of the disinfecting powder at 9% with variations of ±5% humidity.

Preparations of anabasine, especially freshly-prepared ones, cause in insects (in a very short time, after contact with them) paralysis followed by death. The liquid and powdery preparations of anabasine do not affect equipment, do not soil treated objects, are easily washed off with water and do not possess a pungent odor.

Anabasine preparations are contact neuromuscular poisons. They readily penetrate through the integuments of insects and rapidly cause paralysis. They also possess a certain intestinal and fumigational effect. When the vagus nerve is severed the effect of anabasine-sulfate on the cardiovascular system and the respiration of insects is not altered. The first symptoms of poisoning manifest themselves in paralysis of the extremities, spasms in the torso and torpor.

In comparison to [DDT](ДДТ) and pyrethrum anabasine preparations are 10-30 times more toxic; their effectiveness is especially increased by alkalinization (with potash, soda, green soap, lye, saxaul, sunflower or wood ashes) (N. M. Parkhomenko).

After dusting with 5% anabasine-sulfate disinfecting powder (in a mixture with 95% sifted saxual ashes) 100% of the flies manifested paralysis after 3-8 minutes, fleas – after 1-2 minutes, mosquitoes and bugs – after 1-3 minutes, cockroaches – after 2-3 minutes followed by the death of the insects. Under these same conditions 10% DDT disinfecting powders cause paralysis in fleas after 25 minutes, in mosquitoes – after 27 minutes followed by death within 17 hours. Paralysis in cockroaches after the effect of pyrethrum ensues within 3-4 hours. The preparation is also extremely toxic to clothes moths – complete paralysis of butterflies from 5% anabasine-sulfate disinfecting powder ensues within 1-1½ minute followed by death within 35 minutes. The preparation is also toxic and to ticks and mites. It is mainly used to control agricultural and forest pests.

Under the effect of anabasine-sulfate severe alterations are observed in the muscles of flies: the transverse striations of the disks almost completely vanished there remain only traces of them in the form of breaks in the striations; the fibrils also vanish; which in normal muscles go inside the fiber in a longitudinal direction, pyknosis of the nuclei is observed. There are also noted changes in the structure of the ganglia and lesions in the excretory system, which are expressed by the filling of the malpighian corpuscles with fluid, the actual structure of these latter vessels is not changed, the cells are not destroyed, and the nuclei remain in the normal state.

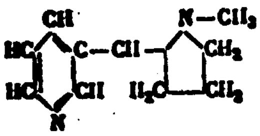
Anabasine is a strong poison for man. Penetrating into the organism through breaks (scratches) in the skin, it causes poisoning: 2-3 drops of pure preparation are considered lethal for a man. It is most important when working with anabasine to put on rubber gloves, and in the case of working with it for a prolonged period of time to wear protective suit. When preparing disinfecting powders it is also necessary to guard against inhaling the dust particles, since this can lead to poisoning (N. A. Sazonova, A. P. Volkova).

In agriculture anabasine-sulfate is applied and contact insecticide by spraying and dusting. Spraying carried out against pests of fruit orchards (plant lice, aphidae, many other sucking pests, caterpillars, and certain butterflies). The testing of anabasine on garden fleahoppers, caterpillars, tortrix moths and others showed that in its effect it completely replaces not only nicotine, but also certain special intestinal poisons (Paris green, potassium arsenate, sodium flucride and barium chloride). The death of all forms of agricultural pests ensues as a result of the application of 0.05-0.2-1% concentrations of anabasine in solution and 2-8% disinfecting powders.

In combating cotton aphidae aviation is used for dusting and spraying (per hectare 1 kg of soap in 50 ℓ of water and 1.2 kg of anabasine-sulfate). With the simultaneous presence on cotton plants of aphidae and red spider mites combined preparations are used – 15 kg of sulfur, 5 kg of lime and 1.2 kg of anabasine-sulfate.

Nicotine

Nicotine – $C_{10}H_{14}N_2$.



Nicotine is obtained by extraction from tobacco plants; it belongs to the alkaloids of the pyridine group and is an oily, colorless liquid with a sharp characteristic odor and caustic taste, which rapidly turns brown in air. It is miscible with water at 60-80° and dissolves in the majority of organic solvents, in alcohol and ether. Its boiling point is 247.3°; its melting point is 80°, the density is 1.009; its index of refraction is 1.528; the specific gravity is 1.6639-1.685. Its vapor pressure at 20° is 0.08 mm Hg, at 25° – 0.0425, at 80° – 2.8, at 100° – 7 mm Hg. It is sublimated with steam.

Nicotine preparations are prepared in three forms: 1) a nicotine-base – a liquid containing 95-98% nicotine-base ($C_{10}H_{14}N_2$); when necessary it is converted into nicotine-sulfate; 2) an aqueous solution of nicotine-sulfate $[(C_{10}H_{14}N_2)_2H_2SO_4]$ containing 40% nicotine-base; 10-15 g of the poison and 40-60 g of soap per 10 ℓ of water; 3) nicotine-disinfecting powder for dusting, prepared from 5-7 parts by weight of nicotine-sulfate and 95-93 parts by weight of slaked lime or ash.

In tobacco plants and tobacco extracts nicotine is combined with organic acids. Metal hydroxides liberate nicotine from these compounds. Nicotine-sulfate is more difficult to decompose than nicotine-base. Tobacco leaves maintain not only nicotine, but also a number of other alkaloids.

Nicotine-sulfate is an ineffective preparation with respect to fleas and bugs, the most satisfactory insecticidal effect is provided by 2.5-3% working emulsions with 0.8% soap with abundant spraying – not less than 200 mℓ/m^2. Nicotine is toxic to common cockroaches – the [LD_{50}] ($ДД_{50}$) is 2150 μg/g. For combating lice, bugs, flies, mosquitoes tobacco dust, tobacco smoke, decoctions or infusions and nicotine sulfate can be used. In preparing an infusion 500-800 g of tobacco dust, makhorka or finely chopped dry tobacco stems and leaves are steeped for 2 days in 10 ℓ of water; the infusion is filtered, the residue is pressed, 10 more liters of water are added and the surface to be treated is sprayed. For better wetting 50 g of soap are added for each 10 ℓ of infusion (S. M. Ignat'yev).

In agriculture nicotine is used for insecticidal purposes in the most diverse forms: in the form of nicotine-sulfate, tobacco extract, tobacco decotion or infusion of tobacco dust, tobacco smoke, and also in the form of so-called lime-nicotine sulfate disinfecting powder [nicodust]. Nicotine preparations are used for dusting or spraying plants against aphidae, fleabeetles, jumping plant lice, young caterpillars, grape moths, ermine moths, bugs and mites; nicotine-sulfate is used as an ovicide in combating the codling moth. The treating of surfaces and vegetation is carried out from aircraft; the expenditure of nicotine disinfecting powder per hectare is 30-50 kg.

Nicotine-base and nicotine salts are highly toxic to animals.

Pasternak

Pasternak. Lichtenstein and Casida isolated a strong insecticide contained in the parasnip root. A small amount of this preparation kills flies; certain agricultural pests are also killed by it, which are not susceptible to the effect of other natural insecticides. This substance contained in the parsnip root can be broadly used, if it can be mass produced.

The authors studied the most wide-spread variety of parsnip — the "all-American" variety. They cultivated it in soil not containing even traces of insecticides and ground the roots into powder, as a result of the application of this powder 40% of the flies perished. Then they isolated the active chemical substance contained in the powder, the so-called myristicin, which along with other related chemical substances is contained in nutmeg and certain vegetables. In parsnips for each million parts there are 40 parts of myristicin.

We must assume that substances are contained in all plants, protecting them from pests, otherwise they would not survive. Work on isolating insecticides from vegetables was started relatively recently, the impetus for the activation of such animals. The insecticide from the parsnip is less active than the preparation from pyrethrum but it possesses other auxiliary properties, which pyrethrum lacks — it drives insects away and, furthermore, kills them with its vapors.

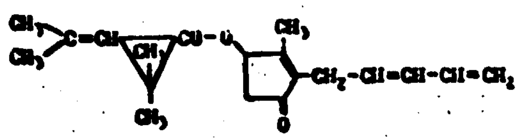
Pyrethrum

Pyrethrum is the most effective of the vegetable insecticides. Up to the present time in the USSR and abroad pyrethrum preparations are unexcelled in their rate of action and their harmlessness to man, agricultural and domestic animals.

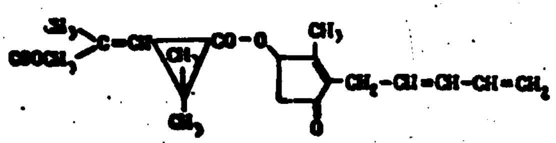
Pyrethrum powder is prepared from the dried heads of camolies [Translator's note: pyrethrum flowers for clarification of camomile] — perennial plants from the Compositae family of the genus Chrysanthemum (Pyrethrum) capable of building-up pyrethrins. Pyrethrum roseum, Pyrethrum carneum, Pyrethrum cinerariaefolium and others belong to these camomiles [pyrethrum flowers].

In the wild state these forms of camomiles [pyrethrum flowers] (P. roseum and P. corneum) are encountered in the mountain regions of the Caucasus on the subalpine and alpine forest meadows at a height up to 2800 m, and also in Northern Iran, Asia Minor and in Dalmatia in The Balkans (P. cinerariaefolium). In Europe pyrethrum has been used approximately since 1800; it was brought into Japan in 1881, where it was cultivated on a rather large scale; for a long time Japan has exported pyrethrins in large quantities. At the present time the main supplier is Kenya; pyrethrum is also raised in large quantities in the Congo.

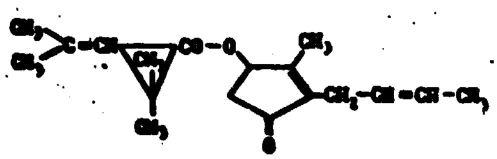
The insecticidal properties of pyrethrum are due to the presence of pyrethrin-I, pyrethrin-II, cinerin-I and cinerin-II. Recently (1964) a new pyrethrin was isolated – zhasmolin. There are also data about the fact that peony flowers (Paeonia albiflora) contain pyrethrins in a considerable quantity.



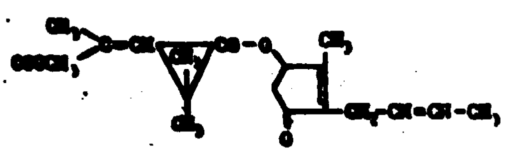
Pyrethrin I



Pyrethrin II



Cinerin I



Cinerin II

The pyrethrins are esters of chrysantheummonocarboxylic (dimethyl-isobutenyl-cyclopropane-carboxylic acid) or chrysantheumdicarboxylic acid and pyrethrolone (methyl-pentadienyl-cyclopenten).

Camomile flowers [pyrethrum flowers] contain 5-10 times more pyrethrins than the stems, and 3-5 times more than the buds. In the flowers the pyrethrin contert fluctuates from 0.4 to 1.6%. The amount of pyrethrins in the flowers depends on the flowering stage: the maximum pyrethrin content (1.64%) is observed at the time of full blossoming of flowers, in flowers in semiblossum it is less (1.4%), and in waning flowers it is still less (1%). In studying the influence of sun, tungsten and infrared lamps on pyrethrins it was established that irradiation within the limits of 2600-4000 Å sharply reduces the insecticidal properties of the pyrethrins. The latter due to the effects of moisture, light and heat decompose, as a result of which they lose their poisonous properties. Therefore, pyrethrum should be stored in dry, dark, cool premises in leakproof, tightly closed cams. Pyrethrum and preparations containing pyrethrins, should not be allowed to come in contact with lead, copper and zinc. The effectiveness of a preparation also depends on how finely it is ground, a preparation should be dry, without lumps and impurities and contain not less than 0.3% pyrethrins. The more finely ground powders rapidly lose their insecticidal properties. The addition of tannic acid and titanium dioxide possessing the ability to reflect light waves inhibits the reduction of the insecticidal properties of pyrethrum. With the addition of hydroquinone as an antioxidant the powders remain highly effective for a long time; even in cases when the powder is strewn in a thin layer on a sheet of paper in the light, it remains very active for a period of 340 days. The aminophenols delay the decomposition of the pyrethrins in ground pyrethrum and in concentrated extracts. For these purposes mixtures of sodium hydrosulfite ($NaHSO_3$) and trioxymethylene.

The pyrethrins (mixture) are a thick light-green (glycerine-like) oil with a mild odor, boiling at 145-155°. The pyrethrins are insoluble in water, readily dissolve in petroleum ether, methyl alcohol and other organic solvents. Contemporary extract concentrates contain 25% pyrethrins; approximately 40% is pyrethrin I, the other 60% are other compounds.

At the Central Scientific Research Disinfectional Institute Yu. P. Volkov and A. V. Starkov by quadruple, successive infusion of the same solution of petroleum ether with fresh portions of pyrethrum containing 0.42% pyrethrins obtained a 0.23% pyrethrin extract; after tenfold steaming of this solution, subsequent extraction with nitromethane, purification of the nitromethane solution by passing it through a layer of activated carbon and steaming the authors isolated in 1964 a colorless, transparent oil containing 97.5% pyrethrins.

The pyrethrins are distinguished by their insecticidal properties. Thus, for example, the application of a concentration (in percent by weight per volume), at which the mustard beetle (Phaedon cochleariae) dies, is: pyrethrin I – 0.001%, pyrethrin II – 0.0026%, cinerin I – 0.002% and cinerin II – 0.005%; with respect to house flies the greatest insecticidal properties belong to pyrethrin I; the insecticidal activity of cinerin I is 25% weaker than pyrethrin I; pyrethrin II is 3 times, and cinerin II is 5 times weaker than the insecticidal properties of pyrethrin I. The time of the advent of paralysis for insects after contact with the pyrethrins does not vary greatly. Thus, after contact with an extract of the pyrethroids (pyrethrin I, pyrethrin II, cinerin I and cinerin II) in house flies paralysis ensues respectively through 13, 17, 10, 20 and 11 minutes. Pyrethrin II as compared to pyrethrin I causes a more rapid advent of paralysis and provides a greater percent of paralyzed flies, but a smaller percent of insect deaths.

With the application of the pyrethrins on the back of the oriental cockroach it was noted that the LD_{50} after 24 hours was 1 μg at 16° and about 6 μg at 35°. By using pyrethin tagged with radiocarbon it was established that at 35° the rate of penetration of the preparation was 2 times faster than at 15°. The poisoning of cockroaches depends on the presence of toxin in the blood, whereas at 35° this toxin did not exert its effect. It was shown that the toxic substance located at this time in the blood was not pyrethrum; apparently, at this temperature the insecticide is somewhat removed from its action site and is less harmful to insects.

Thus, pyrethrins are strong contact poisons for insects (flies, mosquitoes, cockroaches, bugs, fleas, lice and others). They readily penetrate into the insect organism or directly through the integuments, or through the wall of the tracheae, causing in the insect vomiting, profuse elimination of the excrements and paralysis, which is propagated from the posterior end of the body among the nervous and muscular systems. With overall dusting of insects paralysis ensues immediately, and total extermination is accomplished after 48 hours. With partial dusting paralysis of the individual parts of the insect's body comes within 9-10 days. It is necessary to keep in mind that with an insufficient amount of preparation the paralyzed insects (without visible signs of life) survive and return to normal vital activity, and therefore after treating premises with pyrethrum the paralyzed insects swept up and destroyed.

According to Ye. A. Baburina, pyrethrum has an acute destructive effect on the epithelial lining of the midgut of the common cockroach, and the diverticulum of the malphigian vessels and also causes severe degeneration of the blood phagocytes. These data contradict the opinion concerning the selective action of pyrethrum of the central nervous system of insects and, consequently, the question of the cause of death of an insect by poisoning with pyrethrum remains open. In the beginning of the poisoning in the epithelial lining of the midgut and the diverticulum there is observed a certain increase in the type of secretion and regeneration, which, however, is rapidly suppressed by the advancing degeneration and disintegration of tissue. Moreover, the protoplasm of the cells is vacuolated, the cell membranes disintegrate, and the chromatin of the nuclei takes on a fine-grained structure. In the epithelium of the malphigion vessels pyrethrum causes swelling, vacuolization, disintegration of the cell membranes, degeneration of the nuclei and disintegration of the protoplasm. In the poisoning of cockroaches with pyrethrum powder there is observed in the macronucleocytes vacuolization both of the protoplasm, and also of the cells. The first vacuole in the nucleus always surrounds the nucleolus. In the protoplasm the vacuoles have the form of irregular, branched canaliculi. In the poisoning process there occurs the rapid disintegration of the protoplasm with dissolution of the chromatin network.

For warm-blooded animals pyrethrum is practically harmless; the pyrethrins and cinerins are highly specific and possess sharply expressed selective properties with respect to arthropods. The mean lethal dose for vertebrates with oral introduction is 1500 mg/kg, when they are applied to the skin of rabbits at a rate of 400 mg/kg symptoms of poisoning can appear. With the introduction of pyrethrins into the abdominal cavity of guinea pigs the LD_{50} is 150 mg/kg, whereas for insects this value is equal to 0.17 mg/kg (Matsubura, Chadwick, Iradidge).

Pyrethrum possesses only minor toxicity to humans. According to Winkler, in treating 618 patients for scabies with pyrethrin ointment containing 0.75% pyrethrin, only 4 manifested a reaction on the part of the nervous system; sometimes dermatitis was observed. Thus, pyrethrum is the most harmless of the insecticides.

Pyrethins with synergists and without them are manufactured in the form of disinfecting powders, oil solutions and emulsions and rarely in the form of water-dispersed powders. The pyrethrins are added to certain synthetic insecticides to accelerate the onslaught of paralysis in insects.

At the present time pyrethrins are obtained not only by extraction from camomiles [pyrethrum flowers], but also synthetically. These synthetic pyrethrins only to an insignificant degree differ from the natural pyrethrins in their physical and chemical, as well as their insecticidal properties.

Pyrethrum powder consists of finely ground pyrethrin-containing camolie flowers [pyrethrum flowers]; 65% powder should pass through a sifter with 250 apertures per cm^2 and 25% through a sifter with 100 aperatures/cm^2; the particles not passing through the latter sifter, should not constitute more than 10%. The moisture of the powder should not exceed 9%, and the pyrethrin content should not be less than 0.3%. Pyrethrum powder is a straw-yellow or a brownish-yellow color; the powder is light; it is poorly wet by water, because it is held on its surface; upon combustion it burns like grass, leaving a small amount of ash. The powder is stored in a dry, dark and cool location.

In using the powder form of pyrethrum in living quarters only the places where insects stay are treated. In expenditure of powder is 2 g/m^2 of the premises populated by mosquitoes or flies.

Pyrethrum preparations can be burned, since its smoke possesses insecticidal properties, but when candles are used a considerable portion of the pyrethrins burns and, thus, is lost without having any effect.

Pyrethol

Pyrethol – solution of extractive substances of pyrethrin-containing camomile flowers in ethyl alcohol; it contains 1% pyrethrin. The method by which they are obtained in essence in this: dried pyrethin-containing camomile flowers are subjected to hot extraction with benzene or dichloroethane; the benzene or dichloroethane is driven off, the residue is dissolved in ethyl alcohol and the pyrethol extract is decanted. A 2% oily pyrethrum extract is also prepared, which is a solution of extractive substances of pyrethrin-containing camomiles in transformer oil or other solvents. Pyrethol and the oily extract are highly effective upon their dilution to a concentration of 0.06-0.003% by active substance.

Dried, pulverized, pyrethin-containing camomile flowers are subjected to extraction with dichlorothane. The solvent is driven off with steam and the obtained residue is dissolved in transformer oil. The solution is isolated from the undissolved resins. Such an extract should contain not less than 2% pyrethrin; the volatile impurities should not be more than 5%. The oil solutions can be applied in the form of mists, films or aerosols, formed by appropriate apparatuses.

Certain surfaces, such as: brick, plaster, cement, concrete and cardboard, absorbed the pyrethrum oil solutions so rapidly and in such amounts that they do not acquire insecticidal properties; in this case it is first necessary to cover these 4 surfaces before treating with a gelatinous solution, which prevents absorption and makes it possible for the deposits to manifest their full effect with respect to insects landing on or crawling along the surfaces.

Flicid*

Flicid is an infusion of camomile flowers containing pyrethrins in mineral spirits (a petroleum fraction boiling at a temperature of 150-180°; its specific gravity is 0.795) or in a light type of kerosene - ligroin (boils at 100-140°). The preparation is usually mass produced. The pyrethrins are extracted from the plants by infusion and they go into solution. Flicid is a transparent liquid with a light-yellow or greenish color. According to the government standards of the USSR, flicid must satisfy the following requirements: the pyrethrin I content is not less than 0.06%; the specific gravity is not more than 0.795; the beginning of boiling is 165°; its odor is similar to kerosene-benzene; the dry residuum constitutes not more than 1%; the content of aromatic substances is not more than 15%; its flash point is 33°.

*Translator's Note: [Fleacide] (Flicid) - Could possible be taken from this English cognate, but was not found.

In combating flies flicid is uniformly sprayed in the air of premises, i.e., a fine suspension of the sprayed insecticide is created. In spraying the liquid an insecticide fan is necessary to direct it in such a manner that it cuts off the insects way of escape. For this, after approaching to a distance of 1 m from the treatment site, the liquid is sprayed in the proper amount, so that the insecticide gets on the flies, mosquitoes, also including those flying from the walls. After 30-40 minutes the premises can be opened for airing. With the prolonged application of the pyrethrins flies increase their resistance to them (Faine).

For combating lice flicid is also used; clothes are brushed with brushes moistened with the preparation or are treated lightly with a sprayer. On one piece of wearing apparel 30-40 mℓ of flicid is expended on one sheepskin coat - up to 100 mℓ.

The use of flicid in food establishments (factories, kitchens, dining rooms) is not recommended, because the odor of the preparation is readily picked up by the products.

Flicid is an inflammable liquid, therefore when working with it, it is necessary to observe strictly fire-prevention safety measures (do not smoke while working, keep the preparation away from fires).

The mechanism of action flicid is the same, as that of pyrethrum powder with only the difference that insects due to its effect die considerably more rapidly than under the effect of pyrethrum powder.

Pyrethrum preparations can be widely used in combating numerous field, garden and berry patch pests (beet webworm larvae, mulberry moth, cabbage and turnip butterflies, coddling moth, winter moth, ermine moth, sugar beet weevil, fleabettles, cotton aphid and others). Pyrethrum is also used against granary and forest pests.

Pibuthrin

Pibuthrin contains 0.3% pyrethrum and 3% piperonyl butoxide; the latter preparation is added as a synergist and increases the activity of pibuthrin by more than 10 times. Pibuthrin is produced by English industry. It is used in the form of aerosols, disinfecting powders and aqueous emulsions mainly against flying insects (flies, mosquitoes) and in combating granary pests. This preparation is especially active with respect to insects, which have acquired resistance to the chlorinated hydrocarbons.

Synergists of the Pyrethrins

Pyrethrin synergists are used to increase the activity of pyrethrum preparations; their addition makes it possible to apply pyrethrum preparations at low concentrations and to thereby lower the expenditure of the active substance by 2-3 times. The first proposed synergist was sesame oil, from which sesamin was extracted. A more powerful synergist is piperonyl butoxide, which increases the effectiveness of the mixture by approximately 15 times. Due to the spread of resistance among arthropods such mixtures are finding broader and broader application. The best results are provided by the following proportions of ingredients: for example, 24 mg of pyrethrins and 200 mg of piperonyl butoxide per 100 mℓ of solvent. Such a mixture is effective against house flies, bed bugs, fleas, moths, carpet beetles and blood-sucking flies. In combating cockroaches special mixtures are used: 60 mg of pyrethrins and 300 mg of piperonyl butoxide per 100 mℓ of solvent with a dilution of 1:19. Certain other proportions are used, for example 1:2.5 (60 mg of pyrethrins and 150 mg of synergist per 100 mℓ of solvent) etc.

In combating flies the following mixtures are recommended: 0.025-0.05% pyrethrins and 0.125-0.4% piperonyl butoxide in purified kerosene. In effectiveness this mixture is approximately equal to 0.1% pyrethrins. The addition to the mixture of two synergists (piperonyl butoxide and [MGK-264] (МГК-264)) increases the activity of the pyrethrins to a greater degree than the addition of one of them.

In low pressure aerosol preparations there is recommended the use of a mixture containing from 0.2 to 0.4% pyrethrins and 1.6-2% piperonyl butoxide. Such a mixture is biologically equivalent to a 0.5% solution of pyrethrins in its degree of paralyzing action and much greater than it in lethal outcome.

For treating animals a 1:10 proportion is applied.

The physical, chemical and biological properties of pyrethrum make it especially useful for application in food enterprises and in storehouses; this is explained by its rapid action, i.e., by the creation of paralysis in insects, by the absence in it of any significant toxicity to mammals and by the fact that it doesn't soil. The addition of synergists lowers cost, increases stability, and improves the ovicidal and acaricidal effect of mixtures. In treating grain in elevators in the United States not more than 3 parts per million of pyrethrins and 20 parts per million of a synergist are used.

Piperonyl butoxide can also be applied as a synergist of DDT, hexachlorana, chlordane and rotenone preparations.

Leroza, Bertel studied synergism in over 200 compounds: ethers and esters, alcohols, acids, acetones, amide, amines, carbamates phenols and aldehydes. The synergetic activity of 3,4-methylenedioxyphenyl ethers such: the cyclohexane, cyclohexylethyl, 2-butoxymethyl, (2-ethoxyethoxy)ethyl, 2-(2-butoxyethoxy)-ethyl radicals increase the activity of the pyrethrins by 9 times; the cyclopentyl and 2-chloroethoxy-ethyl radicals increase the activity by 6-7 times; the remaining radicals - from 2 to 5 times. Octachloroisoethyl ether increases the activity of the pyrethrins by approximately 6 times.

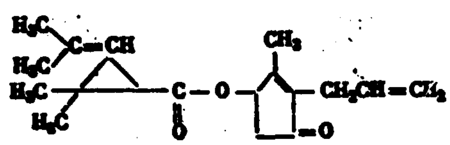
Sulfoxide also increases the effectiveness of the pyrethrins; in mixtures its content is 10 times more than the pyrethrins (Price).

For house flies resistant to the organophosphorus compounds, it is possible to use sugar bait with the addition of pyrethrins or allethrin in a mixture with piperonyl butoxide at a ratio of 1:20.

Synthetic Pyrethrins

In recent years several analogs of pyrethrin have been obtained: allethrin, barthrin, dimethrin and others.

Allethrin – $C_{19}H_{26}O_3$. It is an ester dl-2-allyl-3-methyl-cyclopenten-2-ol-4-one-1 and dl-cis, trans-chrysanthemummonocarboxylic acid.



This ester was synthesized in 1949; later it was called allethrin. Its production in the United States was begun in 1954.

Allethrin is a homologue of cinerin I; it is the first synthetic preparation similar to the pyrethrins.

Cinerin differs from it in that the 2-butyl group is replaced in allethrin by the allyl group. The insecticide obtained from industry is a mixture of 8 optical isomers possessing the characteristic insecticidal properties of pyrethrum.

Technical allethrin is an oil with a light-yellow to reddish-brown color depending upon the content of impurities. The boiling point is 147-150° at 0.4 mm Hg; the density is 1.005-1.015; the index of refraction is 1.5040. It is insoluble in water, but soluble in the majority of organic solvents and miscible with petroleum oil, it is soluble in alcohol, carbon tetrachloride, petroleum ether. It is chemically similar to the natural pyrethrins. Allethrin is more stable when heated and when illuminated with ultraviolet rays than the pyrethrins. Allethrin can withstand prolonged storage. For example, when kerosene solutions were stored in a refrigerator for 10 years its effectiveness decreased by only 14%, when stored under room conditions in a flask of brown glass in diffuse light the effectiveness of this solution was reduced by 30%, and when stored in clear vessels by 38%; when stored in vessels of clear glass under intermediate solar rays the solution lost its effectiveness almost completely within 6 years (Gersdorff).

Allethrin is used in solutions, disinfecting powders and aerosols. Activators are: piperonyl butoxide, n-propyl-isomer, piperonyl cyclonene, n-octyl sulfoxide isomer and isosafrole (Eddy). The 3,4-methylenedioxyphenyl ethers increase the activity of allethrin to $3\frac{1}{2}$ times depending upon the radical, whereas the effectiveness of the pyrethrins with the addition of these ethers is increased by 2-9 times.

Allethrin possesses high insecticidal properties; an insect mortality rate of 50% is observed when allethrin is applied at a dose rate of 0.008-0.015 μg per mosquito, 0.76-1 μg per common cockroach and 0.36 μg per house fly. With the addition of 1 part piperonyl butoxide to 1 part allethrin (1:1) or with the use of 5 times the amount of only allethrin the insecticidal properties with respect to flies are doubled. Allethrin is highly toxic to lice; it possesses larvicidal properties with respect to mosquito larvae and is highly effective in combating flying insects when it is sprayed in the air.

When its preparations are applied on susceptible and resistant female flies or male common cockroaches, and also on the oriental cockroach it has been established that allethrin is equally toxic to both strains of flies, as are the pyrethrins. The LD_{50} in micrograms per insect fluctuates from 0.42 to 0.75 for flies and from 0.95 to 1.1 for the common cockroaches. Flies resistant to pyrethrin, are also resistant to allethrin.

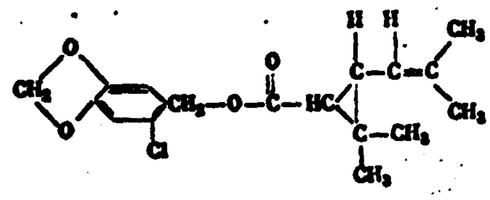
Allethrin has a severe effect on the nervous system of insects. The symptoms of intoxication are similar to poisoning with veratrine: tremor, excitation changing into convulsions, clonic spasms, muscular fibrillation, disturbance of coordination.

Allethrin, just like the natural pyrethrins, is almost completely lacking in phytotoxicity.

To the higher animals allethrin is more toxic than natural pyrethrin. With the oral administration of the 20% solution in kerosene to mice in the amount of 480 mg/kg, 920 mg/kg to rats and 4920 mg/kg to rabbits 50% of the animals are observed to die. With inhalation the lethal dose is 10,000 times greater than for flies. In prolonged experiments (during the course of a year) the feeding of a rat with feed containing 2000 parts of allethrin per million did not affect its condition, changes also were not observed upon hystological investigation. Analogous data were also obtained in feeding rats for 16 weeks with feed containing 5000 mg/kg. The toxicological properties of allethrin are similar to the toxicological properties of the pyrethrins.

Besides allethrin a number of other compounds was synthesized, which are chemically similar to allethrin, including 3(cyclopentenyl)-2-methyl-4-oxo-2-cyclopentyl-chrysanthemummonocarboxylate, which in its insecticidal properties is equal to allethrin and the pyrethrins.

Barthrin - $C_{18}H_{21}O_4Cl$ - 6-chloropiperonyl chrysanthemate. It is an ester of d,l-cis-trans-chrysanthemum acid.

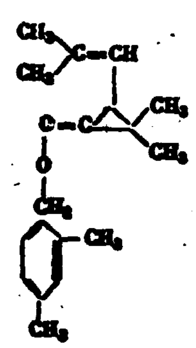


This liquid is light-yellow in color with a boiling point of 158-168°. This synthetic analogue of the pyrethrins consist of 4 isomers. In its insecticidal properties with respect to flies it is 3 times weaker than pyrethrum; with respect to cockroaches it is 16 times weaker than pyrethrum. When used as an aerosol barthrin is highly effective, in this state its insecticidal properties are approximately equal to 3/4 the activity of allethrin (755).

The addition of the synergist piperonyl butoxide does not increase the activity of barthrin.

The preparation is only slightly toxic to warm-blooded animals.

<u>Dimethrin</u> – $C_{19}H_{26}O_2$

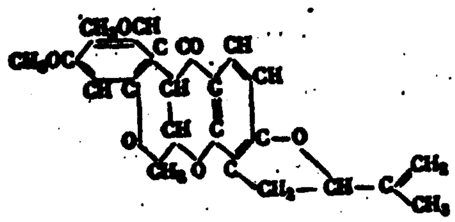


This is a new synthetic analog of the pyrethrins. This liquid has a light-amber color and a specific gravity of 986 at 20°. It possesses high insecticidal properties. It can be used to exterminate body lice, animal lice, mosquitoes, house flies and flies annoying animals (stable flies, horn flies and others). Dimethrin is almost nontoxic to warm-blooded animals (LD_{50} is 40 g/kg), and as a result of this certain authors recommend it for the disinfection of drinking water to combat mosquito-carriers of filariasis in the Far East.

Rotenone

Rotenone - derris (Derris tephorosis) - a type of tropical thick, woody lianas, rarely upright plants consisting of over 2000 species wide-spread on the mainlands and islands of Southeast Asia and tropical Africa, in New Guinea, Australia, South America, Brazil. There are known over 20 species of plants possessing highly effective insecticidal properties, inasmuch as they contain rotenone in their roots. Derris is propagated exclusively in a vegetative manner - by cuttings from mature stems. Derris is cultivated in pure stands or intertilled with other cultures on rubber, coffee and other plantations. The roots, which are gathered after 18-24 months usually do not exceed the thickness of a pencil. Derris is not cultivated in the Soviet Union. In places where it is prepared including in the United States it is applied in the form of a 1% disinfecting powder, just like pyrethrum. Rotenone preparations are also mentioned in literature under other names, for example, rotenoid (malaccol, elliptone, sumatrol and so forth), derris, picolin and others. Data exist to the fact that a wild plant has been detected in Africa, in which rotenone is contained in the leaves. By hybridization and selection a new variety of this plant has been developed in Puerto Rico; if the original plant contained 3.6% of the rotenoid, then the newly-developed varieties contained about 6% rotenoid.

Rotenone - $C_{23}H_{22}O_6$



is a crystalline, colorless substance without odor. Its melting point is 163°, in its amorphous form it melts at 18°; malaccol melts at 244°, elliptone at 159°, sumatrol at 188°. It is slightly soluble in kerosene; it reacts with vinegar, dichloracetic acid and other acids. Rotenone is virtually insoluble in water (15 mg per ℓ at 100°), but it is soluble in certain organic solvents.

In solar illumination it is decomposed within 5-6 days; under the effect of direct solar rays within 3 days. When heated for 2 hours at 100° 75% of the rotenone is destroyed and 54% of the other substances extracted from derris; at 40° for a period of 30 hours 4.6% of the rotenone and 16% of the other extractive substances are decomposed.

Rotenone disinfecting powders are prepared with pyrophyllite or talc fillers with 1 or 0.75% rotenone content. From the disinfecting powders suspension are prepared without the addition of wetting agents.

From rotenone 5% emulsions are also prepared. When an emulsion is used with a lower rotenone concentration synergists or pyrethrins are added. Emulsions are prepared with acetone, pine oil, xylene or alkylated napthalene fillers with the addition of an emulsifier and a synergist.

In preparing aerosols DDT, or methorychlor, or lindane, or pyrethrins with piperonyl cyclonene are added to rotenone.

It is not recommended that rotenone preparations be mixed with lime, Bordeaux liquid or Paris green since they completely lose their effectiveness in this event. It is possible to mix them with aromite, chlordane, DDT, dieldrin, lindane, malathion, nicotine-sulfate, parathion, toxaphene, sulfur, lead arsenate and other preparations.

Rotenone in its various forms is highly effective in combating certain pests of agricultural plants, and also in combating warble flies, cat lice, flies, animal and bird lice, bugs, dog lice, the larvae of Anopheles quadrimaculatus mosquitoes and others. The larvae die when they are submerged in water containing 10 mg/ℓ of rotenone. With a topical application of derris with 25% rotenone on American cockroaches at a dosage of approximately 2000 μg per insect a mortality rate of 50% is attained; the oral administration of 1000 μg/g provides an analogous mortality rate of other cockroaches. Thus, when orally administered rotenone is 2 times more toxic to insects than when contacted. When a rotenone solution in oil is injected the LD_{50} is 6-15 μg per insect for common cockroaches. In spite of the availability of numerous insecticides, rotenone is one of the best preparations for treating animals with warble flies; in this case 0.75-1% disinfecting powders or 0.5-5% emulsions are used. Rotenone is one of the insecticides safe for application in those places, where bees are active.

The administration of rotenone to rabbits with their food, containing 2 mg per kg over a period of 2 years did not cause symptoms of poisoning. Increasing the amount of rotenone in their food to 5 mg/kg caused changes in the liver and the appearance of swelling after 2 years.

Pure rotenone possesses considerable toxic properties and in its toxicity is close to DDT (Fukami). In contrast to DDT rotenone does not accumulate in the fat of the animals. A dose of 200 mg is toxic to man.

Sabadilla

Sabadilla is a perennial, grassy, bulbous tropical plant; it grows in the mountain meadows of Central America and the West Indies. It is a bulb with a size up to 4 cm. The seeds of sabadilla contain from 1 to 4% mixture of the alkaloids; cevadine, veratridine, cevadilline, sabadilline and sabatrine. This mixture under the name of veratrine is used as an agent against lice, especially head ("lice seed") lice.

From sabadilla seeds an infusion (sabadilla vinegar) is prepared, for which to 10 parts of 90° alcohol and 18 parts of 30% acetic acid there are added 10 parts of powder from sabadilla seeds; to the mixture 8 parts of water are added and it is placed in a warm place for a week. Before using, the infusion is filtered and the hairy parts of the body are then washed with it. Also prepared are sabadilla ointment, aqueous solution and alcohol infusion. This preparation is not used in the Soviet Union.

False Hellebore

False hellebore is a perennial plant growing on the marshy and damp forest meadows of the European part of the USSR, in the Caucasus, in Western and Eastern Siberia, in the Far East and in Central Asia. Its rhizome contains 0.2-1% alkaloids. The pulverized rhizome of the white false hellebore (Veratrum album) in the form of a powder or soap solution was recommended as early as 1842 to combat gooseberry worms. False hellebore has been repeatedly proposed to combat flies and rodents, but it has not found broad application in practice. The rhizome of false hellebore in the form of a decoction or powder is applied in veterinary medicine as an external agent against lice, fleas, birdlice.

The toxic properties of false hellebore are ascribed to a group of alkaloids represented mainly by nervin ($C_{26}H_{37}NO_3$), pseudonervin ($C_{29}H_{3}NO_{7}$), proveratridine ($C_{31}H_{51}NO_{11}$) and others. The latter is extracted in its pure form; it crystallizes into tetragonal prisms with a melting point of 238-242°.

The main objects acted on by false hellebore are the transverse-striated muscle tissue, the endings of the sensitive, secretory, vagus nerves, and also the central nervous system. In the beginning these elements are highly excited, and then they are paralyzed.

CHAPTER VIII

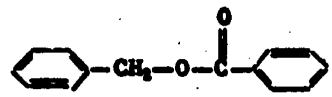
VARIOUS COMPOUNDS POSSESSING INSECTICIDAL PROPERTIES

Albichtol

Albichtol. A product of processing schists-albichtol consists of homologues of thiophene with an admixture of neutral hydrocarbons; it is a transparent, yellow, readily mobile, oily liquid possessing strong specific odor; it contains 10-12% sul r, it burns with the formation soot; the preparation was introduced into disinfestational upon the proposal of T. E. Boldyrev. The preparation possesses insecticidal properties with respect to lice, bugs, cockroaches and their eggs. From albichtol there is prepared a liqueur containing 50% green or naphthenic soap and 50% albichtol. The hairy surfaces of the skin are treated with a 50% aqueous emulsion of the paste and after 10-15 minutes they are washed with warm water. Disinfestation of linen, furnishings and quarters are carried out with a 10% aqueous emulsion. It can be used to exterminate the pre-imaginal developmental stages of flies in manure, for which 1 ℓ of paste is diluted with 5 ℓ of water in a bucket and then applied on 1 m^2. Albichtol at the present time is not used in combating parasites of man and pests in his dwellings. It can be used only in the extreme case of the absence of other substances.

Benzyl Benzoate

Benzyl benzoate – $C_{14}H_{12}O_2$.



Its molecular weight is 212,24. It appears as transparent crystals or a colorless liquid with an ester odor. The melting point of the crystals is 21°, the boiling point is 324° at 760 mm Hg, 180-181° at 16 mm Hg, 156° at 4.5 mm Hg. Its density is 1.118, its index of refraction is 1.568. The molecular weight is 212,24. It is insoluble or only slightly soluble in water; it subliminates with steam; it is soluble in alcohol, chloroform, ether, acetone, in oil; it is insoluble in glycol.

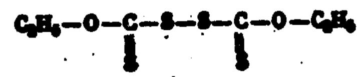
It can be used in the form of 20-25% solutions to combat body and pubic lice (a 25% emulsions of benzyl benzoate + 2% benzyl alcohol + an inert detergent). Abroad preparations having other compositions are manufactured: "benzamol-D" contains 15% benzyl benzoate, coconut soap, isopropyl alcohol up to 100%; "topicide" is an aqueous emulsion for the extermination of head and body lice; it contains 12.5% benzyl benzoate, 1% DDT, 2% benzocaine; "cilate" consists of 36% benzyl benzoate, 52% isopropyl alcohol and 12% alcohol filler.

When topically applied the [LD_{50}] ($ЛД_{50}$) for lice is 22 ml/kg, for bugs it is 75 ml/kg. It is applied by spraying fabrics at a rate of 3.5 g/m^2. A fabric impregnated with this preparation retains its insecticidal properties after two washings; after a third washing the insecticidal properties are considerably weakened. The preparation can also be used to combat fleas. It possesses higher repellent qualities with respect to fleas than dimethyl phthalamate, Indole, rutgers and others.

It is only slightly toxic to warm-blooded animals.

Bisethylxanthogen

Bisethylxanthogen (preparation-K) ($C_6H_{10}S_4O_2$) is a product of the oxidation of ethylxanthogenic acid. In its pure form it is a crystalline substance with a white or light-yellow color and having a mild specific odor. The structure of this preparation can be expressed by the following formula:



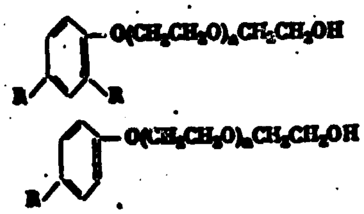
The preparation is almost insoluble in water, slightly soluble in many organic solvents (ether, benzene, chloroform, acetone, carbon tetrachloride), and only very slightly soluble in ethyl alcohol. It contains 52.92% sulfur. The insolubility of the preparation in water gives to it great stability on fabrics. The melting point of the preparation (28-29°) causes insignificant evaporation of it at room temperature. It increases upon the wearing of impregnated fabric on the body. For purposes of disinfestation there are manufactured ointments containing 10-20% bisethylxanthogen, and soap-K (a mixture of household soap and the preparation). The basic form of application of the preparation is soap (F. S. Khanenya, S. V. Zhuravlev, N. I. Soboleva).

From soap-K there are prepared 2-5% aqueous emulsions. Soap-K cut into fine shavings is dissolved in water heated to 35 or 40° and mixed with a wooden blade to obtain a uniform milk-white or slightly yellowish emulsion. The rate of expenditure of soap-K to obtain a 2% is 20 g, and to obtain a 5% emulsion 50 g per ℓ of water. The water emulsions are used to exterminate lice. Linen is placed for 20 minutes in a 2% prepared emulsion at a rate of one unit per ℓ. During this time the linen is stirred with a paddle. In treating bed linen an expenditure of 1 g of emulsion is used for each sheet and pillowcase. After 20 minutes the linen is removed, wrung slightly for drying in the quarters, and in the summertime it is hung in the shade outside at an air temperature not higher than 40-45°. The linen cannot be ironed with a hot iron, since at high temperatures the preparation is decomposed. The dried linen is cold-processed – with a mangle. The linen and wearing apparel treated with preparation-K retain their insecticidal properties for 13-15 days in the summer and up to 20 days in the winter. The impregnation of the linen with the preparation is also carried out on special ribbon machines.

Ointments with vaseline as the fillers are used as prophylactic agents in combating parasites on clothing and on the hairy parts of the body. The ointment is placed with one finder on the palm and rubbed between the palms, after which it is rubbed into the hairy parts of the body until the hair is no longer oily. The rubbed-in ointment with preparation-K is allowed to remain in the hair for 8-9 hours, during which the gradual extermination of the insects occurs. In treating clothing the 20% ointment with preparation-K is placed on a rag, paper, cotton, gauze (bandage) and thoroughly rubbed in a thin layer into the seams on the internal side of a pull-over tunic and trousers. The expenditure of preparation is approximately equal to 10-15 g per unit of clothing. After treating clothing with the ointment the hands should be thoroughly washed. When fabric treated with preparation-K comes in direct contact with the human body skin irritation is observed. Furthermore, the preparation possesses a persistant unpleasant odor. In spite of the indicated deficiencies this preparation has found broad application in disinfestational practice.

Auxiliary Substances OP-7 And OP-10

The auxiliary substances OP-7 and OP-10 (solvents, emulsifiers, wetting agents).

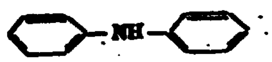


In appearance these are oily or paste-like substance at room temperature with a light-yellow to dark-brown color; in chemical composition [OP-7] (ОП-7) and OP-10 are a mixture of mono and dialkylphenyl ethers of polyethylene glycol - the alkyl residue containing 7-10 atoms (OP-7) or 9-10 atoms of carbon (OP-10), is 0.02-0.03% soluble in water; the solutions moisten the cuticle of insects, the surfaces of plant leaves and others.

The aqueous solutions are resistant to alkaline and alkaline earth metals; with agitation they form. The OP-7 and OP-10 dissolve many organic compounds, and because of these preparations are used to prepare concentrated emulsions of certain water-insoluble insecticides ([DDT] (ДДТ)) and others.

Diphenylamine

Diphenylamine ([DPA] (ДФА))-$C_{12}H_{11}N$



Diphenylamine is a white crystalline, substance possessing a unique odor. Its melting point is 54°; its boiling point is 302°. It is soluble in alcohol, ether, benzene, but insoluble in water. It is applied in the form of a 25% disinfecting powder - 1 part pulverized preparation with 3 parts filler (talc). It is used both for prophylactic purposes, and also for the extermination of body, head and pubic lice. The expenditure of powder per piece of linen is 7-8 g, per pull-over tunic and trousers 9-12 g, per sheepskin jacket and coat 15-20 g. It acts slowly on insects, a person is deloused after 2-3 days; the effectiveness of the preparation in treated articles is retained for 10-12 days.

Green Oil

Green oil (petroleum) is a product of processing of oil and is a thick dark-brown colored liquid, which is insoluble in water; it contains up to 5% napthalene in solution. Its specific gravity is 0.89-0.95. The boiling ranges are 150-350°; not less than 95% is driven off. It is used in reservoirs to control the larvae and pupae of mosquitoes.

The effectiveness of green oil is considerably increased when it is used in dichloroethane. There has been developed the preparation insectol, which in a 5% aqueous emulsion causes the complete extermination of mites, ticks, granary weevils and their eggs.

For the disinfestation of vacant granaries, cellars, external walls and adjacent territories an emulsion is used, which is prepared from green oil concentrate prepared by the factory method. The green oil concentrate contains 86% green oil, 6.6% sulfonated oil, 6.6% napthenic acid, 0.8% alkali.

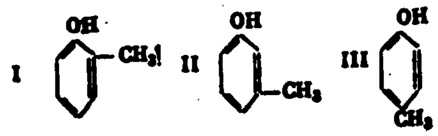
Carbolic Acid

Carbolic acid - phenol-(C_6H_5OH).

Its melting point is 43°; its boiling point is 181°. It is introduced into the composition of certain preparations to intensify their ovicidal properties. In individual cases to combat bugs soap-carbolic mixtures can be applied (35% naphtha soap, 15% phenol, 50% water) at 10% aqueous dilution.

Cresols

Cresols – C_6H_8O.



Synonym: unpurified carbolic acid (raw cresols). It contains 1 – ortho-cresol I (melting point 30°, boiling point 191°), 2 – meta-cresol II (boiling point 201°), 3 – para-cresol III (melting point 35.5°, boiling point 201°).

They are used mainly to pour over rubbish and waste material for the purpose of exterminating fly larvae; 10% aqueous dilutions of soap-cresol emulsion are used (60 parts unpurified carbolic acid, 40 parts naphtha soap). In a number of cases its distillates are used – 5% emulsion (silizol).

Kerosene

Kerosene is a mixture of saturated hydrocarbons of the aliphatic series; it is a fraction of oil, which is obtained by distillation of the latter in the 150-300° interval. The specific gravity of kerosene is from 0.76 to 0.85. Kerosene is inflammable but the possibility of it exploding during disinfestational operations is improbable. Purified kerosene is a light liquid with a mild odor; it does not leave persistent spots on paper and on fabric.

Kerosene is not soluble in water, but is able to form an emulsion with it. The insecticide properties of kerosene are considerable increased when it is used in the form of soap emulsions or mixed with other insecticidal preparations. Kerosene-soap emulsions are prepared from water, kerosene and soap (as an emulsifier). For good stability the emulsion during preparation must be thoroughly mixed and a sufficient amount of soap must be added to it. First, the basic mixture is prepared. For this the soap is dissolved in a small quantity of hot water (approximately 10 times less than the desired amount of emulsion). During the mixing a fine stream of kerosene is poured into the solution and the liquid is simultaneously and thoroughly agitated. When the mixture has taken on a uniformly milky color (after approximately 15-20 minutes), the agitation is stopped and the necessary amount of water is added. A well-prepared liquid has the form of milk and does not become stratified for at least 5 hours. A poorly prepared emulsion rapidly breaks up into its component parts, and the kerosene floats to the top in the form of oily spots. Using kerosene or preparations containing kerosene in its heated form considerably accelerates the extermination of the parasites and their eggs. Kerosene acts like a liquid contact insecticide. It possesses the ability to impregnate, to coat and to stop up the pores of insects and to affect their respiratory tracts. Kerosene is a component part of many mixtures intended to exterminate lice, bugs, fleas and other parasites.

Lethane 384

Lethane 384 – $C_4H_9OCH_2CH_2OCH_2CH_2SCN$. Synonyms: 2-butoxy-2-thiocyanodiethyl ester; 2-[2-(butoxy)ethoxy] ethyl ester of thiocyanic acid; butyl-carbinol-rhodanote; butyl-carbinol-thiocyanate. Its molecular weight is 203,3.

It is an oily liquid having a yellow to brown color; the molecular weight is 203,3; the boiling point is 124° at 0.25 mm Hg; its density is 0.915-0.93, it is almost insoluble in water; it readily dissolves in the majority of organic solvents; in kerosene the flash point is approximately 45°. Lethane 384 (the most wide-spread preparation of this compound) contains by weight 53-56% (average 54.5) or 50% by volume of active substance in the form of an ester of 2-butoxy-2-thiocyanodiethyl. It must be used with caution since it penetrates through intact skin. When it contaminates the skin it should be immediately washed off, when it contaminates clothes they must be washed. It is highly toxic to body lice and bed bugs; the LD_{50} for the former with spraying is equal to 13.5 μg/g, and for the latter 450 μg/g.

Lethane possesses an intermediate toxicity to warm-blooded animals; the LD_{50} upon oral administration to rats is equal to approximately 90 mg/kg, when applied on the skin of rats the LD_{50} is 0.6 mℓ/kg. The toxicity of lethane to guinea pigs is approximately the same, as to rats. Dogs are considerably more sensitive to this preparation than rats, guinea pigs or rabbits. When orally administered to dogs the LD_{50} is equal to 0.05 mℓ/kg.

Lysol

Lysol consists of cresols treated with potassium soap; lysol is prepared by the factory method from technical pure cresol and green potassium soap; it is an oily liquid with a russet color (its specific gravity is 1.035-0.050), frothing greatly when shaken; it has a cresol odor, an alkaline reaction, and is readily soluble in water, alcohol and benzene. The aqueous solutions of lysol are transparent and colorless. With the presence of salts of the alkaline earth metals in water the solutions opalesce to a minor extent.

For disinfestation lysol is used in its hot form 60-70° at 5-10% concentration. In combating fleas the expenditure is 0.1 ℓ or 5-10 g of preparation per 1 m^2.

Lysol is used to combat lice, during which the linen is submerged for 1-1½ hours in a 10% solution of lysol using 800 mℓ per piece of linen. Upholstered furniture is cleaned with brushes moistened with this solution. With repeated disinfestation an odor remains for a long time in the quarters after the application of lysol, and the quarters cannot be utilized.

In carrying out disinfestation at sites of parasitic typhus, and also at sites with mixed infection it is more expedient to use a combined preparation consisting of a 5% solution of lysol and 0.1% DDT; this preparation possesses bactericidal, ovicidal, insecticidal and rickettsicidal action. Fabircs, treated with this mixture retain their insecticidal properties for not less than a month.

According to Z. A. Liganova, the ovicidal action of lysol exhibits a 30-minute effect of the 5% solution on the nits of body lice. In disinfecting lousy linen with typhus sites lysol at a 5% concentration leads to the extermination of the Rickettsiae located in the organism of lice after a 4-hour exposure. Lysol in combination with DDT at this concentration does not affect Rickettsiae located inside the organism of lice. Rickettsiae prowazekii located outside the organism of lice with application of a solution of pure lysol in combination with DDT are exterminated after a 5-minute exposure.

Soap

Soap - salts of high-molecular fatty acids. In technology soaps are considered to be the potassium and sodium salts of the higher fatty acids, the molecules of which contain not less than 8 and not more than 20 carbon atoms, and also the napthenic and resinic acids (rosin) similar to them; the aqueous solutions of these salts possess surface active and detergent properties. Industry turns out various soaps depending upon their purpose.

Green, household or naptha-petroleum soaps possess weak insecticidal properties. However, the addition of soap to a number of disinfecting agents increases their insecticidal capacity, and also increases their ability to wet insects and extend the contact between the disinfecting agent and the insect. Soap serves as an emulsifier and a solvent for disinfecting agents which are insoluble in water. With weekly washing of the body and linen of the lice on man's body and linen are eliminated. The observance of this rule prevents lousiness. Soap in combination with certain preparations is used as an agent for exterminating lice and bugs.

Naphthalysol

Naphthalysol is a russet-colored liquid with the odor of kerosene; it is a mixture of cresol (up to 35%) and naphtha soap (up to 65%). It dissolves well in water. It is used in the form of 5-10% warm aqueous solutions for the disinfestation of linen (soaking for an hour), clothes (by rubbing with brushes moistened with the solutions), footwear, other objects, especially in bath house and sanitation centers.

Petroleum

Petroleum - an oily liquid of various consistency with a brown, almost black color, which is almost completely insoluble in water. Its specific gravity is 0.8-0.95. In chemical makeup it is a mixture of various hydrocarbons with an admixture of organic oxygen, sulfur and nitrogen compounds. It possesses considerable volatility depending upon the hydrocarbons included in its composition. It is a source material for obtaining certain preparations utilized in disinfestational practice. It is used to petrolize marshy places and reservoirs infested with the larvae of the Anopheles mosquito.

The products of petroleum distillation depending upon their volatility are subdivided into petroleum ether, benzine, kerosene, gasoline and light lubricating oils. From the residue after the distillation process there is obtained a large portion of the oils, and also the solid fractions - vaseline and bitumen (from the asphalt residuum). In crude oil aromatic and unsaturated hydrocarbons can be present. Oil finds application in disinfestation, in treating of swamps and reservoirs, in combating the malarial mosquito.

V. M. Gubin (1924), studying the causes of the loss from an aqueous surface of a petroleum film, arrived at the conclusion of the existence in water of bacteria, which assimilate the hydrocarbons, which make up petroleum. In connection with this the author proved the expediency of adding acids which created in a petroleum film conditions unfavorable for the development of bacteria and simultaneously decrease the viscosity of the oil by up to $1\frac{1}{2}$ times.

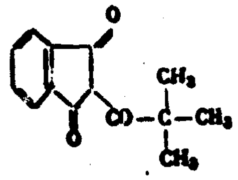
G. V. Khlopin and A. F. Nikitin, Yu. P. Mufel' and E. M. Guterman established the harmful effect of oil on fish when ponds are petrolized. The most poisonous were the naphthenic acids. In using a dilution of 1:50,000-1:330,000 parts water, or 0.02 g per ℓ, fish died. The harmful effect of oil on fish is caused not only by its direct, but also to a considerable degree by its indirect action - by decreasing the food of the fish due to the destructive action of the oil on water fleas. This is especially unfavorably reflected in fish ponds, which contain fry.

These very same preparations on reservoirs with small area bring about the illness and death of water birds, in particular the nestlings.

I. I. Khatuntsev, A. A. Blakhov and A. D. Kuptsova established that oil sharply lowers the density of rice culture, especially during the shooting period. The authors observed burns on plants, and also a considerable reduction in the productivity of this culture.

2-Pivalyl-1,3-Indandione

2-Pivalyl-1,3-indandione $C_{14}H_{14}O_3$



Synonyms: pival, pivalyl-valone, pivalyl-indandione; 2-tert-butyl-1,3-indandione; tert-butylvalone. It is a solid crystalline substance bright-yellow in color with a very weak odor; its melting point is 108.5-110°; it is insoluble in water; it dissolves in dilute alkalis and ammonia. The compound is highly toxic to mammals, it is used to combat rodents, and also for therapeutic purposes (it is an anticoagulant similar to coumarin and its derivatives). Pival possesses high contact toxicity to house flies, lice, animals and their eggs, and is also effective with respect to ticks, mites, flea imagoes and mosquitoes.

The 1,3-indandiones, with acyl replaced in the second position have an increased toxic effect on flies in proportion to the increase of the length of the carbon chain from C_2 to C_5; further lengthening of the chain leads to a reduction in its insecticidal properties.

Pival is a lipoidsoluble neurotoxic poison with respect to insects. It possesses certain selective properties. Thus, for example, as a contact poison it is effective for flies, mites and ticks, but it is ineffective for the American cockroach upon contact or after it is orally introduced. When it is injected into the hemolymph or trachae of the cockroach it has a rapid effect with paralysis after several minutes; the insect does not return to norm.

Although the preparation is toxic to flies as a contact poison, (as are the others acylated 1,3-indandiones) it acts rather slowly (Table 17-18). To accelerate death and the advent of paralysis it is recommended that pyrethrum be added. Its application in a mixture with the pyrethrins can significantly lower the expenditure of the latter. The preparation possesses weak action as an intestinal poison for flies.

Pival in its toxicity to body lice is approximately equal to DDT, but it is not completely harmless to human skin; furthermore, it does not withstand washing (when it is used to impregnate linen).

Table 17. The mortality rate of house flies in percents 24 hours after the application on the back of the thorax of alcohol solutions of the preparations (average data on 5 experiments according to Ye. V. Shnayder).

	Number of flies in one experiment	Mortality rate of flies caused by doses in grams				
		0.5	1	2.5	5	10
Benzoyl indandione ..	200	0	13	17	66	100
Pival indandione	200	13	53	85	100	-

When pival is orally administered to rabbits the lice drinking the blood of these animals died; the minimum effective daily dose in the feed of rabbits is 0.16 mg/kg. Young nymphs feeding on these animals 2 times a day die after 3 days. With a dose of 0.125 mg/kg only 50% die. The toxicity of the blood of a rabbit is retained for 3 days after the cessation of the introduction of the preparation.

Table 18. Death rate of house flies in percents when bread balls rolled in the preparation in its dry form are used (the average data of 5 experiments according to Ye. V. Shanyder).

Name of the preparation	Number of flies in one experiment	Mortality of flies in days				
		1	2	3	4	5
Zoocoumarin............	100	0.6	2	5	22	33
Pival indandione....	100	15	60	96	99	100
Benzoyl indandione.....	100	70	99.4	100		
Control	100	0.6	1.8	1.8	2	2.5

Pival is highly toxic to animals. It belongs to the group of anticoagulants; it possesses cumulative properties. Its toxicity is higher when daily administered in small doses than when administered in a large single dose. With a single introduction the LD_{100} is equal to 75-100 mg/kg for dogs; the subacute dose is 15-35 mg/kg when administered at a rate of 2.5 mg/kg per day. Death comes mainly as a result of hemorrhagic developments.

It is used in the form of poisoned bait containing 0.025% of the preparation in combating rodents. This has been described for wild animals and birds.

Turpentine

Turpentine is a product of the processing of oleoresin extracted from various kinds of coniferous trees by tapping. It is sold in its purified and unpurified forms.

Purified turpentine is an almost colorless, transparent liquid possessing a rapidly volatilizing odor. Its specific gravity is 0.85-0.89. Turpentine is a mixture of several hydrocarbons, of which the main one α-pinene has a boiling point of 155-160°. Unpurified turpentine is a russet-colored liquid with a very unpleasant odor, which can cause headache. Turpentine is not soluble in water and is not miscible with water; it is inflammable and dangerously explosive. The better varieties of turpentine do not leave spots on paper and fabrics, and their odor does not remain long in living quarters.

In disinfectional practice it is used to exterminate bugs and fleas and more rarely to kill lice; turpentine is used in the form of mixtures with kerosene and napthalene or in a form of a water-soap emulsion. The following mixture are prepared from turpentine: 1) 30% turpentine, 70% kerosene; 2) 25% turpentine, 5% napthalene, 70% kerosene; 3) a water-soap, turpentine-kerosene mixture consisting of 40% soap, 30% turpentine and 30% kerosene. The mixture is prepared in the following manner: in a water bath green liquid or solid household soap is melted or brought to its liquid state; the melted soap is taken from the fire, and, observing the rules fire safety, with continuous and thorough mixing turpentine and kerosene are added. As a result a thick, viscous mass is obtained. According to need and before beginning the disinfestational operations a 10% aqueous working emulsion is prepared from the obtained mass.

For this there is added to the mass a measured amount of hot water while stirring energetically before the homogeneous, milk-colored liquid is obtained.

When mixtures and emulsions of turpentine are used bugs, fleas and lice die rapidly and after a longer period of time the eggs of these insects. Furthermore, turpentine mixtures can be used to delouse hairy parts of the body by rubbing the mixture with the subsequent application of dressings to the treated places. After 20-30 minutes the dressings are removed and the preparation is washed off with warm water. It is necessary to take precautions, so that the applied preparations did not get into the eyes. Furthermore, it is necessary to keep in mind that turpentine preparations can irritate the skin and affect the kidneys. After applying a turpentine-kerosene, water-soap emulsion to walls traces and running streaks can remain.

Solar Oil

Solar oil is an oily liquid with a yellow-red to brown color (depending upon the degree of purification); it is a distillate of petroleum obtained during the distillation of petroleum after the kerosene fraction. Its specific gravity is 0.87-0.88. Solar oil is used to combat the pre-imaginal stages of the malarial mosquito by pouring it on reservoirs.

Solvent Naptha

Solvent naptha occurs in two forms - coal-tap and petroleum. Coal-tar solvent naptha is a product of benzene production; it consists of light oils obtained after the distillation of the toluene fraction. Solvent naptha is a colorless or yellowish liquid, insoluble in water, and possessing an odor reminiscent of benzene.

Two types are distinguished: solvent naptha I: its specific gravity is 0.865 g/cm^3 (at 20°); it evaporates at 120-135°. It is a colorless, transparent liquid. Solvent naptha II: its specific gravity is 0.885 g/cm^3 (at 20°); it evaporates at 135-180°. It is a colorless, transparent liquid; slightly yellow coloring is allowed. In the composition of solvent I and II there are included the same hydrocarbons, only in different proportions. In the composition of the solvent there are included hydrocarbons of the aromatic series: 2-5% ethylbenzene; 12-25% mesitylene; 4% o-ethyltoluene; 2-5% p-ethyltoluene; 25-55% m-hydroxylol; 15% pseudomucol; 15-24% other homologues. The solvent is inflammable and dangerously explosive. According to the stipulated requirements, when it is applied to filter paper it should not leave an oil spot.

The chief component part of the solvent are the isometric xylenes: 62% in the first type and 24% in the second; moreover, both types contain toluene. In the second type the amount of coumarone and its derivatives is considerable, which we sometimes specially extracted for the production of the so-called coumarone resins.

Solvent is used in the paint and varnish and rubber industries as a solvent, and also as an additive to auto fuel.

Solvent possesses considerable insecticidal properties. Before the appearance of synthetic insecticides (DDT, hexachlorocyclohexane, chlorophos and others) it was widely applied to exterminate arthropods – carriers of infectious diseases: lice, fleas, ticks, mites and others; cockroaches are the most resistant to solvent.

Petroleum solvent is similar to coal-tar solvent; it possesses an unpleasant odor, it leaves stains and it has weak insecticidal properties, and therefore in the extermination of insects it is not applied. Solvent I is used in disinfestation.

The insecticide properties of solvent were specially studied by a commission in 1916 under the leadership of Prof. N. A. Savel'yev. The commission established that the vapors of solvent kill insects in insignificant doses after 9-12 minutes and do not have side effects on man and animals. In 1931 Ya. L. Okunevskiy worked out the specifications and method for the application of solvent. Its use in combating bugs was limited by its persistent odor.

The boiling point of solvent used in disinfestation is 118-120°, its specific gravity is 0.86-0.87 at 15°; it is a transparent, light-yellow colored liquid with a pungent odor. Solvent naptha is not only a good solvent - it is used as a disinfestational agent in combating lice infestation in its pure form and in soap emulsions (N. A. Savel'yev).

Solvent does not damage articles, which after 3-4 hours of airing are freed from its odor. Solvent damages rubber gaskets, and thus when working with it, it is necessary to use hand sprayers with metallic valves. Footwear is also damaged by the effect of solvent, therefore to protect shoes, boots, etc., it is necessary to coat them with grease.

To exterminate lice articles are treated with solvent naptha from the inside; they are then rapidly folded and stored in airtight boxes or chests with a cover or in rubberized bags. The shielding method is also used to treat articles; in such cases sheets of paper are impregnated with the solvent; these sheets of paper are then laid layer by layer over the articles. After that the articles are packed in boxes or rubberized bags and left for 6-8 hours in a warm place. The expenditure of solvent is estimated at 30-40 g/kg of articles or 100-250 g per standard set of clothes (overcoat, coat, trousers).

When the temperature is increased the insecticidal properties of the solvent vapors are considerably increased. This gave

Ya. L. Okunevskiy the basis approximately 40 years ago to propose a special chamber for the mass treatment of lice-infested articles. The chamber had the form of a small room (4-12 m^3) with two doors. The chambers are heated by steam in coils located on bottom and on each side of the chamber. The heating surface of the coils is 2.4-3 m^2. The chamber is kept at a temperature of 60-65°. The solvent at a rate of 150 mℓ per m^3 is supplied by an injector or is evaporated from a hot griddle, mounted on the coils. A hood should be set up under the injector. For each m^3 of the chamber the load of the chamber should be in winter 2.5-3, and in the summer 3-4 sets of clothes; the whole process should last 70 minutes. The chambers are equipped with in-out ventilation and have an attachment for recirculation of the heated air and solvent vapors. At the present time such chambers are not in use.

From the solvent pastes, emulsions and mixtures with other preparations are prepared.

Solvent naptha possesses a certain toxicity to animals. In rabbits 54 mg/ℓ of solvent naptha I causes within 50 minutes gradual narcosis; 50 mg/ℓ of solvent naptha II does not have a noticeable effect. In man solvent naptha poisoning is expressed by intoxication and spasms.

Soap-Solvent Emulsion

In preparing an emulsion to 35 parts of green soap there are gradually added 56 parts of solvent. As a result there is obtained a yellowish mass with the consistency of vaseline (upon mixing with water it gives a stable emulsion). From this mixture workers prepare 15-20% solutions with hot water. At room temperature when linen is wet with the preparation lice die due to the effect of the solvent within 50 seconds, and nits after 20 minutes.

A hot 15% soap-solvent emulsion (1.5 kg of concentrate per bucket of water) is used to wet the linen (20-30 minutes), 20% for disinfestation of swellings and furniture by moistening them with any of the types of sprayers: atomizer, hand sprayer and others, at a rate of 50-60 mℓ/m^2; a 20% soap-solvent mix is used to treat the hairy parts of the body. To exterminate head lice human hair is wet with 30-35 mℓ of a 20% aqueous emulsion (one should take care not to allow it to get into the eyes) and tied with a bandana for 30 minutes, after which the hair is washed and combed.

The value of the solvent consists mainly in its ability to act in the vaporous state; lice die in the solvent vapors within 2-2½ hours; somewhat more time is required for the nits to die in the solvent vapors; articles abundantly sprayed with the solvent (at a rate of 5% solvent per weight of the disinfested material), are placed in relatively hermetic receptacles – boxes, vats, canvas bags for 6-8 hours.

According to Z. A. Liganova, with the application of 10% aqueous emulsions of soap-solvent paste Rickettsiae prowazekii die within the articles after 4 hours Rickettsiae located outside the organism of the lice perish within 10 minutes after treatment with a 10% emulsion. The addition of 0.03% hexylresorcin reduces the time of the extermination of Rickettsiae to 5 minutes.

The preparation is used to exterminate insects in the absence of other possibilities.

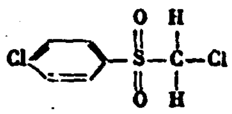
Tedion

Tedion – 2,4,4,5-tetrachlorodiphenylsulfone-$Cl_3C_6H_2$-SO_2-C_6H_4Cl. Its melting point is 145.5-145.8°. It is slightly volatile. It is practically insoluble in water. It is soluble in alcohol, acetone, chloroform and the aromatic hydrocarbons.

The preparation is highly toxic to eggs and all the stages of development of vegetable mites; it possesses ovicidal and larvicidal action. It is slightly toxic to warm-blooded animals; mice withstand a dose of 5 g/kg for 10 days or 500 mg/kg intraperitoneally administered; rats – 2 g/kg intraperitoneally administered; dogs – 1-2 g/kg in their food; moreover, no variations of any kind are noted. In chronic experiments with rats and mice over a period of 3 months with the administration of feed containing 1000 and 500 mg/kg visible changes were not noted; another group of mice were given from 500 to 4000 parts per million over a period of 6 months. Only from the higher dose were retardations in the addition of weight observed; with microscopic examinations no essential pathological changes were detected; nonspecific inflammation of the spleen, liver and kidneys was noted.

Chloromethyl-P-Chlorophenylsulfone

Its chemical formula is $C_6H_7Cl_2SO_2$.



Synonyms: "New lauzeto," chloromethyl-4-chlorophenylsulfone.

It consists of crystals; its melting point is 122°; it is soluble in kerosene and various organic solvents. It possesses considerable insecticidal properties; it acts on lice eggs. It is very effective with respect to adult lice and bugs.

The preparation is ineffective with respect to flies and aphidae. New lauzeto – an outstanding ovicide; it occupies first place among the other ovicides: new lauzeto chloromethyl-(14-chlorophenyl)-sulfone, 3-4 dichlcrobenzyleyanide, diallyl adipate, diallyl succinate, diazoaminobenzene.

CHAPTER IX

PREPARATIONS OF INTESTINAL ACTION

Disinfestational agents of intestinal action are preparations, which do not possess contact action and poison insects only upon getting into their intestines. Such preparations get into the insect organism most frequently with food.

Having gotten into the midgut (a strictly digestive segment), the insecticide being subjected to the action of the secretions discharged by the cells of intestinal epithelium passes into the dissolved state. Under the influence of the preparation changes occur for the most part in the cells of the midgut. These preparations acting on the intestinal tissue cause inflammation, leading to exfoliation and complete or partial necrosis of the epithelium. The most profound hystological changes are usually observed in the epithelial tissue. The changes observed in the midgut of insects vary depending on the poison used and the species of insect. The degree of lesion fluctuates from complete destruction of the epithelium to barely noticeable changes. In the digestive tract of poisoned insects a number of other histological changes can be observed. After the poison penetrates through the intestional walls it gets into the hemolymph and along with it into other parts of the insect organism; as a result of the action of the poison disintegration and destruction of blood cells occur. According to Ye. A. Baburina, in poisoning with sodium fluoride through the digestive tract of the common cockroach considerable structural changes are detected in the epithelium of the mid and anterior section of the intestines and in the formed elements of the blood. In the anterior chitinous section of the intestines under the influence of sodium fluoride there is observed severe vacuolization, breakdown of the protoplasm and disruption of the nuclei due to the dissolution of the nuclear membrane.

Irritation of the intestines in a number of cases causes in insects diarrhea or vomiting (regurgitation), in consequence of which a considerable amount of the poison within a brief interval of time is ejected outside the body, not having the effect peculiar to arsenic poisons. For fluorine preparations, on the other hand, spasms of the digestive tract are more characteristic symptoms, and the progress of the food in the intestines is noticeably inhibited. Intestinal action preparations are designated basically for insects (cockroaches, flies), which mainly eat food products (bread, sugar and others). Furthermore, these same agents are used to exterminate mosquito larvae. They are used in dusting, spraying, and also in baits. Almost all contact insecticides possess intestinal action; especially clearly expressed is the intestinal action of the organophosphorus compounds.

Arsmal'

Arsmal' (copper arsenite). This is a compound of copper and arsenic. This preparation containing 10-11% arsenous anhydride (AS_2O_3) and 7-10% cupric oxide CuO, possesses high toxicity to malarial mosquito larvae. The fineness of the grind should leave a residuum of not more than 4% on a screen with 175 mesh. To improve the navigational properties of the preparation 3% acidol or neutral creosote oil are introduced. It is used in a mixture with dust, tripoli and other ingredients (compilers) for dusting reservoirs populated with larvae of malarial mosquitoes in quantities of 1.5 kg/ha (overgrown and not overgrown) at a rate of one part of the preparation per 13 parts diluent.

Boric Acid

Boric acid – H_3BO_3. This is a fine, crystalline powder with a white color. Its molecular weight is 61,84; in 100 parts of water at 19° 4 parts dissolved, and at 100° – 34 parts. Boric acid is used as an agent to exterminate cockroaches. To prepare poisoned baits in a solution of boric acid (2 teaspoons per glass of water) pieces of black bread are soaked and they are scattered in places, where cockroaches are breeding. To combat ants boric acid is added to sausage.

Boric acid is a very weak bactericide. A saturated 1-18% aqueous solution even with prolonged exposure does not cause the death of Staphylococcus aureus. It possesses certain bacterio-static properties.

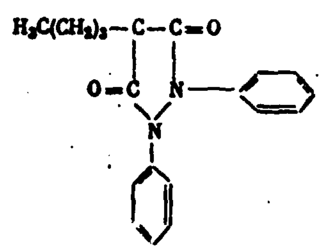
Borax

Borax ($Na_2B_4O_7 \cdot 10H_2O$). It consists of colorless crystal with a molecular weight of 381,43; it readily dissolves in hot water (1:0.5), but with difficulty – in cold water (1:26). It is insoluble in alcohol. For disinfestation calcined (dehydrated) borax is used, it is prepared from an ordinary lump by calcinating on a heated grill or on an iron sheet (until the complete cessation of the elimination of water vapors). Furthermore, borax swells up and is converted into a fine dry, white-colored, odorless powder. Borax is added to bait to exterminate cockroaches. The heated borax is dissolved and mixed with flour or sugar powder; the mixture is used to dust plots where cockroaches are teeming. Borax is also used in bait to destroy ants: to 1 ℓ of water there are added 30 g of borax, 400 g of sugar, 100 g of bee honey, 1 mℓ of vanilla essence, 1.5 mℓ of pear essence. All of this is boiled and poured in 3-4 mℓ amounts into test tubes, which are then spread in places frequented by ants.

The poisoned baits with the calcined borax are almost harmless to man and domestic animals and can be freely applied in kitchens and food product storehouses. Complete extermination of cockroaches is attained after they have consumed 12-16 mg/g of the preparation (with the bait). To the larvae of flies borax is also toxic; [LD_{50}] ($ЛД_{50}$) is attained when they are submerged in a solution containing 2000 mg/ℓ (0.224%). With oral administration the LD_{50} for higher animals is within the limits of 1000-5140 mg/kg depending upon the species of animals. Borax possesses weak bactericidal properties.

Butadion

Butadion – $C_{19}H_{20}N_2O_2$



Synonyms: butalidin, phenylbutazonum, butalidon, 4-n-butyl-1,2-diphenyl-3,5-pyrazolidindione. Its molecular weight is 308,77. In chemical structure and pharmacological properties it is similar to pyramidon. It is a white powder with a slightly yellowish hue; its melting point is 104-106°; it is very slightly soluble in water; it dissolves with difficulty in alcohol; it dissolves in alkalis. Its sodium salt dissolves well in water. When orally introduced into the organism of warm-blooded animals or intramuscularly the preparation is decomposed into 2 metabolites, one of which (1-phenyl, 2-p-hydroxy-phenyl and 4-p-butyl-3,5-pyrazolidindione) is slowly excreted from the organism, having a half-life of 2 days; the half-life of the second metabolite (1,2-diphenyl-4,3-hydroxy-p-butyl-3,5-pyrazolidindione) occurs considerably faster, in the course of 10 hours; the first metabolite, probably, is the active principle. The mechanism of the action of this preparation on lice has not been studied. It is known that in the case of the use by man of butadiona the blood of the host (the sole food of the parasite) becomes toxic, and lice feeding on this blood die. Head lice are more sensitive to the toxic action than body lice.

On bugs, fleas, mosquitoes, pubic lice pyrazolidine preparations do not have an effect.

The insecticidal effect is attained by the intake of the preparation in doses of 20-30 times less than for a course of treatment in therapeutic practice. For the elimination pediculosis a single dose of 0.2-0.4 g of butadion is effective for children of preschool age; 0.5-0.7 g for school children and 1 g for adults. For insecticidal purposes the preparation is used orally according to the following arrangements:

a) with fractional application (the arrangement of the Institute of Epidemiology and Microbiology im. N. F. Gamaley of the Academy of Medical Sciences of the USSR) 0.3 g 2 times each day – 0.6 g per day, a total of 5 times (2.5 days)– the course of treatment for adults is 1.5 g.

b) according to V. V. Kurganov (the arrangement of L'vov Institute of Epidemiology, Microbiology and Hygiene), the insecticidal effect is attained by a single intake of the following dose of butadion: adults 1 g per intake and repeatedly at the same dosage for 10 days; children of senior school age (13-15 years) 0.6 g; children of junior school age (7-12 years) 0.5 g; for children older than preschool age (5-6 years) and younger than preschool age (2-4 years) it is not applied.

The indicated doses of butadion ensure the extermination of lice for 6 days after taking the preparation.

The administration of the preparation to children younger than 1 year was not studied.

With the use of fractional dosage there was observed complete effect and the duration of the action was 15 days. With a single dosage the effect was observed to be 83-84% effective and the action continues for 7-10 days, after which the intake of the preparation should be repeated at that same dosage.

Repeated intake of butadion for 10-14 days is necessary to exterminate hatching larvae.

According to the observations of L. A. Favorova, A. I. Chubkova, A. I. Papovyan, A. P. Kazaryan, G. Kh. Stepanyan, V. S. Avyakan, the greatest effectiveness and duration of action is attained by taking the preparation according to the arrangement: 0.3 g 2 times per day for 50 hours (1.5 g during the course of the treatment). The duration of the insecticidal effect was equal to 15 days, which provided complete extermination of the adult lice and the hatching larvae. The mass extermination of the adult individuals starts toward the end of the second day after taking the preparation; extermination of the larvae occurs in proportion to their hatching for a period of 8-10 days. For treatment purpose the preparation is used against inflammation for the purpose of anesthetizing, for lowering fever and others; it is prescribed for internal use after eating. A single dose of 0.1-0.15 g is used. In the course of a day butadion is taken 4-6 times, but not more than 0.6 g in a day.

Butadion can be used to combat lousiness only in exceptional cases, i.e., when there is no possibility of using other methods and agents. The application of the preparation is contraindicated in the case of disease of the hemopoietic organs with a tendency towards leucopenia and anemia; with disease of the liver and kidneys and with disturbance of their function; with ulcers of the stomach and duodenum; with decompensation of cardiac activity.

During treatment with butadion in individual cases (approximately 1-2% of those treated) there can be observed complications in the form of nausea, vomiting, short-term pain in the gastric region, skin rash, leucopenia, dizziness. The side effects are short-term and pass rapidly after the cessation of the intake of the preparation. With poor tolerance the intake of the preparation should be ceased.

Sodium Fluosilicate

Sodium fluosilicate (Na_2SiF_6) is a white crystalline powder, slightly soluble in water. In view of its considerable toxicity to man and the danger of poisoning connected with this preparation is almost never used in the practice of medical disinfestation. Solutions of sodium fluosilicate and sodium fluoride in various proportions are used to manufacture poisonous paper used to combat flies. Sodium fluosilicate finds application in agriculture. It is used in the aerial-chemical control of rodents and insects, mainly of the sugar beet weevil and in individual cases of forest pests. This preparation within the limits of the applied dosages does not burn the leaves of plants and is less poisonous to animals than sodium fluoride. For aerial dusting (from 8 to 15 kg/ha) the first type of preparation is useful; the remaining types are not useful because they have a coarse grind. The preparation is also used with baits at a rate of from 400 to 800 g per 10 kg of dry bait substance. Its deficiencies are that it is hygroscopic and it deteriorates when stored.

Paris Green

Paris green – $Cu(CH_3COO)_2 \cdot 3Cu(AsO_2)_2$; its molecular weight is 1013,7; it is an emerald-colored powder, which is almost insoluble in water; it is a double salt of copper acetate and copper meta-arsenide. The ratio between these two compounds is usually close to 1:3. At present time there exists about 50 names for this compound (chrome, emerald green, chrome green, Schweinfurth green, etc.); Paris green was first made in 1814 in Schweinfurth.

Factory Paris green contains 51.5-55% As_2O_3, 28-30% CuO and 7 – 8.5% $(CH_3CO)_2$. The preparation should not contain more than 1% moisture and more than 3-5% water-soluble As_2O_3. The fineness of the grind should correspond to a residuum of not more than 4-5% on a screen of 200 mesh.

In the presence of water Paris green hydrolyzes, liberating arsenous acid which is soluble in water. Thus, after standing for one day a mixture of 0.24 g of Paris green and 100 mℓ of water approximately 0.005 g of the As_2O_3 passes into solution which is about 3-4% of the total content of the given arsenic.

The preparation is effective with respect to the larvae of the malarial mosquito and garden pests; for the other stages of mosquito development it has almost no effect. The preparation used in a mixture with the fillers (road dust, tripoli, talc, slaked lime, and others) is intended for the extermination of malarial mosquito larvae in various open reservoirs by: a) ground dusting; for this Paris green is first mixed with fine, road dust or other fillers. The reservoirs are dusted at a rate of 0.8 kg per hectare of open reservoir; 1.2 kg of the reservoirs are overgrown with grass. In the first case the preparation is diluted 25 times, and in second 16 times. In ground dusting the preparation is used at a 4-5% concentration; b) in aerial dusting at a 25-50% concentration.

In Russia Paris green was first applied in 1910. The application of this preparation was many times cheaper than the application of kerosene and oil. O. D. Tishchenko (1927) proved the harmlessness of Paris green for various breeds of fish (crucian carps, bitterlings, tenches, roaches, pikes, gold fish) and for plankton in the doses applied in practice. These data were confirmed by a number of other authors. The preparation is extremely toxic to bees: 0.4-1.5 μg is sufficient to kill bees. The best way to protect bees from extermination - export them to a distance of not less than 7-10 km from the zone of aerial dusting for the whole period of the treatment of the reservoirs.

D. I. Blagoveshchenskiy ascertained the dependence of the toxicity of Paris green on water temperature. The higher the temperature, the greater is the intensity with which the larvae filter and ingest the particles of poison and the faster they die. The author studied the distribution of Paris green in the organism of larvae and established that the basic mass of poison concentrates in the midgut, whence in its dissolved state it passes through the walls of the intestines and penetrates into the hemolymph.

Within 12-24 hours after the dusting of a water surface the greater part of the poison has sunk. The correct dusting of rice fields with a mixture of Paris green and a diluent does not present a danger to the rice. The cases described in literature of the burning of rice appeared in connection with dusting at the time of its blossoming, with the disturbance of the elementary conditions of the dusting process: increased dosage, dusting without dilution, the use of a preparation which had lost its dust-like properties due to improper storage, etc.

A number of authors (F. F. Yarchak and V. P. Vozhenko, L. I. Keyris and N. A. Klökov, M. A. Laryukhin) ascertained that Paris green treated with oil or kerosene has considerable advantages.

An oil suspension of Paris green has the following composition: Paris green 0.8-1 kg, kerosene 2-2.5 ℓ, water 200 ℓ.

In preparing a suspension it is possible to use oil (2-3 ℓ per ha) instead of kerosene. Suspensions can be prepared in the form of concentrates; for this purpose to 0.8-1 kg of Paris green there are gradually (by 1/3) added with mixing 2-2.5 ℓ of kerosene and 1.5-2 ℓ of water; if the suspension is prepared with soap, it is necessary to stir until a thick uniform mass has been obtained. At the work site the concentrate is diluted with water and thoroughly mixed. In dusting marshy places Paris green can be used in the form of granules containing 5% preparation at a rate of 6.5-7 kg/ha.

Paris green, like any arsenic compound, is poisonous, therefore, when it is used, it is necessary to observe caution, in order to eliminate the possibility of the poisoning the working personnel, as well as animals, birds, and bees. When dusting this preparation can come in contact with the mucous membranes of man and cause inflammatory symptoms. A dangerous dose for man is 0.01 g/kg and a fatal dose is 0.06 g/kg.

The use of Paris green from aircraft in its dry form is unsuitable, if the size of its particles on the average equal to

10 μ. Due to the high degree of dispersion, during dusting the preparation is carried by the wind and the losses attain 77-93% (B. I. Rukavishnikov). Therefore, Paris green is applied most efficiently in the form of a suspension with the diameter of particles 20-25 μ for aerial treating of reservoirs against malarial mosquito larvae. Inasmuch as in suspensions the preparation settles rapidly, then in spraying it is necessary to mix the suspension; for this in the aircraft there is a special attachment (a wind motor).

Paris green in a mixture with Bordeaux liquid is used to combat pests and diseases in gardens and vineyards. The preparation is poisonous to man, a fatal dose of it is 180-200 mg/kg. When orally administered to rabbits the smallest lethal dose is 25 mg/kg

Thiodiphenylamine

Thiodiphenylamine – $(C_6H_4)_2NHS$. It is a crystalline substance with a light-yellow color, insoluble in chloroform and slightly soluble in water. In air it slowly oxidizes and takes on a light-yellowish color. Further oxidation leads to the formation of a red-colored compound possessing a mild, characteristic odor and a melting point of 160°. The moisture content in the preparation should not exceed 2%; the residue on a screen with a 175 mesh should not be more than 4%.

At the present time thiodiphenylamine is used to combat the larvae of the malarial mosquito. The preparation is not wet by water and therefore it is retained for a long time on reservoir surfaces. The preparation is used to dust reservoir surfaces infested with malarial mosquito larvae at a dosage of: reservoirs not overgrown – 0.8 kg/ha, overgrown reservoirs – 1 kg/ha in a mixture with a diluent in a proportion 1:16 or 1:20 (road dust, peat dust, tripoli).

In hand treating reservoir by the simplest methods (scattering the poisonous mixture in the wind with shovels, by hand and so forth) 1 kg of poison is taken per 40-50 kg of diluent. In ground operations using a hand duster there is taken per hectare 20 kg of the poisonous mixture, in which there is contained 1 kg of poison and 19 kg of diluent. In aerial dusting the expenditure of preparation on open reservoirs is 750 g of poison and 250 g of diluent per hectare, and on reservoirs severly overgrown with vegetation it is 1 kg of poison per hectare (without the diluent); it is dangerous for bees as a contact poison. The preparation is toxic to bees at an expenditure of 0.5 kg/ha.

Thiodiphenylamine is used in the form of a water-soap and water suspension; in the composition of the water-soap suspension there is included 1.5 kg of thiodiphenylamine, 0.2-0.3 kg of liquid or domestic soap and 250 ℓ of water per ha.

Thiodiphenylamine, possessing great larvicidal activity, at the same time is harmless to warm-blooded animals even when used internally in quantities exceeding by many times the lethal doses for mosquito larvae. But during prolonged work with it thiodiphenylamine causes skin irritation.

According to D. I. Dobrosmyslov, thiodiphenylamine in the doses used by antimalaria stations is harmless for fish, but its navigational abilities are greater than those of Paris green. The investigations of I. K. Ivanov showed, that at an expenditure of 1 kg/ha of undiluted thiodiphenylamine plants are not damaged even when they are used for dusting in the period of flowering (i.e., when the rice is most sensitive to burning) in the early morning hours (4-7 o'clock), although the author notes that a reduction in the rice harvest was noted.

G. Z. Khandanyan points out the complete harmlessness of thiodiphenylamine both for rice cultures (at an expenditure of 0.75-2 kg/ha), so also for Gambusia (at an expenditure of 1.25-2 kg/ha).

Formalin

Formalin is an aqueous 40% solution of formaldehyde CH_2O; it is used in combating flies. Into a glass of water 2 teaspoons of formalin (4% formalin) are poured; they are mixed and poured on plates in the middle of each of which a piece of bread (zwieback) is placed; formalin possesses considerable bactericidal properties and is mainly used for disinfecting.

Sodium Fluoride

Sodium fluoride (NaF) is a crystalline powder; the technical preparation should contain 80-89% pure sodium fluoride. The solubility of sodium fluoride in water at a temperature of 15° is equal to 4.78% at 18° – 4.3% and at 25° – 4.05%. The reduction in solubility at a temperature of 25° is explained by formation of sodium fluoride acid ($NaHF_2$), possessing extremely insignificant solubility in water. The specific gravity of sodium fluoride at a temperature of 18° – 2.7.

In order to increase the adherence of the preparation potato flour or talc are added to it. A preparation with 50% sodium fluoride is sold under the name tal'fton. The preparations are usually compounded in such a manner, that they contain 50-80% sodium fluoride. Thus, for example: 1) 50% sodium fluoride, 50% talc or potato flour; 2) 80% sodium fluoride, 20% talc or potato flour.

The preparation was proposed in 1911 as a control for insects.

The caustic property of sodium fluoride is the basis of its effect on cockroaches; the poison adheres to the legs and the body of insects; cockroaches lick and swallow it; as a result the sodium fluoride gets into the intestines and poisons the insect. The action of the fluorine preparations is expressed on insects in the form of disturbances of the function of individual organs, the breakdown of their coordination, partial paralysis; then death ensues. The poisoning process takes place slowly and the insects sometimes die on the 5-6th day.

It is used against cockroaches in the form of powders mixed with talc and starch. The mixture is dusted in places of cockroach habitation and traffic. Sodium fluoride is used to combat pharaoh's ants; per ℓ of water there are taken 5 g of sodium fluoride, 400 g of sugar, 100 g of bee honey, 1.5 mℓ of pear essence, 1 mℓ of vanilla essence; all of this is boiled, and then 3-4 mℓ are poured in each of several test tubes which are then distributed in places, frequented by the ants. A toxic dose approaching a fatal dose when introduced into the stomach of an animal is 0.25-0.3 g of sodium fluoride per 1 kg of weight of the animal. The median lethal dose for man in 16-18 g.

Caustic Green

Caustic green [Translator's Note: Soviet variant of Paris green (insecticide) containing calcium sulfate] is a powdery preparation with a green color, which is soluble in water; according to technical specifications it must contain not less than 32% As_2O_3, 17.5% CuO, 5% $(CH_3CO)_2$, 3.5% water-insoluble As_2O_3, not more than 2% moisture. The fineness of the grind should not leave a residuum of more than 4% on a screen with 400 holes per cm^2. It is used against Anopheles mosquito larvae.

It contains chiefly $Cu(CH_3COO)_2 \cdot 3Cu(AsO_2)_2$ with an admixture of calcium sulfate $2CaSO \cdot 3H_2O$.

CHAPTER X

GASEOUS AND VAPOROUS AGENTS (FUMIGANTS) USED FOR DISINFESTATION

One of the methods of combating insects is poisoning them through their respiratory system. In these cases the insects are deprived of oxygen or insecticides in the gaseous state are introduced with the air. It is more difficult to deprive insects of oxygen than to introduce an insecticide into the air of an environment where insects are situated. A method proposed in England for storing food products, reducing the expenditures for the extermination of insect - pests, which with the present methods of storage is frequently 25-70% of the total expenditures for storage, is deserving of consideration. The grain is stored in a storehouse with a diameter of 20 m and a height of 6.7 m, made from nylon covered with plastic; this material is sufficiently hermetic and almost does not allow the penetration of oxygen. The grain is poured in from above, almost completely filling the storehouse, which after this is hermetically sealed. The insects situated inside such a storehouse exhaust the oxygen available in it, and then gradually die from the lack of oxygen. It has been confirmed that grain can be stored in this manner for a long period of time, without the application chemicals and without expending money to combat insects.

The grain should have less moisture content than that, which is usually considered safe for storage; otherwise fermentation can start. The cost of storing grain in storehouses of this type is 1.8 times cheaper in comparison to storage in the usual type of storehouses.

In combating insects it is possible to use preparations in the gaseous state – fumigants. Gases are matter located in such a physical state, that the forces acting between the great majority of particles are very small; due to this absence of significant external forces the gases are evenly distributed throughout the total volume, acquiring an appropriate density. Insecticides utilized for disinfestation in their gaseous state are called fumigants.

Fumigation is one of the methods of combating insects and rodents, carriers of causal organisms of infectious diseases (of man and animals), pests and diseases of agricultural plants. The essence of fumigation consists in the addition to air of poisonous gases. In ancient times fumigation meant that the application of smoke obtained by burning grasses and certain plants; at the present time the term "fumigation" means fumigation with chemical substances, the action of which is manifested chiefly in the gaseous or vaporous state.

The most widespread fumigants are hydrocyanic acid (black cyanide, calcium cyanide, sodium cyanide, and others), chloropicrin, ethylene oxide, ethyl bromide, methyl bromide, dichlorethane, sulfurous anhydride, methylene chloride, chlorine, chloroform, formaldehyde, carbon tetrachloride, phosphine, and others. For fumigation not only gases are used, but also vapors of preparations, obtained by volatilization of insecticides and bactericides ([DDT] (ДДТ), hexachlorane, formalin, chlorine, [DDVP] (ДДВФ) and others).

Some of the gaseous substances possess broad action, i.e., are useful both for purposes of disinfestation, and also for disinfestation and deratization. However, in most cases the gaseous substances have a specific action – from some preparations only microorganisms die, from others – only insects, and from a third group – only rodents. Thus, for example, formaldehyde possesses strong bactericidal properties, but its action on insects is weak; sulfurdioxide and chloropicrin possess weak bactericidal properties, acting only on the vegetative forms and not killing the spore forms of microorganisms; at the same time these gases possess satisfactory toxicity with respect to insects and rodents; hydrocyanic acid and DDVP almost do not possess bactericidal properties, but are highly effective agents with respect to insects; carbon dioxide does not possess significant bactericidal and insecticidal properties, but it has importance as a deratizational preparation.

Fumigants differ from each other in their various degrees of toxicity to animals, including insects. Thus, for example, if as unity there is taken the toxicity of carbon bisulfide at a concentration providing complete extermination of mosquitoes after 30 minutes of exposure, then it turns out that hydrocyanic acid is more toxic than carbon disulfide by 900 times, than chloropicrin by 225 times, than chlorine by 90 times, than phosgene by 45 times, than sulfurous anhydride by 30 times and than ammonia by 3 times.

The less toxic fumigants – dichloroethane, carbon bisulfide and CCl_4 – were tested with a 24-hour exposure. A day after fumigation with hydrocyanic acid cadelles, Tenebrioides mauritanicus, cannot manifest signs of life upon mechanical irritation or warming, but in subsequent days it is possible to revive many individuals, the greater portion of which subsequently dies. If on the day after fumigation with carbon bisulfide it seemed that 95% of the cadelle larvae had died then after 90 days it appeared that their mortality rate did not exceed 10%. On the contrary, the dying off of cadelle larvae after fumigation with ethylene dibromide or ethylene chlorobromide occurs gradually: after one day there cannot be any dead individuals, but in the course of 14 days 90% die, after 90 days – 100% (Table 19).

Fumigants act on arthropods and rodents through the respiratory system, into which they gain entrance along with the inhaled air. Certain fumigants also have a contact action (hexachlorane, DDVP, solvent, and others). Sulfurous anhydride and chlorine, upon getting into the tracheae, tracheoles, alveoli, act on their walls. Hydrocyanic acid, DDVP, carbon bisulfide, para-dichlorobenzene and others, although they do not destroy the respiratory system, but, upon getting into the cells of the tissues, they disturb their normal functions, which causes the death of the insects.

Table 19. Concentrations in grams per cubic meter, causing 99% extermination 7 days after fumigation of fourth instar cadelle, Tenebroides mauritanious (Tm), larvae; 2-week old grain weevils, Calondria granaria (Cg); 1-2-week old confused flour beetles, Tribolium confusum (Tc) (according to Bond and Monro).

Name of the preparation	Tm	Cg	Tc
Acetonitrile	8	2,2	3,0
Hydrocyanic acid	13,3	13,5	1,1
Chloropicrin	11,2	30	11,5
Methyl bromide	23,0	5,6	12.8
Ethylene dibromide	25,0	6,9	6,2
Ethylene chlorobromide	68,0	9,6	—
Ethylene oxide	35	7,2	25,5
Sulfur dioxide	23,5	10,2	7,2
Sulfuryl fluoride	16,3	3,5	11
Phosphine	1	>13	~4

Designations: МК = Tm; АД = Cg; МХ = Tc.

Fumigants are used for purposes of disinfection, disinfestation and deratization of closed premises, including living quarters and storehouses, and also for treating railroad cars, aircraft, ships, and other objects; they are used to treat burrows of rodents under field conditions. Fumigants find application in room disinfestation and disinfection of linen, clothes, bed appurtenances and software.

The fumigation of certain objects is also carried out in polyethylene and rubber bags. In large chambers upholstered furniture is treated with hydrocyanic acid for the purpose of combating bugs, moths, etc.

Aerosols obtained by the atomization of an insecticide do not penetrate into the many parts of premises, where insects can be found. In contrast to aerosols vapors of insecticides act according to the laws of the distribution of gases. Upon the evaporation of insecticides of the particle of a vapor do not exceed the size of fractions of a micron. The vapors penetrate into all parts of the premises; if their necessary concentration is maintained for a sufficient period of time, the insecticidal effect of vapors is considerably higher than that of aerosols.

When using insecticidal vapors in the presence of people preparations are used, which possess high selective toxicity, i.e., which are highly toxic to an insect and only slightly toxic to man. Furthermore, such a preparation should evaporate rapidly at ordinary room temperatures, should not have an unpleasant odor, should not cause unpleasant sensations, and should not have at the same time a harmful effect on furniture and equipment. Among the insecticides possessing the enumerated specifications we find in very favorable position the preparation, DDVP.

In the absence of people it is possible to use the vapors of hexachlorane, para-dichlorobenzene and others. The sublimation of hexachlorane and its gamma-isomer is readily carried out heating it on some good, heat-transmitting, surface, for example on sheet iron plates. The strong heating of hexachlorane (above 200°) causes its noticeable decomposition. Upon the heating of the pure gamma-isomer of hexachlorane its rapid sublimation into the air occurs; the addition of 2-40% hexachlorane or camphor prevents its sublimation.

When obtaining aerosols by sublimation or evaporation the insecticide is heated in such a manner that it does not attain that temperature, at which a considerable amount of it is decomposed.

The volatility of fumigants to a considerable extent depends on temperature and pressure. Volatility is usually expressed in grams per m^3 of air; for example, the volatility of chloropicrin at 0° and normal atmospheric pressure (760 mm) is equal to 57.5 g per m^3. It is not possible to obtain a higher concentration under these conditions; to increase the concentration it is necessary to raise the temperature. The volatility of a fumigant depends on its boiling point: the higher it is, the lower its volatility and vice versa, but such a dependence is not the general rule for all fumigants.

A preparation should have such a degree of volatility, at which the concentration of its vapors in the air would be fatal to the insects, against which it is used. The rate of evaporation of fumigants can be increased, by heating the ambient air and the preparation itself, and by lowering the atmospheric pressure or by increasing the area of evaporation.

A fumigant can be significantly adsorbed by the fabrics and by the materials treated (adsorption). Considerable adsorption is an undesirable property, since it delays the rate of degree of penetration of the preparation into the depth of the materials being disinfected. Furthermore, when high adsorption is a factor the expenditure of the preparation increases. Thus, for example, 100 times more chloropicrin is required when assailing a suslik in its burrow than under experimental conditions (in a glass jar), because when treating a burrow the preponderant amount of chloropicrin is absorbed by the earth. Products sorbing a fumigant in certain cases acquire an unpleasant odor; this, for example, occurs when hexachlorane is used.

There is great danger in disinfestating dwellings with highly inflammable fumigants.

In the practical application of fumigants then specific gravity has great importance. The specific gravity of fumigant is the ratio of the weight of 1 ℓ of fumigant vapors to the weight of 1 ℓ of air. Knowing the specific gravity, it is possible to more correctly apply the fumigants: preparations, the vapors of which are heavier than air descent, and substances with the specific gravity of their vapors considerably less than the weight of air ascend. It is necessary to consider this when fumigating premises. The size of fumigant particles is extraordinarily small and is approximately equal one one-thousandth part of a micron.

Fumigant vapors should be easy to identify, should possess stability, should be easily neutralized, degasified, desorbed and should not damage furnishings (paint or material). The presence of fumigant vapors in the air of premises is determined by chemical and organoleptic methods.

When using gaseous and vaporous agents, besides the general information about their physical and chemical properties, it is necessary to know the following:

1) the concentrations, at which a preparation possesses insecticidal properties;

2) the specific gravity of the gas or vapors of a preparation with respect to air;

3) the effect of external factors (temperature, humidity, light, movement of air, and so forth) on its insecticidal properties;

4) the exposure necessary to obtain positive results in disinfestation;

5) the absorptivity of a gas by porous materials (the surfaces of objects, the walls of premises and various articles of furniture);

6) the degree of permeability of a gas into various objects and materials and the ability to penetrate into the depth of porous bodies and other objects;

7) the ability to enter into chemical reactions with treated objects;

8) the conditions inhibiting and accelerating the liberation of objects from gaseous and vaporous agents;

9) neutralizing agents;

10) the degree of change of the objects under the effect of the applied agents.

In order to effectively use fumigants it is necessary to have the premises thoroughly and hermetically sealed to take measures for the equal distribution of the gas, to create in the treated premises the appropriate humidity and the most favorable temperature.

In connection with this, the concentrations at which the overwhelming majority of preparations are used in the practice of disinfection, disinfestation and deratization in their gaseous and vaporous states are also toxic to man; there should be anticipated measures of safety and such a course of treatment of premises, tents, soil, and burrows, which would exclude the possibility of the occurrence of accidents (Roan).

In the field of disinfestation fumigants found broader application before the appearance in 1944 of insecticides possessing residual action (DDT and [HCCH] (ГХЦГ)). At the present time it is doubtful whether it is expedient to use highly toxic fumigants for the extermination of lice, bugs, cockroaches, fleas, flies, mosquitoes, and gnats. If it appears necessary to subject clothes and software to fumigation, then this can be successfully accomplished with the help of aerosols of DDT, HCCH, DDVP and others.

Fumigants are used for the disinfestation and deratization of granaries, grinding mills, apartment buildings, aircraft, ships, hangars (for railroad cars).

When fumigating to combat mosquitoes, flies, and other insects, tobacco smoke, pyrethrum smoke, or smoke obtained by the combustion of special candles, aerosol pots and so forth are used. Tobacco smoke is also used for the fumigation of trees to combat jumping plant lice and suckers (Psyllidae family). An analogous method can be used for disinfection.

Fumigation is permitted only for objects located at a distance of not less than 30 m from industrial locations and operating railroads and at a distance of not less than 50 m from living quarters. During the time of fumigation and decontamination with methyl bromide in elevator silos, in supra-silo and sub-silo premises a protective zone with a radius of 10 m is established. Before fumigation the power and illuminating power line of the storehouse being fumigated are switched off. All matches, lamps, flashlights, and other igniting and illuminating apparatuses are collected from the fumigation workers. All premises being fumigated must be isolated from neighboring premises. The temperature in them should not be lower than that, which is necessary for the effective action of the preparation. The degree of isolation is established by a physician or by the responsible specialist directing the carrying out of the fumigation. When a whole building is not being fumigated, but only individual premises located within the latter should be thoroughly inspected for the presence in it of any slots and holes connecting it with other premises or neighboring buildings. For the purpose of hermetic sealing the premises in it are closed and ventilation holes are covered, cracks in windows, doors, walls (baseboards) and ceilings (near electric wiring) are sealed; it is also ascertained whether gas can get through a cellar into neighboring premises. The stopping-up is carried out with paper strips with a width of 5-7 cm, a length of 80 cm, covered with freshly prepared paste. The hermetic sealing of heated surfaces is accomplished with paper smeared with vaseline or a 2:1 mixture of liquid soap and vaseline.

During fumigation of a whole building for the purpose of disinfestation or deratization the most favorable conditions are created for the penetration of the gas into the cellar and into cracks and apertures. Treating a one-story building one window is closed in such a manner that it can be opened from the outside. The cubic volume of the premises and its degree of loading with object are determined in order to ascertain the amount of preparation required. Plants, animals, food products, water, and when necessary software (linen, clothes) are removed from the premises. The pieces of furniture are moved as far apart as possible and when possible cabinets, chests and so forth are left open. Software which can be treated is spread out and hung up.

When using sulfur or chlorine the fire boxes of stoves or furnaces and the damper openings are smeared with clay. In the damp season premises subjected to treatment with sulfur dioxide are first well heated and aired out to decrease the humidity of all the premises and individual objects. The following should be removed from the premises: upper clothes, dresses, linen, and bed appurtenances (with the exception of mattresses), precision mechanisms - clocks, radios, telephones, and valuable metallic articles (nickel-plated beds, varnished and polished object of furniture, musical instruments). When upholstered furniture with bright-colored upholstering, and also metallic and polished objects are left in the premises to be disinfected they are protected from the injurious effect of sulfur dioxide in the following way: sofas and easy chairs are placed with their legs upwards or the seat and back are covered with rags or sheets of paper; metallic objects are abundantly smeared with vaseline or wrapped with long strips of paper in the form of a spiral; varnished and polished objects of furniture are covered with strips of fabric or paper in the same way, so that gas has access to all the fissures in the furniture and furnishings.

Upon completion of the treatment the premises are defumigated by simple airing out: the doors are opened, currents of air are established, and the ventilation accomplishes its effect.

In opening kegs containing dichloroethane and methylallyl chloride both heating of the plugs and striking them with metallic objects are prohibited. Containers of methyl bromide are placed in such a manner that the workers do not get into the spray jet: the containers most remote from the entrance are opened first. In opening jars with hydrocyanic acid and disposing of the disks you start from the more distant places, gradually moving toward the exit. The doors and windows of a storehouse are stopped up with putty after fumigation; nails should not be pounded into them.

Leakage of chloropicrin, dischloroethane, methylallyl chloride is ascertained organoleptically. Leakage of hydrocyanic acid is detected by bezidine papers. Leakage of methyl bromide is detected with a indicator burner. In an atmosphere of methyl bromide vapors the color of the burner flame changes.

An hour after the beginning of airing in the case of using of highly toxic fumigants members of the fumigation detachment in gas masks and sanitary-hygienic clothes enter the premises in pairs and open the remaining doors. To accelerate defumigation it is desirable to bring the temperature of the premises to +25°, having switched on ventilation devices.

The fumigated premises are kept secure from the moment of the beginning of the treatment with the gas right up until they have been completely aired out.

After the treating of living quarters the people are allowed to move back in only with the permission of a physician or some other highly qualified specialist, under whose leadership the disinfestation was conducted; the return of the tenants to the premises can be permitted only after the persons who conducted the disinfestation are convinced that it is safe to resume living there.

After using strong preparations (chloropicrin, hydrocyanic acid, phosgene) the opening of the premises is carried out in the presence of a responsible director of the operations at the calmest time with respect to traffic on the street (at night); the opening is carried out gradually, in sections, in order to prevent the propagation of the gas over large distances from the place of the operations.

The completeness of the defumigation of hydrocyanic acid is determined by a benzidine test. The completeness of the defumigation of methyl bromide is determined by an indicator burner. The giving over of the grain for processing or for seeds after fumigation with chloropicrin, dichloroethane or methylallyl chloride is determined by the absence of the odor of the preparation. Food grain can be used when the content of the chemical does not exceed the established sanitary norm. Grain fumigated with methyl bromide can be given over for food purposes after five days of passive defumigation.

The special conditions to be fulfilled when using individual fumigants is noted in their descriptions.

Gas chambers are hermetic premises, in which the treatment of bulky objects and even railroad passenger cars is conducted with gases: chloropicrin, black cyanide, ethylene oxide, methyl bromide, liquified sulfurous anhydride and sulfur. The chambers are intended for disinfestation. When using gases it is necessary to observe all measures of personal and public safety. The work is conducted in gas masks and appropriate special clothing. The articles are loaded into a chamber pre-heated to 20-30° after which the gas is introduced into it. Chloropicrin is poured in a thin layer into water or sand baths or burlap moistened in chloropicrin is hung up. The doors of the chamber are closed tightly. The gas dosage is 100 g per m^3 with an exposure of 1 h.

When black cyanide is used it is scattered on oilcloth spread on the floor of the chamber at a rate of 25 g per m^3; the exposure is 4 h.

Ethylene oxide due to its explosiveness is used in a mixture with carbon dioxide. This gas bears the name cartox. It is used to combat grain pests, being supplied into elevator storehouses from containers. Cartox is also used for disinfection of various articles infested with vegetative forms of microorganisms.

Methyl bromide is used for disinfestation and disinfection in special chambers.

Precautionary measures. According to the existing rules, only persons over 18 years of age, physically healthy and specially prepared, and who are able to work continuously in a gas mask for not less than an hour are permitted to work with fumigants. These workers undergo periodical medical examinations, not less than one exam in each 6 month period.

Not permitted to work with hydrocyanic acid and other fumigants are persons, suffering from blood diseases and secondary anemia (hemoglobin content is less than 60%), diseases of the cardiovascular system and of the respiratory organs, organic diseases of the nervous system, epilepsy, expressed neurotic conditions, psychic diseases (including those in the remission stage). Also not allowed in this type of work are people with wounds, pregnant women and nursing mothers.

The main agent of personal protection for persons, engaged in fumigation operations is the gas mask, where the latter is allotted to each individual person. Each time before entering a poisoned atmosphere the airtightness of the gas mask is thoroughly checked. Moreover it is considered that HCN vapors are not absorbed well by activated carbon, therefore the gas mask is additionally supplied with a chemical absorber which retains hydrocyanic acid.

Before fumigating with methyl bromide or hydrocyanic acid the reliability of the gas masks are additionally checked in a fumigation chamber with chloropicrin.

Before fumigating large objects with methyl bromide or hydrocyanic acid a physician questions the participants about their health. Before beginning disinfestation work the director of the operations goes over the pertinent instructions.

It is recommended that a gas mask can not be worn continuously for more than 30 minutes, and that a 10-minute break outside the fumigated premises with the gas mask removed follow this. Besides the gas mask all workers of a fumigation group are provided with coveralls of closely woven fabric, rubber gloves, mittens, and rubber boots. Not less than 2 persons should enter at one time into premises being fumigated, so that in case of an emergency one can help the other. All members of the group should be familiar with the methods of administering first aid. In treating premises with highly toxic fumigants all the necessary elements should be anticipated for administering first aid in case of an accident. The injured person should first of all be carried out into the fresh air. Upon completion of fumigation with hydrocyanic acid the gas mask should be removed only after the clothing have been aired out. The quality of airing is determined with bezidine paper.

It is permissible to enter a storehouse that has been fumigated with chloropicrin, dichloroethane or methylallyl chloride only after the odor of the fumigant has been dispersed.

After gas disinfestation the workers should take a shower or wash with hot water, and also air out their work clothes. Each brigade should have a first aid medicine kit with a complement of drugs depending upon the poison being applied. Upon completion of the work the work clothes and footwear should be immediately removed, well aired out and stored in lockers outside the living quarters. The eating of food and smoking are permitted only after washing upon completion of the work.

Sulfuryl fluoride belongs to the slightly toxic fumigants; it is safe for people working 8 hours per day in premises containing 100 parts of insecticide per million parts of air, whereas the analogous level for hydrogen cyanide is 10 parts, and for methyl bromide – 20 parts per million.

Methyl Bromide

Methyl bromide (bromomethane) CH_3Br is a colorless liquid, but with the presence of impurities is a slightly yellowish color; its molecular weight is 94,95; the specific gravity is 1.73. Its boiling point is +4.5°; it is noninflammable. At room temperature it is a gas. Its vapor pressure at 25° is 1824 mm Hg. The saturation of vapors at 25° is 2869 mg/ℓ; at 40° – 4 atm and at 50° – 5 atm. The vapors of methyl bromide are 3.25 times heavier than air. The preparation possesses bactericidal, sporicidal and insecticidal properties.

The solubility of pure methyl bromide in water is about 0.1% by weight; it is slightly soluble in alcohol, ether, chloroform. It dissolves fats, resins, and rubber well. Gaseous methyl bromide does not react with metals, wood, paints, and varnishes. It is stored under pressure in steel containers holding 60-70 kg of liquid methyl bromide, and also in ampules with a volume of 20 mℓ (the weight of one such ampule is 34 g).

The nonvolatile residue of technical methyl bromide consists mainly of iron bromide, the presence of which determines its dark color. Technical methyl bromide has sometimes the unpleasant odor of mercaptan (of putrescent protein materials), which can be retained in the air of premises subjected to fumigation for several days after the complete removal of the vapors of the preparation, but this odor is not transmitted to fumigated grain, grain products, or the raw oils.

Methyl bromide at expenditure rates used for disinfection does not affect the food and commercial qualities of grain, the output or the raw oils.

The vapors of methyl bromide possess good penetrating ability, thanks to which they readily and rapidly spread throughout bulk grain and other goods being fumigated. As compared to other fumigants it is to a minor degree absorbed by fumigated products and materials and is rapidly defumigated.

Methyl bromide is a highly effective fumigant for combating pests of grain stores. In toxicity it is not inferior to chloropicrin, and with respect to certain species of pests it is even more effective. Methyl bromide is toxic to all stages of development of insects and mites, both in the apparent, and also in the concealed forms of infection (S. A. Berendyayev and others).

A mixture of methyl bromide and ethylene dibromide is highly effective in combating insects.

Methyl bromide is used to fumigate food products in storehouses. It is only slightly adsorbed by the walls of premises and thus penetrates well into deep fissures. Methyl bromide does not have an odor (thus, a 2% chloropicrin solution is added to it as a warning agent); it is almost insoluble in water. Methyl bromide is toxic to all the developmental stages of the grain weevil and is effective against very many harmful insects and fungi; it is not a fire hazard; in fumigating dried fruits it does not form toxic compounds with sugar, which occurs with hydrocyanic acid.

When used to fumigate cheese, oil, etc., it does not change flavor qualitites of these products; it does not affect the germinability of seeds. Methyl bromide is used to exterminate pests in lumber (boards with a thickness of 100 mm are successfully treated at atmospheric pressure in the course of 24 hours).

Methyl bromide is used in its gaseous state for the disinfestation and disinfection of garments, bed appurtenances, and articles of rubber, velvet, silk, and synthetic material (caprone, nylon), and also fabrics colored with various unstable dyes and damaged by the thermal method of treatment.

Methyl bromide is used for disinfestation not only of software but also of furniture. Bugs die in the chambers in the presence of 9 mg/ℓ. It can be used for the disinfestation of software in two-layered polyethylene bags with dimensions of 140 × 70 cm (i.e., with a volume of 0.1 m^3) Because of the considerable toxicity of methyl bromide the disinfestation in polyethylene bags is conducted outdoors.

Fumigation with methyl bromide is permissible when the average temperature of the air in the premises where the infested cargoes are located is not lower than 10° and the temperature of the external air is not lower than 10°.

For the disinfestation and disinfection of articles in the cold season it is necessary to use separate heated premises located at a distance of not less than 25 m from living quarters. When utilizing heated premises separated by a partition, in one half the loading of the bags is carried out, and in the other – their unloading.

Before loading the bags they are checked for holes and other flaws and in the case of breaks patches are applied to the covering with an iron. The seams of the bags are also hermetically sealed with a hot iron and in an extreme case with a heated metallic plate with dimensions of 15 × 4 cm and a thickness of 0.5 cm. For this the edges of the polyethylene covering are placed on a wooden block and closed from above and from below with a sheet of parchment or cellophane in order to avoid the covering adhering to the iron. The seam is made double, first by folding the polyethylene cover over 1 cm and pressing with an iron, but then by folding it over again by 1 cm and ironing again. A robe and gloves are worn when loading the articles.

According to A. A. Subbotin and A. G. Prishchep, with an identical molecular ratio of methyl bromide and ethylene oxide the action of the methyl bromide on the insects (lice, bugs) is more expressed than that of the ethylene oxide. Disinfestation of fur articles in a chamber in bulk is provided by a concentration of methyl bromide in the form of a 10% gas in a volume of 1 m^3, an exposure of 1 h and a temperature of from +18 to +20°, and of 13% ethylene oxide. The disinfestation of fur articles in polyethylene bags in bulk is provided by an expenditure of 680 g of methyl bromide per m^3, an exposure of 1 1/2 hours and a temperature of from +10 to +20°. The disinfestation of wool and cotton articles in polyethylene bags is provided by an expenditure of 340 g of methyl bromide per m^3 and a temperature of from +14 to +15°, with an exposure of 1 h.

The methyl bromide is introduced into the bag by one of two ways: by crushing the ampules or by introducing it from the cylinder. When the ampules are used to facilitate crushing they are placed on a metallic or wooden slab with dimensions of 20 × 4 cm with a thickness of 0.5 cm.

Upon completion of the exposure, if the work were carried out within premises a disinfector (in a gas mask) airs out the premises, by opening the windows and doors. The airing lasts 15 minutes, after which the disinfector (in a gas mask) unties the bags and departs from the premises. A repeated airing lasts 15 minutes, after which the articles are unloaded from the bags and aired for not less than 2-3 hours; only after this can the articles be used.

A dosage of 85 g of preparation per m^3 with an exposure of 3 h under conditions of hermetically sealed premises ensures complete destruction of the insects and their eggs (lice, bugs, common cockroaches).

The fumigation of batches of grain and raw oil products is prohibited in the presence of initial spontaneous combustion effects. Before fumigating the firmly packed bulk material is loosened from above; the foci of initial spontaneous combustion effects are cooled to the temperature of the basic mass of the goods.

According to the rules worked out by the Sanitary-Hygienic Laboratory of Water Transport, for the disinfestation of grain in holds 50-70 g/m^3 is required (Table 20).

Table 20. The amount of methyl bromide in grams per cubic meter required for the disinfestation of grain.

Depth of loading of the hold	Grain and grain products in bulk		Raw oil material in bulk		Packaged grain products and raw oil material	
	rate of expenditure g/m^3	exposure in h	rate of expenditure g/m^3	exposure in h	rate of expenditure g/m^3	exposure in h
Up to 7 m......	50-55	24	60-65	36	50-55	24
Above 7 m......	60-70	48	80-85	48	60-65	24-36

For disinfestation of cargoes, and also for fumigating firmly compressed and highly infested peanuts and grain packed in bulk, the dosage of methyl bromide is increased by 20% and the exposure by 20 h.

Methyl bromide is introduced into premises, also including the holds of ships, in liquid form through spraying jets from cylinders, in which it is under a pressure of 5-6 atm. The cylinders are placed outside the premises being fumigated and the methyl bromide is supplied through hoses connected to the lateral male fittings of the cylinders by adapter couplings with sleeve nuts. The free ends of the hoses are introduced into the premises being fumigated. The cylinders, from which the methyl bromide must be fed at several points in parts, are mounted on scales in order to provide an exact weighing of the necessary quantities of the fumigant.

Within 20-30 min of the completion of the feeding of methyl bromide into the premises being fumigated an indicator burner is used to thoroughly check, whether there is gas leakage into adjacent premises. In the process of fumigational exposure a worker selected from the fumigational detachment conducts a systematic observation to detect methyl bromide leakage. Upon detecting of gas leakage sites they are hermetically sealed.

In fumigating under conditions of reduced external temperatures (lower than 10°) the cylinders to be used are first well heated in the heat of the premises and when they are set up in the cold locations they are heated with hot water. For this the cylinders are placed in barrels, which are filled with hot water in proportion to the opening of the valves of the cylinders; the hot water should be prepared beforehand. Open flame sources must not be used to heat the cylinders – blow torches, jets, and so forth, and also when the hot water is poured into the barrels with the cylinders the valves of the cylinders should be closed.

During the fumigation period chemical control of the concentration of methyl bromide is carried out in the holds. Air samples are taken and they are analyzed by the appropriate methods worked out by the All-Union Grain Scientific-Research Institute.

In the case when the average actual concentrations appear to be lower than those indicated in the table, the fumigational exposure should be extended or when possible additional quantities of methyl bromide should be introduced into the holds (Table 21).

Table 21. Lethal quantities of methyl bromide and the exposures for certain species of grain pests.

Species of insect	Temperature 8-14°			Temperature 15-20°			Temperature higher than 20°		
	lethal concentrations (g/m³) with the exposure in h			lethal concentrations (g/m³) with the expoare in h			lethal concentrations (g/m³) with the exposure in h		
	24	36	48	24	36	48	24	36	48
Rice grainary weevil.......	4,5	3	2,5	4	2,5	2	3,5	2	2
Saw-toothed grain beetle...	4	3	2,5	3,5	2,5	2	3	2	2
Rust-red flour beetle......	5	3,5	3	4,5	3	2	4	2,5	2
Mediterranean flour moth (larvae)..................	3	2,5	2	2,5	2	2	2	2	2
Elongated mite.............	4,5	3	2,5	4	2,5	2	3,5	2	2
Khapa beetle...............	—	—	—	8	5,5	4	8	5,5	4

Due to the fact that methyl bromide is heavier than air it descends downward during fumigation. Uniformity of concentration of this preparation is achieved with the use of fans; they should also be used to air out the premises after fumigation.

It is very advantageous to use methyl bromide together with ethylene oxide. Thus, when methyl bromide is used alone 3 1/2 times more preparation is required than when it is used in a mixture with ethylene oxide (1:1).

Methyl bromide at concentrations of 3.4-3.9 g/ℓ of air with an 18-hour exposure at room temperature can be used for disinfestation of bails of hair and bristles in the presence of high humidity.

Bromide methyl is one of the most potent nerve poisons; it is dangerous to man and animals, and because it lacks an odor special precautions are necessary when working with it. The maximum safe concentration of methyl bromide with prolonged exposure is 0.0017% by volume.

Work with this preparation should be carried out in an oxygen gas mask, coveralls, or a special apron and rubber gloves. Only persons who are well informed and completely healthy should be allowed to work with it.

The permissible concentration in the air of industrial premises is 0.003 mg/ℓ.

In case of accidents the symptoms of poisoning appear only after several hours or after several days. It is characteristic that even in acute poisoning the symptoms of intoxication after intervals of from several hours to 2-3 days. The pattern of poisoning develops very slowly (weeks and months) and recovery goes even more slowly. Methods for detecting of methyl bromide in the air have been well worked out (Dumas).

Hexachloroethane

Hexachloroethane (Cl_3CCCl_3) is a white crystalline (rhombic crystals) powder, insoluble in water, with a unique odor reminiscent of the odor of camphor. Its molecular weight is 236,76. Its melting point is 185°; it sublimates even at room temperature.

It is an effective larvicide in combating flies. Like napthalene, it is sometimes used to treat fur articles against moles. It possesses weak bactericidal properties, it is harmless to man and domestic animals. It is used as an anthelmintic agent for animals. Doses of 0.16-0.2 g per 1 kg of weight of the afflicted animal when orally administered are endured without any side effects.

DDVP

Demethyl dichlorovinyl phosphate (DDVP) has recently attracted special attention. Vapors of DDVP are obtained basically by atomization or evaporation (see p. 391).

Dichloroethane

Dichloroethane [ethylene dichloride] is $C_2H_4Cl_2$. This is a colorless liquid with an odor reminiscent of chloroform and a burning-sweetish taste. Its boiling point is 83.4°; it freezes at -35.3°; it melts at 36°. Its specific gravity is 1.2569. Its vapor pressure at 25° is 79.6 mm Hg. The vapors of dichloroethane are 3 1/2 times heavier than air. Concentrations of 300-350 g/m^3 are fatal to fly, lice, ant, bug, and cockroach larvae with an exposure of 48 h at room temperature. Dichloroethane vapors are toxic to Norway rats and mice at an amount 100 g/m^3 with an exposure of 2 h, but they are not suitable for disinfectional purposes; Bacillus (Esherichia) coli and Staphylococcus do not die after 72 hours from 300 g/m^3 at 37°. Aqueous solutions and soap emulsions of dichloroethane possess insecticidal and some bactericidal properties. The preparation does not corrode metals at normal temperatures and is not much of a fire hazard.

Dichloroethane is a product, located on the brink between inflammable and noninflammable organic liquids; it is ignited by fire with difficulty and it burns with a smoking flame. Spontaneous combustion of dichloroethane is possible in air at a temperature of 448-449°. The lowest limit of possible combustion and explosion of dichloroethane vapors in a mixture with air at a temperature of 20° corresponds to a rate of expenditure of 180 g of liquid dichloroethane per 1 m^3 of space. Sources of combustion and explosion of dichloroethane in a mixture with air in a closed space can be a lit match, a smoldering cigarette, a spark obtained by striking a metal object or a stone, short-circuiting of electrical wires, the presence of smoldering coals in a stove, the presence of products within a space in a state of spontaneous combustion and other sources of fire.

Dichloroethane decomposes in light giving off hydrochloric acid. It is used to fumigate food and seed grain, groats, grits, flour, barges, packing, pallets, and for deratization. The use of dichloroethane is prohibited for disinfecting oil-producing cultures corn, corn flour, and grits, soy beans, and soy flour, pharmaceutical raw materials, laurel leaf, cinnamon, cloves, and other spices, dry vegetables, dried meat, fish, cheese, and other products, and also for disinfestating elevators, grinding mills, hulling mills, steamers, grain dryers, and harbour structures.

The moisture of grain disinfected with dichloroethane should not exceed 16% and products made from it – 15%. When grain has become warm it should be cooled before fumigation. When fumigating grain stored in granaries, empty storehouses, and also barges the expenditure of dichloroethane should be 200-300 g per m^3.

In fumigational treatment for deratization of cellars of storehouses, in which there is not grain dichloroethane is introduced into the cellar through holes in the floor boards; when loading storehouses with grain or grain products dichloroethane is introduced into the cellar by bags moistened in this poison; these bags are fastened to posts, through vents, which after this are closed tight. In both cases dichloroethane is introduced at a rate of 100 g/m^2 of floor area.

The premises being treated should be at a distance from the nearest habitable and public buildings of not less than 50 m. Treating with dichloroethane vapors is not permitted under the following conditions: when the temperature of the external air is lower than 10°, in windy or rainy weather or when it is impossible to hermetically seal the premises; furthermore, simultaneous treatment is not permitted of two or more buildings, located at a distance of less than 200 m from each other.

In premises being subjected to treatment, the temperature should not be lower than room (15-18°) temperature.

The evaporation of dichloroethane is achieved by one of the following methods: by treating burlap or other fabrics with it subsequently hanging them in the premises; by atomization of the preparation with a hand sprayer, automatic sprayer, etc.

Dichloroethane is toxic to man, therefore the treating of premises with it is carried out using gas masks. When working with it, it is necessary to protect all parts of body from the drops.

Dichloroethane causes acute and chronic poisoning; it is most dangerous when it gets into the organism through the gastrointestinal tract. Cases of poisoning are known with a fatal outcome caused by taking internally 20-50 mℓ of dichloroethane.

Dichloroethane is good solvent for fats, wax, various alkaloids, and certain insecticides.

Methylallyl Chloride

Methylallyl chloride (methallyl chloride) is C_4H_7Cl; it is a transparent, slightly volatile liquid with a specific odor; its boiling point is 72°; its freezing point is -80°; the specific weight of the liquid is 0.928 and the molecular weight 90,5; it dissolves poorly in water (0. [Translator's Note: Russian quantity illegible] by weight). Vaporous methylallyl chloride is approximately three times heavier than air. Its vapor pressure 0° is 4 mm Hg, at 20° – 110 mm Hg. According to source material, a mixture of methyllayl chloride vapors with air, containing less than 105 g of methylallyl chloride per m^3 is noninflammable.

With the presence of more than 105 g per m^3 of air the mixture ignites explosively.

The preparation is highly toxic to pests of grain stores. To weevils in the preimaginal stages of development (for all stages of development inside grain) it is more toxic than to beetles coming out of the grain; it does not reduce the germinability either of dry, or moist (up to 20%) seeds – of naked, filmy cultures and corn; it does not impair the biochemical properties and the baking qualities of the grain; it does not corrode metals; it does not decompose rubber.

According to the All-Union Grain Scientific Research Institute, fumigation of grain with methylallyl chloride in storehouses not equipped with active ventilation results in the following.

When the height of the bulk grain is higher than 1.5 m the fumigant is supplied into the grain through gas-distributing pipes, which are introduced in the same manner, as in fumigation with chloropicrin.

Bulk grain with a height of 1.5 m, and also piles of grain in bags are fumigated along with space devoid of grain through holes in the doors or windows of the storehouse; the fumigant is also supplied in disinfestating the supra-grain space and of premises devoid of grain through holes in the doors or windows of the storehouses the fumigant is also supplied in disinfestating the supra-grain space, and of premises devoid of grain.

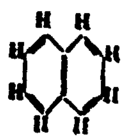
It is possible to fumigate the grain of gramineous cultures destined for seed or food purposes with a humidity of not more than 16% when the temperature of the grain and the air is not lower than 12°.

The fumigant is fed into high piles of bulk grain through a ventilation system. In disinfestating low piles of bulk grain, stockpiles of grain and premises devoid of grain, the apparatus operates according to a fumigation regime.

The dosages of the preparation are: in fumigating bulk grain higher than 1.5 m – 100 g per m^3 of grain; in fumigating low piles of bulk grain and stacked bags of grain – 50-60 g per m^3 of volume, occupied by consignments of grain and premises devoid of grain; into the supra-grain space there is supplied 30 g/m^3 with complete loading of the storehouse and 40 g/m^3 with incomplete loading. The preparation is less toxic to warm-blooded animals than chloropicrin.

Napthalene

Napthalene is $C_{10}H_8$.



Its molecular weight is 128,6. It is a powder of crystalline form; the form of the crystals is extermely various - plate-like, spherical, in the form of granules and so forth. Its melting point is 81°; its boiling point is 217.9°. The specific gravity at 20° is 1.162. Its index of refraction is 1.582. The vapor pressure is 4.92×10^{-2} mm Hg at 20°. It is virtually insoluble in water (about 30 mg/ℓ at 20°); it is soluble in alcohol (1 g per 13 m), and also in benzene, toluene, (1 g per 8 mℓ) chloroform, carbon tetrachloride (1 g per 1.2 mℓ); it is very soluble in ether.

When ignited it burns with a luminescent and smoking flame; its flash point is 79°. It possesses a unique odor and a burning taste.

Napthalene is obtained from coal tar from the middle oil fraction; the tar is driven off at 170-240°. Napthalene is isolated by crystallization, after which it is removed from the liquid impurities, then it is purified with sulfuric acid and by steam distillation.

Of 100 meal worm eggs placed in an atmosphere saturated with napthalene vapors 8 larvae hatch out. With respect to the eggs of the confused flour beetle napthalene is approximately 10-14 times more toxic than para-dichlorobenzene. Napthalene, a weak insecticide, possesses repellant properties.

It is introduced into certain mixtures prepared for the extermination of insects; more frequently it is used as an agent against moths in museums, and also to protect fur and wool articles from damage by the hide beetle, the white-marked spider beetle and other insects. The use of napthalene after articles have already been contaminated by the eggs of pests is in many cases ineffective.

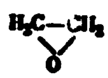
Napthalene possesses antiseptic properties, which cannot be widely used due to the insolubility of the preparation in water. Its antiseptic properties appear in the vaporous state - air containing napthalene vapors formed by its volatilization, inhibit the development of mold fungi and decay bacteria. Napthalene can be absorbed by the skin of man, subcutaneous tissue, the gastrointestinal tract, and also by the lungs when its vapors are inhaled (G. S. Nazarov).

A significant amount of napthalene vapors in the air can cause headache, nausea, and vomiting in man. In man symptoms of poisoning with napthalene are the result of lesion mainly of the gastrointestinal tract, the kindeys and the urinary tract. Furthermore, in animals and man eye lesions are observed.

Cats are very sensitive to napthalene; they die after it is administered at a rate of 1-5 g/kg. Dogs after the administration of 3-5 g per kg exhibit only diarrhea. For therapeutic purposes (as a vermifuge) napthalene is prescribed internally at dosages of 0.1-0.5 g several times per day.

Ethylene Oxide

Ethylene oxide is C_2H_4O.



Its molecular weight is 44,05. At normal temperatures it is a colorless gas. At temperatures lower than 12° it is a volatile liquid. Its melting point is 111.3°; its boiling point is 10.7°. Its density is 0.88; this gas is 1 1/2 times heavier than air. Its specific gravity is 1.3597. The vapor pressure is 760 mm Hg at 10.7° and 1095 mm Hg at 20°. At 25° its vapors saturate air in an amount of 1800 mg/ℓ. It burns and explodes from a spark with the presence in air from 3 to 80% ethylene oxide. It is miscible with water in any amounts; it is miscible with alcohol and with the majority of other organic solvents. It is a good solvent for fats, oils, lubricating substances, wax, and, also, rubber. It is relatively noncorrosive to metals and it does not damage materials (with the exception of rubber). It is a highly reactive compound; it is relatively stable in aqueous solutions. It possesses a pleasant odor.

Ethylene oxide is obtained by the decomposition of ethylene chlorohydrine or by the direct oxidation of ethylene by the oxygen of the air with the help of a silver catalyst. In the latter case there are formed as by-products carbon dioxide and water (50%). The vapors of the preparation are highly toxic. Containers with ethylene oxide are kept tightly closed.

Ethylene oxide as a fumigant possesses high insecticidal, ovicidal, bactericidal, virulicidal properties. It does not damage paper, bank notes, documents, fabrics, polished and painted furniture and metals. It possesses significant diffusibility, penetrating through 32 layers of fabric. Because ethylene oxide burns and is explosive, it is used in a mixture with 80-90% carbon dioxide and 10-20% by weight of ethylene oxide. When ethylene oxide is used to disinfestate in a tightly closed space all insects are killed by a dosage of 90 g/m^3. The mixture ethylene oxide with carbon dioxide (1:9) is known as carboxide and the mixture ethylene oxide with freon as freoxide.

With an identical molecular proportion of methyl and ethylene oxide the effect of methyl bromide on insects (lice, bugs) is more expressed than the effect of ethylene oxide. When a mixture of both preparations are used their bactericidal properties are increased. A mixture ethylene oxide and methyl bromide is more economical than the use of only methyl bromide. Thus, when methyl bromide is used alone approximately 3 1/2 times more of it is required than when it is used in a mixture with ethylene oxide.

The vapors ethylene oxide penetrate well into dry materials being disinfestated and they readily volatilize from them upon airing.

Abroad it is used to exterminate pests of various stores in premises (vacuum and vacuumless chambers), in siloes, etc. Seed and planting material cannot be fumigated with ethylene oxide. Bed bugs die with the use of 20 mg/ℓ of ethylene oxide, an exposure of 5 h, at a temperature of 25° and at an atmospheric pressure of 760 mm Hg.

Ethylene oxide is toxic to man and animals. The toxic effect of the vapors is proportional to the concentration and the time of the effect.

The high volatility of ethylene oxide promotes the rapid liberation of the gas from treated objects. Relatively dry objects are treated in shorter periods of time than highly humid (60-90% humidity) ones.

When it is not possible to use the chamber method of treating, disinfestation and disinfection with ethylene oxide are conducted in polyethlene bags. Such treatments are conducted only in the open air under a canopy, isolating sites for the infestated and disinfestated articles. The canopy should be at a distance of 25 m from habitable and working premises. Before loading the bags are checked for holes and flaws; they are not loaded to more than 2/3 of their capacity. Bags with a two-layered polyethylene film with a thickness of from 0.035 to 0.2 mm (high pressure film) are used.

Bags of various capacity are manufactured (the method of splicing them together is described in the section "Methyl Bromide"). For loading 90-95 kg of things a polyethylene film with dimensions of 2.5 × 2 m is used; for a small number of things (15-18 kg) a bag with the dimensions 140 × 70 cm is manufactured with a capacity of 0.1 m^3. A polyethylene film bag with careful handling and storage can be used up to 15-20 times.

In loading a bag the pockets of clothes are turned inside out and inflammable objects (matches, cigarette lighters, combs, spectacles, and so forth) are removed; things having come in contact with chloride-containing preparations or other strong oxidizers and their solutions are decontaminated after 24 hours of airing.

Ethylene oxide in its gaseous state is introduced into a bag from a cylinder by a dosing apparatus, the hose of which is passed through a hole left in the bag. Before the gas is introduced through the indicated hole the greatest possible amount of air is pressed out, in order to obtain as much space as possible for the gas.

The evaporation of ethylene oxide involves the absorption of a large amount of heat. At temperatures below +10.73° the formation of gas is virtually impossible, therefore to accelerate its formation and to ensure that it will be obtained in the bag, the cylinder with the ethylene oxide is heated with hot water. This is accomplished by submerging the cylinder in a vat of water with a temperature of 70-80°; bubbler is placed in the vat; steam is supplied to the bubbler from a boiler room (from a boiler); the temperature is maintained at the indicated level during the whole period of the fumigation process by regulating the amount of steam going into the bubbler. The vapor pressure in the cylinder is controlled by the manometer of the dosing apparatus mounted on the cylinder; the pressure in it should not exceed 11 atm. It is also possible to heat the ethylene oxide by another method – at temperatures lower than 0° the necessary amount of liquid ethylene oxide is poured into a flask, into the throat of which is inserted a rubber plug with a glass pipe; the flask is placed in a pan of hot water with a temperature of 70-80°, the flask is connected with the polyethylene bag containing the articles by a rubber tube.

During the fumigation process the workers don gas masks, robes, rubber gloves, and boots. Opening of the bags is also conducted in gas masks with type A filter cannisters; their airtightness is checked first. The things are thoroughly aired in open air.

Ethylene oxide vapors are toxic to man and animals. The maximum permissible concentration in working premises is 0.001 mg/ℓ. The short-term stay of a person in an atmosphere containing vapors of the preparation higher than the permissible concentration (0.05-0.1 mg/ℓ), causes dizziness, vomiting, and disturbance of cardiac activity. Poisoning by inhalation is characterized by two stages: the first is purely narcotic with a moderate local irritation effect and the second arising after several weeks is characterized by a toxic effect on the tissues. Prolonged inhalation of air containing small amounts of ethylene oxide is more dangerous than brief inhalations of large concentrations of this substance. The prolonged action on human skin of liquid and gaseous ethylene oxide causes chemical burns with the appearance of blisters. Especially sensitive are the moist sections of the skin (between the fingers and the toes, the armpit region, and others).

In man in the case of stay of 10 minutes in an atmosphere containing ethylene oxide vapors there appear vomiting, a sweet taste in the mouth, dizziness, disturbance of cardiac activity, which can last for several weeks. In acting on the human eyes liquid ethylene oxide causes edema of the corneas. After 1 minute of contact with ethylene oxide there appear within 1-5 hours redness edema small bubbles, which vanish after 6-12 hours. In severe cases these bubbles turn into large blisters.

Para-Dichlorobenzene

Para-dichlorobenzene is $C_6H_4Cl_2$.

Its molecular weight is 147,01. Its crystals have a white, pink, or brown color. It possesses a specific odor. Its melting point is 53°; the boiling point is 174°; its flash point is 67°.

When introduced into a flame it first melts, and then burns with a yellow flame with noticeable green tongues. The vapor density is 6.11 g/ℓ at 20°; the vapor density with respect to air is 5.09. Its vapor pressure at 20° is 0.64 mm, at 25° – 1 mm and at 49° – 5.23 mm Hg. The volatility of the vapors at this same temperature is 38.3 mg/ℓ. It is almost insoluble in water (79 mg/ℓ at 25°); it dissolves well in dichloroethane, benzene, ether, chloroform, carbon tetrachloride, and kerosene. In hot water at temperatures higher than 53° it melts and forms a transparent fusion on the bottom of the vessel.

Para-dichlorobenzene possesses considerable insecticidal properties. Its vapors kill certain insects living in the soil; house fly larvae die within the limits of 50% when the content in 1 kg substratum is 4 g of the preparation. Para-dichlorobenzene is used to combat the clothes moth by treating software in a chamber or in premises at a rate of 100-120 g per 1 m^3. To protect clothes from moths it is recommended that they be placed in polyethylene bags; para-dichlorobenzene crystals at a rate of 300-400 g per m^3 (volume of a bag) are placed in gauge socks above the articles. It is not recommended that they be placed in the bottom of a bag, because they can soften it. The clothes are arranged loosely in the bag to ease the penetration of the vapors of the preparation. When exterminating the common clothes moth the bag is left closed at least for a week, and when exterminating the white-tip clothes moth for not less than 10 days.

Its acute toxicity to warm-blooded animals is not great. When 2562 mg/kg are administered intraperitoneally to rats 50% of the animals die. When 2950 mg/kg are orally administered to rats a mortality rate of 50% is also attained. In a man after taking 20 g (300 mg/kg) no poisoning symptoms were observed at all. After the administration of higher doses symptoms of intoxication were noted.

Pine Oil

Pine oil is a colorless liquid with a pleasant odor of pine needles, obtained by the steam distillation of fresh branches of pine trees; it is volatile even at room temperature. Its specific gravity is 0.952 at a temperature of 15°. Pine oil is used for the disinfestation of clothes, linen, bed appurtenances and for combating head lice. For the disinfestation of linen and bed appurtenances it is used in its pure form and in the form of a paste. Treated articles retain it for various periods of time depending on the ambient temperature and the amount of oil used — at 3-10° and oil with an expenditure of 20 g/kg it is retained for 24 hours; at 10-25° and with an expenditure of 10 g/kg — 24 hours; 26° and higher and with an expenditure of 15 g/kg — 16 h; at the same temperature, but with expenditure of 40 g/kg the articles retain the oil for 5 h.

As was pointed out above, pine oil is also used to combat head lice. In treating lousy linen a paste is used, consisting of 9 parts of pine oil and 1 part household soap. From the paste 2-5% aqueous emulsions are prepared. Linen is left to soak in the 2% emulsion for 20 hours, and in the 5% solution for 2 h. After being treated the linen is laundered in the usual manner.

The vapors of pine oil possess insecticidal properties with respect to flies, lice, and barn pests. They can be used to combat flies by evaporating the pine oil at a rate of 250-300 mg per 1 m^3 of space and with an exposure of 1 1/2-2 h.

Pine oil upon the evaporation of 107 mg/m^3 possesses bactericidal properties with respect to microorganisms dispersed in the air (Staphylococcus albus), and with the evaporation of 12-24 g/m^3 it is bactericidal with respect to microbes found on fabrics (Escherichea coli bacterium and Staphylococcus).

Benzene Polychlorides

Benzene polychlorides are by-products of aniline-dye production; sometimes they are called distillation residues. Benzene polychlorides consist of 9.33% benzene, 34.8% chlorobenzene and 36.56% para-dichlorobenzene. The polychlorides are oily liquids with a dark color and benzene odor; they are used to exterminate the preimaginal stages of mosquito development. Because of their toxicity to animals and man they are not used to treat living or working premises.

Chloropicrin

Chloropicrin is CCl_3NO_2. Synonyms: trichloronitromethane, nitrochloroform. In its pure form it is a colorless, slightly mobile, oily liquid with sharp, pungent odor, boiling at a temperature of 112-113°. Its specific gravity is 1.66 at 15°.

Usually chloropicrin has a yellow color due to impurities. It evaporates well at normal temperatures, forming irritating vapors with a characteristic odor. The volatility of chloropicrin at 0° is 57.5 mg/ℓ at 10° - 104 mg/ℓ, at 15° - 126 mg/ℓ, at 20° - 176 mg/ℓ; when the temperature is increased evaporation is significantly increased. Chloropicrin vapors are 5.7 times heavier than air and they therefore concentrate down in depressions, pits, cellars, and other such locations (Berck). Chloropicrin is almost insoluble in water; it dissolves well in ether, alcohol, etc. One volume of ether dissolves about 0.3 of a volume of chloropicrin. At ordinary conditions chloropicrin is not inflammable and does not react with metals; it softens rubber, but it does not impair the strength of fabric.

Chloropicrin possesses considerable ability to penetrate into porous object and to be adsorbed by fabrics (from 0.4 to 1.7% by weight of fabric). The amount of adsorbed chloropicrin depends on the type of fabric. Chloropicrin vapors penetrate only slightly into the depth of bulk grain; they are adsorbed by it and are difficult to air out of it.

It possesses certain antiseptic properties: 20-30 mg per ℓ inhibit, and 50-60 mg stop milk fermentation. Chloropicrin in an amount of 12.8 mg/m^3 disinfects strips of paper, on which typhoid, paratyphoid, and plague bacilli have been deposited. It is necessary to note that in a guinea pig corpse which died from chloropicrin and which was infected with plague, the bacilli of the latter remained viable. To destroy staphylococcus high concentrations of chloropicrin vapors and prolonged exposures (20 h) are necessary. Increasing the temperature to 38° increases the bactericidal properties of chloropicrin by almost 2 times.

Chloropicrin possesses high insecticidal properties. Cockroaches die from somewhat higher concentrations than bugs.

The eggs of bugs die earlier than the larvae and the adult bugs. With an insufficient quantity of chloropicrin (4-5 g/m^3)

lesions in bugs of the piercing and sucking apparatuses are possible which lead to the death of the insects (Ya. L. Okunevskiy). Chloropicrin possesses sufficient toxicity with respect to insects: it penetrates deeply into fabric, and thus can be used in disinfecting foci of exanthematic, recurrent typhus and plague. It is used to treat premises intended for the storage of agricultural products and premises in which products are prepared (factory-kitchens, bakeries, dining rooms, grinding mill, grit and groat plants, elevators, cellars of various storehouses, and so forth). It is used to treat museum treasures infested with pests, packing, grain bags, things subject to prolonged storage in pawnshops and storehouses, isolated habitable premises, barracks, caserns, huts, mud-huts infested with fleas, cockroaches and other insects. Chloropicrin is used for the disinfestation of food grain intended for prolonged storage, for the disinfection of seed consignments, peas, beans. The humidity of grain fumigated with chloropicrin and with a mixture of dichloroethane with chloropicrin should not be greater than 15%.

Chloropicrin is not only used for disinfestation, but also for deratization. The fumigation of premises should be conducted at a temperature of not lower than 18°. The disinfestational effect is intensified by increasing the temperature of the premises being treated. Operations with chloropicrin are conducted in the warm season at a temperature not lower than 12°, and the carrying out of such operations is prohibited in damp, rainy weather because of the difficulty of defumigating premises under these conditions. The amount of chloropicrin necessary to treat premises is determined by proceeding from the fact that for the creation of concentrations of gas of 0.1% per m^3 it is necessary to evaporate 4.5 mℓ (7.47 g). Usually in disinfestational and deratizational practice a concentration of 0.6% chloropicrin – 37 mℓ (45 g) per m^3 is used. The exposure is 20-48-72 h. As a result of the application of a concentration of 1-2 mℓ per m^3 rats die after 25 hours. The higher the concentration, the faster death ensues; thus, with 20 mℓ/m^3 the rats die within 13 minutes, and with 30 mℓ/m^3 – within 10 minutes (Ya. L. Okunevskiy). A reliable insecticidal effect can be obtained with an expenditure of 30-35 g (20-25 mℓ) of chloropicrin per m^3 of space. In treating premises which are not very airtight, the preparation dose is increased to 50 mℓ per m^3.

The technology of working with chloropicrin is very simple: sacking is soaked in chloropicrin and hung on ropes in the premises to be fumigated. When using the sacking it is necessary to see that the chloropicrin does not fall into the cellar or even on the floor.

When gas treating cellars of storehouses, in which there is no grain, the chloropicrin is introduced through openings of the floor boards. In storehouses loaded with grain or turfy products chloropicrin is introduced into the cellars with bags soaked in this poison and fastened to posts, through vents, which after this are closed tightly. In both cases chloropicrin is introduced into the cellars at a rate of 5 g per m^3 [sic] of floor or cellar area.

Besides the described methods, chloropicrin is evaporated from heated surfaces located on a water or sand bath. As also with the use of sulfur dioxide, the disinfestational effect depends on the rate of saturation of the air of the premises with chloropicrin. For the fastest evaporation from the heated surfaces the thickness of the preparation layer should not exceed 0.5-0.6 cm, and the temperature of the surface being evaporated should be about 90°, since chloropicrin even at the boiling point of water starts to be decomposed. It is possible, finally, to introduce chloropicrin in the premises with the use of apparatuses. Chloropicrin is also used in chamber disinfestation.

In connection with the danger presented by chloropicrinization of premises, the carrying out of such operations is permissible only in individual isolated buildings, and not in individual parts of them. The premises being treated should not be less than a distance of 100 m from living quarters. During the whole time of treatment the premises should be sealed and guarded by a full-time attendant. During fumigation the output of gas should be carried out in such manner, that it does not form a large gas wave. Not less than 24 h is required for defumigation. The fumigation is considered completed, if a subsequent stay in the closed premises of 1-2 h does not cause irritation of the eyes and lacrimation; in the opposite case the airing is continued for 1-2 more days.

When it gets into cellars and burrow, chloropicrin causes the death of rodents, and the traces of it remaining there for a prolonged period of time repel rodents. Fissures and apertures in a cellar after fumigation for deratization should be carefully sealed, so that chloropicrin residua cannot volatilize into the premises.

Chloropicrin finds application under field conditions in treating rodent burrows, where in the burrow it kills not only rodents, but also the fleas parasitizing them. The assault is carried out by wetting tampons in chloropicrin (3 g), packing them into burrows and subsequently trampling the hole.

The most characteristic property of chloropicrin is its irritating effect on the cornea of the eyes, which appears even with the presence of 100 mg/m^3 of air. Higher concentrations causes coughing, nausea, vomiting, and death. In its liquid form chloropicrin can affect the skin and cause ulcerations on it. Cats, dogs, and other animals are sensitive to the preparation; they die within 15 minutes in the presence of 1.8 g/m^3. For man a dose of 1.5 g of chloropicrin per m^3 acting for 15 minutes is fatal.

<u>A mixture of dichloroethane with chloropicrin</u>. To increase the effectiveness of the action of dichloroethane on grain pests and to decrease the dosage, it is used in a mixture with chloropicrin. For fumigating grain the mixture is prepared beforehand or dichloroethane and chloropicrin are introduced separately. When disinfecting premises it is expedient to first introduce dichloroethane, and then to add chloropicrin, hanging the bags soaked in it in places most infested with the pests (near walls, poles, etc.).

The mixture of dichloroethane with chloropicrin is used to disinfestate food grain and bean cultures, with the exception of soya, corn, flour, grits, and groats, scarious cultures (barley, oats, millet, and so forth), and also seed grain, except beans. This mixture is used to disinfestate empty granaries, cellars, packing, railroad car and warehouse pallets, and also to disinfestate grain elevators and grinding mills, grits and groat factories, towed and self-propelled barges of the marine and river fleet.

The moisture content of grain fumigated with a mixture of dichloroethane and chloropicrin should be not higher than 15%. In fumigating grain stored in storehouse the expenditure of the mixture (at a ratio of 12:1) is equal to 120-170 g per m^3 of grain; in fumigating empty storehouses and supra-grain spaces – 40-60 g per m^3 of space.

For the fumigation of grain a mechanized method is employed (using apparatus for active fumigation and defumigation), pipe-probes, and also the evaporation of fumigants from bags soaked in them. A mechanized method using special apparatuses is employed when fumigating with chloropicrin, dichloroethane and a mixture of chloropicrin with dichloroethane when the height of the bulk grain is from 1 to 4 m. Pipe-probes are used in fumigating grain with chloropicron when the height of the bulk grain is 0.75 m and with dichloroethane or its mixture with chloropicrin – higher than 1 m. The method of fumigating with sacks soaked in chloropicrin and dichloroethane is used in disinfecting bulk grain when the piles are not higher than 0.75 m.

The exposure when fumigating grain with dichloroethane, chloropicrin or their mixture is 7-8 days; the exposure when fumigating empty storehouses is 2-3 days.

Hydrocyanic Acid

Hydrocyanic acid, hydrogen cyanide (prussic acid, HCN), is a colorless liquid with a specific gravity of 0.696; it is almost

2 times lighter than water. Its boiling point is 25.6°; its melting point is 13.8°. The weight of 1 ℓ is 1.206 g. Its vapor pressure at 13° is 427 mm Hg. A liter of hydrocyanic acid forms 833 ℓ of gas at 0° and at a pressure of 760 mm Hg. Its vapors are lighter than air (1 ℓ of air weighs 1.230 g), and therefore it rises, however a mixture of hydrocyanic acid vapors and air is only insignificantly lighter than air. The HCN has a typical odor of bitter almonds. Hydrocyanic acid is miscible with water, ether, and alcohol.

For combating plant pests of agriculture hydrocyanic acid was proposed in Russia in 1906, and for combating insects and rodents - carriers of infectious diseases - in 1915 (V. A. Uglov, P. G. Oganesyants, and others).

For fumigating vessels for purposes of disinfestation hydrocyanic acid was first proposed in Germany in 1910, in the USSR - in 1929.

Hydrocyanic acid is sold in steel cylinders or sorbed in the form of tsiklon A and B. The salts of hydrocyanic acid also find application in practice.

Tsiklon-A is a liquid mixture of 90% methyl and ethyl esters of cyanocarbonic acid and 10% chlorocarbonic acid ester (stabilizer) and xylene bromide (warning component). It is a stable liquid with a specific gravity of 1.08. The toxicity of tsiklon is 2/3 the toxicity of hydrocyanic acid. The preparation is contained in special vessels and is under a pressure of 6-10 atm. Tsiklon-A is sprayed just like liquid hydrocyanic acid. This preparation is inconvenient in practice and was long ago replaced by tsiklon-B.

Tsiklon-B is infusorial earth saturated with hydrocyanic acid with a warning compound added. The hydrocyanic acid content in tsiklon-B is up to 35-40%. As warning components bromide and chloride compounds possessing a lacrimating effect are added to hydrocyanic acid. Tsiklon-B is packed in airtight metal cans.

As an absorber, besides infusorial earth, cardboard is also used. This preparation – tsiklon-diskoid – consists of cardboard disks with a diameter of about 92 mm and with a thickness of 3.5 mm impregnated with hydrocyanic acid with the addition 5% chloropicrin (as a warning component). Each disk contains 7.5 g of liquid hydrocyanic acid. In treating premises they are expended at a rate of one disk per m^3, from there will be formed about 6 ℓ of hydrogen cyanide, which is at 0.6% concentration. The disks are packed in metal cans with 70 disks in each can; thus, each can contains about 500 mℓ of hydrocyanic acid. For absorption of hydrocyanic acid just paper pulp is used, which like the disks, are also packed in metal cans; each of which contains about 1.2 ℓ of hydrocyanic acid.

Black cyanide is a solid converted into a powder with a grayish-brown color, having a slight odor of bitter almonds. The composition of black cyanide is cyanide salts with calcium chloride. Furthermore, the preparation also contains salts containing admixtures of calcium oxide, a small quantity of carbon, calcium carbide, cyanamide and others.

According to the technical specifications, black cyanide of the first and second type should contain upon conversion to sodium cyanide 42-47% cyanide, 2% calcium carbide, 0.4-0.7% sulfur, and 4% carbon.

Black cyanide occurs in three forms: a) flaky, b) powdery, and c) dust-like forms.

In combating the pests of grain stores powdery black cyanide is most frequently used; it yields hydrocyanic acid more rapidly and more completely. The size of each particle of the preparation intended for combating insects and rodents should be from 5 to 0.5 mm; not more than 2.5% of the product with a particle size of more than 5 mm and not more than 30% of the product with a particle size of less than 0.5 mm is permitted.

When using black cyanide for fumigation the relative atmospheric humidity should not be less than 70%. Black cyanide under the influence of the moisture and carbon dioxide of the air yields hydrocyanic acid; due to the action of water it, furthermore, yields acetylene. Black dyanide is used to disinfestate naval vessels, mills, grit and groat plants, and elevators.

Hydrocyanic acid possesses great penetrability for fabrics, food products, and porous materials (pillows, mattresses, cotton, wood, brick, concrete, plaster) (V. A. Uglov, P. G. Oganesyants). It is also possible to get an idea of the high penetrability of hydrocyanic acid by the effect, which its vapors have on insects placed under 32 layers of woolen blankets and between tightly joined mattresses (Ya. L. Okunevskiy).

Soft and hard articles readily absorb hydrocyanic acid. With a concentration in the air of 2.5% hydrocyanic acid and an exposure of 24 h its content in 100 g of substance depends upon the object (hard or soft articles) and can be from 2 mg (rubber) up to 126 mg (wet straw); wool flannel holds 74.4 mg, crepe de chine – 14 mg, linen fabric – 13.6 mg. The absorption depends on the air temperature: when the temperature is low the absorption of the gas by the articles is increased; when the temperature increases the degree of gas absorption drops.

The ability of hydrocyanic acid to penetrate into the depth of articles and through cracks and fissures ensures positive results in fumigation, but it also creates at the same time difficulties in making premises airtight.

Because of the high toxicity of gaseous hydrocyanic acid warning component is sometimes added to it, which makes known when dangerous amounts of it are present in the air. As warning components there are used compounds, which possess an acute odor or which irritate the mucous membranes of the eyes (lacrimators), nose, or upper respiratory tract (chloropicrin, cyanogen chloride or methylether of formic acid). It has been established that an irritating substance intensifies the respiration of insects, and consequently the action of hydrocyanic acid also.

Hydrocyanic acid possesses weak bactericidal properties.

The favorable temperature for the application of hydrocyanic acid is 15° but not lower than 10-11°; bugs and lice at low temperatures are resistant to hydrocyanic acid. Thus, at a temperature of 5-6° lice can survive. Clothing and food products should be treated dry; if considerable humidity is noted, then clothing should be dried before treatment. The acid properties of hydrocyanic acid are very weakly expressed (it barely colors litmus); this is why the gas does not damage fumigated articles. When hydrocyanic acid is used to treat a part of any building or object it is necessary to get all the tenants out of the building. Premises being treated should be at a distance of not less than 25 m from neighboring premises. Weather conditions are also taken into consideration. On rainy, foggy, and windless days it is better not to carry out treatment of premises.

The personnel conducting the work should be qualified and prepared in this field. Cyanidation should be directed by an experienced physician-disinfectionalist or other specialist knowing cyanidation; the work is conducted in special, carefully checked masks. When working with hydrocyanic acid it is necessary to have proper protective oxygen apparatuses. A continuous stay in a gas mask with an atmosphere with an admixture of hydrocyanic acid of longer than 30 minutes is not allowed. After this the cyanide workers have a break, staying in pure air for not less than 15 minutes. Resumption of work is allowed only with the permission of a physician who is present during the process of cyanidation of the premises. For the purpose of greater personal safety in fumigating ships cyanide workers do not work alone, but in groups of 2-3 persons.

Before fumigating, food products, beverages, drugs, bandaging material, tobacco, photographic plates preserved in nonairtight packing are removed from the premises.

The concentration of gas (in volume percents) for practical purposes can vary, but should not be higher than 2%. Concentrations of 0.25-1% are most frequently used; in rare cases it is brought to 2%. From the indicated concentration the flour and common clothes mole, mites, ticks, bugs, lice, and flies die. The higher the concentration of hydrocyanic acid the less time is required for disinfestation. Usually for disinfestation a 1% concentration by volume and an exposure of 6-12 h are sufficient, and for deratization the amount of gas can be decreased to 0.4-0.5% and the exposure to 3 h. In the latter case cellars and other places, where rodents nest, are opened to allow the gas to get into them; one should consider that in fumigating loaded steamers the mortality rate of rats at 1% concentration reaches 80%.

When the air in premises is saturated with a large amount of hydrocyanic acid an explosion can occur. The lowest limit of explosivity is with an 8% content of hydrocyanic acid, the highest – with 36.5%. However under conditions of fumigational practice the concentration of hydrocyanic acid, vapors in the air is usually not more than 1-5%.

The whole process of cyanidation and defumigation of a building or vessel should not last more than 21 hours. Practice has shown that with good work organization and qualified cadres of cyanide workers a treatment can be completed in 16-17 h when using tsiklon-B or in 22-23 h when using black cyanide. The approximate allocation of time is as follows: preparation of the building or vessel – 1 1/2-2 h; dispersed of the preparation – 30-45 min; exposure – 6-12 h; defumigation – 8-9 h (of these: preliminary airing – 30-45 min; cleaning up 30-60 min; final airing – 4 h; bezidine test – 1 h; biological monitoring – 2 h).

In working with tsiklon-B for the production of a 1% concentration of hydrocyanic acid 28 g of the preparation are used (with the presence in it of 40% hydrocyanic acid), and for the production of 0.4-0.5% concentration – 11.2-14 g per m^3 of the premises being fumigated. The calculated number of jars is obtained and placed on the floor of the premises to be treated. They are opened and their contents are quickly poured out on the floor; the workers immediately leave the premises being fumigated quickly closing the doors behind them and they then plug up cracks with prepared materials. Tsiklon within 10-15 min yields the basic amount of hydrocyanic acid, and the residua continue to give it off for about 2 more hours (up to a saturation of 99.8%) into the air of the premises. After the expiration of the assigned time the premises are aired out. The harmless residue (diatomite) remaining on the floor is swept up after completion of fumigation.

Several methods exist for the application of block cyanide. The pot method is used with granulated black cyanide. A measured amount of black cyanide is poured into a pot or into a thick wooden box (the bottom is 15 × 15 cm, the height is 20 cm, the top is 20 × 20 cm) and placed in the chamber. Through a tube inserted through a wall of the chamber an equal amount of 10% sulfuric acid is poured into the pot; as a result of the interaction of sulfuric acid and black cyanide hydrocyanic acid is violently given off. This method is used to fumigate in chambers or to treat premises with a large cubic volume, when the expenditure of black cyanide is not less than 200 g, because with the use of smaller quantities complete reaction does not occur. It is also not possible to use 500 g at one time one pot, since the preparation foams violently and throws the reacting mass on the floor. Black cyanide is placed in a pot in a 5-8 cm layer; the layer should not exceed 1/4 the height of the pot. The remainder of decomposed black cyanide after fumigation is first neutralized, forming a suspension of iron vitriol and slaked lime at a rate of 6 parts by weight of iron vitriol and 3 parts by weight of slaked lime per each part by weight of black cyanide; all of this is buried in a pit at a depth of 0.5-1 m so that the mixture does not get washed out by the rain, since these residua without neutralization may cause the death of agricultural plants or animals.

It is possible to apply black cyanide by scattering. In this case finely ground, dust-like black cyanide is used. Drums with the required amount of the preparation are brought into the premises, the black cyanide is scattered in a thin layer with a thickness of 1-2 mm on sheets of plywood, on paper or on the floor at a rate of

70-100 g/m^2, which creates a concentration of hydrocyanic acid of about 1.17% by volume. From the powder hydrocyanic acid is given off by the action of the air, and also of the moisture of the surface, where the black cyanide was scattered. The preparation gives off hydrocyanic acid more completely with a relative humidity in the premises of 80-100% and a temperature of 15-25°. In order to accelerate the decomposition of black cyanide the air is moistened by spraying small quantities of water from a hand sprayer or by hanging up wet burlap. After airing of the premises the residua of black cyanide are carefully gathered up and treated with unslaked lime.

For the production of hydrocyanic acid sodium cyanide or potassium cyanide are also used.

The pouring of the black cyanide, and also the pouring of the chloropicrin into shallow dishes is carried out in the open air or in well ventilated premises in [BN] (БН) gas masks when working with chloropicrin and in Б gas masks when working with black cyanide; the workers should wear gloves and aprons with breast plates.

When working with chloropicrin and black cyanide in the open air the workers should be positioned in such a manner that the poisonous vapors do not come in contact with them (is not blown against them by the wind).

After taking the black cyanide from the can, and the chloropicrin from the barrels these vessels should be tightly closed. When black cyanide is stored for a long time in a can, which is frequently used, the can should be sealed up each time.

The application of liquid hydrocyanic acid is a convenient way of using hydrocyanic acid. Hydrocyanic acid is released in the necessary calculated amounts from the steel cylinders, in which it is contained.

Defumigation is carried out by airing through one of the windows for 12-24 h; 2 hours after opening this window the personnel, who treated the premises enter in masks and open all the remaining windows. In multi-storied buildings defumigation is begun on the lower floors. Soft articles are carried outside and beaten out or cleaned with vacuum cleaners. When fumigated articles are aired out for 6-8 h from 50 to 90% of the absorbed hydrocyanic acid is removed. Mechanical beating of the articles for 15 minutes after the preliminary airing lowers the hydrocyanic acid content by 25%, and vacuum cleaner treatment for 7 min – by 15%. To accelerate the defumigation the premises are heated and ammonia and formaldehyde are also used. The introduction of formaldehyde is carried out with an apparatus intended for this purpose, and defumigation most completely occurs with the introduction of a double amount of 40% formalin in proportion to the amount taken for cyanidation of the salt. The floor is rubbed with mops soaked in a 5% solution of iron vitriol. All this is done in gas masks. The moving of the people back into the premises is permitted after 24 hours of airing.

Hydrocyanic acid finds application in the cyanidation of railroad cars in hangars or in open areas. The cyanidation of passenger railroad cars in a hangar has a great advantage over cyanidation outside a hangar on open fumigated tracks with respect to the concentration and exposure of the gas used, the period of defumigation and the ensuring of safety measures. In cyanidating passenger railroad cars in hangars the concentration of hydrogen cyanide is lowered as compared to the open method of cyanidation; the exposure is reduced; the period of fumigation and thereby the amount of gas ejected into the atmosphere is lowered.

Cyanidation is carried out with liquid hydrocyanic acid, which is obtained from factories in cylinders with siphons and without siphons. From cylinders without siphon tubes liquid hydrocyanic acid can be obtained by simply pouring it through a fitting, for which the cylinder is tilted at a 45° angle with the valve downwards. From a cylinder with siphon tubes reaching down to the bottom of the cylinder, the liquid acid is obtained through a siphon tube due to its vapor pressure on the liquid from above, which is achieved by heating the cylinder. For this the cylinder is placed in a vessel with water at a temperature of 50-70°.

The dosage of hydrocyanic acid is determined by the weight method on ordinary medical scales. A cylinder with liquid hydrocyanic acid is placed on them; the scales are balanced, and then the weight index is moved to the assigned amount, designated to be removed from the cylinder.

To withdraw the gas the disinfector in a gas mask and rubber gloves opens the valve of the cylinder; as soon as the arms of the scales are equalized, the valve is closed. The discharge of hydrocyanic acid from a cylinder with a siphon is completed after 1-5 min, and without a siphon after 5-10 min.

Disinfestation and deratization are carried out at a temperature of 20-25° and with an exposure of 2 h in unupholstered railroad cars at a concentration of 0.1-0.2%, and upholstered ones at 0.2% by volume. When railroad cars have large amount of upholstered articles and with the presence of other aggravating conditions the concentration of the hydrocyanic acid and the exposure are increased.

After the cyanidation of passenger railroad cars in a hanger the hydrogen cyanide is ejected into the atmosphere through a special draw pipe, which takes a total of 5-10 minutes. It is necessary to consider that in cold weather at a temperature of -14.8° when ejecting it into the atmosphere volatilization of the hydrocyanic acid vapors does not occur, but it falls in the form of solid precipitation or increased absorption by the snow cover occurs with subsequent desorption with a rise in temperature. In warm weather, rain water, and also in samples of water on the surface of the earth after discharging the gas from the hangar hydrogen cyanide is not detected. The height of the pipe of the hangar should be calculated taking into account the terrain of the site and the height of surrounding buildings and in all cases it should be not lower than 15 m and higher than the ridges of roofs of habitable buildings located at a distance of 100 m from the hangar.

The fumigation of unupholstered railroad cars in a hangar is carried out in 2 h, the fumigation of upholstered railroad cars - 4-8 h. Railroad cars are released from disinfectional points for cleaning and washing after their cyanidation in a hangar when the traces of hydrocyanic acid in the air in them is not more than 0.001 mg/ℓ.

It is necessary to consider that hydrocyanic acid is readily absorbed by extermely diverse materials: wood, plaster, concrete, rags, etc. The materials absorbing hydrocyanic acid under the usual conditions of fumigation are freed from the gas slowly; for example, it is possible to detect its presence in wood months after cyanidations.

The completeness of defumigation of a building is checked by the bezidine test according to the method N. I. Fomicheva and by the reaction of the formation of Berlin blue.

The bezidine test method consists in the following: in a test tube there are taken equal amounts of a 0.2% solution of bezidine acetate and a 0.3% solution of copper acetate; the mixture should be a greenish color (if the color changes the mixture is discarded). The mixture is stored in darkness in a case protected from the light. The solution is good for up to one month. Before carrying out the determination strips of filter paper are treated with the mixture and it is introduced in a moist state into the premises; they are placed in various places, which are the most difficult to ventilate (in drawers of tables, in folds in articles, under pillows, etc.); furthermore, samples are hung in the upper parts of the premises since the vapors of hydrocyanic acid readily accumulate in the upper layers of air.

With the presence of hydrocyanic acid in the tested air the papers turn blue. When the papers turn blue rapidly and intensely this indicates the presence in air of over 50 mg/m^3 of hydrocyanic acid - a dose dangerous to man even with a short-term stay in such premises. When the papers turn blue in 7 s this means that the HCN content is higher than 25 mg per m^3 of air; this dose is also dangerous to man if he stays there for a long time. If the papers turn blue after 7 seconds, this indicates that the air contains less than 15 mg/m^3, i.e., these concentration are not dangerous to man. At a concentration of 1 mg/m^3 of air the papers turn blue after 10 seconds. Papers turn blue after 1 min in the presence of 0.0001% of hydrocyanic acid in air. Chlorine and nitrogen oxides also cause the reagent paper to turn blue.

The method of N. I. Fomicheva is based on the fact that when the tested air is drawn with a rubber bulb (volume of 180 mℓ) through a glass tube filled with silica gel impregnated with a mixture of bezidine acetate and copper acetate solution, a color forms on the silica gel which is compared with standard scale. This instrument makes it possible to rapidly determine the hydrocyanic acid in air within the limits of from 0.05 to 0.0004 mg/ℓ.

The cylinders after the expenditure of the liquid hydrocyanic acid contained in them are defumigated, since there is always a liquid residue in them sometimes attaining 50 mℓ. The defumigation is carried out at sites specially assigned for this. If the cylinder has s siphon tube, then it is tilted downwards by the neck and the residue of liquid hydrocyanic acid is poured from it on a specially prepared metallic baking sheet, on which there had first been poured 2 kg of a 10% solution of caustic alkali; then to this there is added 2 kg of a 10% solution of iron vitriol. All of this is thoroughly stirred for 5-10 min and poured into a pit prepared beforehand on the territory of the hangar. Into the empty cylinder there is first poured 1 kg of a 10% solution of caustic alkali, and then the same quantity of a 10% solution of iron vitriol; this is thoroughly mixed by rolling the cylinder in a horizontal position for 2-3 min and this is then poured into the pit.

Hydrocyanic acid possesses high toxicity to warm-blooded animals and man. It is one of the strongest poisons for animal and vegetable protoplasm. Hydrocyanic acid causes lethal poisoning, if in the course of one minute approximately 8 mg of the preparation in its gaseous state is inhaled. Man dies from inhaling for several minutes air with a hydrocyanic acid concentration of 0.46%, but withstands for a short time without harm to himself air with a concentration of 0.003-0.004%. The maximum permissible concentration in industrial enterprises is 0.0008 mg/ℓ. The salts of hydrocyanic acid also possess high toxicity; when taken internally the lethal dose of KCN is equal to 200 mg, NaCN – 150 mg and HCN – 70 mg.

CHAPTER XI

FORMS OF APPLICATION OF INSECTICIDES

By V. I. Vashkov

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The toxicity and speed of action of a preparation depend to a considerable extent on the form of its use. For instance, if the preparation is used in a solution, the solvent may exert a strong effect; if it is used in solid form in a mixture with a filler (solid) such as dust, the filler may also alter its action. Besides, the effectiveness can be considerably increased or intensified by the addition of various auxiliary substances.

The temperature and moisture also change the effectiveness of the insecticide. It has been established that upon increase of the temperature from 20 to 30° following processing, in the premises where insects are present, the DDT toxicity decreases and the activity of dildrin and diazinone increases, the toxicity of gamma-hexachloran is not altered although the death incidence of house flies is somewhat higher at high temperatures.

In the practice of disinsection the following forms are used: 1) solutions; 2) pastes and emulsions; 3) insecticide soaps; 4) powders and dusts; 5) granulated insecticides; 6) suspensions; 7) pencils; 8) gases; 9) aerosols (spraying, fumigation, burning of combustible substances impregnated with insecticides; 10) vapors; 11) candles; 12) freon containers (bombs); 13) insecticides in lacquers, dyes, and whitewashing materials; 14) ointments; 15) poisoned baits; 16) feeding of insecticides to vertebrate animals (C. F. Bezuglyy; A. M. Klechetova; M. I. Murav'yev; Blum).

AEROSOLS

Systems consisting of minute particles from 10^{-7} to 10^{-5} cm, suspended in the air, have the general name of aerodispersion systems, or aerosols.

The air represents for these systems a dispersion medium, whereas the solid particles constitute the dispersion phase. Depending on the aggregate state of the particles, aerosols are divided into two types: fumes and vapors. The first usually contain hard particles, the others -- liquid drops. However, no differentiation is often made between vapors and fumes, and they are differentiated only according to their external qualitative characteristics. Both are employed for disinsection purposes. Insecticides possessing fumigation properties are most effective in the control of flying insects when used in the form of aerosols; for instance, aerosols of hexachloran used on insects are twice as toxic as DDT aerosols. Aerosols containing insecticides of contact action possess no fumigation properties and are more suitable for the control of crawling rather than flying insects.

The following classification is used for the determination of the size of aerosols:

a) large-drop sprinkling -- the drops are 400 microns in diameter;

b) small-drop sprinkling -- diameter of the drops, 100-400 microns;

c) coarse vapors -- drops 50-100 microns in diameter;

d) aerosols and mists -- suspended in the air solid and liquid particles consisting to the extent of 80 percent of particles 0.1-30 microns in diameter; no particles larger than 50 microns are found in these systems;

e) fumes -- diameter of particles, 0.001-0.1 microns;

f) powder-like poisons -- coarse particles over 175 mc in diameter; medium size -- 45-175 mc; the powder-like poisons are used where the extensive drift of the insecticide is to be avoided. such as in aviodusting.

One of the advantages of employing aerosol preparations is the considerable increase of the surface covered. For example, whereas one milliliter of fluid spread over a surface covers 6 cm^2, a surface covered with the same volume of substance which is broken up into particles of about 0.00001 cm in size, increases to 600, 000 cm^2. A drop of water dispersed in the form of mist comprises 30, 000 small particles of the order of 4×10^4 cm.

The dispersion contributes to the increase of the chemical, physical and physicochemical activity of the preparation. Upon the use of insecticides in this form, their effect is markedly increased, since they act not only through the cuticle, like powdery preparations or solutions, but penetrate also into the organism of the animal through its tracheal system.

Aerosol is characterized, besides is dispersion degree, also by the number of particles in a given volume of air. The Brownian movement of individual aerosol particles is the original cause of all its properties such as, for instance, its diffusion characteristics. Since the intensity of Brownian movement of aerosol particles is considerable, the possibility of collision of the suspended particles is also great, which thus results in the collision and coagulation of the particles. One of the most important aerosol properties is the presence of electric charges on the particles. The charged state of the particles makes it possible to separate them from the dispersion medium by means of an electric field, which is employed technically for the purpose of purification of the particles suspended in gases as, for example, in the case of dust. This property of aerosol particles in the field of disinsection and disinfection has not been utilized as yet, and it requires further elaboration. As a result of low viscosity and low specific gravity of the dispersion medium (air--gas), the aerosol particles are easily precipitated under the effect of gravity and of the electric field. Aerosols are of little effect when used for the extermination of crawling insects.

In using aerosols for the control of insects, one takes into account that the flying insects receive more drops than sitting insects, because the moving wings are effective collectors of the drops.

Aerosols represent one of the effective methods for the use of insecticides against flying insects (flies, mosquitoes, gnats, moths, etc.), as well as against agricultural pests.

There are numerous methods of obtaining aerosols of organic insecticides. As examples of the mechanical and physical methods of obtaining aerosols, one can cite: atomization of dusts and insecticide solutions under high pressure, or obtaining aerosols by means of generators with the use of high temperature and pressure.

Aerosol autonomous bombs are employed in which halogenized liquefied freon or other gaseous substances compressed into fluid are used as an ejector.

Aerosols are obtained by burning thermal mixtures containing an insecticide, burning of materials permeated with an insecticide, or via evaporation. An insecticide aerosol can also be obtained by means of a chemical reaction between gases: for instance, a fume of ammonium chloride (NH_4Cl) originates upon mixing of gaseous ammonia and hydrogen chloride: $NH_3 + HCl = NH_4Cl$.

The aerosol method of controlling pests and diseases of agricultural and forest cultures is being increasingly introduced into the practice of plant protection; as a rule, one employs DDT or hexachlorocyclohexane dissolved in diesel oil or in green oil. Dildrin or heptachlorine can be used for this purpose (A. G. Amelin).

At present, the aerosol method of the use of chemicals in the national economy of the USSR is widely employed in various areas: the area of processed field crops is measured in millions of hectares, the area of gardens and tree planting occupies hundreds of thousands of hectares, granaries, greenhouses and animal husbandry structures --hundreds of millions of cubic meters, and the extermination of gnats is measured in areas occupying millions of hectares.

Aerosols Obtained by Means of Liquefied Gases (Freon Aerosols). In 1927, a method was first introduced in the United States of using insecticides in the form of aerosols obtained with the aid of liquefied gases (propellents) sealed in bombs; as an ejector only freon-12 (dichlordifluoromethyl) was employed at first.

Due to the fact that freon-12 is a compressed gas which boils at -29.8°, the resilience of vapors creates in the bomb a pressure of 5-12 atmospheres, the extent of which depends on the temperature of the surrounding air. The principle of action of the aerosol bomb consists of the fact that, upon opening the valve, the mixture enclosed is ejected into the air as a result of pressure on the fluid of the saturated vapor above the fluid in the bomb. Freon escapes with great force from the bomb and carries with it the dissolved insecticide; upon its escape from the bomb, freon undergoes vigorous boiling due to changed pressure, and is transformed into a gas, with the result that the insecticide is atomized into minutest drops.

Finely dispersed aerosols (size of particles 2-5 microns) and coarsely dispersed (size of particles 15-20 microns) are equally effective, according to the data of Schechter and Sullivan. An important factor is the concentration of the dispersed insecticide.

The first representative of this type of insecticides which appeared on the market was a bomb consisting of a heavy steel container which was originally designed for other purposes but was later adapted for an aerosol insecticide mixture.

In 1951, 6,000,000 units were manufactured in the United States; in 1961, this figure rose to 796,000,000 units and in 1962, to 915,000,000 bombs. About 20 percent of this number contains insecticides; bombs of this type also contain lacquers, dyes, repellents, bactericides, gutaline, etc.

Analogous bombs are manufactured in England, France, the Federal Republic of Germany, etc. (Bradfury, Schechter).

In order to reduce the pressure in the bomb a mixture of freons-12 and 11 was subsequently used. Freon-11 (trichlormonofluoromethane) boils at +23.8°; when added to freon-12 it makes it possible to reduce the pressure in the bomb to 3-5 atmospheres. It is thus possible to manufacture bombs made of lighter materials such as tin, aluminum, glass, etc. rather than of steel and other heavy metals.

At present, there are propellents of three varieties: one -- on propane for use under high pressure; the second -- on isobutane for medium pressures, and the third -- for lower pressures.

To reduce the pressure in the bomb, as well as for a partial substitution of freon, one began to employ as propellents a mixture of freon-12 with other compounds, such as the following: 1) 85 percent freon and 15 percent dimethylether; 2) 65 percent freon and 35 percent vinyl-chloride; 3) 91 percent freon and 9 percent propane; 4) 90 percent freon and 10 percent isobutane; 5) 45 percent freon-12, 45 percent freon-11 and 10 percent isobutane.

A mixture was proposed of dimethylether and fluorocarbon which is not inflammable, when the content of the first ingredient is under 30 percent by volume. On this basis, the following composition is recommended for obtaining aerosols: 15 percent (by weight) of dimethylether, 75 percent of freon-12 and 10 percent of freon-11.

Attempts are being made at present to use bombs of synthetic materials where the fineness of atomization shows little change.

In connection with the vast amount of manufactured bombs, the use of insecticides abroad in the form of aerosols predominates over other forms of their application.

Aerosol bombs are used for spraying insecticides in the air for the purpose of extermination of flying insects, as well as for spraying various surfaces for the extermination of crawling insects (Fig 2).

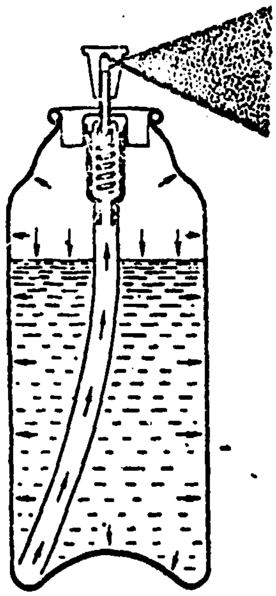

Fig 2. Aerosol Bomb (Diagram).

Aerosol bombs usually contain a mixture of insecticides (one of the insecticides paralyzes or knocks down the insects, the other kills them), synergist, solvent, liquefied gas, etc. Insecticides such as DDT, met-oxychlorine, etc. act on the insects rather slowly; therefore, to speed up their action, in the majority of cases one adds to the composition of the mixture in the bomb some insecticides which rapidly paralyze the insects; as a result, the insects following contact with such a mixture drop immediately, and the slower-acting insecticide finishes them off. Of insecticides possessing a rapid paralyzing effect on the insects one usually employs alletrin, pyrethrum tannite (isobornylthiocyanoacetate, 82 percent, and 18 percent of other active terpenens), to which also 10 percent of pyrethrum by weight is added; lethane (2-butoxy-2-thiocyandiethyl alcohol) is often used in a mixture with 0.1 percent of pyrethrum or alletrin; lethane requires deodorization, so that it is used in the preparation of medium and low stability (Briston). Of insect-killing insecticides, in addition to DDT and metoxychlorine, chlordane, gamma-isomer of hexachlorocyclohexane, dildrin, stroban, pertan, malathione, DDVPh, etc. are used (V. I. Vashkov, V. M. Tsetlin, et al.).

To prolong the action time of preparations which paralyze the insects, insecticides are added in the bombs which prolong their action -- prolongators -- and for the intensification of the insecticide properties synergists are added. The latter permit the use of small quantities of paralyzing preparations. Synergists most frequently used are: piperonyl-butoxide, sulfoxide, preparation 264-N-octylbicycloheptene, dicarboxamide, etc. Combinations of piperonyl-butoxide and pyrethrins are known in the United States under the name of pyrenone, and in England -- under the name of pybuthrin.

Sesame oil, sesamolin and kindred compounds also are added in the bombs. Sesame oil is a synergist of pyrethrum; its activating effect depends on sesamolin; these compounds are poorly soluble in kerosene, and a solvent has to be added in the bombs.

The insecticide solvents used generally have a higher boiling point than propellents; thus, upon atomization in the air, an aerosol is formed which contains the insecticide. As solvents, kerosene or deodorized pine oil are used most frequently.

The stability of aerosol preparations under storage conditions is very important. Preparations containing water and freon are not suitable, because in an aqueous medium a catalysis of the hydrolysis of freon takes place with the liberation of an acid. The bombs are usually good for one year, but very often they can be preserved for 2-3 years.

Mixtures recommended for spraying are subjected, first, to thorough study, the main attention being concentrated on the investigation of their toxicity to warm-blooded animals and to humans; the pyrethrins become rapidly metabolized, whereas piperonylbutoxide passes through the intestinal tract without change, i. e., it is poorly absorbed by the animal organism. Man easily tolerates concentrations up to 42 mg/liter; the absorption of a preparation precipitating on the skin is poor.

According to the data of O. D. Khalizova and Ye. M. Vorontsova, a 5-15 percent mixture of freon-12 to the inhaled air is not dangerous to man. Convulsions in rats appear at 30-40 percent of freon-12 mixture with air; a narcotic state sets in upon raising the freon-12 concentration to 70-80 percent.

An azotropic mixture of freons 124 and C-318 is of little toxicity to warm-blooded animals in concentrations not exceeding 10-15 gm/m^3. These concentrations exert a mild irritating effect on the mucosa of the eyes, and in a concentration of 15 gm/m^3 and higher, the mixture exerts a mild narcotic effect (A. P. Volkova). For the extermination of insects one usually employs 0.5-1 gram of freon per cubic centimeter. Solid carbon dioxide (dry ice) can be used instead of freon as a propellent.

Aerosols for the Extermination of Flying Insects. In order to obtain a higher effectiveness in the processing of closed quarters, it is important that aerosol drops be of small size and remain suspended in the air for a long period of time. Pyrethrum is added to the composition so as to stimulate the flight of insects as well as for the acceleration of paralysis.

The aerosol particles must be so small that the insects could inhale them easily; this contributes to their instantaneous death. About 80-85 percent of propellents (freon-12 and freon-11) are usually introduced in the bombs used for the extermination of flying insects, so as to obtain a fine aerosol. According to the elaborated specification, 80 percent of dispersed particles should be smaller than 30 microns, each of the remaining 20 percent particles must not exceed 50 microns.

Aerosols consisting of fine particles (2-5 microns) are somewhat more effective than the larger particles (15-20 microns). The main factor which determines their effectiveness is the concentration of the insecticide.

According to the recommendation of the Committee on Insecticides of WHO, the newly-recommended freon aerosols are used in the disinsection of airplanes, in the ratio of 35 grams per 100 m^3, provided the biological activity of these aerosols equals or exceeds the effectiveness of standard recipes. Aerosols containing dichlorophos possess high insecticide properties. Freon-11 and freon-12, as well as other freons, can be used as a propellent. In particular, a mixture of the following composition has been suggested: dichlorophos, 4 percent, deodorized kerosene, 11 percent, and a propellent (mixture of freon-124 and 318), 85 percent. With the use of an aerosol of this composition, insects (flies, bedbugs, cockroaches) die within 3-5 minutes. A mixture of this type is of little toxicity to warm-blooded animals. Symptoms of poisoning of warm-blooded animals are manifested when the concentration of this preparation in the air exceeds more than 30-fold its insecticide properties (V. M. Tsetlin, A. P. Volkova, L. N. Pogodina, V. I. Vashkov, L. I. Brikman, et al.).

There is a large number of recipes for filling-up the bombs used in the extermination of flying insects. Bombs weighing 57 grams are manufactured with the dosing atomizer which thus controls the expenditure of the mixture. It is thought that these bombs are more effective than the usual bombs weighing 340 or 170 grams. The method of use is indicated on the labels of bombs used in the control of flying insects. When these bombs are used, the doors and windows are kept closed, the ventilation devices and air conditioners are turned off. When small quarters are treated, for instance, of 28 m^3 volume, the aerosol is sprayed in all directions nearer to the ceiling for 4-5 seconds. The bomb outlet is kept not nearer than one meter from painted surfaces and objects to avoid staining them. Following disinsection the premises remain closed for about 15-20 minutes. The fallen insects are swept out and destroyed.

The aerosol stream must not be directed toward fire or near it. During aerosol processing it is advisable to refrain from smoking. Food products, as well as humans, domestic animals and plants are protected from contact with the aerosol; cages with birds and fish bowls are removed from the room for the entire period of treatment.

Aerosols for the Extermination of Crawling Insects. For the extermination of crawling insects (cockroaches, bedbugs, etc.) aerosol compounds are used which upon spraying form large drops. The aerosol stream is directed into all cracks and, although the insecticides possess residual action, repeated treatment is often required. The fluids employed for the spraying of surfaces contain up to 30-60 percent of a propellent and 70-40 percent of insecticides (by weight).

When using these aerosols the opening of the bomb is kept approximately at a distance of 20 cm from the treated surface. Aerosol is applied in an amount sufficient for slight moistening of the treated surface.

In the extermination of cockroaches, a thorough processing is essential of all possible locations of the insects, especially cracks, as well as around places where food products are stored, etc. It is important to keep in mind that the insects should contact the places treated with the insecticide. Beds infested with bedbugs, mattresses, closets, cracks in the walls of the bedrooms are sprayed. For the extermination of wood borers a special compound is prepared containing 1 percent chlordane, 0.5 percent dildrin, 33.5 percent xylol, 35 percent deodorized kerosene, and 30 percent dichlorodifluormethane.

Aerosols for the Extermination of Moth. Aerosols are very effective in the extermination of moth. It has been demonstrated in practice that at present one employs successfully for this purpose pertan, stroban, and other insecticides -- all of them highly effective. In addition to effectiveness, preparations recommended for the control of moth must possess low toxicity in regard to warm-blooded animals and good solubility in hydrocarbons, as well as easy crystallization. Pertan and stroban meet the above requirements. These preparations are used in a dissolved state; for this purpose, one part of the preparation is dissolved in nine parts of deodorized kerosene; one may add to this concentrate 30-50 percent (by weight) dichlorodifluoromethane. Particles of the size of 100 to 200 microns are usually employed in the control of moth. Instead of one propellent, a mixture can be employed consisting of two propellents (six parts dichlorodifluoromethane and four parts trichlorofluoromethane). The mixture may also consist of stroban (5 percent), kerosene (15 percent), dichlordifluoromethane (30 percent) and trichlorofluoromethane (50 percent).

Treatment wich such an aerosol ensures reliable protection for at least 12 months.

Methoxychlorine is also recommended as an effective means against clothes-moth. Upon excessive moistening of the surfaces with aerosol containing methoxychlorine, crystalline deposits may appear which are particularly noticeable on dark surfaces. As substances preventing crystallization, one sometimes adds dibutylphthalate and dimethylphthalate, but since they themselves represent strong plastificators, they may in their turn be harmful to synthetic wares.

For the control of moth the following compositions are recommended:

Methoxychlorine	5%
Methylated derivates of aromatic hydrocarbons	26%
Dichlorodifluoromethane	34.5%
Trichlorofluoromethane	34.5%

The following preparations can also be recommended: methoxychlorine, five percent, stroban, 4-5 percent, or a mixture of insecticides -- methoxylchlorine, five percent, with dibutylphthalatomide (1-2 percent).

Objects to be treated for moth extermination are preliminarily cleansed to remove dirt and spots, following which each object is treated separately with aerosol by means of placing the bomb at a distance of approximately 45 cm and spraying until the surface is slightly moistened. The amount of needed preparation depends on the structure of the clothing material. The heavier the clothing the more time is required for spraying the objects; 30 seconds are required for the processing of 0.5 kg of clothing. One must avoid excessive treatment and excessive application of the preparation. Particular care should be exercised in the treatment of lapels, seams, cuffs, etc.; if possible, both sides should be sprayed. To ensure the best protection with aerosols it is advisable to spray the inside surfaces of storage places prior to placing the processed objects in them. If the clothes are washed or dry cleaned they should be sprayed again.

Aerosols for the Extermination of Ectoparasites of Domestic Animals. Fleas, lice and ticks on domestic animals can be easily exterminated with aerosols. The following insecticides are recommended: pyrethrins in the concentration (in the bomb) of 0.06 percent with piperonylbutoxide, 0.48 percent, or a mixture containing pyrethrins 0.06 percent, piperonylbutoxide 0.48 percent, and methoxylchlorine 0.5 percent, and the rest up to 100 percent solvents and propellents. Also, alletrine is recommended in 0.075 percent concentration in the bomb with 0.5 percent of the MGK-264 repellent.

The last recipe possesses repellent properties in regard to bloodsucking flies and mosquitoes, and it deodorizes dogs. Aerosol is directed on the animals from a distance of 30 cm. One begins with the tail and by rapidly moving the bomb one treats the entire body of the animal. The animal's fur is ruffled, so that aerosol can penetrate it more thoroughly. One sprays until the fur is slightly moistened. Care should be taken so as not to point the aerosol spray at the eyes, snout, and sexual organs.

Aerosols for Deodorization of the Air. Insecticides are often employed in places where it is necessary to simultaneously remove obnoxious odors; in these cases, the use of insecticides with deodorants is indicated.

Triedman demonstrated that the addition of quaternary ammonium salts to chlordan is very effective. Since ammonium salts are not soluble in the compounds which are used for dissolving the insecticides, the addition of isopropyl alcohol produces satisfactory results.

The compounds recommended abroad contain: chlortene 2.25 percent in a mixture with quaternary ammonium bases 0.1 percent, and with pyrethrins 0.045 percent; also recommended are pertan or stroban mixed with other compounds, etc.

Aerosols Obtained Upon Burning of Thermic Mixtures. In order to obtain combustible materials containing an insecticide, one permeates filter paper, cardboard, sawdust, cotton rags, or hay in 5-7 percent solution of potassium nitrate (KNO_3), in terms of 2.5 liters per kilogram of material; it is then dried for 12-24 hours. Following dessication and repeated weighing, the paper is permeated with a 10-12 percent solution of the preparation, DDT, for example (in benzene, dichlorethane, gasoline or other organic solvents), so that the paper contains about 12-25 percent of the pure preparation (DDT, hexachloran, etc.). After 2-1/2 hours (depending on the solvents employed) of drying the paper and final weighing for a more precise determination of the amount of preparation per unit of its weight, the paper is ready for use.

Combustible materials permeated with insecticides are subjected to smoldering without reaching the stage of combustion, since under the latter condition the insecticide burns up.

It was found that aerosols containing insecticides possess viruli-cide and bactericide properties in regard to the microflora of the air and of the intestinal group of microorganisms (V. I. Vashkov, A. K. Astaf'yeva, A. S. Dyul'dina).

A. V. Gutsevich and Ya. Ya. Podolyan suggested in 1963 the manufacture of candles containing pyrethrum, potassium nitrate, sawdust, flour glue, and water. The mass is prepared according to the following recipe: pyrethrum powder, 100 weight-parts, flour glue, 50 weight-parts, potassium nitrate, 25 parts, water, 50-70 parts, sawdust, 25 parts. The length of the candle is 20 cm, weight -- 20 grams, thickness -- one cm, duration of smoldering -- 30-60 minutes; dosage of the candle -- 0.5-1 gram per cubic meter.

In many countries of the world, smoke-pots containing pyrethrins are made in the shape of a ring (or spiral). They contain sawdust of hard and soft wood, potassium nitrate, aniline-green, paste (in Brazil, made of manioca flour) and pyrethrin I (0.025 percent) to which piperonylbutoxide (0.2 percent) is added. The pulp is rolled in the form of a ribbon, molded in special presses and then baked at 48-50°.

Also recommended are candles which contain 16 percent hexachloran, or DDT, in the following mixtures: a) candles with DDT -- sawdust 125 grams, potassium nitrate 41.5 grams, potato flour 45 grams, water or paste 400 gm, benzene (for dissolving DDT) 100 grams; b) candles with hexachloran -- sawdust 50 gm, tobacco dust 150 gm, potassium nitrate 25 gm, hexachloran 50 gm, potato flour 20 gm, water (for the paste) 150 grams. In the preparation of candles containing hexachloran, the latter is thoroughly triturated in a mortar with sawdust; a starch paste is then made in the proportion of 1:10 and potassium nitrate is added; the paste with potassium nitrate is stirred and poured in a container with the insecticide and sawdust; the mixture is thoroughly stirred and spread out on a board; it is rolled in a thin layer, cut into equal parts, and molded into candles. Candles containing DDT are made in an analogous manner, but in this case the DDT is preliminarily dissolved in benzene for a more uniform distribution of the preparation. The fresh candles are dried at 25-60° temperature; candles containing more than 30 percent of the preparation do not burn well. When the candles are lit, a chemical reaction takes place in them with the result that the temperature of the candle at the burning point rises to 220-224°. At a 150-180° temperature, DDT and hexachloran are transformed into a vaporous state and are sublimated. The USSR industry puts out candles of the following composition: DDT, 50 parts, urotropin, 6.8, potassium chlorate, 17.5, chrysotile asbestos, 5.2, ceramic gypsum, 3.9.

In the use of candles, their consumption depends on the quantity of the preparation within the composition of candles, and it constitutes approximately from 0.7 to 2.2 grams per cubic meter. A single burning of candles in the tent imparts to the tent tissue insecticide properties which last about seven days.

In addition to the above-enumerated methods of obtaining aerosols, the latter are obtained also by burning plant insecticides mixed with potassium nitrate (pyrethrum, tobacco, etc.). For the fumigation of hothouses two grams of tobacco dust are used or 2-4 grams of pyrethrum per cubic meter of air.

The size of aerosols of insecticides in all methods of their manufacture is very small; for instance, in fumigation with tobacco smoke the size of particles is from 1/1000 to 1/15,000 part of a micron.

N. D. Uspenskiy and V. T. Osipyan recommended for the extermination of flying insects in a closed room the following thermal insecticide mixture: DDT 60 percent, potassium chlorate 22.5 percent, ammonium chloride 10 percent, industrial thiourea 7.5 percent. The mixture is made by means of trituration subsequently rubbing the component parts through a No 1-5 sieve. The ready mixture is placed in a tin can. The mixture can be compressed and may also be stored in a packed form in paper packages.

Smoke-pots of two sizes (74 and 300 grams) under the name "Vulkan-Udag-53" recommended by G. G. Tsintsadze for the processing of various premises are prepared from such mixtures.

The insecticide hexachloran smoke-pots (IDG-1) of simple composition (96 percent of hexachloran and 4 percent of aluminum powder) are suitable for briquetting without the use of cementing material.

The slight hexachloran mist obtained by means of these smoke-pots is most toxic for arthropods such as cockroaches, bedbugs, lice, flies, mosquitoes and ticks. The toxicity of insecticide fumes is of the following order, according to its strength: pyrethrins -- DDT -- rothenon (N. M. Parkhomenko). Hexachloran is more volatile than DDT. The residual action of aerosol lasts several days. Pyrethrum possesses no prolonged residual action, with the result that the effectiveness of this type of aerosols in combatting crawling insects, especially on vertical surfaces, is rather low. The low residual effect of fumigation aerosols on treated surfaces is due apparently to the fact that a very small amount of aerosols is precipitated on vertical surfaces.

In closed quarters about 80-85 percent of the insecticide aerosol settles on horizontal, and only about 20-15 percent on vertical surfaces. After burning in a room of the size of 70 m^3 of one fumigation pot containing 110 grams of industrial DDT, and in another room -- a fumigation pot of 120 grams of industrial hexachloran (10-12 percent of gamma-isomer), a determination was made of the amount of precipitated preparations on surfaces situated horizontally, vertically, and in a turned-over manner (ceiling); the largest quantities of these preparations were found on horizontally situated surfaces (Table 22), and the smallest -- on turned-over surfaces (ceiling).

Smoke-pots are also made of 95 percent industrial hexachloran and 5 percent aluminum powder. Upon burning this type of mixture prepared at home, one employs a bucket with perforated walls (in the form of a sieve).

Table 22

Amounts of the Preparation (mg/m^2) on Horizontal, Vertical, and Turned-Over Surfaces

Distance from Floor (in Centimeters)	DDT			Gamma-isomer (Hexachlorocyclohexane)		
	Horizontal	Vertical	Ceiling	Horizontal	Vertical	Ceiling
274-335	204-257	38-59	39-55	309	101	60
183-213	130-148	39-35	39-44	173	30	21
91-121	140-185	32	32	195	-	-

The thermal mixtures are rarely used in residential quarters. Prior to fumigation the premises are vacated of people, domestic animals, birds, fish and flowers. The dishes are taken out of the room or placed in a cupboard and tightly covered with paper or cloth; products which absorb insecticides (bread, cream) are removed from the treated premises. The smoke-pots are placed on the basis of the following data: for a single-stage extermination of flying insects (flies, mosquitoes), 0.2 gram of DDT or some other insecticide is used per m^2 of the treated premises. In order to obtain a prolonged residual insecticide effect 3.5 grams of sublimated mixture are used per square meter of the treated premises. In case of wooden floors, a metallic pad, brick, etc. is placed under the aerosol smoke-pot as a fire-prevention measure, or a layer of sand 2 cm thick and 25-30 cm in diameter is spread under the fumigation pot; stone and asphalt floors do not require this precaution.

In the treatment of non-residential quarters, the windows and doors are closed and the cracks are stopped up.

The required number of fumigation pots for disinsection of given premises is determined in terms of a pot of one kilogram per each 1500 cubic meters. During fumigation the aerosols formed rise, cover the ceiling and walls, and are uniformly distributed in the premises. The latter are kept closed for 2-3 hours; they are then ventilated until the sharp odor of the insecticide is gone (DDT -- 1-2 hours, hexachlorocyclohexane -- to 12 hours, etc.). After airing the premises, the visible residue of aerosols is removed from the treated household objects by means of a wet rag. The paralyzed and dead insects are swept out and burned. The premises can be used immediately upon completion of the cleaning procedure.

For aerosol treatment of civilian and military clothing, stationary and mobile disinfection chambers are used as well as various suitable premises (individual rooms, peasant huts, mud-huts, farm buildings, etc.). The optimum effect of impregnation of sheep-skin coats, overcoats, cotton shirts and trousers is obtained, at temperatures of the outside air, during the fall-winter seasons, with doses of 12-24 grams per cubic meter, in terms per given preparation. The duration of residual insecticide effect is 7-20 days, depending on the type of clothing.

Aerosol thermal mixtures of the following composition were suggested for the extermination of insects in various premises: chlorophos, 50 parts, potassium chlorate, 24 parts, dicyandiamine, 17 parts, and dextrin, 10 parts. These mixtures are placed in polyethylene bags and used as fumigation material. However, these mixtures have not been widely accepted.

For the control of midges aerosol smoke-pots are widely used, especially outside the premises. V. A. Nabokov suggests for the extermination of blood-sucking insects hexachloran fumigation pots in localities which have not been made sufficiently habitable. The industry manufactures aerosol fumigation pots or subliming mixtures of the following composition: a) DDT, 60 percent, thiourea, 7.5 percent, potassium chlorate, 22.5 percent, ammonium chloride, 10 percent; b) hexachloran, 60 percent, thiourea, 7.5 percent, potassium chlorate, 22.5 percent, and ammonium chloride, 10 percent.

For the preparation of such mixtures the ingredients are weighed (according to the recipe), each of them is carefully triturated and made into a powder which can pass through a sieve of 150-200 openings per square centimeter. The ingredients are then mixed and triturated until a homogeneous mixture of white powder is obtained. To this finely triturated mixture one adds potassium chlorate which has been preliminarily pulverized and passed through a sieve of the same type. The mixture containing all compound parts is then stirred until a homogenous mass is obtained and placed into fumigation pots.

The fumigation pot represents a metallic or cardboard box of cylindrical form with a cover containing 5-13 openings, 8 millimeters in diameter. To avoid the loss of subliming mixture through perforations in the cover during transportation of the fumigation pots the latter are closed from the top with another cover of the same material; the covers are fastened by tying the two notches on the rims of the covers with two strings passing through the notches and fastened to the body of the fumigation box; the covers of cardboard boxes are pasted up with paper.

The size of a large pot is 80 x 130 mm; it holds one kilogram of the subliming mixture and is suitable for premises of 150-200 cubic meters; the cover has 13 openings. The size of a medium pot is 70 x 80 mm; it holds up to 0.5 kg of subliming mixture and is suitable for premises of

75-100 cubic meters; the cover has 10 openings. The size of a small pot is 50 x 45 mm; it holds 100 grams of mixture and is suitable for premises of 15-25 cubic meters.

The mixture to be volatilized is ignited through the central opening in the cover of the box by means of a match or a fuse made of cotton string, 4-5 mm in diameter, permeated with a 30-35 percent solution of potassium nitrate and dried at room temperature. One can also employ successfully some filter paper impregnated with the same solution of potassium nitrate and rolled in the form of a 4-5-layer tube, of an outside diameter of 4-5 cm (Fig 3).

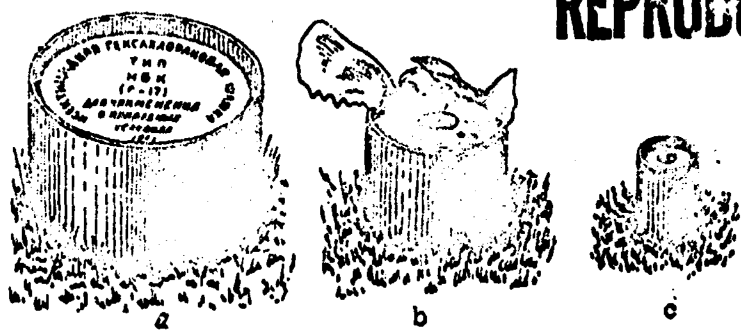

Fig 3. Insecticide Hexachloran Boxes of the NBK type, to be Used Outdoors. a -- general view of the unopened box; b -- box, ready for fumigation (in the center of the box is seen the end of the thread which is connected with the fuse); c -- general view of the testing (neutral) box of the P-6 type for the determination of the direction of air currents outdoors.

Following ignition of the box, the mixture becomes dispersed under conditions of optimal temperature (up to 180°) with a vigorous formation of DDT or hexachloran aerosols; the aerosols are of white color and do not stain. Numerous tests have shown that the process of aerosol formation of large, medium, and small fumigation boxes proceeds within a very short time -- 45-15 seconds, respectively; the formed aerosol rises to an altitude of 16 meters.

Extermination of flying insects (flies, midges and mosquitoes) in 100 mg/m^3 of treated premises can be accomplished with the optimum dosage of DDT transformed into aerosol.

P. G. Sergiyev, V. A. Nabokov and V. V. Burley used fumigation boxes of analogous composition, i. e., containing DDT and achieved via fumigation an almost complete extermination of mosquitoes (Aedes and Culex). During the next 48 hours of the experiment the number of mosquitoes remained reduced by 80-60 percent as compared with the control area. The greatest coagulation of smoke and, hence, a more prolonged effect was observed in the immediate vicinity of the source of smoke formation -- a fact confirmed by the following data: whereas after seven days following fumigation at a distance of 5 meters from the box, six live mosquitoes were caught on a square meter of the surface, at a distance of 10 meters 18 were caught, and at a distance of 25 meters -- 28 mosquitoes.

Outside the buildings, the boxes are used in the morning, at daybreak, or in the evening when there are no ascending air currents from the earth's surface, in calm weather, or at a wind velocity of not more than one m/sec. To obtain a smoke cloud, the boxes are arranged lineally along the front of the fumigated area, at a distance of no more than 30-35 meters from one another. Under these conditions their effect is manifested at a distance of no less than 300-350 meters. No combustible material (dry grass, brushwood, etc.), which could become easily ignited from an accidental spark, should be present near the smoke boxes.

Toxic phenomena in insects (horseflies) are observed within 5-10 minutes, at a distance of 100-200 meters; at greater distances, the toxic phenomena set in later; bees and mosquitoes are highly sensitive to these aerosols; bees perish at a distance of up to 750 meters, mosquitoes -- up to 1500 meters from the smoke box.

The drawbacks of aerosols are that, upon their use outside of the premises, at an unfavorable direction of the wind and ascending air currents, they might be carried away far from the treated objects; besides, a considerable amount of the aerosol does not settle on the treated area and is carried off into the atmosphere.

In animals exposed to repeated fumigation (up to 15 times), at a distance of 10-50 meters, no special deviations from norm have been observed clinically.

A vertical device -- cardboard cylinder filled with an insecticide and explosive material and connected with a tube containing an ejector -- rises (following ignition) up to 27 meters and explodes, thus forming an insecticide mist which settles according to the law of gravity. These devices can be used for spraying high trees as well as objects hidden by bushes, trees, rocks, etc. The formed aerosols cover the upper and lower sides of the leaves.

A horizontal rocket -- a device which is a cylinder with stabilizer "fins" -- contains an ejector and an insecticide. The base of the rocket is made of a light transportable frame. The insecticide is ejected by gases and forms a fairly wide dust belt of approximately 275-450 meters.

The rocket can be ejected between rows of trees or hills in a poorly accessible locality. The rockets can be stored for long periods of time; they are easily transported and can be used by untrained personnel.

For the treatment of small areas, the insecticide powders and dust can be atomized by means of a riffle or rocket device. The manufacture of such rockets is simple, inexpensive, and requires no scarce materials.

Aerosols obtained by means of spraying of insecticide solutions mechanically with the aid of simple devices, complex machines, airplanes, etc., can be employed in calm weather as well as in the moving air. In calm weather the drops descend and hit the animals in direct proportion to the amount of the preparation, precipitation velocity, and temperature of the air. More drops strike flying insects than the sessile ones.

In working in the open air, the best effect can be obtained with drops of 10-20 microns, under conditions of normal wind velocity. In the treatment of forested areas, it is best to use drops of 10-40 microns, because 100-micron drops do not penetrate the tree tops. If the treated insects are seated on the lower part of the leaf, it is best to use 10-20-micron drops.

By means of large and complex machines fogs can be obtained consisting of aerosols (mist).

Mists are widely used outside of buildings in the extermination of flying insects. To obtain mists several types of generators of various power have been developed at present; their yield of sprayed substance varies from 0.5 to 400 liters per minute. The most powerful TFA (thermo-flue apparatus) generators and powerful aerosol generator (PAG) were suggested by the Siberian Branch of the Academy of Sciences USSR. PAG is capable within an hour to cover a very large area -- up to 300 km^2 -- with insecticide containing mist. These machines can be used for the protection of workers employed in midge-infested localities.

B. V. Yakovlev and V. G. Kern investigated the feasibility of using aerosols obtained via atomization with compressed air for the disinsection of passenger coaches, and established that this work is facilitated when an air pipe with compressed air is available at the railroad equipment yards. A systematic impregnation with DDT aerosols of the coaches and equipment makes it possible to dispense with preventive powder and gas disinsection, the implementation of which is difficult and has, besides, a number of major shortcomings.

The use of compressed air for obtaining aerosols can be accomplished also by attaching a rubber hose to the air-pipe which connects the coaches.

Spraying of the solution can be successfully carried out by means of a pulverizer pistol employed in the building industry. They transform the solutions into a mist-like state, the particles being of 4-20 microns.

A strongly ejected aerosol stream directed to the nestling loci of insects ensures a high disinsecting effect. The processing of a coach takes five minutes.

One of the advantages of treating coaches with aerosols is the fact that it is carried out directly at the equipment tracks; it eliminates the need for delivering coaches to special tracks and shortens their out-of-service time.

Thus, the presence at railroad yards of compressed air employed for the testing of brakes makes it possible to utilize this powerful energy in obtaining aerosols without any special technical equipment.

The use of aerosols for the extermination of flies in populated localities is of little effect. Wilson and La Brecque sprayed for the extermination of flies 0.1 percent of diazinone, 2 percent ronnel, 2 percent malathione, 0.1 percent alletrine, 0.1 percent pyrethrin, 2 percent bromo-piperonyl ester of chrysanthemic acid, or the 2, 4-dimethylbenzene ether of the same acid with alletrine and piperonylbutoxide (1:10); the solutions were sprayed in the form of a mist five times weekly; the effectiveness was determined according to the periodic catch of flies on sticky paper. The authors established that as a result of the use of all the above-enumerated insecticides the number of flies decreased by no less than 90 percent within 10 minutes following spraying, but after 24 hours the number of flies became fully restored. These sprayings were continued for three weeks, but they resulted only in a slight decrease of the populations; this was due to the fact that piles of manure were in abundance around the cow-sheds where the spraying was carried out.

GASES AND VAPORS

Quite frequently gases and vapors are employed in the disinsection branch which little differ from each other in their properties; therefore, the division into gases and vapors is arbitrary. Vapors are substances in a gaseous state at temperatures below critical ones, i. e., under conditions of equiponderant coexistence with the same substance in a liquid state. For their use see the Chapter "Gaseous and Vaporous Substances (Fumigants) Employed for Disinsection Purposes."

SOLUTIONS OF INSECTICIDES

Insecticide solutions similarly to the solutions of any other substances are homogenous mixtures of two or more preparations in which all components are in a molecular dispersion state and are distributed in the form of individual particles or groups of a relatively small number of particles -- molecules, ions, atoms. The concentration of the solution is expressed variously: in weight or atomic units, or in moles per liter solution, etc.

As to the content of the insecticide, concentrated solutions are differentiated, in which the amount of the preparation is high as compared to the amount of the solvent, and diluted solutions in which the amount of the diluted insecticide is small as compared to the amount of solvent.

As to the chemical nature of the solvent, one differentiates aqueous solutions (the solvent is water) and non-aqueous (the solvent is an organic or inorganic compound) solutions, both remaining liquid at room temperature; they include also solutions in compressed gases -- freon, sulfur dioxides, methyl bromide, etc.

The solutions of high-molecular compounds possess characteristic viscosity; at high concentrations they manifest abnormal viscosity and may form gels.

The solvent and concentration of the active substance are such that the solution can be used directly but usually these solutions are sold in concentrated form and they have to be diluted prior to using. The simplest case is when the solution is water-soluble, but many insecticides are not water-soluble or very poorly soluble. These preparations are dissolved in oils or other organic solvents. Of organic solvents most frequently used are kerosene, turpentine, white spirit and solar oil. Upon dilution of water-soluble solutions of the preparation in organic solvents an insecticide in a finely-dispersed state is obtained.

Of great importance is the water-solubility of preparations employed for the treatment of surfaces. An important part is played by the quality of the water. Their effectiveness is affected by salts present in large quantities in the water, especially alkaline salts (of sodium, potassium, etc.) and calcium salts in the form of sulfates or bicarbonates. They may enter into combination with the preparations, thus affecting the insecticide properties of the latter.

Effectiveness of the solutions also depends on the moistening properties of the solvent. Upon spraying with contact and intestinal poisons it is desirable that the fluid spreads as much as possible over the surface.

The spreading and running of the fluid in the form of a drop over the surface of a hard object to be disinsected takes place under the effect of molecular cohesion forces. The spreading is the result of moistening; the ability of becoming moistened depends on surface tension. Since the spreading is always connected with the increase of the area occupied by the spreading fluid, the spreading is impeded by the surface tension at the borderline with the air. The spreading of a drop of water is the indicator of the purity of hard surfaces (glass, for instance), i. e., the absence of fat contaminations in them. The spreading is the essential condition for the uniform covering of the surface with a thin film. For better moistening one adds various substances to the solutions which reduce the surface tension of the solution (Petrov's contact, soap, casein, sulfurized compounds, sulfate alcohols, etc.). Correctly chosen mixtures (surface-active substances) contribute to the formation of minutest drops during spraying which thus prevents the rolling down of the solutions from the surfaces. The addition of washing substances and moisteners ensures the spreading of water over a usually hydrophobic surface.

The external layer of the cuticle of insects consists of lipoids and is easily moistened with oils; therefore, an oil solution of a contact insecticide is more effective than an aqueous solution. Oil films containing DDT and hexachloran on non-absorbing materials (glass, metal) are highly toxic at first; subsequently, when the solvent has evaporated there appear over-saturated drops and dry crystalline deposits, and the insecticide properties on the surface diminish. Thus, the transition from moist to a dry state (on the surface) is characterized by a considerable reduction of effectiveness.

The surface covered by the particle of liquid insecticide (a drop) is larger than the one covered by the same amount of preparation used in a powder form. This is due to the fact that a drop of solution of contact poison, upon touching the surface, spreads out, and after drying produces not one minute particle but numerous similar particles (crystals). The size of particles formed upon spraying equals 10-180 microns, depending on the design of the employzed nozzle. Relatively inactive dry deposits can be reactivated following spraying with solvents.

Crystallization can be induced by mechanical stimulation or by insects crawling on the treated surface. A prolongation of the period of effectiveness can be achieved by introducing in the solution some non-volatile oil or substance which retards crystallization (5 percent lanolin to a kerosene solution of DDT, etc.). The crystallization sets in much slower from the solutions of non-purified DDT than from solutions of a pure pp' -- DDT.

Upon using oil solutions on the absorbing materials, the initial high toxicity is not always observed because the oil penetrates inside the treated object. In this connection, a loss of the insecticide is observed on the surface where only a part of the used dosage remains. About 50 percent DDT is left on wood; on clay surfaces we observed only 8-19 percent DDT in the surface layers, 0.1 mm thick; upon spraying of leaves, up to 50 percent of the insecticide was lost as a result of absorption. One of the causes of the loss of effectiveness upon processing of cattle with oil solutions of DDT is their absorption through the skin of animals.

Deep penetration of the insecticides upon surface spraying does not mean a final loss of effectiveness, since as a result of crystallization the preparation reappears on the surface. For instance, a noticeable increase of effectiveness was observed on flies on wooden surfaces treated with a kerosene solution of DDT, during the interval between the first and second check-up; after four weeks, a mass of crystals appeared on the surface.

The "blossoming" of DDT and some other insecticides is most clearly manifested on porous substances such as wood, paper and some clothing, but it is not observable on clay and plastering. The physical state of "blossoming" varies depending on the insecticide, as well as on the volatility of the solvent, including also the solvent properties of the oil. From a kerosene solution of DDT thin acicular crystals are formed (on porous materials), which are easily absorbed by the insects.

To prevent crumbling or shaking off of the insecticide (following evaporation of the solvent) and to fasten it on the treated surface or tissues, gluing substances are added to some insecticides. Each insecticide possesses a definite adherent property, which depends on the property of the insecticide itself or its special ingredients (fasteners or spreaders). For better adherence one adds skimmed milk, sugar, molasses, starch, glue, gelatine, dried blood plasma, etc.; one may also add from 50 to 100 grams of paste per 100 liters of the solution. However, it should be kept in mind that the excessive addition of these substances to the preparation reduces its insecticide properties.

An insecticide employed for the covering of external surfaces, as well as for the extermination of lice, should possess still another positive characteristic, namely, insolubility in water; water-soluble insecticides are, of course, suitable preferably for use inside living quarters. Outside of such quarters the insecticides are rapidly washed off by rain, especially when they are used for treating the external surfaces of buildings, garbage containers, etc.

The advantage of spraying, as compared to dusting, lies in the more economical use of poisons which are easily retained on the surfaces and in the high effectiveness of such processing. In processing large outside areas, spraying has the drawback, as compared with dusting, that it is more labor-consuming, the consumption of water is considerably greater and the results are less effective. The spraying is carried out early in the morning or in the evening by means of apparatus or machines of various designs. Weather conditions should be taken into account. For instance, the spraying should not be performed prior to a rain or immediately after a rain -- or under abundant dew conditions -- or when the wind velocity is higher than 5 meters per second. The spraying of plants should be completed 3-4 weeks prior to harvest time.

In countries with a warm climate and high insolation the ultraviolet rays decompose DDT in the oil films and reduce their effectiveness.

Special apparatus are used in spraying (hydrostands, dyestands, etc.) which produce minutest drops. The effectiveness of this method depends on the uniform dispersion of the fluid which covers the sprayed surfaces and on the ability of the fluid to spread.

It is not permitted to use solutions prepared from gasoline, benzene and other easily inflammable substances for an over-all processing of the premises since they are fire hazards. They can be used for selective processing of places of insect proliferation. In the extermination of bedbugs it is best to use kerosene solutions of insecticides.

POWDERS AND DUSTS

Insecticide powders are finely triturated preparations which are used without the addition of fillers. Dusts (from the English word "dust") are powders of preparations mixed with inactive fillers. Powder preparations have been used for a long time. For instance, pyrethrum has been used as an insecticide in everyday life since the 17th century.

In view of the high toxicity of the majority of poisons used in sanitary practice, as well as burns in plants which resulted from the use of some of them in pure form in agriculture, fillers are added to the insecticides.

The amount of an insecticide in the dust depends on the degree of its toxicity. Dusts may sometimes contain a pure preparation in only hundredths of one percent. Two methods are employed in the preparation of a dust: 1) the insecticide is introduced directly by mixing it with a filler, or 2) the insecticide is added in the form of a solution to an organic volatile solvent and mixed with it. As fillers one employs talcum, kaolin, pyrophyllite, ash which has been obtained upon burning of coal yielding a high ash content (Table 23). The presence of up to 3 percent carbon in the ashes prevents lumping of the dust insecticide. The size of a particle of talcum and pyrophyllite is 30-40 microns. The specific gravity of ashes and talcum is about 2.6-2.65 g/cm^2, and of its bulk density -- 0.92-1.15 kg/liter.

In selecting a filler all possible methods of the use of the preparation should be taken into account, as well as the chemical properties of the filler itself, because some iron compounds (iron salts), for instance, accelerate the decomposition of some insecticides (DDT, etc.) which is accompanied by the liberation of hydrogen chloride. Ashes cannot be used in the manufacture of dust from an insecticide possessing a strong acid reaction, because the filler in this case neutralizes and destroys the insecticide (industrial chlorophos, for instance).

The effect of the nature of filler on the effectiveness of the preparation has been insufficiently investigated; there are indications that dusts mixed with some fillers ($CaCO_3$, for instance) are retained by the insects much better than dusts with other fillers. According to the data of L. N. Pogodina, dusts mixed with a clay filler possess greater adherent properties; the adherence of dusts on talcum and kaolin is somewhat lower than on clay. However, their effectiveness is nearly the same. The relatively higher effectiveness of dusts as compared with other preparations can be attributed to their easier separation from the surface and adherence to the insects. The quality of the dust depends to a considerable extent on the thorough uniform mixing of the chemical poisons with the filler.

Table 23

Chemical Composition of Fillers

Filler	Content in %%								
	SiO_2	Al_2O_3	MgO	Fe_2O_3	TiO_2	CaO	K_2O	Na_2O	C
Talcum	30—60	0,3—2	17—32	0,3—18	—	0,3—13	—	—	—
Enriched kaolin	46—58	18—40	0,2—2	0,2—1,2	0,1	0,13—1	0,1	0—0,2	—
Pyrophyllite	47—73	13—37	0,1—1,5	0,4—7	0,5—1,1	0,2—4	0,15	0,1—0	—
Ashes obtained from coal of the Moscow Area Coal Basin and collected by TETs electric filters	45—52	21—29	1,3—2	10—11	—	5—11	—	—	0,2—0,9
Ashes obtained upon burning ash coal of Ural deposits	44—46	28—30	—	15—18	—	0,5—1	—	—	2—3

Insecticide dusts are manufactured under plant conditions; they represent particles of the filler covered with an insecticide film or particles of the filler with adherent particles of the insecticide, or separate particles of filler and insecticide.

To obtain the greatest effectiveness the dust is obtained in a finely dispersed form, i. e., ground so fine that the particles would pass through a 120-mesh screen. The residue on such a screen should not exceed 2 percent. Particular attention should be paid to the degree of adhesiveness of the dust. One-percent spindle oil added to dust in the form of a solvent of the insecticide contributes to a better adhesion of the preparation on processed surfaces. Besides, the presence of oil in the pulverized larvicide preparations used for the extermination of malarial mosquito larvae increases the floating (navigational) properties of these preparations.

It has been established that the removal of moisture causes a slight rise in the suspension properties; heating for an hour up to 70° also increases the property of forming suspensions (probably as the effect of drying); heating up to temperatures over 70° for an hour causes a decrease of suspension properties; low pressure (25 g/cm^2) exerts a slight effect on the suspension properties, but pressure of 7 kg/cm^2 and higher changes these properties proportionally to pressure.

The dusts have one common defect: a short duration of the insecticide effect on the surfaces as a result of washing off by rain, blowing off by wind, evaporation under the effect of sun rays and air temperature. Therefore, the dust toxicity to insects is somewhat lesser as compared with emulsions and solutions of the same concentration. The quality of the dust depends to a great extent on the uniformity of mixture of chemical poisons with the filler. Dusts are very convenient from the practical standpoint on account of the simplicity of their use; they need no dissolving in water, as is mandatory in the case of moistened powders and emulsions.

In storing dusts in a thin layer in open bowls the darker dusts would lose their toxicity somewhat faster on account of the higher temperature of these dusts under the effect of direct exposure to the sun. In view of the fact that they are kept under sheds or inside the premises, it should be considered that the coloration factor is of no substantial importance to their effectiveness. The length of preservation of the effectiveness of a given dust depends on the physico-chemical properties of the insecticide. For instance, hexachloran dusts lose their effectiveness at least twice as fast as compared with DDT dusts. Deterioration of a dust depends on the presence of iron and hydrochloric acid in the filler.

According to the data of K. A. Gar and V. I. Chernetsov, hexachloran dust kept in a bowl would lose 25 percent of its activity within 70 days. In investigating the effect of a filler on the loss of effectiveness, the authors established that within 47 days dusts mixed with Shibyarov and Il'men talcum lost 35 percent of activity: with Miassy talcum, 22 percent; with kaolin, 80 percent; and with ashes, 5 percent.

Dusts containing phosphoroorganic insecticides are highly effective (K. A. Gar, et al.).

One of the basic qualities of dust preparations is their dispersion property or the extent to which the particles can be crushed. More finely ground preparations are easily pulverizied and are better able to adhere to and remain on a treated surface, whereas particles of a coarser grind are easily shaken off. Besides, when coarsely ground preparations are used as intestinal poisons, the insects ar not always able to swallow large particles on account of the small size of their buccal opening (O. F. Kolesova).

Powders and dusts are applied to the treated objects via pulverization. This is one of the methods of chemical control of arthropods - carriers of infectious diseases, pests, and diseases of agricultural plants -- where the surface to be treated, as well as the arthropods, are dusted with finely ground dust-like toxic powder. In sanitary practice, sprinkling is employed for the extermination of malaria mosquitoes, their larvae, other insects, ticks, and rodents.

Particles smaller than 20 microns are picked up easier and separated with more difficulty from the insect than large particles. The amount of picked-up insecticide during a definite period of contact varies, and depends on the type of insect, structure of its legs, and behavior. For instance, the size of particles is very important in the poisoning of Anopheles mosquitoes which remain immobile, as compared with Aedes which are constantly moving about the surface. This fact was observed in regard to DDT, metoxychlorine, and DDD, but it is less noticeable in regard to aldrin, gamma-hexachloran and dildrin because these compounds are much more toxic than DDT, and even a few particles of these poisons picked up by the insect have a lethal effect.

Dust preparations are used for dusting water areas contaminated with malarial larvae. These preparations must not only settle rapidly from the air on the surface of the pond but also must spread out over the water surface and remain on it for a prolonged period of time. The preparations have to be of a fine grind and contain spreader substances in their composition.

Powders of a coarse grind are ineffective and cannot be employed in the control of malaria mosquitoes because they cannot be absorbed by their larvae, since the buccal openings in young larvae reach only 30 microns. According to the data of the Institute of Medical Parasitology and Tropical Medicine of the Ministry of Health USSR, Paris green, 15-30 microns in diameter, is more effective than the same Paris green consisting of larger particles. Obviously, also the powder particles of other insecticides should not be larger than 15-30 microns.

For the control of bedbugs and cockroaches the particles of dust-like insecticides should not exceed 20-25 microns, since they adhere better and remain on the body of the insect.

The size of particles is limited by the technical possibilities of grinding. Upon dusting of surfaces, the speed of precipitation of the preparation depends on the size of particles. The smaller the particles the slower they precipitate on the treated surface. Particles of 2.5 microns in diameter are precipitated from the air at the speed of 0.047 cm//sec; those of 10 microns, at 0.817 cm/sec; 20 microns, 3.26 cm/sec; 30 microns, 7.3 cm/sec; 50 microns, 20-43 cm/sec; 75 microns, 46.6 cm/sec; 100 microns, 81.71 cm/sec (A. L. Yefimov).

Of particular importance is the size of particles in aviodusting because when finely ground particles are used the air motion may carry away up to 75 percent of the preparation from the treated section. Particles of coarsely ground poison fall out under the plane in a narrow ribbon -- a fact which leads to the over-consumption of the poison. It has been established in practice that in aviodusting particles of the size of 20-40 microns should be used.

In the case of plant lice, particles of 4 microns are most effective; for flies, 10-20 microns; for bedbugs and cockroaches, 20-25 microns; particles of these sizes are more toxic than crystals of 30 microns because they adhere better and are retained on the surface of the insect's body. Thus, for some arthropods the optimum size of crystals is 20-40 microns, and for others -- smaller sizes, or larger sizes in some cases.

It has been established that the pick-up of dust (of lipophilic dyes) during a single contact of insects of various size and structure with the insecticide-treated surface differs little in each species; large insects pick up more in a single contact, but in smaller insects the pick-up of the dust per unit of body weight is higher. The hind legs of the insect pick up about the same amount picked up by the middle and anterior legs together. The first segments of the posterior tarsi pick up more particles than the remaining segments. Upon the presence of 30 mcg/cm^2 (300 mg/m^2) of the preparation on the surface, the pick-up of particles by the posterior legs varies from 50 to 59 percent, by the middle legs -- 21 to 29 percent, by the anterior legs -- 15 to 27 percent. The average pick-up during a single contact is 1.7 micrograms (at the average weight of the insect, 0.006-0.147 grams); the average pick-up of the insecticide per gram body weight is 11.4 to 167 micrograms.

The insects transfer, by means of their cleansing movements, particles of the preparation from one part of the body to the other, although the amount of particles decreases under these conditions.

The degree of grinding (dispersion) is most frequently determined in the weighed portion and passing the dust through the sieve with a certain number of openings, or one determines under the microscope the number of particles of various sizes and calculates their percentage correlation. The size and the number of the sieve is established according to the number of openings (meshes) or threads per square centimeter.

Dust preparations may become lumped during storage (cake); therefore, prior to use they should be triturated, but in these cases their adhesive property to a given surface is considerably weaker than that of preparations which have not undergone caking under storage conditions. Their lumping is caused mainly by hygroscopical property, the presence of admixtures, the shape of the particles, their specific gravity, and to some extent by the electric charge of the particles.

As a filler, finely porous or coarsely porous silica gel is suitable for the preventing of lumping. The addition of 14 percent of silica gel completely prevents the lumping of the preparation.

The hygroscopic property of the preparation is its ability to absorb moisture from the air. Insecticides possessing no more than 2 percent moisture at air humidity of 80 percent are considered most acceptable for use. Upon shipping from the plant the dust insecticides should not contain more than one percent moisture. Paris green and arsmal are an exception: moisture in the first one may reach 1.2 percent, and in the second -- 2 percent.

As to the shape of particles, oval particles are better than flat or crystalline.

Works carried out in dusting from airplanes of dust-like larvicides for the extermination of malaria mosquitoes showed that powders of a globular shape possess lesser surface and lesser propensity of scattering in the air. Particles with numerous facets form a wider dust wave and settle slower than particles of globular shape. Upon their entry into the intestine of an insect, particles of irregular shape are easier dissolved, other conditions being equal. One should not, apparently, attach much importance to the form of crystals because it depends also on the solvent.

It has been established that the amount of dust applied to a unit of surface is of relatively small importance as far as its effectiveness is concerned. The basic role in this respect is played by the concentration of the insecticide in the dust. At the same norm of insecticide consumption per square meter of surface, concentrated dust is more effective than a less concentrated one.

Moistened dusts represent a finely triturated insecticide (approximately 30-90 percent of insecticide) mixed with a filler and with a surface-active lowering preparation (the moistening agent), or emulgator. Surface-active lowering preparations are called preparations which lead into a direct contact the surfaces of two phases (see "Suspensions").

Investigation of the dependence of the quality of a preparation on the type of filler showed that best results are obtained upon the use of second-grade kaolin. As an adherent for these preparations one can successfully employ potato dextrin added to the preparation in the amount of 3 percent (L. N. Pogodina).

GRANULATED INSECTICIDES

For the control of noxious insects inhabiting the soil, a new form of the use of insecticides has been suggested -- granulated insecticides. Various "inert" substances are used as granules. The particles (granules) must pass through a 30-60-mesh screen. The granules are impregnated with the insecticide. It was calculated that one gram of a granulated preparation contains approximately 30, 000 granules.

The effectiveness of granulated preparations depends on the speed of liberation of insecticides from the granules. The basic factors determining the speed of insecticide liberation are the properties of the preparation and auxiliary substance, as well as the method of obtaining the granules. The size of the granules carrier (within 20-60 meshes) plays a lesser part.

Upon uniform distribution of the granulated insecticide, calculated as 15 kg/hectare, about 45,000 particles, or 4.5 particles per square centimeter, will descend on each square meter; upon a twofold increase (30 kg/hectare) of the amount of the distributed preparation, the number of particles per square centimeter will rise to nine particles.

This number of particles is quite sufficient to achieve a contact of the insect with the insecticide. The amount of insecticide, or toxicant, which absorbs the inactive granulated substance, is very important in the composition of the recipe. The amount of the insecticide may vary from 5 percent to 50 percent by weight; preparations with a 5 percent content of the insecticide are easily dispersed from any given apparatus (Mulla). Any preparation absorbed by an inert substance can become a granulated insecticide.

Granulated insecticides have the advantage over dusts in that, under favorable conditions, they do not adhere to the leaves and fall down to the surface of the soil. Granulated insecticides can be used not only for the extermination of insects -- agricultural plant pests -- but also of other arthropods, including carriers of the causative agents of infectious diseases.

In the majority of cases one does not adhere strictly to the above-mentioned sizes of granules; for example, in California, USA, in 1950-1954 granulated insecticides were used which could pass through a 10-20-mesh screen, 15-24-mesh, and 20-30-mesh screens. At present, most widely employed are bentonitic and "attapulgated" granulated insecticides impregnated with 2.5 or 7 percent thiophos, and sand covered with 1, 2, 5, or 7 percent thiophos. The consumption norm is 0.1 kg/hectare of the preparation.

The physical properties of granules make it possible to use them by means of usual apparatus available in kolkhozes. One can employ apparatus designated for dust spraying by introducing some very slight changes.

Granulated insecticides are much more suitable for dispersion from airplanes; they can be dusted at a wind velocity of up to 5 meter/sec; they are not retained by the leaves and settle on the ground, thus exterminating noxious insects in the soil. In this connection they are very convenient in the control of ticks in forested areas. Granulated insecticides can be utilized in the treatment of shallow reservoirs. For instance, upon treatment of ditches with granules containing bytex, in the ratio of two milligrams of active substance per liter of water, the larvae and pupae of mosquitoes disappeared within 2-3 days and reappeared after 15-17 days.

For pastures and non-cultivated soil the following norms of industrial preparations are recommended in kilograms per hectare: aldrin, 6 kg;

dildrin, 3 kg; heptachlorine, 5 kg; chlordan, 8.5 kg; toxaphen, 30 kg; DDT, 30 kg; thiosoph, 1.5 kg.

According to the data of V. A. Nabokov, the effectiveness of treatment with a 10 percent granulated DDT preparation at the expenditure norm of 20 kg per hectare is quite high. The mortality rate of mature ticks on the processed sections reaches 92-100 percent. It seems to us, however, that this amount of preparation is insufficient for the extermination of ticks.

The advantages of granulated insecticides are as follows: absence of deposits on food and fodder crops; high effectiveness; comparative safety in handling; lesser consumption per hectare, thus permitting a twofold increase of labor productivity per worker, and a fivefold productivity of airplane dusting.

The shortcoming of granulated insecticides is their high cost which exceeds the cost of fluid larvicides 4-10-fold. However, this drawback is compensated by the above-mentioned advantages.

SUSPENSIONS

Suspensions are dispersion systems where the dispersion phase is solid and the dispersion medium is liquid. The limits of dispersive properties are determined by the limit of the colloidal area (0.1 micron), on the one hand, and by the size of particles which are precipitated under usual conditions (tenths of a millimeter), on the other. The dispersive property of suspensions is determined usually by the methods of sedimentation analysis, or by the extent of the absorption of admixtures introduced into the dispersion medium.

In practice, suspensions are made of preparations which are insoluble in water. The suspensions may be monodispersive, containing particles of virtually the same size, and polydispersive which contain particles of various sizes. Usually, polydispersive suspensions are used. Upon preparation of suspensions, dust or powder are added to water. The powders must be of the finest grind, because particles of a coarse grind settle on the bottom and the suspension becomes unsuitable, since its upper layer contains little of the insecticide, while the lower layer clogs up the hand sprayer and spraying becomes difficult.

Upon filtration, the power stirred (suspended) in water remains on the filter, and after a brief period of time (depending on the extent of grinding of the insecticide and its admixtures) it is completely precipitated (coagulated). Upon using a given dust the weighted portion of the powder or paste is placed in a bucket and is thoroughly mixed with a small quantity of water so as to obtain a homogenous mass of semiliquid consistency. Water is then added up to the required amount until a suspension of white or gray color is obtained. Upon application of the suspension or whitewashing material to the treated surfaces, it is necessary to continuously stir or shake the preparations to prevent precipitation of the powder. The suspension stays on the treated surface better than dry dusts.

Recently, to increase the adhesion of solid particles to treated surfaces, moistening powders and stabilizing suspensions have been manufactured which retard the precipitation of solid particles in the aqueous medium (following mixing the powder with the water) and ensure the spreading and retention of the suspension on the treated surfaces. Stable suspensions are obtained by using, as a filler, kaolin or some other amorphous filler in the presence of a surface-active compound.

The suspensions acquire these properties when the composition includes emulsifiers and moisteners (sulfonol-alkylarylsulfonate, OP-alkylphenol ester of polyethylenglycol, etc.), as well as substances which increase the retention of applied particles on the treated surface. In addition, dextrin or other substances are added to increase retention on the treated surfaces. Thus, the moistening dusts represent more complex preparations and, hence, are more costly.

In the preparation of suspensions from insecticide dusts, specially prepared for this purpose, up to 90 percent of the insecticide and 10 percent of the filler, emulsifier, and a surface-active substance (film-forming and moistening substance) are used.

These dusts usually do not cake in storing; upon addition of water they become rapidly moistened and the dust is dispersed in the form of a fine suspension. This fact permits spraying the suspensions or immersing the treated objects in them. Some dusts are moistened directly, depending on the nature of the filler (kaolin, for example); others, however, require the addition of detergents or moistening substances; dusts treated in this manner form suspensions upon mixture with water.

Sedimentation does not exceed 35 percent in 30 seconds, and the content of the active principle in the fractions which have precipitated within 30 and 60 minutes, differs from the initial dust maximally by $\pm$ 3 percent. The great advantage of moistened dusts over regular dusts is the fact that they are prepared from finely pulverized powder. Another advantage of the use of moistened dusts is the presence of a large amount of small particles which ensures the good quality of the suspension and a uniform covering of the surface. The first preparations contained 5-10 percent of insecticide and were not very effective; it has been demonstrated that the presence of large amounts of inert substances masked the insecticide, and that the effectiveness of a definite dose of DDT crystals increased when the amount of inert material was reduced. At present, moistened dusts are manufactured with a 50 percent, even a 65 percent, content of DDT. They are most suitable for use outdoors. Following the spraying of a given surface, the particles retain their insecticide properties for long periods of time (they produce residual deposits), at a minimal penetration in depth of the treated objects.

Aqueous suspensions of these preparations are effective on porous materials (plastering, bricks). The suspended solution becomes absorbed, the solid particles remaining on the surface where they become accessible to insects. On non-porous surfaces (glass, metals, etc.) the suspension does not penetrate inside, remains on the surface with the insecticide particles, dries up and becomes firmly adherent to the surface. Therefore, the deposits do not fall off as easily as dust, although in such cases they are less effective than dusts or emulsions. Each insecticide possesses a definite adherent property which depends on the characteristics of the substance itself or its special ingredients (fixers or pulverizers). For better results, sugar, molasses, soap, starch, glue, gelatine, etc., from 50 to 100 grams per 100 ml of the solution, are added. An excessive addition of these substances considerably reduces the insecticide properties of the preparation. Ultraviolet rays have a negligible effect on these deposits, but they are rapidly washed off from leaves by a strong rain. The addition of gluing substances imparts a greater stability to deposits with regard to rain but reduces the accessibility of these deposits to the insects.

A number of authors showed that mosquitoes (Anopheles) become stimulated to flight upon contact with DDT deposits, regardless of the fact whether small or large particles are present on the surface, and whether they are easily accessible or not. A single contact is lethal only when the deposit consists of small, easily accessible particles; otherwise, the mosquito flies away having received no lethal dose of the poison.

A number of works devoted to the study of the effect of the size of hexachloran particles on their toxicity showed that the smaller the suspension particles the greater its toxicity. The size of particles is basically 30 microns, but in the same dust there are particles of 4, 8, 9, 14, and 17 microns.

Suspension Solution. Upon addition to water of dust obtained from preparations which are fully or partially water-soluble, not only a suspension is formed but also a solution of the suspension. For instance, the solution of chlorophos dust in water cannot be called a suspension, since the preparation is water-soluble. Upon mixing with water the preparation is transformed gradually into a solution. However, a freshly prepared solution of a suspension contains only partially the dissolved preparation, since chlorophos is slowly dissolved in water. In connection with the slow passing of chlorophos from a suspension into a solution, one can assume that, upon the use of the suspension immediately following its preparation, a considerable part of the preparation will be retained on the particles of the filler.

On this basis, we think that this form of preparation would be more correctly called a suspension solution. Hence, a suspension solution represents a preparation form in which the active substance is in a suspended and partly dissolved state. The results of observations showed the expediency of employing these preparations for the treatment of absorbing surfaces.

EMULSIONS AND THEIR CONCENTRATES

Emulsions and their concentrates represent a dispersion system consisting of two immiscible fluids and containing an emulsifier which enables the two immiscible fluids to come into a direct mutual contact, with the result that one of these fluids is distributed (becomes emulsified) in the form of more or less minute droplets within the medium of the other fluid. In high-dispersion stable emulsions the diameter of droplets is about one micron. In many instances the insecticide emulsion consists of a preparation dissolved in an organic fluid (solvent) the droplets of which are suspended in water.

Emulsion represents a form of utilizing insecticides which are insoluble in water but dissolve in organic solvents. If one shakes up two superposed mutually poorly soluble fluids (for instance, water and benzene), one of them (benzene) becomes distributed in the other (water) in the form of minutest droplets of globular shape (emulsion). Upon contact, these droplets become immediately confluent and change again into fluid. To form stable emulsions, emulsifiers are used -- substances which lower the surface tension. The emulsification can be speeded up and the emulsion becomes stabilized by means of various surface-active substances, such as soap. These emulsions, as, for instance, benzene in water with soap, or chlorobenzene with Petrov's contact and soap as emulsifier, are very stable (from one to 12 months). Emulsifiers which contribute to the formation of an emulsion and the increase of its stability are sometimes introduced in the largest quantities, and they serve two purposes: a) they reduce surface tension at the borderline of two fluids, with the result that the formation of a high-dispersion emulsion is facilitated, and b) they form a protective film with a heightened structural viscosity and elasticity on the surface of formed droplets, thus preventing their fusion and ensuring the stability of the emulsion. In a number of instances, the insecticide represents an oily fluid which is directly emulsified in water. Since it is uneconomical and difficult to transport the emulsions of preparations which usually contain only from 0.5 to 4 percent of the insecticide, their concentrates of pastes containing 60 percent of the insecticide are manufactured at the plants.

These concentrates represent a saturated solution of the insecticide, or of several insecticides, in an organic solvent with an emulsifier. As emulsifiers one employs sulfonates of alkaline metals, esters, polyethylenglycols of monoesters of pentaerythritol with higher alkylcarbonic acids, monoesters of sorbite and other multiatomic alcohols with higher fatty acids, soap, Petrov's contact, etc. (N. N. Mel'nikov). Upon appearance of crystals in the concentrates and emulsions, the latter should be heated up to a complete dissolution of the crystals formed. To obtain working emulsions the concentrate is diluted with water up to the desired dilution.

The emulsions behave on many surfaces the same as solutions, and the loss of effectiveness on the surfaces takes place in the same way as it does in solutions. The emulsions can be used in the treatment of surfaces of synthetic materials, but they cannot be used in the treatment of wires or cables. The emulsions leave spots on the treated surfaces. Upon the use of an emulsion concentrate containing a non-volatile solvent, there remain deposits of the insecticide solution in the solvent on the treated surface, following the evaporation of the aqueous phase of the prepared emulsion; when, however, the solvent in the concentrate is of volatile nature, then after the evaporation of the aqueous phase as well as of the organic solvent, there remain only deposits of the insecticide alone on the surface of the treated object.

Emulsion-Suspensions. In the preparation of dusts and concentrated 15-25 percent emulsions, a number of difficulties are encountered in the technology of production as well as in the application in disinsection practice. In particular, the manufacture of dust is cumbersome, requires powerful grinding and mixing apparatus, large production expenditures and a considerable amount of an inactive filler (its basic mass is talcum). From the labor point of view the manufacture of dusts has the drawback that the air in working quarters is filled with dust; in addition, the dust is rather poorly retained on the treated surfaces. The manufacture of emulsion, although technically less complex, nevertheless, requires a considerable expenditure of turpentine or white spirit. The manufactured emulsions are insufficiently stable at low temperatures and deteriorate during the winter. The large content of solvents in the preparation leads to its absorption in the treated surface which results in the reduction of the amount and concentration of the active ingredient on the treated object. In addition, the layer of preparation left on the surface is greatly absorbed by the surface and poorly adheres to the insect's body, thus resulting in a sharp reduction of the toxic effect of the preparation. The emulsions, due to their specific physico-chemical properties, can be kept only in heavy metal containers.

The emulsion-suspension suggested by S. F. Bezuglyy, A. V. Molchanov and Yu. N. Bezobrazov, due to its physico-chemical properties, composition and method of production, lacks the above-mentioned negative properties.

The DDT emulsion-suspension is a mass of white color, does not diffuse, is easily cut with a knife, and exudes a mild insecticide odor; its specific gravity is 1.3. The product can be packed in any hard container. Upon addition of water, the emulsion-suspension concentrate forms a stable colloid system consisting of globular droplets of the insecticide solution in oil, 1-2 microns in diameter, and of the insecticide in microcrystalline form, 3-4 microns in size. The dispersion medium is water. The stratification, coagulation and sedimentation virtually do not occur during the first 24 hours. Applied to an object the crystals remain on the surface. The emulsion-suspension consists of 50-65 percent insecticide, the remaining quantity representing a solvent and emulsifier. Before using, the concentrated preparations are diluted with water (Table 24).

Table 24

Calculation of Disinsection Substances Essential for the Preparation of Working Emulsions and Suspensions from Concentrated Preparations

Percentage of Insecticide in the Plant Product	Amount of the Insecticide (in Grams) Required for the Preparation of One Liter of a Working Emulsion or Suspension				
	0,5%	1%	2%	3%	5%
5	100	200	400	600	1 000
7	71,4	142,9	285,7	428,6	714,3
10	50	100	200	300	500
12	41,7	83,3	166,7	350	416,7
15	33,3	66,7	133,3	200	333,3
20	25	50	100	150	250
25	20	40	80	120	200
30	16,7	33,3	66,7	100	166,7
40	12,5	25	50	75	125
50	10	20	40	60	100
60	8,3	16,7	33,3	50	83
65	7,7	15,4	30,3	46,2	77

Note: To obtain the needed amount of the preparation per bucket of 10-liter capacity, the figure obtained should be multiplied by 10.

An analogous emulsion-suspension (paste) was suggested by N. A. Fuks ("TsNIDI (Central Scientific Research Disinfection Institute, Moscow) paste"). The auxiliary substance OP-10 (alkylphenylester of polyethylenglycol) represents the best emulsifier-stabilizer produced by the chemical industry; it ensures an adequate diffusion of the preparation on the treated surface. Due to the presence in these preparations of the surface-active substance OP-10, the formed insecticide layer possesses, as to its physical properties, a loose (non-solid structure which ensures a good contact with the insects; as a result, the preparation crystals easily adhere to the insect's body, thus increasing the effectiveness of the insecticide. Water, combined with the emulsifier, imparts a dispersion property to the system and represents a medium which prevents the formation of crystalline agglomerates of the hydrophobic insecticide and the opalescence of the oil droplets.

INSECTICIDE SOAPS

The use of soap containing certain preparations (phenol, naphthalene, petroleum, sulfur, nicotine, tar, turpentine, volatile oils, etc.) has been known for a long time. However, all previously manufactured soaps possessed hardly any insecticide properties. Only K-soap, manufactured about 20 years ago, exerted some effective action due to its ingredient -- bis-ethylxanthogene. At present, soaps are made containing 5 percent DDT, 3 percent hexachloran, or 10 percent acetophos. The manufacture of insecticide soaps presents no special difficulty and consists of mechanical mixing of the liquid or solid preparation in a solution with a finely-cut regular household soap on a boiling water-bath. The cooled soap (upon addition of a colorless insecticide) scarcely differs from regular household soap, but acquires the odor of the preparation or of its solvent (if the latter is added). If the insecticide is stained (tar), the soap acquires a corresponding color (black, in the case of tar).

The effectiveness of the insecticide in the soap is the same as in an aqueous soap-emulsion or solution, providing that the insecticide does not deteriorate in an alkaline medium; in this case, the insecticide soap loses in storage its disinsecting properties. To obtain greater effectiveness, one adds to the soap, in addition to the preparation, also 2-5 percent of a solvent (oxydiphenyl, white spirit, gasoline, turpentine, CK, vaseline, furfural, 2-2.5 percent of diphenylamine, etc.). The effectiveness of this type of soap is greater than the activity of soap containing an insecticide only (V. I. Mutovin, S. V. Zhuravlev, L. N. Pogodina, S. G. Gladkikh, et al.).

The low percentage of DDT preparation or of hexachloran in the soap permits its use as regular soap in washing the body, hair, and linen. Rinsing of linen which was washed with hexachloran soap and ironing somewhat reduces the duration of its insecticide effect.

INSECTICIDE OINTMENTS

Insecticides (DDT, hexachloran, pyrethrum, K-soap, etc.) are used in the form of ointments. They are prepared by mixing the insecticide, first with vaseline oil and then with vaseline, until a homogenous mass has been obtained. As an example, we shall cite the composition of a hexachloran insecticide ointment: hexachloran, 3 percent, vaseline oil, 10 percent, and vaseline, 87 percent. The composition of an insecticide ointment containing acetophos, includes vaseline oil (69-70 percent), ceresin (18-18.5 percent), paraffin (3-5 percent), acetophos (3-5 percent) and 3 percent perfumed base.

INSECTICIDE PENCILS

In view of the shortcomings inherent in dusts (crumbling from the sprayed surface, irritating effect on the nasopharynx during dusting), in some instances insecticide pencils and graters are used. The length of pencils is 10-12 cm, diameter, 1.5 cm, weight, 20-21 grams; the graters have a form of a broad flat plate with a cross section of 9 x 18 cm. Their method of preparation is identical. According to the method elaborated by Yu. N. Bezobrazov, A. V. Molchanov and V. N. Pivovarov, the composition of insecticide pencils includes, as plasticizers, beeswax and paraffin, and as a filler -- talcum and kaolin.

The preparation process of pencils is as follows: in a heated container with a stirrer (for instance, in an iron tank) the weighed plastificates (wax and paraffin) are melted and hexachloran is added to the obtained fused mass. After the loaded components have turned into a homogenous liquid mass (one must avoid excessive heating and prolonged melting), one adds to it the required amount of filler under constant stirring (talcum, kaolin, or ground chalk); a thick viscous mass is formed. The melted mass is poured into metal forms and cooled until it has become completely solidified. Rods of the insecticide mass (pencils), obtained after molding, are pasted around with paper, and the little bars and graters are glued to wooden slabs. The pencils and grater may contain from 1 to 70 percent of the insecticide, up to 7 percent of beeswax, 32 percent paraffin, and up to 60 percent talcum.

For the control of pediculosis, streaks are made with pencils, with 4-5-cm spacing between each streak, on the inner surface of the linen, clothing, and bedding in the most favored places of the lice habitat (collars, belts, folds, seams, etc.). For the control of bedbugs, flies, cockroaches and other insects, streaks of 4-5-cm intervals are made with pencil on the surface of various objects, furniture, windows, etc. Pencils can be employed also for disinsection by applying the insecticide to broadcloth, wool and other materials, or on a brush, with subsequent rubbing of the treated surfaces. The surfaces and tissues treated with hexachloran pencil retain their insecticide properties up to 1-1/2 months, and in the storing of soft objects -- up to six months. A massive treatment with pencil of body linen, bed linen and clothing is not recommended because hexachloran is easily evaporated; the vapors of this preparation are harmful to man upon prolonged use of clothing treated with this insecticide.

LACQUERS AND DYES

Upon employment of insecticides introduced into the composition of dyes or lacquers for the treatment of surfaces in buildings, the insects perish either as a result of contact with the surface (DDT -- hexachlorocyclohexane) or as a result of fumigation in contact action (aldrin).

Insecticide lacquer is used at present in the majority of countries for the processing of ships: in England, about 2000 cargo-carrying ocean-going vessels are free of insects. Lacquers containing insecticides and applied to the surfaces are highly effective in the control of bedbugs as well as house-ants, flies, mosquitoes, and barn pests. Following treatment of sea and river ships, they become uninhabitable to cockroaches and other arthropods, at least for one year.

The most convenient method of using insecticide lacquers is the use of special aerosol bombs, but they can also be applied with a small brush. Packages of insect-lacquer manufactured by the Shell firm (England) and containing 4 percent dildrin, weighing 4.5 kg, are sufficient for covering at least 80 square meters. Lacquers and dyes containing insecticides are fully adequate for treating uninhabited premises, including warehouses. Insecticide dyes and lacquers are used in control of bedbugs in the cages where laboratory animals are kept.

D. F. Yazykov, V. A. Rundkvist, and V. Ya. Raygorodskaya showed that there is no need of dissolving insecticides preliminarily in organic solvents, because at 40-50° they are easily and fully dissolved in natural drying oil and other oils, with the formation of homogenous solutions. Insecticide drying oils (for oil paints) and lacquers (for enamel paints) were mixed in the regular manner with pigment paste. Dyes, containing 5-18 percent DDT, 1-5 percent hexachloran, or 8 percent DDT + 2 percent hexachloran, do not lose their dyeing properties for long periods of time; they dry up at the established time periods, do not lose their shade, and preserve their luster and water-resistance. A number of authors recommend insecticide dyes with a high DDT content of 10-20 percent. It is perfectly obvious that the presence of DDT in such quantities has a negative effect on the quality of dyes. For instance, P. I. Nikitin and N. I. Fomicheva noted that damp spots appear after a certain period of time on surfaces painted with a dye containing 10 percent DDT. A dye containing 15 percent DDT does not dry up for two months or longer. As solvents of DDT, turpentine, kerosene, white spirit, benzene, xylol, amyl acetate, diethylketone and chlorine derivatives of hydrocarbons were used.

McCay recommends insecticide lacquers containing 20 percent DDT and 2 percent hexachloran, or 10 percent DDT and 5 percent hexachloran. For painting ships and harbor buildings for the extermination of brown cockroaches a gamma-isomer of hexachloran can be added to lacquers. Townsend studied the effect on roaches of surfaces covered with lacquer containing 4 percent dildrin; these surfaces retained their toxic effect on roaches for 180 days; within 24 hours following application of lacquer, the death rate reached 90 percent, and within three days -- 100 percent.

Cyclic compounds containing epoxy- and endomethylene groups (for instance, epoxy-hexachloroendomethylene-naphthalene) prolong the insecticide effect of lacquers. Surfaces painted with this insecticide lacquer retain their effectiveness against every species of insects for prolonged periods of time. A sample lacquer of this type comprises four parts of epoxy-hexachloroendomethylene, three parts of gamma-isomer of hexachloran, 25 parts of titanium dioxide (TiO_2) and 68 parts of this lacquer from the copolymer of vinyl chloride and vinyl acetate.

To increase the length of preservation of the preparation on the treated surfaces, insecticide resins are used. The use of urea-formaldehyde resin causes formation of a very hard film, with the result that the insecticide appears to be "sealed" in it; if one adds to this resin an alkyd oleoresin, as a plasticizer, a softer film is formed and the insecticide is then able to "migrate" to the surface.

For the introduction of DDT or dildrin in the resin, the best ratio is 50:50 (urea-formaldehyde resin). For volatile substances (hexachloran, aldrin) it is recommended to take 40 parts of the insecticide and 60 parts of the resin.

According to the data of A. A. Nepoklonov, I. G. Fel'dman, L. N. Barmina and I. Z. Abezgauz, most effective are urea-formaldehyde lacquers combined with the gamma-isomer of hexachloran, and with a mixture of gamma-isomer of hexachloran with DDT, hexachloran, etc.

Following application of lacquers to a given object, the insecticides are gradually transposed from inner layers of the film to its surface. The prolonged retaining of insecticide properties by the treated surfaces is due to the fact that the insecticide crystals are gradually liberated to the surface of the lacquer. Upon employment of DDT, dildrin, etc., the surface becomes covered with needle-shaped crystals; this phenomenon was named "blossoming." When the insect crawls on such a surface it removes the crystals, but after a little while the crystals reappear on the surface.

A single treatment with lacquers containing an insecticide not only ensures a complete elimination of cockroach contamination of the treated area but it also prevents a new contamination of the premises for a year's period. This insecticide treatment is effective also in regard to bedbugs, brown house-ants, flies, mosquitoes, and pests of food products (small beetles).

Crystals which are formed on the surface of the dye are much smaller than the ones formed with the use of the usual insecticide solutions (5-10 microns long); they adhere easily to the legs of insects; thus, a brief contact (30 seconds) of the mosquito is entirely sufficient to subsequently produce a lethal effect. In regard to house-flies and red cockroaches, dildrin is much more effective than any other preparation; it is 200-fold more toxic than DDT.

Insecticide lacquers containing 1.5-2 percent of hexachloran and applied to the surface in the amount of 40-60 ml/m^2 retain their toxic properties for a long period of time in regard to insects, including red and oriental cockroaches.

The death of cockroaches is observed for 820 days from the moment of insecticide application, at a 24-48-hour continuous contact; for the extermination of bedbugs, a contact is necessary with the painted surface for 48 hours.

Cockroaches, following a 24-hour contact with the dye-covered surface which contains 2 percent hexachloran, perish within two days; with the use of a dye containing 5 percent DDT, within 4-5 days; the extermination proceeds gradually. Upon introduction of large quantities of the insecticide flies also perish.

D. V. Yazykov notes that, upon the use of lacquers with dildrin and aldrin, as well as dyes and lacquers with hexachloran, the female cockroaches, after contacting the surfaces, ejected their oothecae at any stage of the development of the latter; the author never noted any coming out of larvae from the oothecae.

Some authors recommend a compact covering of the surfaces with insecticide-containing lacquers. We do not think that this method of application of lacquers is correct. It is more expedient to apply the insecticide lacquers and dyes in the form of streaks. The processing is limited to the loci of habitation and propagation and to the paths of movement of the insect. For instance, in combatting cockroaches, every crack, hole and hiding place of these insects is treated with dildrin by applying it on the outside in the form of streaks 3-10 cm wide. Cockroaches are night insects; they usually avoid light; it is, therefore, necessary to treat thoroughly the interior of cupboards, the rear walls of chests, the lower sides of tables, chairs and other furniture. It is essential to know the ecology of cockroaches in order to carry out the proper treatment. A somewhat different approach is needed in the control of flies. In the case of the latter, there are favored places where they crawl (projections, corners, hanging objects, etc.). All these places should be treated in the form of circular streaks; this will ensure a complete success of disinsection. In combatting ants, the method of processing is also different; it must be based on their habits and life cycle.

In applying the insecticide lacquer on the surfaces, the disinfector must wear a mask so as to avoid constant inhalation of vapors of the solvent used in the preparation of the lacquer. It is also essential to be careful when mixing the lacquer because an acid catalyzer is used in the transformation of the lacquer into a solid glaze. This acid catalyzer should be added to the mixture directly before using and precisely in proper ratios. Following its application the lacquer congeals within 30-60 minutes and forms a bright, transparent and solid glaze which retains its appearance for several years.

The insecticide lacquer should not be applied indiscriminately all over because it is not a simple "coating" of surfaces; it is an insecticide and it must be used only where crawling insects are present or are presumed to be; the area to be covered depends on the treated object. For instance, in workers' premises the disinsection area is reduced to a minimum.

A study of the hexachloran content in the surface layer and in the air of premises treated with hexachloran dyes and lacquers showed that, at a concentration in the surface layer of not more than 0.12 gram of hexachloran per square meter (at a total hexachloran dose of 2 grams per square meter), the air in the treated premises contains about 2 milligrams of hexachloran per cubic meter.

Neither can we agree with the idea of using hexachloran in wallpaper glue, because it is volatile and because vapors of this preparation escaping in residential premises may be harmful to the inhabitants.

BAITS CONTAINING INSECTICIDES

Baits of this type are used in the deratization and disinsection. They are used, for instance, in the extermination of cockroaches, flies and house-ants. The principle of their use is based on the addition of poisons to dry and liquid food products (sugar, water with honey and sugar, fruit remnants, beer, yeast, etc.). In some cases the poisoned baits are placed in containers from which the insects, once entered, are unable to crawl out.

A detailed description of baits has been given in the corresponding chapters (see "Means of Attracting Insects -- Attractants").

INTRODUCTION (FEEDING) OF INSECTICIDES INTO THE ORGANISM OF WARM-BLOODED ANIMALS

Insecticides, following their introduction in the soil, are absorbed unaltered by plants and impart to the latter toxic properties. They are called systemic insecticides. The same name is applied also to insecticides which, introduced in definite amounts, impart to the blood of the animals toxic properties in regard to insects. At the same time, these doses are harmless to these plants or animals.

V. I. Vashkov was the first to report in the USSR (1948) that the blood of animals who received DDT is toxic to bedbugs and lice. A complete extermination was observed in some experiments with bedbugs, fed on the blood of these animals. Most toxic turned out to be the animal blood fed to insects within 12-48 hours following administration of this preparation to rabbits. V. A. Bayko (1956) tested the effect of DDT-containing baits on house mice and tick larvae.

In organizing extermination work in the foci of transmissive diseases, it is very important to be familiar with the method of single-stage extermination of the carriers and their hosts, since a solution of this problem would permit coming closer to the complete eradication of the natural foci of infection. The method of introduction of insecticides into the organism of animals is used in combatting a number of arthropods: subcutaneous warble flies (Hypodermatidae), gnats, mosquitoes, ticks, etc.

The problems of the use of poisons in the control of rodents and their ectoparasites have not been sufficiently elaborated as yet.

Associates of the All-Union Antiplague "Microbe" Institute demonstrated (1957) the possibility of extermination of fleas and sand-lances by means of baits containing DDT.

M. K. Fedorov (1957, 1958) elicited the length of preservation in the blood of aldrin, dildrin, chlordan and DDT (up to 10 days), and demonstrated the possibility of their use for simultaneous extermination of rodents and their ectoparasites in the foci of hemorrhagic fever. The systemic effect of certain preparations on fleas and gray marmots was shown by S. V. Vishnyakov and coauthors. S. A. Shilova and Yu. Shchadilov (1963) demonstrated the possibility of using systemic poisons in forest deratization which simultaneously exterminates rodents and their ectoparasites, thus permitting the removal from the epizootiological process Gamasidae ticks and fleas whose role in the transmission of tick encephalitis virus has been proven at present (Ye. N. Levkovich, A. A. Tageltsev, Z. G. Kulakova). It is known that there are no other methods of controlling these groups of arthropods under forest conditions.

Aldrin, dildrin and other products are used also in a mixture with zinc phosphide, or ethylfluorohydrin, difluoran, etc. When baits containing these preparations have been digested, the blood of rodents acquires toxic properties in regard to arthropods. This method can be employed in the prophylaxis of plague, tick encephalitis and skin leishmaniosis (E. B. Kerbabayev). Presumably, it can also be used in the prophylaxis of hemorrhagic fever, tick rickettsiosis, tularemia, and other infections.

A large number of insecticides is recommended at present for administration to animals for the purpose of extermination of arthropods.

They are also used in the prevention of proliferation of flies.

The extermination of rodents as well as their ectoparasites is achieved by means of preparations such as pivalylindandione, heptachlorine, etc. possessing simultaneous raticide and insecticide properties.

There are numerous observations attesting to the fact that, upon introduction of a number of insecticides into animal fodder, including that of birds, their feces acquire insecticide properties. For instance, Eddy and Roth fed an insecticide to cows for five days. At the end of this period, samples of their feces were infected with young larvae of flies. The toxicity of remnants of the insecticides was determined according to the number of born flies and their fertility. Of 25 tested insecticides the most toxic to the larvae of houseflies were Bayer 22408 (O, O-diethyl-O-naphthylaminothiophosphate) coralline; upon administration of these preparations to animals with their food in the amount of 1 mg/kg a complete unsuitability of the dung for the development of larvae was observed. When baytex (50 mg/kg) was fed, no complete destruction of larvae was noted. Bayer 22408 and coralline were more effective on larvae of the autumn stable fly than on larvae of houseflies and small horn fly.

Mature flies of three species, bred in the dung of cows which contained remnants of some insecticide, possessed in all cases normal fertility and their eggs showed normal viability. In tests with direct introduction of the insecticide into the dung, the minimal doses of Bayer 22408 and ronnel for the larvae of the three fly species were within the range of 0.1 to 1 mg/kg (of feces). In the case of larvae of houseflies and stable flies, coralline and ronnel possessed similar toxicity (0.25-0.5 mg/kg), and for larvae of the small horn fly they proved to be twice as toxic.

Drummond investigated the toxicity of 10 insecticides on Musca domestica L and the small horn fly (Haematobia irritans L.) following their addition to cattle fodder for 1, 2, 3, 5, 8, and 91 days. Samples of manure were analyzed for larvicide activity. In the 91-day experiment, coralline and Bayer 22408 (O, O-diethyl-O-naphthylaminothiophosphate) in the dose of 0.5 and 1 mg/kg per day, caused a complete extermination during the first week. In the 10-day experiment, phomaphos (O, O-dimethyl-O-p-dimethylsulfamoyl-phenylthiophosphate), Bayer 3734 (O, O-diethyl-O-4-methylthio-3, 5-xylyl-thiophosphate) in a dose of 5 mg/kg, Bayer 37342 (O, O-dimethyl-O-4-methylthio-3, 5-xylyl-thiophosphate (10 mg/kg), and General Chemical 4072 (2.5 mg/kg) caused complete extermination of the horn fly. The same insecticides, with the exception of O, O-dimethyl-O-p(dimethylsulfamoyl)-phenylthio-phosphate, are just as effective against the housefly. Butonate (10 mg/kg), Bayer 29493 (O, O-dimethyl-O-4-methylthio-m-tolylthiophosphate) and Schtaufer 1504 (O, O-dimethyl-S-phthalimidomethyldithiophosphate) (2.5 mg/kg) were effective against the horn fly and mildly toxic to the housefly.

Upon addition of Bayer 9018 preparation (O, O-dimethyl-O-4-methylthio-3, 5-xylyl-phosphothioat) to drinking water in the amount of seven parts per million, effective results have been obtained in the control of warble flies.

In order to ascertain the possibility of feeding insecticides for the prevention of fly-breeding in manure, Sherman determined the lethal dose of 22 insecticides (LD_{50}) for chickens.

He experimented with chicks 7-14 days old, 5-30 chicks in each test. Insecticides were administered to the chicks orally in gelati capsule. In addition to the determination of LD_{50}, observations were carried out on their clinical state, weight increase, and the extent of assimilation of food during constant feeding for 1-2 weeks of 16 insecticides, added in various concentrations to the feed or drinking water. It was established that LD_{50} in milligrams per kilogram is: a) for phosphoroorganic compounds: O, O-dimethyl-5-(N-ethyl-carbomoylmethyl) dithiophosphate (American Cyanamide No 18706) -- 79.4; for O, O-diethyl-O-naphthylaminothiophosphate (Bayer 22408) -- 31.69; O, O-diethyl-O-(4-methylsulfinyl) thiophosphate (Bayer 25141) -- 0.991; leubocide, or O, O-dimethyl-O-(4-methylthio-3-tolyl) thiophosphate -- 28.4; dimethoate -- 36.6; phosphamidon -- 9.04; delnav -- 170; dayco "105" -- 1180; dayco "109" -- 565; DDVPh -- 14.8; dicapton -- 248; coralline -- 14; phosdrin -- 7.52; b) for chloroorganic compounds: kepon -- 480; pertan -- 5000; heptachlorine -- 62.4; stroban -- 139; c) for carbamate compounds: isolan -- 3.32; sevin -- 197; pyrolan -- 10.9. The death of chicks would set in from phosphoorganic and carbamate compounds within 24 hours, from chloroorganic compounds -- within 1-5 days. Upon feeding ruslen, dayco "105," dayco "109," pertan and sevin in doses of 22-440 mg/kg, no changes were observed in the clinical state of the chicks, their assimilation of food or rate of growth, as compared to control chicks. Upon the use of Cyanamide 18706, Cyanamide 12008, Bayer 22408, dimethoate, delnav, and pyrolan in doses of 440-220 mg/kg, a retardation of growth was observed. Bayer 25441, phosphamidon, kepon, and isolon in doses of 220 mg/kg and higher, as well as leubocide in a dose of 440 mg/kg, caused the death of some or all animals; upon the use of smaller doses of leubocide, Bayer 25141, or kepon, a retarded growth was observed in the surviving chicks.

Kepon proved to be the only insecticide which induced symptoms of poisoning in chicks within various time intervals, regardless of the administered dose, thus attesting to the considerable cumulative effect of this insecticide in the chick's organism.

The above-cited data indicate that, upon feeding insecticide for the purpose of combatting insects, it is essential to take into account not only the insecticide properties of the preparations but also their toxic effect on the animals.

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CHAPTER XII

SYNERGISM AND ANTAGONISM OF INSECTICIDES

Many insecticidal preparations are mixtures of two or more compounds having a physiological action on insects. The synergistic or antagonistic activity of compounds contained in a mixture can have a significant influence on the effectiveness of the preparation (the mixture).

Synergism (from the Greek, Synergeia – collaboration, joint action) is the reaction of an organism to the combined (collective) influence of two (or several) pharmacological agents; it is characterized by the fact that the effect of a given combination exceeds the sum of the effect of the components making up this combination.

The phenomenon of synergism can be explained by various mechanisms, not all of which as yet have been studied. It is well known that synergism is observed in those cases, when one of the components of combined pharmacological agents blocks the activity of an enzyme participating in the inactivization of a second. Such a mechanism, for example, lies at the basis of the synergism between acetylcholine and the anticholinesterase substances (the organophosphorous insecticides). The phenomenon of synergism is also observed in those cases, when one of the components of a combination blocks the pathways of excretion from the organism of another active component. In pharmacology synergists are those chemical substances, whose joint action on the animal organism brings about an intensification of the effect rendered by each of them.

An increase in the effectiveness of a preparation can be achieved not only as a result of the addition of a synergist, but also as a result of: 1) improving the adherence of an insecticide to the integument of an insect, 2) the formation of more toxic compounds upon the decomposition of the preparation in the insect organism or an increase in the stability of an insecticide achieved by a chemical reaction, 3) increasing the permeability of the insect cuticle, 4) affecting the behavior of an insect (reducing its activity). These methods of increasing the effectiveness of an insecticide are not considered to be synergism.

Antagonism is one of the possible results of the simultaneous application of chemical preparations which differ in their physiological effect; it is characterized by the complete suppression or by the attenuation of the effect of one substance by another. Thus if the biological activity of a mixture is less than the biological activity of its strongest component, then it is said that in this case antagonism has taken place. Physicochemical or false antagonism and physiological antagonism are distinguished. At the basis of physical-chemical antagonism, or antidotal interrelations, usually lie the adsorption of a poison by another agent, the inhibition of absorption, the mutual suppression of dissociation or solubility, the formation of insoluble or slightly poisonous compounds and processes similar to that. Physiological antagonism is certainly realized by the interaction of pharmacological agents through the functional systems of the animal organism (insect). It is due to the stimulation (or suppression) by one substance of the function of another, or as a result of the stimulation of functions opposed to each other in a physiological sense by agents. In the first case direct antagonism is defined, in the second – indirect antagonism. The presence or absence of antagonism also depends on the species of animal, also including an insect.

For the purpose of obtaining a highly effective and rapidly acting preparation mixtures are compiled, which contain insecticides, which are distinguished by the mechanism of their action. Thus, to DDT are added pyrethrins, which rapidly paralyze insects, whereas although DDT possesses high insecticidal properties, it acts slowly. This mixture rapidly and reliably kills insects; furthermore, it possesses somewhat higher insecticidal properties than DDT alone.

The high cost of natural pyrethrins and such valuable qualities, as low toxicity to man and the ability to rapidly paralyze insects, undoubtedly stimulated the search for synergists. As a result it was established that among a number of tested vegetable oils the most active synergist was sesame (benne) oil. The synergistic activity of sesame oil is partially explained by the presence in its molecule of sesamin.

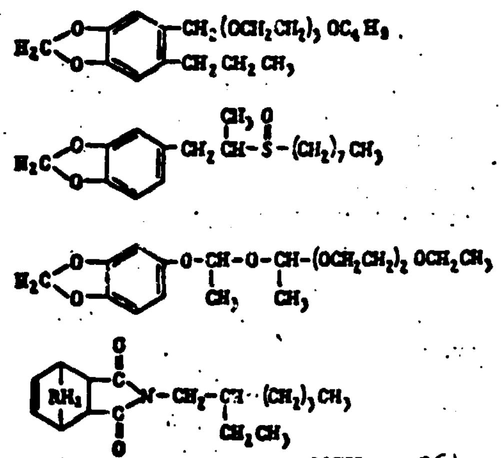
It was found that pyrethroids in the organism of insects are more slowly metabolized in the presence of synergists. This served as the basis for the synthesis and the investigation of a large number of methylenedioxyphenyl derivatives. It was determined that a considerable portion of these compounds possesses synergistic ability; of these the greatest activity if possessed by 1) piperonyl butoxide, 2) piperonyl cyclonene, propylysol, and sulfoxide, 3) sesoxane.

I

II

III

IV



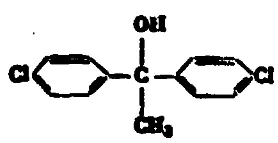
MGK = 264

Sesoxane was discovered after it was established that among the components of sesame oil there is the substance sesamolin. Sesamolin differs from sesamin by the fact that its methylenedioxyphenyl groups are combined with the central part of the molecules by an oxygen atom.

Piperonyl butoxide continues to remain a very important synergist for the pyrethrins because of a number of well-expressed positive qualities: it possesses high effectiveness as a synergist with respect to many species of insects; it is safe for man and warm-blooded animals; it is readily miscible with many organic solvents, including mineral oils and aerosol propellants; it does not possess an odor and it does not leave spots; it is stable under all conditions of storage.

Besides the methylenedioxyphenyl derivatives, other substances have also been discovered which are synergists of pyrethrin: calcium phthal-6-amide, N-replaced benzamides, N-replaced p-bromobenzene-sulfamides, and others. In recent years the synergist MGK-264 has been applied. The methylenedioxyphenyl compounds usually utilized as synergists of pyrethrin on the whole exceed the synergist MGK-264 [N-2-ethylhexyl)-bicyclo-(2.2.1)-5-heptene-2-3-dicarboximide]. Allethin is activated to a lesser degree by these compounds than pyrethrin.

The activity of synthetic insecticides can also be increased. The appearance of house flies resistant to DDT stimulated the search for synergists for a given insecticide, inasmuch as it was expected that synergists would make it possible to apply DDT against resistant flies just as effectively, as previously. Of the large number of studied synergists the most active turned out to be: bis-(p-chlorophenyl)-chloromethane, bis-(p-chlorophenyl)-ethane, bis-(p-chlorophenyl)-methylcarbinol (DMC).



With the addition to DDT of these three compounds in the amount of 7-10-7% its activity with respect to resistant strains of houseflies increased by 50-100 times, and with respect to sensitive strains of houseflies by 5-10 times. It is possible to state that the toxicity of DDT to resistant flies is activated by many compounds, containing two pairs of phenylholoid groups, but the highest activity was noted in the case, when a chlorine atom is found in the para position. If one of the components of the mixture at this concentration at which it is proposed to introduce it into the mixture does not possess insecticidal properties, then it is assumed that in the mixture it also will be nontoxic to insects. Consequently, the increase of its effectiveness in the mixture can be attributed to synergism. The coefficient of toxicity is calculated by the formula:

$$\frac{LK_{50} \text{ of an insecticide without admixtures}}{LK_{50} \text{ of an insecticide in a mixture}}$$

If the results of the calculation are considerably greater than unity, then synergism has occurred and if less than unity, then antagonism has occurred. Thus, for example, if the LK_{50} [Translator's Note: LK_{50} — term not identified] of metaphos is equal to 0.0055%, then after the addition of 1% sesamex the LK_{50} decreases to 0.015%, or $0.0055\frac{0.0055}{0.015} = 0.36$; the results of the calculation indicate obvious antagonism. In literature the coefficient attesting to an increase or decrease in insecticidal properties is called cotoxicity.

This coefficient indicates only the apparent final result of the processes, and if the coefficient is insignificantly larger or smaller than unity, then the presence of synergism or antagonism cannot be demonstrated by statistical treatment of the materials.

The most significant increase in toxicity with respect to house flies (38.7 times) is observed with a mixture containing methyl-3-[ethoxy(p-dimethylaminophenyl)phosphenyloxy] crotonate and 1% sesamex. The results of the determination show that the synergistic or antagonistic activity is explained mainly by the suppression of certain biological oxidizing systems, which activate or detoxicate the compounds. For cyclodiene compounds after the addition of certain synergists an increase in toxicity is not observed. The toxicity of the organophosphorus and cyclodiene compounds, according to Sun Yun'-bey, Johnson, in some cases is increased, in others is decreased as a result of the addition of sesamex. Thus, for example, the activity of malathion with respect to body lice is increased by 10 times as a result of the addition of N-isobutylundecylenomide. With the addition of sesamex to thiophosphates and to thiophosphonates antagonism is noted, but with its addition to organophosphorus compounds containing the vinyl group, and also with its addition to aminoxalate $N(C_2H_5)_2$, to schradan – $N(CH_3)_2$ synergism is observed.

Many mixtures of haloid-containing (especially chlorine-containing) insecticides are somewhat more toxic as compared to the most toxic compound of the mixture. A mixture of DDT with the gamma-isomer of hexachlorane is considerably more effective than each of the insecticides separately. As observations have shown, mixtures containing volatile, rapidly acting compounds, and stable, slowly acting insecticides are considerably more active than mixtures, which contain monotypic compounds. As yet there is little data which make it possible to state beforehand with which combination of insecticides synergism will be observed.

Of the 2900 different insecticidal preparations (aerosols, preparations for spraying, disinfecting powders, and fumigants), which in 1958 were on the market in the United States, 25.3% were mixtures containing two or more active ingredients.

CHAPTER XIII

AGENTS, ATTRACTING INSECTS (ATTRACTANTS)

Various substances due to their physical and chemical properties can attract insects, acting on their sensory organs (olfaction, sight, taste, touch, tactile sensitivity).

The most highly developed in insects is olfaction, but for attracting them there can also be used along with olfactory stimuli auditory and visual stimuli.

Light traps have found broad application as lures. For the purpose of increasing their effectiveness there has been recommended the addition of lysin (a component of blood, attracting mosquitoes) and to change the air blast.

Insects react differently to color. For example, orange and black attract flies, but blue repels them.

The ability to react positively or negatively to any substance or phenomenon has vitally important significance for insects. At the present time great attention is being allotted to this question. Among the attractants there belong substances or preparations (including fodders), whose effect brings about in arthropods a "locomotor" reaction (i.e., a motor reaction). The majority of attracting substances lead insects to a definite goal: feeding, copulation or ovipositing. As a rule, attracting substances possess volatility; their vapors reach the olfactory or other receptors of insects, causing an appropriate response reaction. Thus, attractants are perceived by insects through specialized chemoreceptors.

Individual species of insects differ considerably in their reaction to odor because of the great distinctions in biology and ecology. There are substances which repel some and attract other insects. The strongest attractant substance forces insects to make "directory" movements in the direction of the stimulus; attractants act at a distance approximately like light and sound.

Substances attracting insects can be an effective means of attracting them for purposes of their calculation or extermination. Such substances can be found in nature (in their natural form) or can be obtained synthetically (Alexander, Lindquist). The effect of an irritant on one organ causes in insects a change in the state and functioning of other sensory organs; especially intense is the interaction of the tactile-motive and visual apparatuses. The odor of substances, on which arthropods feed, or the odor of a host, on which they feed, and also heat, light, and so forth attract insects; in certain cases light (especially bright light) repels them. Right up to the present time the mechanism of the action of attractant and repellant preparations has not been completely studied; of paramount importance, obviously, are the chemical structure and properties of such substances.

The most powerful are the sexual attracting substances, which can act on insects at great distances (Beroza, Green). However, the majority of recommended attracting substances acts at distances of tens of centimeters, and certain ones only at a distance of several centimeters (Schoor). Of considerable interest are not only the sexual attractants, but also substances secreted, for example, by ants, which mark their trail in searching for work; working ants strictly follow these trails. At present the structure of these secreted substances is already well-known; they are called pheromones or ectohormones.

Of great importance is the concentration of the preparation, since the same substance at some concentrations attracts, and at others does not cause any reaction, and at still other concentrations repels arthropods. A good attracting preparation is considered one, which does not repel insects at great concentrations and attracts them at very small concentrations, even from great distances.

The action time of highly volatile compounds is extended by limiting the size of the treated area and by adding nonvolatile substances to them.

Attractants cannot be found for all insects, although it is completely possible that in certain species of insects olfaction is poorly developed or is completely absent. Furthermore, for many species of arthropods a method of determining the chemoreceptor potential has still not been worked out. With respect to their habits and life cycle insects differ among themselves according to the acuteness of their olfaction and other properties.

Ammonium attracts the largest number of different insects, where of 29 species 28 belong to the flies (order Diptera); it is used in aqueous solutions. At room temperature ammonium is a gas with high solubility in water. It is generated by the action of alkalis, a buffer or even of water of ammonium salts, urea, amino acid, or food products or simply by the decomposition of organic substances.

Of the acids and anhydrides the most important as attractants are valerianic acid and cantharidin (a saturated derivative of phtalic anhydride). Of the amino acids only arginine possesses weak attracting properties.

Many attracting substances from the group of hydroxy compounds (alcohols and phenols) attract insects, obviously, because they possess an odor approximating the order of food products; therefore they are not specific and cannot be considered highly effective preparations.

Of the aromatic ethers the most effective are the mono- and dialkoxybenzene with substitution and without it. Strong agents are Ceylon citronella oil and methyl eugenol. The combination of this latter with the wettable powder of thiophos is very effective in combating the oriental fruitfly (Dacus dorsalis). Methyl eugenol attracts approximately 1% of the insects (chiefly males) from a distance of 0.5 km, and they cover this distance within 15 minutes; a 3% solution of pyrolan in methyl eugenol attracts male fruitflies from a distance of 0.8 km and more. The extermination of the males causes a reduction in the fertility of the females. For the purpose of combating fruitflies cane (reeds) is treated and scattered at a rate of 20-40 pieces per square mile. The same effectiveness was noted using an analogous solution of DDVP in eugenol.

The majority of aldehydes, apparently, acts just like food attracting substances. Among the ketones the most potent compound is anisylacetone.

Among repellant and attractant substances there is much in common: both the repellents and the attractants act on the sensory organs: some attract, others repel; they also have their distinctions. A repellent can repel several species of insects, whereas an attractant, as a rule, is specific, i.e., it attracts only one species of insects. Even the best repellent effectively protects in the case, when it covers the greater part of the body of a man or animal. This is explained by the fact that insects approach it at a close distance from various sides. A good attracting substance acts at great distances, and arthropods approach only to that point, which attracts them.

The question automatically arises, can an insect develop resistance to attracting substances. It is difficult to answer to this question with respect to all attracting substances; however, with respect to sexual substances, it is possible to answer negatively. If an insect (female) ceases to react to an odor attracting her to the male, then the reproduction potential will be greatly threatened, therefore it is doubtful whether such a perspective is possible. Even if such attracting agents are used to attract insects to places treated with insecticides, then it is almost impossible to conceive that they will cease to react to these attractants. There is no doubt that attracting substances can make the use of insecticides considerably more effective and such joint application of preparations will be an auxiliary means in combating insects. However, the application of an attracting chemical substance along with an insecticide (for example, in a trap) represents a definite danger from the point of view of the possibility of the development of resistance to it, inasmuch as this attractant will "participate" in the selection of the surviving insects.

To distinguish and identify insignificantly small amounts of chemical substances having an odor, attracting insects, there are applied at the present time gas chromatography, ultraviolet, and infrared rays, nuclear magnetic resonance, and mass spectrometry.

Attracting substances affecting the sensory organs of arthropods are divided into three groups: sexual, food, and ovipositing. The dominant mechanism of attraction (be it a source of food, a mating site, or a place for ovipositing) is the positive anemotaxis of an air current with an odor. Upon detecting the odor the insect flies against the wind until it reaches its source. Thus, in essence the main attracting factor is the odor.

Sexual agents secreted by females possess high specificity and attract only males of the same species. Sexual attracting substances are the most effective, because they can act at great distances. In individual cases such preparations are so strong that an insect reacts in the presence of only fractions of a molecule.

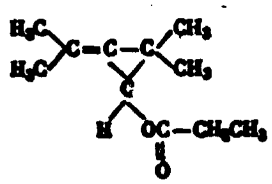
Considerable difference is noted between the reaction of males and females to chemical attracting substances; usually the male reacts more strongly; possibly, the mechanism of the sensory organs of the females is much weaken in comparison with the mechanism of the males.

Drones in flight are attracted to the flying queen bee by substances (trans-9-oxodec-2-enoic acid [Translator's Note: oxodecenoic acid, queen substance]), present (on or in her) submaxiliary glands.

A sexual attracting substance is also secreted by female honey bees. In 1960 in the secretions of the female of pine sawfly the presence of a sexual attractant was detected. In field tests it was demonstrated that a virgin female was capable of attracting an especially large number of males; one isolated female attracted more than 11,000 males. A virgin female beet leafhopper attracts numerous males from a distance of 15 m downwind.

A study of the sexual attracting substances of the silkworn moth showed that males react to a sexual substance when it is present at less than 10^{-4} of a molecule. After 30 years of study in 1963 from the last two abdominal segments of female gypsy moths (Porthetria dispar L.) sexual substances, attracting males were isolated and identified. From 500,000 females 20 mg of pure substance was extracted and identified as dextro-10-acetoxy-1-hydroxy-cis-7-hexdecanol. This attractant was synthesized in the United States. A related chemical compound — 12-acetoxy-1-hydroxy-cis-oxodecene — was called "gyplure"; it is easily manufactured. Traps with living female gypsy moths placed in them attract males located at a distance of 3.2 km (Acri).

From female American cockroaches there was also extracted a substance, which attracts males. From approximately 100,000 females over a period of 9 months there was collected 12.2 mg of pure attractant; this substance had the form of a yellow liquid, not having an odor perceptible to man. The compound was identified as 2,2-dimethyl-3-isopropylidene cyclopropyl propionate.



The substance causes typical intense excitation in males with the presence of approximately 10^{-14} μg, which is approximately equal to 30 molecules.

The females of one species of moth secrete sexual substances, which attract the males of that species; one of these substances is, it is assumed, hydroxy ester, and the second — an unsaturated alcohol. Synthetic compounds — 2,4,6-octatriene-1-ol (unsaturated alcohol) attracts the moth of the silkworn at a concentration of 1 μg/ml; this is approximately 1/10,000 part of the potency of the preparation from the natural attracting substance secreted by the moth.

Recently several synthetic compounds have been obtained, which possess the same attracting properties as the sexual substances: these are capric acid and 4-allylveratrole; the latter preparation is especially deserving of attention.

A very significant achievement was the method used on the Pacific Ocean island of Rota for the purpose of exterminating male Callitroga flies. A strong fragrant bait was used, which attracted only the males of this fruitfly; an insecticide was introduced into the bait. After 5 1/2 months of joint application of the insecticide with the attractant complete extermination of all males was noted; as a result the flies stopped hatching and this species of insect vanished from the island.

Similar baits were created for the Japanese beetle and the European black beetle.

Food attractants are not as effective nor as specific, as sexual attractants, but they are more available and can be broadly applied. For example, for houseflies these substances are fermenting sugar solutions, hydrolyzates of protein, juices, vitamin preparations and bacterial cultures. These substances attract both sexes of flies. Fermenting attracting substances act for a short period — 4-7 days. The addition of such chemical preparations, as pyridine and sassafras oil, somewhat increases the effectiveness of fermenting attractant substances.

Attracting substances for ovipositing. In selecting a site for ovipositing female flies prefer decomposing organic refuse, in which the attractive substance for them is ammonia. In connection with this the addition to food baits of ammonium salts including ammonium carbonate attracts flies, especially females. For certain species of flies proteins are attractants, especially albumin; other species of flies (Sarcophaga) are attracted by skatole, indole, and others.

Substances attracting houseflies. At present with respect to flies there have been mainly worked out methods of applying food baits, whereas the application of the two other types (sexual and for ovipositing) has been only very sketchily studied. It has been determined that ammonium carbonate acts as an attracting substance for ovipositing: when middlings are soaked with a solution of ammonium salts, females readily lay their eggs on such substratum; they readily fly to this odor, even if the substratum contains an insecticide. When flies are caught in flytraps on bait not containing ammonium salts, usually an equal number of both sexes are found to be present.

Carbon dioxide attracts not only flies, but also female mosquitoes, whereas for male mosquitoes carbon dioxide is a repellent.

It is known that houseflies (Musca domestica) feeding on bait secrete some substance, which increases the attractiveness of the bait for other individuals of this species. The nature of this substance is unknown, but it has been established that it can be extracted from these insects and dissolved by ethyl alcohol at 95°. This "fly factor" is an effect of the moisture or humidity of the substrate, which acts as a weak attracting substance.

In combating flies the application of food baits with insecticides is favorably distinguished from the use of only some insecticides by two intrinsic properties: first, when using baits, to which insects are attracted, solid treatment of the surfaces with insecticides is not completely necessary; they are deposited only on individual sections, on approximately 1/20 part of the object (the favorite places where the insects stay); secondly, when using baits the insecticide, besides the intentines, also get on the surface of the insect's body, which intensifies its toxic action. These peculiarities of the bait method make it possible to reduce the expenditure of the insecticide in baits as compared to its expenditure when applied on a surface without baits by 5-10 times and more. Flies feeding on baits in the first minutes after its application die rapidly. The application of baits under practical conditions does not require special equipment. For man these poisoned baits are practically harmless.

Baits, however, must possess certain specific properties; the main one is the absence of a repellent effect on insects. Thus substances possessing repellent properties even to a minor degree are completely unsuitable as baits.

The DDT, hexachlorane, dieldrin, and other chlorinated hydrocarbons, and also pyrethrum according to the statements of certain authors (Z. N. Nudel'man and others), absolutely destroy the attracting action of baits.

Food baits containing an insecticide have already been applied for a long time with varying success; they have been mainly applied in living quarters. Thus, formalin in milk and beer was recommended as early as 1914, formaldehyde and sodium silicylate in 1916, sodium fluosilicate in 1928, ethyl alcohol, ammonium carbonate, and acetic acid in 1949 (A. M. Klechetova); baits containing arsenic are also on sale at the present ("flyagaric").

Nonetheless these baits are used very limitedly because of their low effectiveness. The creation of really effective and fast-acting baits became possible only when new insecticides from the group of organophosphorus compounds began to be broadly used; in particular, the most useful for these purposes were parathion (thiophos), malathion (carbophos), dipterex (chlorophos), diazinon, DDVP, and others. Due to the good solubility of some of these organophosphorus compounds in water the basic form of application of these preparations for combating flies are aqueous solutions (for example, chlorophos solution) with the addition of sweet attracting substances (insecticidal baits). In preparing liquid baits there are used as food products attracting flies sugar, molasses, whey, grain kvass, and others. Acri and others obtained good results using saccharose, Keller with coauthors ascertained the effectiveness of malt baits. Analogous results were obtained by Barns with baits containing hydrolyzate of protein.

According to A. M. Klechetova, acetic acid, and its esters, the higher alcohols and ammonium carbonate attract flies, and the addition of the latter preparation increases the attractivity of baits by more than 2 1/2 times. In exterminating flies in a number of cities M. N. Sukhova with coauthors used chlorophos with ammonium carbonate and obtained good results.

In preparing liquid baits containing chlorophos, there are added to water 5-10% molasses, 5% sugar, 50% grain kvass, or whey and 0.1-0.5% chlorophos. In exterminating flies outside living quarters the baits, which are used most broadly, contain 10% molasses and 0.5% chlorophos.

Liquid baits are mainly applied by two methods — in the first case vessels of sheet metal or any available dishes (cups, plates, cuvettes, and others) are set up; in manufacturing special trays it is recommended that they be made with dimensions of 300-500 cm^2. A layer of 3-5 cm of bait is poured into the vessels and they are placed about at a rate of 1 vessel for 30-35 m^2 of floor. For the flies to land on, there is placed in the middle of the vessel at its full length a plait of rag, cotton or other material or wooden strips, which are somewhat raised above the surface of the liquid. The vessels with the bait are placed in premises containing animals, in such a place and at such a height, that the animals do not have access to them (cannot eat nor overturn them). It is also possible to use paraffinized glasses with a capacity of 300-500 cm^3, in which the bait is poured and pieces of cotton in the form of small wads are placed: the glasses with the bait can be hung up in pigsties, barns, or chicken coops. It is necessary to renew the bait every 6-8 days. Baits in vessels cannot be recommended for combating flies out of doors, in fly breeding places, because they have a pleasant taste and children can eat them.

The second method of using liquid baits consists in applying baits every 1-2 days to surfaces (walls, fences, etc.), surrounding the breeding places of flies. In places containing animals it is recommended that the baits be applied to individual sections making up approximately 1/20 part of the surface of the walls. In proportion to the hatching of imagoes from cocoons flies fly to the bait and die right there. This method makes it possible to obtain good results in a hurry, but its disadvantage is that the bait must be applied to the surfaces quite often (every 1-2 days). In those cases, when in premises containing animals it is possible to set up a screen made from nonabsorbent material (a sheet of plywood painted with oil base paint) especially for the application of bait, the frequency of treatment can be extended to 4-5 days.

The application of insecticides in bait decreases the danger of human and animal poisoning, inasmuch as the amount of preparation applied is insignificant. Granulated baits are pieces of sugar, sawdust, middlings or kernels of corn treated with a solution of the preparation with the addition or without the addition of attracting substances. If granulated baits are prepared for storing, then after being treated they are dried and expended as needed. They are used to combat flies in living quarters, in premises for animals, chicken coops, and other places.

V. I. Vashkov and Ye. V. Shnayder as granulated bait recommend the use of sawdust impregnated with insecticide and molasses. The bait is placed in dishes, and is slightly moistened with water; the dishes are placed in conspicious places; in premises for animals they are placed in places, which are inaccessible to the animals.

Very frequently in premises for cattle granulated baits are scattered on the floor. Keller and Wilson strewed baits in places, where flies accumulate, at a rate of 25-200 g/m^2 depending upon the dimensions of the area being treated. Moreover, corn bait with 2% malathion and 10% granulated sugar provided good results after one treatment; analogous results were obtained with 1% diazinon, and also with dry sugar baits containing 2.5% malathion (carbophos) or 1%

dipterex (chlorophos). The effectiveness of such a method of combating flies is high, but the action of the baits is short term, since with the movement of the animals the baits are mixed with manure and mud and lose their effectiveness.

It is well known that flies readily light on various wires, rope, etc., strung up in premises. Considering this, ropes and other materials (bandages), twisted in the form of ropes are impregnated with bait containing 1% chlorophos or other insecticide, and are hung up in premises. Flies attracted by this bait light on these "antennae" and die as a result of coming in contact with them or licking the bait. Ropes with a diameter of 1 cm are hung up at a rate of 1 m per 10 m^2 of floor. The effect of such arrangements was rather significant.

Keller and Wilson used "antennae" impregnated with sugar bait with 2% malathion or dipterex, hanging them vertically under a canopy above the earth, in barns, cheese dairies, cow barns, and other places; they observed the extermination of 90% of the flies on the first day the preparation was applied.

The disadvantage of this method is that the "antennae" spoil the appearance of premises, therefore they cannot be used everywhere, especially in public places (dining halls, clubs, and so forth). However, for combating flies in kitchens, in corridors, premises for animals, and other such places this method is completely acceptable.

In the United States there are used, furthermore, insecticidal baits consisting of 73-74% grain syrup, 25% water, and 1-2% phosphomide; they are used to treat the heads of cattle at a rate of 3 ml per head. Such insecticidal baits provide mass extermination of stinging flies and reduce their number with 14-21 days by 94-99%. The best results were obtained using phosphomide in the form of oil solutions.

For other species of flies — those stinging and feeding on animals and their corpses (Phenicia sericata, Lucilia caesar, Ph. cuprina, Calliphoridae) — the attracting odors are those odors, which are formed from animal dung and petrescent wool, and also ammonium salt (Stansbury); for flies of these species, and also for stable flies (Muscina stabulans) and houseflies the attractant odors are also the odors of sulfides, ammonium carbonate and other compounds; for Sarcophaga — skatole (attracting for ovipositing).

Substances which to an insignificant degree attract Drosophila are acetic acid, ethylacetate, lactic acid, dilute ethyl alcohol, methyl-, ethyl-, and isobutylacetate. Reed established that weak aqueous solutions of alcohol and acetic acid are only slightly attractive to Drosophila, and Huetner showed that a whole series of chemical substances is attractive to them; among them were diacetyl, acetaldehyde, indole, 3-hydroxy-2-butanone, dioxane, acetal, cyclohexane, and diphenylmethane. However, not one of these attractants is potent enough to compete with the natural attracting substances (West).

Substances attracting blood sucking insects. Various gnats, mosquitoes, midges, and other blood sucking arthropods find their hosts by the odor emanating from them, more correctly by a complicated system of odors, which are created by the amino acids (cysteine, cystine, alanine, glutamine) emanating from the blood through the epithelial integuments, lactic acid, amines, and ammonia (Gouck). Each of these substances possesses weak or no attracting properties at all, and their mixtures act attractingly even with very strong dilution. With an increase of temperature and atmospheric humidity the action of similar mixtures is intensified (O. S. Kuzin).

Carbon dioxide attracts females of certain types of mosquitoes to animals (Wright). Animals with thin skin are subjected to more severe attacks by insects than animals with thick skin because they emanate more odorous components of the blood.

According to Brown, lysine and alanine present in human flood are attractants for Aedes aegupti mosquitoes, all the other amino acids do not attract mosquitoes, but certain ones even repel them.

Nitrogenous compounds do not attract mosquitoes (asparagine, arginine, ammonia), and certain ones of this group of compounds repel them (cadaverine, putrescine). Anopheles maculipennis is attracted by carbon dioxide, but Aedes aegupti – by humid air and carbon dioxide; mosquitoes are also attracted by water in vessels, especially when grass is present in it.

Chlorophos is used to combat mosquitoes not only by treating surfaces, but also in the form of attracting baits, consisting of grass, leaves of trees, and others, immersed in a solution of the preparation (1:10,000). Such baits are placed in clay pots, enameled dishes or in the hollow of bamboo with a diameter of 7-10 cm.

According to the Institute of Medical Parasitology (the city of Kangchou, Chinese Peoples Republic), acid odor attracts mosquitoes; as bait the waste products of a winery were used, to which was added chlorophos (1:10,000); in attractiveness these baits were 7 times more effective than pure water; the attractiveness of water to mosquitoes is increased when it is stored in bamboo vessels. Water containing straw is 2 1/2 times, and water after washing rice in it is 2 times more attractive than pure water. We observed the application of such baits in the parks of Kangchou; baits in bamboo vessels located 3-7 m from each other, were attached at the height of a man to trees both on islands, and also on the shore of a large lake. During inspection of the baits, located in clay pots (in decorative bushes near a hospital) and in bamboo vessels (in the park) mosquitoes were detected. Insects usually fly to such bait and lay their eggs, in the course of which they come into contact with the bait and die; the eggs laid by them also die. It was ascertained that in baits containing chlorophos (1:10,000), the eggs of Anopheles mosquitoes die faster than the eggs of Culex mosquitoes. In bait with chlorphos (1:5000) the eggs of the mosquitoes of the first type died within 2 h, and the eggs of mosquitoes of the second type within 1 h.

According to Jackson, Milichiella lacteipennis midges are attracted under laboratory conditions to ethyl, n-propyl, isopropyl n-butyl, isobutyl, secondary butyl, tert-butyl, n-amine, isoamyl, dimethyl, diethyl, di-n-propyl, trimethyl, and triethyl. The first compound attracts midges at a concentration of 1%, and the next at a concentration of 0.1%; the remaining substance is less active.

Substances attracting cockroaches. To American and common cockroaches water, food, and natural sexual substances are attractive substances; to oriental cockroaches bananas and pineapples (containing oil) are attracting agents. In the United States there has been isolated a natural substance secreted by females; it attracts male cockroaches of the Periplaneta americana species; Jamomota designed a special apparatus for collecting the attracting substance from female cockroaches.

Substances attracting other types of insects. To fabric pests — Tineola biselliella moths, the larvae of carpet beetles Anthrenus flairpes, A. picens — attractants are the urine and sweat of man, tomatoe juice, beer, beef gravy, butter, milk, black coffee, and a 5% solution of sugar. It is considered that the washing of wool and articles made from it liberates them from these attracting substances and inhibits the feeding of insects, with the exception of adult insects, which feed freely on pure wool.

Para-hexanols attract caterpillars of silkworm moths.

According to Tashito and others, fluorescent black color with an energy of 3200-3800 Å has turned out to be very attractive to imagoes of the European beetle Amphymallon mayalis. Traps with such light caught 70 times more beetles than the most attractive chemically poisoned baits in special traps. Light traps also caught beetles during the night.

C H A P T E R XIV

AGENTS REPELLING INSECTS AND ACARINAL (REPELLANTS)

Among the measures directed towards preventing of diseases transmitted by blood sucking arthropods living under natural conditions (gnats, mosquitoes, mites, ticks, and others), a great role is played by repellent preparations.

The use of such substances was known as early as remote antiquity; to repel insects the smoke of fires, products of vegetable (extracts of vegetable oils) or animal origin were used. It is possible to state that the application of repellent preparations has a more ancient history than the application of insecticides.

The study of repellent dates to the beginning of the 20th Century. The term "repellents" came into literature from the English language (repellent - frightening) [sic]. A repellent is used in those cases, when it is impossible by any other way to exterminate arthropods with insecticides. To accomplish the latter under natural conditions (in the woods, fields, etc) is most difficult. Repellent substances can be used not only to protect an individual person, but also whole groups, for example workers - canal builders, peatbog workers, woodcutters, military units, located in camps or at a post (at a site teeming with blood-sucking flies), various geological research parties, etc. (D. I. Kazanskiy, V. I. Stravropol'skaya).

Besides the annoyance, which these blood-sucking flies inflict on man, the saliva of these insects possesses poisonous properties. Many of them are also carriers of human diseases. For example, Anopheles mosquitoes are carriers of malaria, nonmalarial mosquitoes - are carriers of Japanese encephalitis and tularemia viruses; mosquitoes transmit exciters of pappataci fever, Pendinski ulcer and kala-azara; gadflies - anthrax, mites and ticks - vernal encephalitis and others.

Thus, the application of effective synthetic substances possessing the capacity to repel arthropods promotes the prophylaxis of malaria, epidemic encephalitis, tularemia and certain other transmitted human diseases.

At the present time repellents are recommended against mosquitoes, midges, sandflies, gadflies, mosquitoes, flies, cockroaches, fleas, mites, ticks and certain other arthropods. Much research has been conducted to find preparations repellant not only to insects, but also to rodents, and birds; thus, for example, anthraquinone (-9, 10 anthraquinone) - $C_{14}H_8O_2$, chlorazol - $C_8H_{11}Cl_3O_6$ are used for the treatment of seeds to repel birds.

Repellents can render an effect in three directions: 1) prevent the insect from selecting a host, i.e., by neutralizing the natural odor of the skin and depriving it of its attractiveness to insects; 2) prevent the lighting and the puncturing of the skin (antibite effect) - in this case the preparations affect the olfactory organs of arthropods; 3) provide mechanical protection for the skin (vaseline). The penultimate group of compounds has obtained broad application under practical conditions.

Repellents are produced not only synthetically, but also by extraction from certain plants. Of the substances of vegetable origin, possessing repellent properties, it is necessary to mention the alkaloids of pyrethrum, derris, tobacco, anabasis and the oils - citronnela, eucalyptus, clove, thuja, bergamot, laurel and others.

Of the chemical preparations repellent substances were first broadly applied as prophylactic agents by the Russian scientist A. I. Grigor'yev, who in 1904 used for these purposes Malinin's ointment. Using it as a repellent agent he obtained a reduction in malaria morbidity among the troops of the caucasus district by $7\frac{1}{2}$ times as compared to the morbidity in a group, where repellent preparations were not applied.

Malinin's ointment is an antiparasitic agent prepared in the following manner: 20 parts of fresh pyrethrum are infused in 100 parts of turpentine for 7 hours, then the pyrethrum is filtered out centrifuged and once again infused in 50 parts of turpentine. The powder is again centrifuged; both filtrates are mixed and placed in a metal can with a gauze filter. There are then added 5% carbolic acid, 5% cinnamon oil and filtered. The fabricated preparation is applied as an insecticide in a mixture with kerosene 2:1 or 1:2 as a spray for articles and premises.

In 1938-1941 Ye. N. Pavlovskiy, G. S. Pervomayskiy and K. P. Chagin tested the suitability of a number of substances for treating protective netting and recommended the following compositions for practical use: 1) 15 parts of lysol, 8 parts turpentine and 77 parts water; 2) 20 parts naphthalysol, 10 parts turpentine and 70 parts water; 3) 30 parts lysol, 10 parts turpentine, 5 parts vegetable oil or fish fat and 55 parts water; 4) 10 parts tar, 90 parts 5% caustic lye; 5) 1% aqueous emulsion of creolin.

Furthermore, Ye. N. Pavlovskiy also recommended the following compositions: 1) 10 parts of 6% citronnella oil, 40 parts of camphor alcohol, 20 parts of cedar oil and 30 parts water; 2) one part castor oil, one part alcohol, one part lavender oil; 3) one part cintronella oil, 4 parts liquid vaseline; 4) 89 parts vaseline, 10 parts napthalene, one part camphor.

Good results were obtained during a study of lysol-turpentine mixtures and a 10% emulsion of purified birch tar oil; well impregnated netting, when properly used, protects against mosquitoes for 10-12 days. For repelling mosquitoes Ye. N. Pavlovskiy recommends another mixture consisting of anise, eucalyptus and turpentine oil.

An effective repellent agent against mosquitoes, gnats, mites and ticks are 5-10% solutions of preparation-K (Ye. K. Kachalova, V. G. Polezhayev, P. G. Sergiyev, I. A. Tiburskaya, I. N. Skorin), the protective effect of which lasts up to 3 hours.

According to A. S. Monchadskiy, D. I. Blagoveshcheyenskiy, N. G. Bregatova and A. N. Ukhina, the alpha-pinene fraction of juniper oil is an effective agent repelling mosquitoes. The duration of the protective action of netting impregnated with this substance, is 4-6 days.

Also finding application are aerosols of DDT and hexachlorane, and also fumigating candles filled with a mixture of snuff (60 parts), pyrethrum (30 parts) and saltpeter (10 parts).

Repellents are also used to protect agricultural animals.

The above-mentioned substances do not posses strong repellent properties, and thus for a long time attempts have been made to create synthetically highly effective repellents. The synthesis of repellents is being carried out in a number of countries using compounds from various chemical groups.

A great stimulus to the development of repellent research was the fact that the Anglo-American troops on the Pacific Ocean and Burmese fronts of military actions (1942-1945) sustained large losses from malaria and other tropical diseases caused by insects — louse-flies, ticks and mites. The problem of obtaining highly effective repellents had at that time a military, strategic character. The Anglo-American troops were powerless against the mosquitoes; many military units lost 50-60% of their personnel from malaria within the first 10 days of their arrival at an area; in individual places after 6 weeks 90% of the arriving replacements had been put out of action. As a result of intensive research a number of substances was synthesized, which were used in the army; among them were - dimethyl-phthalate (known as early as 1929, but then forgotten), 2-ethyl-1,3-hexanediol proposed in 1935, and indalone - in 1937.

Interest in repellent preparations even after the Second World War not only did not wane, but continued to expand, which is attested to by the numerous publications about new repellents and the scientific, research works in this field. Simultaneously there was an expansion of the region of repellent application - they began to be used not only to insects, but also rodents. Extensive work is being conducted to find repellents to protect new forest plantings. Before 1954 for the purpose of repelling mice tetramine was used. In this direction about 5000 different preparations have been investigated, but up to the present there is not universally recognized repellent for rodents.

The disproposition between the great number of studied compounds and the number of preparations detected among them, possessing repellent properties can be explained by the fact that in studying the huge number of obtained substances the premise is followed that all the synthesized compounds have to be investigated from the point of view of the presence or absence in them of properties repellent to arthropods. Such an approach to the search for new preparations can be called a search in the dark; these searches, undoubtedly, lead to desirable results, but they require the expenditure of huge amounts of labor. Thus, the importance of repellent substances recommended for combating arthropods does not have a scientific basis resting on the chemical structure of the given substance; in connection with this not one of the repellents recommended in practice satisfies our requirements completely.

The criteria of a truly ideal repellent are: the complete protection of man or animals from arthropods; maximum effectiveness in a minimum dose; the absence of an undesirable odor; the absence of toxicity (or mild toxicity) to warm-blooded animals; a low cost for the preparation and, finally, facility in its application. The preparation should neutralize the odor of man for insects and should possess prolonged repellent properties when it is applied to clothes in small quantities.

Attempts were made to find repellents possessing repulsive properties, when they are taken internally. However, it is obvious that such repellents cannot be recommended for broad application, inasmuch as in principle it is more correct to use repellents as external agents.

In a number of countries (USSR, the United States, Czechoslovakia, England and others) attempts are being made to shed light on the mechanism of the action of repellents.

In studying the connection between the effectiveness of a preparation and its structure it was established that the majority of compounds effective with respect to Aedes aegypti mosquitoes for 3 hours or longer, belongs to the following four classes: amides, alcohols, ethers and esters. Few good repellents have been found among the hydrocarbons. Almost all 1,3-diols possess repellent properties to a certain extent. Certain hydroxy esters also had a repellent action. This served as a clue for further investigations, as a result of which it was established that the N,N-dialkylamides are deserving of special attention.

Also studied was the dependence of repellent properties of preparations on the presence of individual atoms and their position in the molecule. It was shown that the effectiveness of preparations used against mosquitoes increases with the presence of oxygen in the molecule independently of its position; the best compounds are those which dissolve well in fats and water. The attempts to determine the influence of a nitrogen atom on the repellent properties of substances were not successful. Systematic investigations of organic compounds in the form of chemical series were conducted for the purpose of establishing the dependence of repellent action on the presence or location of both radicals and also atoms in the molecule.

As a result of the investigations it was established that phenyl radicals and the presence of the hydroxyl group intensify the repellency of a preparation (in experiment). The effectiveness of compounds of homolgous series of cyclohexanes aliphatic acids increases in proportion to the increase of the number of carbon atoms in the structural chain, but only to certain limits, after which the activity starts to decrease. Among the 10 preparations of this series the most effective turned out to be cyclohexane, carboxylic acid, cyclohexaneacetic acid, cyclohexanepropionic acid and cyclohexanebutyric acid.

V. I. Vashkov, M. I. Brun, M. L. Fedder and Yu. F. Shumayeva studied 51 preparations from different chemical groups; the best results were obtained with acetylanalide compounds, which in effectiveness are almost equal to dimethyl phthalate.

Dimethyl phthalate and propyl-N,N-diethylsuccinate are effective against a mixed population of mosquitoes.

An effective repellent is the ester of amygdalic acid, which with difficulty is removed by washing and prolonged wearing (up to 40 hours).

According to P. S. Batayev, L. V. Ivanova, Z. G. Vorob'yeva and V. V. Almazova, N-benzoylpiperidine, N-phenylucetylpiperidine and N,N-diethylamide phenoxyacetic acid are highly effective repellents with a considerably more prolonged protective action than dimethyl phthalate.

There are also data about the fact that the amides with the dimethyl groups on the same carbon atom united by a double bond (carbon with carbon), possess good repellent properties. Chlorine-substituted amides on the whole possess high and stable arthropod repellent properties, but many of them have a harmful effect on the human skin.

There has also been studied the dependence of the repellent qualities of a preparation on the physical, chemical properties, including the boiling point of the substance.

However all efforts to establish an exact dependence of the repellent properties of a substance on the chemical structure have turned out to be up until now unsuccessful.

The repellent properties of a preparation depend on its volatility; only those compounds whose boiling point is not lower than 280° are suitable as repellents effective for 6 hours. Any preparation with a boiling point of 200° at 760 mm Hg is unsuitable. Roadhouse showed that the maximum repellency is noted in those compounds, whose boiling point fluctuates from 230 to 260°. A similar point of view has also been expressed by other researchers. There is no doubt that the preservation of the repellent properties to a considerable extent depends on the boiling point of a preparation, which should exceed body temperature by approximately 8-10 times. With such relationships the preparation slowly evaporates from the open parts of the body, especially if it is subjected to insulation.

According to Wright, the physical basis of repellency (with respect to mosquitoes) is molecular vibration causing infrared adsorption (21.7 μ). Unfortunately, the author does not present data about whether insects are repelled by substances, a molecule of which possesses this or some other characteristic vibration.

According to Gousk and Bowman, repellents applied on the hands of 3 men did not affect the liberation of moisture, but dimethyl phthalate, diethyltoluamide and ethylhexanediol reduced the amount of carbon dioxide, liberated by 2 men, and for the 3rd – only from the effect of the diethyltoluamide. In the presence of the natural attractiveness of the human skin in the absence of a repellent the formation of carbon dioxide has a direct relationship to its attracting properties and the formation of moisture is inversely proportional to these properties.

Obviously, the degree of repellency of preparations depends not only on their physical, chemical properties, but also on the chemoreceptors of the insect. Therefore a clarification of the mechanism of the action of repellents is possible only by combining the investigations of the insect receptors and the chemical properties of the repellents. Although chemoreceptors are very simple sense organs, their location and morphology up to the present time have not been exactly ascertained, with the exception of certain cases.

By 1962 the repellent properties of approximately 20,000 compounds had been studied. Basically the investigations were dedicated to searching for preparations possessing universal properties, including the ability to repel blood-sucking flies. For practical use for the purpose of protecting people about 60 compounds were recommended. This number does not satisfy the need for repellents because each preparation possesses its greatest effectiveness with respect to only one particular species of insect. Furthermore, one should not forget that insects with prolonged application of one and the same preparation adapt to it and become resistant.

A List of Repellents Which were Effective
in Laboratory and Field Tests

N-cyclohexyl-alpha-butoxyacetamide;

N-cyclohexyl-2-butoxyethoxyacetamide;

N-n-butylacetanilide;

N-n-propylacetanilide;

2-phenoxyethyl ester of acetic acid;

2,2-thiodiethyl ester of acetoacetic acid p-methoxyacetophenone;

Di-p-propyl ester of adipic acid;

o-chloro-N,N-diethylbenzamide;

o-ethoxy-N,N-diethylbenzamide;

2-chlorophenyl ester of benzoic acid;

Benzyl benzoic acid ester;

Benzyl ether;

Cis-dimethyl ester of bicyclo-(2,2,1)-5-heptene-2,5-dicarboxylic acid;

Furfural-copolymer of butadiene;

1-(O-methoxyphenyl)-3-butene-1-ol;

Trichloroacetylchloroethylamide;

P-propyl ester of cinnamic acid;

Citronellal;

2-cyclohexylcyclohexanol;

2-methyldecanediol-3,5;

Diethyl ester of cyclohexane-1,2-dicarboxylic acid;

2-(2-butoxyethoxy)-ethanolacetate;

2-(2-ethylhexyloxyethoxy)-ethanol;

2-phenoxy-etanolacetate

bis-(2-butenylene)-2,3,4,5-tetrahydrofurfural;

bis-(2-butenylene)-2,3,4,5-tetrahydrofurfuryl alcohol;

2-ethyl-1,3-hexanediol (Rutgers-612);

Beta-phenylethyl ester of hydracrylic acid;

Alpha-hydroxyphenyl ethyl ester of isobutyric acid;

Amyl ester of amygdalic acid;

Hexyl ester of amygdalic acid;

n-propyl ester of amygdalic acid;

tert-dodecyl mercaptopolyoxyethylene;

Alpha-naphthol-(1-napht-ol);

Beta-naphthol-(2-naphth-ol);

2,3,4,6-tetrachlorophenol;

2,4,6-trichlorophenol;

Phenoxanthine;

Dibutyl ester of phthalic acid;

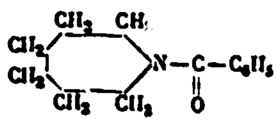
Diethyl ester of phthalic acid;

Dimethyl ester of phthalic acid;
N-s-butylphthalamide
Alpha-test-butylpiperonyl alcohol;
Bytoxypolypropyleneglycol (MB 800);
2-ethyl-2-butylpropanediol-1,3;
2-amino-3-isobornyloxy-2-methylpropanol-1;
Alpha, alpha, beta-trichloropropioamide;
Dipropionate-pentanediol-1,5;
Propiophenone-oxime;
Butyl ester (indalone);
3,4-dihydro-2,2-dimethyl-4-oxo-2H-pyran-6-of carboxylic acid;
Diethyl ester pyridine-2,5-of dicarboxylic acid;
Dipropyl ester pyridine-2,5-of dicarboxylic acid;
2-phenyl ester of salicylic acid;
N-n-diethyl-propyl ester of aminosuccinic acid;
N-amylsuccinamide;
p-dimethylamine-phenyl ester of thiocyanic acid;
N-n-diethyl ester of m-toluamide;
Undercylic acid.

At the present time of the large number of recommended agents the following preparations are widely used in practice: benzimin, dimethyl carbate, dimethyl phthalate, diethylmetatoluamide (DET), indalone, kiuzol and 2-ethyl-1,3-hexanediol (EHD) and others.

Benzimim

Benzimim – $C_{13}H_{17}NO$



Synonym-hexamid. From the amide group P. B. Terent'yev, A. N. Kost and A. N. Terent'yev suggested N-benzoylhexamethylenimine as a repellent and developed the technology for obtaining it.

This preparation is a colorless or slightly yellowish liquid, slowly crystallizing in air and having practically no odor. Its molecular weight is 203.27; its melting point is 34-36°; its boiling point is 147° at 1-2 mm Hg or 190-190.5% at 12 mm Hg. Its coefficient of refraction at 37° is 1.55. The specific heat capacity in the temperature interval 19-30° is equal to 0.68 cal/deg. It is insoluble in water, but dissolves in methyl, ethyl and isopropyl alcohol, acetone, chloroform and dichloroethane. It is moderately soluble in benzene, gasoline, solar oil. With water in the presence of emulsifiers (OP-7 and others) it forms rather stable emulsions together with DDT and other chlorinated hydrocarbons. It is stable during prolonged storage and under the effect of sunlight.

The repellent properties of the preparation have been studied by a number of authors (K. P. Andreyev, M. L. Fedder; S. G. Gladkikh; N. A. Sazonov; Ye. Kh. Zolotarev and others). According to the data obtained the preparation in summer at 23° protects a man for 9 hours, and dimethyl phthalate under these same conditions protects for $1\frac{1}{2}$ hours. In the Artic region the protection time provided from mosquitoes by benzimin is 8 hours, and by dimethyl phthalate is 3 hours. In the region of Noril'sk at a temperature of 20° the protection time provided by benzimum was 16 hours, and by dimethyl phthalate $3\frac{1}{2}$ hours.

A dose of benzimin of 5 $m\ell/m^2$ prevents mosquito bites through fabric; at this concentration its repellent properties are equal to diethyltoluamide. Benzimin is used to treat clothes, netting, etc.

When it was used to protect agricultural animals from gadflies it turned out that after spraying cows, calves, and horses, with a benzimin emulsion the preparation protected them for 51-91 hours depending upon the activity of the gadflies. Under analogous conditions polychloropinene protects for 46 hours. After treatment with benzimum deer were not subjected to attack by blood-sucking flies for 11-15 hours.

Benzimin is of indubitable interest from the point of view of being a raw material (a waste of chemical production) and it is relatively inexpensive.

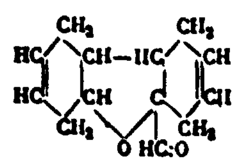
According to N. A. Sazonova and A. P. Volkova, benzimin is only slightly toxic to animals. Thus, upon its oral administration in vegetable oil to white mice the LD_{100} was 1750 mg/kg, and the LD_{50} was equal to 1250 mg/kg; a dose not causing toxic symptoms is equal to 750 mg/kg. When oil solutions of benzimin were administered subcutaneously the LD_{100} for white mice was equal to 1250 mg/kg, and the LD_{50} – 750 mg/kg; a dose not causing toxic symptoms was 250 mg/kg.

The application of 0.5 ml of pure benzimin on 25 cm^2 of the skin of a rabbit causes mild, barely noticeable hyperemia, and the use of the preparation in the form of 50-25-10-5% alcohol solutions also for cutaneous application to a rabbit at the same rate does not cause skin irritation.

With the introduction of 1 drop of pure benzimin into the conjunctival sac of the eye of a rabbit there was noted within 10 minutes hyperemia of the mucous membrane, which became considerably more pronounced in the course of twenty-four hours simultaneously there is also observed turbidity of the cornea. After 2 days the hyperemia begins to decrease, but it remains quite considerable even on the 3rd day; the turbidity of cornea lasts for more than 7 days.

Bis-Butenylene-Tetrahydrofurfural

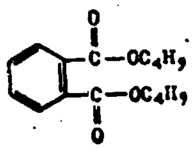
Bis-butenylene-tetrahydrofurfural or 2,3,4,5-bis(Δ^2-butenylene)-tetrahydrofurfural-$C_{13}H_{16}O_2$.



Synonyms: repellent MGK-11, butadiene-furfural copolymer and others. It is a pale-yellow liquid; its boiling point is 307°, its index of refraction is 1.5240, the specific gravity at 20° is 1.120, it is not soluble in water and in diluted alkali. It forms oxime, its melting point is 97-98°; 2,4-dinitrophenylhydrozone, its melting is point 153°. It was proposed in 1952 as a repellent, it acts effectively on cockroaches, stable flies (common and cow), mosquitoes; it is recommended for the treatment of dairy cattle, it is compatible with the majority of insecticides. It is used in combination with pyrethrin and with a synergist in oil, at 0.2 weight % for treating cattle. The acute oral LD_{50} for (rats) is 2500 mg/kg. There is no noticeable effect when they are fed with it for 90 days at a rate of 20,000 parts per million per day.

Dibutyl Phthalate

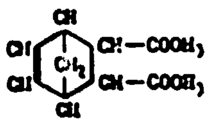
Dibutyl phthalate – $C_{16}O_4H_{22}$ – dibutyl ester of phthalic acid.



It is a transparent, colorless, oily liquid with a very weak odor. Its specific gravity is 1.046. Its melting point is 35°, its boiling point 324°; viscosity is 2.80. The preparation possesses rather strong repellent properties with respect to ticks and mites.

Dimethyl Carbate

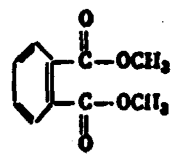
Dimethyl carbate – $C_{11}H_{14}O_4$.



This is a liquid with a light to dark-brown color and a pleasant odor; its specific gravity at 25° is 1.155; its index of refraction at 25° is 1.4829; its boiling point is 114-115° at 3.8 mm Hg. It dissolves in organic solvents and does not dissolve in water.

Dimethyl Phthalate

Dimethyl phthalate – $C_6H_4\ (COOCH_3)_2$.



It is the dimethyl ester of phthalic acid. It is obtained by the action of methyl alcohol on phthalic anhydride. Dimethyl phthalate is a colorless liquid with a weak aromatic odor, readily soluble in organic solvents (alcohol, ether, acetone, benzene) and almost insoluble in water. Its specific gravity at a temperature of 20° is equal to 1.1905; its boiling point at a pressure of 760 mm Hg is 282-285°. This preparation is inflammable therefore it is necessary to store and to use it, taking precautions against fire; it is necessary to store it in dark, glass dishes.

The preparation is produced by industry in large quantities for technical purposes.

Dimethyl phthalate is highly effective with respect to mosquitoes. It is used for the direct treatment of exposed parts of the body, and also for treating clothes and other soft articles (gauze hoods, kerchiefs, protective netting, stocking, socks, gloves, oversleeves, and others). Pure dimethyl phthalate protects from gnat and mosquitoes bites for 1-6 hours; 15% glycerine or vaseline emulsions and a 20% alcohol solution – for 1-5 hours; a 10% alcohol solution protects for 1-1½ hours.

Dimethyl phthalate is nontoxic for animals even with its prolonged use. According to S. G. Gladkikh, repeated application of the preparation (in certain cases daily during the course of $1\frac{1}{2}$ months) does not cause any toxic symptoms; when it was used in large quantities no complaints were forthcoming about this preparation.

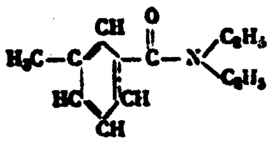
Among the homologs of dimethyl phthalate the most repellent properties belong to: dipheptyl phthalate, dioctyl phthalate and dinoyl phthalate (the last two substances were first obtained at the Central Scientific Research Disinfectional Institute in 1950 by M. I. Brun).

Among the analogs of dimethyl phthalate the repellent properties are best of all expressed in methylterpinyl phthalate, ethyldimethyl phthalate and methyl-(beta-chloroethyl)-phthalate (these substances were also first synthesized by M. I. Brun).

Strong repellent properties are also possessed by ethylene-bis-methyl phthalate and triethylene-bis-methyl phthalate. Among the analogs of dimethyl phthalate there is observed a general tendency towards an increase in the repellent properties for substances with higher molecular weight.

Diethylmetatoluamide

Diethylmetatoluamide – $C_{12}H_{17}ON$ – N,N-diethylmetatoluamide.



Synonyms: metadelphene, DET. It was proposed as a repellent in 1956. Orlando laboratory in Florida (the United States). In the USSR it was synthesized in the Central Scientific Research Disinfectional Institute in 1958 by Ye. S. Iglitsina. The preparation is produced in three isomeric forms. At room temperature the meta-isomer is a liquid; the ortho- and paraisomers – solids. The commercial preparation usually contains 85-95% metaisomer and 15-5% para- and orthoisomers respectively. All three isomers possess repellent and insecticidal properties (insecticide-repellent); the most active is the metaisomer (Ya. A. Mandel'baum).

The preparations produced in the United States and Holland contain 95-97% diethylmetatoluamide; its refractive index at 20° is 1.5204-1.5235; its boiling point is 111° at 1 mm Hg. The molecular weight is 191.25. The flash point is 155°. Its viscosity at 30° is 13.3; the acidity is 0.01-0.15; the moisture content is 0.08-0.3%. Its chromaticity according to Hansense is 50-100. Its odor is weak (in the absence of impurities).

Diethylmetatoluamide possesses universal properties – it repels all forms of gnats, stable flies, gadflies, biting midges, mites, ticks, and other arthropods. The purer the preparation, the more effective it is. The presence of acid and other impurities irritates the skin. The preparation is used to treat skin and clothes either in the form of 50% alcohol solutions, or in the aerosol form with freon.

The DET, when used in its pure form forms on the surface of the skin an oily layer, which, drying within several minutes, is turned into a film. Being applied in the form of alcohol solutions or in the form of aerosols containing alcohol, it gives an almost inconspicuous film, which insignificantly affects skin respiration and preserves the properties to repel insects for several hours. It differs from other repellents, which, being applied in the necessary amounts, leave the skin with an oily or fatty sensation. The absence of greasiness combined with the mild odor also makes DET completely acceptable from a cosmetic viewpoint.

According to A. I. Cherepanov and N. P. Golkoyunova, netting worn next to the skin and net-like hoods impregnated with diethyltoluamide of metatoluoid acid, protect a person well from attack by mosquitoes and gadflies for a month and more. They are convenient to use and do not cause skin irritation (with good purification of the preparation). They can be used with success for the individual protection of people from blood-sucking flies in lumbering, on geological exploration survey parties, in agricultural field work and other works in the northern regions of Siberia.

For treating netting canopies V. I. Saf'yanova recommends using diethyltoluamide at a rate of 20 ml of pure preparation per m^2 of netting. Coveralls impregnated with DET and benzimin retain their repellent properties for 2 years.

As a result of tests conducted by N. A. Biolovich, A. A. Potapov and V. V. Vladimirova it was established that 30-40% solutions of DET in 70% ethyl alcohol repel gadflies of the genus Tabanus (Tylostipia) for 8 hours. A definite dependence of the action of repellents on the species makeup of Tabanus was established; T. bromius and T. maculicomis appearing in July are not driven away by repellents as well as the spring species.

The repellent action of DET, obviously, depends mainly on the vapors of the preparation, and in the presence of low concentrations when the insects are in contact with the treated clothes it has an irritating effect on the insects themselves.

The DET dissolves plastic articles, but it does not affect nylon, dacron and natural fibers; however it cannot be applied to acetate fabric. It softens artificial silk and dynel; painted and varnished surfaces can be damaged if this preparation is applied to them.

One of the great advantages of DET is that it continues to have a protective effect even after the skin is washed with water. This is very important for fishermen, and also for servicemen, who have to be frequently out in the rain, cross streams, go through swamps in regions teeming with mosquitoes, etc. The preparation holds fast to fabric and is retained even after washing. According to Pierce, in experiments with stable flies DET was retained on the skin of the arms and hands after 28 attempts to wipe it off with a piece of fabric.

According to the cited author the preparation protects against Amblioma americanum ticks; when applied to clothes it repels ticks for 3-4 weeks.

Data exist concerning the fact that DET possesses high repellent properties with respect to Anopheles and Culex mosquitoes. After it is applied to fabric it preserves its repellent properties with respect to Aedes aegypti for 58 days.

Diethyltoluamide is also effective with respect to Xenopsylla cheopis fleas.

In comparison with unpurified DET dimethyl phthalate (40%) with a cream filler with respect to Anopheles and Culex (females) laboratory cultures it turned out that dimethyl phthalate with the cream was effective for $4-4\frac{1}{2}$ hours, whereas diethyltoluamide protected from mosquito bites for 18-20 hours.

Schmidt and others applied diethyltoluamide tagged with radiocarbon to the skin of guinea pigs at a rate of 6.97-7.11 mg per cm^2; within 6 hours there had evaporated from this area 0.96-0.98 mg, as a result of absorption when the repellent was removed only 1.32-3.4 mg/cm^2 were obtained; the remaining amount of preparation had been absorbed by the skin. Measurements of radioactivity showed that its peak in the urine was reached 12 hours after the application; after 24 hours with the urine there had been excreted 80%, and after 8 days 93% of the preparation absorbed by the skin and only 0.75% had been eliminated with the excrement. A very insignificant amount of radioactivity was noted in the blood, skin, and hide.

All 3 isomers of diethyltoluamide are slightly toxic to animals, and the orthoisomer is the most toxic, then come the meta- and para-isomers.

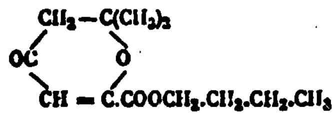
With the application to normal and injured skin of various solutions of DET containing 70% of the meta- and 30% of the paraisomers, there was not observed any noticeable irritation or increase in the sensitivity of the skin. Applying the preparation to injured skin did not lengthen the healing time. Furthermore, there cannot be applied to the skin a 50% DET solution and then put treated clothing directly on the body (without underclothes). Because of the irritating effect of DET solutions to the mucous membrane of the eyes, it is necessary to guard against the indicated solutions getting into the eyes.

DET is slightly toxic to animals. With the daily administration of the preparation to rats and dogs at a dosage of 300 mg/kg daily for 90 days no symptoms of poisoning were noted. Acute toxicity with the oral administration to rats of LD_{50} is 1950 mg/kg. When applied to the skin of rabbits the LD_{50} is equal to approximately 1000 mg/kg. The placing of DET in the eyes of a rabbit causes an irritation which does not pass for a long time.

According to Gribosky and others, DET can cause symptoms of encephalopathy. Thus, for example, in a $3\frac{1}{2}$ year old child tremor appeared and the child began to yell; after 6-10 minutes he returned to normal, and then the symptoms were again repeated several times. In the blood, urine, and cerebrospinal fluid there were not noted any deviations from the normal; cultures for the detection of bacteria and viruses gave negative results. Therapy with amytal sodium brought about the recovery of the child within 2 days. It was ascertained that the cause of the poisoning was, apparently, the DET with which each night for a period of 2 weeks the child's bed had been treated.

Indalone

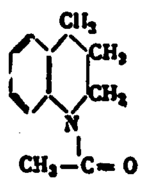
Indalone — $C_{12}H_{18}O_4$ or 2,2-dimethyl-6-carbobutoxy-2,3-dihydro-4-pyrone.



This preparation is a light-yellow, thick oil with a rather pleasant odor. Its specific gravity is 1.0503; its index of refraction at 20° is 1.4830. The boiling point is 170-172°. It is an effective repellent with respect to blood-sucking insects. It dissolves in organic solvents (alcohol, acetone, ether, benzene); it is not soluble in water. It is harmless to warm-blooded animals, the oral LD_{50} for rats is 7.4 ml/kg.

Kiuzol

Kiuzol — 1-acetyl-1,2,3,4-tetrahydroquinoline.



Kiuzol is a syrupy liquid with a yellowish color, readily soluble in organic solvents (acetone, alcohol, benzene, gasoline, toluene). It is not soluble in water. The preparation has a mild odor. When it stands for a long time in light it turns yellow however, it does not lose its protective properties. Its boiling point is 295°. The preparation dissolves varnishes and certain plastics; it discolors certain paints. It was proposed in 1958 by A. P. Terent'yev and N. G. Naumov.

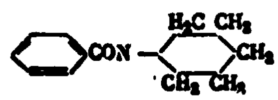
Kiuzol is used as an agent for the individual protection of people from the attacks and bites of taiga ticks (carriers of vernal encephalitis) and blood-sucking flies (mosquitoes, midges, sandflies and others). The preparation has been studied by a number of authors (A. V. Babenko, K. N. Bolotova, Ye. Kh. Zolotarev, M. L. Fedder, S. G. Gladkikh) on mosquitoes, sandflies and fleas.

When the preparation is applied to exposed sections of human skin sometimes irritation is observed: one should not smear the preparation on skin having cuts, scratches, scars, and other lesions. It is necessary to guard against kiuzol getting into the eyes. The application of the preparation should be stopped if skin irritation appears. One should not smear it on the skin of the face immediately after shaving. It is recommended for treating clothes, netting, etc., basically for organized contingents (workers of lumbering enterprises and others). Tulle kerchiefs treated with kiuzol retain their effectiveness for two seasons.

The preparation is slightly toxic to warm-blooded animals. According to A. P. Volkova and N. A. Sazonova, with the administration of kiuzol to white mice perorally the absolutely lethal dose is 1500 mg/kg; a dose of 250 mg/kg is nontoxic. The inhalation of kiuzol vapors for 30 days did not cause irritation of the respiratory organs in rabbits and mice. With daily rubbing of the preparation into the sheared skin of a rabbit for 9 days at a rate of 0.5 mℓ/kg of weight of the animal each day there were not observed any pathological symptoms in the overall state of the animal or deviations from the normal in the composition of the blood. However, after 7 days there appeared on the skin hyperemia and severe desquamation of the epithelium. Upon hystological examination of the skin no pathological changes were detected. When the preparation was placed in the eyes it caused severe inflammation and swelling of the mucous membrane. Kiuzol is removed from the skin by simple washing with soap and water.

Repelin-Alpha

This is a mixture of two repellents: dimethyl phthalate and N-benzoylpiperidine.



This oily, syrupy liquid is yellowish in color with a mild specific odor. The main active substance is N-benzoylpiperidine ($C_{12}H_{15}ON$) – this is a white crystalline substance. Its melting point is 48°. It dissolves readily in benzene and alcohol; it dissolves poorly in water.

Repelin-alpha contains 50% N-benzoylpiperidine, 48% dimethyl phthalate and 2% ethylcellulose. In the manufacture of repelin-alpha ethylcellulose is dissolved in dimethyl phthalate and to this solution there is added alpha-benzoylpiperidine. For treating exposed parts of the body 3-6 g are used. When there are large numbers of mosquitoes liquid repelin-alpha exceeds dimethyl phthalate in the duration of its protective action by 1.6 times (V. V. Almazova).

EHD

EHD – 2-ethyl-1,3-hexanediol, $CH_3CH_2CH_2CH(OH)CH(C_2H_5)CH_2(OH)$; among the diols possessing strong repellent properties this preparation is the most effective. Synonym: Rutgers 612. With respect to mosquitoes this repellent is one of the best; it also repels many other insects, including gnats, fleas and ticks.

According to its external qualities EHD is glycerine-like liquid possessing a high boiling point (243°) and a sweetish odor. It is mainly used in a mixture with other preparations.

Mixtures of Repellents

The great number and variety of proposed repellents indicates that not one of them satisfied our requirements completely. Even the broadly used dimethyl phthalate possesses a number of deficiencies of which the most basic is its incomplete protection against all species of insects and even against all species of mosquitoes. At the present time we do not have an "ideal" repellent, which possesses a general-purpose effect, i.e., which protects against various species of insects, and, furthermore, which provides with a single application prolonged protection. Because of this the most expedient approach has appeared to be the manufacture of mixtures; in particular, in the USSR, the United States and other countries research is being conducted to find the most effective mixtures possessing a broad range of action (in their composition there are included dimethyl carbate, dimethyl phthalate, hexanediol and others).

Smith and his colleagues have reported that mixtures of dimethyl phthalate and ethylhexanediol with dimethyl carbate, propyl-N,N-diethylsuccinate and p-chloro-N,N-diethylbenzamide were effective as repellents against several species of Aedes mosquitoes. However, it was noted that some of these more active mixtures (with respect to Aedes) were ineffective against Anopheles quadrimaculatus.

According to Altman and Smith, the effective mixtures were preparations containing 40% dimethyl phthalate, 30% ethylhexanediol and 30% N,N-diethyl-m-toluamide, o-ethoxy-N,N-diethylbenzamide or propyl-N,N-diethyl succinate; the best mixture was the one that contained 30% undecylenic acid, 30% N-butyl-4-cyclohexane-1,2-dicarboximide, 30% N-butylacetanilide and 10% emulsifier (Tween 80).

The following mixtures have become the most widely known:

1. Dimethyl phthalate 60%, indalone 20%, 2-ethyl-1,3-hexanediol 20%;

2. Mixture-M-2020 – dimethyl phthalate 40%, 2-ethyl-1,3-hexanediol 30% and dimethylcarbate 30% (it is used in the Unites States for cutaneous application in the army);

3. Benzyl-benzoate 45%, di-n-butylphthalate 45%, Tween 80 10%;

4. N-n-butylacetanilide 30%, 2-n-butyl-2-ethyl-1,3-propanediol 30%;

5. Mixture 1960 – benzoyl benzoate, butylacetamide, 2-butyl-2-ethyl-1,3-propanediol (used for treating clothes).

The first two mixtures are used mainly against mosquitoes, stable flies, gnats, mites, and ticks; the third with respect to mites and ticks, and the fourth with respect to ticks, mites, fleas and mosquitoes. Bruce proposed, moreover, a mixture of di-n-buty butylsuccinate (1-98%) with thiocyanates (99-2%) from the group of isobornyl thiocyanate, β-butoxy- or β-thiocyanodiethyl ether. Also proposed were mixtures of repellents with insecticides. For example, 2% by weight of di-n-butylsuccinate with 98% chlorinated insecticide or 99.5% di-n-butylsuccinate, with 0.5% chlorinated insecticide. For the manufacture of these mixtures insecticides are taken from the group, whose composition includes dichloro-diphenyltrichloroethane, diethyldiphenyldichloroethane, and methoxychlor.

The greater effectiveness of mixtures as compared to individual preparations can be explained by a number of facts: first, a mixture contains preparations of equal activity with respect to individual species of insects (some against mosquitoes, others against midges, and still others against ticks); secondly, in mixing preparations the effectiveness of some of them becomes in the mixture greater than when used separately. On the other hand, certain mixtures are unsuitable because of the chemical or physical incompatibility of their ingredients.

Widely employed is the mixture DID: 75% dimethyl phthalate, 20% indalone and 5% dimethyl carbate. This is a yellow, transparent, oily liquid with a rather pleasant odor. For practical application in the USSR DID was proposed by P. A. Petrishcheva, I. A. Tarabukhin, V. M. Saf'yanova, I. Ya. Mandel'baum and B. A. Gayko.

The DID is a very effective agent repelling blood-sucking insects, when they attack in masse. The duration of the protective effect exceeds the activity of dimethyl phthalate employed under analogous conditions at the same dosage. Thus, in the forest zone of the central belt of the RSFSR with a median number of mosquitoes (100 and more attacks on an arm bared to the elbow in 30 minutes) the duration of the protective effect of DID is not less than 8 hours, whereas the effect of dimethyl phthalate does not exceed 6 hours. When preparation DID is used during considerable heavy work the period of its protective effect is reduced as compared to the effect of this preparation under conditions of work not involving a great amount of activity; however, even under these conditions the duration of the effect of DID considerably exceeds the effect of dimethyl phthalate.

It is necessary to store this preparation in tightly closed cans at room temperature. It is inflammable.

Forms of Repellent Application

Repellents are applied in pure form, and also in the form of cellulose acetate jelly, aerosols, ointments and creams, lotions, solutions, emulsions and pastes.

Cellulose acetate jelly with a repellent is used to treat protective netting; it is manufactured in the following way – one part by weight of cellulose acetate is dissolved in 10 parts of acetone and 4 parts by weight of benzimin are added.

Aerosol cylinders containing repellents. Aerosols are obtained by spraying repellents in the form of solutions and emulsions using various apparatuses (sprayers), and also using aerosols cylinders containing 70% propellent (35% dichlorofluoromethane, and 35% trichlorofluoromethane) and 30% mixture of repellents. Let us present several formulas: 1) diethylmethyltoluamide 15% isopropyl or ethyl (dehydrated) alcohol 15%, propellent 70%; 2) when using ethylhexanediol or benzimin 20% is employed and the amount of alcohol is decreased to 10%; 3) dimethyl phthalate 12.77%, hexanediol 3.77%, butyldimethiodehydrogamma-pyrone-carboxyl 3.46% (a mixture of 3 repellents), isopropyl alcohol 10% and propellent 70%.

Insectocidorepellents in the form of aerosols can also be applied in veterinary medicine for the treatment of cattle, horses, sheep, birds and domestic animals. In this case the mixture should contain 30% insecticidorepellent and 70% propellent by weight. An example of an insecticidorepellent is the following preparation: "Crag"-repellent (5.3%), methoxychlor (90%) 6%, velsicol-A-50) 15.5% and kerosene distillate 25.2%, propellent 48%. The following mixtures are also used: 1) 1.44% allethrin (technical), 2% piperonyl butoxide, 3% methoxychlor (100%), 12% deodorized kerosene, 12.56% deodorized basic oil, 69% propellent; 2) 0.2% allethrin, 2% lethane-384, 2% MGK-264, 3% technical methoxychlor, 10.8% methylated aromatic kerosene derivative, 12.8% kerosene distillate, 69.2% propellent; 3) 0.2% pyrethrins, 2% piperonyl butoxide, 2% thanite, 3% methoxychlor, 10% methylated aromatic derivative, 12.8% kerosene distillate, 70% propellent. Source material is available about a number of other repellents, including 2,3,4,5-bis-(2-butylene)-tetrahydrofurfural (MGK-11) and dipropyl-isocinchomerate (MGK-326), which are effective preparations for the treatment of cows.

With an expenditure of 1 g/s and a duration of treatment of 6-8 seconds daily the treatment ensures the protection of an animal of medium size from stable fly bites, etc. It is sufficient to treat an animal on each side for $1\frac{1}{2}$ seconds, moreover, one should avoid wetting of the hide of the animal. When treating places containing animals one should not direct the aerosol stream toward uncovered milk or milk containers. In treating premises the expenditure of preparation is determined according to the time of spraying at a rate of aproximately 5 seconds for each 28 m^3. During the treatment and for at least 15 minutes after it the doors and windows are kept closed to prevent the preparation from getting out of the premises before it can settle on surfaces. Such a treatment also accomplishes the extermination of flies and other flying insects.

Ointments and creams. Various ointments containing repellents are broadly used; such an ointment is one containing 40% benzimin. Of 8 ointments tested by us (jointly with M. I. Brun) the following gave the best results: 1) dimethyl phthalate 67%, zinc stearate 23% and magnesium stearate 10%; 2) dimethyl phthalate 20%, diethylamide-o-chlorobenzoic acid 60% and magnesium stearate 20%. Under the conditions of the experiment the effect of these ointments lasted about 6 hours. Good repellent properties are possessed by creams containing glycerine, monostearate, lanolin, alcohol, paraffin, triethanolamine, hexanediol-1,3, dimethyl phthalate and indalone.

In England two cream formulas were proposed: 1) emulsifying wax 5 g, triethanolamine 9 ml, oleinic acid 27 ml, dimethyl phthalate 100 ml and water 100 ml; 2) ethylcellulose 2.7 g, cellulose aceto-butyrate 23 g, propylene-glycol-monostearate 2 g, dimethyl phthalate 55.8 g, ethylenehexanediol 18.6 g, and indalone 18.6 g. Also proposed were creams giving the skin a tan color.

Repellents in creams when applied to fabric are less effective than solutions.

Lotions are applied to the skin of the face, neck, arms, and legs. They are a mixture of repellents, glycerine, alcohol, odorant and other substances. Industry turns out the lotion "Taiga" with the following composition: 1) 20% hexamid [benzimin], 5% glycerine, 60% alcohol, 15% water; 2) 45% repellent, 3.5% glycerine, 36% alcohol, 14% water, 1.5% odorant. The lotion "Angara" contains 40% benzimin, besides, glycerine, odorant and water.

Repellent solutions are most frequently used for treating of clothes, headgear and protective netting. As solvents there are utilized alcohol, acetone, freon and others. For the preparation of 1 ℓ of a 40% solution of benzimin there are used 400 mℓ of the latter, 400 mℓ of alcohol, 200 mℓ of water (2:2:1); in preparing a 40% acetone solution 600 mℓ of the latter and 400 mℓ of repellents are employed.

Emulsions are used for application on the exposed parts of the body (arms, legs) and for treating clothes with a fine spray. To prepare an emulsion there are used glycerine, vaseline, OP-7 or OP-10. Thus, to prepare an emulsion of dimethyl phthalate to 85 g of glycerine or vaseline 15 g of repellent are added and thoroughly mixed. In preparing aqueous emulsions with OP-7 or OP-10 2 parts of repellent, 4 parts of water and 4 parts of emulsifier are used.

The Application of Repellents Against Blood-Sucking Flies

Preparations are used for the direct treatment of the exposed parts of the body, for the treatment of clothes and other software – gauze hoods, kerchiefs, protective netting, stockings, socks, gloves, oversleeves and so forth or they are used to treat various surfaces, vegetation and air (smoke from fires, candles, aerosols and others). The duration of the protective effect of a preparation depends on its boiling point, and also on the amount applied on the skin or clothes, atmospheric temperature and humidity, the strength of the wind and the presence of precipitation, and also on the type of work being performed by the person (Ye. I. Pokrovskaya, Alexander, Atman); on marches or while performing heavy work a man perspires profusely, as a result of which part of the preparation is washed away, and because of this the time of the protective effect of the repellent is reduced.

To lengthen the effective period of a repellent there is added to the active component a prolongator, which promotes the fixation of the preparation to a given surface. In this respect interest has been expressed in the results of the experiments of M. I. Brun on the application of rosin as a prolongator; these experiments were conducted under field conditions in the summer of 1952 in the delta of the Volga and showed that rosin doubles the effective period of dimethyl phthalate. Abroad for this purpose there were added as stabilizers gum tragaconth and gum arabic; such a repellent mixture consisting of hydrogenated naphthol and hydrogenated biphenyl compounds provided 10-13 hours of protection against mosquitoes under tropical conditions.

The development of perspiration-resistant repellents is, in our opinion, the most important problem in this field, since precisely because of perspiration the repellent is washed off the skin and this stops its action; this explains why even the most effective repellents are ineffective during the hot period of the day.

The exposed parts of the body are covered with the preparations before going into places teeming with mosquitoes and gnats. It is not recommended that the preparations be applied to the skin before this. A repellent is applied in its pure form or in a solution, emulsion, paste or other forms.

A single application to the face, neck, hands (up to the elbow) requires 1.5-2 g (15-20 drops) of the preparation. It is placed in the palm, then evenly spread over the surface of the body; when applying the preparation to the face it is necessary to be careful of the eyes, because if the preparation gets on the conjunctiva it causes burning and can entail serious injury to the mucous membrane of the eyes. It is necessary to keep in mind that when applied to freshly shaved skin repellents also cause burning.

Certain repellents (dimethyl phthalate, dibutyl phthalate) are good dissolvers of plastic, therefore all articles from it should be carefully protected from coming into contact with them.

Gauze or muslin kerchiefs, stockings, socks, gloves, cotton coveralls, puttees and gauze hoods are treated with solutions, emulsions or pure repellents. The expenditure of pure preparation is calculated on the average at 40 mℓ/m^2 of clothes or 32 mℓ per 100 g of fabric, also including gauze. In impregnating canopies, netting, preparations are applied at a rate of 20 mℓ of repellents per m^2. During the daytime it is recommended that the curtains be kept rolled up in special bags in a cool place.

Outer clothes (shirt, trousers, jacket, skirt and others) are treated by rubbing the preparation into them. For this there is taken enough liquid (0.3-0.4 mℓ) at such a rate, to slightly moisten the palms of both hands; then the repellent is rubbed into the clothes, spread on an even surface, firmly pressing the palms on the fabric. Socks and trousers can be treated without taking them off, but it is better to remove one's shirt. To sufficiently ensure prolonged and reliable protection to a set of clothes, including coveralls or trousers with a pullover tunic, for women – a skirt, jacket, and stockings, and also to male clothing – 300-400 mℓ of solution are evenly applied. For treating headgear (with dimensions of about 0.5 m^2) 50 mℓ of solution are expended. It is not recommended to take a great deal of preparation on the palm, since in this case spots can be left on the clothing. In treating clothing manually it is necessary to remember that the repellent is more effectively applied to dry than to moist fabric, therefore it is desirable to treat dry clothing.

Clothing can also be treated by spraying with the pure or diluted preparation 2-4 times (the emulsion, when being applied must be shaken all the time). However as a result of such treatment oil spots can appear on clothes due to the application of large drops. When using mechanized sprayers giving too fine a spray, the drops penetrate poorly into the fabric being treated and do not ensure the required effect. Furthermore, with this method of treatment an excess quantity of preparation is expended.

The application of a solution to clothes is accomplished by treatment with any liquid atomizer ('dezinfal'", avtomaks, garden sprayer, aerosol bomb, barbershop sprayers, pushkiflit and so forth).

In the absence of liquid sprayers a solution can be applied to clothing with the help of a brush for washing of hands, a piece of felt, etc., or by soaking.

Clothing treated with diethyltoluamide have a weak odor and can be used for daily wear (outside premises). Pavlovskey nettings, kerchiefs, pieces of tulle or gauze are put on the head over a hat or service cap so that they can be lowered to the forehead, they border the neck, but do not touch the skin. When necessary netting and tulle can be lowered to the face.

Impregnated suits provide reliable protection from midges and other varieties up to 2 months, from ticks the duration of the protective action is less. The effect of rain and sun decreases the duration of protection.

Washing and ironing remove the preparation from fabric.

Treated articles of clothing before they are used and in the intervals between wearing should be kept folded and tightly packed (polyethylene or oilcloth bags, parchment paper, etc.) that extends the period of repellent action.

In all cases fabrics impregnated with dimethylphthalate protect a person longer than dimethylphthalate applied on the skin.

The type of cotton fabric does not affect preservation of the repellent properties. The storage of treated clothes (up to 90 days) does not affect its effectiveness. Tulle kerchiefs impregnated with repellents are not less effective than netting; kerchiefs of artificial silk and synthetic fabrics (caprone) weakly adsorb repellents, and their effectiveness is low.

For the purpose of economizing a repellent in places abounding with blood-sucking flies it is recommended that clothing be worn closed as tightly as possible, leaving exposed only the hands and the face. During a prolonged stay under conditions of massive attacks of blood-sucking flies in the case of a weakened protective action of a repellent, it is necessary to apply it repeatedly to the exposed parts of the body.

Many repellents (dimethyl-, dibutylphthalate, diethyltoluamide, hexamide and others) possess toxic properties with respect to mosquitoes, gnats, lice, ticks and other arthropods. Ticks crawling on a fabric treated with one of the preparations experience paralysis in an hour followed by death.

In using repellents for the protection of dwellings from the infiltration of mosquitoes and gnats it is better to use not pure dimethylphthalate, but a 5% emulsion in 0.5% soap solution or dimethylphthalate with cellulose acetate, which are used to impregnate window curtains, other curtains and tent netting with sprayers at a rate of 25-35 g/m^2 of surface. The duration of the preservation of the repellent properties is approximately equal to 8 days.

Blood sucking midges are encountered in the USSR almost everywhere, the most infested zones are the taiga and the deciduous forest. In the spring-summer period these insects are very numerous during the day and at night. After sunset the gnats hide in vegetation, but biting midges appear. In certain regions of Eastern Siberia and The Far East gnats are the basic component of blood-sucking flies and they inflict huge damage on the national economy.

The ecology and biology of gnats are still insufficiently studied. In connection with this a sufficiently developed system of measures is lacking for the destruction of these blood-sucking flies, which increases the value of the individual protection of people, including the application of repellents to ensure the normal life and work of the people. Burdensome sensations from the attack blood-sucking flies are caused not only by bites (sometimes hundreds and even thousands of insects), but also by multiple landings on the skin, by their crawling under clothing, in the eyes, nose, mouth and their continuous appearance before eyes. Besides the local and general reaction to bites, there are sometimes observed very burdensome subjective sensations, not connected directly with the bites. Therefore the application only of antibite measures (the cutaneous application of repellents) although it protects from bites, it does not ensure full protection, since even the strongest repellents do not prevent the landing of gnats on skin treated with a preparation, their entry into the eyes, etc. In this case cutaneous application of repellents has only an auxiliary, secondary value.

Consequently, in the presence of mass attacks of midges and gnats prolonged and sufficiently complete protection of people can be ensured only by treating the clothes or by special protective suits with repellents; with respect to mosquitoes a cutaneous application of repellent agents is usually sufficient. In impregnating clothes it is desirable to use khaki color or other green shades, since according to available observations these colors least attract midges.

Inasmuch as gnats do not bite through clothes, the complete treatment of them is inexpedient; to prevent insects crawling under clothes it is possible to limit this by selective treatment of the color, the cuff of the sleeves and trousers, socks and stockings with 40% solutions of repellents.

During a study of the repellent properties dimethyl phthalate and other preparations at the Astrakhan' national forest reservation in 1951-1952 sharp divergences were obtained in the periods of preservation of the protective effect of preparations applied to the skin of humans (Table 25).

As was shown, the duration of the protective action of repellents with respect to blood-sucking flies depends on the intensity of the attack. Thus, in 1951 dimethylphthalate, when rubbed on the hands of a man, protected in the open air (in reeds) for 240 minutes, but in 1952 only for 62 minutes; the frequency of bites in the first case was 3-4 per minute (in individual cases 25-30), and in the second it amounted on the average to 34 (in individual cases 76). The species of attacking mosquitoes in 1951 were: Anopheles hyrcanus 65.3%, Aedes vaxans 23.2%, A. captiuss 9.1%, Anopheles maculipennis 1.8% and Culex modestus 0.6%. In 1952 – Aedes vexans 98%, Anopheles hyrcanus 1.5% and Culex 0.5%.

Table 25. Duration of the preservation of repellent properties of preparations applied to the skin (according to M. I. Brun).

Name of preparation	Average-protective time in minutes	
	1951	1952
Dimethylphthalate	240	62
2-ethyl-1.3-hexandiol	227	98
Methylterpenylphthalate	294	88
Diethylphthalate	49	6
Dibutylphthalate	59	2
Neril-isopropylphthalate ...	87	16
Terpineol	163	31

For the application of repellents on the skin and clothes aerosol bombs were also used. During the spraying of the liquid the bombs are held at a distance of 15-45 cm from the surface being treated; one should not direct the aerosol towards the eyes and towards the mouth cavity to avoid accidents; one should not forget that aerosol spoils acetate and other synthetic articles, including plastic articles (frames of spectacles, fountain pens, varnished and painted surfaces, buttons and others). The duration of treatmemt from aerosol bombs depends on the dimensions of the object. For example, for treating stockings and socks 10-12 seconds are sufficient.

With respect to mosquitoes (Ph. sergenti, Ph. papatasii, Ph. caucasicus) repellent properties are possessed by benzamides, which, according to M. I. Brun, protect the skin of men from bites for 1 hour 45 minutes-5 hours. For the same purposes different mixtures were proposed, in the composition of which were glycerine, monostearate, lanolin, alcohol, paraffin, triethanolamine, dimethylphthalate, indalone, and others in different proportions.

It is necessary to dwell specially on nettings protecting people from bites of flying blood-sucking insects outside habitable premises. They were proposed in 1938 by Ye. N. Pavlovskiy, G. Ye. Pe~vomayskiy and K. P. Chagin; it was agreed to call them Pavlovskiy nettings. The nettings are prepared from fishing nets (dragnets with dimensions of the mesh 1-1.5 cm in diameter); for impregnation with repellent preparations they are soaked in the repellent for 2-3 hours, then they are taken out, wrung out and dried for 1-2 hours. The expenditure of repellent for treating one netting on the average was equal to 300-350 g. Such nettings possess repellent properties, according to some data, for 6-10 days, according to other - 20 days.

For the purpose of securing the repellent to the netting cellulose acetate jellies were used, the preparation of which was described above. Nettings treated in such a manner preserve their repellent properties for about a month.

In the case of the absence of synthetic repellents it is possible to use other preparations, including various mixtures, containing lysol, naphthalysol and others.

Nettings intended for the protection of the head (face, head, and neck) are made with dimensions of 50·75 cm; the border is trimmed with cotton fabric, on two opposite angles of one of the longer sides there were sewed bands at 30-40 cm, and on the opposite side of the netting at its angles (below) they are fastened by one safety pin. The netting is thrown over the headgear in such a manner that the front edge (by length) ... down to the forehead to the superciliary arcs, the lateral edges of the netting (by width) - to the shoulders and the read edge closed the neck; on the back the netting was fastened to the clothes by safety pins. In the front the netting was secured to the headgear by the ends of straps or the ends of the latter were tied under the chin in such a way that the greater part of the face remained exposed. During a mass attack of blood-sucking flies to protect the face the front edge of the netting was lowered to the chin, and the ends of the bands were tied around the neck.

Freshly-impregnated nettings were not worn more than 2 hours in a twenty-four hour period, otherwise the persons continuously using them, could note irritation of the skin and headache. Thanks to the use of the netting the number of insect bites was decreased by 85-100%. With continuous wearing the netting is a protective means for 600 hours, with periodic use - up to 300 days.

For the purpose of lengthening of the period of the protective action of the netting it is kept in a special case of oilcloth or leatherette fabric. To the case there is fastened a band allowing it to be worn on the shoulder. Before packing the netting it is tightly folded 3 times on the narrow and 4 times on the wide side, and then it is tied with the free end of the band. With the weakening of the repellent properties of the netting it is repeatedly treated.

The netting can be replaced by a two-layered gauze hood; between the layers of the hood along the edges it is better to place a band of hygroscopic cotton with a width of 3-4 cm. After impregnation such a hood is worn, as the netting, over the headgear.

For protection of the hands oversleeves of netting are used with dimensions of 35·25 cm; the oversleeves are sewed in the form of a cylinder with a diameter of 12-18 cm and a length of 25 cm; the edges are trimmed with a band or cotton fabric and through one of the seams a string is passed. The oversleeves impregnated with repellent preparations are fastened to the cuff of the shirt, blouse, etc., in such a way, that its free end reached to half the length of the fingers.

Protective nettings can also be used for the collective protection of people, for example in tents. For this, strips of drag-netting with a width of 50 cm and a length of 16-17 m are impregnated with repellent preparations. The entrance and the whole bottom of the tent (around) on the outside are curtained-off with nettings. Furthermore, the tents are sprayed with repellent substances.

For the purpose of prophylaxis of leishmanioses and mosquito fever it is recommended that the individual curtain-nettings be treated with repellent. Such curtains are made from drag-netting with dimensions of the mesh not more than 18·18 mm. The best effectiveness is provided by treatment with diethylamide at a rate of 20 ml of pure preparation per 1 m^2 of netting. The impregnated nettings are stored in cellophane or oilcloth cases (as far as possible in a cool place). Repeated impregnation is conducted after 15 days (V. M. Saf'yanova).

Application of Repellents Against Ticks

The use of acaricide-repellents is most important in foci of tick spring-summer encephalitis, where all measures of individual protections are directed towards preventing the crawling of ticks under the clothing.

The results of tests of 63 organic compounds (V. I. Vashkov, M. I. Brun, L. I. Brikman) showed that the greatest repellent properties with respect to Dermacertor marginatus are possessed by diethylphthalate, ethylpropylphthalate, diisopropylphthalate, methylisobutylphthalate, methylbutylphthalate, diethylbenzamide, terpineol and 2-ethyl-1,3-hexandiol; dibutylphthalate in effectiveness is inferior to the enumerated preparations by almost 2 times.

Among the 72 preparations studied on the nymphs of ticks Ixodes persulcatus, the best results were showed by 16 substances, which preserved for more than 15 days a coefficient of repellent action close to 50 (V. I. Vashkov, V. I. Zakolodkina). On the day of the application of the preparation to paper this index was equal to 100. These compounds were as follows – diethylphthalate, methylisopropylphthalate, methylisopropylphthalate, ethylallylphthalate, propylallylphthalate, isopropylallylphthalate, butylallylphthalate, methylterpenylphthalate, cyclohexylallylphthalate, allyterpenylphthalate, phenylallylphthalate, isoamylallylphtnalate, benzoylbenzoate, a mixture of dimethylphthalate with diethylamide-o-chlorobenzoic acid.

With respect to mature ticks I. persulcatus of 64 studied preparations the most effective turned out to be 6-diethylphthalate, methylterpenylphthalate, allylterpenylphthalate, butylacetylanilide, diethylamide-o-chlorobenzoic acid, a mixture of dimethylphthalate with diethylamide-o-chlorobenzoic acid (1:1).

The given data attest to the fact that the same preparations do not possess uniform repellent properties with respect to different species of ticks Dermachentor marginatus, Ixodes persulcatus.

Shmidt and others in studying 44 compounds in the form of acetone solutions and 21 in the form of emulsions, which they applied on clothing at a rate of 2 g per 1000 cm^2 with the use of 1.5-3.6 g of the mixtures on the same area. The best results were provided by the following repellents: n-butylacetanilide, n-propylacetanilide, alpha-butoxyn-n-cyclohexylacetamide, cyclopentylsuccinate, n-isopropylacetanilide and methylpropyl ether of bicyclo-(2,2,1) heptene-2,3-dicarboxylic acid. Somewhat less effective were undecylenic acid indalone, n-butyl-4-cyclohexane-1,2-dicarboxymide, dimethylcarbate, hexyl-mandelate and butyladipate.

The most effective "universal" mixtures were those, which contained n-butylacetanilide.

The treatment of clothes with aerosols showed that not all repellents can be used in this way. During treatment with aerosols of ethyl-beta-phenylhydracrylate, 2-butyl-2-ethyl-1,3-propanediol or dimethylcarbate the results were just as effective, as with the application of emulsions or solutions for the impregnation of clothes; aerosol treatment with indalone was ineffective. This can be explained by the fact that the quantities of preparation applied during aerosol treatment were too small as compared to those, which are required for giving repellent properties to clothes utilized against ticks. Therefore, the application of repellents in aerosol treatment were too small as compared to those, which are required for giving repellent properties to clothes utilized against ticks. Therefore the application of repellents in aerosol bombs against I. persulcatus was ineffective and hardly expedient. For the purpose of protecting from ticks in foci tick-borne encephalitis at the present time there is recommended a 50% solution of diethyltoluamide (DET) in an organic solvent. Repellents are usually more effective with respect to nymphs than the imagoes of ticks, and somewhat more active with respect to males than females.

The impregnation of wool with an emulsion of butyladiapate, according to Grannet and French, protected dogs by 90-100% against American ticks, during the course of several weeks with the application of 2 g of preparation per 1000 cm^2 of wool surface. Dibutyladipate or di-n-butyl-adipate [$C_4H_9OOCC_4H_9OOC(CH_2)_4COOC_4H_9$] repels Ixodes ticks, fleas, and also mosquitoes. Almost analogous results were obtained with hexylmandelate. These substances withstand two washings of the clothing. The preparations can also be applied in aerosol form, which has the advantage of making it possible to apply the repellent easily and rapidly. It is necessary to note that dibutyladipate is better than hexylmandelate because it does not irritate the skin and it does not have an odor. At the applied dosage this preparation is harmless to man.

For the purpose of strengthening the protective properties of clothing, special belts, oversleeves and so forth, they are impregnated not only with repellent preparations, but also with acaricides. According to I. N. Skorin and others, the wearing of clothing correctly fitted and impregnated with a 6% emulsion of soap-K completely protects the body of a man from the penetration of ticks for 8-10 days. When wearing underclothes, impregnated with this preparation (3%), the number of ticks getting to the body of a man is decreased by 3-8 times, and the number of which adhere to the body by 4 times.

Special belts impregnated with 10% soap-carbolic emulsion preserve their repellent properties for 5 days. The application of Pavlovskiy nettings impregnated with 5-10% solutions of carbolineum or lysol-tar mixture, a 15-20% tetrachlorophenol (one part) with trichloroxydephenol (one part) and Petrov contact (3 parts) lowers the number of ticks penetrating to the body, by 16-23, 7-10, 14-23, and 25-30 times respectively.

For the purpose of protecting man from ticks coveralls or work clothes are impregnated 200-300 g of preparation; the upper part of the trousers should be impregnated with special care – a barrier with a width of 20-30 cm, and the upper part of the shirt – a barrier with a width of 10-30 cm near the collar, the cuffs of the sleeves; it is also necessary to thoroughly treat the fly of trousers and other places of possible penetration by ticks. Such clothes without washing preserve their protective properties for 1-3 months. For treating the bottom of trousers and jacket 50 g is required on the average, and for treating a pair of cotton stockings 60 g of preparation.

According to L. I. Brikman and N. N. Gorchakovskaya, with solid treatment of clothes by dibutylphthalate the number of ticks on one person per hour was reduced by 3 times with a normal expenditure 1 mg of substance per 1 cm^2 and by 4 times with an expenditure of 1.8 mg/cm^2 or 25-40 g per set. Analogous data were obtained in treating clothes with dimethylphthalate.

The application of barrier treatment of clothes with the use of dibutylphthalate in the form of barrier strips on trousers in the knee region with a width of 40 cm, on the collar and cuffs of shirt of 15 cm lowers the average number of ticks from 13.5 to 11.2 with a normal expenditure of 1 mg and up to 4.7 times with an expenditure of 1.8 mg/cm^2. Treating trousers with dimethyl- and dibutylphthalate to a level of 73-80 cm provided the best results: the number of ticks in both cases was reduced by almost 10 times. This is explained, apparently, by the increased rate of expenditure of preparation (11 mg/cm^2 of surface or 100 g per set). The treatment of puttees also gave good results (the decrease in the number of ticks on one man per hour was almost 10 times), which, obviously, is explained by the same cause – the greater rate of expenditure of preparation – 34 mg/cm^2 or 60 g per pair of puttees.

The given data attests to the dependence of the degree of effectiveness on the quantity preparation applied to the surface of the treated fabric. Thus, during marches and at work not connected with prolonged rest in the wood, for the purpose of protecting from attack by I. persulcatus only the trousers are subjected to treatment (11 mg/cm^2 or 100-115 g per pair of trousers); in treating a whole suit the expenditure of preparation is 250 g.

S. G. Gladkikh showed that dibutylphthalate, diethylphthalate, dimethylphthalate, acetylhydroxynolin, formylhydroxynolin, diethyltoluamide possess repellent properties to ticks and can be used with success for the purpose of prophylaxis of spring-summer tick encephalitis.

According to Gertler and others the most effective with respect to ticks are dibutylloluamide, the paraisomer of which preserves its activity for 70 days. Of the large number of repellents only diisopropyltoluamide withstands washing with soap and water; N,N-diisopropyl-p-toluamide withstands 7 washings without the loss of its activity.

Application of Repellents Against Fleas

In a study of the repellent properties of certain preparations with respect to fleas M. L. Fedder, M. I. Brun, Yu. F. Shumayeva, and others showed that good results are provided by the following compounds: diethylamide-o-chlorobenzoic acid, hexylacetanilide, isoamylacetanilide, butylacetanilide, dibutylbenzamide, diethylbenzamide, monobutylate-2-ethyl-1,3-hexanediol and dimethylphthalate. Dibutyladiphate or di-n-butyl-adipate also repels fleas; it is more effective than the repellents named. In field tests on suslik fleas Setosa formyltetrahydroxynolin, acetyltetrahydroxynolin, dimethylphthalate and terpeniol showed rather strong repellent properties.

Comparative experiments (M. L. Fedder, N. V. Novokreshchenova) carried out with 6 forms of fleas showed the presence of specific differences in sensitivity to the repellents; the most susceptible were the fleas C. fasciatus, the least sensitive were P. irritans. According to M. L. Fedder, acetyltetrahydroxynolin possess considerable repellent properties with respect to both fleas, and mosquitoes; especially effective were acetylhydroxynolin and formyltetrahydroxynolin. With cutaneous application these compounds provided protection for 2-8 hours from the bites of human and suslik fleas.

With the storage of clothes treated with repellents in tightly sealed oilcloth bags the repellent properties of such fabrics are preserved for more than 6 months (V. T. Osipyan).

Application of Repellents Against Cockroaches

Repellents are finding a place for themselves among the new agents for combatting cockroaches. In the United States they are used to impregnate boxes with food products, boxes for transport of beer and so forth.

Repellents applied against blood-sucking flies are ineffective when used against cockroaches. According to M. L. Fedder, among 5 repellents tested by her (diethyltoluamide, acetylhydroxynolin, formyltetrahydroxynolin, indalon and dimethylphthalate) not one provided complete protection even under the most favorable conditions; the best results were obtained with diethyltoluamide (Table 26).

Table 26. The repellent action of preparations on common cockroaches (according to M. L. Fedder).

Preparation	Cockroaches feeding on the preparation, %
Diethyltoluamide	16
Acetylhydroxynolin (kiuzol)	64
Indalon	57
Diemthylphthalate	69
Control	75

Below is given a list of certain repellents applied to repel cockroaches (Table 27).

Table 27. Firm name of certain repellents applied in the United States to repel cockroaches.

Firm name	Chemical composition
Tabutrex	Di-n-butylsuccinate
P11	2,3,4,5,bis-(n-butylene)-tetrahydrofurfural
No. 55	Tert-butyl-sulfenyl-dimethyldithiocarbamate
MGK 264	N-octyl-bicycloheptenl
874	2-hydroxyethyl-n-octylsulfide
949	2-hydroxypropyl-n-octylsulfide

In foreign literature there are available data about the application of special repellents against cockroaches, in particular dibutylsuccinate (Tabutrex), proposed by an experimental-research laboratory in Chicago (the United States). This is a colorless liquid, almost nontoxic for animals (LD_{50} for rats 8000 mg/kg) is applied in its pure form, as an oil solution or in emulsion form. The preparation does not cause skin irritation, lesions to internal organs or loss of weight after 90 days of feeding it to animals. Dibutylsuccinate is nontoxic to insects; it simply makes surfaces treated with it unattractive to them, and they move to other places. It is used by itself or in mixture with pyrethrins.

Bruce proposed a mixture consisting of 2% di-n-butylsuccinate and 98% (by weight) organophosphorus insecticide (malthion), which, according to his data, possesses good repellent properties with respect to cockroaches.

For combatting cockroaches resistant to insecticides in breweries in the United States they use the indicated mixture to treat packing boxes; the insects do not go near them.

The following preparation finds application – repellent-11 [2,3,4,5-bis-(N-butenylene)-tetrahydrofurfurole], which is a high-boiling liquid with a weak, pleasant odor, dissolving in organic solvents; from it they prepare concentrates and emulsion. A typical recipe is: 10% repellent-11, 2% repellent MGK-264, 2% emulsifier, 16% purified kerosene and 70% water (repellent MGK-264 strengthens the action of repellent-11, i.e., it is its synergist).

A synergist for pyrethrins and allethrin is repellent MGK-264. It is used to prepare preparations and to destroy dwelling parasites, cattle parasites and pests of stored goods.

Versatile repellents effective with respect to a number of insects are 2-hydroxyethyl-n-octylsulfide (repellent-874) and 2-hydroxypropyl-n-octylsulfide (repellent-949).

Repellent-874 is an organic compound, a slightly amber colored liquid with an insignificant odor reminiscent of mercaptan; it is readily miscible with purified kerosene and the majority of organic solvents; it dissolves poorly in water; its density is 0.925-0.935 g/ml at 20°, its index of refraction is 1.470-1.478; its viscosity is 50.6 at 37.7°; its flash point is higher than 75°; its solidification point is about 5°; its boiling point is 98° at 0.1 mm Hg. Its LD_{50} for white rats is 8.53 g/kg.

Repellent-919 is also a highly effective preparation; it, like the preceding repellent, preserves its repellent properties with respect to cockroaches for 14 days.

These two preparations in effectiveness exceed repellent-11 by approximately 2 times. They repel ticks and stable flies.

An effective repellent against cockroaches is also tert-butyl-sulfenil-dimethyldithiocarbamate (repellent-55). According to the laboratory data of Burden and Estok, cardboard treated with this preparation repelled common cockroaches for 90 days; its effectiveness is higher than the activity of repellents-11 and repellent-874. Among its negative properties are its higher toxicity to warm-blooded animals and odor stronger than repellents 11 and 874.

Repellent-55 repels not only insects, but also rodents; in laboratory experiments it was shown that for rats this is a strong repellent and rabbits would sooner die from hunger than eat feed containing 0.1% of this preparation. Because of these qualities it is used to treat bags, in which grain is packed.

As a result of the comparative study of these repellents it was established that they can be placed according to the degree of their effectiveness in the following order: repellent-11 – repellent-55 – tabutrex – diethyltoluamide.

Goodhue and Howell recommend a mixture of the following composition: 0.075% pyrethrins, 1% repellent-11, 0.15% piperonylbutoxide, 0.25% N (2-ethyl)-hexyl-bicycloheptene-dicarboxym and 0.525% distillate of kerosene.

Isolan repels cockroaches well; it also possesses simultaneously insecticidal properties (contact poison). Its toxicity for warm-blooded animals, however, is great (its LD_{50} is 54 mg/kg) which prevents its broad application.

Application of Repellents Against Flies

There exists a number of compounds repelling varies species of flies. La Brecque and Wilson studied 65 substances for repellent properties (vapors and contact) with respect to house flies; 28 preparations possessed to one or another degree repellent properties for 2 days and more; di-n-octylamine, n-propyl-p-octylsulfoxide and 3-chloro-propyl-n-octylsulfoxide turned out to be effective for over 90 days; allyl-n-octylsulfoxide and N-amyl-2,3-norcamphene dicarboxymide were active for a period of 30 days.

N-(n-pentyl)-succinamide, N-(n-heptyl)-phthalimide and secondary pentyl-phthalimide preserved their effectiveness for 14 days.

Below is given a list of certain repellents applied in the United States for flies.

Special importance is presented by the preparations repelling blood-sucking flies, in particular stable flies (Stomoxys calcitrans). Under practical conditions the following repellents are used: butoxypolypropyleneglycol (Crag-repellent) with methoxychlor (concentrate of the emulsion); N,N-diethyl-m-toluamide 15% in a mixture with methoxychlor 1% (aqueous emulsion); 1,3,4,5-bis-(2-butylene-)-tetrahydro-furfurole 0.4% (MGK-repellent) with N-octyl-bicycloheptene 0.2% (MGK-264 — a synergetic for insecticides increasing and prolonging the action of the repellents), piperonylbutoxide 0.1% and pyrethrins 0.035%. All these preparations are applied to an animal at a rate of 75 ml daily. The results were good – the milk yield was increased (Malasse).

Table 28. Firm's name and chemical composition of certain repellents applied in the United States for repelling flies.

Firm's name	Chemical composition
MGK	1,3,4,5-bis-(2-butylene)-tetrahydrofurfurole
Tabutrex	di-n-butylsuccinate
Crag-repellent	butoxypolypropyleneglycol
R-11	2,3,4,5-bis-(N-butylene)-tetrahydrofurfural
MGK-264	N-octyl-bicycloheptene
MGK-326	di-n-propylisoether-2,5-pyridinedicarboxylic acid
R-440	2,3,4,5-bis-(2-butylene)-tetrahydrofurfuryl alcohol
G-929	2-hydroxylpropyl-n-octylsulfoxide
R-1131	dibutylsuccinate
R-1207	3-chloropropyl-n-octylsulfoxide

In 1957 these repellents were proposed (di-n-butylsuccinate (Tabutrex) and di-n-propyliso-ether-2,5-pyridinedicarboxylic acid (MGK-326). The latter is a high-boiling, light-colored liquid with a weak odor; the preparation is not soluble in water, but dissolves well in organic solvents.

For the purpose of strengthening its effectiveness to it there is added diethyltoluamide, in connection with which it is possible to apply it as an agent of individual protection from stinging insects (flies, mosquitoes and so forth); its protective action is preserved for approximately 4-7 hours (Bruce, Decker).

Di-n-propylisoether-2,5-pyridinedicarboxylic acid is an excellent repellent with respect to house flies. It prevents the contamination of lamps, windows, mirrors and other analogous objects; it repels flies from screened objects (windows, doors and others).

Di-p-propylisosynchomeronate at 5% concentration can be used for the treatment of storage places for products and the area around them. Basically the preparation is used in solutions for treating cattle in the following combination: 0.4% di-p-propylisosynchromeronate, 0.05% pyrethrins, 0.12% piperonylbutoxide, 0.2% synergist MGK-264 and 99.23% petroleum ether. In combatting stable flies the preparations are applied at a rate of 0.2 g per 1 m^2 of surface, in treating premises for animals the duration of action oscillates from 1 to 13 days. In treating animals themselves (calves) the duration of the protective action of di-p-propylisosynchromeronate or di-n-propyl-2,5-pyridinecarboxylate (repellent, 326) R-326) and butylene-tetrahydrofurfuryl (repellent-11) was 12 and 13 days respectively. In keeping in darkness various surfaces treated with repellents their effectiveness was preserved from 11 days (on iron) to 67 days (on wood and plastering). Approximately such effectiveness is possessed by 2,3,4,5-bis-(2-butylene)-tetrahydrofurfuryl alcohol (repellent-440).

The basic area of application of repellents-11 is the treatment of cattle. Its 0.2% solutions in petroleum distillate (98.7%) are used with pyrethrins (0.025%) and the synergist MGK-264 (1%).

Bruce and Decker consider Tabutrex (di-n-butylsuccinate) the best repellent against stable flies. Oily solutions or emulsions repel insects for 1-6 days; flies lose the ability to orientate themselves. In its effectiveness Tabutrex exceeds the activated pyrethrins (pyrotsin), which is a slightly colored extract containing 20% pyrethrins. The best results are provided by a mixture of one part Tabutrex with one part Velsicol LR-50 and 4 parts olenic acid. The mixture diluted with water 1:4 is applied on a large animal in the amount of 150 ml; the duration of complete protection is 80 hours. With the addition of methoxychlor the mixture protected for 56 hours.

However, clenic acid acts harmfully on animals. Attempts to replace the additive to Tabutrex with thermolabile insecticides were successful, especially with the use of pyrethrins. Effective also was the introduction to Tabutrex of such preparations, as lethane and malathion.

The treatment of cows with methoxychla alone or in a mixture with butoxypolypropyleneglycol or Tabutrex provides effective results with respect to stable flies; although the second mixture is more active, the difference in the action is small. Treating the animals did not affect the milk yeild.

Preparation 3-chloropropyl-n-octylsulfoxide (repellent-1207) is a low-melting solid almost without odor, soluble in oils, but insoluble in water. Its density is 1.96 at 25°; its index of refraction is 1.4746; its melting point is 37-39°. Its LD_{50} for white rats when orally administered is 5.66 g/kg; when applied on the skin of a rabbit it is 8 g/kg; when introduced in the feed for 90 days at a dose of 20,000 parts of preparation per million parts of feed there were no noticeable toxic symptoms. It repels house flies, stable flies and ticks very well both when applied on the animals, and also in the treatment of fabrics; it is also a good repellent with respect to various Tabanids; the preparation repels certain species of cockroaches and weevils. In effectiveness it is equal to repellent-326, but its action is stronger and more prolonged. It is considered that the basic area of its application is in the treatment of animals for the purpose of protecting them from stinging flies. Good results are provided by the following recipe: repellent-1207 0.5%, MGK-264 2%, pyrethrins 0.25%, petroleum distillate 97.75%. With respect to house flies repellent-1207 is 2 times more effective than repellent-326, 10 times more active than repellent-11 and in 20 times stronger than repellent-1131. To provide complete results the following concentrations of repellents are recommended: 1207-0.2%; 326-0.4%; 11-2% and 1131-4%.

The addition of the synergist MGK-264 increases the repellent properties of preparations 1207, 326 and 11, but does not affect the activity of dibutylsuccinate (repellent-1131).

The new preparation 2-hydroxylpropyl-n-octylsulfoxide (repellent-929) is very effective with respect to Tabanid; it completely protects cattle for almost 24 hours after one treatment with a 1% aqueous emulsion of the preparation. It repels stable flies and Drosophilae very well.

According to N. A. Zakomyrdin, polychlorpinene, polychlorocamphene and strðban repel horseflies and mosquitoes; the insecticidal action of a 3% emulsion of polychlorpinene is preserved on the wool of animals for 8 days.

Bruce proposed as an agent for repelling flies from domestic animals, n-butyl and n-propyl diesters of maleic, fumaric and succinic acids. The addition to them of fatty acids (especially the unsaturated ones -- oleinic, linoleic, ricininic) considerably increases the repellency of these compounds. As a repellent agent there can be applied the following mixture: 2% di-n-butyl ester of succinic acid, 5% oleinic acid, 92.5% mineral oil harmless for animals 0.5% methoxychlor.

M. L. Fedder under laboratory conditions studied the possibility of using diethyltoluamide, kiuzol and dimethylphthalate for repelling stable flies. It turned out that the first two preparations in undiluted form completely, and the last one partially protect the bait attracting flies. In a test of 50 and 20% solutions complete protection was provided only by diethyltoluamide. Dibutylsuccinate also repels flies; flies gathering in huge quantities around doors and penetrating into a building ceased to land on the treated surfaces.

For combatting flies, mosquitoes and ticks an aerosol preparation of the following composition is also recommended: 0.5% repellent-11, 0.5% MGK-326, 2% MGK-264, 2% diethyl-m-toluamide, 10% seltrol-170, 25% isopropanol, 60% freon-11 and freon-12 (mixture 1:1). From this same recipe there is prepared an ointment, but without freon, and it is diluted with isopropanol to the required concentration.

The presented data indicate that the application of repellents in combatting flies is expanding. There is no doubt, that they can be recommended for the protection of animals under field conditions from stinging flies. Regarding, however, the use of repellents in inhabited localities for the purpose of protecting man and his habitations from house and other flies, in the type of application there is little promise for them. In this case the sanitary purification and the application of insecticides have incomparably greater value than the use of repellents.

Application of Repellents Against Lice

With respect to body lice although repellents are limited, nevertheless they were used before the introduction of DDT. From the time of the discovery of preparations possessing high insecticidal properties the expediency of the application of repellents decreased even more. Nonetheless a number of authors are giving attention to the search for preparations repelling lice.

Z. Zolotovskiy showed that cotton fabric impregnated with 20% dimethylphthalate in 96° ethyl alcohol acquires repellent properties with respect to clothes lice (imago). It seems to us that these conclusions need confirmation under practical conditions.

Metcalf considers effective repellents with respect to body lice N-p-butylacetanilide, methoxyacetophenone, and theamide of succinic acid.

According to M. L. Fedder, a short-term effect of repellent action with respect to lice is observed after treating the skin with terpeniol. Such repellents, as kiuzol (butylacetanilide) indalon, diethyltoluamide and dimethylphthalate, are very effective with respect to blood-sucking flies; they were ineffective against body lice. The author did not confirm the data of Metcalf about the effectiveness of N-p-butylacetonilide and other preparations as lice repelling compounds.

Application of Repellent Against Bugs

With respect to bed bugs repellents have not found application, but searches for them are being conducted. According to M. L. Fedder, acetyldetrahydroxy-nolins act with respect to bugs longer than dimethylphthalate. Tests conducted in a laboratory in Orlando (the United States), showed that ethylhexanediol repels bed bugs.

Application of Repellents Against Ants

According to laboratory data (M. I. Brun and L. I. Yevreinova), benzamides possess insecticidal properties and repel red ants (Monomorium pharaonis). Considerable insecticidal and repelling properties are possessed by: diethylbenzamide (ants die after 1-2 hours), dipropylbenzamide, dibutylbenzamide, and diisoamylbenzamide (the death of ants occurs after 48 hours); the greatest repellent action on ants is rendered by dibenzylamide, dibutylbenzamide and diisoamylbenzamide. They are also repelled by dibutylsuccinate (Tabutrex).

Application of Repellents Against Moths

As moth-repelling preparations napthalene and paradichlorbenzene are used, and also a number of other substances; they have found broad application for a long time (see "The Moth and Its Control").

CHAPTER XV

USING THE NATURAL ENEMIES OF ARTHROPODS

Contemporary, highly-toxic, synthetic insecticides destroy not only the pests of agriculture, but also the entomophages, as a result of which in a number of cases there are created conditions promoting the mass reproduction of the pests. Because of this in using chemical agents attempts are being made to preserve the entomophages by creating insecticides of selective action (for example, systox), by innovating the periods of chemical treatments, etc. Furthermore the use of the smallest, and most effective doses of insecticides is recommended.

Inasmuch as biological method is very specific in combating pests of agricultural plants, recently considerable attention has begun to be given to it. This, of course, does not mean that the biological methods of control have to replace the chemical methods. At present this is impossible and it is doubtful, that this will become possible sometime in the future.

The biological methods of controlling arthropods are based on the use of the natural enemies of insects — pathogenic microorganisms, viruses, parasitic and predatory insects, ionizing radiation and chemical agents with the main purpose of depriving insects of the ability to reproduce descendants. A large role in combating insects is being played by various pathogenic microorganisms.

The basic pathogenic agents for carriers of infectious diseases of man are the protists. The majority of the protists has a stable stage, which is able to withstand not only the action on them of the digestive juices, but also drying during the transmission from host to host.

The advantage of the microbiological method of controlling insects is high, the specificity of the majority of pathogenic micro-organisms, which is important for the preservation of useful insects. The application of exciters of infectious diseases of insects makes it possible to use sick individuals against the healthy ones of the same species.

Among insects there are encountered various diseases, caused by bacteria (bacterioses), viruses (viroses), fumgi (mycoses), and also small round worms from the class nematode.

Disease of insects, pests of agricultural cultures frequently assume a mass character, are epizootic, which lead to their extinction over considerable areas.

The idea of using pathogenic microbes in combatting harmful insects was first expressed by the well-known Russiam microbiologist I. I. Mechnikov. In 1879 he discovered and described the grain beetle disease, caused by microscopic fungi, and made the first attempt to artificially spread this disease in combatting harmful insects.

The appearance of the idea of using entomophilous fungi for combatting certain species of insects, pests of forests, citrus plants, corn, sugar cane, etc., belongs to the last century, when it was considered that entomophilous fungi could be of use in those places, where temperature, humidity and other natural factors promote their growth and development.

Basically bacteriological methods of controlling insects were studied and are studied for the purpose of destroying pests of agricultural plants (I. N. Grishchenko).

Of the large number of micro-organisms causing disease in insects, only certain ones have found application as "insecticides." At present there is being broadly studied the possibility of using Bacillus thuringiensis and Bacillus cereus var for destroying insects.

For combatting plant pests there has been developed a technological regime of obtaining the dry powdery preparation — entobacterin-3 from the strains Bacillus sereus galleriae (from the group Bac. thuringiensis). Extensive testing of this preparation has demonstrated its excellent qualities.

A significant contribution to the theory of obtaining of biological preparations was the development of morphologic indices of selecting virulent strains of spore bacterial cultures by protein crystalline inclusions. The form of the inclusions makes it possible to control the purity of the cultures, and their quantity determines the virulence of the strains within the limits of a definite species of bacteria (G. N. Zhigalev, N. S. Fedorinchik).

The Bac. thuringiensis was discovered more than 50 years ago in larvae of the Mediterranean flour moth.

From Bac. thuringiensis various preparations are made. Such preparations are sometimes called living insecticides.

Industry in the United States is producing this culture under the name biotrol.

In the Soviet Union it is also cultivated by a number of establishments and is used basically in agriculture.

In their toxicity to insects the strains of Bac. thuringiensis differ from each other. In combatting arthropods not only Bac. thuringiensis is used, but also endotoxin and exotoxin, prepared from these bacteria. Endotoxin is the preparation from spores, and exotoxin is the preparation from the cultural filtrate, which is more effective.

Bac. thuringiensis belongs to the aerobic spore-forming micro-organisms; they complete their development with the appearance of a a resistant stage of spores (one for each bacterium). These spores withstand boiling for several hours, heating to 150°, drying, freezing and do not die from the effect of many bactericidal agents. Bac. thuringiensis forms, furthermore, simultaneously with the spore a second "body" - rhomboid or diamond-shaped; it is called a crystal or a crystalline inclusion. For maximum formation for entomopathogenic micro-organisms of crystalline toxins and spore formation in depth and surface cultivation different media are used. Practice has shown that the composition of the medium and the conditions of cultivation of micro-organisms play a decisive role in the accumulation of crystalline toxins. The same culture can be ineffective with respect to insects, if it is grown under conditions and on a medium, unfavorable for spore formation (E. G. Afrikyan, R. A. Babikyan and R. A. Bayakhchan, V. G. Tumanyan).

The formation of crystalline toxins is observed only in the process of spore formation. Vegetative cells of crystallomorphic entomopathogenic bacteria do not possess toxicity. It is assumed that precisely the crystals give the micro-organisms its unique property to destroy insects.

The most susceptible to Bac. thuringiensis are Lepidopterae - moths and butterflies, whose larvae in most cases are leaf-eaters; several minutes after consuming a sufficient quantity of the mixture of spores with crystals in the larva there develops paralysis of the intestines. In certain species after several hours general paralysis occurs and the insect slowly dies from starvation.

The living spores, from which the crystals are removed, do not render any effect, whereas the extracted crystals are highly toxic to insects. Thus, the basic role is played by the crystalline chemical substance, and not by the spores themselves.

The Bac. thuringiensis maintains the balance of nature and does not destroy useful insects; the bacteria can be obtained in mass quantities by cultivation for 72 hours at 30°; they yield a stable and uniform mass of spores. The dried and ground spore culture is mixed with an inert filler up to a concentration of from 30 million to 3 billion spores per g. The preparation is a powder of light color. It does not lose its virulence for several years. When used it is diluted with water.

In combatting pests of agricultural plants the preparation is sprayed with the help of diverse technology, including from a helicopter, and for destroying other insects it is added to food for them (cockroaches, ants). When used in agriculture in the form of suspensions of the culture the results were worse than when it was applied in the form of a powder. In experimental procedure the preparations were successfully applied in combatting the flour moth and cabbage pests.

The preparation entomobacterin-3 was widely tested under field conditions in various zones of the Soviet Union – in Central Asia, in the Far East, in the Baltic states, in Moldavia, in the Ukraine, the Caucasus, in Byelorussia, in the Voronezh, Moscow, Leningrad and other regions. It was applied in combatting the white apple tree butterfly, the lackey moth, the fall web-worm moth and other pests; on vegetable cultures – against the cabbage and turnip butterfly, the diamond-back moth; it was tested to protect nut-fruit trees and forest-park plantings from moths, Lema spp, the satin moth (V. P. Vasil'yev; V. F. Volkov). All industrial experiments showed that entomobacterin-3 is a highly effective preparation in combatting the enumerated pests (A. Ya. Leskova).

The effectiveness of entcmobacterin-3 when sprayed depends on the species of insects, their susceptibility to the bacterial preparation. In combatting the majority of susceptible insects spraying with 0.5-1% entomobacterin-3 is effective. With large concentrations the insect dies in a shorter period (1-2 days) from primary symptoms of toxicosis. With small dosages the dying period of the pest is more prolonged (7-10 days and more). In this case the majority of caterpillars dies with evident symptoms of septicemia. The concentration of entomobacterin-3 can be decreased to 0.1%. The death of the insects occurs as a result of the spores getting into the intestines, as well as from the micro-flora of the intestines due to the disturbance of the normal physiological activity of the organism as a result of the effect of the toxins.

A great influence on the effectiveness of the preparation is rendered by temperature. According to A. Ya. Leskova (1959), with a decrease in temperature below 17° there occurs a gradual decrease in the effectiveness and a lengthening of the period of destruction of the pest. Conversely, an increase in temperature from 18° and above considerably accelerates the death of insects and the effectiveness of entomabaclerin is increased. Its use under conditions of cold weather with the addition of an insecticide at a sublethal concentration (for example, 0.005% DDT by active substance) increases its effectiveness.

One of the advantages of the new "living" insecticide obtained on the bas.s of viable spores of Bac. thuringiensis, is its nontoxicity to man, animals and plants. This was confirmed (Fischer, Rosher) on 18 volunteers, who agreed to take this preparation internally. A material was used, containing approximately $9 \cdot 10^9$ viable spores per g; the volunteers each received $3 \cdot 10^9$ per g during a period of 5 days (they took 1 g of preparation per day). Of the 18 volunteers 5, in addition to taking the preparation orally, inhaled it in the form of a powder during the period of the same 5 days, 100 mg each day (a total of 500 mg). The laboratory investigations did not show any deviations from normal. Furthermore, the constant contact with the preparation while it was being compounded was not reflected on the health of the workers.

Food also does not acquire toxic properties when these bacteria get into it.

For the purpose of establishing whether the preparation does not acquire virulent properties in the infection of animals by each other, Bact. thuringiensis was administered to mice by intraperitoneal injection of 0.1 mg of a 24-hour culture with its subsequent determination in the blood. It turned out that the micro-organisms were retained in the blood for 48 hours. The inhaling of Bact. thuringiensis sprayed into a chamber also did not have a harmful effect on animals. Furthermore, with the introduction into the stomach of rats of a 33% suspension (up to 24 g of microbe mass in the form of spore for each kg weight of the animal) with the help of a probe the authors did not observe any symptoms toxin poisoning; hystological investigations also gave negative results. It is interesting to note that Bact. thuringiensis belongs to the same taxonomic group as B. anthracis, however it does not possess the properties of the latter.

According to A. A. Yevakhova, O. I. Shvestova and V. A. Shchepetil'nikova, industrial application of domestic forms of entomophages was started in our country, and also there was introduced into practice the use of multipoison representatives of the genus trichograms (Trichogramma evanascens westw). Trichogram is widely and successfully applied in combatting the turnip moth (Agratissegetus schrft), which belongs to the Nosturdae family — order Lepidoptera. The female (trichogram) lays her egg in the eggs of a host-pest. The larvae feed on the contents of the host eggs.

The possibility of using ants in combatting tree pests was discovered. Observations showed that ants feeding on larvae of harmful insects destroy them all over the tree, even in the deepest cracks.

The presented data about the application of the biological method for the purpose of destroying pests of agricultural plants indicate that the method was found for itself certain application in combatting harmful insects; this method can also be employed in combatting grain pests (Hudon). However, it is necessary to state that at present the use of the biological method (also including the bacteriological method), and also of natural enemies for destroying arthropods has little promise.

This in part is why the biological method of combatting human parasites and pests in his dwellings is least developed; at the same time it is impossible to categorically negate the possibility of its use not only for the suppression of the mass multiplication of arthropods - the carriers of causative agents of infectious diseases, but also for prevention of their development (flies, mosquitoes, gnats, gadflies, fleas, cockroaches, lice, ticks and others).

The number of micro-organisms pathogenic for insects having medical significance is great (Weiser). Enormous also is the number of predators, which can be used in combatting human parasites and pests in his dwellings (Table 29, 30).

Till now the majority of bacterial infections in insects has been caused only under laboratory conditions.

The fact is that the contact with pathogenic bacteria and viruses by certain insects is very limited, thus, for example, causative agents of diseases can only get into the organisms of lice and ticks with the blood of an animal or man. Such insects as flies can be completely contaminated without direct contact with man or animal. This indicates that further study of this method, possibly, will make it possible to expand its application in combatting arthropods having medical significance.

Table 29. A number of predator-insects important in an epidemiological respect (according to Jenkins).

Species of insects / Predators	Crustaceans	Arachnoids	Odonata	Hemitera	Trichoptera	Diptera	Coleoptera	Hymenoptera	Fish	Amphibians	Birds	Animals	Total
Mosquito larvae	18	3	18	42	3	60	45	—	164	18	14	—	394
Adult mosquitoes	—	15	27	7	—	21	1	8	—	6	4	1	90
Gnats	—	2	3	4	7	25	1	4	10	1	9	—	66
Moss fly	—	9	—	—	—	8	7	18	—	—	—	—	47
House fly	—	1	2	—	—	2	1	4	—	—	1	—	11
Tse-tse fly	—	2	4	—	—	2	4	0	—	—	3	3	24
Ticks	—	4	—	1	—	—	9	4	—	—	5	2	24
Fleas	—	—	—	—	—	—	5	—	—	—	—	—	5
Cockroaches	—	10	—	1	—	—	—	5	—	3	2	1	22
Lice	—	—	—	—	—	—	—	3	—	—	—	—	3

Table 30. A number of parasite-insects, important in medical practice (according to Jenkins).

Species of insects / Parasite	Rickettsia	Bacteria	Fungi	Protists	Nematodes	Arachnoids	Diptera	Hemiptera	Total
Mosquitoes	3	23	50	75	20	12	—	—	183
Gnats	3	1	4	16	4	4	1	2	32
Room fly	—	9	6	5	5	14	—	27	66
Gadflies	—	—	—	3	4	3	7	20	37
Tse-tse fly	—	1	1	6	2	—	11	24	45
Ticks	—	5	3	6	—	—	1	6	21
Fleas	1	6	—	18	3	2	—	1	31
Cockroaches	—	6	3	2	3	2	—	12	28
Lice	19	2	—	1	—	—	—	—	13
House fly	—	2	1	2	1	5	—	6	19

A conference convoked by the Universal Organization of Public Health to discuss the problem of combatting carriers of causative agents of infectious diseases resolved to recommend for combatting the latter: a) mass reproduction of pathogenic micro-organisms, b) mass production and accimatization of eggeaters against Triatoma bugs, c) the discovery and study of midge parasites, in the first place mermitids, and their use, d) experiments on the chemical sterilization of carriers, e) improving the methods of breeding a host and its natural enemies, f) the investigation of substances attracting insects.

Using the natural enemies of flies. For destroying flies no highly effective biological method of control has as yet been found. In rural areas a certain effect has been attained with the use of hens, which, raking rubbish, carefully select larvae and pupae. Nonetheless with the help of this method it is impossible to obtain good results.

There is a considerable number of predators, which destroy flies (in the imaginal and preimaginal stage). Thus, for example, in premises for animals there are predators such as spiders, wasps, trichogrammatel egg parasites (in the broad sense of the word) and birds. In cobwebs there are found house flies, lesser house flies, stable-flies, i.e., species, which play the role of transmitters of diseases; Anopheles and Aedes mosquitoes also get into cobwebs. Among the 55 species of trichogrammatel egg parasites 3 species parasitize on flies, mainly on stable-flies inhabiting premises for animals. Wasps (German and common) catch house flies and lesser house flies, and also stable-flies. Birds also play a role. However all these enemies of dipterons have little significance from the point of view of decreasing the number of flies. A study of such predators, possibly, will make it possible to discover individual species useful for the application under practical conditions for the purpose of destroying house flies.

It has been established that a number of micro-organisms are highly pathogenic to flies. From bacteria 9 species (6 genuses) can be used. Among them the most promising are B. lutzat and staphylococcus muscal, but they also need detailed study to establish their practical value.

Knipling, Simmonds give preference to the bacterial method over the method of sterilization with gamma rays, because to obtain a 75% reduction in the number of an insect population it was necessary for one contaminated insect in the first case (infecting of insects) to produce 55 individuals, whereas with the second method (gamma irradiation) to achieve the same results it was necessary to produce 900 insects.

Under laboratory conditions Hall, Araka showed that the imago of the house fly is not susceptible to Bact. thuringiensis with the introduction of the dry culture into the food of the insects, but larvae of various strains die rapidly from doses of 0.125-0.5 g of concentrated spore material (150 billion spores per g) per each 40 g of substrate. The number of larvae in the substrate decreased by 24%; a small number died from septicemia, but the majority from the toxic effect of the crystalline inclusions present in the infectious material.

The death of larvae of house flies within the limits of 15-35% occurs with the presence in their food of Bact. thuringiensis in an amount of 400-4000 parts per million, whereas with the use of chemical insecticides there occurs their complete destruction with the presence in their food of baytex 40 parts per million, Ronnel 200 parts per million, DDVP 400 parts per million and delnava 800 parts per million parts of substrate. Thus, it is absolutely obvious that the chemical insecticides in combatting the preimaginal stages of flies are considerably more effective than Bact. thuringiensis.

With the oral introduction to animals of Bact. thuringiensis (strain 0-3-30) the latter are excreted with the excrement. The presence in the excrement of animals of Bact. thuringiensis prevented the breeding of flies.

Poultry-breeding enterprises abound with huge number of flies; the careless application of insecticides sometimes leads to the destruction of birds, due to which there is interest in finding other means of combatting flies. One of the methods of combatting flies, which is harmless for birds, is the use of the microbiological method (Sreve).

Brigges introduced 7 strains of Bact. thuringiensis into the feed to chicks and hens at a rate of 2-4.5 g per individual per day, and in all cases there was observed a decrease in the number of developed larvae of house flies in the droppings of the hens. The complete absence of pupation of larvae was noted on the 7-th day with a dose of 4.5 g of preparation per day per chicken. All spores given to the hens were detected in the feces. At all levels of food intake the author observed some period during which the number of viable spores decreased as if to zero. During the course of 2-year experiments there was not noted any harmful effect of such treatments on the birds. There was also not noted any considerable difference in egg-laying between the experimental and control hens. In another series of experiments the author added Bact. thuringiensis to the hen excrement at the same rate as to the feed. The development of larvae was suppressed both by the introduction of whole culture, and also of diluted cultine by 10 times. The author also used a culture of B. series; the latter, as it turned out, suppresses the development of fly larvae to a lesser degree than Bact. thuringiensis.

The favorable results in decreasing the number of larvae in the excrement the author explains by the fact that he introduced washed cultures in a suspended state, in the liquid phase of which there were contained toxic substances, the latter upon drying are only partially preserved.

Briggs notes that the administration of antibiotics to hens with their feed was more effective with respect to fly larvae than bacteria.

There is little basis to assume that these means will be able to find wide practical application in the near future in combatting house flies.

Data exist on the use of spores of Beauveria bassianae for the purpose of combatting house flies, ticks and other insects.

Reassuring results are given by the fungi Empusa mescae, although several experiments under practical conditions gave different results in effectiveness.

Various mites although also detected on flies, but, probably, will not be useful for practical purposes.

Among the parasites of pupae attention is being focused on Spalangia chaleidoidae, and also on Cunipidae.

In combatting insects it is also possible to use the method of turning out sick insects or insects infected with a large number of pathogenic micro-organisms.

From the parasites capable of being used in combatting stable-flies the following deserve attention: B. delendae muscae and the parasitic Spalangia. However, there is little basis to assume that these agents will be able to find wide practical application in combatting flies in the near future.

<u>Using the natural enemies of mosquitoes</u>. The most effective measures in combatting mosquitoes are: the filling of various

places of possible mosquito development, the draining of swamps, the improvement of sanitary conditions and the application of insecticides.

To the use of natural enemies of adult mosquitoes and larvae much works has been dedicated.

The basic advantage of biological agents as compared to chemical insecticides consist in the fact, that the former belong to living organisms, can search out insects and attack them.

For a long time for the destruction of mosquito larvae ducks and Gambusia fish (Gambusia attinis) have been used. In the Chinese People's Republic, besides Gambusia, carp species of fish (Cyprinus corpic) and others are used. Idelius fish consume not only larvae, but also the weed grasses of rice fields. According to the Shanghai Institute of Parasitology on a section, where such fish were used, the number of larvae was sharply reduced and the rice harvest was increased due to the fertilizing properties of the fish excretion and the decrease of weeds.

In connection with the appearance populations of mosquitoes, their low-sensitivity to chlorinated hydrocarbons, the necessity of using parasites and predators destroying the mosquitoes became greater, since at all stages in their development mature mosquitoes and their larvae have many natural enemies. Among these enemies belong specific bacteria, rickettsia fungi, the protists Coelenterales, flat and round worms, mollusks, crustaceans, ticks, insects, fish, amphibians, reptiles, birds and warm-blooded animals. Many predators attack mosquito larvae; according to Beirn, there are 27 forms of such predators.

The prolonged process of determining the effectiveness and the relative role of their natural enemies in combatting mosquitoes has been considerably simplified thanks to the isotopic tracer method, – a swallowed insect "can signal" the place where it is located in the organisms of the predator. Mosquitoes can be easily tagged with radioactive phosphorus, and subsequent measurements of radioactivity of insects and amphibians (beetles, spiders, frog) consuming them make possible a quantitative analysis of their role in destroying mosquitoes and a selection of the most effective natural enemies of the insect for practical biological control.

With the use of the method of tagged atoms it was established that short-winged varieties of Aedes communis do not attack man and, probably, can be used for the suppression of populations of long-winged varieties of mosquitoes which are carriers of malaria.

Biological control can also be conducted with the help of pathogenic agents of mosquitoes – various rickettsia, bacteria, protists, fungi, viruses. Thus, a virus, which under normal conditions coexists with a carrier, can become harmful to the latter, if it is cultivated or suspended in a medium such as alanine tagged with radiocarbon.

According to source material 15 kinds of bacteria and 16 kinds of fungi are pathogenic for mosquitoes; data exist on the possibility of using for these purposes certain rickettsiae causing harm to mosquitoes and their larvae. The greatest effectiveness is attained with the use of Leptotrix buceolis, which, located in large quantities in a medium inhabited by larvae bring about the death of the latter.

With respect to micro-organisms it has been expressed that Bact. thuringiensis is pathogenic for mosquito larvae, but the preparation turicide made under industrial conditions and containing spores of this micro-organism, turned out to be absolutely harmless for larvae of Aedes nigromaculatus both in laboratory, so also in small field experiments in California (the United States) and with respect to Culex tarsalis – in the laboratory. The majority of cases of destruction in laboratory experiments was a result of the effect of the solvent or impurities existing in product, and the spores themselves caused only insignificant destruction of the mosquitoes or did not cause any whatsoever (Kellen, Lewalen).

According to Laird, of the micro-organisms worthy of attention there are Siderocapsa Treubii, Streptococcus margaritaceus, Sphaerotilis dichotomus, Sphaerotilis nataus, Loogloca ramigera and others.

There is information, that biological insecticides or toxins kill mosquitoe larvae under laboratory conditions (Thompson). Thus, aqueous extracts of spores (Beduveria bassmia) possess considerable insecticidal activity.

From 16 kinds of fungi pathogenic for mosquitoes the most thoroughly studied is the type Coelomomyces, Stegomyia, which are injurious in tropical countries to Aedes mosquitoe larvae. Laird and others used this spore-forming fungus for combatting mosquitoes on the Tokelau Islands. As a result after $1\frac{1}{2}$ years a decrease was attained in the number of mosquitoes by 60%. Certain fungi of the species Entomophtore also deserve attention.

Protists can be used for the destruction of mosquitoes and gnats at all stages of their development. Of the type Mastigophora certain species destroy mosquitoes, but the effect observed is insignificant. Sporosoa includes many harmful forms, including Microsporidia, such as Mosema and Tnelohania and others, described species (10 names). Of potential value is the type Stempellia and Plostophora; over 20 species of Caliphora of 12 genuses also destroy mosquito larvae.

Fungi are the most widespread parasites of insects — carriers of exciters of infectious diseases. Coelomomyces, for example, destroys Anopheles gambiae larvae. Certain fungi imperfecti

(Beauveria, Isaria, Spicaria) are harmful in Europe to many hemipterous and dipterous insects and ticks, including Ixodes ricinus - carriers of various virus diseases.

It has been established that 10 species of nematodes parasitize insects, 78 - dipterous insects and 4 - fleas; many of them are harmless inhabitants of the intestines of insects. However, the representatives Mermithidae, Steinermatidae and Tylenshida are harmful to tissue.

These nematodes are cultivated in the bee moth. When a moth is thrown into a pond, in which live mosquito larvae, the latter consume the moth containing the nematodes and die within approximately 36 hours.

Using the natural enemies of gnats. Protists and nematods (Mermithid wornos) kill gnats; among nematodes 15 species are well-known, which destroy gnats. Of the protists Thelohania is deserving of special attention. As a result of an infestation partial destruction of the insects is observed. Various predatory insects especially Trichoptera larvae feed on gnats and their larvae.

Using the natural enemies of gadflies. As yet there have not been detected bacteria, protists and fungi, which could be used to destroy these insects. However the use of the eggs of Phanurus emersoni hymenopterons (Hymenoptera) furnishes a certain hope in this respect. Field tests showed that with the help of this parasite it is possible to attain a decrease in the number of gadflies by 50%. Other species of Hymenoptera as yet also require study for the purpose of establishing the possibility of their use, especially the genus Telenomus.

Using ants for the purpose of destroying lice. For lice certain species of bacteria are pathogenic; they cause disease in lice, however such micro-organisms as yet do not have practical value.

In literature cases have been described, when under prolonged march conditions ants have been used for the destruction of lice in underclothing. For this purpose the lousy underclothing was placed near an anthill. Carrying food to their nest for other ants and construction materials for nest, the ants encountering this linen on their way, liberated it from insects and in the course of a half hour removed from it all the nits and lice. The ants removed only the living nits; the nits killed during sanitary treatment (boiling, ironing) almost remained completely untouched. The underclothing liberated in this manner from lice and nits had a specific odor of formic acid (CH_2O_2), which vanished after washing and laundering (N. N. Bogdanov).

Using Bac. thuringiensis for destroying cockroaches. Certain species of bacteria inflict great harm on cockroaches, but this method of controlling them has been only slightly developed.

L. I. Brikman and M. I. Alekseyeva made an attempt to use Bact. thuringiensis to combat common cockroaches. Tentative investigations were conducted with 3 strains of bacteria (C-4; 6-58 and USA-58). The action of each strain on cockroaches was studied in spore and vegetative form; to the insect they gave bait containing per 1 mℓ 6 mg of culture of one of the strains. All 3 strains were equally virulent with respect to the males; with respect to females somewhat less virulence was possessed by strain C-4. A difference between the effect of the vegetative and spore forms was noted only for the males. Female cockroaches were more resistant to Bact. thuringiensis, with the exception of the period of carrying the cocoon; the destruction of females with the cocoon on the 15-th day reached 77%, without the cocoon – 32%. There was also noted a delay in the development of eggs in females contaminated with Bact. thuringiensis; the yield of larvae for experimental cockroaches was 46.5%, and for control of cockroaches – 92%.

According to the authors, under laboratory conditions there occurs a transmission with cockroaches — males and females — of Bact. thuringiensis from the experimentally contaminated insects to the uncontaminated ones. This was confirmed both by the death of the insects, and also by microbiological investigations. It has been established that in the case of infection of cockroaches both by spore, and also by vegetative forms, there is noted a transovarian transmission of Bact. thuringiensis to the offspring — a bacteria culture was extracted from 75% of the insects of various ages.

Using Bact. thuringiensis to destroy red house ants. L. I. Brikman and M. I. Alekseyeva applied the bacterial method in combatting the red house ant; the authors considered that diseases among ants will be transmitted by their contact with each other and that they will carry the infection into the colony; the experiments were conducted with 3 strains of Bact. thuringiensis (C-4; 6-58, and USA-58); the effect of each strain was studied in spore and vegetative forms.

The best results were obtained using the vegetative form of Bact. thuringiensis strain 6-58, which was most virulent in a mixture with 1 g of food bait containing 6 mg of culture. Infected ants died within the limits of 5-18 days.

The vegetative form of Bact. thuringiensis of all strains on all food bases gave a considerably greater number of experiments with positive results than the spore form.

Microbiological investigations showed that Bact. thuringiensis does not die in the organism of the red house ant (of 56 experiments in 40 there was obtained a growth of colonies) and the death of the insects was a result of disease in them, and not of toxic effect, as occurred in the work with certain other insects.

Using the natural enemies of bed bugs. The biological method of controlling bugs has been only slightly developed. Parasites playing an essential role in decreasing the number of these insects have not been detected.

Data exist concerning the fact, that for destroying bugs it is possible to use the fungi Aspargillus flavus. When it is used the fungus appears on the body of the infected bugs at t 20° and 90% relative humidity.

Using the natural enemies of fleas. Certain rickettsiae, protists and helminths are harmful to fleas and cause their death, but no data as yet confirming their practical value in combatting fleas exist. Plague bacillus causes the death of fleas, but it, for absolutely intelligible reasons is inapplicable under practical conditions.

Using the natural enemies of ticks. Although certain species of bacteria, protists and fungi kill ticks, their practical value is small. Viruses of diseases in ticks have been detected - phytophages. This shows that, possibly, analogous pathogenic of agents will be also detected in ticks, which have medical value.

E. Steinhaus observed under laboratory conditions how ticks Dermacentor andersoni feeding on guinea pigs died from bacterial infection. As a result of a study it has been established that the disease in the guinea pigs was caused by salmonella, which, getting into the organism of ticks, also caused their death.

CHAPTER XVI

DESTRUCTION OF INSECTS BY STERILIZATION WITH SONIZING RADIATION

The latest methods and means of combatting insects is by using some insects against others, and also self-destruction.

This can be attained in the following ways: 1) by the production of sterile males and females subjected to the effect of X- and gamma rays 2) by the application of preparations causing the sterilization of insects (males and females); 3) by the production of imagoes contaminated with pathogenic micro-organisms, which transmit the infection directly to mature individuals of the same species, and also through larvae by infecting their breeding places; 4) by the breeding and production of strains of insects, which have certain organic deficiencies.

Research on the sterilization of insects with the help of ionizing radiation was begun in 1950. As a result of the work carried out, the necessary quantities of radiation and the optimum time of irradiation providing the achievement of effective results have been established (Coll). The purpose of these investigations was the production of sterile males to be released in places inhabited by these species so that they entered into competitive relations with a smaller number of unirradiated males (fertile ones); this method gives good results especially in those cases, when the female insects rarely mate.

G. A. Nadson and V. S. Filippov (1925) in experiments on yeast showed the possibility of causing mutations by the effect of X-rays. In 1927 it was discovered that with help of X-rays it was also possible to cause mutations in fruit flies (Drosophila melanogaster). The latter observation attracted the attention of geneticists and cytologists, who studied this phenomenon from the point of view of heredity and evolution. The investigations were conducted mainly on fruit flies, wasps, mosquitoes, grasshoppers and bees.

Analogous results were also obtained by the prolonged effect of ultraviolet rays on insects. However the latter possess poor penetrability and cannot be used in broad experiments.

Undoubtedly, radiation can also be used and in doses lethal for insects; however one should consider that insects are 100 times more resistant to radiation than majority of vertebrates. Therefore the most reassuring results were obtained with the use of rays with relatively small activity, calculated to disturb the metabolism, the processes of reproduction, to cause sterilization or the creation of defective short-lived mutants. It is necessary to consider that not all mutations are necessarily unfavorable; in certain cases it is possible to observe an increase in the life-span of insects.

The use of radiation on a large scale for the irradiation of insects for the purpose of changing their genetic characteristics with the subsequent release of these insects into nature opens broad possibilities for their biological control. By creating lethal mutants (dominant or recessive) of one or the other sex, sterile hybrids or strains with the predominance of any one sex in a population, and also by selecting defective strains it is possible to prevent the development of resistant forms. It is especially because of this, that the genetics of insects is acquiring great significance.

At present the method of sterilizing insects with ionizing radiation has become completely practicable because of the presence of by-products of various forms of isotopes. The simplest method of sterilizing insects is by externally irradiating them with beta- or gamma radiation, and it is also possible to apply the method of administering radioisotopes to insects.

Alpha-, beta-, gamma-, and X-radiations have their own peculiarities: furthermore, they also differ in their ability to penetrate into objects being treated. Alpha particles of a helium atom, emitted by the nuclei of certain radioactive substances, are readily absorbed by various objects. Thus, they penetrate into the skin of man and animals to a depth of several tens of microns. Beta-rays consist of particles or electrons (or positrons) and possess weak penetrability. Gamma-radiation is electromagnetic radiation (a form of pure energy), identical to X-rays, but it possesses greater penetrability.

For sterilizing insects it is possible to use X- and gamma-rays.

Because of the prevalence of X-ray equipment (with the help of which X-rays are obtained), the obtaining of precisely these rays is the most accessible, but with prolonged operation the tubes of X-ray apparatuses rapidly burn out; this impedes their use. For example, the guaranteed period of operation for a 1BPV1-60 X-ray tube for a RUM-7 apparatus is 300 hours.

Beta-, gamma- and X-rays, passing through living creatures, act destructively on organs and tissues, causing the same phenomenon — ionization, which can destroy such vitally necessary cellular elements, as genes and enzymes. This action varies depending upon the species of organism. Thus, man is more sensitive to ionizing radiation than insects, and insects are more receptive than bacteria.

Distinctions in sensitivity to radiations are also observed depending upon age, stage of development and so forth. For example, the eggs of insects are more sensitive than larvae and larvae are more susceptible than imagoes.

The LD_{50} of gamma-radiation with cobalt-60 for body lice, house flies, oriental and common cockroaches, crickets, bugs, red house ants varies from 130 (for the eggs of house flies) to 190,000 R (for clothes lice in nymph stage and for females of house ants). The doses of gamma-rays, which are required to provide complete destruction of these insects, varied from 600 to 250,000 R. It was also noted that the LD_{50} varies inversely proportionally to the size of the insects. A dose of 75,000 R and above inhibits the reproduction of clothes lice, and the lice which are resistant to DDT are not more resistant to radiation than the ones susceptible to DDT. Insects which have been subjected to irradiation are considerably more sensitive to insecticides than those not subjected to irradiation.

It has been noted that the sex cells are more sensitive to irradiation than the other cells of the organism. Cytological investigations have shown that after the irradiation of 5-day pupae of flies (Callitroga hominivorax about half of them contained in the sexual organs of the males sperm and spermatids (spermatozoa), the others - spermatogonial cells and spermatocytes (the male sex cells in the period of their growth and maturation). Only the completely matured sperm and, possibly, the spermatids survived. Thus, the irradiated males possessed in the best case a power of fertilization equal to half the power of normal males.

According to Rhode Lores, Eguis, after the irradiation of 4-day old pupae of the Mexican fruit fly with a dose of 2000 R further development of these insects ceased, while of 8-day pupae after the effect of doses of 7000-12,000 R the hatching of the imagoes was 40-18%. When 12-day pupae were subjected to the effect of 5000 R in the irradiated females eggs did not develop. Both sexes became sterile until death, sometimes for a period of 107 days after hatching, where the duration of life seemingly was normal. The indicated dose did not affect either the population or the aggressiveness of the males in the early stage, but in the 30-39-day males there was observed a decrease in activity - they copulated a total of 50 times as compared to 141 times for the unirradiated males.

In a study of the effect on 12-day pupae of doses of from 1000 to 5000 R at a rate of 90; 70; 50; 30, and 10 R/min it was established that with a critical dose of 2000 R in proportion to the increase of the intensity of the effect the females laid even less eggs, and the irradiated males became less fertile. Females, which obtained a dose above 2000 R, did not lay eggs, and the number of viable eggs laid by unirradiated females which had copulated with irradiated males gradually decreased until complete sterility was attained with a dose of 5000 R.

According to Bushland, sterilization of Callitroga hominivorax flies is attained most expediently by irradiating 5-day pupae maintaining the thermostat at 24° during the 5 days. Males were sterilized with a dose of 2500 R, and females 5000 R; females irradiated by such a dose did not lay eggs or laid anomalous masses with a quantity of less than 50 eggs, whereas flies from the same culture which were sensitive to insecticides laid about 200 eggs at one time.

A dose of 7500 R and above prevented oviposition. Males and females endured sterilizing doses of 20,000 R without any external effect, just as they endured a dose of 5000 R. From irradiated pupae imagoes emerged, just as they did from the control pupae, but the irradiated flies did not live as long a time, as the unirradiated ones. When normal females were placed in breeding boxes with irradiated males for copulation, and then normal males were added to them, they did not copulate a second time (Calitroga copulates once), but they laid only sterile masses of eggs. In the presence of sterile and nonsterile males the ratio of sterile eggs to normal eggs was approximately analogous to the ratio of the number of sterile and normal males in the vivariums, which indicated the presence of identical activity on the part of sterile males.

After the irradiation of Calitroga flies with a dose of 7500 R in the first weeks after emerging from the pupae the irradiated males inseminated as many females, as the normal ones (Diamant). Nonetheless no offspring were obtained from them even after 3 weeks of copulation. The employed dose provided complete sterility without the return of fertility to the Calitroga males. If the females copulate repeatedly, the sperm of sterile males is mixed in the spermatheca and competes with the sperm of the normal males. Thus the decrease of the biotic potential of this species has the same significance, as other species, which copulate only one time. With a ratio of sterile males to nonsterile of 4:1 from 80% of the eggs laid by the female fly larvae did not hatch.

Knipling developed a simple mathematical theory for determining the number of sterile males for the purpose of combatting natural populations of insects of the same species (Table 31).

Table 31. The ratio of the number of sterile males to normal ones with the release of the former into nature.

Natural population of females in the region	Number of released sterile males of each generation	The ratio of sterile males to normal ones	Females copulating with sterile males, %	Theoretical population of normal females in last generation
1,000,000	2,000,000	2:1	66.7	338,333
333,333	2,000,000	6:1	85.7	47,619
47,619	2,000,000	42:1	97.7	1,107
1,107	2,000,000	1807:1	99.95	Less than one

So that the method of sterilizing males would be effective in combatting insects, Knipling cites 5 conditions, which have to prevail: a) the method of mass reproduction of insects should be practicable; b) it is necessary to try to get uniform distribution of the released sterile males; c) the method of sterilization should not harmfully affect the copulation of the males; d) the female insects which are being combatted should normally copulate a total of one time; if several matings occur, then the sperm of the gamma-irradiated males should successfully compete with the sperm of the normal males; e) the density of the insect population should be low or the population should be decreased by other methods to a level, at which it is possible with reasonable success to release a predominant population of sterile males for a prolonged time.

Mechanism of sterilization, according to Bushland, reduces to the fact, that with the use of gamma-rays part of them (adsorbed) is converted into a negative electrical charge causing chemical changes in the cells of the insect organism.

As a result of the effect of the gamma-rays direct physical and chemical changes occur in the genes and chromosomes. It is also possible the enzymes inside the cells are inactivated. Their inactivation disturbs the normal physiology of cell division. However the greater part of the mutagenic effect is considered as a result of the chemical changes in the desoxyribonucleic acids inside the chromosomes. Desoxyribonucleic acid belongs to the class of acids, which in combination with phosphates are considered self-reproducing chemical substances composing the genes. Thus, any chemical reorganization changes the gene and this change is repeated in cell division, thereby causing a change in heredity.

Strong irradiation of dividing cells causes considerably physical and chemical changes, due to which the cells degenerate. If a large number of cells in a living organism is subjected to such an effect, the insect dies; cells not subjected to irradiation at the time of division have their chromatin in a diffuse state throughout the nucleus. In such a state the cytoplasm and the nucleus are considerably more resistant to irradiation. However, when the cells are dividing the chromatin is concentrated in specific chromosomes, as a result of which the chromosome are to a greater degree subjected to the harmful effect of the radiation. This pertains both to the cells of the somatic tissues, multiplying by mitosis, and also to the germ cells in the testes and ovaries subjected to chromosomal consecutive division or meiosis [meiosis - one of two consecutive divisions of developing sex cells, the so-called maturation (reduction) division of the number of chromosomes in two].

In an adult individual or an individual in the last pupa stage, where the formation of the imago is almost completed, in the somatic tissues cell division occurs slowly. Only in the sex glands do mitosis and meiosis occur rapidly. In such cases a dose of gamma-rays is readily endured by the somatic cells, at the same time this dose causes mutations in the germ cells. If this dose is lower than that, which is necessary for complete sterilization (several hundreds roentgens), then many mutations will occur. Sperm can endure changes in one or several genes, which do not deprive the insect of the ability to fertilize the eggs or do not affect the ability of sex cells to survive and to multiply.

If the harmful effect of gamma-rays on the sex cells makes the offspring incapable of surviving, this is called a lethal mutation. In a number of cases lethal mutations do not appear in the first generation obtained from irradiated males and normal females, but appear later, when the offspring breed.

Another lethal mutation can be dominant and will overpower the effect of the corresponding gene obtained from the normal mother, so that the zygote (a zygote is a cell formed as the result of the merging of sex cells) dies.

At the time of irradiation of the pupae or young imago there is observed full spermatogenesis and the individual mobile spermatozoa are already fully matured. The chromatin material inside the head of the sperm is sufficiently modified, so that in each of them lethal mutations start dominating. When a male treated in the young imago or pupa stage by a sterilizing dose of radiation copulates with a normal female, then the irradiated sperm is deposited in the spermatheca in the same way as is the normal sperm. When the female lays her eggs, each of them is penetrated by a sperm and the eggs are fertilized.

Irradiation causes genetic injuries both to the spermatogenic cells, and also to the spermatids, simultaneously with injury to the latter and the sperm. A dominatant lethal effect in a sperm, probably, depends on chromosome breakage.

The chromosomes transmitted with a spermatozoon can be so greatly modified that the transmission of inheritance to the zygote is insufficient even for one cell division. In case of the division of many cells the zygotes die after a certain time, as a result the larvae do not hatch from the eggs. When a sterilizing dose is adjusted in such a way, that the male-parent obtained exactly sufficient radiation to prevent the hatching of the fertilized eggs, then a simple inspection of the eggs under a microscope with good illumination will show that the embryos died inside their shells.

Therefore, apparently, it will be an error to call the irradiated males sterile, inasmuch as they form mobile sperm, which fertilize eggs. However, inasmuch as the embryos die without hatching, it is convenient to say that the males are sterile, and the eggs are sterile.

Analogous irradiation causing sterility of the germ cells of the male also provides a similar effect on females. But whereas a male pupa can already contain completely formed sperm in the testes at the time of irradiation, oogenesis does not occur as rapidly as spermatogenesis and the ovaries of the pupa-female do not contain well-developed eggs. The development of eggs occurs after the emergence of the imago from the puparium and the dose of radiation can so damage oogenesis that the female becomes incapable of forming eggs. Thus, the female in the more exact meaning becomes sterile than the male, inasmuch as in her eggs cannot be developed and be subject to fertilization.

The irradiation method can be applied, apparently, only with respect to imagoes or pupae, in the organism of which there have already been formed the vitally necessary organs. If the preimaginal stage of insect development is irradiated with the same doses, then the effect is not sterilizing, but lethal. This is explained by the fact that in immature insects mitosis consists in the differentation and growth of somatic tissues. Somatic cells during rapid division are very sensitive to irradiation. Therefore a sterilizing dose of radiation undergone by the somatic tissues of imagoes is lethal for these tissues at an earlier stage of development.

In the United States the method of sterilizing males was used for the purpose of combatting Callitroga hominivorax flies. These flies have a limited place of inhabitation - in the tropic and subtropical part of the western hemisphere. According to Knipling, flies were sterilized under laboratory conditions from a source of radioactive cobalt, which provided the best results. Pupae were subjected to irradiation on the 5-th to 6-th day after pupating or 2-3 days before the emergence of the imago from the pupae; during this time the pupae were kept in an incubator at 44°. A dose of 2500 R caused sterility in the males, and a dose of 5000 R - in sterility in females without any disturbances to their biological characteristics, feeding, behavior, instincts, etc.

In Florida (the United States) there was a well equipped laboratory, which received in the beginning 13,000,000, and then 50,000,000 sterile flies per week (Callitroga hominivorax). These flies were scattered over Northern Florida and Sourthern Georgia during the first half of 1958. These measures were successful.

For the breeding of such a quantity of insects the development of a special substrate was required, consisting of a mixture of ground, unfat meat, blood and a small quantity of formaldehyde. It turned out that it was sufficient to release 100 sterile males per week per 1.6 km^2, in order to ensure a decrease in the density of the natural population. In further experiments for the complete destruction of flies on an isolated island (2600 km^2) during the course of 10 weeks males were scattered from an aircraft - up to 500 individuals per 1.6 km^2 per week. As a result it was observed that approximately 70% of the natural females was paired with sterile males. It is necessary to emphasize that a single mating, peculiar to Callitroga females is not a necessary requirement when using this method of destroying insects.

In using this method on the mainland under conditions of open terrain complete destruction of the flies was not successfully accomplished due to the fact that the locality was not isolated and a constant migration of insects was observed from the surrounding area. However, inasmuch as 70% of the matings were sterile, it is necessary to recognize the fact that the competition of the sterilized males was completely successful. The latter indicates, that it is possible to raise millions of sterilized flies and release them for the purpose of successfully destroying a given species of insects.

Data exist about the fact that at distance of 30 km from the place of release of sterilized insects sterile masses of eggs can be detected.

According to Bushland, on the island of Curacao (80,000 km^2) success was achieved with the use of pupae irradiated with gamma-rays (radioactive cobalt); 130 of them were placed in each sack with a rate of 80% emergence, which gives 100 sterile flies (50 females and 50 males). The flies were conveyed to the island by aircraft and dropped on the ground 2 times per week, running the aircraft along lines at a distance of 800 m from each other. In the first series of experiments 2 times per week insects were dropped at a rate of 100 individuals per 1.6 km^2 (i.e., 100 males and 100 females per week). The release of 100 males per week was ineffective. With an increase of the release of flies to 400 males per week per 1.6 km^2 success was attained. Because of the increase of the release of sterile males the productivity of the laboratory had to be increased from 13 million to 50 million flies per week (20 million males and females and 10 million of waste). A source of gamma-rays of 70 curies, used earlier for the sterilization of the flies, was replaced by a source of 480 curie.

In these experiments for scattering the flies cardboard boxes with a weight of 453 g (1 pound) were used; they were ventilated, the irradiated pupae were placed there with a rate of hutching of 400 flies in each) and they were maintained under appropriate conditions of humidity and temperature until the hatching of the imagoes. After that the boxes were loaded on aircraft, from which they were dropped with the help of a special mechanism, in accordance with a previously set rate.

As soon as the island was saturated with sterile males, 69% of the eggs laid became sterile. The releasing of flies in analogous quantities during the course of 4 weeks showed that after the appearance of a new generation of imagoes the quantity of females laying eggs greatly decreased and the percent of mating increased. After two new generations only sterile mating was recorded. The whole operation of destroying Callitroga flies on the island of Curacao continued from 12 July 1954 to 6 January 1955. The destruction was attained between the 14-th and 22-nd weeks when the release of sterile insects was stopped. These first achievements in the genetic methods of controlling insects showed the practicality of the mass raising and releasing of insects with distinctive genetic characteristics. After the effect of various doses of radioactive cobalt on the pupae of Lucilia sericata flies positive results were also obtained. Pupae at an age of up to 3 days of development did not yield imagoes in the case of using radiation of 300 R. The percent of yield of imagoes from pupae at an age over 3 days at the time of irradiation was normal to a dose of 12,000 R, but decreased to 24% with the use of a dose of 24,000 R. The duration of life of imagoes with the increase of the dose was progressively increased starting with a dose of 100 R and above; with a dose of 9000 R the duration of life was reduced by 2 times.

The percent of viable eggs from irradiated females decreased with the effect of doses higher than 2000 R, although their quantity remained at the former level; after 3000 R and higher than oviposition ceased. Analogous results were also observed in working with males;

after irradiation with a dose of 3000 R 3% of the males remained able to fertilize the females; with the use of a dose over 3000 R the males were completely sterile. Morphologically normal sperm was discharged by the males at all doses of radiation up to 24,000 R; its morbility was observed only to a dose of 6000 R.

No positive results were obtained in pairing females first with normal, and then with irradiated males; the eggs continued to remain normal and from them larvae emerged. For the sterilization of both sexes of these flies and the prevention of oviposition doses of 8400-10,000 R of gamma-source were required, but such doses destroyed the sexual abilities of the males; in decreasing the dose to 6700-8400 R there was noted the development of permanent sterility in the irradiated males, but after 30-50 days some of them again successfully fertilized females.

An attempt was made to decrease the number of the Lucilia sericata population on the isolated territory (on Holy Island near the northeastern shore of England) by the method of sterilizing males. The attempt was unsuccessful.

The release of sterile fruit flies under field conditions also did not give results - a depression of the population was not observed.

With the use of this method for the purpose of combatting Anopheles quadrimaculatus mosquitoes the population was decreased to an insignificant degree and on the following year was completely restored.

In the opinion of Knipling, this method can be used for combatting moths and Anopheles mosquitoes. An analogous opinion is held by a number of other investigators.

According to Davis and others, irradiation of the pupae or imagoes of Anopheles quadrimaculatus mosquitoes with a dose of

8865-2900 R led to complete sterility; in the copulation of unirradiated males with irradiated females the latter did not lay eggs; with the copulation of unirradiated females with irradiated males eggs were laid normally, but larvae did not hatch from the eggs. When irradiated insects were placed in a vivarium with unirradiated ones at a ratio of 10:1, the number of eggs laid and fertilized decreased by 80%. Analogous data were obtained with Aedes aegypti mosquitoes.

Weidhaas and others irradiated the one-day pupae of Anopheles quadrimaculatus mosquitoes with gamma rays from radioactive cobalt at a dose of 12,000 R, and then after hatching 1 to 2-day old males were released on the islands of Crimer and Torrey (5 km^2) in Florida (the United States). During the course of 11 months 390,000 irradiated males were released with an average of 1480 males per km^2. As a result the authors succeeded in decreasing the mosquito population on one island by 65-110 times, and on the other by 10-60 times. After cessation of the release of sterile males the mosquito population on the island was quickly restored.

These achievements must be examined as an event of great importance and as a new landmark in the whole history of entomology.

According to the laboratory data of Lindquist, normal malarial mosquitoes react to irradiation and copulate just the same as Callitroga flies. The author conducted a small experiment under practical conditions on an island with an area of 7 km^2; per week 1000-1500 males were released per km^2, which exceeded by several times the size of the normal population.

Laboratory investigations studying gamma-irradiation and the possibility of the use of this method for the sterilization of males were conducted on a number of insects (the malarial mosquito, the cotton pest, moths the tse-tse fly and others) (Davies, Lindquist). The data obtained made it possible to draw the following conclusions.

1. The method of raising insects should be simple and cheap.

2. The insects should belong to a type, which can be dropped from aircraft and which can live in open nature for a certain time.

3. The method of sterilization should not have a harmful effect on copulation or appreciably harm the males; the males must possess the ability to actively look for the opposite sex and to copulate with normal females.

4. The species, which are being combatted should not be numerous; it is necessary to consider the seasonal fluctuations of the insects and to conduct the work in the season, when the insects are not numerous.

5. The region being subjected to the treatment should be sufficiently well protected from new colonization; it is best when it is separated by water or mountains.

6. The males, which are released, should not inflict harm on people and animals.

7. The method of separating the sexes should be simple and mechanized.

8. The workers should have accurate knowledge about the biological and ecological peculiarities of the insect (the number of generations in a year, the duration of the various stages of development the sites and yield of breeding, the number of insects per unit of area).

9. It is necessary to know the effect of irradiation on the various species of insects, the dependence of the effect of ionizing radiation on air temperature, the number of different gases in the air and the composition of the food.

10. For carrying out these investigations great expenditures are required for equipment, in particular for obtaining a good source of gamma-rays. This method is inapplicable in those cases, when the released males will themselves present a threat to the health of people.

The given data indicate that the method of sterilizing males and females with ionizing radiation requires highly qualified personnel and expensive equipment, the use of which is dangerous to the health of the workers. The method is expensive, therefore it cannot find application in wide practice.

The method of sterilizing with ionizing radiation is applicable in combatting arthropods in isolated regions, for example on islands, places separated from the surrounding area by high mountains, those species of arthropods, which multiply rapidly and have an annual cycle of development.

C H A P T E R XVII

THE DESTRUCTION OF INSECTS BY STERILIZATION WITH CHEMICAL AGENTS

The search for chemical substances, which would deprive insects of the ability to multiply, is of great interest. Such preparations will promote the more successful destruction of their populations than the use of insecticides alone. Chemicosterilizers and oviposition inhibitors were discovered in 1952 by Goldsmith and Frank.

A number of such agents is known some of which prevent the formation of sperm and eggs or cause the destruction of sperm and eggs after their formation, other compounds cause genetic damage to spermatozoa, as a result of which the latter do not fertilize egg. In this and analogous directions numerous investigations have been conducted, as a result of which a considerable number of various preparations has been proposed.

Chemicosterilizers can be introduced into the insect organism in various ways: through the intestinal tract with food, through the cuticle in result of the contact of the insect with the preparations, and also by their topical application to the insect.

Of the large number of studied compounds (over 1100) some of them possess sterilizing properties, to which a considerable number of species of insects is sensitive. In the sterilization of arthropods the rule is adhered to that the sterilized males should freely compete with normal males, satisfying the need of the females in mating. The investigations of a number of authors (Ascher and others) have shown that many anticancer preparations possess a chemicosterilizing effect. Borkoves divides anticancer preparations into four groups:

1) alkylating substances; this group includes compounds of ethyleneimine and derivatives of azirdine;

2) antimetabolites, for example antagonists of folic acid, glutamine, purine and antagonists of pyrimidine and others;

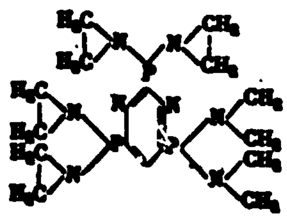
3) radiomimetic compounds (compounds causing effects analogous to irradiation).

4) mitotic poisons; this term in its narrow meaning most frequently is applied to colchicine and its derivatives and to the group of biologically active quinones. Using this term in its broad meaning this group also includes the radiomimetic compounds and almost all the anticancer preparations. To these preparations belong aminopterin and methotrexate (4-amino-N-methylpteroylglutamic acid), the antagonists of folic acid; when fed at a concentration of 0.5% with sugar bait) they prevent oviposition of flies, but do not have a harmful effect on the males. Both preparations are used for therapy in leukemia, neoplasms and other illnesses. The compound 5-fluorouracil (a compound having an effect on neoplasm) at a 0.25% concentration inhibits oviposition, and at a 0.05% concentration prevents the hatching of larvae. Also studied was the effect on the fertility of house flies of certain preparations belonging to the poisons affecting mitosis, — the sodium salt aminopterina (4-amino-pteroylglutomic acid), colchicine, podophyllotoxin and methyl-bis-(beta-chloroethyl-)amine hydrochloride. The latter suppresses the synthesis of nucleic acids necessary for the growth and reproduction of cells. The preparations are administered in diluted skim milk at a rate of 0.2; 0.5; 0.8, and 2 mg/ml and fed to flies from the time of their hatching. The flies of one sex treated in this way were allowed during the course of 4 hours to copulate with untreated

flies (at an age of 3 days), after which the females were returned to their former feed for the whole period of oviposition. Not one of the enumerated preparations had any effect on males; podophyllotoxin also did not have an effect on females, but those flies, which obtained the other 3 substances did not lay eggs. Dissection showed that the development of ovaries in these insects was inhibited; eggs in the ovaries of flies treated with aminopterin contained less yolk than the eggs of normal flies; the remaining elements were seemingly identical with the exception of egg size. It was noted also what oviposition also depended on the food; females fed a 5% aqueous solution of saccharose did not oviposit, but started to do this 2 days after the saccharose was replaced with skin milk; conversely, flies fed untreated milk after they had been fed food with one of the above-indicated 3 mitotic poisons were not impregnated and did not oviposit. Females copulating with males on saccharose laid viable eggs.

Recently for this purpose 4 substances have been proposed: aphoxide, aphomide, apholate and methyotep which gave encouraging results with respect to the sterilization of house flies, mosquitoes and other insects; they simultaneously sterilize males and females. Aphoxide-tris-(1-aziridinyl)-phosphine oxide; aphomide-N,N-ethylene-bis-p-bis-1-aziridinyl)N-methylphosphine amide; apholate-2,2,4,4,6,6-hexa-(1-axiridinyl)-2,4,6-triphosphate-1,3,5-triaxinome, methyotep-tris-(2-methyl-1-aziridinyl)-phosphine sulfide.

The chemical sturcutre of apholate is:



When topically applied to flies (stable flies) these compounds caused sterility in males and females; 1 μg of apholate causes almost full sterility in those cases, when the treated males copulate with treated females. Apholate and aphoxide sterilize both sexes of house flies when given to insects with feed at a concentration of 0.25-1%. Such a treatment acts stronger on females than on males. The preparation affects flies at all stages of development. A certain amount of destruction is noted with the treatment of larvae or prepupae. Morphological investigations showed a diminution of the ovaries and testes. A change was observed in the ovaries and testes of drosophila (melanogaster). The formation of spermatozoa in males deteriorated, starting with the upper region of the testes; the disturbance progressed being accompanied by necrosis of the germinal epithelium. The ovaries in the treated females were smaller; ruptures in the ovaries were observed and a lowering of the number of eggs in them. Examination of the ovary showed impairment of the nutritive cells of the oocyte (oocyte, ovule) and the follicular cells. Treatment of the larvae led to a noticeable change in the state and form of the pupae and imagoes subsequently forming.

The effectiveness of apholate as a chemicosterilizing preparation in combatting house flies was checked under practical conditions. Corn bait containing 0.75% apholate was scattered in a dump once a week for a period of 7 weeks, and then 5 times a week for a period of 5 weeks. The number of flies decreased by 20 times. The hatching of eggs was within the limits of 12-49%. The bait was prepared in the following manner: to 2 parts of maize there was added 1 part of the usual feed for fly imagoes (6 parts of dry milk, 6 parts of granulated sugar, 1 part of dry egg yolk). The dump (0.8 hectare) was treated with 16 kg of bait during the first 7 weeks (once a week) and with 7 kg during the period of the remaining 5 weeks (5 times a week). Somewhat better results obtained by La Brecque in the treatment of a heap of waste material in an inhabited locality on an island during the course of 5 weeks (once a week); as a result the number of flies was decreased, and 80-98% of those remaining turned out to be sterile.

The same author carried out treatment of two nurseries (9·45 m each) containing 1000 hens each in individual cages; the bird droppings were treated with granulated bait with 0.5% methyotep [tris-(2-methyl-1-aziridinyl)-phosphine sulfide]. The best results were provided by treating 2 times a week with bait containing 67% corn flour, 15% sugar, 15% powdered milk, 2.5% egg powder and 0.5% sterilizing substance. For a single treatment of the nursery there were expended 5 kg of bait. As a result the number of viable eggs laid by flies decreased by 10 times. A further decrease was not observed. After cessation of the treatment the number of eggs normalized after 5 days.

Among other compounds the most effective at concentrations of 5-0.1% were 3 preparation: p,p-bis(1-aziridinyl)-N-(p-methoxyphenyl)-phosphine amide; 5-fluoro-orotic acid and 1,4-piperazine di-or bis-[bis-(1-aziridinyl)]-phosphine oxide. During a study of chemicosterilizers on flies (Musca domestica, Stomoxys Calcitrans and others) it was established that chemicosterilizers possess specific specificity. The ease of penetration and the internal transmission these compounds to the place of their action can vary from one species to another and, possibly, in this is contained the essence of the specific specificity of the majority of chemicosterilizers. The question of sexual specificity is more complicated. Aziridines can cause sterility in males and females, whereas many other compounds including 5-fluorouracil, aminopterin, methotrexate are sterilizers for females (inhibitors of oviposition). Apholate, aphoxide (tepa) and methyotep without difficulty cause sterility in males and females of stable flies with the topical application of 1 μg per fly, and when only sex is treated, then higher doses are required.

Apholate aphoxide and methyotep are effective in sterilizing gadflies. In using Aedes and Anopheles mosquito larvae and imagoes aphoxide completely sterilized the males and almost all of the females with the presence of 10 parts of the preparation per 1,000,000 parts water; apholate in this dose was not so effective with respect to Aedes mosquitoes.

In working with Anopheles it was established that 500 mg/m^2 of aphoxide and methyotep provided complete sterility of the males and females; practically no larvae appeared. The sperm in the spermreceivers of treated Aedes aegypti females was numerous and mobile for 6 weeks after the effect of Thio-Tepa. On the 15-th day after treatment the males were mated with the females, however the later laid nonviable eggs. Later the males partially recovered the ability to fertilize. The investigations of Altman showed that the development of Plasmodium galeinaceum in its carrier Aedes aegypti was reduced as a result of the effect of TEPA. Burden, Smitt conducted two series of laboratory experiments with common cockroaches for an appraisal of 12 chemicosterilizing compounds. In the first series into the feed of second-stage numphs there was introduced 0.05-0.5% chemicosterilizers and their toxicity and effect on the development of numphs was determined. In the second series of experiments they determined the sterilizing effect on cockroach nymphs: of 1% apholate, 1% methylapholate, 0.25, 0.5 and 1% aphoxide, 0.25 and 0.5% methyotepa. For each 25 treated males or females there were 25 treated or untreated individuals of the other sex. The most effective was aphoxide: sterility in males was attained with a concentration in the feed of 0.1%, and in the females of 0.25%. Apholate at a 1% concentration sterilized only the males; when fed to females there was caused only the deformation of a part of the ootheca and the nonviability of part of the eggs. Only with the feeding both to males, and also to females of 1% methylapholate was complete sterility attained: the feeding of methylapholate only to males or only to females caused only partial sterility. The feeding to males and to females of 2% aphoxide caused complete sterility, but it was accompanied by considerable mortality among the insects. Aphoxide and apholate are very toxic compounds. The toxicity of apholate when orally administered or injected into man and laboratory animals occurs with 0.5-75 mg/kg; it can be absorbed through the skin. For rats LD_{50} is 30 mg/kg. This compound is considered toxic because it injures the tissues of the organs of reproduction and the bone marrow. Aphoxide when used in cancer therapy at a rate of 1.6 mg/kg sometimes causes the death of patients. Its methyl analog [trist(2-methyl-1-aziridinyl)] phosphine oxide, methaphoxide or methyo-TEPA causes the death of mice when 100 mg/kg are administered. Besides the enumerated preparations attempts were done to use natural substances given off by insects; it has been established that a queen bee exudes a compound, suppressing the development of ovaries in worker bees. At present time this substance has been synthesized (9-oxodec-trans-2-enoic acid). When administered to house flies this preparation suppresses the development of ovaries in as yet unhatched insects. Among analogous methods and agents for destroying insects there is also the use of preparations, disturbing certain biological and physiologic functions, for example the loss of the ability of insects to diapause, the loss of the ability to fly (in flying insects), disturbance in the preimaginal stage of development, the loss of the ability to fasten eggs to the fur of animals or to vegetation or to other objects; there also belongs here the inhibition of the growth of larvae, the deformation of their oral organs, the incapability to form the pupa or to delay the emergence of the imago from it.

For bringing about sterilization in insects other methods have been proposed: some of them consist in the breeding of females not able to mate, others – in the fastening to the abdomen of females of small pads impregnated with chemicosterilizing substances; males in attempting to mate with such a female are sterilized; each female can sterilize a large number of males.

The chemical sterilizing agents, obviously, exceed sterilization with ionizing radiation (gamma-irradiation) in importance. Similar methods will possibly find application in the future. The combination of contact, intestinal and other insecticides with sterilizing preparations or preparations disturbing the normal development of insects will absolutely increase the effectiveness of the chemical method of combatting arthropods.

Chemical sterilizing compounds are highly toxic and dangerous for man and animals; they change the organization of the nucleic acid in the chromosomes (this is the effect they have on insects). The use of chemicosterilizing substances on a broad scale depends to a considerable degree on whether effective methods of their applications can be found eliminating the danger to man and other animals.

Because of this it is necessary to continue the search for new "sterilizers" safe for man; these should not be substances altering the metabolism of nucleic acids (DNA), since they are similar for all living things. Possibly, a preparation having a specific effect only on insects will be discovered.

Data are available about the fact that the cross mating of certain species of insects lead to the obtaining in reproduction of 90-95% males, the greater part of which is sterile.

By genetically altering insects it may be possible to give to certain species such peculiarities, as the preferable selection of a host; food preferences, a change in the degree of endophilia, sensitivity to insecticides and ability to transmit insect diseases. The use of genetic mechanisms for destroying harmful insects, especially those having medical significance is of great interest. Methods of genetic control can be used for breeding new genetic species or variants of species harmless to man but having the same ecological peculiarities, which before this destroyed harmful insects; thus, a site is populated by stronger insects, which protect it from repeated settlement by harmful insects.

The cumulative volume of knowledge about the genes of insects indicates the direction for further investigations for the purpose of developing new methods of biological control.

CHAPTER XVIII

MECHANICAL AND COMBINED METHODS AND MEANS FOR DESTROYING INSECTS

In combatting insects various methods are used; the basic ones are mechanical, physical, chemical, biological and combined methods. All these methods are finding broad application. Their specific importance depends on the time, place and purpose, for which the disinfestation is being conducted.

In disinfestational practice there is frequently employed a combined method of controlling insects, which inflict certain harm on man. By the combined method is understood the simultaneous application of several methods, for example mechanical, physical and chemical; physical and chemical or mechanical and physical application of repellents and attractants. Also employed are mixtures of certain insecticides with others or a mixture of insecticides with fungicides (in agricultural practice). Mixtures are used which act on insects simultaneously both as contact (through the integuments) and as intestinal poison, and as fumigants (through the respiratory tracts). Mixtures are also used, which possess bactericidal and insecticide, deratizational and disinfestational properties.

In sanitary practice the method of the combined effect of increased temperature (52-62°) and a chemical preparation (formalin) is finding application.

The bath-laundry treatment has also been investigated as a combined method, inasmuch as it includes simultaneously the treatment of the body surface (washing) and the treatment of clothing and linen (disinfection, disinfestation, washing). The bath-laundry method in sanitary practice is the basic measure in combatting lice as carriers of infectious diseases. There, where people frequently bathe, launder their linen and keep their clothes in order, there are no conditions for the appearance of lice, scabes, certain skin diseases and parasitic diseases transmitted by lice. Such a rule of personal hygiene, as the systematic washing of the whole body in a bath and the changing of linen not less than once in 7-10 days with its subsequent laundering has basic importance in the prophylaxis of pediculosis; the maintenance of cleanliness of beds, mattresses and other bed appurtenances is important in preventing the reproduction of bugs.

The mechanical method of combatting insects has not as yet lost its importance, in spite of the existence of very effective insecticides. Beating, shaking out, laundering, cleaning with brushes, removal of dust, rubbish and similar other measures are widespread in everyday life. The observance of the rules of personal hygiene, of hygiene in dwellings, the observance of the rules of the collection, storage and removal of liquid and solid waste material, the maintenance of cleanliness of animals located in living quarters deprives arthropods (lice, fleas, bugs, cockroaches, moths, flies, ticks) of the conditions necessary for their reproduction. However the application of mechanical methods of combatting insects with the exclusion of other measures sometimes does not achieve this goal. Thus, for example, the beating of upholstered furniture, infested with moths does not yield positive results, because the larvae of the moths are usually located under the upholstery of the furniture, where the moth oviposits.

Of great prophylactic importance is the good sanitary condition of the means of transportation — steamboats, aircraft, railroad cars, subway, streetcars, busses, trolley busses and other forms of transport intended for the mass transportation of people, various cargoes and goods.

Various screens are widely used. Thus, for example, protection from flying insects is achieved by the screening of doors, windows and air vents with metal screens. To prevent the infestation of gnats screens with a mesh of 0.75 mm^2 are used, of flies and mosquitoes 1.5-2 mm^2; in the absence of metal screens gauze or screens of synthetic fabrics are used.

Adhesive (fly) paper and fly traps in dwellings and outside, are employed to catch winged flies; for catching cockroaches various traps are used.

To protect dwellings from the infestation of flies through doors strong air blasts are used. Thus, for example, for the purpose of preventing the infiltration of flies from an insectarium into other premises it is recommended that the door of the insectarium be equipped with a device, which when it is automatically opened would produce a vertical air blast with a speed of 500 m/min. Furthermore, the walls, and also as far as possible the ceiling and floor, and electric wiring should be made from materials with a smooth and brilliant surface.

CHAPTER XIX

THE PHYSICAL METHOD AND MEANS OF DISINFESTATION

For destroying insects with physical methods and means there are employed high temperature, fire, hot, dry and humid air; also resorted to are scalding with hot water, the use of steam, cold, ionizing radiation and others.

Fire. It is used to burn valueless objects infested with insects. Thus, for example, old wallpaper which has been stripped from walls and which is contaminated with insects is burned, also old furniture contaminated with bugs and unfit for further use and rubbish are burned. Flies and mosquitoes swept up during hibernation are burned, and also after treating premises with the preparations DDT, hexachlorane, pyrethrum and especially with aerosols of these preparations. Places infested with insects are also burned out with fire. Thus, for example, for burning sites of bug reproduction a blow torch (400-600°) is used, using it only on such objects, which are not spoiled by this, for example iron beds, kitchen ranges, stone walls. In destroying insects with the flame of a blow torch at first one should rapidly burn the surface being treated, trying only to burn the insects and thus to render them immobile. Then the same surfaces are treated repeatedly, thoroughly burning them for the purpose of destroying the eggs and the insects. Even with such a method of treatment it is very difficult to attain destruction of all the insects, since some of them manage to conceal themselves in places inaccessible to the flame of the blow torch.

Thus, the effectiveness of this method is low, inasmuch as with it, it is impossible to treat all places of insect reproduction in premises. When fire is used the reservoir of the blow torch should not be more than 2/3 filled with kerosene and it is necessary to observe the rules of fire safety. When carrying out this procedure one should beforehand remove all objects, which can catch fire, and prepare a bucket of water; the worker's clothing should not be contaminated with gasoline, kerosene or other inflammable substances.

The burning of insects previously found broader application than at the present time. At present instead of burning insects it is recommended that cracks and the surfaces around them be treated with insecticides – DDT, hexachlorane, chlorophos and others, which possess prolonged residual action (from 2 to 6 months).

Hot air. Thermal death occurs for the majority of insects at a temperature of between 39 and 54°. The maximum temperature which can be endured by insects is probably somewhat higher than 63°. The humidity has a great influence on the degree of tolerance of an insect to high temperature. Usually in dry air insects have little resistance to high temperature (Table 32).

Table 32. The thermal death point of certain species of insects (according to Knipling).

Species of insect	Exposure in minutes	Mortality rate (%) 24 hour after exposure at a temperature of				
		40°	45°	50°	55°	60°
Colorado beetle	15	—	0	0,5	24	100
	30	—	0	41	93	100
	45	—	1	100	100	100
	60	—	13	100	100	100
House fly	15	—	1	85	100	
	30	—	5	100	100	
	45	3	22	100	100	
	60	6	63	100	100	
Aedes mosquito	15	0,5	83	100		
	30	1	100	100		
	45	8	100	100		
	60	24	100	100		
Culex mosquitoes	15	14	100			
	30	96	100			
	45	100	100			
Anopheles mosquitoes	15	16	100			
	30	48	100			
	45	55	100			
	60	71	100			
Dermacentor ticks	15	—	0	0	24	100
	30	—	0	41	93	100
	45	—	1	100	100	100
	60	—	13	100	100	100

As a result of the effect of high temperature insects manifest local or general burns, thermal torpor or thermal stiffening, death.

A temperature of 50° and above acts lethally on insects, and therefore hot air finds broad application in destroying lice in linen, bed appurtenances, under clothing and outer clothing. For the purpose of disinfestation a hot iron is also used, since the ironing of linen kills lice and the majority of nits. When disinfestating clothes with an iron one should very thoroughly iron the pleats and seams ("Lice and their control").

Dry hot air can also be used to destroy bugs in furniture, which is not damaged by the effect of high temperature. In commercial organizations hot air is used to disinfestate packing and sacs.

For the disinfestation of upholstered articles disinfestational chambers are widely used. The latter are apparatuses or specially built structures, in which with the help of physical, chemical or simultaneously of those and other means the disinfestation of various objects is conducted. Disinfestational chambers are designed for the disinfestation of clothes, bed appurtenances; they are used for the disinfection of wool, bristle, utility scrap, books and other objects, which it would be difficult to decontaminate by other methods.

These chambers are available in medical-prophylactic and sanitary-antiepudemic establishments, at sanitary stations, dormitories, and industrial enterprises having contact with contaminated material. A disinfectional chamber consists of a chamber, in which things are loaded, a source of heat (a steam boiler, a fire or gas furnace, an electroair heater), control-measuring instruments, equipment for the introduction of chemical disinfecting agents (injector, evaporator), attachments for ventilation (a steam ejector, fan).

According to their purpose chambers are divided into disinfectional and disinfestational. Depending upon the active agent utilized in the chamber the following types of chambers are distinguished: steam, steam-formalin, vacuum-steam-formalin, hot-air and gas chambers.

For the disinfestation of articles with hot air industry is turning out special chambers. In such chambers there is carried out the disinfestation of various articles of wearing apparel, including leather and fur, bed appurtenances, carpets and other upholstered inventory with hot dry air.

The heating of the air in the chambers is carried out with iron or brick furnaces, batteries, electroair heaters and others. The sources of heat can be wood, gas, electricity.

The hot-air chambers are stationary and portable. In the chamber there is a control thermometer and tributary-exhaust ventilation in the form of holes in the lower and upper part of the chamber, which open with the help of a damper and close when necessary.

The articles subject to disinfestation are thoroughly examined; all inflammable objects (match, combs, cartridges, articles of celluloid) are removed.

Upon completion of the loading of the chamber the disinfector carries out disinfestation of the floor of the loading section, takes off the robe, loads it into the chamber and proceeds to work in the clean half of the chamber.

The active agent in disinfestation according to steam-formalin method is a steam-air mixture in combination with formaldehyde at a temperature of from 42 to 59° (according to an outside thermometer). The active agent in disinfestation by the steam-air method is moistened hot air (a steam-air mixture). Disinfestation is conducted at a temperature of 49-57° and 80°. Disinfestation of cotton and wool articles is carried out with a steam-air mixture at a temperature of 80-90°, leather and fur articles - at 49-51° and 57-59° (Table 33).

Table 33. Time and temperature for disinfestation of articles in a steam-air chamber.

Chamber designation	Preparing it for operation	Loading the articles	Disinfestation process	Unloading
Disinfestation of wearing apparel, fur, bed appurtenances, carpets, and other soft inventory, felt boots and other footwear	The chamber is heated to 80° according to outside thermometer. Then the tributary ventilation is opened	When the temperature descends in the chamber to 40-45°, the loading is started the articles are hung freely on clothes-hangers, not being allowed to come into contact with the heating devices. Blankets are hung on hooks: matresses are placed on shelves and separated by spacers. The articles are dried in open ventilation and at a temperature of 45-48° for a period of 10-15 minutes	The tributary-exhaust ventilation is closed. The temperature in the chamber is brought according to an outside thermometer up to 80-105° (the beginning of the exposure). The exposures last 20 minutes	The tributary-exhaust ventilation is opened. The furnace is turned off. Watching the outside thermometer, when the thermometer reaches 40-45° the unloading of the chamber is begun

After termination of the disinfestation the valve for letting the steam into the chamber is closed; it is ventilated for 10-15 minutes and then the articles are unloaded.

The capacity of the chamber is determined by the number of sets of clothing loaded (the average weight of a set is 6 kg). It is not recommended that a chamber be built with a capacity of more than 10-12 m^3. If a chamber with a capacity of more than 10 m^3 is required, then several chambers are set up, the overall capacity of which should correspond to need.

Humid hot air has broad application in disinfection and insignificant application in disinfestation. Although humid hot air penetrated more rapidly into the depth of articles, in disinfestation it is inferior to dry hot air, inasmuch as insects under the influence of humid hot air die more slowly than under the effect of hot dry air.

The disinfestation of wearing apparel can be successfully carried out in steam chambers at 100°, with an exposure of 5 minutes and a loading 10-12 sets per m^2 effective chamber area. Bed appurtenances at a rate of 50 kg/m^3 in such chambers can also be subjected to disinfestation at a temperature of 104-111° with an exposure of 10 minutes.

Boiling. Hot water and steam are used to destroy lice and nits in linen, inasmuch with the application of boiling water under the condition of complete submersion in it of the articles for 15 minutes insects and eggs perish. The boiling is carried out in vessels suitable for this, and also in disinfectional, steeping vats.

Hot water scalding is finding application for the destruction of bugs in mattresses, boards, beds (metallic and wooden), unpolished furniture and for baseboards. Boiling water is also used for scalding cockroach [illegible] sites. However by scalding alone it is difficult to achieve the complete liberation of dwellings from insects, inasmuch as it causes damage and discoloration of fabric. Due to this the treatment of articles for insects is usually not carried out in steam chambers and for disinfestation dry-heat chambers are used.

For treating bug nesting sites special hand apparatuses are used — bug-killers, the action of which is based on the use of steam.

Steam obtained from high pressure boilers is used for the disinfestation of freight cars. The method consists in the fact that a railroad car is first cleaned of mud and rubbish, but then washed with a steam jet, yielding upon condensation a considerable amount of hot water. Such an application of steam for treating railroad cars in a course of 15 minutes is considered one of the most effective methods of getting rid of insects and pests, especially from barns.

Low temperatures. Insects are resistant to cold. Many insects having significance both for agriculture and also for public health, die within an hour at a temperature of from -15 to -30°; house flies and mosquitoes transmitting yellow fever die after 30 minutes or somewhat longer at -20° (Table 34).

Table 34. Mortality rate (in percents) of certain insects after 24 hours which have been subjected to low temperatures for an hour (according to Knipling and Sullivan).

Species of insects	Stage of development	Mortality rate (%) at					
		0°	-5°	-10°	-15°	-20°	-30°
Mosquito Aedes aegypti	Imagoes	62	99	100	—	100	100
Oriental cockroach	Nymphs	2	71	98	100	100	100
House fly	Imagoes	4	41	88	100	100	100
Dog ticks	"	0	26	48	100	88	100

Note. The flies, mosquitoes and cockroaches were maintained and raised at 27°.

Short-term cooling to 0° and -8° does not cause the complete death of many insects (bugs, lice, mosquitoes and others), but causes in them a state of rigidity the onset of which can be observed during temperature fluctuations within the broad limits of from +10.5° (flies) to 0° and considerably lower (mosquitoes, bugs). The majority of insects dies upon the freezing of the tissues of the organism. The direct cause of their death can be dehydration of the tissues or mechanical damage to the cells with the formation of ice crystals. The latter theory at the present time is rejected by many.

Under the influence of cold in the insect the movement of hemolymph ceases and the vital processes almost stop. The insect falls into a state between life and death, into a so-called state of anabiosis (Greek work anabiosis), when the maximum cessation of vital activity occurs with its possible subsequent restoration. The main factor bringing about anabiosis is the removal of water from protoplasm by freezing; or by drying at a high temperature or by an increase in the concentration of salts.

When placed under favorable conditions insects located in a state of anabiosis, revive. Thus, for example, some mosquito larvae revive after being for several hours at a temperature of -10° (V. N. Beklemishev).

The onset of permanent rigidity in different insects occurs under conditions of different periods of time (Table 35).

Table 35. Mortality rate (in percents) within 24 hours of the imagoes of house flies and mosquitoes after being kept at -20° for various periods of time.

Exposure in minutes	Mortality rate (in percents)	
	house flies	Aedes aegypti mosquitoes
1	12	96
3	44	97
6	79	100
12	87	100
15	98	100
30	100	100

Cold within known limits does not cause the death of insects, but only has an effect on the speed of development of their individual stages. Cold is sometimes applied for the temporary cessation of vital activity of insects and for bringing them to a state of anabiosis. For these purposes low temperatures are recommended for the storage of pelts, furs, carpets, leather and grain. Insects poorly endure repeated, consecutive, sharp temperature transitions from low to high and back; in a number of cases to this has been used to destroy both adult insects, and also insects in the preimaginal stage.

Electric currents and currents of high frequency.[1] Electricity in disinfestational practice has not found broad application because of complexity and economic inefficiency, although there are source materials showing that insects can be killed by the application of electrical current (electric fly traps).

The effect of high frequency currents on insects has as yet been insufficiently studied. Oscillations of high frequency currents can be obtained from special apparatuses, a description of which we will not dwell on here. According to G. A. Mikhel'son and A. N. Karaseva, with an electric current voltage up to 5600 V, with a width of the capacitor place of 100-185 mm and with a distance between them of 36 mm the death of lice and their eggs occurs within 20 seconds, and with a distance between the plates of 150 mm and with a width of the plates themselves at 200-220 mm the death of lice and nits occurs within 60 seconds. On moistened objects lice and nits die 2 times faster than on dry objects.

Clothes not containing metal buttons and hooks, subjected to multiple disinfestation with a high-frequency field do not change

[1]Currents of high frequency are currents with a period of oscillation per second of from $3 \cdot 10^6$ to $3 \cdot 10^{10}$, i.e., currents with a frequency of pulsation of from 3 MHz/s to 30 GHz/s. As is known, the electrical current utilized for the purpose of illumination has 50 periods (oscillations per minute).

their qualities. In places where metallic clasps are attached clothes burns. For the disinfestation of a cotton jacket 90 seconds are necessary.

The effect of high frequency currents on pests of flour and grain was studied. Contaminated materials on a transporter were passed between the electrodes of a current generator (frequency 10^6). With an increase of the temperature of the flour to 100-125° death of the pests was observed at all stages of development within 10 seconds and fungi spores died. The treatment does not affect the flavoring, food and vitamin properties of the flour. The application of this method against pests of wood is also possible.

Ultrasonics. Sound vibrations with frequencies of 50 kHz destroy almost 50% of the caterpillars of the cornborer. Ultrasonics similar to the sounds emitted by bats repel the caterpillars of the cornborer. Attempts were made to destroy mosquito larvae by submerging them in the water of an ultrasonic generator. After 15-20 seconds of ultrasonic action (500,000 oscillations per second) the eggs of Aedes aegypti mosquitoes in the water did not manifest any acceleration in larvae hatching, and with a 30-second exposure larvae hatching decreases; decreased hatching is preserved for 20 days.

Mosquito larvae can be killed in water by ultrasonics at 40,000 cycles per second. Death is due to the rupture of trachea caused by the rapid expansion of the air contained in it. Mature larvae and pupae are more resistant than young larvae. With the use of ultrasonics other water organisms also die, which contain air inside their body.

Microwaves - radio waves - the indestinctly limited region of electromagnetic waves. In literature this term is used to designate decimeter, millimeter waves or superhigh frequency or very short waves. We could not find data about the effect of microwaves on human parasites and pests of his dwellings, therefore we cite information about their effect on grain pests, in particular with respect to the destruction of insects which are harmful to wheat.

Wheat and flour are good absorbents of microwave energy, and the selective heating of wheat or flour or insects contaminating them is not noted. Because of this, in order to achieve the death of insects, it is necessary to heat the whole mass of wheat or flour to a temperature lethal to the insects, used as test-insects. At a temperature of 92° and an exposure of 21 seconds complete destruction of the pests of flour was attained, but in a week from 23% of the insect eggs larvae hatched. Increasing the temperature to 99° and with the same exposure larvae hatched from 2% of the eggs after a week. A temperature of 100.5° with an exposure of 18 minutes was lethal for 100% of the flour beetle larvae.

Ionizing radiation. Under the effect of large doses of ionizing radiation all insects and their eggs located on various objects including those in both packed and unpacked food goods died. Their effect did not prevent reinfection. With this method of treatment there were no viable remainders, from which resistant strains of insects could appear. In order to bring about the effect on objects containing insects beta and gamma radiation were used.

Beta radiation consists of particles or electrons. Gamma radiation is a form of pure energy. Gamma radiation within the limits of 20,000 R sterilizes adult grain weevils; doses of less than 6000 R inhibit the development of hide beetles. Irradiation at any stage of development with doses of 5000, 8000, and 12,000 R sterilizes almost all beetles – food pests. In order to disinfect grain goods in a granary 8000 R is sufficient.

With the effect of gamma rays (radioactive cobalt) on insects in various phases of development their death was observed. For adult insects (females) the following doses of gamma rays were found to kill 50% of them: for the American cockroach 48,000 R, for the common cockroach 72,000 R, for the house fly 110,000 R, for the bed bug 150,000 R, for clothes lice 170,000-180,000 R, for the red house ant 190,000 R. Complete destruction of insects at various phases occurred from doses, which exceeded the LD_{50} by approximately $1\frac{1}{2}$ times. Males and females, as a rule, did not differ in resistance; an exception was house flies, the males of which were $1\frac{1}{2}$ times less resistant in comparison with the females.

Between the weight of insects and the doses of radiation an inverse relationship was established. The eggs of house flies had hardly any resistance to gamma rays; the LD_{50} was equal to 130 R. House flies which were resistant and sensitive to DDT did not differ from each other in their resistance to gamma rays.

A study in the United States of the toxicity to animals of products, subjected to the effect of ionizing radiation, showed that the feeding of food irradiated with ionizing radiation to about 300,000 rats, mice, dogs, apes, chicks, and a certain number of people did not have a harmful effect on their health. Supply control of the United States Army proposed in 1962 to use irradiated bacon to be fed to soldiers (bacon was the first food product, which was permitted for consumption in the United States).

Thus, the control insects with gamma-radiation is a technically feasible process, but it is still vague, whether it is desirable to use it because of the danger of working with radioactive isotopes.

CHAPTER XX

FLEAS AND THEIR CONTROL

Fleas belong to the Insecta class of insects, order Aphaniptera or Suctoria.

On the earth about 1050 species of fleas have been counted. In the USSR 334 species of fleas have been registered. Thus, the flea fauna of the USSR is very diverse (two subfamilies, six families, and genera).

All species of fleas are bloodsucking parasites of warmblooded animals, birds, and man (V. Ye. Tiflov). The usual dimensions of a flea are from 1 to 5 mm; females are larger than males; wings are absent. Their color varies from straw yellow to dark brown. The flea body is flattened from the sides; the abdomen has ten segments; in the males it is shorter than in the females; it is turned upwards at the end in males. Two pairs of spiracles in fleas are located on the thorox, 8 pair – on the abdomen. On the three segments of the abdomen there are three pairs of legs, which are highly developed, especially the rear ones, with powerful jumping musculature. The tarsus has five segments; on the last segment is a pair of strong claws. The size of the jump of the human flea is about 32 cm in length and 9 cm in height. On the head of the flea is a pair of simple eyes which are developed to an unequal degree in various species of fleas. The antennae consists of three segments, two short basic ones and a third, fused from many segments, the so-called antennal club. The oral apparatus of the flea is for piercing; it consists of an upper lip (epipharynx) and the hypopharynx located near the base of the upper jaws; on its free end a salivary gland duct opens. The oral apparatus of the flea has one unpaired piercing organ (the piercing stylet) fluted from the inside and originating from the upper lip. The pair of lower jaws and the lower lip are equipped with palps. The upper jaws are well developed (Fig. 4).

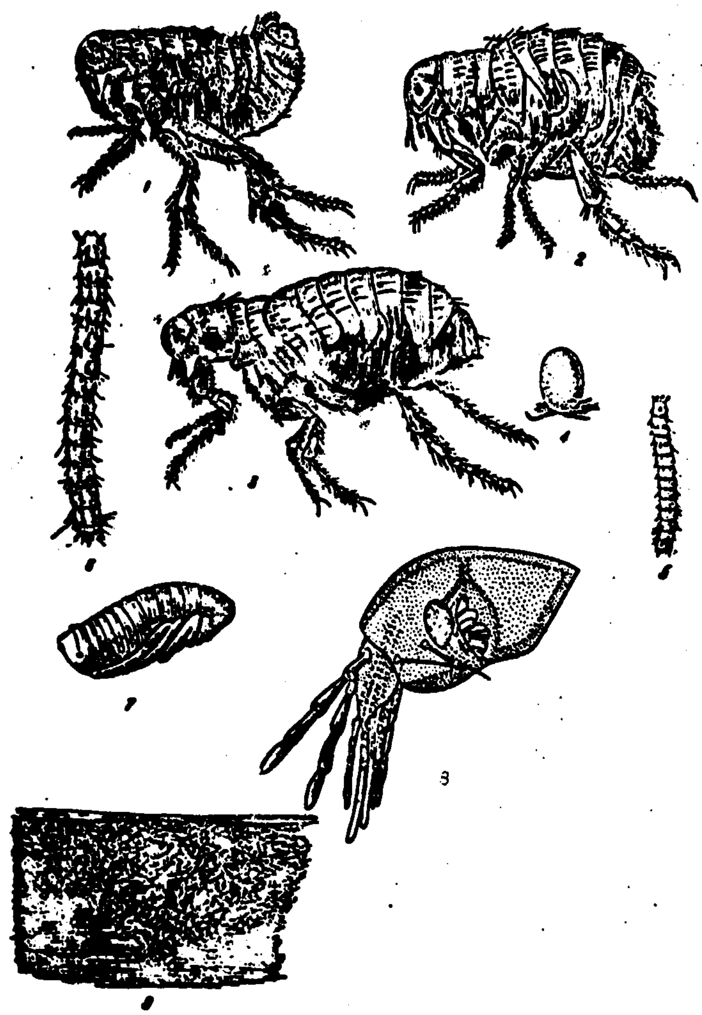


Fig. 4. The human flea Pulex irritans. 1 – male; 2 – female; 3 – the dog flea Ctenocephalides canis (female); 4 – egg; 5 – first stage larva; 6 – second stage larva; 7 – pupa; 8 – head of a flea with the piercing apparatus; 9 – pupa of a flea, covered with mud.

The oral organs act as piercers of the skin of the host; the blood is pumped into the stomach due to the action of a system of muscles of the head section of the foreintestine, which is covered with hairs and setae.

Fleas, apparently, introduce their oral apparatus into the skin of a host, and the upper jaw serves as a cutting organ. After the penetration into a suitable vessel the tip of the epipharynx penetrates into the opening, and the upper jaw with its salivary canals remains outside. The fleas then suck blood, releasing periodically drops of secretion from the salivary glands (saliva) of the jaw into the place near the puncture in the wall of the vessel, but not into the opening. The saliva prevents blood coagulation; moreover a change occurs in the thickness of the skin and an inflammatory swelling appears around the place of puncture, which is maintained for a certain time, and then vanishes. The act of sucking and also the movement of the flea on the body of the host causes in the latter skin irritation and etching. Scratching the skin can be severe and can sometimes be complicated by suppurations (I. F. Zhovtyy).

On the back of the 8th segment lies the scetellum with the sense organs. On the surface of the head and other parts of the flea body are hairs, setae, denticles, dens. The latter are arranged in rows.

The organs of digestion consist of an esophagus, passing into the proventriculus of the midgut or stomach and hindgut, which passes into the rectum. The proventriculus is thickly covered with chitinous setae directed towards the back, which do not disturb the passage of food, but simultaneously it is like a valve inhibiting the reverse flow of the stomach contents. On both sides of the intestines lie 2 salivary glands consisting of a small number of giant cells. The ducts of both glands unite into a common duct, which broadens towards the heat into the so-called salivary pump.

The greatest epidemiological significance belongs to those fleas, which are encountered in the human environment, namely:

1) the human flea (Pulex irritans), parasitizes man; it is frequently encountered on domestic and wild animals; the inhabitant of human dwellings is widespread everywhere;

2) the dog and feline flea (Ctnocephalides canis a. felis) parasitizes domestic animals (dogs, cats) and is also encountered on man;

3) the rat flea (Xenopsylla cheopis) mainly parasitizes gerbils and rats in the southern belt of the Soviet Union and Central Asia; it plays an important role in epidemiology of plague;

4) the rat and mouse flea (Ceratophyllus fasciatus) is a widespread parasite of rats and mice;

5) the suslik flea (Ceratophyllus tesquorum) is a parasite of susliks; it is a carrier of plague; it can be passed on to man;

6) the marmot flea (Cropsylla silantiewi) parasitizes marmots and bobak; it is a carrier of bobak plague.

Fleas usually lay from 3 to 15 eggs (depending upon the species of fleas) in cracks in floors, in rags, in dust, in rat nests, in doghouses, in waste plant material, in bird nests, in the soil, and so forth. The eggs, as a rule, are white, with a slightly yellowish hue. During their whole life fleas lay about 450 eggs. Dog fleas lay eggs in the wool of the animals, gluing them slightly to the fur; this gluing is so weak that when dogs are combed the fleas and their eggs are combed out onto the floor. Human fleas also sometimes weakly glue their eggs to the fibers of fabric. The embryo developing in the egg has on its head a sharp thorn, with which it ruptures the shell of the egg and the larva emerges outside. From the egg after 3-5 days there hatches a white, worm-like, very mobile larva, which feeds on decomposed organic substances and the excretions of its parents, which with excess feeding ejects through the anus undigested blood; the dry feces of fleas is also food for the larvae. The body of a larva consists of a head and 13 segments: the oral organs are of the gnawing or scratching type. The larvae increase in size, molt three times and pupate. Thus, two moltings of the three pass into a period of an active state of the larva, and the third – into a cocoon. From the cocoons there emerge nymphs and mature insects. The periods of the stay in the cocoon are different and fluctuate from 7 to 373 days, which depends on the temperature and humidity. Under favorable conditions (temperature of 18°) the whole cycle of flea development can be completed in 3-4-5 weeks.

Under laborato.·y conditions the length of the life of a flea is very diverse. The flea of steppe rodents can live up to 1725 days; the human flea can live from 300 to 513 days; the rat flea — up to 100 days, the dog flea — up to 243 days. Under natural conditions fleas can exist much longer. They can also live for a rather long time in the absence of a host (in nests, burrows).

The number of fleas depending upon the season of the year is different for different species and different localities. Thus, for example, the rat flea becomes the most numerous towards autumn (September). The maximum number of human fleas is observed in August-September, and the minimum occurs in January.

Upon emerging from the cocoon fleas can live, without feeding. Besides they do not multiply. For the maturing of eggs it is necessary that a flea for a certain interval of time suck the blood of its host.

Fleas can pass onto predatory animals from their host. This is why on cats it is possible to find rat fleas and fleas of other rodents, as, for example, suslik fleas, which has great importance in the epidemiology of plague. Fleas in the adult state under favorable conditions feed on the blood of mammals and birds every 2 h.

The duration of the bloodsucking act for human flea is about 15 minutes; dog fleas, according to some authors suck blood for about 2 hours, according to others— about 4 hours. The human flea during the first 30 minutes after taking food defecates 10-20 times. Temperature influences food consumption, and some species of fleas are not able to suck blood at a temperature lower than 13°, and other suck the blood of suslike which have fallen asleep at a temperature of 6-7°. High temperatures with a deficiency of humidity act lethally on fleas; a temperature above 40° causes their rapid death.

The Epidemiological Significance of Fleas

In a flea for a prolonged time there remain viable the exciters of various infectious diseases, which with bloodsucking can be transmitted to man. There have been registered 24 species of wild mammal fleas which parasitize man and his dwellings.

The majority of authors considers that fleas can transmit from a sick animal or a man to a healthy animal or a man 7 infections; certain authors express the assumption that fleas can even transmit 18 infections (I. G. Ioff). However, the information cited in this respect contraction cannot be considered sufficient. Only data about the propagation and the duration of the preservation in a flea of the exciters of such infections, as plague, tularemia, endemic typhus, Japanese river fever and yellow fever (Yu. M. Rall', Ye. N. Zagniborodova) have been indisputably proven.

Recently attention has been focused on them as propagators of rickettsial-pathogenic agents from the group of parasitic typhuses, and others.

The role of fleas in the transmission of plague has been especially thoroughly studied. This infection strikes not only man, but also a number of wild animals, for example, mice, rats (gray, black and laminar-tooth), susliks, bobaks, jerboas, gerbils, field voles, lemmings, mole-voles, hamsters, hares, and others. From home animals can sicken camels, sheep, big cattle.

Plague is mainly a rodent disease characterized by natural focalization. A large role in the propagation of infection among man is played by rats. The black rat (Rattus rattus), populating homes up to the upper floors and attics has a great possibility to come in contact with man and to contaminate his dwellings with rat fleas, as a result of which this species of rat more frequently serves as the source of the infection of man with plague than the gray rat. In the period of epizooty fleas which have sucked the blood of a rodent sick with plague remain to the end of their life, frequently for several months, carriers of the infection. Contaminated fleas can be found not only on diseased, but also on healthy rodents, in their burrows, etc., (Yu. S. Balashov, V. A. Bibikov; V. A. Bivkova, and V. V. Sakharova; Barbes).

The infection of fleas occurs only in those cases, when they suck the blood of a diseased rodent during extraordinarily intense sepsis — in the last hours before its death.

In a study of the intensity of infection with plague bacillus of fleas during the epizooty of plague among wild rodents it was shown that in the first 3 weeks of epizooty fleas are contaminated by an insignificant amount of plague bacilli, and in the last 3 weeks with massive infection.

According to I. G. Ioff with the feeding of fleas a few hours before the death of a diseased animal not more than 70% of the insects are contaminated, but feeding them 18 hours and more before their death infection in them is only very rarely observed. Under conditions of natural epizooty it was possible to detect plague infection in 70% of the fleas taken from plague-stricken susliks found in the steppe. The period of preservation of the infection depends on the duration of life of the female fleas. Data exist, that the marmot flea can preserve infection up to 358 days, and the flea of other steppe rodents — up to 296 days. The maximum period of life of a plague stricken rat flea is equal to 50 days. After the death of a flea the death of the microbe in its corpse was observed between the 4th and 24th day. Regarding the possibility of hereditary, i.e., the transovarian transmission of bacterial infection in fleas, in this regard no positive results were obtained. The possibility of the preservation of bacteria in the flea organism during its metamorphosis from the larval stage to the imaginal stage was rejected. The plague microbe vanishes from the intestines of the larva not later than 12 hours after it has consumed the infection material (I. G. Ioff).

In 1933 M. P. Pokrovskaya extracted from fleas during epizooty a plague culture infected with a bacteriophage. An analogous phenomenon was noted by other researchers. Under the influence of a phage in the flea organism lysis of the microbes occurs, as a result of which it is liberated from the latter. It was determined that a phage in the organism of a flea is preserved up to 32 days.

The mechanism of the transmission of plague by the flea was realized in the following way: after the sucking of an infected animal (with intense bacteremia) the plague microbes multiply in the digestive organs of the flea, as a result of which the proventriculus is blocked by a solid plug of these bacteria preventing passage of new blood batches into the stomach. With subsequent sucking the blood from the wound in the body of the host ascends through the proboscis into the esophagus and encounters a barrier in the form of the bacterial lump; it returns back, attracting with it a large number of plague bacteria. Infection occurs then, when the blocking is incomplete; in such cases the blood partially enters the stomach of the flea, but because of the disturbance of the functions of the proventricular valve there occurs the reverse flow of blood from the stomach into the wound. Sometimes after a new puncture and bloodsucking the flea regurgitates into the wound of the host this blood with a part of the bacterial plug, in consequence of which infection occurs. The formation of blocks occurs slowly: in the rat flea in 10-45 days, and in other species in 2 months.

With the presence of a block the fleas are not in a state to suck blood, as a result of which they die from hunger. Fleas more frequently than usual, puncture the host, which increases the possibility of the propagation of plague infection by them.

The fleas of gray rats and house mice in endemic focuses, attacking man, can also transmit rat exanthematous typhus. The pathogenic agent of rat or endemic typhus is Rickettsia typhi. If rickettsia prowazekii is transmitted to man through lice, then rickettsia of murine typhus is transmitted by the rat flea. Rats are the reservoir of the pathogenic agent of rat exanthematour typhus; the pathogenic agent can be inoculated into piglets, mice, rabbits, susliks, hedgehogs, and other animals. The role of carrier is also played by mouse, dog, and cat fleas.

After infection with ricksettsiae the human flea remains contaminated for life. In fleas as well as in lice rickettsia infection is confined to the epithelium of the stomach. Intestinal rickettsiosis in fleas does not cause their death and has something like a symbiotic character, where in the case of normal blood feeding they regularly excrete rickettsiae with the feces. Contaminated fleas which remain for 12 days without blood feeding cease to be dangerous; but with the restoration of this they again become dangerous after 48 hours.

Rickettsiae excreted along with the feces are well preserved in the environment (for 40 days), but readily die in the presence of moisture (24 hours after submersion in water). An infectious dose for man is 0.01 mg, which corresponds to 1/5 part of the flea defecation.

In the salivary apparatus of fleas rickettsiae are absent, and thus a flea during bloodsucking cannot transmit the rickettsiae into the wound of the animal. Rats and mice are infected through the urine of diseased rodents and the feces of fleas containing rickettsiae. Fleas infected on rodents and then attacking or getting into his dwellings can transmit the infection to people due to their excreting rickettsiae with fecal matter.

The method of infection can be various: rickettsiae can penetrate through injured skin (rubbing them into scratches in the shin), the mucous membranes of the mouth, the conjunctivae, and also through the intestines in the case of their getting there alone with food. Infection most frequently occurs, apparently, as a result of the rickettsiae getting on mucous membranes along with the feces of fleas or by inhalation (the inhaling of rickettsiae which have been raised with dust).

It was established in experiments that fleas are very susceptible to rickettsiae prowazekii – the pathogenic agents of epidemic typhus. Infected fleas, obviously, preserve all their life in themselves the pathogenic agents of infection, which are excreted with their fecal matter. The mechanism of infection is the same, as in murine typhus.

Tularemia can be transmitted from a diseased rodent to a healthy one by fleas. In rodent nests the number of fleas is great. For example, in the nest of a field-vole up to 800 fleas can be found. In the cold season tularemia microbes can live in the body of a flea for months (V. Ye. Tiflov, N. G. Olsuf'yev).

Fleas collected on people sick with leprosy and in the dwellings of these patients contain in large numbers leprosy bacteria. However, the possibility of transmitting leprosy by fleas has not been demonstrated. A British commission on leprosy studying the possible role of insects in the transmission of this disease arrived at negative conclusions.

Cases have been observed of the isolation of the pathogenic agents of pasteurellosis, salmonellosis erysipefoid, of the virus of lymphocytic choriomeningitis and tick-borne encephalitis from fleas collected in nature. Under laboratory conditions it was ascertained that certain species of fleas are able for a prolonged period of time to preserve bacteria pathogenic for man (viruses and rickettsiae) of erysipeloid, pseudotuberculosis, melioidosis, pasteurellosis, anthrax, rickettsiae of American rocky mountain spotted fever, Q fever, Japanese river fever, pneumococcal infection of rodents.

Certain data exist about the fact that fleas participate in the transmission of the pathogenic agents of hemorrhagic nephrosonephritis, tetanus, myxomatosis, in rabbits, smallpox, leprosy in rats, and others.

The epidemiological significance of fleas in transmitting the enumerated pathogenic agents of infectious diseases is insignificant or has not been proven, nevertheless indications exist of the necessity of combatting fleas both in the field, and also at populated points (I. S. Tinker, I. Kh. Ivanov).

Measures for Combatting Fleas

Measures for combatting fleas should be directed mainly toward the creation of conditions for preventing the reproduction of insects, and for destroying them in their breeding places. It is necessary to strive first of all to keep premises in a state of cleanliness, especially public places: dispensaries, hospitals, subways, theaters, movies, schools, stations, railroad cars, vessels, etc.

Rubbish, rags, bedding for animals, waste material and others should be regularly removed, since they can serve as places for the breeding of fleas (R. B. Kosminskiy, M. N. Timchenko and others, P. I. Shiranovich and others).

In destroying fleas, besides sanitary-hygenic measures, insecticides are broadly applied.

According to A. N. Alekseyev, the sensitivity of the flea of Muridae rodents to DDT, gamma-hexachlorane and chlorophos at the egg and larva stage is different. With the constant maintenance of the larvae on a substrate treated with insecticides, the most toxic to them was gamma-hexachlorane, the least – chlorophos; DDT occupies an intermediate position. The most sensitive were the larvae of the younger instars, less sensitive – the larvae of the third instar, the pupae, and eggs.

The insecticides penetrate through the shell of both the egg and also the cocoon. The shell of the egg is more protected than the shell of the cocoon from the effect of gamma-hexachlorane and DDT by 100 times, from chlorophos by 10 times.

The sensitivity to insecticides of mature fleas depends on their sex, stage (instar) and the degree of their saturation. "Old," females (one- and two-weeks old) feeding on an animal are less sensitive to chlorine-containing preparations than "young" (one-day old) females. Chlorophos was equally toxic both to one-day old hungry fleas, and to "old" females.

Hexachlorane preparations containing both 80% and 98% gamma-isomer possess approximately identical toxicity. Readily soluble components consisting of the oily admixtures hepta- and octo-chlorocyclohexane which are by-products of the production of the gamma-isomer of hexachlorane, also possess considerable toxicity to fleas. The alpha- and beta- and delta-isomers of hexachlorane are practically ineffective with respect to fleas.

The development of paralyses in Ceratophillus consimilis wog fleas occurs in proportion to the degree of their sensitivity to insecticides; the fastest of all is in young females and males, the slowest – in old females. Great epidemiological significance belongs to the established fact that C. consimilis fleas preserve the ability to feed on the blood of man even in the presence of expressed symptoms of paralyses.

According to insecticidal properties with respect to fleas the preparations are arranged in the following order: gamma-hexachlorane > > dieldrin > aldrin > chlordane > DDT > pyrethrin > allethrin > > toxaphene.

With the prolonged use (for a period of 3 years and more) of insecticides fleas become resistant to the latter.

Reports of cases of the ineffectiveness of certain insecticides with respect to various species of fleas under natural conditions are rather numerous. Of special interest is the work of Vera, who reported on the ineffectiveness of DDT in a focus of plague in Ecuador against various species of fleas and about the rate of increase of cases of plague disease due to this. According to Patel with coauthors, as a result of 14 years of treatment with DDT of one of the regions there appeared high resistance among fleas, which was

3000 times greater as compared to the control fleas. According to the reports of the Universal Organization of Public Health, fleas preserve resistance acquired by them for over a year.

According to V. I. Vashkov and A. N. Alekseyev, with the cultivation for 28 generations of all phases of development of rodent fleas (C. consimilis) on a substrate containing DDT, in the insects resistance to this insecticide increased by 8 times. The development of resistance was noted both for the imaginal and also for the preimaginal phases. The eggs and larvae of an experimental strain of fleas were more resistant to DDT than the initial control strain. The number of offspring after contact with lethal doses of DDT in the resistant strain was 20 times greater than in the control strain. In the experiment resistance developed slowly and became noticeable only after 20 generations. This makes it possible to draw the conclusion that in the course of not less than 2-3 years it is possible to apply the same preparation to combat them. Upon hatching from the cocoon the young fleas of the resistant strain are highly sensitive to insecticides; this makes it possible in combatting them for a certain time to achieve success by increasing by 2-3 times the expended insecticide.

Treatment of domestic animals. It is necessary to attentively watch domestic animals and the places where they are kept and where they rest – their niches, doghouses, stalls, baskets, mats, boxes with pads, bedding, etc. It is necessary to treat the latter with pyrethrum, DDT disinfecting powders, carbophos, chlorophos, or hexachlorane at a rate of 5-10 g/m^2, 10% solutions of naphthalysol, lysol, soap-cresol liquids or soap-solvent emulsion, with an expenditure of the liquid of 300-500 g/m^2. Two hours after the treatment the premises are thoroughly cleaned and washed. The animals should be systematically subjected to treatment with pyrethrum, carbophos powders, DDT, hexachlorane. In combatting fleas of domestic animals (dogs, cats) it is possible to dust them with 0.25% anabadust with a filler of soxoul ashes or 0.5% anabadust with other fillers (coal, millet ashes, chalk or worked gypsum) at a rate of 30-50 g per treatment per animal. Anabadust cannot be removed from the animal.

One should not apply large doses of DDT powder and hexachlorane, since the animals can lick it and die; cats are especially sensitive to DDT; it is better not to treat them with this preparation. A single toxic dose of pure DDT and hexachlorane is approximately equal to 200 mg or 2 g of 10% dust per kg of weight of the animal. Carbophos is the least toxic (1800 mg/kg of pure preparation of all the insecticides. For washing the animals it is better to use soap with DDT or hexachlorane. Not recommended for use in washing the animals are oil solutions of DDT and hexachlorane, because in this form the preparation is readily absorbed and the animal can die.

Combatting fleas on dogs and cats can be carried out with carbophos (malathion) in the form of 3-5% disinfecting powder or a 0.5% solution (or submersion in a bath containing 0.25% of the preparation). Sevin can also be used in the form of 2-5% disinfecting powder or by submersion in a bath containing 0.5% solution. Also used are disinfecting powders containing 1% rotenone or pyrethrum, 10% methorychlor, 1% lindane or 2-4% chlordane, and also a 0.2% emulsion of DDVP (for external application).

Derris powder can be used: one teaspoon of derris powder is mixed with a double quantity of wheat flour and rubbed into the wool of animals or dusted from a gauze sack. Rotenone powder cannot be used for the treatment of bird cages, because they can easily become ill with pneumonia. In such cases pyrethrum powder is used. For treating small cats and dogs it is possible to use silica gel at a rate of 30 g per animal. For larger dogs and cats – 60 g per animal, which is to be subjected to treatment. For several days silica gel powder is rubbed into the fur and removed by washing.

Ronnel is used in the form of a 0.25% solution both as an external and as an internal agent. A solution or tablets of ronnel are given with the food to animals at a rate of 100 mg/kg of weight of the animals, which after 2-4 days provides effective results. Tablets with dipterex are recommended for administration 2 times per week (a dose of 68 mg/kg). In the absence of insecticides a soap-kerosene emulsion is used, which is prepared in the following manner: 31 g of soap are dissolved in 1 ℓ of water, the solution is brought to boiling; to the hot liquid there are added 1250 g of kerosene and thoroughly mixed, and then the mixture is brought to a volume of 20 ℓ. For the washing of animals it is also possible to use lye. In necessary cases the destruction of fleas on birds is carried out.

Individual human protection. Under conditions, where the possibility of an attack on fleas infected with plague on man is not excluded, one should don special clothing and boots with high tops; the ends of the sleeves of the coveralls and trousers should be tightly tied over the mittens and boots. It is necessary to don safety glasses and respirators. Repellent agents and insecticides are also used: lysol, napthalene, DDT, hexachlorane and pyrethrum, with which the clothing is treated (see "Repellents").

The destruction of fleas in dwellings. For destroying fleas in dwellings there are used preparations containing DDT, hexachlorane and its gamma isomer, dieldrin, chlordane, chlorophos, DDT, carbophos and others. Mature fleas in dwellings can be destroyed by dusting the floor and furniture with 10% DDT disinfecting powder, 6-12% hexachlorane disinfecting powder at a rate of 2-6 g of insecticide per m^2. Pyrethrum is atomized at a rate of 5-25 g/m^2 (Table 36). Dusts and powders are atomized on the surface of the floor, linen, clothing, beds, bed appurtenances. The places to be most carefully dusted are the baseboards, cracks in the floor, collected rubbish, animal resting places (cats, dogs) and their bedding. In an analogous way there are also used a 1-2% suspension of disinfecting powders, a 1-2% emulsion of desinsectal [Translators Note: a solution of DDT in a hydrocarbon solvent used as domestic vermicide], a 1-2% solution of chlorophos at a rate of 0.5-2 g/m^2 of insecticide, fleacide [Translators Note: pyrethrum solution in mineral spirits used as household insecticide] at a rate of 40-50 $m\ell/m^2$. The preparations are applied not only on the floor, but also on rubbish and on the walls to a height of 1 m. In dwellings the preparation is removed 2-3 hours after its application (dusting); it is not recommended that linen, clothes, and beds be treated with hexachlorane.

Table 36. Normal expenditures of preparations for destroying fleas (developed by the Central Scientific Research Disinfectional Institute).

Insecticide	Unit of measurement	Expenditure of preparation per single application, g	Method application and solution concentration
Chlorophos	Square meter of floor	2	Treatment with 1-3% aqueous solution
Trichlormetaphos-3	The same	1	Treatment with a 1-2% emulsion
10% DDT disinfecting powder	" "	20	Dusting of the floor and furniture
	Set	20	Clothing, underclothing
	"	60	Bed appurtenances
	Animal	40	Cat, dog
DDT suspension	Square meter of floor	15	Treatment of floors, walls with 1-2% suspension
25% DDT emulsion	The same	6	Treatment with 1-2% emulsion of floors, walls to a height of 1 m and furniture
Disinsectal	" "	50	Treatment of floors, walls, furniture
12% HCCH disinfecting powder	" "	20	Dusting of floor and furniture
	Set	15	Clothes, underclothing
	Square meter of floor	12	Treatment of floors and walls with a 1-2% aqueous emulsion
12% HCCH dininfecting powder	Set	60	Bed appurtenances
	Animal	40	Cat, dog
Pyrethrum	Square meter of floor	25	Dusting of floor and furniture
	Set	20	Clothes, underclothing
	"	60	Bed appurtenances
	Animal	40	Cat, dog
HCCH emulsion	Square meter of floor	10	Treatment of floors, walls in uninhabited premises
Fleacide	The same	50	Treatment of floors walls, furniture, and bedding for animals

In using pencils containing hexachlorane or other insecticides strips are drawn with intervals of 4-5 cm on the lower parts of the walls (up to 1 m), on the floor, furniture, beds, and so forth. When using soap-K 5% aqueous emulsions are applied.

The treating of premises with a 1% emulsion of chlordane, diazinon, malathion, gamma-isomer or dipterex at a normal expenditure of 50 mℓ/m^2 showed that the most effective was diazinon providing complete destruction for a period of 63 days. The gamma-isomer with respect to insecticidal properties is close to diazinon, whereas carophos and chlorophos give satisfactory results for a total of 7 and 35 days respectively. A concentration of 5% emulsion of chlordane provide a reduction in fleas by 84%.

With the presence in fleas of resistance to DDT preparations a 2% emulsion of malathion or a 1% emulsion of diazinon is applied. When disinfecting powders are used 10% DDT and 2-5% malathion are applied; the fastest effect is provided by 0.5% DDVP (V. T. Osipyan, M. D. Dunayeva, L. N. Pogodina).

For dusting a floor and furniture 1% anabasine-sulfate disinfecting powder with a powdered slaked lime filler or 0.8% anabasine-sulfate disinfecting powder with a sodium carbonate filler are used at a rate of 5 g/m^2; it is possible to use with complete effectiveness for combatting fleas a 1.25% aqueous solution of anabasine-sulfate with a filler of 0.5% emulsion of household soap. For this 100 mℓ of this solution are used to treat 1 m^2 of the surface being treated.

Disinfecting powders and other preparations are carefully applied to the places of rat movement and the entrances to their burrows so that poison gets on their fur and gets carried to their nest. Fleas attacking such rats die. For the complete destruction of fleas two-three treatments of premises are necessary. They also treat rubbish chutes, cellars, and so forth. Simultaneously with this there is conducted deratization.

Repeated treatments are conducted according to indications. There are also applied hot emulsions of 10% naphthlysol, 10% soap-cresol preparations, 5% phenol or 10-15% lysoform, which are used to treat walls and floors of dwellings, where one should thoroughly treat all cracks of floors, and also the spaces behind the baseboards; 2 hours after treatment the floors have to be thoroughly washed.

Aerosols of DDT, hexachlorane and others are applied (V. T. Osipyan, M. D. Dunayeva).

Poisonous gases are also used (chlorine, sulfur dioxide, prussic acid, chloropicrin, and others); most widely applied is chloropicrin, which is not only a disinfestational, but also a disinfecting agent with respect to the nonresistant plague microbe (see "Fumigants").

In all cases after disinfestation it is necessary to carefully sweep up and burn the dead insects, inasmuch as the insecticides do not kill the microorganisms, located inside the insects.

The destruction of fleas in clothing, linen and bed appurtenances is carried out by dusting the articles with 10% DDT disinfecting 5-12% hexachlorane disinfecting powder, 5% chlorophos disinfecting powder or carbophos or pyrethrum disinfecting powder at a rate of 15-20 g per set. The fleas die approximately after 2 hours. In the case of the absence of powdered preparations it is possible to use surface moistening with a 1% DDT emulsion, a 2% chlorophos solution, 5% naphthalysol, lysol, soap-cresol liquids, a 5% soap-K emulsion. After treatment the articles are cleaned and beaten out.

For the purpose of destroying fleas there can be used preparations of anabasine, with which linen, clothes and bed appurtenances are dusted at a rate of 125 g per set – 0.25% anabasine-sulfate disinfecting powder with a filler of saxaul ashes or 0.5% anabasine disinfecting powder with a filler of sifted chalk, or 1% anabasine-sulfate disinfecting powder with a filler of sifted gypsum. The shaking out of the disinfecting powder and insects from the clothing is carried out 10-30 minutes after the application of the insecticide.

Destroying fleas in rodent burrows (susliks and gerbils) is achieved by introducing liquid chloropicrin (2-5 g per burrow) into their burrows or by the application of 10% DDT disinfecting powder or 10% hexachlorane disinfecting powder. It is necessary to keep in mind that chloropicrin, black cyanide and others, even at higher doses than necessary for poisoning rodents do not kill according tc I. G. Ioffa the entomological fauna of the burrows, because the gases and vapors of these substances do not penetrate into the nests of the rodents in the necessary quantity, but remain near the entrance and poison the rodents only when these latter pass through the formed gas plug. Therefore if when destroying the susliks it is also desirable to destroy their fleas, then the designated burrows should be thoroughly stopped up to ensure their reliable and prolonged isolation from the environment.

Good results were yielded by hydrogen cyanide, and also by methyl bromide. As a result of the application of 10 g of a preparation into a burrow not only the rodents die, but also the entomological fauna of the burrows, including the ticks. The application of methyl bromide requires extraordinary caution; inhaling its vapors can lead to poisoning, and illness starts only after several hours and even days (P. I. Shiranovich, A. K. Shishkin).

Harvey for the purpose of studying the possibility of destroying fleas on animals orally administered to white rats an alcohol emulsion of ronnel at a rate of 300 mg/kg, 25 mg/kg of rogor and determined the mortality rate of rat fleas, planted on the animal. The best effect was observed with the use of rogor: after 1-3 days 82-85% of the fleas died. With the use of ronnel after a day there was observed the destruction of 14-16%, and after 3 days 56% of the fleas.

According to source material, with the oral administration of rogor (50 mg/kg) to rats the mortality rate of the fleas reached after an hour 95%, after 4 hours 3%; of baytex (125-150 mg/kg) after an hour 89-93%, after 12 hours 59-60%; of American cyanamide of phosphorthian acid; 0,0-dimethyl-0, p-(dimethylsulfamide)-phenol ether (12-15 mg/kg) after an hour 84-85%, after 12 hours 40-18%.

Combatting fleas under natural conditions has great epidemiological significance, since rodent fleas after the destruction of the rodents remain viable in the nests for a prolonged time, and part of them migrate to the exit of the burrow onto the surface of the ground, which promotes the subsequent propagation of infection. For the purpose of destroying fleas on animals and preventing their migration methods have been developed in recent years for the simultaneous destruction of rodents and their ectoparasites, including fleas and ticks, for which a mixture of insecticides and raticides (DDT and zinc phosphide and others) have been used; these are highly toxic insecticides, which are mixed with bait; systemic insecticides are also used (see "ticks and their control"). Methods for destroying fleas in rodent nests have also been developed.

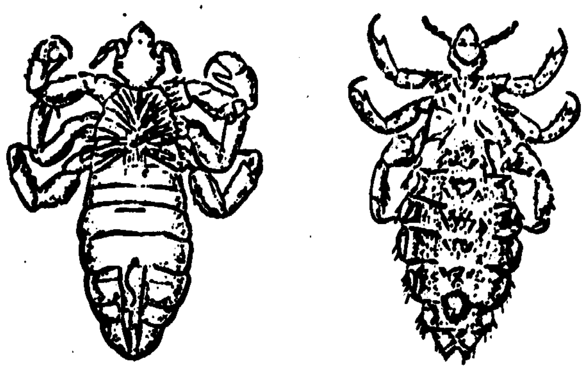
Mechanical methods of destroying fleas are so ineffective that there is no necessity to give a description of them. The application of traps can be of significance only in carrying out of research works. In bait there have been used such animals, as dogs, cats, guinea pigs, and others, which are placed in cages with the walls covered with sticky paper: the fleas trying to attack the animal get onto this paper.

CHAPTER XXI

LICE AND THEIR CONTROL

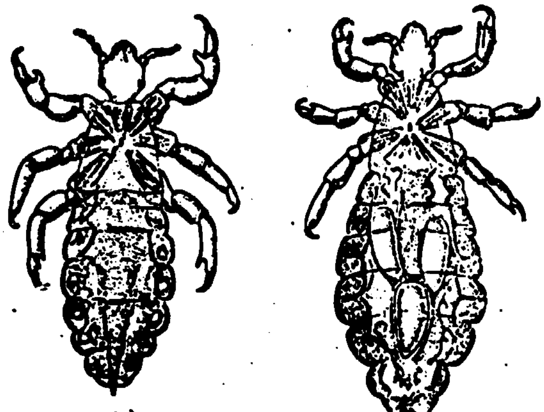
Lice belong to the insect class Insecta, the order false-proboscidiae. Lice (they number about 200 species) parasitize mammals and man, the blood of which they feed on. Each species of mammal has its own individual species of louse, which parasitizes only this animal and does not go over to other hosts. Thus, for example, pig lice do not go over to dogs, they also do not go over to man. In lice the grasping reflex is well-developed; the presence of strong tarsal claws on the tarsi makes it possible for them to hold firmly onto various surfaces and fabrics. Such appendages permit the insects to hold onto the hairs and the clothing of the host, and in the case of the contact of the host with another man they easy pass over to the latter. Three species of lice parasitize man: head (Pediculus humanus capitis), body (P. humanus corporis) and pubic or crab (Phthirus pubis) lice (Figs. 5, 6, and 7). With respect to the first two species variants exist; some consider them individual, although related species, other combine them into one species having two varieties.

Body and head lice in external features differ very little from each other. Body lice multiply chiefly in the underclothing and clothing found on man, and great lice infestation can be encountered in the upper clothing and bed appurtenances. Head lice multiply mainly in the hair of the head and differs from the body lice in that they have greater pigmentation on each side than on the middle of the torso. In body lice the body is uniformly gray. Sexual,



A) B)

Fig. 5. The body louse, Pediculus humanis corporis. A) male; B) female (according to Ye. N. Pavlovskiy).



A) B)

Fig. 6. The head louse, Pediculus capitis. A) male; B) female (according to Ye. N. Pavlovskiy).

Fig. 7. The crab louse, Phthirus pubis (according to Ye. N. Pavlovskiy).

crescent-shaped appendages on head lice are broader than on body lice. Among a population of body and head lice there are encountered up to 6% hermaphrodites. In size the body louse is larger than the head louse. The length of a male body louse is 2.1-3.75 mm, the females 2.2-4.75 mm. The length of a male head louse is 2-3 mm, the female 2-4 mm.

The pubic louse has a broad, flat body, thus the reason it is also called the crab louse; the length of the male is 1 mm; the female is 1.5 mm. It is chiefly encountered on the hairs of the pubes; it lays eggs on them and can also be encountered on other hairy parts of the body.

At a temperature of from +5° to -6° the movement of lice ceases. The optimum temperature for the life of lice is 30-32° and 70% relative humidity. At 40° they die within 1-2 hours. A louse can live under water at 15-18° for 2 days. Animated movements in lice are observed during hunger (searching for food) and in laying nits. They are the most mobile at a temperature of 25-37°. With a decrease in temperature the activity of a louse falls off (O. V. Kozulina). A louse crawls approximately 30-35 cm per minute. All species of human lice in all stages of development are blood-sucking. The piercing proboscis of lice is concealed in a special sheath in its head. When used for piercing it protrudes outside. Suction occurs only upon the submersion of the oral organs into the thickness of the integuments.

Lice can endure hunger for approximately 10 days at a temperature of 10-20°. They develop and multiply best of all with three feedings per day, but can also develop with a single feeding. During each feeding the female sucks about 1 mg of blood, and the male 3 times less. The sucking act lasts from 1 to 20 minutes.

Olfaction in lice is weakly developed. Satisfied lice avoid substances repulsive to them, hungry lice can feed in the presence of repulsive odors.

The mating of lice occurs at any time. After copulation the number of spermatozoa for the laying of fertilized eggs by the female is sufficient for 20 days. With the placing of males on the 7-10th dav with females, which have copulated once in their life, it is possible to increase the number of fertilized eggs. The great number of eggs laid is obtained from females located with a small number of males. The best combination of males and females for body lice is 1:3. Usually the number of fertilized eggs is 60-80%, and for young females it can reach 87%. The females of body lice lay nits - eggs chiefly on the inside of underclothing, on the seams along the length of a thread or a hair, but they can also lay them where the threads cross; head lice lay eggs - nits along the length of hairs. The eggs of lice are ejected from the genital opening lubricated with the secretion of the glue glands, which that immediately congeals and firmly glues the nit to the substrate.

The fertility of females fluctuates. With the double feeding of lice per day for 20 minutes each the lice lay at one time 2 times more eggs, and with triple feeding 3 times more eggs than with a single feeding. During the course of a day a female body louse lays 6-14 eggs per day, and during her life-time 50-329 eggs (O. V. Kozulina), and according to Ye. P. Pavlovskiy, during its life-time body louse lays a maximum of 295 eggs. The female of head lice in a day lays not more than 4, and during her life-time lays approximately 50 eggs. The nits of all three species of human lice differ somewhat from each other (Fig. 8). The nits of head and body lice although they are similar, also have certain differences in form and size. The size of nits of body lice is equal to 0.9-1 mm and of head lice 0.75-0.8 mm. The nits of pubic lice are still smaller - 0.65-0.67 mm.

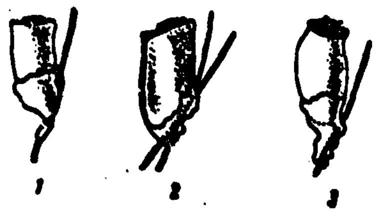


Fig. 8. The nits (egg) of the three species of human lice: head (1); body (2); pubic crab lice (3).

The shell of a nit protects the embryo very well from the effects of the environment. Nits survive at 1-3° for a week and for 35 minutes at 54°, at a temperature of 98° they die within 30 seconds. The submersion of nits in kerosene or ether for 10 minutes does not have any harmful effect on them. They die after a 10-minute stay in 2.5% carbolic acid, after a 5-minute stay in a 2% solution of lysol, after a 2-minute stay in a 15% solution of acetic acid.

The duration of the embryonic development of lice in nits depends on the ambient temperature. The optimum conditions for the hatching of the larvae of body lice are: a temperature of +37° and a relative humidity of 70%. The minimum period of development is 4 days; at 35° the period of development of body lice increases to 6-8 days; at 30° - from 7 to 14 days, at 25° to 16 days. In clothes which aren't taken off larvae hatch within 7-10 days. At 40° and lower than 22° larva do not hatch.

In summer the process of the hatching of the larvae of body lice proceeds somewhat more slowly than in winter. This is explained by the fact that in winter under the clothing on the surface of the body more favorable conditions are created for lice than in summer, in particular the temperature under the clothing in summer is lower than in winter. Thus, winter is a more favorable season for lice reproduction.

The emergence of the larvae from the nits occurs as a result of the action of a special apparatus, which is developed before hatching. With the help of this apparatus the larva pushes off the egg cap and by means of highly developed legs and spasmodic contraction of the body, and by air pressure pumped to the bottom of the egg shell by the digestive tract it emerges outside. Lice develop with incomplete metamorphosis, passing through three phases of development: the egg, a larva of three stages and the mature louse. There is no pupa stage. Not all the developed embryos hatch from the eggs; dryness or excessive atmospheric humidity reduces the emergence of larvae from the eggs. A larva which has only just hatched looks like an adult louse; its size is 1 mm in length; it is light-yellow in color and almost transparent. In contrast to the adult louse the larva has an inproportionately small abdomen and three-segment antennae. Larvae are in a state to suck blood a half hour after emerging from the egg shell (Fig. 9).

Fig. 9. Body lice larvae, Pediculus humanus corporis 1 - first instar; 2 - second instar; 3 - third instar.

The duration of the stages of development of larvae is dependent upon nutrition, the individual peculiarities of the insect, the temperature and humidity. On the average the whole larval period lasts approximately 12 days. The development time of lice is made up of the time of the individual phases of development; in the embryo (egg) from 10 days to 6 weeks; the larvae of the first stage last - 3-5 days; the larvae of the second stage last 4-5 days and the larvae of the third stage of development last - 3-4 days.

The larvae moulting process, i.e., the shedding of the epidermis, occupies approximately 5 minutes. The new, young epidermis after 45 minutes becomes thicker and the louse can suck blood. Female and male body lice are able to mate 24 hours after the termination of the third larval stage; during this time in the virgin female there occurs the development of the sexual apparatus and the maturation of the eggs. With continuous location on the body of man the duration of the whole period of development from the time of oviposition to the maturation of the female is 16 days. The greatest development of the sexual apparatus is achieved on the 6-7th day of life of the female; on the 12-13th day the sexual apparatus of the female starts to degenerate. The duration of life of a mature female body louse is approximately equal to 46 days; the male – 32 days; the duration of life of female head lice is 32 days; the male up to 27 days.

According to A. M. Burylov and A. M. Pshenichnov, as a result of prolonged experiments (2 years) directed toward varying the selection of individuals it is possible to obtain populations of body lice, which are able to feed on guinea pigs and rabbits. Compared to the original strain in the lice adapted to the blood of rabbits and guinea pigs there was observed a decrease in fertility, a reduction in the duration of life, but they did possess the ability to assimilate foreign blood.

When sucking blood the louse injects saliva secreted by bean-shaped and horseshoe-shaped glands. At the place of injection after 8-10 hours there appears a hard bluish papule having an itching and burning sensation, after approximately 3-4 days it becomes smaller, loses its color and disappears. The bluish color is due to local homorrhage and inflammatory vasodilatation. The consistency of the papule is explained by the formation of an infiltrate. With the reverse development of the latter a small spot remains.

These pathological changes explain the itching (the irritation by the lice saliva of the nerve endings of the cells). The secretion of the bean-shaped, salivary glands of crab lice causes the formation of bluish spots on the skin. The presence of these spots on the body is a characteristic of the infection of man with crab lice. When sucking blood the louse excretes from the anus one or several drops of fecal matter or undigested blood, which in the air thickens and becomes fastened to the skin.

The itching from the bites of the lice causes scratching, which spread the various microflora, as a result of which there can develop eczema, pyoderma (furunculosis, impetigo and others). In the presence of lousiness of the hairy part of the head nits are detected near the base of the hairs, mainly on the occipital and temporal part of the head (more frequently in women and children). As a result of the bites, scratching and excretion weeping, cortical, impetigenous eczema develops; also observed are individual, pustular eruptions on the face, pyococcuc intertrigo behind the ears, conjunctivitis, blepharitis and enlargement of the neck and submaxillary nodes; copious, serous-purulent secretion sticks the hairs together and a matted-like mass is formed - plica polonica.

Body lice from the folds of underclothing pass over for feeding to the body of man, especially in those places where the clothing are in close connection with the body (at the collar, in the lumbar region and others).

In the lumbar region and in other places scratching and pyoderma are observed. Furthermore, in the region of the shoulder blades, the shoulders, waist, the internal surfaces of the hips, and sometimes other sections of the skin becomes a dry, dirty-brown color, exfoliates, is covered with old (white colored) scars and also fresh scars with scratchings and crustae. These data indicate that lousiness in most cases can be easily determined by these symptoms.

With the presence of crabe lice, they are first looked for on the skin of the pubes. They are encountered also on the chest, in the armpit cavities, in mustaches, in beards, on eyelashes, eyebrows, and on children on the hairy part of the head. Crab lice are firmly fastened by their proboscis to the orifice of hair follicles, and by the front legs to the hairs. Infestation, as a rule, occurs during sexual intercourse.

Besides microbes pathogenic to man in the organism of lice there are also contained symbionts. The symbionts which harmless to lice and man are necessary to maintain the existence of lice. Without them the nutrition of the insect and its ability to reproduce are severely reduced. The symbionts have the form of a long bacillus, and are contained in the organism of the lice in the mycetome known under the name of the "abdominal disk." This small formation has a spherical or oval form; it lies in the ventral wall of the mid-gut, right on the mid-line of the insect body, somewhat nearer to the anal end than to the head. The abdominal disk consists of cells derived from the mid-gut and is covered on the outside with a layer of mesodermal tissue.

Symbionts are transmitted to the following generation of lice by penetrating into the egg through ovular petiole.

The Epidemiological Significance of Lice

Body and head lice have great epidemiological significance. Lice are carriers of pathogenic agents of exanthematous and recurrent typhus, Volhynia fever, and, according to certain authors, in experiment of lice can transmit the pathogenic agents of tick typhus of Northern Asia and Marseille fever. The pubic louse does not have great epidemiological significance. The basic role in the transmission of parasitic typhus belongs to body lice, they are readily infected with rickettsiae of both epidemic and also exanthematous rat typhus.

Epidemic typhus was first described by Fracastero, however for a long time many objections were advanced against acknowledging this disease as independent. The question was finally solved as a result of the investigation of Jenner Edward in 1850 and others, who showed that exanthematous typhus is a special specific disease, differing from abdominal and recurrent typhus.

O. O. Mochutkovskiy in 1875, who infected himself with the blood of an exanthematous patient, showed that the pathogenic agent of this infection is in the blood. This experiment has been successfully repeated by a number of authors on man and apes.

G. N. Minkh in 1871 expressed, and in 1878 published his data about the significance of lice in transmitting the pathogenic agent of exanthematous typhus. In 1909 Sh. Nikol' (Nicolle Charles) confirmed these data. Rickets in 1910 detected in the intestines of body lice, infected with Mexican typhus, oval and bacilliform formations reminiscent of the bacteria of hemorrhagic septicemia. Identical formation were found in exanthematous typhus louse by

Prowazekii (1913) and others, as a result of which the pathogenic agent of exanthematous typhus began to be called rickettsia Prowazekii which in size is larger than a virus and smaller than bacteria; the young forms have a length of 0.3-0.4 μ (when dividing 0.6-0.9 μ). In both arthropods and also mammals pathogenic rickettsiae, as a rule, are intracellular parasites causing harm to the insect. In lice rickettsiae multiply in the cells covering the internal walls of the intestines. Rickettsiae from the lice organism are excreted together with the fecal matter. Rickettsiae do not penetrate into the hemolymph of lice; they do not occur in the salivary glands. Outside of the organism rickettsiae can be preserved up to 66 days; in dead lice up to 7 days. The overwhelming majority of other pathogenic rickettsiae dies rapidly in environment with the exception of rickettsiae Bernet (to the pathogenic agent of Q fever). However under specially created conditions they can remain for a long time in a viable state (in a dried state in a vacuum). In a humid medium rickettsiae die rapidly at a temperature of 50-70°; at low temperatures (from -20 to -70°) they remain viable for a long time. Rickettsiae Prowazekii in the dry feces of exanthematous typhus lice on the hairs of sheepskin can survive for 12 months and 23 days. Under laboratory conditions with a considerable number of rickettsiae in the air they easily penetrate into the human organism through mucous membrane of eyes and respiratory tract, as a result of which the disease appears. The rickettsiae from one laboratory can penetrate into neighboring premises through the ventilation system or even through cracks.

According to A. A. Bereznyakova, rickettsiae of exanthematous typhus, rat typhus, located outside the organism of lice are nonresistant to the effect of high temperature and disinfectional preparations. Chloramine solutions at a 0.1% concentration completely inactivate the rickettsiae of exanthematous and rat typhus outside the organism of a carrier in 2 minutes. Solutions of formalin, lysol and carbolic acid at a 0.5% concentration inactivate the rickettsiae of exanthematous and rat typhus after 30, 10, and 5 minutes respectively. Thus, for the destruction of rickettsiae located outside the lice organism, the most reliable agent is temperature. Of the chemical agents for this purpose it is possible to use chloramine, lysol and phenol at the concentrations and exposures officially recommended for disinfection.

Recurrent typhus has existed from time immemorial. It was first described as a mass disease in 1843. The pathogenic agent of recurrent - Spirochaeta was discovered by Obermeier in 1868 and was described in 1873, and as a result the pathogenic agent of recurrent typhus was called Spirochaeta Obermeier.

Spirochaeta Obermeiera is a filiform, spirally bent microorganism with a small number of curls (up to 5, rarely more). The length of Spirochaeta is 10-40 μ; the thickness is 0.25-0.5 μ. Spirochaeta Obermeiera dies at 45-48° after 30 minutes. At 0° it remains viable up to 3 days, when frozen - up to 8 hours; at room temperature in liquid media - up to 14 days (in sealed tubes).

In 1874 the Russian scientist G. N. Minkh infected himself with the blood of patients and became ill with recurrent typhus. In this way he proved that the pathogenic agent of the infection circulates in the blood. In 1876 Minkh in Russia first paid attention to the role of insects, as transmitters of the pathogenic agents of contagious diseases, in particular of exanthematous and recurrent typhus. All over the world for a long time there has been studied the possibility of the transmission of the pathogenic agent of recurrent typhus by such insects, as bugs, fleas, mosquitoes, ticks, lice. As a result it was established that the louse is the insect, which transmits the pathogenic agent of this infection from the sick to the healthy, when a patient has been infected with recurrent typhus mainly in the feverish period; in the apyrexice period the possibility of infecting lice is minimum. In a study of the role of insects in the transmission of the pathogenic agent of recurrent typhus Nicol and others on 5 volunteers showed that not one of them in the experiment for 21 days got sick in spite of the fact that one of the volumteers recieved 129 lice bites, another - 377, the third - 485, the fourth - 4707, and the fifth - 6515.

It was subsequently shown that only 5-9 days after sucking a patient the louse becomes able to infect a healthy person. Furthermore, it is established that Spirochaetae Obermeiera in large numbers are encountered in lacunary cavities in the hemolymph of lice, and a mass of them accumulates in the hemolymph of the tarsi. Apparently, all three species of lice can be carriers of recurrent typhus. However, the role of pubic lice as compared to body and head lice is insignificant. In the sucking of the blood of an infected person the female is mainly contaminated; the number of contaminated females is approximately 53%. The infection of man occurs not as a result of the injections of lice, but as a result of crushing it (or only its paws and antennae). As a result of scratching into the wound from the injection or excoriation from the scratching the hemolymph (the coelom liquid) of the injured or crushed louse containing a large number of Spirochaetae is rubbed in. A louse preserves its ability to infect man for 15-25 days. The pathogenic agent of the infection is not transmitted to the offspring of lice.

Infecting with recurrent typhus is more difficult than with exanthematous typhus. This difficulty is caused by the necessity of combining the crushing of the louse and disturbing the integuments of the skin of man which also explains why recurrent typhus is less widespread.

Exanthematous and recurrent typhus are mass and threatening diseases. They strike a large number of people, especially in wartime, when the possibility of observing the elementary rules of personal hygiene is absent and because of the deficiency of dwellings people have to sleep close to one another. Such a situation in previous centuries was created in the armies of a number of countries, because during war large subdivisions of troops were repeatedly incapacitated in units and the army as result of diseases; these losses were considerably greater than those due to combat fighting itself.

In the propagation of rat rickettsiosis (rat or endemic typhus) among wild rodents, besides fleas, apparently, rat lice also have significance.

Under certain conditions rat typhus can become epidemic for man and be transmitted from an infected person to a healthy one by body louse just like classical typhus.

The transmission of rickettsia by lice or fleas occurs through the contamination of the bite site by highly infected insect defecation. Rickettsiae of Volhynia fever in the dried stomachs of infected lice are preserved up to $2\frac{1}{2}$ years.

The main role in the transmission of so-called "trench (Volhynia)" fever from man to man is played by body lice.

Lice feeding on a person ill with trench fever become infected within 5-9 days, but, once they have become infected they remain infected for at least 4 months. Persons ill with trench fever can preserve the ability to infect lice feeding on them for not less than 443 days after the beginning of the disease. The pathogenicity of lice defecation is very great. Lice can transmit the disease either by biting, or by introducing of defecation into scratched skin. It is possible to cause infection by placing the hands on the mucous membrane of the eyes.

Lice excrete the pathogenic agent of the infection with their excrement for 60 days. The virus is not transmitted to lice offspring. The pathogenic agent of the infection can be preserved in the feces of lice for up to 4 months. Rickettsiae of Volhynia fever die at an air temperature of 60° within 5 minutes. Heating in a humid medium at 50° for 30 minutes also brings about the death of rickettsiae. With an increase of temperature to 70 the rickettsiae die within 2 minutes. As a result of the application of steam (99-100°) the rickettsiae of Volhynia fever die within 3 minutes. This species of rickettsiae is also nonresistant to chemical agents: a 0.5% solution of chloramine activates the rickettsiae in 5 minutes, a 0.5%

solution of formalin in 30 minutes, a 0.5% solution of lysol - in 10 minutes, a 0.5% solution of carbolic acid - in 10 minutes. The etiology of trench fever has not as yet been completely studied. The majority of authors classifies the pathogenic agent of this infection among the rickettsiae. The source of the infection is a person ill with this disease.

This infection mainly strikes soldiers located in trenches and this is why it has been called trench fever. The disease arises in the presence of unsatisfactory sanitary conditions.

Salmonellal survive in lice and their excrement in large numbers for more than a year (sometimes 4 years). It was possible to infect lice by letting them feed on rabbits which were sick with bacteremia. But the transmission of the infection to healthy animals was not observed. Experiments with membranes showed that lice cannot transmit salmonellae through a puncture. If the lice are infected by feeding sick animals, in the blood of which there are contained more than a thousand microorganisms per mg, then they can transmit samonellae in the same way as they transmit the pathogenic agents of recurrent typhus (Melner and others).

Besides pathogenic rickettsiae, intracellularly and extracellularly in the intestinal tract of lice there are also encountered nonpathogenic ones, such as Rickettsia rochalimae Weige, Rickettsia Weige (unclassified rickettsiosis). There is also encountered (in focuses) plague bacillus, but there is no proof of their transmission.

In the organisms of body and pubic lice caught on patients with leprosy there is encountered the pathogenic agent of leprosy. The pathogenic agents of bacillary infection of lice have also been detected in the fecal matter. The gram-negative coccusbacterium (Bacillus pediemi) is considered a parasite of the copulative apparatus; it is most frequently detected in the vesica penis folds of the male, and also in the vagina and the ducts leading to the ovaries of the female.

In the organisms of body and head lice there are also encountered staphylococci and other cocci (Steinhaus).

Measures for Combatting Lice

Material guarantees, a high cultural level and hygienic awareness among the population exclude the development of lousiness. At present throughout the world the problem of controlling pediculosis has still not lost its significance. In the Soviet Union all necessary measures are being taken to eliminate lice as a biological species. There is no doubt that with the elimination of pediculosis exanthematous and recurrent typhus will vanish from the earth.

With the presence of lousiness, which is possible among individual groups of people, special measures are being conducted. The latter according to their character are divided into prophylactic measure, or those preventing the appearance of lousiness, and exterminatory. Furthermore, besides hygienic measures, various chemical agents are being employed.

Of the chemical agents for the destruction of lice it is possible to use DDT, carbophos (malathion) at a 0.5% concentration as an ovicide and at a 0.1% concentration against adult forms, acetophos (V. D. Larionova), hexachlorane and its gamma-isomer, sevin, pyrethrum, kerosene, acetic acid (dilute) and other insecticides, which are nontoxic to mammals.

Of the 60 derivatives of carbamic acid the one with the greatest toxicity to lice is sevin. On wool fabric treated with a 0.0025% acetone solution of sevin or dusted with 1% disinfecting powder, all lice die.

In the United States for the destruction of lice there is also recommended the powder "Mil" which contains 0.2% pyrethrin, 2% sulfoxide (synergist), 2% 2,4-dinitronizole (ovicide) and 0.1% phonol "S" (antioxidant). This composition is effective in combatting resistant lice. It is recommended that two treatments be conducted with a week interval. Another preparation "Nbin" contains 68% benzyl benzoate, 14% emulsifier (tween), 12% benzocaine and 6% DDT. For preparing an emulsion one part of the concentrate is diluted in 5 parts water. Before using the mixture is thoroughly agitated. In treating the head the hair is thoroughly moistened. The application of this mixture leads to the destruction of lice in all stages of development. After applying the preparation the head is not washed for 8-10 days; the residual action is preserved for 2 weeks. For combatting crab lice freon aerosols are used. Derris is also recommended.

As a result of the prolonged application of these same insecticides the sensitivity of lice to them considerably decreases. The appearance of which are resistant to chlorinated insecticides is an indisputable fact. Information about the appearance of DDT resistance in body lice in places, where this preparation is widely used appeared for the first time in the foreign press in 1950-1951 and continues to appear at the present time. The lowering of the sensitivity of lice to insecticides occurs slowly. Resistance becomes noticeable with their cultivation on tissues only after 5-10 generations. Thus, for example, L. N. Pogodin cultivated body lice on tissue containing DDT, with the gradual increase of its concentration. After $4\frac{1}{2}$ years the lice remained viable on tissues containing DDT in amounts 2000 times greater than at the beginning of the experiment. An attempt to develop resistance to malathion during a period of 44 generations gave negative results.

According to Cole and others races of body lice which are resistant to DDT do not lose their resistance for a period of 30 generations. Races of such insects are also more resistant to other insecticides, including sevin.

Prophylactic measures consist in carrying out the normal requirements of personal and public hygiene. One of the most important sanitary-hygienic requirements is the observance of the rules of personal hygiene and the systematic changing of underclothing not less frequently than once in 7-10 days with the subsequent washing of them which has basic significance in the prophylaxis of lousiness. This makes it possible not only to prevent the appearance of lice, but also to eliminate them in those cases, where they have appeared. Among the measures for the prevention of lousiness there is also the proper organization of a network of baths, laundries and barbershops. Of special importance in preventing the propagation of lousiness is the thorough observance of sanitary conditions in dormitories, hotels, apartment houses, rest rooms, railroad passenger cars and other public places. The prophylactic measures against exanthematous and recurrent typhus should guarantee the detection and the complete elimination of cases of lousiness among a given population.

The detection of cases of lousiness should be carried out in an active manner:

a) during medical examinations of patients in medical-prophylactic institutions;

b) during sanitary examinations of organized children populations (childrens' institutions, schools, pioneer camps, etc.);

c) by observing groups living in dormitories and groups in which the composition is continually changing.

Depending upon the epidemiological indications sanitary treatments of these contingents are carried out. In cases of the detection of patients with pediculosis during an examination the information is transmitted from the place of residence of the infected person to a sanitary-epidemiological station or to the sanitary-epidemiological section of the regional hospital for the carrying out of the necessary measures in the family of the person with pediculosis.

With the nonobservance of a hygienic regime and the presence of conditions conducive to the spread and development among individual groups of a population (under conditions of march life, under overcrowded conditions, with a deficiency of linen, and with irregular washing), it is necessary along with the carrying out of prophylactic measures to carry out a systematic, sanitary treatment of the population. By sanitary treatment is implied a complex of sanitary measures directed towards the simultaneous destruction of lice on the hairy parts of the head and body of man, on his linen, clothing (under- and outer-), beds and in his dwellings.

The destruction of lice on the human body. Before beginning sanitary treatment at sanitary-delousing stations the persons to be subjected to treatment are first examined for the detection of lousiness on the hairy parts of the body. Washing the body with hot water with soap promotes the mechanical removal mainly of body lice, which are readily washed off with water. The nits on the hairy parts of the body upon washing with soap and a piece of base (or a coarse rag) are to a great extent washed off. It is considerably more difficult to get rid of head lice. With the presence of long hair it is absolutely impossible to free the hair from nits by simply washing the head. Therefore with the presence of head lice the hair, if this is possible, is cut with a machine or treated with insecticides which are harmless to man with such an application (pyrethrum powder, 10% DDT disinfecting powder, 6% hexachlorane disinfecting powder, carbophos disinfecting powder, metaphos preparations, DPA disinfecting powder, kerosene emulsions, soap DDT and HCCH). The powders are rubbed into the roots of the hairs. If the treatment of the head is carried out at a sanitary-delousing station then the disinfecting powder is not washed off for at least 30 minutes. In the case of treating the head under home conditions the head is treated in the evening before sleep, after which it is tightly wrapped in a kerchief and left wrapped for 2-3 hours or better still until morning - for 8-12 hours (Fig. 10). Then the insecticide is washed off or only brushed out. The DPA disinfecting powder is not washed from the hair for 2-3 days. The expenditure of powdered agent for treating the head is 10-15 g.

For successfully combatting lousiness it is possible to use soap containing 5% DDT or 3% hexachlorane, and the washing of the body and head are carried out in the same way as with household soap: the hairy parts of the head are usually left soaped for 20-30 minutes, and then the soap is rinsed off; the expenditure of soap for one washing is 50 g. For the purpose of destroying head lice it is possible to use an ointment 3-5% acetophos at a rate of 10-40 g per head. The ointment is washed off after 30-60 minutes.

Fig. 10. ·The application of a dressing for treating a lice-infected head.

It is possible to treat the head with a 2% solution of soap K. Also used is a soap-kerosene emulsion, in which there are 45 parts kerosene. In using liquid insecticides and ointments the hair is profusely moistened and the preparation is rubbed into the roots of the hair; in doing this it is necessary to protect the eyes from the preparation. The head is wrapped with a kerchief, which is removed after 30-40 minutes, after which the hair is thoroughly washed with warm water and soap. The insecticide expenditure is 80-100 g. For greater effect the hair if combed after washing.

For destroying lice in the hair on the head it is recommended that a headgear be treated on the inside with 2% alcohol solutions of one of the following preparations: DDT, the gamma-isomer of hexachlorane, carbophos, DDVP, a 5% solution of acetoxon. It is also possible to use other insecticides which are not toxic to man. Highly effective are the preparations of acetophos, which are used in the form of 3-5% insecticidal ointments with a vaseline filler, a cleansing agent with shampoo and Eau-de-Cologne also containing 5% acetoxon.

In order to get rid of pubic lice, the hair on the pubes, legs, in the armpits, and also on the face (beard, mustache) should first of all be shaved and gray mercury ointment should be rubbed into the shaved places; the ointment can also be rubbed into the parts of the body affected by the public lice without the preliminary shaving. After 2-3 days the ointment is washed off and when necessary it is rubbed in a second time. It is also possible to get rid of pubic lice by dusting the hairy parts of the body with preparations of carbophos, acetophos, pyrethrum, DPA disinfecting powsers and DDT powder and by rubbing them into the roots of the hairs. The powder should not be washed off for 2-3 days.

In destroying lice it is also possible to use soap-kerosene emulsion (1:1). A 10% emulsion is rubbed into the hairy parts of the body. After treating the hair of the head it is wrapped with a kerchief for 15-20 minutes, after which it is washed with hot water. A soap-solvent emulsion is used in exactly the same way as soap-kerosene emulsion.

An effective method of destroying blood-sucking insects is by acting on them through the host. This method is useful first of all for combatting ectoparasites of rodents. Recently a number of authors has recommended this method for combatting lice on man (V. T. Osipyan, V. S. Kazhdan, M. D. Dunayeva and others). This method of combatting blood-sucking insects was accidentally discovered in 1956. It has been established that the preparation which is being widely applied in practice when introduced into the human organism imparts to the blood of the latter insecticidal properties with respect to body lice. For the purpose of disinfestation the preparation is taken internally; preferably after food, according to the following instructions: 1) according to the instructions of the Institute of Epidemiology and Microbiology im. N. F. Gamaley - the dosage application is 0.3 g 2 times per day for $2\frac{1}{2}$ days (a total of 5 times); for adult treatment there is expended 1.5 g of the preparation; 2) according to the instructions of the L'vov Institute of Epidemiology, Microbiology and Hygiene a single application for adults is 1 g per time and it is repeatedly taken at the same dosage for 10 days; for children from 1 to 7 years old it is not used (G. S. Mosing).

The mass destruction of lice was noted toward the end of the 2nd day. The duration of the insecticidal effect was equal to 15 days. Of the three derivatives pyrazolane-anturane, butalion, and tenderil received in the experiment the greatest insecticidal effect was brought about by the latter (L. A. Favorova and G. F. Golgov); this preparation has an insecticidal effect on lice in doses, 2-3 times smaller than butadion (a single dose of 0.2 g of tenderil kills lice for a period of 2-5 days). The most rational application of the preparation for insecticidal purposes was three times with intervals of 4 days at a rate of 0.2 g per dose which provides an insecticidal effect in the blood for 12-13 days.

After taking the preparations complications were observed in individual cases in the form of nausea, vomiting, pain in the stomach region, skin rash, dizziness. The side-effects were short-term. The contraindications were diseases of the hemopoietic organs, the liver and kidneys, stomach and duodenal ulcers, decompensation of cardiac activity.

These preparations can be used for combatting lousiness only in the exceptional case, i.e., when there is no possibility of using other methods and agents. We assume that this method of combatting lousiness is incorrect in principle and cannot be recommended for broad application.

Disinfestation of linen and other articles. Linen is best of all subjected to boiling in a 1-2% solution of soda for 15 minutes or steeping (at a rate of 1 kg of linen per 4 ℓ of liquid) in a 1% emulsion of DDT, a 1% aqueous solution of acetion, a 5-10% solution of lysol, naphthalysol, soap-kerosene liquid, in a 2% emulsion of soap-K, preparation-SK for 2-3 hours.

For delousing linen disinfecting powders are used, containing one of these preparations: 10% DDT, 5% acetophos, 2.5% sevin, 1% carbophos (malathion), 1% gamma-isomer of hexachlorane, pyrethrum powder (the property of pyrethrum is not stable). They use 20-30 g for a few pieces of linen or the linen is washed with DDT soap. The expenditure of soap is 30 g per kg of linen for hand washing and 20 g for mechanical washing. Toxicological experiments showed that 1-5% malathion disinfecting powders are safe for people when carrying out treatment 5 times per week with 60-80 g of disinfecting powder for each few pieces of linen. Pyrethrum powder is ineffective in combatting lice, but if one treats with an extract and inert fillers, as, for example, pyrophyllite, then such powders are highly effective in combatting lice.

Clothing and soft objects (pillows, mattresses, blankets), being used by persons passing through sanitary treatment and also members of their families not having been at a sanitary station are brought to disinfestational chambers (when it is impossible to disinfect them at the site). The disinfestation of clothing is carried out in disinfestational chambers, by the gas method, by spraying, by dusting and other methods. For the disinfestation of clothing at a center or sanitary point there are used for spraying solvents, emulsions of DDT, carbophos, and others. When using a solvent the articles are sprayed on the inside, are rapidly folded and placed in tightly closed boxes, chests, or rubberized sacs. It is possible to impregnate sheets of paper with a solvent, which are then placed between the various layers of articles; articles with the paper sheets are also packed in boxes, chests, and rubberized sacs, and tightly closed for 6-8 hours and placed in a warm place (near a stove, air heaters and so forth). The expenditure of solvent is calculated at 30-40 g per kg of articles or 100-250 g per set. In working with a solvent one must observe fire precautions.

For the disinfestation of articles 10% DDT disinfecting powder or pyrethrum powder is used. Bed appurtenances (pillows, mattresses, blankets), clothes and other wearing apparel are placed in disinfestational chambers or treated with 10% DDT disinfecting powder or pyrethrum powder on all sides and stored in a bale. In individual cases these objects are placed in sacs and disinfected with solvent vapors. In order that the disinfecting powder is evenly distributed over the articles, they are beaten several times with a stick, and then left for 2-3 hours, after which the disinfestation is considered completed.

For the complete treatment of the linen, clothes and bed appurtenances of one man from 140 to 175 g of disinfecting powder are required; proceeding at the following rate: for one set of underclothing 20-25 g, for a uniform or suit 20-25 g, for overcoat, topcoat or sheepskin coat 35-40 g, for bed appurtenances 40-50 g, for felt boots 20-25 g, for a headgear 5-10 g. When it is not necessary to use the treated articles immediately they are stored not beating the disinfecting powder from them until they are used. Usually soft articles treated with pyrethrum powder and not being used preserve their insecticidal properties for 6-8 days; articles treated with DDT disinfecting powder preserve their insecticide properties for several years (L. N. Pogodina).

In the absence of disinfestational chambers and chemical insecticides soft articles can be disinfected by ironing with a hot iron or by thoroughly cleaning with brushes.

Inpregnating linen and wearing apparel with insecticides. Linen after impregnation acquire insecticidal properties for a longer period of time than with treatment with disinfecting powders. For the purpose of impregnating the linen is submerged for 30 minutes in a 0.5-1% aqueous emulsion of DDT or a 2% aqueous emulsion of soap-K. The expenditure of emulsion per article of linen is 0.7-0.8 ℓ (7-8 g of active substance), per bed-sheet — 1 ℓ. After soaking the linen is wrung out and dried, preferably in the open air. The linen is treated with a DDT preparation and ironed in the usual way, but linen treated with soap-K is not ironed with a hot iron, because the preparation is decomposed by this. Clothing and articles which cannot be impregnated by submersion, are treated by moistening, spraying and cleaning with brushes, moistened in the disinfecting liquid; in the case of mass impregnation it is possible to use special machines, which apply the preparation with the help of a carding machine (L. N. Pogodin).

In lice, which get on clothing impregnated with DDT, paralysis occurs within 1-2 hours with their subsequent death after 1-2 days. Linen impregnated with a DDT preparation being worn preserve their insecticidal properties for more than 3 weeks (with 1-2 washings), and linen located in storage, for several years. Linen impregnated with an emulsion of soap-K preserves its insecticidal properties for 10-12 days; washing sharply reduces the effectiveness of this method.

According to M. I. Murav'yev, L. I. Brikman, upon the contact of lice with 6% hexachlorane disinfecting powder (a rate of expenditure of 30 g per summer military uniform) for 10-15 minutes in the insects there occurs a period of excitation and the majority of them lose their ability to feed; after 45-60 minutes of contact paralysis sets in.

From contact with 10% DDT disinfecting powder all insects cease to feed after 2 hours and 45 minutes, whereas paralysis occurs in them 5 hours and later. In treating clothing with insecticide pencils containing 40-70% hexachlorane with spaces between the drawn bands of 1.5 cm in lice after 10-15 minutes excitation was observed; almost all the lice lost the ability to feed after 15-30 minutes, while with the use of pencils containing 40-70% DDT about half of the lice ceased to feed only after 3 hours and 30 minutes.

Upon contact with fabric treated with a 1% emulsion of hexachlorane at a rate of 1-2 g of technical preparation per summer military uniform, lice lose the ability to feed after 15 minutes, and with an increase of the amount of preparation to 3 g — after 5 minutes. Whereas with the use of DDT emulsion lice lose the ability to feed after 2 hours and 30 minutes.

In the case of detecting in lice of resistance to DDT, hexachlorane and its gamma-isomer 1% carbophos disinfecting powder is used (both against imagoes, and also against the eggs of body lice). Because of the presence in carbophos of an ovicidal effect a single treatment is sufficient. Such a treatment is effective and safe; toxicological investigations in the United States showed that 1-5% malathion disinfecting powders are harmless for man when treating 5 times per week with 60-90 g per treatment (for a period of 12-16 weeks). Carbophos and chlorothion disinfecting powders kill lice at a 0.001% concentration.

With the absence of resistance in head and pubic lice when combatting them 2 treatments (with 15-30 g each) with 10% DDT disinfecting powder is sufficient. For the same purposes pyrethrins with synergists in a kerosene base are adequate.

Powders and disinfecting powders are carefully applied to the internal surfaces of clothing, especially to underclothing, focussing special attention on the seams and plaits. Usually sufficient for treating one man are 50 g. The treatment can be carried with the clothing on or off the person.

Inasmuch as one treatment with DDT or carbophos is effective for 3-4 weeks, this is usually limited to this and it is not repeated. With the use of gamma-isomer of hexachlorane, pyrethrum or allethrin repeated treatment is required 7-10 days after the initial treatment for the purpose of destroying newly hatched lice.

For destroying lice a soap-kerosene emulsion can be used (50 parts soap and 50 parts kerosene). Linen and other washable articles are soaked in a 10-20% aqueous solution for 20-30 minutes and then subsequently washed.

Dusting man and his clothing with disinfecting powders. When treating without undressing automatic or hand dusters are used. The technique of treating without undressing is carried out with dusters by introducing the pipe or nozzle of the duster alternately under the collar, into the sleeves, under the belt, into footwear and under headgear. Disinfecting powder is preserved on linen and clothing for 2-3 days. It is necessary to consider that with the application of the disinfecting powder between the underwear and the body up to 70% of the preparation settles on the body of the man and can partially clog up the pores of the skin. Frequent treatment with DDT disinfecting powder is not recommended, because the possibility of its harmful effect on man is not excluded, inasmuch as the preparation can dissolve in the fatty lubrication of the skin. Data exist on the possibility of combatting lice with fabrics, made from textile fibers of a definite size. Although this method has not yet been substantiated we are giving certain considerations to the use of this method.

The diameter of human hair varies from 17 to 170 μ; the hair on the body rarely exceeds 100 μ, and on the average is about 60 μ. Fabrics having fibers within these limits, gave the highest indices of entropment of lice. Fibers with a diameter of over 200 μ are not very well suited for the fastening of lice to them and for their movement on them. Females are more firmly held to fabric in the presence of fibers with a diameter of 43 μ, males – 25 μ.

In destroying lice by starvation linen, clothing, and other articles are left in premises in a tightly closed box for 3 weeks. The alternate cooling and heating of clothing inhibits the development of lice. Thus, for example, the development of lice in nits is prolonged up to 5-6 weeks.

Disinfestating premises. Premises subjected to delousing are washed with hot water and soap, soda or alkaline water, prepared with an ash filler, or are treated with insecticides (liquid, powdered) and then they are subsequently cleaned mechanically (vacuumed). For the disinfestation of premises a 5-8% lysol solution, a 10% naphthalysol solution, a 10% soap-kerosene or soap-solvent emulsion, a 1-2% emulsion of DDT or hexachlorane, or a 10% emulsion of albichtol paste. The expenditure of liquid insectices on the average is 200-300 mℓ per m^2 of treated area. It is also possible to use 10% DDT disinfecting powder and 6-12% hexachlorane disinfecting powder. The expenditure of the disinfecting powder is 4-5 g per m^2 of treated area.

The cleaning up of the premises is carried out not earlier than 2 hours after termination of the disinfestation. Usually after the treatment of premises not only the lice, but also the flies, bugs, cockroaches and fleas die. On steamers and railroad cars, besides the above-mentioned preparations, they also use insecticides in a gaseous state.

Under rural conditions, if there are no sanitary delousing stations and disinfestational chambers, the whole system of sanitary treatment is retained, but its individual stages are modified, simplified or combined. Thus, for washing they use bath-tubs, shower setups or they wash in houses near a very hot stove, where the water is warmed and the linen is boiled. As disinfestational chambers under these cases they use a Russian stove or they use DDT and hexachlorane preparations, rubberized sacs (chests) and so forth.

All stages of sanitary treatment should be carried out at the same time, in other words, dwellings and the software in them should be disinfected while the people are being washed at the sanitary-delousing station, which is especially important in the disinfestation at a focus of parasitic typhus. Such sanitary treatment is called simultaneous treatment. In the presence of unfavorable sanitary conditions for preventing lousiness among individual groups of a population simultaneous, sanitary treatment should be carried out several times repeating it at intervals of 7 days until the lice are completely eliminated.

Disinfestation upon the appearance of diseases of parasitic typhus. In the case of the appearance of a disease of parasitic typhus the treating physician or the doctor's assistant should immediately make known to each person ill with the disease or suspected of having it the disinfectional section of the sanitary-epidemiological station or the sanitary-epidemiological section of the regional hospital for the carrying out of hospitalization and disinfestational measures at the focus.

The hospitalization of a patient with parasitic typhus or suspected of having this disease is carried out immediately after its detection.

The patient is sent to the hospital in the same linen and clothing in which he was wearing at home. The person who has this disease should not be allowed to change his clothing before being sent to the hospital, if disinfestation is not carried out simultaneously with the evacuation.

The delivery of the patient with exanthematous or recurrent typhus or one suspected of having this disease) to the hospital is carried out on a vehicle of the sanitary-epidemiological or medical establishments and the person is accompanied by a medical worker.

Vehicles used for transporting patients with parasitic typhus, are subjected to moist disinfestation with a hand sprayer with the subsequent mopping out of the vehicles.

In the disinfestation of a vehicle it is possible to use: a 25% DDT emulsion, or 10% DDT disinfecting powder and 6% hexachlorane disinfecting powder, preparations of chlorophos, carbophos and others at the same concentrations.

When using any random vehicle to take a patient to a hospital the latter should also be thoroughly disinfected. The straw, hay and so forth used for bedding should be burned.

The persons accompanying the infected person must also undergo sanitary treatment: under rural conditions at a hospital - at a sanitary station or bath for personnel, and under urban conditions - at a sanitary station operating according to epidemiological indications.

Measures at the hospital. A person with parasitic typhus or suspected of having this disease upon admittance to a hospital should be subjected to sanitary treatment with the observance of strict continuity, using insecticidal soap.

The premises of the sanitary station at the hospital after treatment of the patient are subjected to disinfestation with the agents and at the concentrations indicated for treating the vehicle.

The underclothing and outer clothing removed from the patient are collected in a sock or bed-sheet, soaked in disinfestational solutions or emulsions of DDT, acetone, acetoxon and others, and subsequently subjected to chamber treatment in a hot-air, steam or steam-formalin chamber, after which the articles are kept in the hospital until patient is discharged.

Without disinfestational treatment these articles cannot be removed from the hospital. The bed appurtenances (blankets, mattresses, pillows) are subjected to obligatory chamber treatment after the discharge of each patient.

When necessary patients in hospitals are examined for the presence of pediculosis, and upon detection of the latter repeated sanitary treatment is carried out.

Measures at a focus of parasitic typhus. Disinfestation at a focus of exanthematous typhus should be carried out in cities simultaneously with the hospitalization of a patient or within the first 3 hours, and at a rural site – within the first 6 hours after the hospitalization of the patient.

Disinfestational measures at all focuses of exanthematous typhus should be conducted under the direct supervision and control of a physician.

The disinfestation conducted at a focus of exanthematous typhus should guarantee the complete destruction of lice on the people, their clothing and articles of furniture.

The disinfestation of an exanthematous typhus focus is ensured by the disinfestation of all clothing, the sanitary treatment of people, in former intercourse with the patient (at sanitary-delousing points or in adapted baths), the disinfestation of bed appurtenances, articles of furniture and the premises.

All these measures are conducted simultaneously: people undergo treatment at sanitary stations, their clothing are treated in disinfectional chambers (or in extreme case with chamical agents) and premises with disinfestational agents.

In the process of a subsequent observation of a focus and upon detecting pediculosis in persons living with a patient it is necessary immediately to conduct repeated sanitary treatment and disinfection of the premises (see "Disinfestation of premises").

Sanitary treatment of people who have been in intercourse with patients. Sanitary treatment of people who have had intercourse with patients with exanthematous and recurrent typhus or suspected of having this disease is carried out at sanitary stations or in adapted baths with the observance of the rules of continuity.

Under the condition of carrying out sanitary treatment in usual baths of the toliet type simultaneously with washing of people there is conducted disinfestation of their clothing in a disinfectional chamber brought to the bath. The dressing premises (floor, benches, and others) should be thoroughly washed and treated by scalding with boiling water, a 5% carbophos emulsion, a 10% lysol solution, a 5% nephthalysol solution, with the subsequent mopping of all surfaces with rags moistened with disinfecting solutions. The disinfection is carried out while those washing themselves are still in the washroom.

In the absence of a sanitary point or a bath the washing is set up under home conditions: in a bathtub, shower, tanks, basins, and so forth. For the washing in sanitary treatment insecticidal soap with DDT and HCCH is used.

After the sanitary treatment inspection is immediately carried out, and in the case of detecting pediculosis a repeated treatment is conducted with the application of disinfestational agents.

Linen is subjected to disinfestation (see "Disinfestation of linen").

Outer clothing and other clothing are treated with 0.5-1% emulsion of DDT on the inside with atomizers, hand sprayers or brushes. The places to be most thoroughly treated are the collars, belt, seams and fold of clothes, where when pediculosis exists insects are most frequently detected.

Hexachlorane pencils are used by applying streaks at intervals of 4-5 cm on the internal surface of linen and clothing and the places where insects are most frequently found (belts, collars, folds, seams). The insecticidal effect of hexachlorane on articles is preserved up to $1\frac{1}{2}$ months.

The hair on the head and all the hairy parts of the body are simultaneously and well treated with DDT insecticidal soap or DDT powder, or preparations of acetophos.

After washing the head the hair is combed with a fine comb to remove the nits. For the best removal of nits the hairs should be moistened with 10-15% warm (27-30°) solution of acetic acid; for 15-20 minutes the head is covered with a kerchief, after which the hair is thoroughly combed with a fine comb.

Repeated treatment with DDT insecticidal soap is carried out when necessary.

In the absence of special disinfectional chambers the disinfestation of articles can be carried out in Russian stoves, and also by ironing the clothing with a hot iron or by treatment with insecticides (DDT, HCCH and others).

The disinfection of linen can be carried out by boiling, and the disinfestation of linen – by soaking it in a 1% DDT emulsion (Table 37).

Table 37. Rates of expenditure of preparations for combatting lice.

Name of the preparation	Unit of measurement	Single expenditure of preparation (in g)	Method of application and concentration of the working solutions
5% DDT soap	Kilogram	30	Hand washing of linen
	"	20	Mechanized washing of linen
	1 man	50	Washing the body and the hairy parts by double soaping
DDT emulsion 25%	Set	15	Treatment with a 0.5-1% aqueous emulsion of the upper clothes and underclothing
	Set	25 30	Soaking in a 0.5-1% aqueous emulsion: underclothing, bed appurtenances
10% DDT disinfecting powder	Set	50	Dusting of the bed appurtenances
	Set	25	Dusting of the underclothing
	Set	25	Dusting of the outer clothing
	Set	40	Dusting of an overcoat or topcoat, or sheepskin coat with headgear
	Set	25	Dusting of felt boots
HCCH pencil 70%	Set	20	Applying streaks at intervals of 4-5 cm on the internal surface of clothing

Table 37 (Cont'd).

Name of the preparation	Unit of measurement	Single expenditure of preparation (in g)	Method of application and concentration of the working solutions
3% HCCH soap	Kilogram	30	Hand washing of linen
	"	20	Mechanized washing of linen
	1 man	50	Washing the body and the hairy parts by double soaping
Pyrethrum	Set		Dusting of appertunances:
		60	bed
		25	underclothing
		25	outer clothing
		40	overcoat or topcoat, or sheepskin coat with headgear
	Steam	25	felt boots
Methyl bromide	A sack with a volume of 0.1 m^3	34	Disinfection of articles in polyethylene bags: woolen, cotton articles and bed appurtenances
		68	Disinfection of fur articles at a temperature of 8-20°
		34	" " " " 20°

Note: Repeated treatment with all the preparations is carried out according to the indications after 8-10 days.

Destroying lice on animals and birds. For destroying lice on animals and birds the same insecticides are used, which are used to destroy lice parasitizing man. In combatting lice on cattle there are recommended 0.5% suspensions containing 0.5% chlordane, 0.06% heptachlor, 0.03% dieldrin, and 0.5% malathion. With the use of the enumerated preparations almost analogous results were obtained; the duration of the protective action was preserved for approximately 4-5 months. It was ascertained that after bathing sheep in solutions (suspensions) containing 0.01-0.005% aldrin, diazinon, gamma-hexachlorane or malathion the lice died; the residual effectiveness of the treatment on the wool coat was preserved for 16-20 weeks;

diazinon at a 0.1% concentration possessed a protective effect for 32 weeks. Carbophos at a 1% concentration was also effective in combatting lice on birds; complete destruction of the lice was observed from the 3rd to the 20th day after treatment with solutions of 0.1% ronnel, 0.1% toxaphene, 0.05% malathion and 0.25-0.5% sevin; complete destruction from the 5th to the 20th day was observed from 0.05% dimethoate, and from the 1st to the 20th day from 0.025% dibrome. In treating bedding complete destruction of lice with the 5th to the 20th day was observed as a result of the application 5% sevin (225 g/m^2) and 4.6% ronnel (45 g/m^2); 5% Co-Ral provided the destruction of from 93 to 100% of the insects at a rate of expenditure of 2.25 g/m^2.

CHAPTER XXII

TICKS AND THEIR CONTROL

Ticks belong to a class of arachnids (Arachnoidea) of a type of arthropods (Arthropoda). At the present time ticks are divided into three orders: the first order – the real ticks – Acariformes – include the armorclad ones (Oribatei), the scabby and feathery ones (Acaroidea), the trombiculids (red-heifers) (Trombiculidae) and a large number of other ticks; the second order – the gamasid ticks – the Parasitiformes – combine the gamasids (Gamascidea), the ixodids (Ixodidae) and certain other groups related to them; the third order – "harvest" ticks – Opilioacarina – a little known group of predaceous ticks in the USSR represented by one species.

The world fauna includes about 209 families and about 1400 genera of ticks.

The Superfamily Trombeae Turk, 195?.[1] In the composition of this group of ticks are included two families: Trombidiidae Leach, 1814, and Trombiculidae Ewing, 1944. The representatives of the first family are parasites of insects and arachnoids. Of medical significance are the representatives of the second family included in the composition of the subfamily Trombiculidae Ewing, 1929 – trombiculid ticks (red-heifers) are so called because of their color. The world fauna already numbers about 500 species of these ticks belonging to 17 genera.

Trombiculids are common in all countries of the world; the most widespread are the genera Trombicula and Neoschoengastia. In the USSR more than 50 species have been recorded, belonging to 5 genera.

The larvae of the trombiculids are ectoparasites of animals. Adhering to man and animals, they cause itching, local inflammation, fever. In many regions of Eastern Asia certain species of ticks are well known as carriers of pathogenic rickettsial – pathogenic agents of Japanese river fever – tsutsugamushi.

In the sandy desert of Central Asia from the trombiculids Leeuwenhoekia major there has been isolated the pathogenic agent of Q fever (Z. M. Zhmayeva with co-authors). In the central belt of the USSR there has been ascertained the natural inflatation of the trombiculids Tr. autumnalis, Tr. zachvatkini, Neoschoengastia Sp. – with the rickettseal of infectious nephrosonephritis (O. S. Korshunov).

The carriers of these diseases are wide-spread over a huge expanse from the western to eastern borders of the USSR. Tr. autumnalis is a real cosmopolite, excellently adapted to parasitism and having very wide circle of hosts.

In second place in distribution is L. major; it is common from the Stavropol region in the west to the steppes of southeastern Transbaykal; it lives mainly in the deserts and steppes and parasitizes in the spring-autumn period.

The third species – Tr zachvatkini – has been recorded only in the European part of our country. It parasitizes in the summer months.

The fauna of trombiculids on rodents of the coastal regions is very rich. Of the 7 species recorded the most widely spread are Tr. zhmajevae and Tr. tamiyai.

In an epidemiological regard as carriers of Japanese river fever (tsutsugamushi) Tr. palpalis and Tr. pallida deserve attention;

they are wide-spread in the Far East. In the Far East the trombiculids live in shrubs, waste lands overgrown with tall weeds, and the shore zone of reservoirs.

Morphologico-ecological characteristics. Trombiculid ticks have three active stages of development: larvae, nymphs, adults. The body of the larva consists of a gnathosoma and an idiosoma. The gnathosoma – oral organs – in the larvae of the majority of species is rather large, it is located in the anterior section of the body. The idiosome – the body proper is 2-5 times larger than the gnathosoma; its form is oval, elongated or round; it is a bright-red or orange color. The soft integuments have a parallel, wavy striation.

The larvae have three pairs of legs covered with bristles having great diagnostic significance.

The numphs in contrast to the larvae have four pairs of legs and two pairs of oval genital tentacles. The body has at the level of the third and fourth pair of legs a constriction, which gives the body the form of an hourglass. The whole body is thickly covered with feather-like bristles.

The adult ticks are similar to the nymphs, but considerably larger than them; they have not two, but three pairs of genital tentacles (Fig. 11).

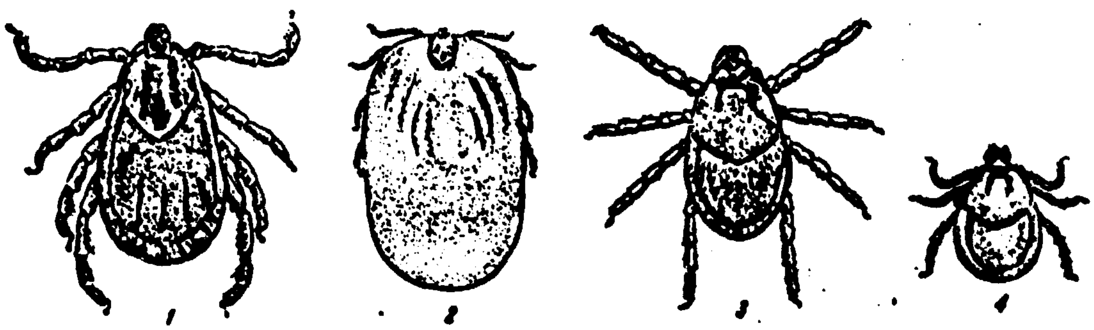


Fig. 11. The active stages of ixodid ticks. Females: 1 – hungry; 2 – saturated; 3 – nymph; 4 – larva.

The nymph and mature ticks are free-living inhabitants of the soil. They are recorded, as a rule, in the warm (but not hot) season in the layer of vegetation right at soil level and frequently in the burrows of small rodents.

The female trombiculids oviposit in piles of 20-50 very small (0.15-0.2 mm in diameter) eggs with a light-orange color. The development of the eggs takes 2-3 weeks. The larvae emerging from the eggs are red in color, very small, very mobile (up to 100 cm/min) and after only one day are able to attach themselves.

The larvae are temporary ectoparasites of vertebrates, mainly mammals, more rarely of birds and reptiles. Most frequently the larvae parasitize the representatives of the mouse family, and subsequently hedgehogs. On the body of the host the larva are localized in small groups. On rodents and birds the larvae, as a rule, are located in the concha auriculae, in reptiles – in the inguinal folds, on the head and tail. The duration of feeding of the larvae depends on the speries of parasite, the ambient temperature and the reservoir host. Thus, Tr. akamushi become satiated on white mice on the average in 69 hours, and on rats for a more prolonged period (Chen.-Hsu, 1959). Tr. altreddugesi parasitize reptiles up to 30 days. With a decrease in temperature the number of satiated larvae is sharply reduced (Sasa Manabu, 1961).

The complete cycle of development of trombiculids has been insufficiently studied. It is considered that the duration of the complete cycle is equal on the average to 70-93 days. And for the transformation of a larva into a nymph is required 15-20 days, and for the appearance of the imago 30-40 days. From the time of the emergence of the females until oviposition usually about a month passes (Ye. G. Shluger, Sasa Manabu).

From the available source material it is possible to conclude, that trombiculid ticks during the course of a season go through up to three generations. Furthermore the largest quantity of them was noted in the southern regions, in places with a moderate temperature (in mountains, the floodplains of rivers).

The superfamily Gamasoidea Reuter, 1909 – gamasid ticks. These ticks are encountered all over the earth, over 20 different families have been counted and included in the suborder Mesostigmata Canestrini. A considerable number of families represent predatory species inhabiting soil, forest bedding, the substrata of burrows and nests, where their food consists of arthropods-saprobionts. In the USSR up to the present time there are known about 150 (basically parasitic) of species of gamosid ticks.

The representatives of a number of families parasitize various animals (insects, reptiles, birds, entomophege, small predators, pinnipedes, monkeys and others).

Tomasid ticks, as was indicated above, have almost omnipresent distribution. Very frequently they immediately in large quantities abandon their dwelling place and attack man. Frequently ticks attack man, when the latter lies down to rest on old hay stacks and dry grass. As a rule, in such stacks there are large numbers of rodents, and consequently, the species of ticks parasitizing these rodents attack man.

If the attack is prolonged, then in these people there are noted general weakness, headaches, disorientation, the appetite diminishes and sleep is disturbed, there is also observed weight loss and even a subfebrile temperature.

Cases of the mass attack of gamasid ticks have been recorded in all geographic zones of our country from the very south (Crimea) to the extreme north and the far east (Vladivostok and Sakhalin) (A. I. Alifanov, I. F. Zhovtyy, V. D. Boldaruyev, L. Zakirov, Ye. N. Nel'zina, V. G. Fedorov).

Only two species have been recorded as attacking species. Bdellonyssus basoti and Dermanyssus gallinae.

Ticks attack man from April up to December. The cause of the appearance of D. gallinae in all cases was the presence of birds (hens and pigeons) in the house. Most frequently ticks penetrate through ventilators and ventilator openings, where pigeon nests are found. The appearance of B. bacoti has been connected with the presence in premises (on a ship) of rats and house mice. Gray rats are parasitized by ticks from May up to October, and black rats – the whole year round. The maximum number of ticks on rodents occurs in August.

Gamasid ticks are able to transmit almost all groups of pathogenic agents – from filterable viruses to protists; moreover, they are also intermediate hosts of certain parasitic worms.

The majority of gamasid ticks are parasites of animals, which have close contact with man.

The presence of the large number of families in the composition of the group of gamasid ticks indicates the existence of considerable morphological variety; however, among them there is much in common in body structure.[2]

The body form – idiosoma – is oval or round; it is depressed in a spinal-abdominal direction. In certain families the body of ticks is divided by transverse groove into two sections: the cephalothorax and the abdomen. On each side of body at the level of the III and IV coxal there are spiracles (stigmae) – tracheae apertures (respiratory tubes). All over the body of ticks are tactile tristles of various form. The form and disposition of the bristles are broadly used to determine the species of ticks.

In the process of development ticks pass through from 4 to 5 stages: egg – larva – nymph I (protonymph) – nymph II (deutonymph) – adult and (imago). The complete cycle of development (all 5 stages) produces oviparous species.

In oviparcus species the egg sizes are 0.1-0.3 mm; they are oval or round in form, milk-glass in color. The eggs mature in the body of the female one after another 5-6 days after blood-sucking. Egg-laying lasts from almost the whole period of the life of the female; at intervals of 5-7 days she lays from 1 to 7 eggs at a time. The maturation of the eggs is different for individual species and geographic latitudes.

The larvae, and in certain species the protonymphs also do not feed, but live on the embryonic yolk. The deutonymph appearing after 5-6 hours sets about blood-sucking; after 2-7 days they molt into the imago.

The duration of life of a female depends on many factors and thus she is subject to sharp variations of from several weeks to several months. Thus, when feeding on blood the life of a female H. mandschuricus lasts 38-43 days, and Bdellonyssus bacoti 150-180 days.

The Superfamily Ixodidae Bank, 1894 – ixodid ticks. About 20 genera have been counted in two families: Ixodes Murr – ixodoid ticks and Argasidae Canestrini – argasid ticks. Isodid ticks are found on all continents of the earth. In the USSR there have been recorded 6 genera of ixodid and 2 genera[3] of argasid ticks numbering more than 80 species.

Among the broad circle of ixodid ticks of the fauna of the USSR there are distinguished specific inhabitants of individual zones: taiga, forest, steppe, desert, valleys and mountains. Owing to the ecological peculiarities of the ticks and their host-reservoirs migrations of ticks are possible not only within the limits of the landscape zones of one geographical zone, but also between various geographical zones. These migrations can be accomplished by the transmigrations of birds, by the migrations of large wild animals, and also as a result of the activity of man (the importation of H. scupeuse, Q. silvarum to Sakhalin with cattle from the mainland).

In the presence of favorable conditions ticks on a new location can become accustomed to a place and intensively participate in the dispersion of infection (N. A. Violovich, Hoogstraal, Theiler).

The body of ixodid ticks is not segmented; it has an oval, elongated form in length and a flattened form in the dorso-ventral direction. Tick larvae have three pairs of legs, whereas all the subsequent phases – the immature ones (nymphs) and mature ones (imago – males and females) have four pairs of legs.

As was indicated above, the superfamily Ixodoidae includes two families – the ixodid and argasid ticks. The distinctive peculiarities of these families are: in the former there are sharply expressed chitin spinal and ventral shields with bristles; the frontal position of the proboscis; distinct sexual dimorphism; each stage of development feeds only one time. In the second family – the integument (hypoderma) without shields is wrinkled or warty; the proboscis is located on the ventral side; each stage of development feeds many times.

Ixodid ticks have a general tone of body coloring, most frequently dark-brown, more rarely red, yellow, gray; in certain species the the spinal shield has a silvery-enamel pattern.

All stages of development of ixodid and argasid ticks are external parasites of ground vertebrate animals. The period of blood-sucking (up to complete saturation) lasts from several minutes up to many days, thanks to which they can be transported by their animal-reservoirs hundreds of kilometers.

According to the character and type of their feeding ticks are divided into three groups: those having one host, two hosts and three hosts. Among those having three hosts are the ticks in which in each active phase there is a separate host. This group of ticks uses for feeding a very broad circle of animals – from amphibious and birds to large vertebrates.

The fertilized female, being satiated, drops off, finds a place for oviposition and after 4-60 days starts oviposition. She usually finishes in 5-8 days; up to 15,000 eggs and more are concentrated in one laying. Females ixodid ticks die after ovipositing.

The larvae, which have emerged from the eggs, as a rule, during the first days sit near the site of oviposition. Having found a host, the larvae most frequently attach themselves to the head and tail of the animal and are in the adhesion stage with it up to 8 days. Nymphs attacking an animal attach themselves besides to the head and tail, also to the groin, the back and hips. The period of blood-sucking in the nymph lasts up to 15-18 days.

All the phases of development of ticks (larvae, nymphs, imagoes) after emergence or molting are for a certain time only slightly mobile, during which there occurs physiological completion of their development. After the completion of their development they crawl away.

Thanks to the presence of a number of peculiarities in ticks there are observed various durations of life cycles. The life cycle is the time necessary for the development from one phase to the same phase in the following generation. In ixodid ticks there are species with one-year, two-year, three-year and four-year cycles of development.

The number of species of ticks increases sharply as one goes from north to south. Thus, in the trans-polar region, on the islands and along the sea coast of the Arctic Ocean as yet only one species has been noted – C. putus – a parasite of birds, which lives in the nests of cormorants, guillemots, loons and others; they also attack man. Under the severe conditions of the northern taiga, in the forest floor, there live 2-3 species of only one genus – Ixodes. As one approaches 60° north latitude the number of species increases to 5; there also appear representatives of the genus Haemmaphysalis [H. concinna in the Yakut region (N. I. Yel'shanskaya, V. N. Yakuba)].

South of 60° north latitude the number of genera begins to rapidly increase, especially in the european part of the USSR and in the republics of Central Asia. In Byelorussia there have been recorded 9 species of 3 genera – Ixodes, Haemaphysalis, Dermacentor; in the Ukraine – 21 species, in Georgia – 35 species; in Turkmenistan – 54 species, a total of 8 genera noted for the USSR. As one proceeds towards the east the number of species starts to decrease: in Tadzhikistan – 28, in Kirghizia – 27, in Eastern Kazakhstan – 14, the Altai Mt. region – 7, in Transbaykal – 6, in the southern seacoast region – 11, on Sakhalin – 8 (I. T. Arzamasov, O. V. Afanas'yev, I. G. Galuzo, R. V. Grebenyuk, Ye. M. Yemchuk, B. V. Pototskiy and others).

Independent of the geographical location of the species many of them can be combined into individual groups according to the character of their ecological peculiarities. Some species completely spend their whole life cycle in burrows and are connected only with the animals, living in those burrows; others spend only part of their life in burrows; certain forms are adapted to life under the conditions of populated areas and are completely connected with domestic animals.

Proceeding from the adaptability of ticks to life under one or another set of conditions, we proposed to divide them into three groups.

1. Synanthropic species adapted to life under the conditions of populated localities and able to pass all stages of development on domestic animals – H. detritum, H. anatolicum, A. persicus, C. tholozani, R. sanguineus.

2. Semi-synanthropic species parasitizing domestic animals in the imago stage – H. asiaticum, H. plumbeum, R. bursa, R. turanicus, D. silvarum, D. nuttalli, D. marginatus, D. pictus, I. ricinus, R. persulcatus, H. punctata, H. concinna, H. japonica douglasi.

3. Burrow species parasitizing burrow animals, – O. verrucosus, O. tartakovskyi, I. trianguliceps, I. apronophorus, I. occultus, I. crenulatus, H. numidiana turanica.

The group of synanthropic species is recorded in populated localities during the whole year round. The greatest infestation by them is noted from the end of April to the end of June. In the winter months there are very few ticks and they are encountered mainly in larva and nymph form. Apart from the economic territories, ticks of the synanthropic species group are also detected outside inhabited localities – on the land, in burrows, on birds and other vertebrates. This phenomenon emphasizes the presence of a great ability in these ticks towards adaptability and a permanent habitat in nature.

The semi-synanthropic species of ticks are recorded, as a rule, on animals turned out to pastures. The season of parasitism of the majority of species on cattle is approximately identical – April-September. Individual specimens are also recorded in winter. The development of the preimaginal stages occurs from early spring to late autumn.

The species of this group are the most dangerous in an epidemiological regard. Having two and three hosts, and also a large circle of hosts among birds, rodents, insectivores, small predators and reptiles, this group of ticks promotes the dissemination of pathogenic agents and their passage. Characteristic for all semi-synanthropic species is their concentration in the places of the simultaneous stay of host-reservoirs of mature ticks and preimaginal stages. With the elimination of one of these basic links the number of ticks drops sharply.

Numerous observations have shown that the intense settling of ticks occurs with the help of domestic animals. Therefore, it is not accidental that foci of mass reproduction are concentrated on the outskirts of inhabited localities, in pastures, at watering places, along paths, caravan routes, along cattle tracks, along roads. All these places are elements of the cultural landscape, which are the richest in the number of species of rodents and birds — the reservoir-hosts of larvae and nymphs.

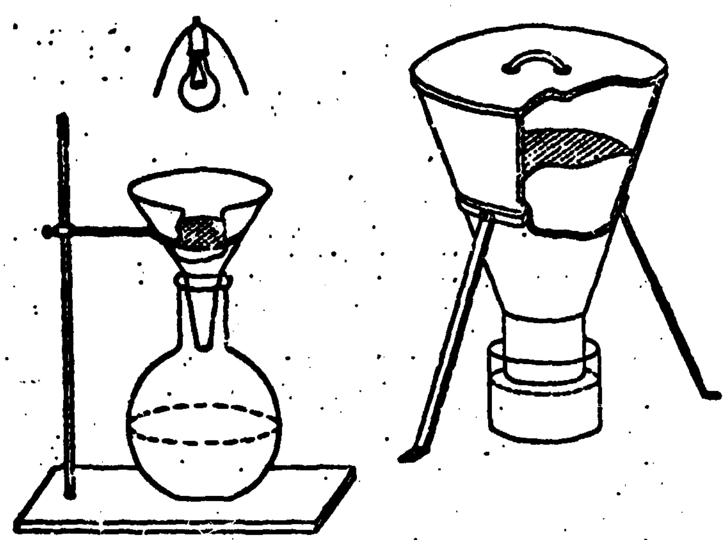


Fig. 12. Various types of devices for the expulsion of arthropods from a substrate.

The group of burrow ticks has its life cycle completely connected with the host of the burrow. Species of this group promote the circulation of a pathogenic agent between animals and preserve it in nature. When visiting places where burrows abound in the warm season of the year, man can be subjected to attack by ticks and be infested by them.

All the mobile stages in the development of ticks are blood-sucking. As ectoparasites they inflict great damage on the national economy: the animals sharply lower their productivity; their skin is covered with scars and becomes poor quality material for the leather industry. Of especially important significance are ticks as carriers of diseases; about 80 different diseases are transmitted by ticks from animal to animal; of this number of infections man is susceptible to more than 20.

Deserving of special attention among these diseases are tick-borne encephalitis, marceille fever, tick-borne rickettsiosis, Q fever, tick-borne recurrent typhus and tularemia. The propagation of these infections is connected with the area of the carrier.

With the purpose of the more correct substantiation and selection of the methods and agents of combating ticks in a focus of infection it is necessary to examine certain aspects of the ecology of the basic species of ticks – the carriers of the pathogenic agents of the most wide-spread diseases.

A typical carrier of tick-borne encephalitis is the tick I. persulcatus, then I. ricinus, H. japonica douglasi, H. concinna, D. silvarum. The first of these is wide-spread from the extreme west (Latvian Soviet Socialist Republic) to the Kurile Islands and Kamchatka in the east and to the mountain forests of Central Asia on south (Kirghizia, the East-Kazakhstan region). Its northern border goes in the northwest of the USSR near 63° north latitude, in Western Siberia near 61° north latitude and in The Far East near 53° north latitude. It is necessary to note that there are data about the presence of ticks in the Yakut region – one feeding female was taken from the head of a girl; another satiated female – from the neck of a woman in June of 1961.

The period of activity of adult ticks starts immediately after the snow has melted. The first females appear in cleared glades, borders, meadows, southern slopes, i.e., in places well heated by the sun. The maximum number of ticks is noted in May-June; in July the adult individuals are rarely encountered, however in places individual specimens are recorded even in the middle of October (M. N. Slonov).

The duration of the period of activity for larvae lasts in the southern sea-coast region and the Khabarovsk region from April up to November, and in the european part of the USSR – from May to

September. The activity of nymphs in passing from east to west is also noticeably shortened and continues for approximately the same period as for larvae.

Man is attacked and infested by adults and nymphs, frequently by larvae also. The two latter stages usually parasitize on small mammals and birds nesting or feeding on the surface of the land or in the lower stratum of vegetation. The imago parasitizes mainly large, wild and domestic mammals. A special place among the host-reservoirs of mature ticks is occupied by hares, which are very widely spread in the taiga and forest zone.

I. ricinus inhabits fir-deciduous forests, deciduous and underbrush biotopes, where moderate moisture is observed. In the USSR it is widely spread in the european part from Karelia to the Black Sea and in the Transcaucasus republics and from the western border to the Trame-Ural region, 67° eastern longitude. Data exists about the recording of these ticks in the East-Kazakhstan region (from Zaysan to Bukhtarma) (N. O. Olenev, L. M. Tsemitseva); in the Altay Mountains (V. I. Benkevich), in the far east (A. I. Shpringol'ts-Schmidt) and in central Kopet-Dage (Turministan) on the border with Iran (E. B. Kerbabayev).

Ticks are active throughout the warm period of the year (under the conditions of the Crimea the imago parasitizes the whole year round). The first to appear are adult individuals, as a rule, soon after the melting of the snow, a month later – larvae and nymphs.

The maximum number of adult ticks is observed in the northern regions in July-August; in the south the number curve has two peaks – the larger one occurs in May-June, the smaller in August-September; in the Altay Mountains the maximum occurs in May-June, a second rise is observed in August.

Ticks winter in all stages of development in the forest floor and in burrows.

The host of mature ticks are most frequently various large domestic and wild animals. The larvae and nymphs mainly attack small land vertebrates and birds. Among the wild animals those deserving special attention are the hares, hedgehogs and squirrels.

D. silvarum — according to the nature of its distribution is an eastern form. Its area extends from the Maritime Region through the Ural Region, Eastern Siberia, the Burgat Autonomous Soviet Socialist Republic to Western Siberia — the Kemerovo Oblast; in the north it extends to Yakutsk. Individual specimens have been detected in Petropavlovsk-on Kamchatka and on Sakhalin, and also on islands in the Japanese Sea (N. A. Violovich, M. A. Gorbuzov, P. P. Kalmykov).

The species is confined: to forest formations, where it dominates in sections with shrub vegetation of the secondary type; in sections of meadow association along rivers and near inhabited localities; in thinned fir-deciduous and deciduous forests.

Parasitism by ticks starts with the rise in temperature in spring — on the islands in the Japanese Sea and on the southern sea-coast from the first days of March to October with the maximum in May-June and in August-September; under the conditions of Western Siberia it parasitizes from the end of April until September, having two rises in May-June and in August. In the Amur region adult ticks parasitize only in early spring; the larvae — in June-July, and the nymphs — in July. The cycle of development of ticks is one year.

The second infection transmitted by ixodid ticks, having relatively wide propagation, is tick-borne rickettsiosis or tick-borne exanthematous typhus of Asia, which is recorded in the eastern part of our country. The most western point, where a natural focus of this disease was detected, is Kirghizia. The main carrier of this disease is considered to be D. nuttalli; then D. silvarum, D. marginatus,

D. pictus, H. concinna, H. punctata. The pathogenic agent was also extracted from the tick H. asiaticum; the ability of these ticks to transmit pathogenic agents is by biting, it has been ascertained.

D. nuttalli – a typical representative of the steppes. In the USSR the northern border of its area, extending over the steppes of Transbaykal, the Trkutsk Oblast (to the Tayshet-Lena railroad), goes through Abakan, Sayan, Altay Mountains, and also into the forest-steppes of the Omsk and Novosibirsk Oblasts.

It inhabits the foothill and mountain steppes, the forest-steppes, the desert-steppes and the semisecured sands; considerable tick foci appear in pastures. The distribution of ticks is intimately connected with the ecological peculiarities of the main host-reservoirs; larvae and nymphs parasitize small mammals, the inhabitants of burrows, and the imagoes – large vertebrates.

The first to be recorded on animals are adult ticks immediately after the melting of the snow; their maximum quantity is observed in May; in July-August only larvae and nymphs are detected, in September-October mature forms again parasitize animals; they frequently winter on cattle.

Marseille fever is transmitted by R. sanguineus ticks, which are wide-spread on all continents of the earth. In the USSR the dog tick is common on the Black Sea Coast; it is recorded in the Transcaucasus republics, Turkistan, Tadzhikistan, Uzbekistan. It is a common parasite of dogs, which are considered its main (and even its only) host, thus the habitation place of ticks is determined by its interrelation with its host. It is known that dogs in rural areas are very widely used for the protection of cattle and birds. In places of intense cattle-breeding it is possible that these ticks are wide-spread and they have been recorded on other domestic animals and even on wild animals.

The season of parasitism in the european part of the USSR lasts from February to October with the maximum number of adults in April-May and August-September; in the republics of Central Asia – the whole year round. In Turkmenistan starting with March, the number of mature ticks increases and attains its maximum number at the end of April and in May. Then their number gradually decreases and from November they are rarely noted. In the warm period of year in the same time all active phases of development parasitize.

According to a number of researchers, R. sanguineus are involved in the transmission of 18 infectious diseases, among which are: Marseille typhus, Q fever, Rockey Mountain fever, Spanish tick-borne recurrent typhus. From ticks there has been extracted cultures of viruses of street rabies of dogs and Leishmaniosis of dogs.

Tick-borne, recurrent typhus is transmitted by ticks of the genus Ornithodorus; they are wide-spread from the southern regions of the Ukraine through the Caucasus, Central Asia, Kazakhstan to the borders of northwestern China. The main carriers of this disease in the Ukraine and Caucasus are O. verrucosus – a burrow parasite; in the republics of Central Asia and Kazakhstan – O. tholozani and O. tartakovskyl.

O. tholozani – is confined to the foothill and mountain belts, where it inhabits the burrows of various animals and caves; to the east of the Amu-Dar'ya it is very frequently recorded in dwellings; on the plains it is wide-spread along the ancient caravan routes, being encountered in the ruins of fortresses and buildings adjacent to them.

O. tartakovskyi – an inhabitant of the deserts and the desert-steppe hill country; it inhabits, as a rule, only the burrows of wild animals. It penetrates into inhabited localities with hedgehogs, tortoises and gerbils, where it settles in their burrows, frequently establishing itself along the shoulders of roads, in cellars, in the foundations of dwellings and auxiliary premises.

Individual Agents and Methods for Controlling Ticks

The control of ticks is determined by the degree of harm, which they inflict in propagating infectious diseases. At the basis of all prophylactic measures lies the nature of the work and the living conditions of the protected contingent of people and the epidemiological peculiarities of the infection, inherent to a given zone.

The basic principles of the prophylaxis of people at a natural focus of disease depend on the duration of their stay on this territory. Thus, during a short-term stay methods of personal protection are used; under march and field (stationary) conditions along with the methods of personal prophylaxis also carried out are measures directed towards the temporary sanitizing of the site.

In cases of living in a focus (inhabited localities, rest homes, sanatoriums, pioneer camps, etc.) prophylactic measures are carried out taking into account the potential danger of the territory.

The simplest protective measures are the means of individual protection. It is known that in mature ticks – the carriers of tick-borne encephalitis (I. persulcatus, I. ricinus), adhere to vegetation mainly at a height of up to 1 m. In attacking man, ticks first of all get on the lower extremities, then they crawl all over the body.

The simplest procedure of individual protection is good care of clothing: the shirt (the pull-over tunic, etc.) is tucked inside the trousers and the belt is pulled tight; the cuffs are made with a very small cross section, they are tightly adjusted, and it is better to make them tight further up the arm with a cord; the trousers are tucked into the socks (with a foot-cloth, and by winding) and they are also pulled tight with a tape. About 90% of the ticks accumulate under the collar of the jacket.

With the use of flounce-traps the number of ticks getting to the head, is sharply reduced; under the flounce (with a width of 5-6 cm) there accumulates up to 80%, under the collar about 15%, only 5% of the ticks get on the neck.

Increasing the number of flounce-traps to two – at the level of the shoulders and somewhat higher than the belt – makes them almost impassable to ticks (Fig. 13).

Fig. 13. Flounce-traps against ticks on coveralls.

Along with such a simple form of clothing there also exists special antitick suits, at the basis of which also lies the tightening of the sleeves, collar, hood, and trousers with a tape or a rubber band.

With any form of clothing it is necessary after 2-3 hours to carry out self- and mutual-inspection. After returning from the forest for the purpose of preventing the carrying of ticks into the house the removed clothing are inspected in uninhabited premises or in the street. All the ticks collected during the inspection are destroyed or crushed (but not only with the bare hands).

To supplement the measures of individual protection it is desirable to apply preparations repelling ticks (dimethyl phthalate, repudin, diethyltoluamide, kiuzol and others). The outer clothing are treated with one of the repellents at a rate of 200 g of substance per set of clothing (for treatment 1 of 20% solution is used). After drying for a day it is possible to wear this suit. The number of attacking ticks is sharply reduced. The repellent action of the preparations is preserved for 8-15 days.

In stationary operations at a potential ficus of infection one of the first measures is the clearing of the site of unnecessary vegetable residua; the clearing of fallen trees, the thinning of adjacent forests, the mowing and burning of grass and shrub vegetation. This mechanical clearing of a site impairs the conditions of existence of ticks and their reservoir-hosts, small mammals and other animals.

The territory, where there will be immediately set up tents, trailer-homes, and houses, it is necessary to preliminarily clear even of the forest floor, since ticks are concealed in it. It is desirable to burn the forest floor. For each structure (tents) it is recommended that a clear site of not less than 20 m^2 be prepared. The cleared territory is well surrounded "by an earthen bank", free from any vegetation. Ticks usually do not crawl on bared sections of land. When possible the site of a camp and especially the site for the deployment of tents should be preliminarily treated with chemicals: for this purpose it is possible to use a 5% solution of lysol, benzene, solvent, a 10% aqueous solution of phenol at a rate of a half-liter per m^2, suspensions of DDT and hexachlorane at a rate of 0.3-0.6 g/m^2 and other preparations.

Subsequently it is necessary to carry out periodic treatment of the territory with acaricides.

With the presence in the economy of animals (horses, dogs) it is necessary to subject them to obligatory treatment with acaricides and not to allow them on the camp site, and what is more important into living quarters without preliminary inspection.

For the protection of persons living in inhabited localities located at the focus of a disease all the preceding measures of prophylaxis are acceptable. Of decisive significance in the prevention of the formation anthropurgic foci is the bringing about of a cultivated state and the maintenance of cleanliness at the site of habitable buildings and the areas adjacent to an inhabited locality.

Along with broad agrotechnical and forestry measures there is conducted continuous deratization, thereby reducing the possibility of the mass infiltration of rodents, and along with them ticks also. As the observations of S. A. Shilova with co-authors showed, for forest deratization the most useful preparations are zinc phosphide and zoocoumarin.

Special attention is focused on the shoulders of roads and paths, where, as a rule, the most favorable conditions are created for the existence of many forms of vertebrates and arthropods. It is particularly in these areas that there exists a real possibility of the infection with contagious sicknesses – not only during the time of a short rest, but also when passing near these areas. Therefore paths and narrow-roads should be widened by up to 4-1.5 m, so that branches do not droop over the paths; the areas should be regularly mowed in these areas and it should be eliminated along the shoulders. Along roads and especially at crossroads, where people rest while awaiting the passage of vehicles, along with the enumerated measures it is necessary to apply insecticides, spraying the shoulders of the roads and paths from the edge to a depth of 10 m into the woods.

It is recommended that the forest floor and the lower stratum of vegetation be treated to a height of 1 m.

A dose of DDT disinfecting powder of 0.5 g of active substance per m^2 is completely sufficient for getting rid of ticks for one season (S. I. Rybalko with co-authors).

According to a number of authors, at foci of tick-borne encephalitis ticks frequently penetrate into inhabited localities, in consequence of which anthropurgic foci will be formed (N. P. Belikova, M. A. Smetanina).

Ticks are transported both by domestic animals, and also by synanthropic rodents and birds. Therefore, for the purpose of preventing disease prophylactic measures should start with an inhabited locality.

It is necessary to take strict measures, so that cluttering and the accumulation of weed grass does not occur. Within a circumference of an inhabited locality (up to 200 m) in pastures and wood-cutting areas it is necessary to eliminate cluttering. Also it is necessary to carry out the regular total destruction of rodents both in the inhabited locality (to pay special attention to kitchen gardens), and also in vicinity surrounding it (in a radius of not less than 500 m). Along with this it is necessary to exterminate ticks in the inhabited locality, its surroundings, it is also necessary to combat the tick-infestation of cattle. In an inhabited locality DDT disinfecting powder and hexachlorane are applied at a rate of 2-5 g/m^2 (0.2-0.5 g of active substance), three-chlorometaphos-3 at a rate of 0.5 g of active substance per square m; kitchen gardens, plots and a 20-meter zone around them are also treated.

For the rapid treatment of comparatively small territories (places of temporary stay, pastures, etc.) insecticidal smokes can be used.

I. persulcatus ticks are very sensitive to hexachlorane smoke. One day after treatment with smoke (a dose of 0.05-0.064 g/m^2 and an exposure of 20 minutes) the number is reduced by 98.1-100%, and they are practically absent for about two weeks (Yu. I. Gadolin with co-authors, T. P. Povalishina with co-authors).

For the sharp reduction of the number of ticks for a prolonged period of time it is proposed that a triple smoke treatment of the site be conducted: first – at the end of April-the beginning of May; the second – at the end of May-the beginning of June; the third – in the middle of June (N. N. Gorchakovskaya).

Smokes are very effective also in combatting I. ricinus.

Smoke treatment is conducted 18-30 hours before the admittance of people. As practice has shown, the treatment of small territories, as a rule, does not reduce the sick rate. For combatting ticks over large areas aircraft and helicopters are widely used at the present time.

The use of aviation in treating forests for the purpose of combatting ticks – the carriers of encephalitis, was first carried out in 1953 in the Kuybysheva Oblast under the management of a group of comrades headed by N. N. Gorchakovskaya. Up to the present time on the basis of laboratory and field experiments it has been established that the minimum toxic dose of DDT disinfecting powder causing a high percent (96-99) of tick destruction is, 20 kg/ha.

From this dose hungry individuals die on the 7th day; with a dose of 30 kg/ha – on the 5th day; with 50 kg/ha – on the 3rd day.

After a single spring treatment with DDT disinfecting the number of hungry ticks are decreased by up to 99.8%. The satiated ticks mainly remain alive and they are able to lay viable eggs, and 36-37.5% of the larvae and nymphs mold normally. Thus in carrying out sanitary measures it is recommended that the treatment of a site with insecticides be conducted not less than 2-3 years in succession. (From hexachlorane disinfecting powder the number of active ticks is decreased by 26-82%.)

At the present time early-spring treatment on snow is being broadly used.

The dusting of snow from an aircraft can be carried out only on a plain, since under mountain or hilly conditions it is very difficult to carry out thorough treatment.

Along with dusting aerial spraying is also being employed. They are employing a 20% mineral-oil emulsion of DDT and a 50% emulsion of DDT paste. For the elimination of ticks on an area of one hectare doses of 2 kg of active substance (30 l of solution are sufficient). Spraying is $1\frac{1}{2}$-2 times more economical than dusting.

For spraying from aircraft they also use solutions of polychlorpinene (PCP) at a rate of 2 kg of concentrate (30 liters of solution) per hectare. The treatment can be carried out both before the appearance of leaves on trees, and also after they have opened. The effect is equally good (A. B. Levit).

Spraying with a mixture of PCP and DDT (with 1.9 kg/ha and 2 kg/ha respectively according to technical preparation) also gives a good effect – 97.2-100% of the ticks die (V. S. Rekunov).

For achieving a stable reduction of the number of ticks and even the complete destruction of a population it is recommended that the treatment of domestic animals with acaricides be carried out – mainly the reservoir-hosts of the mature ticks. According to the materials of S. P. Karpov with co-authors, with the systematic treatment of cattle during the course of a season with DDT disinfecting powder one time per week there is attained a stable reduction in the number of ticks on a site during the first year and their complete disappearance during the third year of treatment. S. G. Gladkikh and S. A. Shilova propose treating cattle once each 10 days.

In recent years chlorophos obtained acceptance as an acaricide: according to laboratory data, with a dose of 0.025 g of active substance per m^2 and an exposure of 30 minutes all hungry I. persulcatus die; with a dose of 0.05 g/m^2 analogous results are attained even after 15 minutes of contact; with a dose of 0.1 g/m^2 – after 5 minutes of contact. The residual effect of the preparation is short: from a dose of 0.1 g/m^2 after 9 days only 43-90% of the ticks die (V. I. Vashkov, Ye. V. Shnayder). From a 3% solution of chlorophos (a dose of 1.5-3 l per head) complete destruction of ixodid ticks is observed only after 7-13 days.

Of great significance also in the prophylaxis of tick-borne encephalitis is the regulating of cattle pasturage – the creation enclosed pastures (2-2.5 hectares per animal). M. A. Shumkov and V. N. Semenova ascertained that the greater the age of the pasturage and the greater the intensity of pasture usage, the less it is infested with rodents – the reservoir hosts of larvae and nymphs.

Also the rodents are distributed along the edges of the enclosure in places, which are not very accessible to cattle. Comparing the indices of tick abundance on wild animals and domestic animals located in free pastures and enclosed pastures, it is evident that on "free pasturage" this index is 5-7 times greater.

According to the authors, the effect of the pasturage of cattle on enclosed pastures is striking: if this measure is supplemented by the destruction of rodents (in their natural habitat) and by the treatment of cattle with insecticides, it is possible to attain complete disinfestation of the territory adjacent to a settlement. Thanks to this the possibility of ticks being brought into the inhabited locality will be prevented.

For the destruction of rodents it is desirable to employ systemic poison or combined baits simultaneously destroying the beasts and the ticks parasitizing them. The most promising preparations in this respect are dieldrin, aldrin, heptachlor and mixtures of zinc phosphide with DDT. Preparations at a dose of 2-3 mg caused the death of the animal (the white mouse, the gray and red field-vole) on the 3rd-4th day, at the same time hungry larvae of taiga ticks died in 96-100% of the cases.

Field testing of bait with a mixture of zinc phosphide with DDT (4% ZPh + 1% technical DDT) showed that with a dose of 1 kg/ha almost complete destruction of the rodents is attained. On individual rodents poisoned during the course of 2 months (June-July) there were no larvae and nymphs.

Analogous results were also obtained from baits containing 3% heptachlor.

At the present time three ranges of disease have been distinguished: frequent diseases, sporadic outbreaks and single cases. In the range of frequent diseases it is necessary to carry out a whole complex of prophylactic measures both in the region of active foci, and also potential foci.

In the range of sporadic outbreaks prophylactic measures are carried out, as a rule, only according to the epidemic indications – around the active foci and children's sanitation institutions.

In the range of single cases it can be limited to treatment around children's sanitation institutions.

Combatting Other Ixodid and Also Gamasid and Trombiculid Ticks

In human habitations it is possible to record the most diverse ticks: in rodent burrows – gamasid ticks (B. bacoti, L. agilis and others), in the nests of birds (under slate, behind window frames, in attics, in ventilator openings – gamasid and argasid ticks (Hg. casalis, St. viator, D. gallinae, A. persicus and others), in slots and cracks of walls – gamasid, argasid and ixodid ticks.

The main prophylactic measure should be the maintenance of a building in a proper, sanitary condition – to make it inaccessible to birds and rodents (tightly fitted boards, screened attic windows and ventilator openings, the sealing up of cracks, the plastering and white-washing of walls, the prevention of cluttering). Along with this there should be carried out the destruction of rodents by all accessible methods and means.

It is necessary to note that after destroying rodents and birds — the sources of food for ticks, the latter, as a rule, start to attack man. To avoid this it has been proposed to first carry out disinfestation, and then deratization.

Against ticks it is possible to use all known insecticides. Ye. A. Nel'zina applied fleacide against B. bacoti, poured pyrethrum on upholstered furniture, daubed the cracks in floors with soap-K. After 2-3 such treatments with an interval of one week between the treatments no ticks were detected in an apartment.

According to the materials of I. I. Seledtsov and V. P. Protsenko, B. bacoti ticks upon contacting 10% DDT disinfecting powder (a dose of 2 g/m^2) die after 30 minutes.

With the blowing of DDT and hexachlorane disinfecting powders into rodent burrows (1.5-2 g) a stable effect is observed. It is feasible to apply liquid preparations (solutions, emulsions). In the treatment of furniture it is necessary to focus attention on cracks, the internal surfaces of chests, the lower surface of shelves, carrying out a solid treatment of them. All internal and lower surfaces are treated with an emulsion or solution of the preparation in kerosene. In the absence of liquid preparations chests and shelves can be treated with disinfecting powder. After treating the working surface of a table it is covered with paper, and the insecticide is not removed for as long a time as possible.

In infested premises papers, books and other articles are subjected to treatment. The disinfecting powder is introduced between books, packs of papers and similar materials. When necessary the clothing of persons being subjected to massive and systematic attacks of ticks, is dusted with DDT or hexachlorane disinfecting powder; it is then folded and left for 2-4 days in tightly sealed bags of closely woven cloth or paper (pillowcases, paper bags, etc.) or subjected to treatment in chambers.

In foci, where attacks of rat ticks on people have been recorded, before carrying out disinfestation the rodents are caught by mechanical methods both on the area of the premises infestated with the ticks so also in neighboring premises, taking in as large an area as possible. To prevent the ticks from crawling from the rats which have been caught in the traps frequent inspections of the traps are organized in order to provide the rapid removal of the rats from the traps and snares. The corpses of the rats caught in the traps (both are then infestated with ticks) are immediately treated with DDT or hexachlorane disinfecting powder and placed in sacks of closely woven cloth, treated with the same preparation on the inside. After placing the rats in the sacks, the sacks are tightly tied up. The places where the snares and traps stood are also treated with DDT or hexachlorane preparations for a radius of up to 2 m. After the trapped rodents are removed their burrows are treated with DDT or hexachlorane disinfecting powder as well as possible and they are as thoroughly sealed up as possible.

When it is necessary to use premises suspected of being infestated with ticks it is desirable to subject it to fumigation with sulfur dioxide or chloropicrin, taking all necessary measures of precaution to eliminate the possibility of poisoning people.

In combatting ticks in artificial nests (birdhouses, hollow in trees, pigeon coops, attics) it is also possible to employ aqueous suspensions and disinfecting powders of insecticides. It is desirable to carry out treatment 2 times – before the arrival of the birds (in March) and after the end of nesting (August).

In recent years in combatting gamasid ticks there have been applied silica gel [a silicoorganic compound, containing 4.7% $(NH_4)_2SiF_6$], malathion, gamma-isomer, chlordane, diazinon and chlorophes. Silica gel disinfecting powder has been used to dust habitable rooms, basements and attics at a rate of 5 g/m^2. After treatment ticks were not recorded for a total period of observation – of from 6 weeks to 1 year. After applying 4% malathion disinfecting powder (82 g per linear meter) ticks were absent for a period of 5 months.

Against gamasid ticks there are applied 1% gamma isomer, 2% chlordane, 2% malathion and 0.5% diazinon (Rodriquez, Trumm).

We observed, as a result of the application of a 2% solution of chlorophos all bird ticks D. gallinae died, which were occupying working premises. In treating 24 m^2 2.5 l of solution was expended.

Also applicable in combatting gamasid ticks are insecticidal smokes. With a dose of 5-8 g of active substance per m^2 there is observed the death of all active stages of ticks located outside a deep dug-out.

Measures for Combatting Ticks at Populated Points

The most important problem in combatting ticks at inhabited points on the whole is also keeping them in a proper sanitary-hygienic state. As prophylactic measures it is recommended that there be carried out: 1) the solid clearing of the territory of a habitable section and the zone surrounding it (into the depth of a forest, a steppe) to a distance of 300 m from the outskirts of the populated section; 2) the persecution of rodents at an inhabited point and in its surroundings; 3) the disinfestation of foci of tick reproduction; 4) the treating of domestic cattle.

One of the wide-spread, earlier methods of protecting animals from ticks was the bathing of cows and sheep in special basins with the addition of various preparations. For the bathing of the cows there was used a 1% solution of SK-9, for sponging them down – 3% solution. The period of effect of a preparation in early spring, in autumn and in winter was 15 days, and in summer 10 days. For these same purposes there are used arsenic preparations (a 0.225% solution of sodium arsenide). Antitick measures should be started in spring before the pasturage of cattle in the fields and continued during the whole time, that ticks preserve their mobility, at intervals of 10 days (S. F. Vyazkova).

For prophylaxis, and also for the destruction of ticks during the period of their stay on animals there are recommended various insecticides possessing high acaricidal properties (Table 38).

Table 38.* Insecticides and tick control.

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
Anabasine, 1 and 5% solutions in soapy water; 0.5% soap	Large cattle		Spraying	Paralysis in the ticks, D. pictus, D. marginatus, D. silvarum, H. plumbelum after 5-10 minutes	N. M. Parkhomenko, 1952
AsO_3, 18% solution	The same		Sponging down	Female I. ricinus die at a rate of 11-58%	V. P. Onufriyev, 1959
DDT, 10% disinfecting powder	The same	29-30 g	Rubbing it into the ears, neck, sinciput	99.83% of the D. pictus ticks died	L. N. Pogodina, N. G. Olsuf'yev, 1950, the central belt of the RSFSR
DDT, 10% disinfecting powder	Large and small cattle	50-70 g	Dusting	I. persulcatus die on the cattle	S. G. Gladkikh, S. A. Shilova, 1959, the Central Urals Region
DDT, 10% disinfecting powder	Large cattle	75-100 g	Dusting	I persulcatus, D. pictus, D. marginatus, D. silvarum, H. concinna ticks die within 7 days	S. P. Karpov, V. M. Popov, A. G. Kolmakova, 1960; Western Siberia
DDT, 5% suspension and 2.5% suspension	Large cattle and horses	0.5-2 l on the head	Sponging down the animals	Protective effect 7-10 days; all I. ricinus, D. marginatus ticks die	Ya. S. Bolgov, Ye. I. Pokrovskaya, 1952; Voronezh region
DDT, 5% emulsion with solar oil	Large cattle	0.5-1 l	Sponging down the tail, neck, mane, extremities	Ticks did not stick by suction for 7 days	I. V. Lazovskiy, G. A. Buyanova, 1954
DDT, 1.5% emulsion	The same		Sponging down	Satiated female I. ricinus die at a rate of 17-56%	V. P. Onufriyev, 1959
HCCH, 2.5% suspension	Large cattle and horses	0.5-2 l on the head	The same	The protective effect lasted 7-10 days; all attacking J. ricinus, D. marginatus die	Ya. S. Bolgov, Ye. I. Pokrovskaya, 1962; Voronezh region
HCCH, 1% suspension	Large cattle	2-3 l on the head	Sponging down every 3 days	All stages of I. ricinus died within a day except the satiated females	A. Ya. Baydalin, 1950
HCCH, 0.4-0.8% emulsion	The same		Sponging down	Protection from attack by H. anatolicum, H. detritum for up to 3 days	A. M. Netsetskiy, 1960; Uzbek Soviet Socialist Republic

Table 38 (Cont'd.).

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
HCCH, 0.25% solution in 1% creolin	Sheep	0.5-0.6 l	Spraying	All ticks die within a day; protective effect 8 days	N. Ye. Grishayev, D. V. Mantsev, 1960; Krasnoyarsk Kray
SK-9, 3-5% solution	Large cattle	0.5-0.6 l	Sponging down	Protection from the attack of H. anatolicum, H. detritum ticks for 3 days	A. M. Netsetskiy, 1960; Uzbek Soviet Socialist Republic
SK-9, 3% solution	The same	2.5 l	Spraying	Hyalomma ticks die on cattle during the course of 10 days	R. A. Nurayev, 1960, 1961; Turkmen Soviet Socialist Republic, middle course of the Amu-Dar'ya
SK-9, 3% solution	The same	1.5 l	Spraying	All ticks die within 6 days	Yu. N. Pil'shchikov, 1959, 1961; Southern Kazakhstan
SK-9, 5% emulsion	The same		Sponging down	13-39% death rate for satiated I. ricinus females	V. P. Onufriyev, 1959
Chlorten, 1-0.7% solutions	The same		Sponging down and bathing	Complete destruction of B. calcaratus, H. detritum ticks on cattle within 48 hours; residual effect 7 days	S. F. Vyazova, Z. M. Bernadskaya, A. M. Stepanova, 1957, 1959
Chlorten, 2% solution	The same		Sponging down	Destruction of 12-36% of the satiated I. ricinus females	V. P. Onufriyev, 1959
Nicochlorane with 0.2% gamma isomer HCCH	The same	2.5 l	Spraying	Hyalomma ticks die on cattle within 10 days	R. A. Nurayev, 1960, 1961; Turkmen Soviet Socialist Republic, middle course of the Amu-Dar'ya
Polychlorpinene, 25% emulsion		0.3-0.5 kg/ha, 0.2 kg/ha	Treatment of wooden surfaces and contacting of hungry J. persulcatus larvae	With an exposure of 15 minutes after 48 hours 100% of the ticks have died from 0.3-0.5 kg/ha and 85% from 0.2 kg/ha	S. A. Shilova, 1962
Chlorophos, 3% aqueous solution	Large cattle	1.5 l	Spraying	All ticks die within 13 days	Yu. N. Pil'shchikov, 1960, 1961; Southern Kazakhstan

Table 38 (Cont'd.).

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
Chlorophos, 2-3% aqueous solution	Large cattle	2-3 l	Sponging down, spraying, bathing	All active stages of H. detritum, H. anatolicum, H. asiaticum, B. calcaratus ticks die within 79 days	U. Ya. Uzakov, 1962; Uzbek Soviet Socialist Republic
Chlorophos, 5, 7 and 10% disinfecting powder	Large cattle	75-100 g	Dusting	All active stages of H. detritum, H. anatolicum, B. calcaratus ticks die	A. M. Netsetskiy, 1963; Uzbek Soviet Socialist Republic
Chlorophos, 2% aqueous solution		0.2-0.3-0.5 kg/ha	Treatment of wooden surfaces and contacting hungry J. persulcatus larvae	With an exposure of 15 minutes after 48 hours 100% die from 0.3-0.5 kg/ha and 98.8% from 0.2 kg/ha: with an exposure of 10 minutes – 100% from 0.5 kg/ha; 95.6% from 0.3 kg/ha and 0.2 kg/ha	S. A. Shilova, 1962
		0.1-0.3--0.5-1 kg/ha	Treatment of wooden surfaces and contacting satiated I. persulcatus larvae	With an exposure of 30 minutes after 48 hours 100% die from 1-0.5-0.3 kg/ha and 46.5% from 0.1 kg/ha	
Chlorophos, 0.5% solution	Large cattle	3.7-7.4 l	Spraying	43% of the Amblioma americanum ticks die within a week	Drummond, Moore, Wrich, 1960
Heptachlor 1% emulsion	Laboratory orthropods	1-2 g/m^2	Contact for 60 minutes	86-100% of the I. persulcatus ticks die within 1-2 days	A. A. Ivannikov, 1958
Heptachlor, 10% disinfecting powder	The same	0.1-0.5 g/m^2	The same	The same	The same
Chlordane, 1% emulsion	The same	1-2 g/m^2	The same	The same	The same
Chlordane, 10% disinfecting powder	The same	0.1-0.5 g/m^2	The same	The same	The same
Malathion, 0.5% solution	Large cattle	3.7-7.4 l	Spraying	55% of the Amblioma americanum ticks die within a week	Drummond, Moore, Wrich, 1960

Table 38 (Cont'd).

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
Gamma isomer, 0.025% solution	The same	3.7-7.4 l	Spraying	20% of the Amblioma americanum ticks die within a week	The same
Toxaphene, 0.5% solution	The same	3.7-7.4 l	The same	64% of the Amblioma americanum ticks die within a week	The same
Toxaphene, 25% emulsion	Laboratory experiments	0.5-1 kg/ha	Treatment of wooden surfaces and contacting satiated I. persulcatus larvae	With an exposure of 30 minutes after 48 hours 100% died from 1-0.5 kg/ha; 98.2% from 0.3 kg/ha; 90.1% from 0.2 kg/ha and 50% from 0.1 kg/ha.	S. A. Shilova, 1962
			Treatment of wooden surfaces and contacting of hungry I. persulcatus larvae	With an exposure of 15 minutes after 48 hours 100% died from 0.5-0.3-0.2 kg/ha; with an exposure of 10 minutes 80% from 0.5 kg/ha and 71.1% from 0.3 kg/ha	
Co-Ral, 0.5% solution	Large cattle	3.7-7.4 l	Spraying	85% of the Amblioma americanum ticks die within a week	Drummond, Moore, Wrich, 1960
Ronnel, 0.75% solution	The same	3.7-7.4 l	Spraying	55% of the Amblioma americanum ticks die within a week	The same
Delvan, 0.15% solution	The same	3.7-7.4 l	Spraying	75% die after a week	The same
Sevin, 0.5% solution	The same	3.7-7.4 l	Spraying	71% die after a week	The same
Bayer 22408, 0.5% solution	The same	3.7-7.4 l	Spraying	63% die after a week	The same
Bayer 22408, 0.25% solution	The same	3.7-7.4 l	Spraying	62% die after a week	The same
Ryuilen, 0.5% solution	The same	3.7-7.4 l	Spraying	35% die after a week	The same

Table 38 (Cont'd.).

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
Dicapthon, 0.5% solution	Large cattle	3.7-7.4 l	Spraying	23% die after a week	Drummond, Moore, Wrich, 1960
Trichlorometaphos-3, 50% emulsion	Laboratory orthropods	0.25 g per 1 m^2	Contact of sexually mature I. persulcatus with a treated surface for an hour	Complete destruction of Amblioma americanum ticks after 2 days	Yu. M. Shchadilov, I. V. Gvozdeva, 1963
Trichlorometaphos-3, 2% disinfecting powder	The same	0.1 g/m^2	Contact of sexually mature I. persulcatus with a treated surface for 30 minutes	Complete destruction within 2 days	The same
Trichlorometaphos-3, 2% emulsion	The same	1-2 g/m^2	Treating of a sand substrate, contact of all active stages of H. detritum, H. anatolicum, R. sanguineus ticks for 5-10 minutes	Complete destruction of all ticks on the 4th day except satiated females	E. B. Kerbabayev, 1962; experiments were conducted in the Turkmen Soviet Socialist Republic
Wofatox, 0.6% disinfecting powder	The same	0.1-0.2 g/m^2	Dusting of the walls of test tubes and Petri dishes and the contacting of ticks for 10 minutes	Destruction of 62% of all the ticks on the 4th day	The same
Wofatox, 1.25% disinfecting powder	Laboratory orthropods	0.1-0.2 g/m^2	Dusting of the walls of test tubes and Petri dishes and the contact of ticks for 10 minutes	Destruction of 86% of all ticks on the 4th day	E. B. Kerbabayev, 1962; the experiments were conducted in the Turkman Soviet Socialist Republic
Wofatox, 2.5% dusting powder	The same	0.1-0.2 g/m^2	The same	Destruction of 79% of all ticks on the 4th day	The same
DDVP-1, 0.2% kerosene solution	The same	0.1 g/m^2 (100 ml)	Treating of a loess and sand substrate, contact for 5 minutes of all active stages and various degrees of satiation of H. anatolicum, H. detritum ticks	Around the 7-9th day, as a rule, all stages of development died except saturated females; 50-70% of the latter died at this time, and by the 10-26--35th day absolutely all of them died	The same

Table 38 (Cont'd.).

Preparation name	Species of animals	Dose	Method of application	Result	Authors, test site, year
DDVP-1, with polyphosphonate, 0.1% kerosene solution	Laboratory orthropods	0.2 g/m^2 (100 m l)	Treating of a loess and sand substrate, contact for 5 minutes of all active stages and various degrees of satiation of H. anatolicum, H. detritum ticks	Around the 7-9th day, as a rule, all stages of development died except saturated females; 50-70% of the latter died at this time, and by the 10-26--35th day absolutely all of them died	E. B. Kerbabayev, 1962; the experiments were conducted in the Turkman Soviet Socialist Republic
Phosphamide (rogor) 0.4% aqueous solution	The same	0.02 g/m^2 (100 m l)	The same	The same	The same
Methyl-ethyl-thiophos, 0.2% aqueous solution	The same	0.03 g/m^2 (200 m l)	The same	The same	The same

The treatment of cattle against ticks is carried out mainly in the spring-summer period. However in combatting certain species it is also necessary to carry out treatment in the cold season. Thus, according to the materials of A. F. Kas'yanov (1947), under the conditions of the Khabarovsk region D. nuttalli ticks – the basic carrier of tick exanthematous typhus of Asia – winter on cattle situated in stalls.

O. lahorensis ticks – the carriers of brucellosis, tularemia, toxoplasmosis and hemosporidiosis parasitize cattle from December to March; all stages development of H. scupense, the larvae and nymphs of R. bursa, and in the southern regions the imagoes of ticks of the genus Haemaphysalis also parasitize cattle in the cold season. Consequently, it is at this time that there should be concentrated control, which is carried out by the method of dusting animals.

In treating of animal husbandry economies along with dusting and spraying insecticidal aerosols are also applicable. In treating premises with DDT and hexachlorane aerosols 15-20 ml/m^3 are sufficient with an exposure of 2 hours. A solution of chloroethane (5-8%) containint 44.1% chlorine, in an amount of 15 ml/m^2 causes the death of all larvae and hungry females of R. bursa, H. plumbeum after 15 minutes of exposure.

Of aerosols under laboratory conditions we tested smoke mixtures containing chlorophos, dithiophos, octamethyl, DDVP, thiophos and sulfur. In the experiment there were included all active stages of O. tartakowskyi, H. anatolicum, H. detritum, H. asiaticum ticks and I. persulcatus larvae. With a dose of 20 g of active substance per m^3 and an exposure of 20 minutes the greatest percent of all species (90-100%) died from smoke mixtures – octamethyl (0-3), chlorophos (x-1), a mixture of chlorophos with dithiophos (D-7) and thiophos (m-3).

In the complex of prophylactic measures along with treating cattle and premises there should also be included the disinfestation of pastures and places frequently visited by people. For these purposes it is possible to employ all the doses of poison and forms of their applications expounded in the division on the organization of control at foci of tick-borne encephalitis.

Against trombiculid ticks along with general sanitary measures (clearing the area of clutter, destroying the rodents, etc.) insecticides are also applied. Good results were provided by a 1% emulsion of chlordane and 0.2% emulsion of lindane at a dose rate of 16.5 l/m^2 (20 gallons per acre) and wettable powders and disinfecting powders of these preparations and hexachlorane at a dose rate of 140-225 g/m^2 (1.25-2 pounds per acre) (Trautman, 1961).

Traub and Dowling (1961) under the conditions of Malaya carried out a broad experiment against trombiculid ticks. The site heavily overgrown with coarse grassy vegetation and small shrubs, in which rats bounded which were severely infested with tick larvae was sprayed with a 15% oil emulsion of dieldrin. Per m^2 they applied from 226.8 to 567 g (2-5 pounds per acre). On the area, where fine dispersion was applied the index of abundance fell from 315 to 9, and where the solution was coarsely dispersed – from 370 to 13. After 26 months the index of tick abundance did not exceed 16.

The authors also checked the possibility of sanitizing a region by the method of burning the vegetation. If burning the vegetation had no effect on the rats, there was a certain noticeable reduction in the number of larvae, however after 7 weeks it was completely restored.

Footnotes

[1]At the basis of the description of the trombiculids used by us are the works proposed by Ye. G. Shluger, 1955.

[2]At the basis is offered the description by A. B. Lange (1955).

[3]According to the system of families proposed by M. V. Pospelova-Shtrom (1953), in the fauna of the USSR 4 genera are mentioned. We adhere to the system accepted by the leading scientific establishment of our country – the Zoological Institute of the Academy of Sciences of the USSR.

CHAPTER XXIII

BUGS AND THEIR CONTROL

The bug – Cimex lestularius, order Rhynchota, family Cimicidae.

Its body is russet colored, has an elongated or round shape; on its degree of satiation affects it – in a hungry bug the body is flattened. The female is larger than the male: the length of the female is 6 mm, male is 5 mm. The body of the male is narrower; the body of the female is broader and has a rounded shape. The head of the bug is only slightly mobile and is equipped with four-segment antennae. The eyes are simple and highly convex. The oral apparatus is of the piercing-sucking type.

From the anterior end of the head extends a proboscis; at rest it is folded over on the abdominal side. The proboscis is formed by the lower lip; in it are hidden 4 piercing bristles serving to perforate the skin. With the proboscis the bug sucks blood into the digestive tract.

The bug has pedicels, which terminate in three-segment tarsi with two claws. It moves with a speed of 1-1.25 m/min.

In the male on the anterior end of the abdomen is located a capulative apparatus with a crescent-shaped form.

The development of the bug passes through three phases: the egg, the larva, the sexually mature individual.

Bugs multiply rather rapidly. In one day the female can lay from 1 to 12 eggs, and during her whole life up to 500 eggs. The eggs of bugs have an oval shape; the female attaches them in a vertical or slanting position with a glue mass, which being softened in water readily swells, which distinguishes it from the glue of lice. Oviposition depends on the conditions of feeding and temperature; the most favorable is a temperature of 25°. A decrease in temperature or its increase up to 40° unfavorable effects the number of eggs laid. Starvation reduces the number of eggs laid, but it does not stop oviposition.

The development of the larva in the egg depends on temperature: at $35\text{-}37^{\circ}$ it lasts 4-7 days, and at $22\text{-}26^{\circ}$ on the average 8-9 days; with the temperature of a room at $14\text{-}18^{\circ}$ the period of development of a larva is extended up to 15-29 days.

A bug larva after its emergence from the egg goes through 5 molts; after each molt the larva has to without fail, at least once, suck blood. At a temperature of about $25\text{-}30^{\circ}$ all stages of its development occur in 28 days; under less favorable conditions the development is extended up to 3 months and more. Larvae are resistant with respect to both hunger and cold; they can fast up to 150 days. After the last molt the larva is turned into a sexually mature insect capable of further reproduction (Figs. 14, 15).

The development of bed bugs from the egg stage to the sexually mature individual occurs in 1-4 months; the duration of life of a bug is up to 14 months.

A bug does not withstand high humidity, especially if the latter is combined with an increase in temperature. Both the larva and the mature bug at 45° die within an hour. Bugs withstand low temperature well: at -10° they do not die, and at -17° they can survive for about 24 hours. Possibly, they can remain viable even at lower temperatures, since there are indications of the fact, that in a bug at a temperature of -21° rigidity appears. In cold water they live 24 hours.

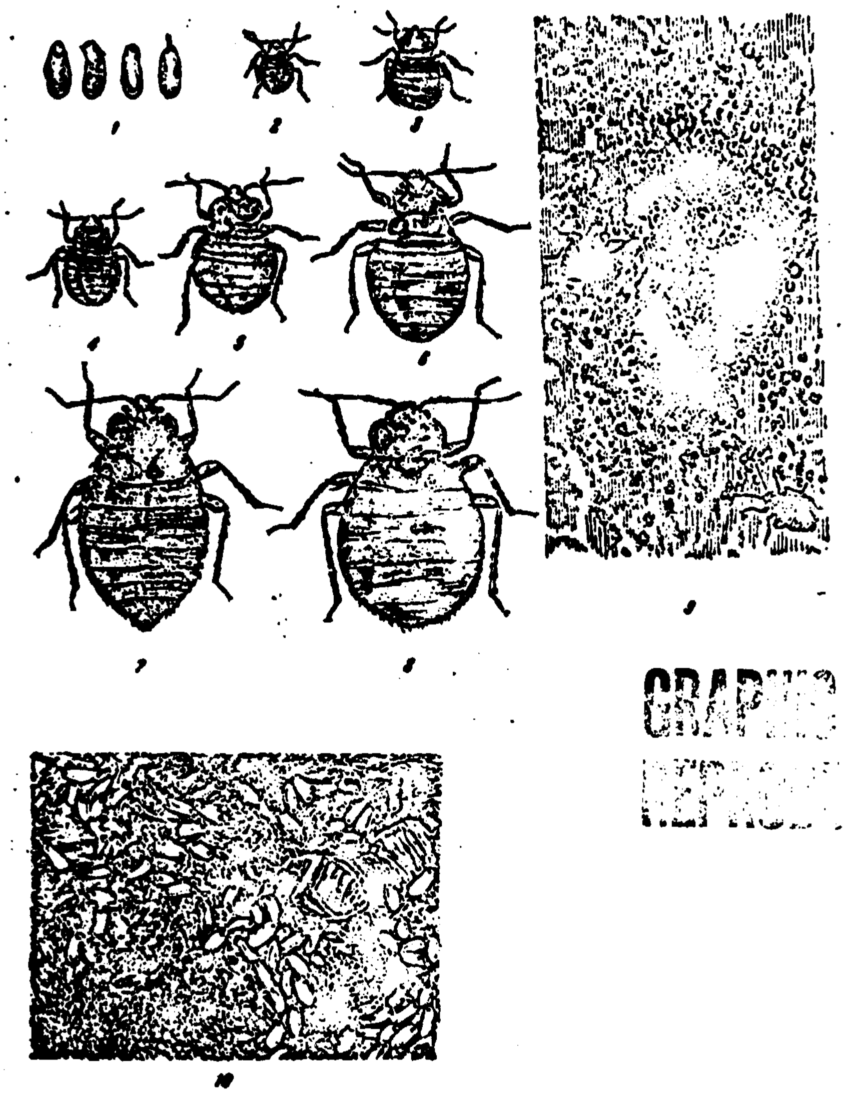


Fig. 14. The bed bug Cimex lestularius. 1 – eggs; 2 – first instar larva; 3 – second instar larva; 4 – third instar larva; 5 – fourth instar larva; 6 – fifth instar larva; 7 – male; 8 – female; 9 – the infestation of wallpaper with bugs; 10 – a nest of bugs.

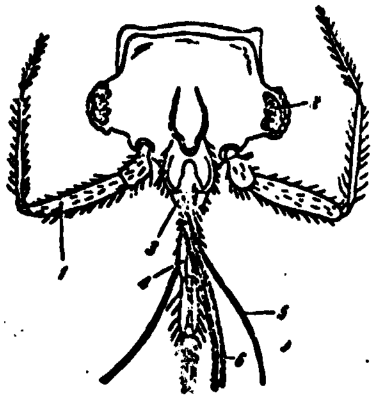


Fig. 15. The oral apparatus of the bed bug C. lestularius. The proboscis with the piercing bristles withdrawn (according to Kholodkovskiy). 1 – antenna: 2 – eyes; 3 – upper lip; 4 – lower lip; 5 – upper jaws; 6 – lower jaws.

Bugs carry on a night form of life, and during the day they hide in their resting-places. They are also afraid of artificial light. Bugs most frequently attack man at night, but a hungry bug can also attack in the daytime.

The puncture of a bug is hardly felt. The bite is perceived after the disappearance of the bug because into the wound during the piercing the bug introduces saliva containing anticoagulin and possessing irritating properties.

Usually a bug pierces several times before finding a suitable place for sucking. However the bite sensation appears only after the bug has crawled away. People are not uniformly sensitive to the piercing of a bed bug: in some soon after the puncture on its site a blister appears with an itching and burning sensation; in others the reaction sets in after several hours.

The amount of blood, which a bug can suck is equal to twice its weight – about 7 mg. The sucking process lasts about 15 minutes. Usually bugs feed every 24-48 hours on human blood, but they can also feed on the blood of animals (guinea pigs, mice, rat, rabbits, bat, and others) or birds. Bugs can be artifically fed through a membrane. They withstand hunger well, at low temperature they can fast for 18 months. Bugs give off an odor, which depends on a secretion secreted by odoriferous glands located in the mature bug on the abdominal side near the base of the third pair of legs, and in larvae – the back side.

The biological peculiarities of the bug, its mode of life, its resistivity to external influences, its rapid multiplication, and also its ability to move rapidly promote the wide distribution of this parasite.

The simplest and the most frequent method of bug distribution – its being carried on articles, furniture, clothing, etc. They can be transmitted from one location to another, from one house to another, they can be transported from one city to another. Bugs can be transported from old to new homes with furniture, if it is not subjected to thorough disinfestation before being moved to a new location. They can pass through cracks and fissures from neighboring apartments. Upon the entering into an apartment of at least a pair or one fertilized female bug reproduction under favorable conditions occurs rather intensively. Poor sanitation in living quarters is one of the basic conditions promoting the propagation of bugs.

The Epidemiological Significance of Bugs

Epidemiological observations do not yield to bases to consider that the danger of disease propagation by bugs is great. However there are a number of indications of the possibility of the transmission of pathogenic agents of 41 human diseases – bacteria, rickettsial, spirochaetae, Protosoa viruses, helminthea and others. It has been determined that bed bugs feeding on the blood of a patient with recurrent typhus remain carriers of spirochaetae. S. G. Tiktin expressed assumption that this sickness can be transmitted by crushing the bugs on the skin and scratching the latter with fingernails. The experiments of D. T. Verzhbitskiy with bugs infected with plague bacilli showed that the crushing of bugs at bite sites or at sites of skin damage led to the infection of the experimental animals with plague.

It has been shown that many micro-organisms can pass through the walls of the intestines of the bug and penetrate into its body tissues; not excluded is the possibility of the transmission of a virus through the salivary glands with the piercing and the injection of saliva from the glands into the wound.

In the digestive tract of a bug contentedly for a considerable period of time there can live a number of micro-organisms including bacilli of tuberculosis, plague and leprosy. Sanders detected leprosy bacilli in 20 of 75 inspected bugs feeding on the blood of a person sick with leprosy. The microbes could be detected in the proboscis of the insect for 5 days, and in the digestive tract – for even 16 days. Furthermore, they were found in the feces of the bugs.

McFadzean studied the possibility of the transmission of leprosy bacilli (on tarsi) and arrived at conclusion that the pathogenic agents of leprosy are not taken up by bugs from the skin of leprosy donors.

Certain micro-organisms can not only be preserved in the body of a bug, but can also multiply there. Bugs placed on the corpse of a rat, which died from plague, become infected with plague bacteria, and the speed of infection depends on the temperature of the corpse. Plague bacilli are preserved in the body of a bug for from 10 to 83 days; Spirochaetae Obermeyer – up to 62 days. There are indications of the possibility of the transmission by bugs of Leichmanial – pathogenic agents of tropical splenomagalia or kala-azar. The pathogenic agents of leichmaniosis can live in the body of a bug for up to 41 days. The pathogenic agents of exanthematous typhus can be preserved up to 10 days when feeding on sick guinea pigs, but the infected bugs themselves are not able to infect healthy guinea pigs. The infection occurs after the introduction to the guinea pigs of an emulsion of such bugs.

Under experimental conditions bugs can be carriers of pneumoccoci infections (type I and II), transmitting them during the sucking of the blood of a healthy animal. Bugs can transmit hemolytic streptococcus to mice, guinea pigs and rabbits for 14-15 days, but to the bugs themselves this micro-organism, apparently, is harmless. Smallpox virus lives and multiplies in the body of a bug for up to 17 days. Bugs can transmit this infection to healthy rabbits while sucking their blood in approximately 1/5 part of the experiments. They can preserve in their organism Rickettsia prowayekii (A. B. Deyter). With respect to tularemia it has been established that bed bugs feeding on infected pigs or mice can infect healthy animals only for 15 hours after their feeding on the sick animal, but the tularemia microbe preserves its virulence in the body of a bug for up to 250 days. There are indications of the possibility of the transmission by bugs in a purely mechanical way of anthrox. Eggs can be infected by the pathogenic agents of paratyphoid fever. Under experimental conditions bed bugs can transmit the virus of rat exanthematous typhus, and also yellow fever. From bed bugs there have been extracted micrococcus and diphtheroid micro-organisms.

The majority of these works is based only on indirect data and therefore does not reflect the true epidemiological role of bed bugs. Actually the natural infectivity of bugs has been proven only for the following pathogenic agents: Wucrhereria bancofti, Brugia malayi, Trypanosoma cruzi, Brucella melitensis, Coxiella burnetii and Rickettsia prowazchi. In the feces of bugs there have been detected pathogenic agents of dermal leishmaniosis, kala-azar, Chagas' disease, anthrox, tularemia, brucellosis, paratyphoid fever, yellow fever, rickettsialpox and lymphocytic choriomeningitis. In experimental infecting very considerable divergences are observed in the periods of survival of one and the same species of pathogenic agent depending upon the strain of bugs used and their physiological state. Rectal infecting with micro-organisms in many cases has been considerably more successful than oral infecting. Transovarian transmission was noted only for C. burnetti, the pathogenic agents of exanthematous typhus, Minas geraes and symbiotic R. lectularius and R. hirundiniis. The death of bugs was observed only with their infection by the pathogenic agents of plague and pneumonia. Instances of occurrence of naturally infected bugs, successful laboratory infection and even the transmission of infection to susceptable species of laboratory animals are insufficient as proof of the participation of bugs in the transmission of any infection in nature. At the present time there are acknowledged with very great reservations the possible role of bugs in the transmission of leprosy, dermal leishmaniosis, kala-azar, Q fever, recurrent typhus and brucellosis (Burton).

The cited data makes it possible therefore, to assume that bugs can play a certain role in the transmission of individual types of infections.

However bugs cause the greatest harm to people by their bites, depriving people of their normal sleep and rest, which lowers their efficiency. Through the bites and scratching it is possible to introduce the pathogenic agents of skin diseases.

Because of the fact that bugs disturb the normal rest of people and are possible carriers of certain infections the destruction of bugs is absolutely necessary.

Measures of Controlling Bugs

In apartments and dormitories bugs are combatted by the tenants themselves; in hotels, medical, children's and other establishments – by the maintenance personnel. In those cases, when for some reason institutions or occupants of houses cannot themselves combat the bugs, they conclude an agreement with a disinfectional establishment, which on a contractual basis or by single applications carry out this work.

The disinfestation of medical and children's establishments, and units with large number of bugs and in the presence of other complicated circumstances is carried out under the leadership of a disinfector or another specialist in this field.

For the purpose of spreading the knowledge about the biology of everyday insects and methods of combatting them institutes of sanitary education issue leaflets, memoranda, and placards, organize lectures and discussions. As a rule, the effectiveness of control is reduced due to the fact, that coordination is lacking in treating not only a whole dormitory, but even one of its floors. Dwellings are not treated as a whole, even apartments are not always completely treated. The control of bugs is also hampered by the fact that effective agents for combatting bugs are not always on sale.

Success in combatting bugs can be guaranteed only if disinfestation is carried out methodically and correctly with the cooperation of a whole population and in conjunction with other sanitary-hygienic measures.

Bed bugs can live in dwellings, in bird and animal cages, on poultry farms and in vivariums, etc.

In dwellings bugs conceal themselves in various crannies and other secluded places: under loose wallpaper, between sheets of dry plaster, under window sills, cornices, under carpets, pictures, shelves, in books, electric wiring, and with severe infestation of dwellings also in other objects of everyday home use: in suitcases, radios, television sets, table clocks, umbrellas, in boxes of footwear.

Favorable conditions exist for the penetration of everyday parasites, including bugs, from dwelling to dwelling because there still exist a large number of dwellings of wooden construction and with dry plaster. Bugs readily crawl from place to place through ventilating systems, by the progress of technical pipes, and in the warm season along the outside of houses.

For the purpose of preventing the reproduction of bugs prophylactic and sanitation-engineering measures have great importance. Proper (without cracks) internal finishing of premises creates unfavorable conditions for the reproduction of insects. Of significant importance is the systematic repair of dwellings, the smoothing of plastered walls and whitewashing them.

To prevent the reproduction of bugs it is necessary periodically, not less frequently than once a month, to attentively examine all places, where bugs can find refuge for themselves. Cracks in walls behind baseboards and along heating and electrical leads should be sealed and filled, loose wallpaper should be glued. It is necessary to inspect beds, mattresses, night-stands or tables, and also to check whether there are bugs under carpets or behind pictures on walls, especially in places, where nails have been pounded.

Before setting about destroying bugs, the disinfectors find their reproduction sites. For this they first inspect the premises to be subjected to disinfestation, and by interrogating the tenants they collect all the information (about the degree of infestation, etc.) necessary for carrying out the operation.

The exposure of bugs and the checking of the quality of the work is carried out visually by inspecting the sites of the possible reproduction of bugs (cracks in walls, places where wallpaper is falling off, electric wiring, books, etc.) and bed appurte .nces for the purpose of detecting of traces of bugs; but the absence of the latter cannot serve as proof that there are no bugs in the premises. The presence of bugs in bed frames and mattresses is checked in the following way: one side of the bed is raised to a height of 15-30 cm and dropped with force on the floor; if bugs are present in the bed they will be found on the floor.

In cracks it is easier to detect bugs with thin, but rather elastic metal hooks or with cotton mointened by ammonium hydroxide, which are inserted into the cracks.

Disinfestation is mainly carried out in the morning hours with open windows or air vents, which are not closed until there has been complete airing out of the premises.

Before beginning disinfestation dust and dirt are removed from the surfaces of the baseboards. Furthermore, in dwellings furniture is moved away from the walls, carpets are taken up, pictures and tapestries are removed from the walls, suitcases and baskets are opened.

After this the methods and means of disinfestating the inspected premises are designated. These articles (mentioned above) are not removed from the premises; they are also treated with insecticides.

Especially broad propagation has been recently obtained by the chemical method; the powders and liquid of synthetic or vegetable insecticides are being employed.

In disinfestating premises and articles and furniture located therein insecticides are applied to the sites where the bugs live (cracks in walls, furniture, beds, mattresses, behind baseboards, wallpaper, under carpets, behind pictures, etc.). Solid treatment of premises (walls, ceilings and so forth) is possible only in the case when they are subsequently reconditioned.

Liquid insecticides are used mainly for treating of sites where bed bugs are found: in walls, stucco moldings, furniture, carpets, blinds, etc. Furthermore one has to consider that some of these (disinsectal, chlorophos) can leave spots on the surfaces of polished furniture and on wallpaper.

Of the insecticides the most effective combatting bugs are DDT, the gamma isomer of hexachlorane, chlorophos, carbophos, trichlormetaphos-3 and pyrethrum. Powdered preparations are atomized into the cracks between window and door frames and walls, behind wallpaper in places where it is coming off the walls; they are also used to treat books, etc. The average rate of expenditure of working solutions, emulsions, disinfecting powders per m^2 of floor varies depending upon the infestation of the apartment with bugs and the insecticide applied (Table 39).

Table 39. Rates of expenditure of preparations per m^2 of floor when destroying bed bugs (all preparations are used for treating sites where the bugs live).

Preparation name	Single average expenditure of the preparation (g) for systematic disinfestation: No. of operations (per year)	with a physical area infested with bugs: over 10%	over 20%	over 30%	Average expenditure of the preparation (per year)	Concentration and method of application
Chlorophos	2-4	1	2	4	8	2-3% aqueous solution
5% chlorophos disinfecting powder	4-6	2	6	10	15	
Trichlormetaphos-3, 30% concentrate	2-4	0.5	1	1.5	2	0.1-0.2% aqueous emulsion
Trichlormetaphos-3, 50% concentrate	2-4	0.3	[illegible]	0.9	1.2	The same
25% metaphos disinfecting powder (Wofatox)	2-4	2	[illegible]	4	5*	Without dilution or in a mixture with 10% DDT disinfecting powder at a rate of 2:5
10% DDT disinfecting powder	4-6	2	6	10	15	
25% DDT emulsion	4-6	4	6	8	12	2-3% aqueous emulsion
Disinsectal	4-6	8	25	50	70	Without dilution
Preparation No. 5**	4-6	8	25	50	70	The same
12% HCCH disinfecting powder	4-6	1	3	5	7*	In a mixture with 10% DDT disinfecting powder at a ratio of 1:2 or 1:3
A mixture of 5% DDT disinfecting powder with 1.5% gamma-isomer of HCCH	4-6	2	6	10	15	
15% HCCH emulsion	4-6	2	3	4	6*	1.5-4% aqueous emulsion, prepared from a mixture of 15% HCCH emulsion with 25% DDT emulsion (1:2)
Pyrethrum	4-6	2	6	10	15	
Fleacide	4-6	10	15	25	35	Without dilution

*Given is the expenditure of 12% HCCH disinfecting powder, metaphos disinfecting powder, 15% HCCH emulsion.

**Composition of preparation No. 5:5% DDT, 2% technical HCCH, 3% napthalene, 0.2% sulfonol, 5% turpentine, 84.8% kerosene.

All preparations are used for treating the sites where bugs live with a 2-3% aqueous solution.

The equipment used for applying liquid insecticides includes disinfectors, piston liquid atomizers, automatic sprayers, hand sprayers, brushes, etc.

Powdered preparations are atomized with various atomizers, rubber cylinders and double gauze sacks.

After applying the preparations to surfaces an effort is made to preserve them there as long as possible; inasmuch as they possess a residual effect. Beds, sheets, pillows, blankets are not treated with insecticides.

DDT Preparations. Of the DDT preparations there are applied for destroying bugs 10% disinfecting powder, aque[illegible] emulsions of concentrates and DDT pastes, and also solutions in kerosene and turpentine. The amount of DDT preparation in working emulsions and solutions should not be lower than 1%.

DDT disinfecting powder acts slowly on bugs. In a period of 4-5 hours after disinfectation paralysis appears in them; their death can occur after 2-5 days. If the DDT preparation has not been preserved on the treated articles by the time of the emergence of the larvae, then the newly hatched larvae are destroyed by repeated treatment.

The periods of death of bugs from DDT preparations depend on the amount of preparation applied to a surface. Thus, for example, in treating a surface at a rate of 10 g of pure DDT per m^2 the death of insects ensues after 3 hours; in using 1 g/m^2 – after 48 hours, and with 0.1 g/m^2 death was not observed at all.

Surfaces treated with DDT preserve their insecticidal properties for various periods of time. Cement, unpainted wood and glass preserve their insecticidal properties for about 6 months after applying the preparation at a rate of 2-3 g/m^2; wood painted a long time before preserves the insecticidal properties for a month, and freshly painted wood for 2 days. The solvent also plays an important role. After evaporation crystals remain; and a solvent which remains in the form of crystals after evaporation is more economical.

P. I. Nikitin showed that with the impregnation in railroad cars of fabrics and surfaces with 1-2% DDT emulsions (1-1.5-2-3 g/m^2) they preserv their insecticidal properties for from 11 to 27 months, and paralysi. in insects occurs in 1-2-3 days, and death – within 3-9 days.

DDT, as is known, is nonovicidal. The most sensitive to the preparation are larvae just emerging from the eggs, and their susceptibility to it decreases in accordance with the number of molts (development). Sexual distinctions in susceptibility to DDT in larvae have not been noted. Resistance in mature bugs to the preparation is different and depends on the degree of their satiation and the temperature of the premises. Males are more resistant after 3-5 days, and females 3 days after feeding. Among bugs, which were maintained at various temperatures (23-25-30°), the most sensitive were those, which were kept at 30°.

Hexachlorane is applied in the form of powders containing 6-12% of this preparation. The expenditure of disinfecting powder for destroying bugs varies from 6 to 10 g/m^2 or when calculated for 1 m^2 12-25 g depending upon the infestation and the sanitary state of the premises. Hexachlorane disinfecting powder acts slowly on bugs; 1-1$\frac{1}{2}$ hours after disinfestation paralysis appears in bugs; death ensues within 2-3 days. The paralyzed insects have low mobility and are not able to bite.

Hexachlorane is also applied in the form of solutions, aqueous emulsions and suspensions. The methods of applying these preparations are the same as when using DDT.

The gamma isomer possesses high insecticidal properties; in combatting bugs it is used at a 0.1% concentration.

It is necessary to keep in mind that inasmuch as hexachlorane possesses expressed fumigational properties and a specific odor, it cannot be recommended for treating all premises. It is necessary to subject to treatment only the nesting places of insects. For this purpose it is possible to also use hexachlorane pencils, which are used to mark these places.

Premises, objects and articles are protected from infestation by bugs for 1-2 months.

In a number of cases in combatting bugs there are used for treating habitable premises (vertical and horizontal surfaces) DDT and hexachlorane aerosols obtained by thermal sublimation. Such agents are not always effective. DDT aerosols on horizontal surfaces preserve their effectiveness (complete destruction) for 2-3 days; on vertical surfaces only a portion of the insects dies. With the use of hexachlorane aerosols complete destruction of bugs is not attained even on the first day of their application.

With the use of such contact insecticides, as dieldrin, tocaphens, DDT, pyrolan, their effectiveness (complete destruction) on paper is preserved for 6 months; the effectiveness of the gamma isomer of hexachlorane, allethrin is preserved for 10-30 days, chlordane and aldrin – 3-10 days.

Pyrethrum acts faster than DDT, and hexachlorane is 10 times stronger than DDT, however the effectiveness of pyrethrum even 2 weeks after treatment has considerably decreased.

The organophosphorous insecticides are highly effective: chlorophos, metaphos, trichlormetaphos-3 and others.

Chlorophos (2-3% aqueous solutions) is applied like an emulsion of DDT, at a rate of 2-4 g of technical preparation per m^2. When employing chlorophos pencils the latter are used to draw streaks around the sites of possible bug reproduction. The effectiveness of the applied preparation is preserved for about 30 days.

Metaphos is applied in the form of a 2.5% disinfecting powder (Wefatox) or one part by weight of it is thoroughly mixed with 3-10 parts by weight of DDT disinfecting or with 4 parts of talc. It is applied like DDT disinfecting powder at a rate of 12-25 g of disinfecting powder per m^2. The effectiveness of the applied preparation is preserved for about 20 days.

Trichlormetaphos-3 is used like chloraphos, but its expenditure is considerably lower. The sites of bug inhabitation and movement are treated with 0.2-0.4% solution at a rate of 0.2-0.4 g/m^2; the preparation preserves its effectiveness on a surface for 20 days.

Pyrethrum. Another effective method of destroying bugs is the application of pyrethrum powder. The reproduction sites are treated with the powder (at a rate of 4 g per m^2). The insects as a result of the effect of the pyrethrum lose their mobility, after 1-3 hours they drop and stop feeding. In cleaning up the premises it is necessary to sweep them up and burn them, because if left in a state of paralysis they die only after 5-10 days.

Fleacide (pyrethrum infusion) is more effective than pyrethrum powder, but as an inflammable liquid it requires careful attention. Its expenditure is equal to 5-6 ml per m^2 of area.

Anabasine – a 5% disinfecting powder of anabasine-sulfate with a filler of saxaul ash causes the death of bugs within 3 minutes (M. N. Parkhomenko).

In combatting bugs still other preparations find application, as kerosene, carbolic acid, acetic acid, solvent, ammonia and others. As a result of the application of kerosene bugs die within 10 seconds, turpentine – 60 seconds, and benzine – within 120 seconds. The enumerated preparations are used both separately, and also in mixtures with each other for treating insect nesting sites.

There are also used preparations, in whose composition soap is included. The number of such mixtures is very great, but we will limit ourselves to two examples: 1) green soap (or liquid household soap) 40 parts, pure kerosene or in half with 60 parts turpentine; 2) green soap or liquid household soap 50 parts, xylene 30 parts, turpentine 20 parts.

For the production of similar emulsions soap is heated with the addition of a small amount of water until a liquid consistency is obtained, after which (after removal from the fire) with constant mixing the remaining ingredients are added. The mixture can be prepared beforehand. Before using it on a site it is diluted with hot water to obtain a 10-15% emulsion. At the present time these preparations are almost not used because of the existence of highly effective insecticides. Furthermore, such preparations act only at the time of application, they soil articles and are also inflammable.

In combatting bugs it is also possible to employ the gas method. For these purposes there find application sulfur dioxide, chloropicrin and others. The new insecticides have considerably limited the use of fumigants, but they have not been completely eliminated.

Abroad in combatting bugs prussic acid is used for the disinfestation of furniture in large chambers (with a volume of 50 m^3), specially in the case of moving to another location.

High insecticidal properties are possessed by methyl bromide. In combatting bugs it is used just like prussic acid. Methyl promide has the advantage over prussic acid that it less is toxic to warm-blooded animals than prussic acid. When it is applied at a temperature of 15° at a rate of 1 l/m^3 all bugs in so. wares die after 5 hours of exposure.

Despite the fact that in such a treatment the exposure is longer than when using of prussic acid, the airing out of the premises occupies less time. Thus the overall treatment time is actually identical. The danger to workers is considerably less than with prussic acid; the list of objects, furniture and bed appurtenances, which can be subjected to treatment with methy bromide is longer than that, which can be treated with cyanide. The proposed method of disinfection is suitable for combatting the furniture beetle and the clothes moth. Among its deficiencies are the fact that its desorption from objects longer than that for prussic acid, and its vapors are $3\frac{1}{2}$ times heavier than air.

Resistance. As a result of the prolonged application of the same insecticides bugs acquire resistance to the compounds being employed. In almost all countries of the world there have been found insects resistant to the chlorinated hydrocarbons, the organophosphorous insecticides and the carbamates. The resistance of bed bugs to DDT was first noted in 1948 in tropical countries (in the Hawaiian Islands after 3 years of applying this preparation in practice for combatting bugs).

In subsequent years the presence of resistant population of bugs at first to the chlorinated hydrocarbons, and then to the organophosphorous insecticides and carbamates was established in many countries of the world: in Congo, Guiana, Israel, Iran, Greece, on the American continent. At one inhabited point in Mexico bugs were not sensitive to 1-2% DDT emulsions, and from a 4% emulsion only 10% of the insects died.

In the soviet Union the resistance of bugs to DDT in various cities was studied by N. S. Garin, M. G. Ryk-Bogdaniko, V. I. Vashkov, V. I. Zakolodkina, Ye. V. Shnayder, V. P. Dremova, V. I. Malitskaya and others. As a result of the investigations conducted it was established that in almost all cities, in which the study was conducted, resistant populations were detected. Insects according to their sensitivity to DDT and hexachlorane were 4 times (Sverdlovsk) and 37.7 times (Groznyy) lower than the insect strain. In those populated places, where sensitivity to DDT and hexachlorane had dropped, it was also lower to chlorophos (by 3-7 times).

In those places where resistance to DDT appeared, positive results were provided by treating with 0.1% gamma isomer of hexachlorane (beds and mattresses) or 0.5% (the remaining infested places in the premises), and also with 1% ronnel, 0.5% DDVP or 0.5-1% malathion. When using the enumerated preparations it is necessary to observe caution when treating mattresses and beds and to permit only weak coverage of these objects with the indicated insecticides. When using DDVP it is necessary to treat only the edges and the seams of mattresses; in no case is it possible to abundantly moisten mattresses with a solution of this compound. When using DDVP for treating mattresses it is necessary to air them out until they are completely dry at least for 4 hours before use. With negative results of treatments repeated disinfestation can be performed at an interval of not less than 2 weeks. It is necessary to avoid treating children's beds, and also cradles.

Inasmuch as bugs hide in cracks and crevices, the addition to preparations with a residual insecticidal effect of pyrethrin (0.1-0.2%) increases the effectiveness and this causes the crawling of the insects from their places of reproduction and thereby improves the contact of the bugs with the residual deposits. Diazinon is highly effective when it is used at a rate of 50 mg/m^2.

With respect to bugs resistant to DDT pyrethrin solutions (0.2%) are effective with synergists, with the use of which, however, there are required 2 or more treatments at intervals of 2-6 weeks.

The cited data indicate that in destroying bugs and other arthropods it is necessary with the appearance of resistance to change the insecticides. Such a necessity arises approximately after 3 years of application of one and the same insecticide. The employed insecticides can again be applied after 3-4 years.

Physical means of destroying bugs include dry heat; the flame of a blow torch is used to burn all sites of insect nesting, which are noncombustible (metallic parts of bugs and others). Before the appearance of pyrethrum, DDT and other insecticides this method was the most reliable, because the high temperature destroyed the bugs and their eggs in a few seconds. However this method constitutes a fire hazard and it is ineffective in the presence at sites subjected to the effect of a blow torch, of deep cracks (brick walls), where the effect of dry heat does not reach.

Steam also finds application; it is obtained from so-called bug-killers, but with respect to bugs nesting in deep cracks of walls steam is not always effective, inasmuch as it condenses near the entrance to the cracks and does not provide the penetration of heat into the depth of the cracks.

For destroying bugs in soft articles it is possible to use disinfestational chambers.

Presence of oviposited eggs in bug dwelling sites not to accessible to the effect of an insecticide, accidental omissions of bug nests in treating sites of bug reproduction — all of this serves as an indication of the necessity of repeated treatment. The periods of treatment depend on the preparation applied and the method of disinfestation. It is most expedient to time the repeated treatment to the periods of the hatching of larvae, i.e., 7-10 days after the first treatment in the case of applying preparations which do not preserve for a long time their insecticide properties on the surfaces treated with them.

For the purpose of destroying bugs there are also used varnishes and paints containing insecticides, which are applied on surfaces (sites of reproduction and movement). As a result of the application of such varnishes the surfaces preserve insecticidal properties for $1\frac{1}{2}$ years, and according to some data up to 6 years (see "Varnishes and paints").

C H A P T E R XXIV

MOSQUITOES AND THEIR CONTROL

The Pathogenic Significance of Mosquitoes

Among the blood sucking mosquitoes with medical significance is the subfamily Culicidae. To it belong the genus Anorheles, the representatives of which are carriers of malaria and 9 genera of the tribe Culicini, of which deserving special attention are the genera Aedes, Culex, Culiseta. There are more than 40 species of Aedes mosquitoes, 20 species of Culex mosquitoes and many species of Culiseta mosquitoes which are capable of receiving, preserving for a long time and transmitting the pathogenic agents of Japanese encephalitis, West Nile encephalitis, St. Louis encephalitis, equine encephalitis, dengue fever, Japanese fever, Rift Valley fever, lymphocytic choriomeningitis, tularemia, anthrax, pathogenic agents of filiariosis and many other diseases.

Of the virus diseases on the territory of the Soviet Union there was first extracted from mosquitoes a culture of Japanese encephalitis in The Far East in 1939 by P. A. Petrishcheba and A. K. Shubladze.

A year later the virus of Japanese encephalitis was extracted from 4 more species of mosquitoes.

In the western part of our country, in the Transcarpathian Region, almost 20 years later there was detected another neurotropic virus related to lymphocytic choriomeningitis (P. A. Glushchenko with co-authors, Mitamura).

Attention is being focussed on a report about the ability of C. pipiens v. pallens mosquitoes to maintain within themselves poliomyelitis virus for 3 weeks. Outbreaks of this infection were noted in May-July -- during the time when these mosquitoes are present in large numbers. In Cuba (Kalver) after decimating the population of Culex fatigans mosquitoes an outbreak of poliomyelitis was sharply reduced. Under experimental conditions C. apicalis mosquitoes picked up the pathogenic agent of tularemia and excreted it with their feces for 23 days. Mice, which ate these mosquitoes, fell ill with tularemia (V. M. Belokur). The pathogenic agent of tularemia can also be transmitted by bites. For 27 days Aedes vexans, Aedes lutescens, Man. richiardii mosquitoes transmitted this infectious disease at the time of blood-sucking (N. G. Olsuf'yev).

The External Structure of the Adult Mosquito

The body of a mosquito has a well-proportioned, elongate shape and three main sections: the head, thorax and abdomen.

The head is small and has a spherical shape; the lateral surfaces of the head are almost completely occupied by large, compound eyes. From the base of the proboscis extend two mandibular palps (antennal), attaining a rather considerable length. In the females the antennal have a small number of short hairs, but in the males due to the abundance of hairs the antennal seem fluffy. The oral organs of the mosquito form a complexly organized proboscis.

The thorax consists of 3 main parts: the prothorax, the mesothorax and the metathorax. All three parts have a similarity of rings consisting of several lamellae. The mesothorax is the best developed; to it are fastened the wings and one pair of limbs.

Mosquitoes have three pairs of legs attached to the thorax. The wings are attached to the dorsal side of the mesothorax. The latter have an elongated-oval shape with a large number of longitudinal and transverse veins.

The abdomen of a mosquito is oblong and elongated in shape, it consists of 10 segments, of which the last two differ greatly from the others. They are adapted to carrying out the function of reproduction and are called the genitalia. Between the 2nd and 6th segment of the abdomen in the pleura are 6 pairs of abdominal spiracles (stigmas).

Mosquitoes have 4 stages of development: egg, larva, pupa, image.

The Egg of Culicidae is cylindrical of cigar-like in shape with a rather flat external shell.

Mosquitoes of the Anopheles and Aëdes genera lay their eggs, as a rule, one at a time; Culex, Culiseta, Uranotaenia mosquitoes – in compact piles, reminiscent in their structure of a saucer or a small boat.

The mosquito larvae of the family Culicidae have spindle-like shape with an enlarged anterior end; the larva body consists of three sections: head, thorax and abdomen covered with a large number of variegated hairs.

The head of the Anopheles larva is egg-shaped form, broad, severely extended in a transverse direction. On the head of the larva are two pairs of eyes, inherent only to fourth instar larvae.

The thorax of the larva has a rectangular shape and consists of 3 fused segments, forming the widest section of body. The hairs covering the thoracic section are pinnate-branched which are characteristic for the genus Anopheles; nonmalarial mosquitoes do not have these hairs.

The abdomen of the larva consists of 9 segments well separated from each other. From the 8th segment on the dorsal side of nonmalarial mosquitoes extends a respiratory tube, or siphon. At the top of the siphon open spiracles, or stigmas; in mosquitoes of the genus Anopheles the stigmas are located on the stigma plate on the dorsal side of the 8th segment.

Ecological Characteristics of Mosquitoes

Malarial mosquitoes. The main carriers of malaria in our country are An. maculipennis and An. superpictus (Fig. 16, 18). The first species is very widespread. Its boundary in the north is the southern edge of the taiga. This species has also been noted in the Yakut Region. The second species is well-known in the Caucasus and the republics of Central Asia.

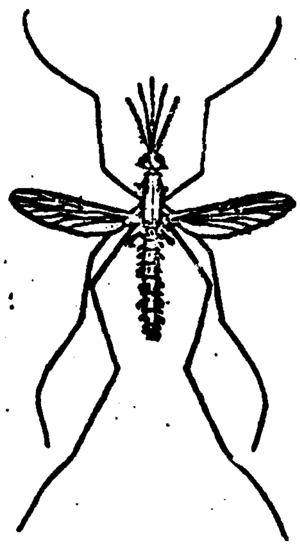
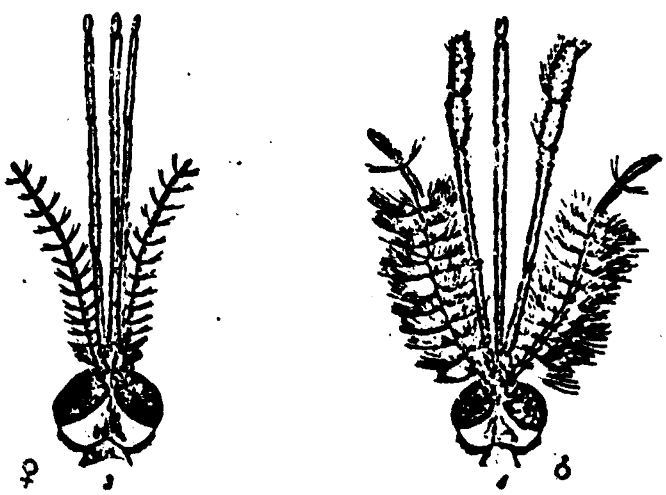


Fig. 16. The Malarial mosquito, Anopheles maculipennis.



♀ ♂

Fig. 18. The head of the female and male of Anopheles mosquito: female (3); male (4).

The breeding place of An. maculipennis are shallow stagnant or slow flowing ponds, which are not contaminated with organic substances, are well illuminated, with various floating and submerged vegetation. Mosquito larvae are found in ponds located in the floodlands of rivers, in along-shore shallow parts of reservoirs, canals, swamps, lakes, in reservoirs, quarries, rice fields and water-collecting systems.

The duration of development from egg to winged mosquito depends to a large degree on the water temperature. Larvae can hatch in reservoirs at temperatures of 7-33°; larvae are also detected in reservoirs with a temperature of 37°.

Mosquito larvae appear the earliest (in March) in the southern regions of the country. They appear latest (in mid May) – in the Yakut Region. The flight of the first generation starts in Eastern Transcaucasia and Central Asia in the middle of April, and in the northern regions of country and in the Yakut Region – at the end of June. Invasions of mosquitoes appear earliest of all in Central Asia (the beginning of May), the latest – in the north of the European part of the USSR – at the end of July and the beginning of August (N. A. Zakhar'yants, T. S. Nikolotova, N. K. Shipitsina, Z. M. Dylindina).

An. superpictus in the larval stage is an inhabitant mainly of flowing reservoirs well illuminated by the sun. It is found that the basins of drying up river beds, in rice fields with circulating water, very frequently it is detected in small depressions – hoof prints, excavations, pools, and so forth.

The first larvae are detected in the middle of April, their maximum number is reached at the end of July – in the beginning of August. In the middle of September the number drops sharply. The larvae hatch in reservoirs at a temperature of 10-37° (V. V. Almazova, G. A. Pravikov, L. V. Popov).

They pass the winter mainly as adult mosquitoes-impregnated females. Their wintering places, as a rule, are caves, burrows, hollows of trees, permises for cattle, basements, heated attics, haylofts, cellars, warm habitable apartments. On wintering the main mass of mosquitoes fly a distance of up to 3 km, individual specimens up to 18 km.

The emergence of mosquitoes from their wintering places starts with a rise in the temperature of the ambient air of up to +9°.

Nonmalarial mosquitoes. This group of mosquitoes, as was already stated, participates in the transmission of viral and bacterial diseases, and also the pathogenic agents of filiariosis. Especially are excreted mosquitoes of the genus Aëdes, which are widespread almost everywhere, especially in the deltas and floodlands of large rivers. In individual seasons their number constitutes not less than 80% of all blood-sucking insects making up the composition of blood-sucking flies collectively.

Mosquitoes of the genus Aedes winter in the egg stage. In spring from eggs laid in the previous season larvae emerge. Aedes mosquitoes are the earliest blood-suckers.

After the spring floods, when large areas are flooded with a shallow layer of water, this water in these reservoirs begins very rapidly to become heated and favorable for the development of larvae.

The most intense development of larvae occurs at 15-25°. In the southern regions of the country in spring the development of monquitoes is completed within 14-16 days, and in the northern regions – in 30-40 days. In summer at a water temperature of 30° the cycle of development lasts 6-11 days.

Winged mosquitoes in the southern republics appear in March, disappear in October-November; in the middle belt – in May and September respectively, and in the north – in the middle of June and August respectively. Then maximum number is noted in the south of our country in May, July-August, in the middle belt of the European part of the RSFSR – in May-June; in Western Siberia two peaks are recorded – the first in May, the second at the end of July-August; in the Far East – at the end of May-June; in the north – at the end of June-July (V. N. Beklemishev, A. V. Gutsevich, M. S. Dudkina, G. A. Kudryavtseva, A. V. Maslov).

Hatching mosquitoes stay about one day near the hatching site, then in short flights they move out, getting up to 2-5 km from the hatching site. In searching for food mosquitoes can fly this distance and 2-3 times more.

Frequently animals "bring" mosquitoes to populated points. Cases are well-known of the mass following of these insects for great distance after slow moving animals.

After 2-4 days the satiated females set about ovipositing. During the time of the active life – activity of mosquitoes (on the average 40-45 days, a maximum of 90) the females drink blood not less than 6-10 times and as often as that also oviposit.

The sites of egg laying are various kinds of reservoirs, ponds, etc.

Thus, for Aëdes caspius breeding sites are chiefly open reservoirs, either temporary, or permanent ones, with a clay bottom and poor green vegetation; for Aëdes communis – temporary reservoirs (puddles, ditches) with a bottom covered with leaves; the water in these reservoirs usually has the color of coffee grounds.

Aëdes cinereus prefers reservoirs of the more permanent type, poor in higher green vegetation (rivers, brooks, especially swamps).

Culex modestus (Fig. 17) has very wide distribution. In the republics of Central Asia this is the most active blood-sucker. The larvae develop in small, mainly freshwater reservoirs, rich in green vegetation and well illuminated by the sun (rice fields, ponds, wells, pit, bogs). They winter both as in the egg stage, so also in the winged stage. The latter spend the winter exclusively in vegetation.

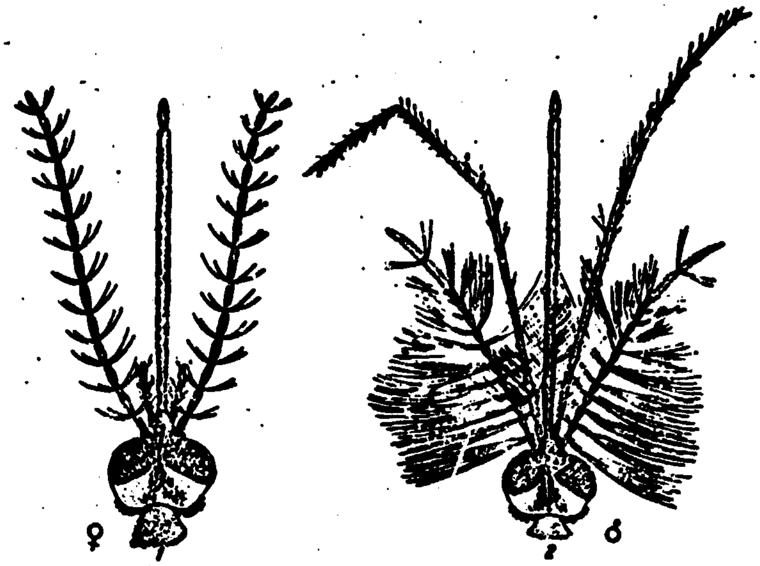


Fig. 17. Head of the female and male Culex mosquitoes: female (1); male (2).

Aëdes togoi – an inhabitant the rocky sea coast of the Yellow and Japanese seas.

Aëdes aegypti in the Soviet Union is widespread only on the Black Sea Coast of the Caucasus, where it behaves as on exceptional synenthrop.

Reservoirs of the most diverse types – barrels with rain water, tanks, bathtubs, cistern, pitchers and vases for flowers, spittoons and so forth – are populated by larvae both around man's dwellings and also inside them. Larvae can also developin hollows in trees; according to a report by Kellett and Omardeen larvae have been recorded in tree hollows up to heights of 13 m. Thus mosquitoes have very wide distribution; sites of their mass breeding exist within populated points and at a distance from them. Frequently the same reservoirs are breeding sites for both malarial and nonmalarial mosquitoes (Fig. 19).

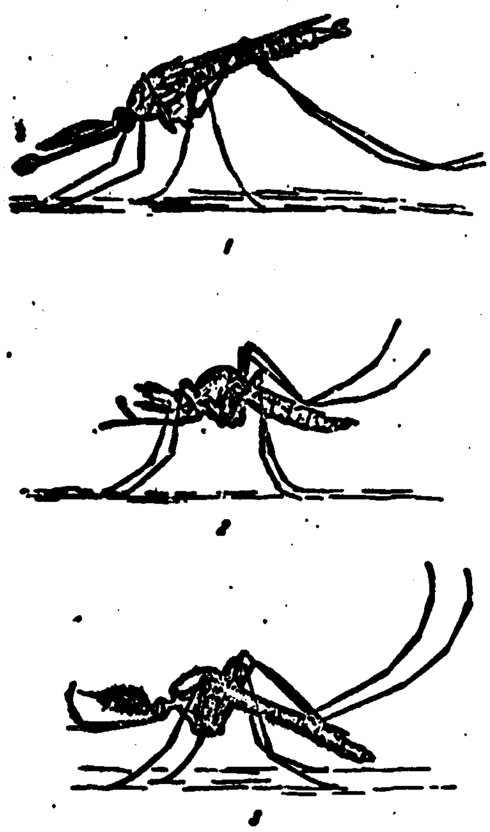


Fig. 19. The landing of mosquitoes. 1 – Anopheles maculipennis; 2 – Aedes argentens; 3 – Culex pipiens.

Man frequently creates breeding sites, which sometimes become the main sites. Considering all this, it is easy to see, that measures for protecting against mosquitoes must have two basic directions: individual and collective.

Basic Means of Combatting Mosquitoes

Measures for combatting mosquitoes are very diverse and depend on natural, industrial and domestic conditions. As a rule, mosquito control consists in destroying the winged mosquitoes, their larvae and also in eliminating and reducing their breeding sites.

The most efficient method yielding a stable, sanitary effect is the method of hydrotechnical measures.

Among the number of small-scale hydrotechnical operations are the filling in of puddles, excavations, quarries, pits, etc., in a 3 kilometer zone around populated points.

The larger reservoirs located in this same zone and not being used for industrial purposes should be eliminated, by draining off the water into the nearest river, lake, or canal.

Not of lesser significance is keeping barrels, vats and cisterns closed with tight fitting covers. Along with this it is also necessary to periodically change the water in them.

In regions with irrigated agriculture the irrigation canals should be regularly (in spring and fall) cleared of vegetation and silt. Of great importance in these regions is the strict carrying out of all the rules of water usage.

It is necessary to note, that very frequently in shutting off a branch irrigation ditch an embankment is piled up 40-60 cm from the edge of the main water-carrying irrigation ditch. In the calm pool which forms malarial mosquitoes frequently multiply.

An excellent place for the breeding of malarial mosquitoes are "hoof prints" — hoof tracks left on the banks. Thus it is expedient to set off specific watering places for cattle and it is necessary to keep a very strict watch over these sites.

It is also necessary to maintain hydrants in good condition; puddles and marshy areas should not be allowed to form around hydrants and wells.

Among the major hydrotechnical measures are the drainage of swampy and marshy areas and the preventing of their formation by reinforcing dikes, building dams and drainage ditches; at reservoirs the main prophylactic measure preventing the formation of mosquito breeding sites is controlling overgrowth (V. A. Nabokov, P. G. Sergiev, A. I. Yakusheva).

The main part of the plan of prophylactic measures should be the comprehensive and rapid detection of malaria cases, their treatment and clinical observation of them for 2 years, When necessary one should employ measures to control the carriers of malaria. At present in view of the presence of stable insecticides control of adult mosquitoes has been advanced to first place. The method of treatment (focus, barrier, solid) varies with the epidemiological indications.

Controlling Adult Mosquitoes

For combatting nature mosquitoes aviation and ground methods are used. Depending on the problem and situation insecticides are applied in the form of powders (disinfecting powders), liquids (emulsions, suspensions, solutions) and aerosols.

The best agents for destroying insects in premises are contact insecticides. For more uniform distribution of the insecticide the spraying of the liquid should be carried out at a distance of 0.5-1 m from the surface.

In spraying a suspension or an emulsion of DDT and hexachlorane there is expended per 1 m^2 of surface to be treated 60-100 mℓ of liquid, which contains 2 g of active substance.

The duration of the effect of the preparations depends strictly on the character of the surface being treated and temperature conditions. It is considered that in the middle belt inside premises the effect of DDT is preserved for 4-5 months, and hexachlorane – 2-3 months.

Under conditions of a hot climate this period is reduced by almost half.

The duration of the insecticidal effect of an aqueous emulsion of DDT at a dose of 0.8-1.0 g/m^2 is preserved 10-12 days (F. T. Korovin with co-authors).

In treating the green part of plants the insecticidal effect of an emulsional DDT decreases very slowly (in 30 days by 10%), but on glass even after 1-4 days it has decreased by almost half.

Recently chlorophos and DDVP have begun to be broadly introduced into practice. Under laboratory conditions the disinfecting powder of chlorophos at doses of 0.025-0.5 g/m^2, and its suspension in the amount of 1 g/m^2 after 5-15 minutes of contact (with wooden surfaces) causes the death of 96-100% of the mosquitoes (V. I. Vashkov, Ye. V. Shnayder).

For destroying nature mosquitoes it is sufficient to treat the surface of structures with a 2% aqueous solution of chlorophos, repeating the treatment in 2-3 weeks.

For combatting nature mosquitoes the preparation DDVP has been proposed. A dose of 0.2 μg/ℓ of air is sufficient to bring about the death of 95% of the mosquitoes. For treating premises DDVP is also employed in cartridges. The cartridge with a length of 60-70 cm and a width of 10 cm is filled with a preparation and suspended under the ceiling in premises to be treated (Hall).

The fumigational properties of DDVP are also used for treating vehicles (aircraft). For bringing about the death of nature insects it is sufficient to create a concentration of 0.2 mg/ℓ of air. The atomization of the vapors of the preparation through the ventilation system is not reflected on the sheathing of the aircraft nor on the passengers.

The Department of Agriculture of the USA has reported on the possibility of the broad use of DDVP solutions in diesel fuel, in places where birds and animals are located. A prepared 0.5-1% solution in diesel fuel is sprayed at a rate of 1 or 0.5 ℓ respectively per 2400 m^3.

Certain authors consider, that DDVP on treated surfaces preserves its toxic properties against mosquitoes for up to 3-4 weeks. In our observations loess plastering treated with 0.2% kerosene solution at a rate of 100 mℓ/m^2 causes the death of all adult An. superpictus for a period of 35 days (the period of observation).

Analogous data with respect to A. caspius were obtained by us with a 0.4% solution of phosphamide.

Metaphos is very toxic to adult mosquitoes. The minimum dose of an aqueous suspension providing under laboratory conditions the complete destruction of mosquitoes on glass is 0.01 g/m^2 on an oil surface 0.2 g/m^2, on a wooden board 0.3 g/m^2, on plywood 0.2 g/m^2, on plaster 0.6 g/m^2, on wallpaper 0.5 g/m^2 (V. I. Vashkov with co-authors).

For the one-time destruction of mosquitoes inside premises (camp tents) insecticidal aerosols (cylinders, pots, paper and so forth) can be used.

The rate of expenditure of insecticides in aerosols per 1 m^3 of premises is for DDT 0.3-0.5 g, hexachlorane 0.3 g, chlorophos 0.2-1 g. Premises treated with aerosols are kept closed for 1-2 hours when applying DDT and hexachlorane and 5-25 minutes when using chlorophos.

When carrying out of treatments it is necessary to consider the duration of the residual effect of the preparation and, proceeding from this, to plan the time for repeated treatments. It is known that the insecticidal effect of DDT against mosquitoes begins to be sharply reduced from the 20th day, and chlorophos – from the 5-7th day. Consequently, after this number of days it is necessary to repeat the treatment.

In combatting adult mosquitoes outside premises it is possible to use mechanical and chemical methods of control and zooprophylaxis.

By mechanical control is understood the clearing of woods (gardens, parks) of dead standing trees, cut shrub overgrowth. Thanks to these measures the heating up and the drainage of soil is increased. This produces a reduction in swampy areas – the breeding sites of mosquitoes.

A good effect with wintering adult mosquitoes is brought about by the burning of dead standing vegetation. Under the conditions of the middle belt this is best carried out in early spring, in the republics of Central Asia – throughout all of autumn, winter, and in spring up to the 10-20th of March before the appearance of mosquito activity.

After the mosquitoes start flying it is possible to carry out treatment of a site with insecticides in the form of powders, liquids, aerosols.

As the observations of many authors showed well treated vegetation in reliable place, where satiated females flying in for oviposition died. Aqueous suspensions of disinfecting powders and emulsions are retained well on vegetation; especially well preserved is the insecticidal effect (up to 40 days) of water-soap suspensions.

A high percent of mosquito destruction is noted with doses of active substance per 1 m^2 of: DDT and hexachlorane – aqueous suspension – 0.3 g, pastes and mineral – oil emulsions of DDT 1-1.5 g, chlorten 1 g, chlorophos 0.5 g, DDVP 0.2 g, phosphamide 0.02 g.

The duration of the residual effect for DDT and hexachlorane with treatment with aqueous suspensions is up to a month, and with disinfecting powders – 5-18 days.

A good means of diverting mosquitoes from man is by the use of zooprophylaxis. The great amount of experience in combatting malaria has showed, that the basic principle of zooprophylaxis consists in not allowing of mosquitoes to get to man. On the travel line of mosquitoes from the reservoir to a settlement a unique zoobarrier is created. And the greater the density of the cattle distribution, the more reliable the barrier. Good results were observed with a space of up to 3.5 m between cattle pens.

Considering that the basic mass of mosquitoes flying into cattle barns is composed of exophilic species, their destruction can be achieved by treating the animals with insecticides (at a rate of 30-40 mℓ/1 m^2 body surface; the surface of a horse and a cow contains about 6 m^2, a pig, calf, sheared sheep and goat – 2 m^2; nonsheared sheep and goats – 3 m^2) (A. I. Bandin).

Combatting Mosquito Larvae

In the system of measures directed towards destroying the larve of mosquitoes it is necessary to distinguish two divisions: combatting malarial and nonmalarial mosquitoes.

Combatting nonmalarial mosquitoes consists first of all in combatting larvae which are emerging from eggs which have passed through the winter, then with larvae emerging from eggs laid by females during the current year.

Beginning in early spring, when ice is still on reservoirs, and the water already has a temperature of 1-2°, the first larvae (Fig. 20) are recorded at some sites. With each warm day the number of larvae rapidly increases and attains a maximum in the period of seasonal floods and soon after the first rains. In other words, in proportion to the degree of flooding of lowlands there occurs the hatching of larvae from eggs which have passed through the winter. Considering this, the treatment of all future hatching sites – the bottom of dried-up, flood-land reservoirs and coastal lowlands flooded during the period of seasonal floods, should be carried out in autumn by the first snow. For treatment there is used DDT and hexachlorane disinfecting powder at a rate of 20 and 40 kg/ha respectively (G. G. Zima).

As was already stated, the ephemeral reservoirs are the basic producers of mosquitoes of the genus Aedes. All these reservoirs are formed in spring; due to the low temperatures the development of the larvae at this time proceeds slowly (2-3 weeks). Therefore spring inspection makes it possible to more exactly detect all mosquito producing reservoirs, to determine the zone to be subjected to treatment, and to correctly plan all measures.

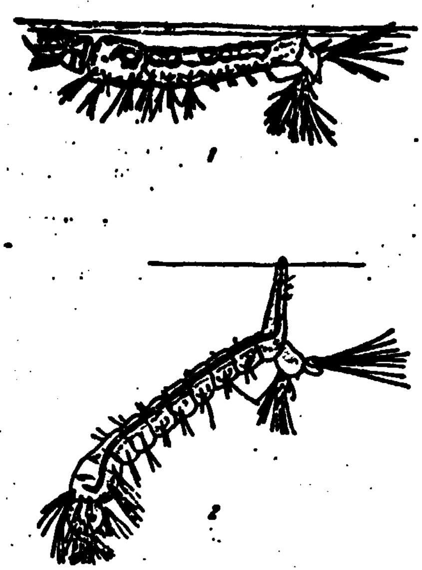


Fig. 20. Larvae of Anopheles (1) and Culex (2) mosquitoes under the surface of water in the act of breathing.

Early-spring delarvational treatment can be most conveniently conducted with the help of aviation. It is expedient in the Central-Asian republics to begin the aviation treatments in March, in Transcaucasia – in the first ten days of April, in the central belt of the RSFSR – at the end of April, in the northern regions and in Siberia – in May.

Because of the absence of leaves on the trees in period of early – spring treatment disinfecting powder loss is reduced.

In the southern regions of the country and on the southern sea coast (the Far East), where summer floods and rains promote the hatching of mosquitoes of polycyclic species, it is desirable in the second half of summer to conduct repeated treatment of mosquito hatching sites.

For treatment of reservoirs powdered preparations are used – usually 10% DDT disinfecting powder and 12% hexachlorane disinfecting powder.

The application of these insecticides in various regions of the country showed their high effectiveness. Thus, under the conditions of the Groznyy region complete destruction of larvae ensued within a day from a dose of 0.1 g of active substance per 1 m^2.

The residual effect of the preparations was preserved for more than 2 months. In the forest zone of the central belt of the RSFSR these preparations at doses of 0.1-0.24 g/m^2 caused the complete destruction of larvae within 36 hours, and the pupae – within 48 hours. The residual effect was preserved for about 1 1/2 months (V. M. Saf'yanova with co-authors, B. P. Fedyayev).

In combatting mosquito larvae the dose of DDT and hexachlorane depends on the degree of overgrowth of the surface of reservoirs and the site of their location. Thus, in the central belt for open reservoirs and reservoirs located in a deciduous forest not yet in leaf, the larvicidal dose is equal to 0.1 g/m^2, in a thick coniferous forest this dose increases to 0.24-0.3 g/m^2. Under the conditions of the Far East the dose of these preparations should be brought up to 0.5 g/m^2. Under the conditions of Central Asia for open reservoirs a dose of 0.09 g/m^2 is sufficient, and for those overgrown with shrubs and thick grassy vegetation – 0.1 g/m^2 (F. K. Makunin).

For conducting ground methods of controlling mosquito larvae there can be used all means, starting with hand means to complicated mechanisms. Thus, the treatment of reservoirs can be conducted by allowing the disinfecting powder in gauze sacks submerged on a stick in water at a depth of 25-30 cm to get into the water and by employing dusters mounted on tractors for dusting.

Good results were obtained by the allowing 10% DDT disinfecting powder at a dose of 0.5 g/m^2 to escape from these sacks; after 5 days the reservoirs were free Aëdes casrius.

In treating with 12% hexachlorane disinfecting powder the dose is cut in half; the effective action lasts about 1 1/2 months.

For the dusting of insecticides it is possible to use the high-speed pneumatic duster – OPS-30B mounted on a tractor, and a TsNIDI blower duster with a weight of 22 kilograms. A powerful stream of air atomizes the disinfecting powder up to a distance of 30 m.

In certain enterprises of our country (licorice and jute-hemp factories) production technology requires the setting up of a large number of pits, in which the raw material is soaked. These so-called soaking pits are an excellent breeding site for nonmalarial mosquitoes (mainly Culex pipiens). For combatting larvae in these reservoirs F. K. Makunin suggests kerosene and hexachlorane at a rate of 100 ℓ/ha and 80-85 kg/ha respectively.

In California (the United States) for combatting mosquito larvae at enterprises for the processing of olives in vats emulsions of malathion and parathion (close to the Soviet preparations carbophos and thiophos) are poured in doses of 0.15 and 0.002 mg/ℓ. V. M. Caf'yanova reported about the possibility of employing thiophos disinfecting powder as a larvicide for Aëdes and Culex. For laboratory experiments there were taken 5 parts of talc by weight and to it there was added one part of 1% thiophos disinfecting powder by weight. As a result of the application of 2.5 mg/m^2 of this disinfecting powder within 10 hours all Aedes caspius larvae died, and within 14 hours — all the pupae. For obtaining analogous results in nature a doubled dose of thiophos is required. For combatting mosquito larvae in the United States dieldrin, heptachlor and toxaphene are applied. In severely overgrown reservoirs up to 90% of the Aedes larvae died from 0.01 g/m^2 of toxaphene. With a single treatment with granulated heptachlor and dieldrin a swamp was liberated from larvae for 62-26 days respectively.

In Brazil the toxicity of aqueous suspensions of certain organic insecticides has been studied. In an experiment third instar larvae were taken; the LD_{50} in grams per 100 mℓ for the gamma isomer of hexachlorane was 7.6; aldrin 5.4; DDT 6.2; toxaphene 14; dieldrin 9.3; heptachlor 11.2; methocychlor 4.4; malathion 5 and 5.6; chlordane and sevin more than 100.

The residual effect of heptachlor at a dose of 5.6 kg/ha lasts 7-14 weeks.

Baytex turned out to be a highly toxic preparation. Even at a dilution of 1:1,000,000, 99-99.5% of the larvae died (Kellett, Gilkes).

For combatting larvae and pupae emulsions are also employed. Complete destruction was observed with the use of a 25% DDT emulsion at a dose of 0.1 g/m^2, with the application of 50% DDT paste and a 65% concentrate of chlorten and chlorindane at a dose of 0.03 and 0.1 g/m^2 respectively a reservoir is liberated from larvae for a period of from 32 to 60 days. After this period in the reservoirs larvae appear from eggs laid by females of the population of the current year.

Complete destruction of mosquito larvae for 24 hours was noted as a result of the application of polychlorpinene at a dose of 1 mℓ of concentrate per 1 m^2 of water surface.

In recent years the derivative preparations of phosphinic acid — Bayer-L-13/59, dipterex, DDVP and chlorophos have gone through broad testing.

Foreign scientists have used water-soluble Bayer-L-13/59 for combatting mosquito larvae in irrigation water. The larvae of Aëdes, Culex, Anopheles mosquitoes are completely killed by water containing 1 mg/ℓ of the preparation or in dilution at 1:1,000,000.

The preparation dipterex gave an analogous effect at a dose of 0.5 mg/ℓ, and parathion — at a dose of 0.02 mg/ℓ. It is necessary to note that water treated with these preparations was toxic to mosquito larvae at a distance of up to 3 km downstream.

In California (the United States) against mosquito larvae DDVP emulsion has been applied. With coarse-drop spraying of a reservoir with 0.12 and 0.25% emulsions at a rate of 95-140 ℓ/ha complete destruction of larvae was observed; the mosquito eggs taken from these reservoirs were mainly lifeless, and if larvae did emerge, they immediately died. The residual effect of DDVP emulsion was somewhat more than twenty-four hours. The DDVP was also tested for destroying the eggs of Aëdes aegypti mosquitoes. With the concentration of the preparation in a solution at 0.06 μg/ℓ from 87 to 100% of the eggs died.

Field experiments showed that as a result of the application of 1.12 kg/ha of granulated preparation more than 95% of the eggs died.

Chlorophos – a domestic preparation, is also highly toxic to mosquito larvae. It was ascertained that complete destruction of Culex molestus is provided by a dose of 0.5 g/m^3 or by a concentration of 0.00005%. The authors note that 0.001% solutions provide complete destruction of larvae within 2 weeks. Under practical conditions or for combatting mosquito larvae in small reservoirs (vats, pits, ditches) there is recommended the application of 1 g of preparation per 1 m^3. Complete destruction of mosquito larvae is achieved as a result of the application of 0.15 g/m^2 of a 1% chlorophos solution. Considering that the residual effect of the preparation is very short, repeated treatments are recommended after 8-10 days.

Acetoxon stands close to chlorophos by virtue of its insecticidal effect on mosquito larave. Solutions at a dilution of 5:10,000,000 (0.5 g/m^3) caused the complete destruction of larvae.

In order to guard sanitized reservoirs against infestation by females it is recommended that insecticidal barriers with a width of 20-50 m be created around these sections. As observations have shown, such a barrier inhibits the infestation by mosquitoes of the protected section and thus, the sanitized reservoirs for a prolonged period of time are not used for oviposition. Consequently, an object located on such a section, will be protected from mosquito attack for a prolonged period of time (A. V. Maslov).

It is desirable to carry out the creation of barriers in spring before the beginning of the flights of mosquitoes. Under favorable meteorological conditions for the development of mosquitoes the barrier treatment should be repeated not less than twice in a season. To avoid the infestation by mosquitoes from an inhabited locality it is necessary to treat with contact insecticides not only all the cattle sheds, nearby structures and vegetation, but also the vegetation in the zone of the protected section located on the animals travel path from the pasture to the inhavited locality.

The height of treatment of the vegetation can be limited to the lower layer. In creating insecticidal barriers around children's establishments the treatment of the vegetation should be carried out up to a height of 2 m.

In combatting the preimaginal stages of mosquitoes with insecticides there exists an essential deficiency — for destroying pupae higher dosages are needed than for larvae. Any increase in the dose of insecticides does get by without affecting other habitants of the reservoirs (Table 40).

According to O. V. Sore, in treating reservoirs at a rate of 200 g/ha with a DDT preparation, the latter for a period of 2 years is detected in fish.

Proceeding from what has been said above, a new method of combatting the preimaginal stages of mosquitoes is attracting attention — the gas-foam method proposed by V. S. Odintsov. The principle of the method consists in the fact that the water surface is covered with foam, the former of which is sulfur dioxide, the basis — the foaming solution.

The foam covering the water surface is retained for several hours and even for several days. Thanks to this conditions are created for isolating the water surface from the air medium by the layer of sulfur dioxide.

Mosquito larvae and pupae, as is known, breathe air, and to do this they rise to the surface and put out a siphon. When the water surface is covered with foam with sulfur dioxide conditions are created in which the larvae pupae breathe the poisonous gas and die.

Table 40. Application of insecticides against mosquito larvae.

No in order	Preparation	Dose	Method of application	Effectiveness	Residual effect	Test site	Source
1	10% DDT disinfecting powder	1-1.5 g/m^2	Ground	Destroys first – third instar larvae	7-10 days		M. L. Fedder (1947)
2	The same	0.2 g/m^2	Aerial dusting	Complete destruction of all larvae	55 days	Central belt of the European part of the USSR	B. P. Fedyayev with co-authors (1957)
3	The same	0.1 g/m^2	Aerial dusting in water	The same	All season	The same	V. M. Saf'yanova with co-authors (1957)
4	25% DDT emulsion	0.025 g/m^2	Hand treatment	All larvae die	All season	The same	V. M. Saf'yanova with co-authors (1957)
5	50% DDT paste	0.03 g/m^2	Aerial treatment	The same	Up to 2 months	The same	P. A. Petrishcheva with co-authors (1955)
6	12% HCCH disinfecting powder	0.24 g/m^2	Aerial treatment	The same	25 days	The same	M. F. Shlenov with co-authors (1953)
7	The same	0.024-0.06 g/m^2	Aerial dusting	The same		Tashkent	F. K. Makunin (19[illegible]9)
8	The same	0.05-0.06 g/m^2	Ground	The same		Central belt of the RSFSR	M. F. Shlenov (1957)
9	12% DDT disinfecting powder	0.4-0.6 g/m^2	Aerial dusting	Complete destruction of all larvae	2-2½ months	The same	P. A. Petrishcheva with co-authors (1955)
10	The same	0.24 g/m^2		Larvae and pupae die	1½-2 months	The same	M. F. Shlenov with co-authors (1958)
11	Chlorten, 65% concentration	1 g/m^2	Aerial treatment	All larvae die	2-2½ months	The same	P. A. Petrishcheva with co-authors (1955)
12	Chlorten, 65% concentration	1 g/m^2	Aerial treatment	The same	2-2½ months	The same	The same
13	Polychlorpinene concentrate	1 ml/m^2	Ground	The same	7-9 days	Belorussian SSR	G. F. Dem'yanchenko (1961)
14	Parathion	0.2 mg/ℓ	Added to the water stream when irrigation rice fields	All larvae die at a distance of up to 9 km downstream	24 hours		Gahan (1957)

Table 40. (Cont'd)

№ in order	Preparation	Dose	Method of application	Effectiveness	Residual effect	Test site	Source
15	Baytex, $1 \cdot 10^{-5}$ concentration in water		Under laboratory conditions	99-99.5% of the larvae of Aëdes, Culex mosquitoes die			Kelleff with co-authors (1960)
16	0.2% thiophos disinfecting powder	2.5-5 mg/m^2	Hand treatment	The larvae and pupae of Aëdes mosquitoes are all killed and Culex larvae - 87%			V. M. Saf'yanova (1953)
17	Dipterex	0.5 mg/ℓ	Added to the water stream when irrigating rice fields	All larvae die downstream at a distance of up to 9 km	5 days		Gahan (1957)
18	1% Chlor[illegible] solution	0.15 g/m^2	Ground	All larvae die	7-9 days	Belorussian SSR	G. F. Dem'yanchenko (1961)
19	1% Chlor[illegible]	0.5 g/m^3	Laboratory experiment	All larvae of C. molestus mosquitoes die	Up to 2 weeks		V. I. Vashkov, E. V. Shnayder (1962)
20	1% Chlorophos	1 g/m^3	Treatment in nature	Larvae and pupae die	Up to 2 weeks		Ogden with co-authors (1960)
21	Granulated DDVP	1.12 kg/ha	The same	About 95% of the eggs of A. aegypti mosquitoes die			Judson, Hakama, Bray (1962)
22	DDVP concentrate	0.0002% solution	Laboratory experiment	An. pulcherrimus larvae of the fourth instar all die within 3 hours			E. B. Kerbabayev (1963)
23	DDVP with polyphosphanate	0.0007% solution	The same	The same within $2\frac{1}{2}$ hours			The same
24	Methyl-ethyl-thiophos	0.00006%	The same	The same			The same
25	Phosphamide	0.0001%	The same	The same			The same
26	Phosphamide	0.003% solution	The same	All A. caspius larvae of the fourth instar died within 30 minutes	Through 31 days all larvae die within 75 minutes		The same

Complete destruction of the mosquito pupae and larvae occurs within 3-4 hours.

Other representatives of the water fauna are not subjected to the effect of the gas, since it volatilizes and in time the foam completely vanishes.

As the experiments showed for treating 1 hectare of surface 100 ℓ of the foaming agent solution and 0.5 kg of sulfurous anhydride are required. In combatting larvae and pupae in a malarial focus along with the above named preparations oily substances are employed: petroleum and its by-products, and also lubricating oils and powdered poisons (Paris green, arsmal [Translator's Note: copper-arsenic insecticide], calcium arsenite, thiodiphenylamine and others).

The methods of petroleum treatment are very expensive, but in certain cases they can be applicable. For the delarvation of reservoirs with slow flowing water the drop method is applied. On a board spanning a gutter, irrigation ditch or canal there is placed a barrel with oil, through a hole in the bottom of the barrel there is placed a cloth wick. The liquid escapes along this wick and drop by drop is discharged into the water and spreads over it in a thin film. This film spreads to all places with inhibited flow, where the larvae of the malarial mosquitoes accumulate.

The liquid from the barrel-dripcock should proceed at a rate of 1 drop per second for a ditch width of 1 m and with a speed of water flow of 0.1 m s. The working time of the barrel is not less than 5-6 hours. During this time there will be santized an area up to 400-500 m downstream.

For the purpose of decreasing the expenditure of larvicide it is possible to apply the roll-over method (the stage method). Across a canal there is placed on board, which arrests only the surface layer of water. Upstream an oily larvicide is discharged; it is retarded by the crosspiece, spread over the surface and kills the larvae located in the impounded space. After 2-3 hours this crosspiece is removed; the whole oily film rushes downstream, where at a distance 100-150 m it is again retarded by a new crosspiece. Thanks to this method one portion of oil moving in stages liberates several sections from mosquito larvae.

In treating of large water surfaces it is also possible to use oil. Open reservoirs are sprayed on an average per 1 m^2 with 30 g of oil, those covered with vegetation with 40 g, heavily overgrown sections with 50-60 g.

In combatting malarial mosquitoes with powders arsenic preparations can be applied. The latter are diluted with neutral dust-like additives: road, forest, peat dust, talc and so forth.

Along with larvivorus fish it is necessary to raise herbivorous fish – white amur and silver carp, which, feeding on the young sprouts of water plants limit reservoir overgrowth.

The Application of Aerosols in Combatting Mosquitoes

Methods of obtaining and applying mists (aerosols). For the production of mists mechanical, thermal and thermomechanical methods are used.

Aerosols of the mechanical type are obtained with gases condensed under pressure with centrifugal and piston compressors and spinning disks.

Aerosols of the thermal type are obtained by heating an insecticidal liquid in a vessel from a kettle to a large boiler), by sublimating the insecticide located in combination with a thermal mixture (charge, briquettes).

An aerosol of the thermomechanical type is produced by using thermal energy and the speed of the exhaust gases of internal combustion engines and engines of the pulsating type (turbojet engines).

For producing aerosols of the mechanical type it is possible to use automobile equipment - DUK-1, DUK-2, OKS and ONK-B combined sprayers and others.

Aerosols of the thermal type. The first attempts at creation smoke pots in our country were made in 1935, when A. V. Gytsevich and V. Ya. Podolyan proposed pyrethrum candles. For the production of an insecticide effect against dipterous blood-sucking flies a dose of 0.5-1 g of candle per 1 m^3 was required.

Starting with 1953, in Soviet Union insecticidal aerosol bombs began to be tested.

In an area treated with one NBK[1] bomb the mosquitoes died within 30-40 minutes and were practically absent during the next few days.

With a single smoke treatment of not less than 30-50 ha of open terrain at a rate of one bomb per 1 ha (1 kg/ha) the number of mosquitoes does not increase for a period of 5-10 days.

Observations of the effectiveness of insecticidal aerosols showed that not only the amount of preparation, but also the area subjected smoke treatment determines the duration of liberation from persistent blood-sucking flies.

It is acceptable to consider that with a steady wind, blowing at a speed of 0.5-1.5 m/s, one NBK-G-17 bomb provides a uniform smoke treatment of a territory with an area of 1 ha. Moreover, the highest concentration of the preparation, which was lethal for adult mosquitoes, was noted within the distance of the first 100-150 m from the bomb. Over more distant sections the toxicity of smoke treatment sharply decreases, but it can be provided by exposure, i.e., by the transit time of smoke. The minimum necessary time for poisoning 100% mosquitoes with smoke from NBK-G-17 bombs is an exposure at a distance of 100 m of 1-3 seconds, up to 300 m of from 5 to 30 seconds, up to 400 m about 5 minutes.

In order to increase the initial concentration and density of smoke it is necessary to reduce the distance between bombs by up to 10-15 m. In this case a toxic dose of smoke is provided by 2 bombs under conditions of open terrain up to 2 km, in a sparse forest up to 300 m, in a thick forest up to 200 m. From 3 bombs smoke spreads up to 500 m into a sparse forest (K. P. Andreyev, A. M. Mitrofanov).

The penetration of smoke into the depth of a forest depends both on the character and the density of the forest, and also on the speed of the wind. Thus, with a wind speed of 1-2 m/s smoke penetrates up to 100 m into a thick, deciduous forest, and into a thick coniferous forest – up to 180 m; into sparse forests – 180-380 m respectively. With a wind speed of 8 m/s insecticidal smoke can penetrate into a sparse forest to a depth of from 260 m (deciduous) to 600 m (coniferous). With a mild wind smoke fills hollows, where it settles, and with a high wind it jumps over hollows.

In each case it is necessary to consider the situation and proceeding it to determined the necessary number of bombs per 1 ha and how they should be deployed – in one line or in two – in checkerboard fashion. Smoke according to the degree of movement settles both over land and over water.

Mosquito larvae swallow particles of the poison or come in contact with it and die. Considering that the larvae of Aëdes mosquitoes are for a long time on the bottom, it is necessary that the smoke treatment of a reservoir be carried out for 20-50 minutes and then it is possible to attain complete destruction of the larvae.

At a wind speed of 0.5 m/s a decrease in the number of larvae is noted at a distance of up to 170 m; with a wind of 1.5 m/s up to 50 m.

Aëdes vexans and Culiseta bergrothi larvae die within 24-36 hours at a distance of up to 400 m from a dose of 0.03 g/m^3, from NBK-G-17 aerosol bombs. From a smoke[2] mixture of DDT and hexachlorane at a dose of 0.02-0.05 g/m^2 there is observed complete destruction of the larvae and adult mosquitoes at a distance of up to 500 m within 12 hours; the imagoes died at a distance of up to 500 m within 24 hours.

Thus, for destroying mosquitoes in a region for a short period of time insecticidal aerosol bombs can be used. In preparing a site for a short-term respite it is possible to smoke the region at a rate of 0.1-0.5 kg/ha (2 bombs per 3 ha); for a stay of several days it is necessary to increase the dose to 1 kg/ha, treating not less than 30 ha. In preparing a site for a short-term stay one should apply "the moving bomb" method (V. A. Nabokov, G. I. Getta).

The treatment of the site is carried out from the leeward side; deeping the bomb in the hands or on a "sleigh," it is moved along a 200-300 m front. It is desirable the first thing in the morning before the arrival of those who are to sojourn there to smoke reservoirs, groves and other places where mosquitoes spend the day.

In combatting blood-sucking flies in premises bombs can also be successfully used. One NBK-G-17 bomb is sufficient to destroy all blood-sucking in premises with 500 m^3. And the residual insecticidal effect is preserved up to 10-15 days.

Considering that insecticidal aerosol bombs can be used only once, after which the container is discorded, and also the fact that the transportation of ready-made bombs is inconvenient in view of their bulkyness, it is possible to successfully use a multiply acting bomb – the IDG-3 smokegenerator.

For a one-time destruction of mosquitoes in premises with a smokegenerator a dose of 0.3 g/m^3 is applied, to produce a residual-effect the dose is increased by 5 times. Under the conditions of open terrain to produce analogous results the doses are respectively 5-6 kg/ha. Mosquitoes will be observed dying at a distance of up to 800 m.

In recent years tests have been conducted with chlorophos aerosols.

With the burning of "aerosol paper"[3] at a rate of 50 mg of preparation per 1 m^3 all the mosquitoes (Culex molestus) died within an hour (G. G. Tsintsadze and others).

Of the aerosols of the mechanical type broad application in living quarters, in berths, on aircraft can be found for insecticidal cylinders.

An insecticide dissolved in freon is dispersed due to the evaporation of freon at room temperature, and the higher temperature, the less the dose should be.

For producing doses toxic to insects the criterion determining this dose is the feed time of the aerosol from the cylinder. From an application of freon aerosols of 3% DDT and 5% hexachlorane and 2% extract of pyrethrum at a temperature of 21-22° mosquitoes (and flies) in premises died within 5-10 minutes with a dose of 10-15 s per 100 m^3 (i.e., 0.1 s/m^3).

Aerosols of the thermomechanical type. For combatting blood-sucking arthropods in a state of nature and for a one-time destruction of insects over large territories aerosols of the thermomechanical type are the most practicable.

In the Soviet Union the introduction of aerosol technology was begun in 1949 (V. F. Stepanov).

At the present time generators of various types are being used, beginning with light ones — "Micron" (19.5 kg) to powerful aerosol generators mounted on motor vechicles and even on tracked cross-country vehicles (AG-L6; AG-UD-2; GBA-25; TDA; MAG and others).

As toxic agents there are applied: technical DDT and hexachlorane, 65% chlorten, polychlorpinene. As solvents — solar, spindle and green oil, diesel fuel and petroleum distillate extract.

Working solutions getting into the vaporizing chamber are volatilized and outside the generator, condensing, are turned into a smoke cloud. The moving cloud envelops all objects, drifts into all uneven sections of the soil. The speed of treatment and the area covered with smoke depend upon the productivity of the generator and favorable natural conditons. Thus, small aerosol generators turn into an insecticidal cloud within a minute up to 1 ℓ of a working mixture; AG-L6 – up to 6 ℓ; AG-UD-2 – up to 9 ℓ, and MAG – up to 100 ℓ/min.

The insecticidal aerosol cloud produced possesses high toxicity to adult mosquitoes. In those places through which the mist posses their complete destruction is provided. The residual effect of the mist is very short (1-6 days). In the process of settling on a water surface there will be formed an insecticide-oil film, which is retained for about 3 hours.

For the production of a stable aerosol deposit the diameter of the particles should not be less than 45 μ. The largest particles occur in immediate proximity to the generator. Thus, the diameter of particles of AG-L6 at distance of 25 m varies from 10 to 80 μ, 50 m – 10-50 μ, 100 m – 5-30 μ, 500 m – 0.5-1 μ.

With the latest generators where it is possible to regulate the dispersiveness it is possible to obtain a cloud with a diameter of the particles, which practically do not settle and, conversely, the main mass of the cloud can settle. Therefore depending upon the problem it is necessary to apply the existing technical possibilities.

The most favorable conditions for applying aerosols over an area are observed with a temperature inversion and isothermy. In the first case in the lower layers (near the soil) air temperature is higher than at a height of 2 m; in the second – temperature along the vertical does not have a transition; it is identical in all layers. In an inversion, which acquires complete development after sunset and is disturbed within 1-2 hours, a stable air state is created, which is necessary for treatment.

Isothermy frequently forms during overcast weather and in the predawn hours in summer.

For treating plavni [Translator's note: flooded areas] it is possible to use the day, morning and evening hours. During the day treatment should be carried out from the reservoir, since the layers of air and the aerosol cloud move in the direction of land. In the morning and evening the smoke screen is carried from the land, because the cloud will be rushing toward the middle of the reservoir.

Under the conditions of a forest zone only the part of an aerosol cloud right near the periphery (field, edge) gets into the heart of a forest. Its basic mass moves swiftly over the forest. Due to the fact that strong vortex streams are created over the forest, the cloud is attracted downwards. As a result of this the penetration of the aerosol into the depth of the forest, into the calm zone is provided.

Calculating and Evaluating the Results of Combatting Mosquitoes

Reservoirs are inspected before treatment and 8-10 hours after treatment.

Calculation is carried out with a standard net made from No. 29-35 silk mesh with a diameter of 20 cm, a depth of 25 cm, a handle length of 1 m. Each probe serves as a unit of calculation — a sweep with the net through the water for a distance of 1 m. In doing this the net is submerged halfway up the rim and it is passed through the water parallel to the shore. The contents of every probe are calculated taking into account the stage of development. The quotient from the division of all larvae and pupae by the number of probes conveys the number of larvae and pupae in a given reservoir.

In treating small (200-300 m in circumference) reservoirs 20 probes are taken each 10 steps. In large reservoirs all places differing sharply in the character of vegetation and the conditions of illumination are inspected. If the conditions are identical probes are taken each 300 m. At each of the inspected sites 10 probes are made.

For inspecting small, shallow reservoirs A. S. Monchadskiy suggests using a gauze disk with a diameter of 10 cm. The disk is submerged almost to the bottom, in an attempt to get it under the larvae, then the net is pulled up quickly and the caught larvae lying on the gauze are washed off into a small tub or in a test tube.

If upon inspection of the reservoirs larvae older than first instar are netled, this indicates that the measures carried out were unsatisfactory. If the number of larvae in even one probe does not exceed 0.1, then in this case with a large water surface the number of adult mosquitoes produced by this reservoir will be appreciable. Thus after establishing the boundaries of the areas where larvae still exist this section is treated once more.

Calculating the Number of Adult Mosquitoes*

Various methods exist for calculating nature mosquitoes:

1. A calculation is carried out once in five days at five different sites of the same zone. At each site mosquitoes are caught with a standard net (the diameter of the hoop is 30 cm, the length of the handle – 30 cm, the depth of the net – up to 60 cm) at three points. The mosquito catching is carried out at twilight, when the insects are the most active. One hundred sweeps with a net (one sweep per second), or 3 minutes of catching around oneself constitutes one calculated catch. The caught mosquitoes are killed in an insect-killing for and after 3-5 minutes are dumped from the net into a paper packet or test tube.

2. The catching of mosquitoes at their daytime rest sites is carried out with a Ye. N. Pavlovskiy catching cylinder, an ordinary test tube, a test tube-live box and aspirators of various types.

A sitting insect is covered by the bottom of the cylinder, livebox, test tube or aspirator. The insect gets inside through a hole.

3. The K. A. Breyev method of collecting blood-sucking flies is based on attracting insects to an animal. The catching of the insects is begun at the head and then is carried out on each section of the body only once.

4. A. S. Monchadskiy and Z. A. Rodzivilovskaya proposed the method of catching them "on one's self."

A man sets motionless under a suspended "bell" for 5 minutes, then he is quickly covered with the bell. All the insects trapped under the bell are collected. Usually the collecting of the insects is carried out with an aspirator. It is necessary to note that the collecting of insects with a labial aspirator is very laborious, thus it is better to apply the hygienic mosquito-catching systems of V. A. Nabokov and Yu. A. Zayfert.

We successfully replaced the aspirator with a small air net (diameter of 20 cm): the lower edge of the bell is pressed to the earth with the leg and on drawn fabric with a rapid movement the catching of insects is accomplished. Usually within 2-3 minutes it was possible to carry out the complete collection frequently of insects number in the several thousands.

For collecting insects from under the bell A. N. Alekseyev proposed a mechanized process.

To the intake manifold of a motor vehicle with a sleeve connection of a windshield wiper there is joined a hose on the other end of which there is placed a catching cylinder into which all the insects are sucked.

5. K. A. Breyev proposes carrying out the catching of the insects with a bell not "on one's self," but on an animal.

6. Yu. A. Berezantsev developing K. A. Breyev's idea recommends sewing the bell not out of white coarse calico, but out of a dark, closely woven material and with a height based only on the animal. And on the dome of the bell there is left a hole, framed with a metallic ring and closed with a cap of gauze. The insects getting under bell try to fly toward the light and, consequently, get into the cap.

The caps are replaced every 5 minutes.

7. K. V. Skuf'in proposed a stuffed animal-trap: a wooden framework is fastened to 4 poles, it is covered with a dark fabric; over the stuffed animal there are places traps of the net-like fly trap type.

The insects are attracted by the stuffed animal; they crawl under it, get into the dark space, see the light, rush toward it and get into the trap. The time of each calculation lasts 20-60 minutes.

In 1961 M. L. Fedder, E. B. Kerbabayev and A. N. Alekseyev made a comparative appraisal of the methods of calculating the number with a Monchadskiy bell with sticky sheets (BUChN-100) and by catching with an air net "on one's self."

Under the same meteorological conditions the total numbers of insects (midges) caught on the sticky sheets was analogous to the number caught with a bell during the same time interval.

With net catching their were always fewer insects (midges); the difference was more noticeable with a large number. However, the dynamics of the number were identical.

Considering this, and also the fact the method of catching with an air net is very simple and convenient; it can be successfully employed at permanent stations and also while on the move.

The obligatory conditions when using this method are standardization of the catching conditions, the size of the net, uniformity of net movement, clothing with a black color when calculating the midges and so forth.

Footnotes

[1]NBK the initial letters of the surnames of the authors: V. A. Nabokov, V. V. Burley, V. I. Kazakova who developed the formulas and technology for the G-17, and also for the D-17 and D-20 bombs.

[2]For the simultaneous sublimation of DDT and hexachlorane there were employed the bombs proposed by S. S. Degtyarev and O. S. Sakovich. The authors reconstructed "DM-11" smoke-screening bombs introducing in them 50% disinfecting powder of 25% technical preparation of DDT and hexachlorane.

[3]Aerosol paper is prepared by soaking filter paper in a solution of 10% chlorophos and 7% potassium saltpeter (KNO_3). For 100 cm^2 of paper 2 mℓ of solution are used (or for 5 m^2 of paper there are used 5 ℓ of solution).

[4]An analogous method of calculation is also applied for adult gnats and midges.

CHAPTER XXV

MIDGES AND THEIR CONTROL

Midges and their significance in pathology. Midges belong to the family Heleidae (ceratopogonidae); they number more than 350 species 18 genera; they are very widespread throughout the world.

In our country there have been recorded three blood-sucking genera: Culicoides Latreille, 1809; Leptoconops Skuse, 1890, and Lasiohelea Kieffer, 1921, and they are recorded from the central mountain belt right up to the tundra itself.

The most characteristic landscapes for them are the forest and taiga regions; here they are widespread almost everywhere.

Midges are the smallest of the blood-sucking diptera (1-4 mm). Their eyes are well developed and kidney-shaped; their proboscis is short; the wings in the majority of species have spots; they are covered with hairs. Their wings at rest are folded above the abdomen. Their legs are well-shaped and elongated.

In certain places midges are mass ectoparasites and greatly harass people, agricultural and game animals. Midges are annoying not only under natural conditions, but sometimes even in dwellings.

Landing on the body, female midges begin to move about rapidly and look for a suitable place to bite.

During blood-sucking these insects inject a toxic saliva and after biting severe itching appears and papules form. The persistent harassment by the midges and the severe itching sharply (by 15-30%) decreases labor productivity, reduced the yield milk of cattle and causes all animals to lose weight.

Midges have been established as intermediate hosts Filaria (Onchocerca gibsoni, O. cervicalis, Acanthocheilonema pertans, Mansonella ozzardi, Onchocerca cervicalis), which they transmit by biting man and animals.

In tularemia focuses in western Siberia strains of this infection have been extracted from midges. In the western Ukraine from Culicoides pulicaris midges neurotropic virus has been extracted (A. V. Gutsevich and others).

Under experimental conditions there was ascertained the possibility of transmitting Haemosporidia – Hamoproteus nettionis, H. canachites – to domestic and wild ducks by biting them.

Midges of the genus Culicoides transmit African catarrhal sheep fever – blue tongue disease, African horse plague and Venezuelian horse encephalitis (Fallis).

In the province of Fukien (Chinese Peoples Republic) from Lasiohelea taiwana midges there was extracted Japanese encephalitis virus. Also the curve of seasonal dynamics of the number of midges coincides with the curve of disease incidence (Chang and others).

Ecologic characteristics of midges. No matter how broadly midges are distributed, there are nevertheless in each topographico-geographical zone regions with an abundance of these insects, moreover there is even the confinement of individual species to specific topographies.

Thus, if in the forest-tundra zone in the region of 68° north latitude only three species are recorded, then in the Caucasus there are 58, in the central belt – 14, in the Ukraine – 10, in Kazakhstan – 20, in Turkmenistan – 7, in the Far East – 29 species.

The most widespread are the midges of the genus Culicoides, of which 18 species are numerous. In the mixed forest and taiga zone the species, Culicoides nubeculosus, C. stigma, C. arakawae, C. pulicaris, C. fascipennis, C. chiopterus, dominate.

In the steppe zone C. riethi predominates; also numerous are Culicoides pulicaris, C. pictipennis; C. fascipennis dominates in the forest – tundra in Turkmenistan – C. puncticollis, C. desertorum; in the Caucasus – C. obsoletus, C. puncticollis, C. saevus.

Midges breed in stagnant water (puddles, hoof prints, ponds), in humid soil, marshy areas around springs, mochezhinas [Translator's Note: land permanently wet from outflow of underground water], rice fields in humid shore soils of low-land and foothill reservoirs. Cases of the mass breeding of midges on the bottom of stagnant canals and in tree hollows are known.

In our country the breeding and distribution of the basic species of midges are intimately connected with river valleys. Especially favorable conditions for the development of midges exist in floodlands and river deltas with deep, stagnant, ground water. The soils moreover can be of the most diverse types – from marsh-meadow to saline-sand (Fig. 21).

Under the conditions of the forest zone midge reproduction also takes place in humid forest floors. Frequently excessively wet, rotting wood is a very conducive place for the breeding of midges.

In the Central Asian Republics midges develop in great numbers in troughs for the watering of cattle.

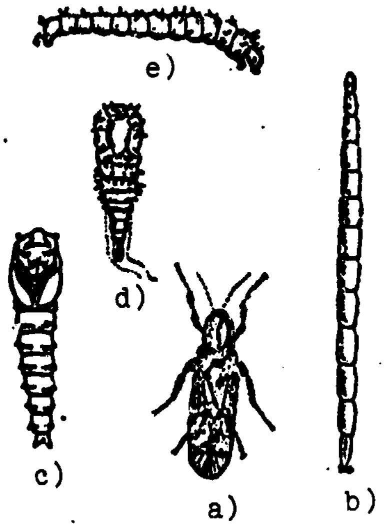


Fig. 21. Various stages of midge development. a) female; b) larva of one of the species developing in water; c) pupa of one of the species developing in water; d) larva of one of the species developing on land; e) pupa of one of the species developing on land.

Larvae do not develop in very shaded reservoirs and in reservoirs with a flow faster than 1.5 m/s.

Midge larvae developing in water, are light, thin (up to 2 cm in length), thread-like creatures; they move in a twisting serpentine manner.

Larvae developing on land are short and worm-like in shape. They feed on putrescent matter. In shallow marshy areas they are evenly distributed; in lakes, rivers and streams the larvae concentrate in the silt in shallow places of small isolated sections of water.

Normal vital activity of larvae occurs at a water temperature of 13-38°. During its period of development the larva passes through four stages: each stage of development ends with a molt. In Culicoides pulicaris midges the first instar larvae are transformed in second instar larvae after 5-8 days, into third instar – after 10 days, into fourth instar – after 2 more days.

Hungry first instar larvae without food die within twenty-four hours; third instar larvae survive up to 45 days.

The optimum temperature for the development of larvae is 20-25°, the maximum 35-40°, and the lowest temperature - 10.6°. At a temperature of 5° and lower the larvae stop developing.

In a period when reservoirs dry up midge larvae go as deep as possible into the earth (up to 90 cm), where they go into a state of dormancy, which can last 3 years (Fontaine and others). Larvae frozen in ice do not die.

Under favorable conditions larvae after 17-23 days actively migrate from the water into the damp, shore soil, where they pupate in the roots of vegetation.

A pupa does not feed. An adult insect is formed within 3-18 days, then it hatches and flys a short distance away from its place of hatching. They, if it can be so expressed, are pasture insects and permanently concentrate near cattle pastures. Midges are almost never found at distance of more than 2-3 km from pastures.

They are caught in the greatest number in the steepe zone in a 500 m radius around a pasture, and in the forest zone - at a distance of half that (Kettle).

After hatching the females for the first few days suck blood, and 2-7 days after this they begin to oviposit. The number of eggs laid by certain species exceeds 200. The eggs are dark-brown in color, oblong and rounded at the ends. At a temperature of 22-23° the larvae hatch from them within 3 days.

The whole cycle of midge development (at a temperature of 24-26°) lasts on the average about 30-60 days. Within the Soviet Union midges can produce 2-4 generations.

The spring flight begins earliest of all in the southern regions - at the end of April; in the northern regions it takes place a month later. The activity of midges even in Karelia lasts until October, and in the southern regions isolated individuals are found in December.

Midges are especially annoying during the period of mass attack. In Karelia this is observed in July; in the central section of the European part of the Soviet Union, in western and eastern Siberia – at the end of July, in August; in the Far East – the end of June, in July, and sometimes in August; in the Caucasus -- in May, July and August.

Midges attack man and animals in open terrain during the crepuscular period – in the evening and morning. In overgrowth they also attack during the day. There are species (C. bidentatus), which start their active flight during the lightest time of the day; at twilight and during the night they are in concealment. Insects en masse fly into living quarters and cattle sheds, where they frequently attack people and animals.

The wind is not an obstacle to their attack. Even at a wind speed of 3 m/s midges are active. Only a wind of more than 3.5 m/s suppresses their activity (Billingmayer).

Midges fly at a height of 1.5-3 m from the ground and from there swiftly attack their victim. The whole process of blood-sucking lasts 3-4 minutes, sometimes up to 40 minutes. With an increase in temperature higher than 29^{o} insects almost do not attack. The optimum temperature for midge activity is 13-23^{o}.

Combatting midges. Measures for combatting midges are still insufficiently developed. A number of authors investigated the possibility of applying insecticides both against the mature stages and also against the larvae.

Benzene polychlorides have been used for combatting midges. Their breeding places are treated with an emulsion at a dose of 12-30 mℓ/m^2. Both doses killed all the larvae in silt (Yu. E. Selens).

A. V. Gutsevich reports that treating humid soil with a hexachlorane emulsion at a dose of 1 g of active substance per 1 m^2 72% of the midge larvae and pupae died. Insects located at a depth of up to 1 cm died.

M. V. Voronin and Ye. V. Molev under laboratory conditions ascertained that the most toxic insecticides are carbolin, ichthyolin, ichthyolin with the gamma-isomer of hexachlorane; at a ratio of 1:5000 they cause the death of larvae and pupae within 24 hours, and DDT and hexachlorane at the same ratio within 48 hours. The residual effect of these preparations lasts for about 2 weeks. Kerosene, solar oil, terpeniol and chlorten were less toxic; the death of the preimaginal stages occurred within 24-48 hours from the preparations at a ratio of 1:1000. Studying the survival of midge larvae and pupae with the effect on them of chorophos, the authors noted that their complete destruction occurs even at a ratio of 1:70,000. At such great dilution death ensues only after 4 hours.

Under field conditions creolin, ichthyolin, carbolin, DDT in a mixture with hexachlorane and solar oil were tested.

The experiments showed that the death of all larvae occurs within a few hours as a result of the application of ichythyolin and carbolin at a ratio of 1:2000; from DDT and hexachlorane at a ratio of 1:6500 all larvae died within 48 hours. From solar oil only insignificant destruction of them was noted. Treating a coastal zone with 60 $m\ell/m^2$ of 20% creolin the authors noted that after 24 hours the number of larvae was reduced by more than 40 times.

In combatting larvae under the conditions of the Khabarovsk region good results were obtained as a result of the application 0.3-0.5 kg/ha of DDT and hexachlorane disinfecting powders with surface treatment and 0.3-2.5 kg/ha using aerial treatment. Just as effective were the suspension and emulsion of hexachlorane. For treating midge breeding places these were successfully applied a 0.24% suspension and a 0.4% oil-turpentine emulsion at a dose of 100 $m\ell/m^2$ of ground. For producing a perceptible effect – lowering of the number of adult insects – it is recommended that the treatment be conducted 2 times per month (Sh. M. Dzhafarov).

The noticeable reduction in the number of adult midges (by 4.7 times) in places, where in spring treatment was carried out on the Yenisei shore zone with a DDT emulsion from an aircraft, was reported on by O. F. Buyanova (1960).

Abroad very good results were obtained from the application of 1-5 kg/ha of DDT and hexachlorane. For treating reservoirs chlordane, malathion and toxaphene are recommended at doses of 1-3 kg/ha with dieldrin emulsion at a dose of 0.1-0.4 kg/ha.

The residual effect of DDT preparations on larvae is very prolonged; even 2 years after treatment the number of larvae is 95-99% lower than initial number. Against midge larvae under the condition of the Nakhichevan Autonomous Soviet Socialist Republic P. A. Lavrent'yev applied chlorophos. In shallow and small reservoirs 10 mg/m^2 of chlorophos crystals.

Large reservoirs were treated with a 0.5% solution; the shore zone of a reservoir was treated with 100-250 mg/m^2. The soil around an isolated section of water was treated with crystalline chlorophos at a rate of 23 mg/m^2, 31 mg/m^2 and with a 0.1% solution. The death of the larvae came in all the experiments and, as a rule, in first 80 minutes; the pupae died within 24 hours and only by treating with crystalline preparations.

Aqueous solutions even at a dose of 250 mg/m^2 did not have any effect on pupae and, from them completely viable insects emerged.

The control of adult midges is almost not covered at all in literature. This is an indirect indication that when measures were carried out to combat mosquitoes or ticks there was also observed a sharp reduction in the number of midges. Therefore it is necessary to consider that in combatting flying insects the dosages applied against mosquitoes are acceptable.

As A. M. Mitrofanov reports, after smoking a site with hexachlorane aerosols at a dose of 3 g of active substance per 1 m^2 midges disappear within 18 days.

The sensitivity of adult midges to chlorophos and acetoxon is reported on by M. L. Fedder and A. N. Alekseyev. The highest percent of insect death was recorded with 5 minutes of contact with a glass surface treated a 2% concentration of chlorophos (100% died) and 1% acetoxon (97.6% died). Coming in contact with a wooden surface and leaves of shrub vegetation treated with 2% aqueous solutions of chlorophos (a dose of 2 g/m^2) the authors noted that the effect of chlorophos was worse on the wooden surface. Even after an hour's contact the percent of midge death barely exceeded 36, whereas among midges contacting leaves 94.6% died.

Abroad for preventing the infestation of midges into premises all openings permitting the passage of light are screened up. Considering, however that midges crawl through even very fine mesh netting, the latter are treated with insecticides (with a 7.7% solution of malathion; 10% DDT oil solution). All midges flying through netting treated with malathion died within an hour; those flying through netting treated with DDT began to die within a few hours. Screens treated with malathion possessed a lethal effect for 3 weeks.

For preventing the infestation of midges into premises it is expedient to apply repellents. The one-time treatment of a screen with diethyltoluamide reliably protects a dwelling from midges for a whole season.

A good protective effect is provided by repellents when they are applied either on the body or on clothing. According to a number of authors with application on the skin the anti-bite protection lasts from 3 hours (dimethyl phthalate) up to 6 (diethyltoluamide). The longest lasting protection from midge attacks is observed by treating clothing with repellents.

Even the application of one tulle cloak, which extends the head over the bare back to the waist, reliably protects against midges.

In the summer of 1962 in the Soviet Union the testing of a new method of applying repellents was carried out – in the form of aerosols (M. L. Fedder, V. M. Tsetlin, E. Ya. Grikitys).

The protective effect of DETA in form of aerosols when applied to the skin on the average lasts in the central belt and eastern Siberia from 25 to 135 minutes; when applied for 10-20 s to fabric – from 80 minutes up to 5 hours. If the duration of treatment is increased up to 40-60 s, then the protective effect can last up to 2-3 weeks.

Considering that the effect period is more prolonged the treatment should be repeated 2-3 times.

The new form of application is convenient not only because of its uniqueness and simplicity, but also because there falls on the body of man and his clothing an extraordinarily small amount of an absolutely harmless preparation.

CHAPTER XXVI

MOTHS AND THEIR CONTROL

The moth belongs to the class insecta, order Lepidoptera and family Tineidae. Most frequently by this name there is designated a group of 14 species of moths inhabiting dwellings, storehouses for wool and fur raw material or ready-made products (Laiback, Pence). Not touching on all the various species of moths, we will give a short description of only the clothes, fur and carpet moths.

Clothes moth (Tineola biselliiella) (Fig. 22) – the size of this moth with extended wings is 8.5-12 mm. The maxillary palps are underdeveloped; the eyes are straw-yellow in color; the head is rust-red in color. It has two pairs of wings: the front ones without spots are ocher colored; the rear ones are yellowish-gray with a gray fringe.

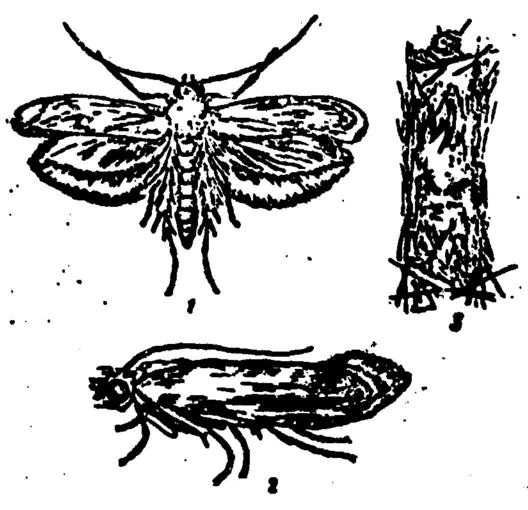


Fig. 22. The clothes moth, Tineola biselliiella. 1 – 2 – the moth; 3 – the larva.

The female begins oviposition shortly after copulation. The time during which she oviposits (from 2 to 30 days), and the number of eggs laid (from 60 to 220 eggs), depend on the temperature and nutrition. The dimensions of an egg: the length is 0.4-0.7 mm, the width is 0.28-0.38 mm; the color is light-yellow. The duration of egg development also depends on the temperature: at 20° the emergence of the caterpillar from the egg occurs on the 12th day; low temperatures of from -1° up to +7 cause the death of eggs after 3-6 weeks; a temperature higher than 40° acts lethally in the same way.

A caterpillar which has only just hatched has a total length of 1 mm, therefore it is hard to discern among the material, in which it has hatched. After emerging from the egg the caterpillar constructs a cocoon, in which it lives until complete development, emerging through openings located at the ends of the cocoon in quest of food. The caterpillar constructs a cocoon from the material, on which it lives; it usually has the same color as the material, which greatly hampers its detection. During the time of its development the caterpillar molts up to 17 times and considerably increases in weight and size: by the 90th day its weight has sometimes increased by 385 times, and its length reaches 10-11 mm; during this time it is easy to detect in the articles and materials.

The duration of the period of development of the caterpillar depends on temperature, the amount and quality of food; at 20-25° in the case of feeding on the hair of cattle and rabbits it develops within 3 1/2-4 months; in feeding on wool fabric its development is protracted up to 10 months. With identical nutrition, but unequal temperature the development periods of moths are different. Thus, at 15° development lasts about 200 days, and at 30° – 73 days. Mature caterpillars possess considerable resistance to low temperatures: at 4-7° they preserve their viability up to 4 months and in the case of the advent of favorable conditions they complete their development. They withstand sharp temperature fluctuations poorly: an increase of from -5° up to +10° with a subsequent drop to -5° and a second increase up to +4.5° causes the death of caterpillars.

For metamorphosis into a pupa the caterpillar leaves its feeding place and constructs a new (second) cocoon, the form of which facilitates the emergence of the moth. This cocoon is also difficult to detect, inasmuch as it consists of the material on which it is located. The pupa stage lasts 14-44 days; upon the expiration of this period the moth emerges from the cocoon. The duration of the life of a flying moth is approximately 30 days. The clothes moth during the day is found in dark, concealed places in furniture, clothing and in the folds of carpets. They emerge from their hiding places in the evening with the presence of artificial illumination for oviposition; with the presence in premises of large numbers of moths they even fly during the day.

Moths damage fur articles, wool clothing, felt footwear and fabric hanging freely, folded and in rolls; they penetrate under fabric upholstering of furniture and into interwall spaces, if there is felt there, where the moths eat the hair. Moths also destroy bristles, articles made from bristles and the upholstering material of furniture. In the presence of large numbers moths and in the absence of wool materials they can eat stored casein and vegetable fabric materials.

The fur moth (Tinea pellionella). The size of the moth with extended wings is 11-17 mm. The head is yellow, the antennal and maxillary polpsare dark; the eyes are broader than the distance between them. The wings vary in shade - from light-yellow to dark-brown; the front pair of wings is yellowish-gray, with three black spots; the rear wings are light-gray with the same width as the front ones; their border is yellowish.

The development of the fur moth in many respects is similar to the development of the clothes moth, with the exception of that its caterpillar has a black head; they live in a cocoon spun by them, which they drag everywhere during their development, and, finally, in damaging fur they in contrast to clothes moths do not leave their wooven home. The fur moth devours wool materials, fur, feathers, carpets, and also intestines, bovine bladders and so forth. They are most frequently encountered in commercial enterprises.

The carpet moth (Trichophaga tapetzella). The size of the moth is 14-24 mm. The head and the base of the front wings are dark brown in color; the remaining part (2/3) of the front wings are yellowish-white in color; their central part has a grayish tint; the rear wings have one color, a bluish-gray color. The length of the caterpillar of the carpet moth is 13-15 mm; just like the clothes moth caterpillar, they damage wool fabrics gnawing through them; from this same material they make their cocoons or cases. The carpet moth damages coarse fabrics, the trimmings of furniture, tanned skins and furs.

Measures for combatting moths. The presence of moths in premises is determined both by the number of flying moths, and also by the damage to articles. The measures for destroying moths are carried out in two directions: by combatting flying (mature) moths and combatting the preimaginal stages of their development.

Flying moths are not difficult to kill. Many insecticides are suitable for destroying them. Almost all the preparations utilized in combatting flies can also be used in the same amounts for combatting with flying moths (see "The application of individual preparations").

Moths damage articles not when they are being worn, but during storage, therefore it is necessary to pay attention to the methods of storing articles: wooden chests and cabinets, where articles are stored, should not have any cracks and the doors should be tightly closed.

Before packing articles for storage it is absolutely necessary to first thoroughly and carefully clean out the chests (chests of drawers, wardrobes, clothes closets and so forth). Also desirable for the summer storage of winter outer wool and fur clothing, felt boots, etc., is to sew them in sacs made from some material including from paper; a linen sack is covered over with thick, glossy paper or with wrapping paper; it is also recommended that there be as few angles as possible. The coverings or wrapping paper should be treated with an insecticide on the inside or outside. For storing articles industry is turning out special sacks made of polyethylene. In articles stored in sacks not treated with insecticides there are applied in several places, for example, in the sleeves and pockets of the clothing repellent preparations: napthalene, paradichlorbenzene, camphor, camphor-napthalene, ball, makhorda, eucalyptus and laurel leaves, lavender roots and others.

Repellent preparations are also used by suspending them in socks near the object or on it. Thus, for example, for a fur overcoat it is sufficient to hang 6-8 gauze packets with one teaspoon (6-8 g) of napthalene in each packet.

The basic measures of control should be directed against moth larvae, which damage keratin-containing articles (wool, fur, feathers, etc.); keratin is a nutrient for moth larvae. Therefore it is first necessary to create conditions hampering the development of the caterpillars. For this it is necessary from time to time to subject stored articles to shaking out, cleaning and drying; this is especially recommended during February and March – in the months of moth oviposition (Ya. L. Okunevskiy). The beating of upholstered furniture infested with moths does not give positive results, because the larvae are usually located under the upholstering. In the cleaning of articles having eggs in them they are removed, because they are not attached to the fabric.

After cleaning the clothing it is necessary to hang it in the sun, because moth larvae are sensitive to sunlight. The eggs of clothes moths under the influence of the direct rays of the sun with heating up to 53^{o} die within 11 minutes, and at 43^{o} – within 31 minutes. Such a method of destroying moths can be used, however, only in the south and in Central Asia, where the air temperature frequently attains these temperatures.

The application of dry heat is effective. The larvae of fur moths die in articles at 54-55° within 24 hours.

It is also possible to recommend heating articles (if they are not damaged) for 30-60 minutes at 77-80°. For felt the heating time is increased up to 2-4 hours; this ensures the destruction of moths in all stages of development. Goods results were obtained by steam treatment and by boiling articles, which can withstand this method of treatment (blankets, outer-and underclothing and so forth). Fabrics, which cannot be subjected to the effect of steam and boiling, can be treated formalin vapor chambers. Furniture can be treated in hot-air chambers at a temperature of 71-77° (if it is not damaged).

In combatting moths temperatures lower than zero (-3°) can be utilized, but this method is unreliable, because the larvae are resistant to the indicated temperatures. Transitions from heat to cold lead to the destruction of moths. Thus, if articles infested with moths are cooled for several days at a temperature of -5°, then for a short time the temperature is raised up to +10°, then again lowered to -5° and finally kept at a constant temperature of approximately +4°, then all the moths die. Thus it is recommended that articles to be stored be subjected to the effect of 2-3 temperatures, before they are placed in permanent storage at a temperature of from -4 to -5°; lower temperature are not needed. Cold hinders the feeding of larvae. If infested furniture is carried out onto the street at -17° for 5-6 hours, this provides good results.

The exposure while treating materials at negative temperatures depends on the quality of the affected material and on the phase of development, of the insects. Thus, for example, when treating thick felt (with a thickness of 5-20 mm) the exposure should be increased by 2-3 times as compared to treating broadcloth or velvet. The treatment of infested upholstered furniture of the heavy type is still longer and can be as long as 3-5 days (A. K. Zagulyayev).

However, the main place in combatting moths is occupied by chemical preparations (Table 41). Insecticides are used for the purpose of combatting flying moths, for destroying the preimaginal stages of their development, and also for prophylaxis of damage to fabrics, upholstered inventory and others.

Table 41. Rate of expenditure of preparations in combatting moths.

Preparation	Unit of measurement work	Average expenditure	Method of applying and concentration working solutions
Chlorophos	1 m^2 of floor	2	Treating (selective) walls, ceilings, upholstered furniture, blinds, carpets with a 2-3% aqueous solution
10% DDT disinfecting powder	1 m^2 " " "	10	Dusting walls, upholstered furniture, blinds, carpets and their storage sites
25% DDT emulsion	1 m^2 " " "	6	Treating walls, ceilings, upholstered furniture, blinds, carpets, felt and other stuffing with a 1-2% aqueous emulsion
Disinsectal	1 m^2 " " "	50	Without dilution
DDT solution in 2-3%	1 m^2 of treated surface	120	Without dilution introduced under furniture upholstering
	1 m^3	40	Atomization into the air
	1 m^2 of floor	50	Treatment just like with chlorophos
DDT aerosols (pots, cylinders and so forth)	1 m^3	0.25 Technical HCCH	One-time destruction of flying moths inside premises
12% HCCH disinfecting powder	1 m^2 of floor	10	Just as disinfecting powder DDT, but in uninhabited locations
13% HCCH emulsion	1 m^2 " " "	10	Just like with DDT emulsion but not in living quarters
HCCH aerosols (pots, cylinders and so forth)	1 m^2 " " "	0.25 Technical HCCH	One-time destruction of flying moths inside uninhabited premises
Pyrethrum	1 m^2 " " "	3	Just as with 10% DDT disinfecting powder
	1 m^3	5	Atomization into the air
Fleacide	1 m^2 " " "	10	Just like with pyrethrum
	1 m^3	12	

For destroying moth larvae in upholstered furniture insecticidal solutions are used, in particular 2-3% DDT solutions, which are introduced under the upholstering in the necessary place with the help of a large syringe and an appropriate needle.

For destroying flying moths various insecticides are used to treat the places where they land in order to prevent oviposition or, if they have already oviposited, to attempt to kill them or the larvae hatching from these eggs. For this there are used disinfecting powders or solutions, or emulsions of one of the following insectisides: DDT and its analogs (methoxychlor and perthane), dieldrin, chlordane, sodium arsenite, hexachlorane, the gamma-isomer of hexachlorane (lindane), chlorophos and others. DDVP preparations are highly effective.

Clothes moths are extraordinarily sensitive to DDT aerosols; a dose of 0.17 mg/ℓ of air causes their complete destruction within 24 hours even with an hour's contact with treated surfaces. Somewhat less toxic with respect to clothes moth larvae are the aerosols.

In treating articles with DDT aerosols at a rate of 0.88 mg/ℓ of air with 3 hours of exposure 75% of the larvae die within 1.3 and 5 days. Clothes moth larvae are considerably more sensitive to hexachlorane aerosols than to DDT aerosols. Thus, for example, with the use of 0.2 mg of hexachlorane per 1 ℓ of air with 24 hours of contact of the larvae with treated surfaces 100% of the larvae die within 24 hours (V. I. Vashkov, L. N. Pogodina, T. Yu. Dolinskaya).

Positive results are obtained using traps in which pieces of fabric treated with fish flour or an alcohol extract of fish flour are placed in the traps; adult individuals (females) fly into these traps and oviposit.

For prophylaxis of damage to wool materials, carpets, furniture having hair or wool stuffing, and also for prophylaxis of moth infestation of various insulating material a large number of insecticides can be used.

The DDT acts as a contact and intestinal poison: 28-day larvae (with a length of from 2 to 4 mm) placed on wool treated with DDT at a 0.2% concentration die for the most part within 4 days. Larvae which are ready to pupate are more resistant to DDT, but they also die when attempting to eat wool treated with this preparation.

For the purpose of preventing of the possibility of moth (females) penetration it is best to place valuable articles in covering or sacks of broadcloth or cotton fabrics treated with DDT preparations at the same rate as when normally treating fabrics (soaking in 0.5-1% emulsions or treatment with disinfecting powder). It is possible to wrap articles carefully in newsprint sewing the edges or pinning them with pins. Moreover, it is necessary to dust the articles with DDT preparation.

The dusting of wool articles and outer clothing with powder containing 10% DDT is carried out at a rate of 125 g per set or 12 g/m^2 (carpets, upholstered furniture, curtains and others). In treating expensive, dark cloths one should not pour the DDT directly on the fabric, because the preparation, upon decomposing, gives off chlorine and causes weak discoloration of the fabric in those places, where the DDT falls. The preparation should be atomized in such a manner that it covers the material with a uniform, thin layer.

When impregnating wool fabrics it is best to use 5% DDT solutions or emulsions. The impregnating of wool fabric and felt is carried out at such a rate that they contain 1% of the preparation per weight of the dry fabric. The preparation protects fabrics, which are in use, for over 6 months. In storage the effectiveness of the protection of such tissues is preserved for up to 5 years. Washing and dry cleaning reduce their insecticidal properties by approximately 60%, therefore the articles after washing should be treated again.

Certain authors recommend for the purpose of prophylaxis of damage to fabrics by moths or hide beetles, that the fabrics be treated with DDT at a rate of 0.05-0.25% per weight of the material. With the use of 5% DDT solutions in kerosene or disinfecting powder at a rate of 0.15% per weight of the fabric there are observed satisfactory moth-protective properties. Carpets treated with a DDT preparation at a rate of 0.5% per weight were protected from moths for 18 months. Prophylactic treatment (spraying, dusting) should be limited to the edges of a carpet, i.e., those places which are not subjected to external effects (walking and so forth), and where furniture or other objects stand, and also places close to radiators. In order to provide uniform distribution of the insecticide during treatment of the materials the atomizer should not be held close to the objects being treated.

As moth-protective agents there can also be used 1% solutions of methoxychlor at a rate of 0.2-0.5% per weight of the fabric. This preparation protects fabric from moth damage for a year. It also possesses ovicidal properties.

Perthane protects against moths when applied to material at a rate of 0.3% per weight of the fabric. A mixture of perthane with DDT is more effective than either preparation separately.

Hexachlorane is an effective insecticide, but it should be applied only in extreme cases, inasmuch as it fumigates and its vapors possess an unpleasant odor. The rates of expenditure for hexachlorane are the same as when using DDT.

Sacks and cases intended for the storage of articles are subjected to individual treatment with liquid hexachlorane preparations on the inside and on the outside. For this prupose hexachlorane pencils can be used, which are used to mark strips with intervals of 3-4 cm.

Articles treated hexachlorane should before use be thoroughly shaken out or cleaned and aired in the open air.

Gamma-isomer (lindane) is unsuitable when storing fabrics outside chests and tightly closed boxes because of its volatility. For impregnating fabrics 0.25% solutions of gamma-isomer can be used.

Crystals of the preparation at a rate of 50 g/m^3 protect wool articles (in chests or boxes) from insects for 3 years and more, whereas napthalene crystals (460 g/m^3) protect for one year. To avoid contaminating the clothing with crystals of gamma-isomer a special method is proposed, consisting in fastening the crystals with a sticky substance to strips of paper and in this manner the insecticide is introduced into containers storing articles ("linjane boards"). When using gamma-isomer in storehouses it is fastened to panels, which are placed between bales of wool fabric; at a concentration of 320-720 g/m^3 the preparation also protects articles from damage Attagenus piceus olive, Anthrenus flavipes L. (Landani) beetles.

Laboratory experiments demonstrated when gamma-isomer is used in considerably smaller quantities – 100 and 200 g/m^3 – it is also effective (Landani and others).

For protecting fabrics there is also used 0.5-0.05% dieldrin (this preparation resists washing and dry cleaning) or 2% chlordane in solution; both preparations are effective in combatting moths and also hide beetles. Chlordane should be used at a rate of 2% per weight of fabric; before putting on clothing treated with chlordane, it is necessary to subject it to thorough cleaning.

Moth-protective properties can be given to tissues by impregnating or spraying them with a 0.5-1% solution of sodium arsenite.

Napthalene-napthalene balls at a rate of 230 g per 0.14 m^3 are toxic with respect to moth larvae, when they are in a hermetically sealed box for 3-4 weeks; napthalene flakes are effective when they are scattered over clothing; it is even better to strew them between newspapers. From the effect of naphthalene 40% of the hide beetle larvae die within 15 days. At a dosage of 180 g/m^3 in a hermetically sealed box at a temperature of 18-22^o complete destruction of adult moth individuals is observed within 5 days, and their eggs die within 4 days. At a dose of 160 g/m^3 moths in all stages of development die. Napthalene is more toxic to moths than paradichlorbenzene; the odor of the latter is not preserved in fabrics for as long time, as the odor of napthalene.

Paradichlorbenzene is effective against moths at all stages of their development. To produce a reliable effect 2-3 g/m^2 are required. It is applied mainly to destroy clothes and carpet moths. Paradichlorbenzene at a temperature of 23-29° (with an exposure of 24-36 hours). Solutions of paradichlorbenzene also find application in gasoline, kerosene, carbon tetrachloride and other solvents. With 30 cm^3 of carbon tetrachloride there are taken 10 g of paradichlorbenzene and there are added 15 cm^3 of purified turpentine. This composition is used to treat articles and they are then stored in tightly closed boxes or chests, because the preparation evaporates rapidly. It is necessary to consider that carbon tetrachloride is toxic to people.

Hexachloethane is just as volatile as paradichlorbenzene; it is applied on articles at a rate of 100 g/m^3; it evaporates after a certain time. The time of evaporation depends on the temperature of the premises therefore the articles after treatment should be stored in good packing (paper sacks) or in tightly closed chests and boxes.

Carbolic acid, turpentine and kerosene are applied in the form of mixtures of the following composition: 2 parts of turpentine as mixed with one part of kerosene and 7% pure carbolic acid is added. This mixture evaporates rapidly; its odor also disappears in a short time. No traces are left on fabrics (if pure preparations are used). According to Ya. B. Levinson moths, their eggs, larvae and pupae die rapidly under the effect of this mixture; he recommends applying it in combination with cleaning articles.

Vegetable insecticides. Pyrethrum powder is used to dust surfaces of fabrics at a rate of 4-5 g/m^2. Fleacide is an excellent agent; it is used to impregante fabric at a rate of 10 $m\ell/m^2$.

For destroying moth larvae camphor is also recommended. Camphor possesses insignificant insecticidal properties; it repels moths and earlier found application in combatting these insects.

Tobacco dust and pepper possess repellent properties, therefore in the absence of other agents it is possible to dust articles with them; as a result of such a treatment moths do not oviposit.

Nicotine-base and nicotine sulfate preparations are used either in the form of 0.15-0.2% aqueous solutions (based on pure nicotine) or in the form of disinfecting powders. Also applied are 0.3-0.5% aqueous solutions of anabasine sulfate for spraying and impregnating wool, felt, felt raw material and articles made from them.

Benzimidazole is recommended by M. Kortslof for protecting wool, felt and other keratin-containing materials from clothes moths. Articles are impregnated with 0.5% benzimidazole in a water-acid solution at a pH of 2.0 in an amount of 1-5% of the weight of the treated material.

In combatting moths also effective are solutions containing organic thiocyanates (lethane, thamite).

Reliable results are given by treating articles in chambers with gaseous preparations. For this purpose chloropicrin, prussic acid, dicloroethane, paradichlorbenzene, carbon tetrachloride, T-gas, carbon disulfide, ethylene oxide, methyl bromide, sulfurous anhydride and others are used. Chloropicrin, according to A. D. Petrov, possesses good insecticidal properties; with a content of 15 g/m^3 and at a temperature of 10^o moths die within 1 1/2 hours; in the presence of 9 g/m^3 - within 2 1/2 hours, and at a concentration of 1.5 g - within 72 hours.

Prussic acid is used in treating storage premises; the exposure lasts 12-15 hours, after which it is necessary to air out the premises for 6-12 hours. A lethal dose for moth larvae is considered to be 50-70 g/m^3 with an exposure of 3 hours.

Chloropicrin is used in fumigating storage premises at a dose of 15-40 g/m^3; the exposure is 2-3 days and more.

Dichloroethane is used at a rate of 300 g/m^3 for fumigating empty warehouses and 600-800 g for fumigating warehouses loaded with furs, furniture and other things. The exposure is 5-8 days with a subsequent airing out of 2-5 days. Dichloroethane is also used in a mixture with chloropicrin in fumigating empty warehouses at a rate of 80-90 g/m^3 (74-83 g of dichloroethane and 6-7 g of chloropicrin). In fumigating premises loaded with furniture the concentration of the gas is increased to 250-300 g/m^3 (230-270 g of dichloroethane, 20-30 g of chloropicrin).

Methy bromide is used for fumigating by the chamber or tent method at a rate of expenditure of 60-100 g/m^3.

Fluosilicate salts (giving fabrics moth-protective properties) are effective agents for the prophylaxis of moth propagation. Among such compounds belong the sodium aluminate of fluosilicic acid; sodium fluosilicate; a mixture of magnesium fluosilicate with ethanolamine fluosilicate; lithium fluosilicate; ammonium and zinc fluosilicates. Fabrics impregnated with these preparations are preserved; they do not yield to moth damage for several years; however it is more reliable to repeat impregnation annually. In treating with the enumerated compounds fabric is immersed in a solution or thoroughly sprayed, especially the edges and seams. Washing in water can bring about the removal of these substances from the fabric, therefore when necessary after washing the fabric should be retreated. When the fabric is dry cleaned only an insignificant amount of the preparation is removed.

When using a DDT preparation for treating fabric a larger concentration is required than when impregnating with fluosilicate. In treating materials this latter compound is used at a rate of 0.5-1% per weight of the given material. Fluosilicate does not lose its protective properties under the influence of light; when washed in water it is more resistant than fluorine salt; washing with soap and water does not destroy the moth-protective properties, it only lowers them.

In preparing a sodium fluosilicate solution the latter should be very pure and should have an extremely fine grind, which ensures its rapid solution. The foreign preparations – arsklet, arsklen or gardinol (a sodium salt of a sulfur ether of a higher aliphatic alcohol) – are used in the following way: 0.5 kg of dry substance are mixed with 1.5 kg of sodium fluosilicate, then 28 g of this mixture are dissolved in 4.5 ℓ of boiling water and stirred for several minutes. It is recommended that sodium fluosilicate be dissolved in boiling at a rate of 2.46 g per 100 mℓ of water and approximately 1 g per 100 mℓ of water at normal temperature.

Abroad the preparation larvex (sodium aluminate of fluosilicic acid) is also recommended; Its composition: sodium fluosilicate 0.6 g, potash alum 0.3 g, oxalic acid 0.03 g and water 99.07 g. Larvex is applied in concentrated solutions with a 0.5% content of fluosilicate or more; the addition of dissolved aluminum salts increases its solubility: also used are dilute solutions with a fluosilicate content lower than 0.1%.

The concentrated solutions are used either for spraying, or for treating articles by submerging them in it for not more than 1-2 minutes. The solution is sprayed mechanically or by a continuous action handsprayer (for example sprayers adapted to vacuum cleaners). It is also possible to rub materials with a moistened sponge: the latter method is used in the antimoth treatment of seams, folds and pockets. Also the following of norms are adhered to: for treating a man's suit (consisting of 3 pieces) – 0.75-1 ℓ; an upholstered couch – 2-2.5 ℓ; an upholstered chair – 1 ℓ; a carpet or shaggy blanket (with dimensions of 2·2.5 m) with a front and back side – 6-7 ℓ.

The objects are sprayed or treated on the street, because this process is connected with the thorough cleaning of articles, the beating out of dust and the removal of spots. Silk and viscose linings, and also fur linings and finishings should be covered with a cloth. They cannot be sprayed with liquid, because the lining can shrink and harden, and fur can become dull. Furniture is treated either with a vacuum cleaner or the dust is beaten from it and spots are removed. Articles having cotton inside are covered with a heavy fabric or paper. The wooden parts are covered with paper or oil. On a set of 3 objects approximately 4.5-5 ℓ are used.

In the process of treating hair (a component part of furniture) it should be thoroughly moistened; spraying is repeated within a year. Furniture having Angora wool cannot be treated by the wet method, because this can lead to a change in the direction of the hair, which in turn leads to the formation of shady places reminiscent of spots. The best results were attained by using a continuously acting sprayer providing a uniform continuous stream of fine drops.

Carpets with a jute and glue backing can only be treated on the front side. To prevent spraying of the floor and furniture newspapers are spread around the carpet. It is necessary to allow one part of the carpet (front) dry before proceeding to treat the second part (back). Only carpets, which have stable dyes can be treated with moth-protective agents.

Silk, sateen broadcloth and other cotton cloths cannot be treated with an aqueous solution of a moth-protective preparation: run streaks appear on such materials: furthermore, under normal conditions moth larvae do not damage these.

After drying the treated object it is treated with a vacuum cleaner to remove small fluosilicate crystals, which remain on the surface.

Such objects as woolen covers, bathing suits and other small wool objects should be soaked in one of the solutions of larvex, containing: 1) 2% magnesium fluosilicate, 1% wetting agent and 97% water; 2) 0.708% magnesium fluosilicate, 0.568% ethanolamine fluosilicate and 98.724% water.

The use of magnesium fluosilicate sometimes leads to the hardening of fabric and to the deposition on dark fabric of a noticeable layer of powder.

Fluorine compounds or fluoride compounds are used in their dissolved state. For this there is prepared a saturated solution of sodium fluoride by boiling 1 ℓ of water for 5 minutes; the water contains 45 g (an excess) of sodium fluoride; this latter dissolves in boiling water within the limits of 4%. Such a solution has a satisfactory moth-protective action.

Also recommended is a mixture of sodium fluoride with Glauber's salt: sodium fluoride 1%, Glauber's salt 0.6%. The basic deficiency of sodium fluoride is that it is readily washed from fabric.

Other compounds imparting moth-protective properties to fabric. Data exists about the fact that 0.5% solutions triethylpyridine, pyridine-sulfonic acid, picolinic acid and sulfanilamide in treating fabrics at factories impart to them moth-protective properties. The materials are treated with these substances in bath at a temperature of 20°. They do not disturb the strength of the fabrics, but they cannot be used for treating ready-made articles.

"Martius yellow" (2:4-dinitro-alpha-naphthol) was one of the first compounds used for antimoth treatment of fabrics; it is now used for treating wool at a rate of 0.03% per weight of fabric; the material is moistened at 30°.

Dinitro-o-cresol utilized at a rate of 0.025%, replaced "Martius yellow" to a certain degree, but this preparation is unstable with washing.

Preparations "eulan-C_N" and "eulan-C_N-extra" belong to preparations of the sulfone group and derivatives of triphenylmethane. When used to treat wool the latter becomes toxic and inedible for moths; the triphenylmethane compounds change keratin so that it is not broken down by the enzymes of the larvae and cannot serve as nutrient. "Eulan-C_N" is used at a concentration of 1.5% just like dye is used in dyeing bath; the calculation is carried out by weight of the material taken for treatment. Essentially these preparations are dyes; they are soluble in water and are permanently combined with the wool. They can be used to treat wool in aqueous solutions at any stage of production or such treatment can be combined with dyeing.

After the introduction of the insecticide simultaneously with the dye the preparation is held fast by the tissue even after repeated dry cleaning. The latter is explained by the fact that dyeing of fabric is carried out by heating it and at the time of treatment the insecticide penetrates inside the fiber, where it is fixed upon cooling, especially when the fiber thickens, it secures both the dye and also the insecticide.

"Eulan" preparations are resistant to the effect of sunlight and preserve their effectiveness during the normal w... ing period of the material.

For imparting moth-protective properties to materials a number of other preparations are also used, in particular "mitin – F, F" [sodium salt N-(3,4-dichlorophenyl)-N-2-(2-sulpho-4-chlorophenoxy)--5-chlorophenylurea].

This white odorless powder contains 42.5% active substance. Its solubility in water is low; at room temperature it is 0.05%, at 71° solubility increases to 0.4%, and at 95° – to 5.5%.

The presence of the sulf-group makes it possible for mitin to combine chemically with the schleroproteins of wool fabrics like other dyes. From solution the preparation is completely adsorbed by the fabric, and therefore the dosages are expressed in percent content of mitin to fabric. Thus, for example, for treating 40 kg of wool it is necessary to take 800 g of mitin; after drying it will contain 2% mitin. Mitin is first dissolved in a small amount of hot or boiling water, which is then poured into the general tank for dyeing, where the dissolved dye is located (if fabric is simultaneously dyed with this).

This preparation has a close relationship to "eulan-C_N" and is also used in dyeing baths. The moth-protective properties of fabrics impregnated with a 3% solution of "mitin" are not lost under the effect of light, water or in an acid medium. The preparation behaves like a fast dye. Those fabrics which are seldom washed preserve their moth-protective properties for the whole period of their use.

To this group of preparations there belongs "lanoc" (sodium dihydroxypentachloro-triphenylmethanesulffonate).

Bokon-1,6-diamino-2-2-difluorohexane – is a water-soluble moth-proofing substance, which, being mixed with a solvent, will form an emulsion. This preparation changes the chemical structure of wool.

Mistox – an insecto-fungi-bactericide – is a pentachlorophenol compound (laurylpentachlorophenol); it is used at a rate of 0.5% per weight of fabric. At enterprises for treating fabrics it is diluted in a dyeing bath. Because of its toxicity and instability with washing this preparation has found only limited application.

A preparation known as "amino" is also finding application; this is triethanolamine hydrofluosilicic acid.

CHAPTER XXVII

SAND FLIES AND THEIR CONTROL

The Pathogenic Significance of Sand Flies

At the present time in world literature there have been described more than 300 species of sand flies: 127 species of 34 varieties have been counted in the Old World and more than 150 in America.

In the USSR sand flies are encountered in the sourthern regions: in Moldavia, in the south of the Ukraine, including the Crimea, in the Caucasus, in Central Asia and Kazakhstan. They occupy first place in breadth of distribution and number in the hot deserts of Central Asia, where they are permanent inhabitants of burrows and primary external parasites of man.

In the USSR at the present time there have been recorded 25 species belonging to two genera: Phlebotomus and Sergentomyia.

The greatest number of species (19) was recorded in Turkmenistan, the least (three species each) was detected in Moldavia and in the south of the Ukraine. The most widespread species are Ph. papatasii, Ph. chinensis, which are recorded everywhere. The richest fauna of sand flies are found in the mountain regions; in a relatively small territory here it is possible to detect more than 15 species, whereas in the huge expanses of the plain with a monotypic topography – only 5-6 species.

A peculiarity of sand flies is that they attack in the evening hours of the day; hungry individuals before imbibing blood for a prolonged period of time look for a convenient place for blood-sucking. Here they pierce the skin (from 3 to 20 times) and introduce, although insignificant, a dose of a secretion from the salivary glands. For an unaccustomed person and especially for sensitive people sand fly bites are very acutely painful; they cause unbearable itching, deprive a person of normal sleep, appetite, and efficiency drops sharply. Frequently the itchy parts of the body are scratched and are covered for a long time with nonhealing papules.

Sand flies are carriers of pathogenic agents of dermal leishmoniasis, visceral leishmoniasis, pappataci fever. According to materials of foreign researchers sand flies transmit Bartonella bacilliformis - pathogenic agents of Oroya fever, Peruvian fever, Carrion's disease in Peru, Bolivia, Chile, Ecuador. The disease caused by this pathogenic agent can take a serious course and frequently ends in death. In literature there are indications of the possible participation of sand flies in transmitting the pathogenic agents of yellow fever and dengue fever (according to P. A. Petrishcheva).

The pathogenic agent of pappataci fever - a filtrable virus, is preserved in the organism of the female sand fly during the course of her whole life and is transmitted transovarianly to the offspring. Deserving of special attention is the report by N. I. Khodukin, V. A. Lysunkina and A. I. Kubeyeva about the fact that the virus of pappataci fever can possibly infect rabbits and dogs frequently encountered at populated points. Of wild animals it is assumed on the basis of indirect evidence that in the circulation of the virus there participate the birds: turtle-doves, coraciiforms, the green and golden bee-eaters, the bacterial owl, reptiles populating rodent burrows.

This disease to an equal degree can appear both in populated points and also far from them.

The reservoir of visceral leishmaniasis is considered to be the dog. Many researchers have found the pathogenic agent of this disease in the skin and in the internal organs of this animal. In individual cases among apparently healthy dogs up to 40% and more were affected with visceral leishmaniasis.

In literature there are indications of the fact that among a group of wild animals (gerbils, foxes, mongooses, porcupines) there have been recorded individuals the internal organs of which were affected with Leishmaniae.

A carrier of the pathogenic agent can be sand flies having frequent contact with man and dogs. At foci of the disease there are frequently found Ph. chinensis, Ph. kandelakii, Ph. tobii sand flies. Ph. caucasicus are comparatively susceptible to the pathogenic agent and under the conditions of Central Asia they are considered the usual carriers of visceral leishmaniasis.

Dermal leishmaniasis has very broad distribution: the foci of this disease almost coincide with the distribution of the carrier.

Within the USSR this disease is recorded in the Central Asian republics and in the Caucasus. The largest number of people ill with this disease is constantly noted in Turkmenia.

According to the clinical course and epidemiological peculiarities there are distinguished anthroponotic dermal leishmaniasis, or type I, with prolonged incubation, a prolonged chromic course and dry sores and zoonotic dermal leishmaniasis, or type II, with short incubation, rapidly necrotizing, with weeping sores.

Type I dermal leishmaniasis is recorded only in cities, where it has focal distribution. As the experiments of Ye. M. Bolova, showed, there are susceptible to type I pathogenic agent, besides man, the short-tailed bondicoot rat and the red-tailed Libyan jird, which frequently inhabit cities.

It has been established that Ph. papatosii, Ph. sergenti are carriers of the pathogenic agent. Repeatedly people ill with this disease have also been recorded in places where other species congregate.

Type II dermal leishmaniasis is recorded in the USSR only in the republics of Central Asia. The reservoir of the pathogenic agent this disease and the source of this disease are wild animals – great, midday and red-tailed gerbils, the Transcaspian hedgehog and the long-clawed ground squirrel. With experimental infection the highly susceptible ones were the short-tailed bandicoot rats, Chinese striped hamsters, house mice.

Dogs are infected with type II dermal leishmaniasis and the disease lasts about 4 months.

The classical reservoir is considered gerbils, among which the percent of infected animals sometimes reaches 100 (M. P. Vavilova). Such a high percent of infected animals occurs in ancient colonies and, as a rule, $1\frac{1}{2}$ to 2 months after the first flight of the sand flies, i.e., in July-August. In winter and in the spring months infected gerbils are recorded at 7-15%.

The duration of the course of dermal leishmaniasis in gerbils is 4-10 months. At certain areas the foci of dermal leishmaniasis have almost solid distribution. A. B. Karapet'yan and T. N. Remyannikova, investigating the instar peculiarities of colonies in the epidemiology of dermal leishmaniasis report that the percent of infected sand flies is highest in ancient colonies (45.5); in old colonies the percent of infected sand flies was 15.6, and in young ones 5.8. A man passing through a zone of a natural focus is subjected to the attacks of infected sand flies and becomes ill. Newly arriving contingents (migrants, builders) especially suffer from dermal leishmaniasis (M. G. Gaipov, 1956; A. I. Dyatlov, 1961, and others).

The Morphologico-Ecological Characteristics of Sand Flies

Sand flies - small, two-winged insects with a length of 1.3-1.5 mm, light-yellow, sometimes gray or brownish in color. The whole body of the insect is thickly covered with hairs. On the head are prominent, large, black, compound eyes. Above the eyes are 16-segment antennae. The proboscis short and, piercing. The males have no upper jaws.

The thorax is thick and has three segments. On the thorax are three pairs of very long legs (up to 4 mm) and one pair of wings. The latter are relatively wide, pointed, thickly covered with hairs along the edges and characteristically raised upwards (Fig. 23).

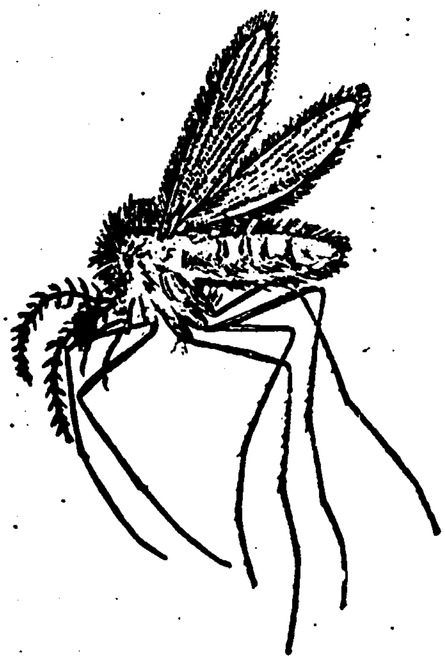


Fig. 23. Overall view of a female sand fly.

The abdomen consists of 10 segments; two of the latter are highly modified and are the external genitalia. The latter are especially important for determining the specific affiliation of the sand fly. For determining the species (females) there are also taken into account the structure of the pharynx and the oral cavity.

The egg has an oval shape. Several hours after emerging from the oviduct the egg begins to darken and becomes a dark-brown color. The surface of the egg has a unique, lattice design. The size of the egg varies from 0.35 to 0.38 mm in length and 0.09-0.13 mm in width.

The larva has a light color and has 13 well-defined segments. The head is distinguished by its dark color and is round and highly chitinized. The oral apparatus is of the gnawing type. The larva has two stages of development – the first stage has one pair of stigmas, the second – two. Beginning with the second stage at the end of the larva body there appear four long, tail filaments, two each on each of two protuberances. The larva molts 4 times; after the fourth mold it begins to pupate (Fig. 24).

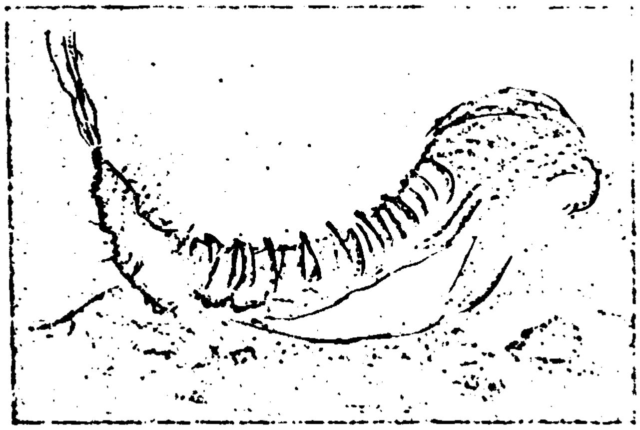


Fig. 24. The pupa of a sand fly.

The pupa has a light color, a shiny surface, and a clavate shape. Its length is up to 3 mm. The mature pupa moves energically which aids in bursting the pupae case between the head and the abdomen. After this rupturing the mature insect emerges.

The whole life of sand flies in nature is only connected with burrows. Here the sand flies have all the conditions for normal vital activity: the optimum temperature conditions, an accessible food supply (vertebrate animals) and a suitable substrate for the development of the preimaginal stages. A typical shelter is the burrow of rodents — great gerbils — the main inhabitants of the desert. A gerbil burrow is a complicated labyrinth of passages located mainly at a depth of about 1 m. On the surface of the ground it opens with a great number of outlets, frequently the number of them reaches 70-120. In hilly sand plains and on hills their colonies extend for hundreds of meters.

The underground galleries of the burrows are usually disposed in three floors. The first two floors are dug to a depth of about 1 m and make up about 90% of all the passages. The third floor of passages goes to a depth of up to 2 m and more. Depending upon the moisture level and the soil structure in a colony there are allocated chambers with food supplies, sleeping areas for the rodents, and defecatorid. The amount of vegetable food in the "storehouses" varies from several hundred grams to tens of kilograms. In accordance with the volume of their reserve supplies the gerbils also expand the "storage-premises." We chanced in excavating the burrows of great gerbils to uncover feed chambers, in which one man could easily set or lie down. In these chambers, as well as in the nesting chambers, there are frequently old and half-rotten vegetable remains, in which sand fly larvae develop very well. The temperature conditions in the burrows favor the development of sand fly larvae: in the summer period the temperature remains almost constant, within the limits of 24-26°. Relatively stable temperatures are also observed in autumn. In spring the temperature curve starts to rapidly rise upwards. This promotes the early development of the insects, which at a low ambient temperature do not leave the burrows and continue their vital activity in it, feeding on blood and ovipositing (Ya. P. Vlasov, T. I. Dergacheva, E. B. Kerbabayev and others).

Sand flies can suck the blood of all vertebrate animals inhabiting burrows (rodents, reptiles, birds). After each satiation the females look for a place to oviposit. Sand flies can oviposit up to 60 eggs. The duration of egg development depends on the temperature. At 24-30° their development fluctuates from 4 to 13 days. Coming out into the light the larvae feed on decomposing organic substances. In the process of development they molt 4 times; the whole cycle of development from the egg stage to the imago is completed within 27-58 days. According to the materials of A. E. Karapet'yan, under the conditions of Turkenia the majority of females complete this cycle within 33-45 days. Sand flies winter mainly in the fourth instar larval stage. The larvae withstand dryness poorly; excessive moisture affects them to a lesser degree. Staying in water for 3 days slightly inhibits their development.

Emerging from the pupa the young insect impelled by its instinctual attributes in the warm season attempts to leave the burrow. The exodus from the burrow starts 30-45 minutes before sunset; the maximum number of emerging sand flies is reached within 40-70 minutes, then it drops sharply and all during the night right up to dawn only single individuals emerge from the burrow. A wind speed of 2-3 m/s does not affect the activity of the sand flies, their flight is stopped only by a wind force of about 7 m/s. The sand flies emerging from the burrow move over the surface in short (up to 10 m) hops.

The more broken the terrain, the shorter the distance flown by the sand flies during the night. Sand flies fly at a height of up to 2 m; their main mass flies at a height of 30-40 cm. During the night the sand flies can cover a distance of up to 1.5-2 km.

As a rule, in inhabited localities there is a large amount of concealment, which frequently contain many sites for oviposition. These can be leave accumulations, various waste materials, heaps of stones among which are diverse organic remains; cracks in house walls and fences located in the shade; cellars; contaminated barns, vegetable warehouses; moderately humid places under the flooring in animal premises; chicken coops, rabbit warrens, pigeon coops, bird nests, etc.

Man and his domestic animals are themselves always an accessible and unlimited food supply. Thus, there is no necessity for the sand flies to fly very far and in time they become synanthropic insects – the constant inhabitants of an inhabited locality.

Under the conditions of an inhabited point the following adapt and propagate fastest of all: Ph. papatasii, Ph. chinensis, Ph. major, Ph. smirnovi, Ph. perfilievi, S. arpaklensis and several other species.

In villages they form foci of mass infestation (breeding sites), whence they slowly spread all over the inhabited point. In a large city the main mass of sand flies (up to 99%), as a rule, remains near the site of its permanent host; within a radius of 10-15 m, they fly very short distances (up to 25 m), at most up to 100-135 m (A. V. Dolmatova, P. A. Petrishcheva).

Because of this sand flies very frequently come in contact with the surfaces of walls and fences. Getting into the habitations of man sand flies are usually located on the upper part of walls close to the corners formed by the walls and ceiling along cornices. The most active flight of sand flies into premises occurs in the first hours after sunset and before sunrise (to 23-24 and about 5 o'clock).

Sand flies under conditions of inhabited points, as a rule, take up habitation in all the burrows encountered here.

The beginning of the flight season of sand flies depends on the air temperature. Sand flies first of all appear in living quarters, and then outside the habitations. In Central Asia this is observed at the end of April, and in the Ukraine – at the end of May – the beginning of June.

The mass flight of sand flies in the republics of Central Asia usually takes place in June, July, August, and in the Crimea – in July-August. If in the southern regions of Turkmenia sand flies have 2-3 generations per season, then in the northern regions and in the other republics, as a rule, there is only one generation. The duration of life of female sand flies is about a month.

Frequently once formed at an inhabited point a disease focus continues its existence for a very long time.

Basic Directions and Agents for Combatting Sand Flies

At populated points it is possible to carry out prophylactic measures, as well as measures directed towards eliminating sand fly breeding sites.

Among the prophylactic measures there are the following.

Measures for maintaining cleanliness - the regular cleaning of premises and areas of rubbish and manure (including excrements of the silkworm moth and the remains of uneaten leaves); cutting under the roots of weeds; keeping gardens, flower gardens and kitchen gardens clean; eliminating the accumulation of unnecessary objects, especially near walls. Measures of sanitary maintenance - regular, not less than 2 times a year, repair to the crumbling bases of walls, thorough filling in all cracks; destroying all ruins, filling in of abandoned ditches and channels and inoperative wells.

Systematic development of an area, the creation of a new cultivated landscape - the carrying out of successful prophylaxis of diseases transmitted by sand flies. To this division of labor it is necessary to relate the control of stray dogs and the regular observation of the health of othea with respect to leishmaniasis.

For treating of sand fly breeding sites in order to combat their larvae A. G. Grobov recommended the use of naphthalene, and Ginsburg - thiophos (1.25 kg/ha). According to the author, thiophos is more toxic to sand fly pupae than DDT. For combatting the preimaginal stages of sand flies paradichlorobenzene is also acceptable. This preparation is placed in cracks and crevices at a rate of 75 g/m^2.

The toxicity of paradichlorobenzene is so great that a single treatment is completely sufficient for a whole season.

For disinfecting sites suspected of breeding sand flies it is possible to use a 20% solution of chlorinated lime at a rate of 5 ℓ/m^2.

N. V. Bespalova studied the effect of aqueous suspensions of DDT and hexachlorane on these preimaginal stages of sand flies. Coming into contact with surfaces treated with the preparations at a dose of 0.5-1 g of active substance per m^2 for a period of from 5 minutes to 4 days it was not possible to obtain complete destruction of the sand flies. The most sensitive were the first instar larvae: about 95% of them died in the first 3-5 hours; less sensitive were the pupae - on the 8th day about 93% died. Treating assumed breeding places with these preparations at the indicated doses, the author obtained a reduction in the number of sand flies by 23.4-60.9 times. Treatment was carried out 2 times per season - accumulations of rubbish were completely drenched, and rodent burrow were dusted - the front section of burrows and the soil around them were dusted in a radius of 50-60 cm.

B. N. Nilolayev and F. T. Korovin under laboratory conditions tested the effect of DDT aerosols on Ph. papatasii sand fly larvae. All larvae of the second and third instar died from a dose of 0.75 g/m^2 within the first 48 hours after contacting the treated surface. Good larvicidal effects were given by chlorine-derivatives of benzene - paradichlorobenzene benzene (PDB) and polychloride PCh). Both preparations upon heating evaporate, but since their vapors are considerably heavier than air, then they are spread along the surface and into the depth of the substrate.

At assumed sand fly breeding sites depressions of up to 10 cm are made placing them 30 cm from each other. In each hole there are placed 7-15 g of PDB or FCh. The expenditure of larvicide is on the average 75-150 g/m^2 of each preparation respectively.

Measures Applied Against Mature Sand Flies

In the complex of measures directed towards protecting people from sand fly attacks there are included mechanical and chemical methods.

Bed covers of fine-mesh tulle or well starched gauze provide excellent protection for people from the attacks of blood-sucking insects.

Before going to sleep the ends of the cover are tucked well under the mattress and the sleeper is reliably protected not only from the penetration under the cover of blood-sucking insects and ticks, but also from poisonous animals crawling in bed – scorpions, spiders, snakes. For screening windows and doors fine-mesh screens (0.75·0.75 mm) are used: per cm^2 such a screen should not have less than 36 cells. The frames with the screens should fit tightly into the window and door openings.

Cellar air vents are also covered with fine-mesh screens during the whole summer period.

For catching sand flies flying into premises the rackets of academician Ye. N. Pavlovskiy[1] and sticky paper are used.

For catching sand flies on sticky paper the latter is hung in premises at sites frequented by insects – in the upper corners of a room, behind cabinets, and also in animal quarters.

For the individual protection of people from sand fly attacks repellents are also applicable. The duration of the protective effect of repellents depends both on the repellent properties of the preparation and also on the form and methods of its application.

Of all the proven preparations - dimethyl phthalate (DMP), a mixture of DMP, indalone and dimethylcarbate (DID), benzimin and diethyltoluamide (DET) - the most effective were DET and benzimin.

Upon applying repellents to the skin the period of the repellent effect fluctuates for DMP solution within the limits of $2\frac{1}{2}$ to $4\frac{1}{2}$ hours, for DMP cream -- 4-6 hours; benzimin in the form of pencils containing 25% preparation protects up to $2\frac{1}{2}$ hours; in the form of a 20% lotion - 3.3 hours; a solution of the pure preparation - 7.3 hours; DID - $6\frac{1}{2}$ hours; DET - up to 8 hours.

We tested the properties of diethyltoluamide in the south of Turkmenia - we impregnated gauze netting[2] at a rate of 80-100 g/m^2. Before hanging the netting in openings where light comes in it is necessary to let it air out for 6-9 days.

Premises (tents) protected by such netting should be well ventilated; sand flies and also mosquitoes do not fly into them for 25-40 days.

Insecticides are being broadly used to kill adult sand flies. For combatting sand flies disinfecting powders, emulsions, suspensions, and aerosols of DDT and hexachlorane are also recommended.

The main application of DDT and hexachlorane is for the treatment of surfaces of inhabited and uninhabited premises and also for the treatment of vegetation surrounding living quarters. It is necessary to keep in mind that the treatment of surfaces in living quarters should be carried out only with DDT preparations, but for treating the external walls and surfaces of uninhabited premises it is possible to use hexachlorane.

The most convenient forms for the application of these preparations in treating surfaces are emulsions and suspensions. Per each square meter of treated area there are expended from 1 to 2 g of DDT or hexachlorane based on the active substance. The insecticidal properties of the treated surfaces in such premises are preserved in the first case for up to $1\frac{1}{2}$ months, and in the second – for up to 15-20 days.

In treating premises they are first cleaned of dust (otherwise dirty spots or streaks will form), and then in sequence the peripheral sections of the ceiling, walls, doors and windows are treated. The floors and ceilings are treated to a width of 2 m from the wall; wooden ceilings and ceilings in low premises are treated completely; floors, the lower surfaces of furniture and its parts turned toward the walls are completely treated, because sand flies hide in these sites. Carpets, pictures, and furniture are treated if the preparation does not leave traces on them and articles of furniture should not be rubbed immediately after treatment; they must be allowed to dry. On the outside of buildings surfaces around windows, doors (to a width of up to 0.5 m) and the doors themselves are treated. In pioneer summer camps they completely treat the external and internal surfaces of tents, the lower surface of furniture and various flooring. The work is carried out in dry weather. Animal quarters are also treated: stable, pigsties, chicken coops.

For these purposes it is possible to use pencils containing hexachlorane or DDT, which are deposited on a surface in stripes in the form of a grid. The surfaces are rubbed with a rag before applying the pencil, and the floor and ceiling are swept with brushes (brooms) rubbed with a pencil.

In treating terraces, parks, public gardens and other open places the vegetation is treated first of all, and then the lower surfaces of benches, chairs, etc.

Only those plants are treated, which are next to dwellings. For treating vegetation emulsions and suspensions at 2% concentrations are used. The best results were provided by water-soap suspensions. The treating of parks in toto is not recommended, because this may cause the destruction of useful insects (bees, bumble-bees, Ichneumon-flies), and also birds. These insecticides should not be applied in large areas of open nature at the time of the blossoming of plants pollinated by insects. According to P. A. Petrishchevoy, sand flies very rarely land on vegetation and do not remain on it during the day, and therefore there is no need to treat flower gardens and decorative shrubs. Vegetation should be treated only when it is very near to places where people spend evenings out of doors.

DDT aerosols are applied with great success for destroying sand flies in closed premises. Good results are also obtained and with the use of freon aerosols of DDT at a rate of 0.2-0.3 g of active substance per m^3 space. Outside premises it is also possible to use freon aerosols or aerosols obtained by spraying oil solutions of insecticides (at a rate for prolonged residual effect). It is necessary to carry out aerosol spraying from the leeward side. Trees, shrubs and grasses treated with insecticidal aerosols are not damaged; at a dose of 0.4 g of active substance per m^2 sand flies die within 1-3 hours after smoke-treatment. If in the first 17 days paralysis in the majority of sand flies appears after 30 minutes of contact with a treated surface, then by the 50th day the time of contact had to be not less than 2 hours. Aerosols cannot be applied immediately after rain or when there is dew.

Pyrethrum is atomized at a rate of 2-4 g/m^3 directly at the sites of sand fly accumulation and also on surfaces, where particles of the powder can be retained (rough walls, cornices, reverse sides of pictures, etc.). The effectiveness of pyrethrum powder atomized on surface is preserved up to 7 days. For repeated dusting the old powder is removed.

For fumigating they use pyrethrin candles containing about 0.08% pyrethrins; repellent dose in a closed room is 0.5-1 g/m^3, and with open windows 1-2 g. Fumigation can be carried out by burning pyrethrum powder; for this it is placed at a rate of 3 g/m^3 of premises on iron trays or frying pans, which are heated. In the burning of pyrethrum there is liberated a large amount of smoke causing the paralysis and death of sand flies.

For the one-time destruction of mature sand flies it is possible to carry out treatment of uninhabited, and in certain cases also of habitable premises with a 3% soap emulsion prepared at the work site from naphtha soap or technical green soap at a dose of 25 $m\ell/m^2$ of surface. It is necessary to spray the ceilings and walls of premises from top to bottom without lapses, especially the corners, the space behind furniture and various curtains. In the absence of naptha soap and green soap it is possible to use soap-kerosene emulsions: 3% kerosene, 0.6% soap; the soap is ground and dissolved in hot water (1/10 part). Then to the soap emulsion there is gradually added kerosene at the rate indicated above with thorough and constant stirring. The stirring is stopped when the liquid acquires a uniform, milky color. The obtained liquid is diluted with 10 parts of water. The emulsion does not separate into layers for a day. During spraying and for 45 minutes after it the premises should be closed, after which the premises are aired out.

V. M. Saf'yanova together with I. I. Seledtsov tested the effect of chlorophos on sand flies under industrial conditions. In a small settlement of the Serakhs region (Turkmenia) structures of raw brick were treated. The preparation was applied at a rate of 2 g of active substance per m^2. The duration of the residual effect of chlorophos was equal to 7 days.

These authors checked the toxicity of acetoxon on sand flies and noted that it was only slightly toxic to them.

Numerous operations at foci of pappataci fever and dermal leishmaniasis showed that only a complex of measures gave the desired result – a sharp reduction in the number cases of these diseases. Thus, at foci of pappataci fever (Crimea, Turkmenia, Armenia) along with the general sanitary measures all structures were treated with preparations of DDT and hexachlorane during the first 2 years. Then barrier and focal treatment was conducted. The number of cases beginning with the second year was sharply reduced and in the third year decreased almost to zero.

For carrying out disinfestation economically it is more efficient to use the wet treatment method with sprayers, starting with portable highly productive MRZh apparatus with a weight of about 9 kg to powerful ARS-12 engine mounted on a vehicle.

At a focus of dermal leishmaniasis an appreciable reduction in the sick rate was observed, if along with the insecticidal treatment of the structures there was carried out dusting of the burrows, and also destruction of the rodents. For this disinfestation should be conducted not less than 2 times a month.

Measures for Combatting Burrow Inhabitants – Sand Flies and Vertebrates

As was already stated, animal burrows are the main breeding place of sand flies and the main site of the preservation of pathogenic agents in the organism of vertebrates and insects. Therefore the destruction of burrow inhabitants is basis of combatting the reservoir and carrier of leishmaniasis and pappataci fever. It is necessary to reach the state, where at inhabited points there are no burrows. For combatting the hosts of these pathogenic agents such effective methods are acceptable, as catching rodents with all mechanical trapping means and destroying them with poisoned baits. After destroying the burrow inhabitants it is necessary to seal up the burrows, clogging them up with earth and stopping them up with clay.

Along with prophylactic measures at an inhabited point special attention should be paid to the environs, also extending to them the basic aspects of the measures of good management. The main attention, however, should be paid to combatting the inhabitants of the burrows.[3]

The first use poisons in rodent burrows as an antiepidemic measure at foci of dermal leishmaniasis disease was conducted by N. I. Latyshev in August 1938 in the Murgabskiy basin (Turkmenia). On an area of 1250 ha about 500,000 burrows were treated with poison. In each burrow hole there was placed 3-4 g of chloropicrin, after which the burrow was trampled in.

During the winter months 2 men visited the treated zone daily and according to the number of newly settled burrows they carried out repetitive poisoning with chloropicrin. Thus, the possibility of a rodent invasion of the treated area from another area during the winter was prevented. The effect due to the conducted work was enormous: in the year of treatment the disease incidence was reduced by 10 times, and after a year a total of only 3 men fell ill. The incidence of disease decreased from 70% down to 0.4%.

The multiyear experimental work of a number of specialists, using chloropicrin, showed that the mortality rate of gerbils fluctuates mainly from 88 to 95%.

The greater reduction in the number was attained by carrying out double the number of poisoning operations during a season. This prevented a mass epidemic of dermal leishmaniasis for 1-2 years. At heavily populated points the disease incidence decreased by 20 times and more - only from 0.1 to 0.7% of the population was infected; in small villages the disease incidence decreased by

3-10 times. In cities it was mainly the inhabitants of the outskirts who became ill with the disease.

The essence of the chloropicrin method of control consists in the fact that in each burrow hole at a depth of 20 cm there is placed a cotton tampon moistened with poison. Then the burrow is firmly trampled shut. As was already indicated, the method is sufficiently effective, but labor-consuming: in 8 hours of work on a site, where the density of burrows per ha varies from 500 to 1000, one worker manages to treat 0.7-1 ha. Apparently, therefore the chloropicrinization method with trampling has not found broad application. The seeding of rodent burrows with poison without closing them up is ineffective.

As the works of L. N. Yeliseyeva with co-authors showed, even with a reduction in the number of gerbils by 92-98% the disease incidence among the population remained high.

This, apparently, is explained by the fact that the burrow were not closed up and they continued to exist as a source of sand fly breeding. Even in sand deserts the period of preservation of colonies of great gerbils in treated areas was very long. According to the observations of N. I. Vologin, V. P. Nikitin and A. F. Milovanov in colonies, where the rodents were exterminated and there were no signs of life, up to 50% of the burrows remained open for up to 4 months after the treatment. In colonies, where only a portion of the rodents was poisoned, life did not cease.

Our observations (E. B. Kerbabayev, A. B. Karapet'yan, T. N. Remyannikova, L. L. Semashko, G. A. Babayants, Ye. M. Belova) conducted in 1959 in the region of Ashkhabad agree with the preceding data. In clarifying the effect of poisoning rodents on the biological situation of sand flies it was established that sand fly breeding even in uninhabited burrows goes on intensively. Moreover, it was also established that uninhabited burrows are widely used by sand flies as daytime rest sites. Among the sand flies caught in uninhabited colonies more than 9% were infected by leptomonads.

In sections, where the burrows were not inhabited by rodents, the infestation by sand flies reached 12.5%. Consequently, the destruction of the rodents without the elimination of the burrows does not stop the existence of sand fly breeding sites; these burrow can be used as shelters by infected sand flies flying over from inhabited colonies.

L. N. Yeliseyev with co-authors proposes not giving up in the bait method, but applying it more broadly. With this method the bait must be placed in each burrow at a distance of 10-15 cm from the mouth of the entrance.

For complete destruction of the rodents the authors propose four treatments during the season. The labor-input and the uneconomicalness of this modification is evident, and the epidemiological effectiveness, analogous to the chloropicrinization method with the filling in of the burrows, is very high – the disease incidence decreases by 10-20 times.

V. M. Katkov reports on the results of combatting dermal leishmaniasis at a focus by the method of poisoning the site only with grain with zinc phosphide at one section (around 32 inhabited points) combined with dusting of the burrows with insecticides – at a second (around two settlements). The poisoned bait contained 10% zinc phosphide; as the insecticide there was applied 25% DDT disinfecting powder at a rate of 4-5 g in each burrow.

As a result of the deratization there was attained a mortality rate of the rodents of from 53 to 87%. Analysis of disease incidence showed that to attain this reduction only by deratization was not possible. In one settlement, around which along with the poisoning operations there was carried out dusting of the front sections of the burrows, the disease incidence decreased by 78%, at another not one case of dermal leishmaniasis was recorded.

In seeking the most effective method of control, namely trying to find agents for the simultaneous destruction of the inhabitants of burrows and sand fly hosts, starting with 1959, disinfecting powders, aerosols and gases were tested.

In 1959 independent of each other I. S. Turov (Central Scientific Research Disinfestational Institute) and Yu. D. Chugunov (Institute of epidemiology and microbiology im. N. F. Gamaley) with co-authors applied for poisoning burrows their deep dusting with insecticidal disinfecting powders.

It was established by observations that the method of the forced supply of disinfecting powders with exhaust gases was the most effective, if the filling in of the burrows was carried out. In this case not only the arthropods died, but also a considerable portion of the vertebrate inhabitants of the burrows. The method was sufficiently effective only in territories with a small number of rodents (great gerbils). Considering that in treated sections the number of rodents quicly begins to re-establish itself, it is recommended that a repeat treatment be carried out in a month; with a great density of colonies and a large number of rodents – once in a ten-day-period (Yu. A. Dubrovskiy with co-authors).

A parallel investigation of the effectiveness of the method with respect to sand flies shows that immediately after treatment the number of sand flies emerging from the burrows is reduced by 6-8 times. After a month the number of sand flies is restored by 70-80%.

The effectiveness of the method with respect to sand flies is small in that it is inferior to the preceding one – the number of sand flies emerging from the burrows is reduced by 5-6 times. The experiments showed the presence of considerable nonsusceptibility to DDT and hexachlorane in a group of sand fly species. The least sensitive were Ph. papatasii, then Ph. sergenti, S. arpaklensis. Even with a dose of 6 g/m^2 (DDT) about 20% of the individuals remained alive (M. L. Fedder, A. N. Alekseyev).

N. V. Nekipelov and N. F. Zhovtyy obtained aerosols from the sublimation of technical hexachlorane and DDT with hot gases. To the exhaust pipe of a motor vehicle there is attached a metal cylinder, in which there is inserted a pen-case with many holes. The technical insecticide is placed in the pen-case. The hot gases (not higher than 160°), passing through the insecticide sublimate it. The aerosol moves along the hose into the burrow. In using insecticidal smoke pots a temporary and very weak effect is observed.

In our opinion, the most promising method of control must be considered the method of the forced supply of insecticidal-raticidal aerosols into burrows.

The process of treating with aerosol generators consists in the fact that the nozzle of the working apparatus is placed close to the burrow; the insecticidal DDT smoke rushes along the passages of the burrow and immediately begins to emerge from all the holes.

Within 3-5 minutes from one position there is completely created a colony with an average diameter and with 80-120 exits located on an area of 900-1200 m^2.

A calculation of the effectiveness of treating with aerosol generators showed that the smoke cloud possesses high insecticidal-raticidal properties. Thus, after treatment for 16 months (the period of observation) all colonies were without signs of life; not one burrow was opened. Excavations carried out showed that the animals, which had lived in the burrows, had died.

If before beginning the treatment from the burrows sand flies emerged (up to 3 per burrow), after treatment sand flies did not emerge from the burrows for 5 months (the period of observations). In the burrows fleas also died.

Table 42. Preparations tested against certain arthropods and small vertebrates.

No. in order	Code	Name of the preparation and amount in the mixtures		Subject of investigation
1	Kh-1	Chlorophos	30%	White mice, great gerbil, X. cheopis, fleas
		Thermal mixture	70%*	All stages of H. asiaticum, H. anatolicum, H. detritum
2	Kh-5	Chlorophos Zinc phosphide	20% 10%	The same
3	Kh-6	Chlorophos Zinc phosphide	15%	White mice, great gerbil, fleas; all stages of H. asiaticum, O. tartakovskyi
4	Kh-7	Chlorophos Zinc phosphide	20% 20%	White mice, fleas
5	KhK-1	Chlorophos Alkaline additive - I	30% 6.2**	White mice, great gerbil, fleas, persulcatus larvae; all stages of development of H. anatolicum, h. detritum, O. tartakovskyi
6	KhK-2	Chlorophos Alkaline additive - I	30% 2.35%	White mice, great gerbil, fleas, I. persulcatus larvae; all stages of development of H. anatolicum, H. asiaticum
7	KhK-3	Chlorophos Alkaline additive - I	30% 1%	White mice, fleas
8	KhP-1	Chlorophos Alkaline additive - II	30% 10%	White mice, great gerbil, I. persulcatus larvae; all stages of development of H. anatolicum, H. detritum
9	KhP-2	Chlorophos Alkaline additive - II	30% 4%	White mice, great gerbil; all stages of development of H. anatolicum, H. detritum
10	KhP-3	Chlorophos Alkaline additive - II	30% 1.5%	White mice, fleas, I. persulcatus, larvae
11	No.10	Zinc phosphide	50%	White mice, fleas, H. asiaticum, larvae
12	No.12	Zinc phosphide HCCH	20% 20%	The same " "
13	D-12	Zinc phosphide Gamma-isomer	20% 20%	" " " "

Table 42 (Continued).

No. in order	Code	Name of the preparation and amount in the mixtures		Subject of investigation
14	D-12	DDVP Chlorophos	5% 25%	White mice, fleas, H. asiaticum, larvae The same
15	D-7	Chlorophos Dithiophos	25% 20%	Fleas, white mice; all stages of development of H. asiaticum, H. anatolicum, H. detritum, O. tarakovskyi
16	T-3	Thiophos	20%	White mice, fleas; all stages of development of H. asiaticum, H. anatolicum, O. tartakovskyi
17	O-3	Octomethyl	20%	All, except O. tartakovskyi, but plus H. detritum
18	SG	Sulfur	60%	White mice, great gerbil, hedgehogs, fleas; all stages of development of H. asiaticum, H. anatolicum, H. detritum

*In all the remaining compounds the thermal mixture constitutes an amount short of 100%.

**The amount of alkaline additives is calculated above 100%.

The process of treating burrows with aerosols pots consists in the fact that the ignited pot is inserted into the burrow. A stream of air from a fan is fed along a hose into this burrow. With the flow of air the smoke spreads throughout all the passages, fissures and dead-ends.

As insecticidal-raticidal mixtures we tested under laboratory conditions 18 different formulas containing DDT, hexachlorane, gamma-isomer, chlorophos, thiophos, dithiophos, DDVP, octomethyl, zinc phosphide and sulfur (Table 42).

As can be seen from Table 42, the smoke-mixture compounds were diverse, and to some of them alkali was added (1-10%).

Tests of the insecticidal-raticidal properties of these preparations showed that all of them are highly toxic to arthropods (fleas and ticks). The death of the arthropods occurred within 10-15 minutes. At the same dose (20 g/m^3) vertebrates (white mice and great gerbils) died fastest of all (within 10 minutes) from smoke-mixtures of chlorophos and gamma-isomer with zinc phosphide (codes Kh-6, L-12).

Footnotes

[1]A rocket of academician Ye. N. Pavlovskiy is a sheet of plywood with dimensions of 25 × 25 cm attached to a light stick of the required length. On both sides of the corners of the plywood there are fastened or glued corks or small wooden blocks 2-3 cm square. To the plywood there are pinned sheets of sticky paper. The rocket is more parallel to the surface of the walls. Sand flies taking off stick to the paper.

[2]The gauze netting was sewn from strips of gauze with a width of 2-3 cm. The netting protected windows and doors, but when netting with large mesh was applied the protective properties were sharply impaired.

[3]To illustrate combatting dermal leishmaniasis at foci we will endeavor to expound the basic positions.

CHAPTER XXVIII

BLACK FLIES AND THEIR CONTROL

The Pathogenic Significance of Black Flies

Black fly fauna - family Simuliidae - numbers more than 900 species; of these there have been recorded in the USSR 322 species and 43 subspecies belonging to two subfamilies: Gymnopaidinae, Simuliinae. Both subfamilies contain 17 genera.

Black flies belong to insects with complete metamorphosis. The preimaginal stages of development (eggs, larvae, pupae) develop in running ceservoirs. The mature forms of black flies are dipterous insects completing cycle of development in an air environment.

In the forest and taiga zones of the country black flies are one of the most important components of blood-sucking flies.

Black flies are annoying blood-suckers; they attack man and animals en masse, they get into the eyes, mouth, flock into the hair, ears, get up under the clothing. They impede work, fatigue and exhaust with their bites, and sharply lower the productivity of labor.

The bite of black flies at first is not felt, then a bleeding wound is opened, severe burning and itching is sensed, swelling appears.

This severe effect of black fly bites is explained by the toxicity of their saliva. The intensity of the dermal reaction depends on the individual peculiarities of the organism, the season and the species of black fly, which bites.

Bites on the face, especially in the region of the eyes cause rather severe aftereffects: severe swellings, a local and sometimes a general temperature increase, toxin poisoning.

Hystological investigation shows that toxin getting into the organism, damages connective basis of the skin with the muscular and nervous bundles imbedded in it. The toxin spreads throughout the organism; with the blood stream it causes inflammatory changes in the myocardium, damages the renal glomeruli and causes hemolysis.

Domestic animals especially suffer from black flies. With the advent of May black flies become a scourge for them. Sometimes, fleeing from the harassing blood-suckers, the animals literally "turn into wild animals." The mild yield drops sharply, the animals become emaciated and even die.

Besides the aggravating effect, which these insects inflict on man and animals, they are specific carriers of a number of diseases: haemosporidiosis, onchocerciasis, myxomatosis.

Thus, haemosporidiosis in birds is a disease of the febrile type; it is caused by hematic, protozoal, pathogenic agents. From this disease the mass death of poultry has been recorded.

Myxomatosis according to observations in nature and in the laboratory, is transmitted by the black fly S. melatum.

Onchocerciasis is a disease caused by a round, thread-like worm, which is transmitted by black flies during the blood-sucking period. In the organism of an animal Onchocercae reach 1 m in length and are localized both in the internal organs (Onchocerca lienalis stilis) and also in the neck ligaments (O. gutturosa Newm.), the subcutaneous cellular tissue, the intermuscular tissue (O. cervicalis Rail. et Henry), where they cause inflammation and tumors.

This disease weakens the human and animal organism, lowers their efficiency and productivity, and frequently leads to blindness.

In the Soviet Union of the carriers of Onchocercae there are known Odagmia ornata, Boophtora erytrocephala, Simulium argyreatum, S. morsitans, S. galeratum.

Black flies, besides the enumerated specific diseases, as blood-suckers can mechanically transmit anthrax, glanders, tularemia, leprosy, plague and several other infectious diseases. This in turn makes it necessary to focus special attention on them.

The Morphologico-Ecological Characteristics of Black Flies

The adult insects have a body length of from 1.5 to 7 mm. The body is thickset; the head is somewhat bent downwards; the compound eyes have a bright-brown color; the proboscis is short and thick. The thorax is humpbacked, spherical, and covered with a great number of hairs. The wings are long, transparent, and without spots. The legs are strong and short. The color of the females in most cases is dark-gray or black; the males are velvety-black (Fig. 25).

Black fly eggs have a rounded-triangular or oval shape. The color of the eggs depends on how long before they were laid: freshly-laid eggs have a light-ocherous color, in time they acquire rusty- or dark-brown color.

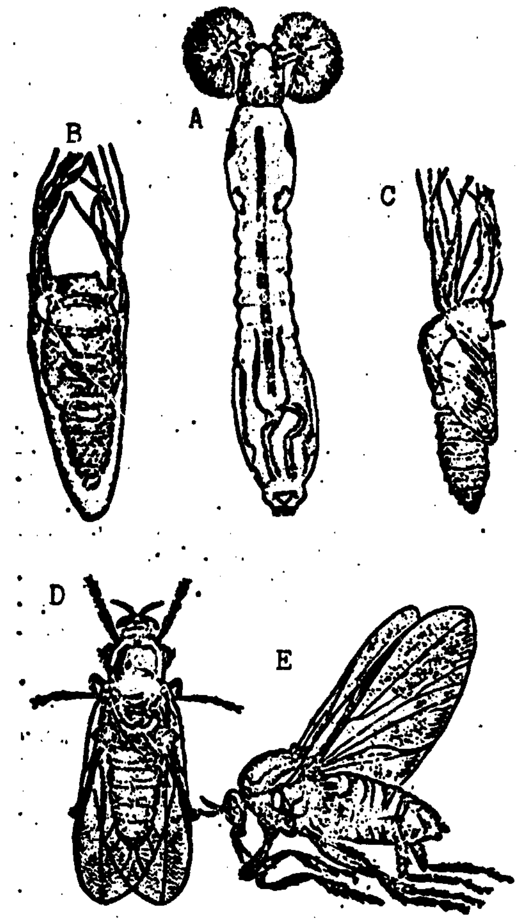


Fig. 25. Black flies (Simulium). A – larvae, view from the back; B – pupa in its "house" view from the back; C – pupa, side view; D – female, view from the back; E – female, side view.

The larvae are worm-like, with a pear-shaped elongation at the rear and a slight one in the front. The head is well-defined and dark. On each side of the head are eyes in the form of spots. On the abdominal side of the prothorax there is an unpaired "legs" furnished at the end with hooks. At the rear end of the abdomen there are 3 papillae, one of which is a sucker. The latter is furnished with hooks. With the help of this sucker and the thoracic "leg" the larvae hold themselves on objects and move.

Black fly larvae have four stages of development. The distinguishing features of each stage [illegible] dimensions of the head. The duration of larvae development lasts about a month.

Black fly pupae rest in a special cocoon "house" woven by the larvae and fastened to the substrate. The pupa is considerably shorter and thicker than the larva, with the head is directed toward the anterior open part of the cocoon, through which protrude respiratory filaments. The pupa is not a feeding phase of an insect.

The eggs and pupae of black flies are firmly fastened to objects, but the larvae lead a "semifastened" form of life. Due to a whole series of reasons the larvae move in water. The retention of the larvae on objects is due to the filaments, formed by the silk glands. The larvae are fastened to the most diverse objects submerged in water.

The larvae of the majority of species of black flies are plastic with respect to a flow speed of from 0.2-0.3 to 1.12-1.46 m/s, and such species as G. cholodkowskyi, W. equina, S. arnatum, S. venustum v. austeni have also been recorded in places with a flow of 1.6 m/s. The stationary distribution of larvae in a reservoir is different depending on the stage of development. Thus, larvae of the first and second instars are usually encountered in the coastal zone, where the flow speed is low. Larvae of the third and fourth instar are usually encountered in places with a maximum flow.

Such a distribution of larvae is in direct dependence on their need for oxygen and nutrition.

As is known, a change in the level of a river produces a change in flow speed, turbidity of the water and temperature. Numerous observations show, that both with a decrease, and with an increase of the river level unfavorable conditions are created for the development of larvae and pupae. In a period of level decrease mainly the immobile stages of development die - the eggs and pupae. The larvae, as a rule, move downstream in the river and into deeper places.

High water in the pupation period of black flies hampers the emergence of mature individuals and a considerable portion of them dies.

The viability of black fly larvae does not suffer during a short-term change in the environment.

Black flies winter in the egg and larval stages; their development occurs depending upon the water temperature. In the reservoirs of Armenia, where in November there were recorded only I and II stage larvae, in January with an average temperature of 11° there were already detected larvae of the older instars. The development of larvae is arrested at 3.5° and below. Thus under the conditions of the Murmansk region the hatching of larvae also begins with 4°. The flight of mature black flies in the southern regions of the country starts in April, in the middle belt – in May, in the northern and eastern regions – in June, in Yakutia – at the beginning of July; in the south by this time the flight of the second generation is beginning; in the eastern and northern regions the flight of the second generation is noted at the end of July – the beginning of August. Flying out from the reservoirs the black flies frequently settle on the shore vegetation, in which they remain for the first 1-2 days. Then they begin to fly away in all directions. The dispersion occurs mainly along the paths of man and animals (along roads, cattleruns, to the pastures).

On the basis of epidemiological data (onchocerciasis in people) and experimentally it has been established that the disperson of black flies from their breeding place can be to a distance of up to 10 miles. Browne notes that the main mass of black flies is usually recorded within a two meter radius from their breeding site.

The duration of the life of black flies is subject to wide variations. The phytophagous species live from several days up to one month, and the females of blood-sucking species live on the average one month under conditions of a moderate climate up to 3 months under the conditions of western hemisphere.

The duration of life of the insect is severly reduced without water and nutrition.

Among the black flies possessing organs of the blood-sucking type (the majority of the known species), few species attack warm-blooded animals.

I. A. Rubtsov considers that the degree of blood-sucking activity of black flies as well as other insects – mosquitoes and horseflies depends on the conditions of larva development.

Most frequently the producers of active blood-sucking black flies are the large rivers with unfavorable conditions for the nutrition and development of larvae (Angara, Yenisey, Volga, Kura, Danube).

Black flies, which attack domestic animals, also attack man; their feeding on the blood of amphibians, birds, squirrels, mice-like rodents and others has, apparently, an accidental character.

As has already been said, their physiological development depends on the nature of the insect nutrition.

The newly hatched females still have underdeveloped eggs. After receiving a full portion of blood (after one or several bloodsuckings) the rapid development of the eggs begins. The digestion of the blood and the complete ripening of eggs takes 5-7 days, after which the eggs can be laid. In the case of the absence of conditions for oviposition (cold weather, rains) the females can delay oviposition for 15-20 days.

The number of eggs laid varies greatly (from 1 to 100 eggs) and is in direct dependence on the amount of initially imbibed blood.

On the basis of observations in the laboratory, in the nature and epizootological data it has been established that a considerable percent of the females suck blood repeatedly; some of them go through up to five gonotrophic cycles. The majority of black flies (up to 95%) go through 1-2 gonotrophic cycles.

Proceeding from these data, it is necessary to assume that repeated blood-sucking, apparently, for all blood-sucking species is the rule. This in turn is very important in an epidemiological respect - in the dissemination of diseases.

In the process of development males emerge from the eggs several days earlier; they have been concealed in shore vegetation and feeding on the material extracted from flowers and leaves. Their main mass is concentrated along the shore in a section of from 500 to 900 m.

After the males the females hatch in unison in the course of 6-8 days. For a certain time they also concentrate in the vegetation: after copulation they disperse and in approximately a week they return to the reservoir for oviposition. During this period they hide in the shore vegetation during the morning and evening.

Phytophagous species copulate on land. Under the conditions of Karelia the black flies of this group cover the shore belt in a solid layer.

During the time of copulation (from 20 minutes to $1\frac{1}{2}$ hours) black flies almost do not react to external influences.

The mating of black flies of the blood-sucking group occurs, as a rule, in flight. For many species swarming has been noted; the basic mass of which is composed of males. The distance the swarm moves from the breeding site can be considerable (several kilometers) (Z. V. Usova).

Species of the genus Simulium form incredibly huge swarms with a dimension of several tens of meters.

After fertilization the females attempt to find victims for blood-sucking or they can proceed to oviposit.

An attack of black flies in nature is determined by the influence of external factors.

In the south of our country (the Volga delta) black fly attacks are recorded at a temperature of 9-26.9°. Moreover an attack by black flies at 9° is possible only with clear, sunny weather, when the body of black flies is heated by the direct rays of the sun. The optimum temperature conditions for the activity of black flies is the range between 12 and 26.9°, when more than 90% of all individuals attack. In the curve of the number of attacking black flies during this period two peaks are observed – at 15-17.9° and at 24-26.9°. Starting with a temperature of 27° the number curve drops sharply. At a temperature higher than 30° black flies are not encountered. The activity of black flies during the day, proceeding from indicated temperatures, starts at 5 o'clock and ends at 9 o'clock P.M., having its maxima from 7 to 9 A.M. and from 4 to 8 P.M.

Under the conditions of the north (Karelia) black fly attacks are observed within the range of 6-29.9°; the optimum temperatures are included between 12 and 27°; at higher temperatures the number curve drops. The greatest number of attacks is recorded at 18-26.9°.

During the black fly flight season in the north two rises in number are noted – the first in June, the second – at the end of July – the beginning of August.

The optimum temperature of the first wave is within the range of 12-21°, and of the second – 24-26.9°. Under the conditions of Eastern Siberia (the Angara river) in the Bratsk region black fly attacks are observed between 7 and 33°.

Thus, the activity of black flies in various zones has its own temperature limits. Thus, in the tundra zone black flies are active within the limits of 6-29.9°, in the forest zone (the middle belt, Urals, Western Siberia) within the limits of 8-28°, in the taiga zone (Eastern Siberia, The Far East) within the limits of 7-33°, in the forest-steppe zone within the limits of 9.5-33.5°. The optimum temperatures in almost all the zones fall between 12-28°; only in the taiga zone does the lower optimum boundary begin at 16°.

In our observations on the Ilim River (a tributary of the Angara) (M. L. Fedder, E. B. Kerbabayev, A. N. Alekseyev) the activity of black flies was observed from 0730 until 2130 hours. The activity curve usually had two peaks – a morning peak before 0930 hours and an evening peak – from 2000 hours until 2130 hours.

In overcast weather black fly attacks were very severe and also in the middle of the day. Every time the curves of humidity and temperature converged, the activity of black flies increased; in proportion to the divergence of these curves the number of attacking black flies fell sharply.

The leading role in the attack of black flies on a subject for blood-sucking was played by their organs of sight. These troublesome blood-suckers attack only during daylight. Moreover the number of attacks of black flies is considerably affected by the latitude with its peculiarities. Thus, in the south of European part of the USSR the flight of black flies begins with dawn and reaches its maximum within the limits of 1000-3001x (this coincides with the time of 6-8 o'clock A.M.). The further increase in illuminance begins to suppress the black flies and by 10 o'clock their activity is practically equal to zero.

The restoration of black fly activity begins at 1700 hours, when illuminance is noticeably dropping; in proportion to the decrease in illuminance the number increases, the curve of which with the approach of darkness is immediately broken off. For example, under the conditions of Krasnoyarsk black fly attacks are observed from

16 to 16,995 lx. The optimum illuminance was 1000-13,500 lx. Black flies on the lookout for optimum illuminance in the evening move to the tops of trees. This, apparently, explains the absence of these insects at night in low vegetation and their instantaneous disappearance with the approach of darkness. In the north in the first half of summer twilight does not occur – it is light around the clock. Illuminance reaches 60,000 lx and more. However, this is almost not reflected on the activity of black flies.

The only thing that hinders their flight here is the low temperatures, lower than 6°, and the increased relative humidity up to 90% and at 8.8° there is no black fly flight.

The suppressing effect of the wind on black fly activity is indisputable, but it appears differently under different conditions. In closed habitats (overgrowth, flooded areas, shrubs) flight noticeably decreases with a speed up to 2 m/s, and with a further increase of it stops altogether. In open habitats a decrease in the number of black flies is noted at a wind speed of up to 1 m/s. Their flight ceases at a speed of more than 1.5 m/s. Especially strongly expressed is the suppressing effect of wind outside the optimum temperature conditions. Black fly attacks chiefly occur the windward side.

Almost no effect on black fly flight is rendered by relative humidity within the limits of 18-100%. Black fly flight ceases only with the presence of fog, but light rain does not interfere with their activity.

Basic Principles of Combatting Black Flies and Prophylaxis of Their Attacks

Combatting black fly larvae. The idea of combatting the water stages of black fly development appeared long ago. Almost 80 years ago for decreasing the population of black fly larvae rivers were treated with a kerosene emulsion, burnt lime, carbonite sulfate, tobacco smoke and pyrethrum. Along with the application of larvicides which had a specific effect, it was considered expedient to use dredges to remove the larvae and pupae from their breeding places.

In 1934 I. A. Rubtsov and N. A. Vlasenko published the results of their experiments in determining the necessary doses of larvicides for destroying the water stages of black fly development.

It has been determined that of all the water stages the most highly sensitive are black fly larvae; eggs and pupae are extremely resistant.

In Guatemala against black fly larvae there were applied low doses of DDT emulsion: at a ratio of 0.1 part of preparation per million parts of water complete destruction of larvae was attained for a distance of 10 km downstream.

Under conditions of Kenya into the current of a river there was fed a 5% solution of DDT in kerosene and oils by the drop method for 35 minutes at a rate of 0.2 part per million parts of water. The destruction of black fly larvae was observed downstream to a distance of up to 65 km.

For obtaining a noticeable reduction in the number of mature black flies in a region where larvae were being combatted it was necessary to exterminate larvae for a 100 days (10 times with 10 day intervals). Then the intervals between treatments were increased to 2 weeks, and, finally, to one month. During the black fly breeding season, i.e., for 5 months, the river was treated 15 times. This was sufficient, so that in the subsequent half year in the region adjacent to the treated river, there would not be any mature black flies.

As a result of a check of the larvicidal properties of DDT, hexachlorane, chlordane and toxaphene at different dosages it was established that DDT dissolved in mazut and supplied at a rate of 0.1 part per million parts of water, and the gamma-isomer of hexachlorane at a rate of 0.2 part per million give an excellent effect with a 15-minute exposure. Broad testing showed that DDT is the most acceptable as a larvicide.

DDT dissolved in diesel fuel is introduced into the water of a river for 30 minutes at a rate of 1 g per m^3 of water. This is also immediately reflected on the number of adult insects; it is reduced by almost 97%.

Under the conditions of Guatemala, Kenya, eastern Africa and Alaska considerable success was attained as a result of the application 1 g of active substance of DDT per m^3 of water, with treatment at each 1.6 km.

The gamma-isomer in the form of a 0.0001% emulsion gives a large effect at an exposure of 5 minutes and can be applied once a month without harm to other animals. The larval population after such treatment even after a day is reduced by 95-96%.

According to laboratory data there act lethally on black fly larvae: gamma-isomer at a concentration of 1:1,000,000 with an exposure of 1 minute; DDT emulsion at a dose of 10:1,000,000 with an exposure of 1.7 minute; DDT paste at a dose of 10.5:1,000,000 with an exposure of 5 minutes. Lea and Dolmat (1954) under the conditions of Guatemala established that at a dose of 1:1,000,000 heptachlor, chlordane, aldrin, dieldrin and DDT possess high larvicidal properties. By lengthening the exposure to 1 hour the dose could be reduced by 10 times.

Comparing the toxicity of chlorophos, acetoxon, trichlormetaphos-3 and phosphamide with DDT A. N. Alekseyev notes that of all the preparations the most toxic was acetoxon (Table 43). The remaining preparations are inferior to DDT in toxicity.

Table 43. Laboratory data about the destruction of black fly larvae from different insecticides (in percents).

Preparation	Exposure in minutes	Concentration (number of parts of preparation per million parts of water)									Author
		0.2	0.5	1	2	10	50	100	500	1000	
		destruction of black fly larvae, %									
EPN	30	100	100	100	100	100					Lea u Dolmat, 1954
Dieldrin	30	—	89,3	96	100	100					
DDT	30	—	47,8	53,2	78,4	100					
Gamma-isomer	30	—	39,1	31,1	66,7	79,2					
EPN	15	90,4	97,8	97,5	100	100					The same
Dieldrin	15	—	92,3	97,6	100	100					
DDT	15	—	26,9	52,4	65,5	84,5					
Gamma-isomer	15	—	33,9	32,3	40	90,4					
EPN	5	27,1	37,8	83,7	100	100					" "
Dieldrin	5	—	87,5	100	100	200					
DDT	5	—	—	40	62,8	68,2					
Gamma-isomer		—	—	41,7	62,9	58,7					
DDT	30	—	0,7	14,8	—	47	52				A. N. Alekseyev, 1963
Acetoxon	30	—	2,2	6,4	—	93	—				
Chlorophos	30	—	2,2	14,9	—	35	—	52,4	74,6		
Trichlormetaphos-3	30	—	0	2,5	—	35,4	—	—	—	98,2	
Rogor	30			18,9	—	24,5	—	44,1	68,1		

Studying the effect of insecticides on fish under experimental conditions it was established that DDT at 1:1,000,000, and the gamma-isomer of hexachlorane at a dose of 1:300,000-1:600,000 are not toxic to fish. A number of authors warns that the accepted concentrations are dangerous for plankton and for young fish. The danger is in places with impeded flow, where increased concentrations of the preparation are created.

All the cited data on treating rivers were connected with the method of surface application: most frequently the treatment of reservoirs is carried out from ordinary ships, cutters, boats, a raft or a bridge. For treating rivers which are not too accessible, mainly small rivers and brooks, aircraft and helicopters are used.

Brilliant results were obtained with the use of a special emulsion of DDT (1 part of 12% DDT solution; 50 parts of velsicol-alkylnaphthalane; parts combustible oil) – the larvae were exterminated at a distance of more than 100 km and for a number of years mature black flies at a given site were practically absent.

Deserving of the greatest attention is the fact that larvae hatching within a month from the eggs also died.

It is also recommended that reservoirs also be treated late in autumn for the purpose of destroying wintering larvae, and as an insecticide DDT be used at a dose of 1-16 g per ha of water table.

Davis with co-authors used for aerial spraying a 5% DDT solution in diesel fuel at a rate of 5.7 ℓ/ha. Water currents were treated in 200-meter strips; complete destruction of larvae ensued within 2 weeks. An analogous period of larvae destruction was also observed as a result of the application of 50 g/ha of dieldrin; in the subsequent 4 weeks there was also noted the destruction of more than 90% of the larvae.

During recent years in the Soviet Union considerable attention has also begun to be allotted to the study of the effect of insecticides on black fly larvae.

Tests conducted under the conditions of brooks and small rivers showed that for successful control there can also be applied 20% solar oil emulsions of DDT and hexachlorane. Upon mixing with water the emulsions spread over the whole area and are in very insignificant amounts: at a ratio of 1:1,000,000 and even less the destruction of larvae was attained with an exposure of 20-25 minutes; larval death was noted 16 km downstream on the 6th day.

S. G. Grebel'skiy in the region of the Bratsk hydroelectric power plant used an aircraft with a sprayer for treating the Angara River. Within 3-6 days into the river on a section of 75-80 km there was poured about 2 t of 20-25% DDT emulsion. The effect was good - at a distance of 10-15 km larvae died; however, in view of the high costs of this method it had to be abandoned.

L. V. Timofeyeva with co-authors on the Yenisey and Angara Rivers applied 25% standard DDT emulsion, feeding it into the river at a rate of 0.138, 0.25, 0.27, 0.45, 0.51, 0.89 parts of DDT per m^3 of water. With an exposure of 30 minutes there was obtained an absolute effect at a distance of up to 70 km at the first dilution and up to 150 km at all the others.

Combatting mature black flies. After black flies hatch they congregate in shore vegetation. Thus in treating a broad zone of vegetation with insecticides there can be observed a reduction in their number. In years with a small number of black flies spraying vegetation with an aqueous emulsion of DDT at a dose of 10-16 kg/ha is accompanied by their sharp reduction - by 3-10 times.

However to obtain any prolonged effect with a large number of black flies by this method is not possible - after several hours there number is restored due to those flying in from other areas.

More effective in combatting black flies was the method of applying aerosols. In Byelorussia 20-minute smoking of vegetation with NBK-G-17 smoke pots (a doze of 23.3 mℓ of active substances per m^3) protects cattle and people from black fly attacks for up to 9 days. In a region with a large number of insects (eastern Siberia) treating forest sections with NBK-G-17 smoke pots gives good, but short-term results. Therefore it is recommended that this be combined with other methods.

For protecting the builders of the Bratsh hydroelectric power plant S. G. Grebel'skiy for a number of years used aerosols produced by generators.

With the beginning of black fly flight the whole construction site was systematically smoked. The number of black flies decreased by 75-100%. With the help of massive treatments a huge territory was liberated from black flies for a period of up to 10 days.

According to the materials of foreign authors, the creation of protective barriers by spraying insecticides on a limited territory produces a noticeable reduction in the number of black flies.

For achieving a stable effect - sanitizing the area against black flies, both foreign and domestic scientists came to the conclusion that only a complex of measures - the destruction of water and mature stages - can provide this.

Methods and Agents for the Individual Protection of People

During a stay in natural conditions man is subjected to acutely painful attacks by blood-sucking black flies. The simplest method of protecting against black fly attacks are mechanical means: wearing coveralls of closely woven fabric, mosquito cowls (mosquito netting), thick gloves, thick stockings, puttees or boots, fitting tightly to the legs.

However, even such "wrappings" during the period of the most intensive black fly activity rarely provides salvation - they actively force their way into the smallest apertures in clothing. To this it is necessary to add that with such shielding it is extremely difficult to work during hot summer days.

For protection against black fly attacks man resorted a long time ago to various fragrant, repellent agents: clove oil, lavender, peppermint, burdock oils, birch juice, tar, kerosene, creolin and others.

During the period 1951-1952 on the Kola Peninsula in the Karelia was the antibite action of dimethylphthalate (DMP) was tested with respect to black flies. Netting impregnated with phthalate jellies protect for the course of a whole season (from 22 June until the beginning of September).

The protective effect is so great that the labor productivity of the workers is increased by 2-3 times.

Smearing the exposed parts of the body with a DMP solution gives protection for 1-3 hours. When applied to the skin the protective effect of the ointment lasts 4-7 hours.

Along with DMP, A. V. Maslov tested a whole series of benzoic acids, terpeniol, kiuzol, repudin and others both in the form of solutions and in the form of creams. The author notes that the antibite properties of the preparations were very good. However, the black flies do not fly very far away from the person, but keep flying near his face; flashing before the eyes they impede normal vision "white light" and sharply lower the work capacity.

Ye. Kh. Zolotarev, V. M. Saf'uanova and T. V. Kalakutskaya tested kiuzol in the middle belt: Ye. N. Pavlovskiy netting was impregnated with the repellent at a rate of 5, 10 and 20 g of the pure preparation per m^2.

V. M. Saf'yanova also tested the protective action of suits impregnated with the preparation, expending on one set of clothing 100 mℓ of pure preparation.

Clothing impregnated with kiuzol preserve its repellent properties for 3-4 months.

N. A. Violovich tested the effect of diethyltoluamide in western Siberia. A 20% solution of the preparation was applied to the skin. The antibite action lasted 8 hours and more.

We (M. L. Fedder, E. B. Kerbabayev, A. N. Alekseyev) in the summer of 1961 in the Nizhne Ilimsk district of the Irkutsk Oblast tested diethyltoluamide (DETA), kiuzol, benzimin. DMP was used as a standard. These preparations were used to impregnate black cotton coveralls and standard Ye. N. Pavlovskiy netting. Impregnation was carried out with the help of an automatic sprayer with an acetone solution of the tested preparations at a rate of 200 ml of preparation per set of coveralls and 20 ml per piece of netting. For soaking coveralls 1000 ml were used and for netting 100 ml of a 20% solution. The tests were conducted at an average temperature of 21° and a relative humidity of 79%.

A testing of the protective effect of the suits was conducted every 5-6 days and showed that moistening and treating give approximately identical results.

The best indices of the coefficient of protective effect (CPE) were obtained in testing kiuzol (96%), diethyltoluamide (92.3%). DMP protected 91.3%, and benzimin 84%. After a year a test was conducted of the protective effect of these suits. The latter had been stored all winter packed in oilcloth sacks. In testing the suits treated with kiuzol gave coefficients of protective effect of 68%, and with diethyltoluamide 43%.

It is necessary to note that even the impregnation of all clothing does not protect the hands from bites.

Black flies do not bite only those parts of body, which are covered with fabric, even though it is tulle. For protecting the face, neck, and head along with Ye. N. Pavlovskiy netting we tested black tulle cowls. The experiments showed that tulle cowls impregnated with kiuzol and diethyltoluamide reliably protect the head and face from black flies for the whole season. In applying the preparations to the skin irrespective of the form of application (solutions, lotions, ointments, etc.) and concentration it was not possible to obtain complete protection even for a very short period: black flies flash before the eyes, stick to the skin of the face, get in the eyes and mouth.

In the summer of 1962 work on the study of the protective effect of diethyltoluamide was continued. For impregnating clothing a 50% solution of the preparation was tested. During the period of the tests the weather was very dry and hot with daytime temperatures of 25-30°.

Treating one suit with an automatic sprayer with a pressure of 2 atm lasted 15 seconds. For treating a complete set of clothing (trousers, shirt, coveralls) 300-400 mℓ of 50% DETA solution is required.

Clothing treated by the spray method protects from black fly bites under very hot summer conditions for a month.

In individual protection the color of the fabric from which the clothing is served is very important. We noted that people dressed in white and especially in green (khaki colored) clothing were subjected to considerably fewer black fly attacks than people dressed in black (dark) clothing. Thus, black color attracts 8-9 times more black flies than white and green colors. If one were to calculate the protective effect of green and white colors with respect to black, then for the first it was equal to 90%, and for the second 84%.

Consequently, only due to a change in the color of a suit it is possible to obtain a sharp reduction in the number of attacking black flies.

For protecting small groups of people from black fly (and other types of blood-sucking flies) attacks it is necessary to screen the windows and doors of dwellings with fabric (tulle) netting, curtains, pretreated with repellents.

When using tents for living quarters it is necessary to spray their external walls with repellent mixtures to a height of 0.5 m from the ground, both flaps of the entrance and all round the viewing ventilation) apertures. The spraying is carried out at a rate of 20 mℓ of solution per m^2. In proportion to the reduction of the repellent effect of the preparations it is necessary to repeat the treatment (spraying, wetting). Thus, when treating with dimethylphthalate spraying should be repeated within 4-5 days, in treating with diethyltoluamide within 25-40-60 days.

N. L. Simbirtsev used "protective domes" in eastern Siberia for protecting animals. Parachutes used in transport aviation (with an area up to 50 m^2) were moistened by a hand-sprayer with a 10% emulsion of chlorinated phenol ethers (CPE) and stretched above the ground in the form of a dome with a height of up to 170 cm. In treating one parachute 10 ℓ of emulsion are expended.

These umbrella-domes reliably protected animals from black fly attacks, horseflies and other types of blood-sucking flies for 10 days.

Similar protective umbrellas can also be used for protecting people: places are set up under them for resting, eating and even for spending the night.

CHAPTER XXIX

ANTS AND THEIR CONTROL

Ants belong to the order of membranous-wings (Hymenoptera), to the class of insects of the arthropod type, to the family Formicidae; the ant family consists of 5 subfamilies (340 genera, 6000 species).

Ants live in large families, frequently numbering tens and hundreds of thousands of individuals. Polymorphism is well developed among ants, i.e., the presence of different groups of individuals – females, males and workers (Fig. 26). The males and females are winged, while the workers are wingless. In a specific season in a family males and females hatch. Upon achieving sexual maturity they fly out of the nest and mate in the air. After mating the males quickly die and the females shed their wings and establish new nests. The young female oviposits and rears the first group of workers herself; subsequently the worker ants take care of the offspring. Females can live about 15 years; the life of the males is considerably shorter. Females and worker ants emerge from identical fertilized eggs, but in the larval phase they obtain different food both with respect to quantity and, possibly, with respect to quality.

The larvae of working ants are not as well fed, in consequence of which their sexual organs do not develop sufficiently. Working individuals are underdeveloped individuals. In certain species of ants, besides the usual workers, there are individuals with very large heads and large jaws, which are called soldiers. Their duty is to protect the nest.

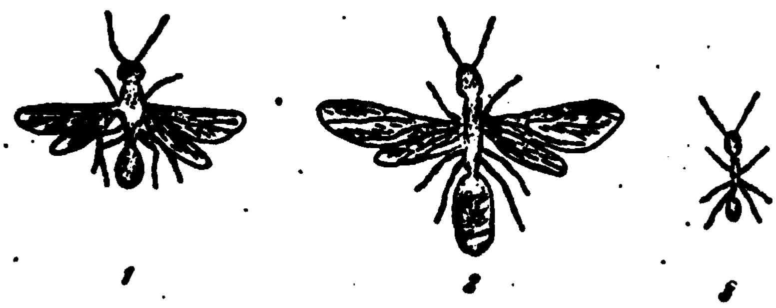


Fig. 26. The red house ant. 1 – male; 2 – female; 3 – worker.

Certain species of ants have very well developed stingers and can sting. Thus, for example, tropical ants can attack man and animals, and the bites of certain of them are very poisonous. In other ants the stingers is reduced in size; they eject a caustic liquid containing formic acid.

The majority of species lives in open habitats, a portion of them live near houses, and certain species are adapted to permanent living inside buildings.

In dwellings mainly four species of ants are encountered: the red house ant (Monomorium pharaonis) the garden [corn-field] ant (Lasius Niger, Lasius alienus), the red-chested carpenter [wood-borer] ant (Camponotus herculcanus).

The red house ant makes its nests in heated premises, the garden ant makes its nests outside, the Lasius alienus ant settles both outside and inside. In nature the red house ant is encountered in the tropics, from where more than 100 years ago it was brought into port cities in ships, thus this species of ant is sometimes called the ship ant. From port cities the red house ant was spread to other populated points; at present it is encountered in many cities of our country. They live in families, in each of which there are females, males and worker ants. The reproduction of ants takes place in the following manner: the females lay whitish eggs with an ellipsoid shape; the worker ants protect them and care for them. The hatching larvae are whitish in color and are legless; the anterior section of the larva is thinner than the posterior and somewhat bent in shape. The larvae are nursed by the worker ants; the workers feed and protect them from any eventuality, carrying them from place to place with the setting up of a new nest. The time of development of the larva depends on external conditions – temperature and abundance of food. The development from the egg to the adult insect lasts 36-39 days (for sexual individuals it is 3 days longer).

Red house ants are very small in size. The worker ants have a goldish-yellow color; in the female the posterior part of the abdomen is dark; the male is almost black; the length of the female body is 3.5-5 mm; the male is 2.8-3 mm, the workers 1.75-2.5 mm (the weight of each individual is approximately 0.06 mg or 17,000 individuals weigh 1 g). The ant has three distinctly separate body sections: the head, thorax and abdomen.

The red house ant lives in dwellings, various medical establishments, food-producing factories, stores, storehouses and other places. They make their nests in cracks in plaster, under floors, in partitions, between a wall and the baseboard, under window sills and, finally, even in canned food jars, cabinets, rags. Red house ants prefer to set up their nests in premises with high temperature and humidity (laundries, washing and bathrooms, restrooms, kitchens, food enterprises).

Ants live in families: individual families can number more than a million individuals, and the number of queen ants in such families can reach 200 individuals. The annual increase of such colonies can amount to 30,000 individuals. From a family there will separate new colonies which migrate to other places, sometimes to adjacent premises. In this way they colonize individual homes and sections of a city.

Red house ants are omnivorous. They feed on meat, flour products, sugary and other substances, are able to remain without food and water for 3 days; on the 4th day half of them die, and on the 5th only separate individuals remain alive. Insects are the favorite food of the red house ant (dead flies, cockroaches, wasps and others).

They use any food, on which man feeds, except oil; they prefer beef over pork; liver, apparently, is a most attractive bait (it can attract females). They are attracted to sugary products, flour and other substances; getting into food products, ants make them unfit for human consumption. The saliva and skin secretions of man strongly attract them, special danger threatens breast babies having wounds on the head and suppurations.

Red house ants harrass people, especially little children and those seriously ill; they can consume pus, sputum, and corpses in mortuaries. Due to the fact that they also crawl in on and over infected matter (used dressing material and others), excretions, sewage, they can mechanically transmit various micro-organisms, as for example, the pathogenic agents of typhoid fever, dysentery, plague and, possibly, anthrax.

Red house ants at a temperature lower than 2° go into a state of anabiosis.

Measures for combatting ants. In combatting red house ants various insecticides are used: fumigants, preparations of intestinal and contact action. Combatting ants in human dwellings is fraught with extraordinary difficulties. It is especially difficult to combat them in multistoried and multiapartment buildings. Before carrying out control measures it is necessary to look for and destroy their nests.

Inside premises in those cases, when it is not possible to find the nests or when they are located in inaccessible places (between the floors and ceilings of different apartments, etc.), palliative measures are taken: all visible cracks are filled in, and the ants are destroyed with poisoned baits. The best measure in such cases is the use of gases. But in a multiapartment building it is doubtful whether it is possible to use the gas method, especially when all the apartments are infested, because it is impossible to simultaneously move out all the tenants, and treating the individual apartments one after the other does not give a sufficient effect. Treatment with disinfecting powders, emulsions, and solutions of DDT, hexachlorane, and chlorophos, as a rule, temporarily disinfests the treated premises due to the repellent effect of these preparations.

The DDT and hexachlorane have a toxic effect on ants: under laboratory conditions ants coming in contact for a period of one minute with surfaces treated (at a rate of 2-2.5 g of pure preparation per m^2) with a 10% disinfecting powder or a 5% emulsion of DDT died within 3-5 hours. But under practical conditions for partial treatment of the surface DDT and hexachlorane preparations cannot be applied, because the ants sense the presence of these insecticides on the surfaces and avoid these surfaces. This was also confirmed by laboratory experiments: if half of the bottom of a glass beaker is treated with DDT or hexachlorane disinfecting powder and a test tube with sausage is placed on the treated surface, the ants do not pass through the disinfecting powder to get to the sausage, but, on the contrary, try to keep as far away from the preparation as possible.

Hexachlorane is more effective against ants than DDT. After one minute and more of short contact of ants with a 6% disinfecting powder of hexachlorane in some of the insects within 3-5 minutes there are observed the first symptoms of paralysis, and after 30-40 minutes in all the insects there appears profound paralysis.

With the solid treatment of walls and floors with DDT or hexachlorane preparations ants for the most part die, and the others abandon the premises; but as soon as the preparations applied to the surface lose their effectiveness the ants reappear (L. I. Yevreinova).

In those cases, when the number of ants in apartments is small, it is possible to apply (around the places where they come out) pencils of hexachlorane at a rate of 2 g of pure preparation per m^2; other insecticides also have considerable effectiveness.

Pyrethaum in toxicity is stronger than DDT and hexachlorana. Thus, for example, contact for a minute with a surface treated with pyrethrum powder causes paralysis in ants within 3-5 minutes, and then their death. Pyrethrum possesses less expressed repellent properties than DDT and hexachlorane, and ants bypass surfaces covered with this preparation for 2 days after treatment, and then stop avoiding them, pass through them and die. Fleacide and pyrethol (an alcohol extract of pyrethrum) possess the same insecticidal properties, as pyrethrum powder. The application of DDT, hexachlorane, chlorophos and other contact insecticides for the most part extends the disinfestation period of premises.

Poisoned baits are a basic means of combatting ants. Baits are effective in combatting all species of ants encountered in premises.

The application of poisoned baits is based on the one hand, on the principle of destroying the worker ants, which leads to the cessation of the food supply the care of the nest with the subsequent destruction of all the ants in it. On the other hand, with the use of poisoned baits it is assumed that the worker ants can carry the baits to the nest and, by feeding it to the larvae, the young individuals and females their death will ensue.

Baits are prepared according to the following formula. Per liter of water there is taken one of the following insecticides: borax 30-35 g, sodium fluosilicate 5 g, sodium fluoride 5 g (the insecticide must be applied in its chemically pure form), sugar 400 g, honey 100 g, vanilla essence 1 mℓ or pear essence 1.5 mℓ.

According to L. I. Yevreinova and L. I. Brikman, ants prefer baits with a large concentration of sugar (40-60%) and plus 10% honey. Ants go less readily to baits containing 5% honey.

According to effectiveness of action borax can be put in first place and then sodium fluosilicate and fluoride.

To liquid baits to protect them from decay it is recommended that glycerine be added; such baits can be stored for several months, but without glycerine for not more than 3 weeks. Therefore it is necessary to replace the baits not less frequently than once every 3 weeks.

According to L. I. Brikman, T. L. Potsheba with co-authors, baits with the following composition are effective: 1) borax 3.5%, glycerine 20%, sugar 38%, honey 7%, water 31.5%; 2) borax 3.5%, sugar 25%, honey 7%, water 63.5% (more effective than with glycerine); 3) sodium fluoride 0.3%, water 66.7%, sugar 26%, honey 7%.

For preparing baits the insecticide is completely dissolved in hot water, sugar is added and the solution is heated to boiling with constant mixing to avoid caramelization of the sugar. Honey is added to the hot solution, and essence - to the cooled solution.

The bait is cooked in a clean enamel dish specially made for this purpose. It is desirable to store the solution in a cool place under lock and key, in premises without extraneous odors. On the dish with the solution there should be a label showing the formula.

Poisoned baits with borax are poured: into flasks (for penicillin) to a height of 2 cm (6 mℓ), into a glass to a height of 1 cm (35 mℓ), into test tubes 3-4 mℓ of solution. For poisoned bait with sodium fluoride and fluosilicate there are used only penicillin flasks, filling them to a height of 1 cm (2.5 mℓ). The flasks are placed in a tilted position in places most frequently visited by ants at a rate of one test tube per 2-4 m^2. In a number of cases it is expedient to hang up the packing with the bait. In enterprises and establishments it is better to use unbreakable packing.

Toxic preparations (arsenic compounds, borax, sodium fluoride, thallium sulfate) are mixed with food substances, which insects eat readily. All strong preparations (arsenic and thallium sulfate) are applied at a concentration of from 0.1 to 4%. Because of their toxicity they cannot be recommended for broad application in combatting ants, thus their use is permissible only in those places, where the preparations cannot get into the food of animals.

The composition of baits with arsenic is as follows: 1) equal amounts by weight of sugar and water with the addition of white arsenic at a rate of 0.125-0.250 g per 120 g of sugar syrup; 2) water 1 ℓ, tartaric acid 2 g, sodium bezoate 2 g, sugar 850 g, honey 150 g, sodium arsenide 40 g.

Sponges are impregnated with bait with thallium sulfate; the sponges are placed on plates or simply dumped into small plates, saucers, paten or Petri dishes covered with lids with openings.

In combatting ants meat baits are also used. For preparing such baits 100 g of meat or sausage meat is taken, thorougly mixed with 10 g of finely ground borax. The baits are placed in patens, saucers at a rate of 1-2 tablespoons (30 g), etc.

Also used are dry baits containing 50% sugar and 50% of one of the insecticides: sodium fluoride or fluosilicate, barium chloride, borax, potash (it is possible to take somewhat more or less of one or another insecticide); dry baits are less effective than liquid baits.

In dwellings, in medical and children's institutions, stores, in cupboards and dining rooms, where both carbohydrate and protein food are readily accessible to ants, mainly sweet poisoned baits are distributed; they are changed every 7-10 days; in bakeries, confectioneries and other places, where carbohydrate products predominate — meat bait. A good effect is attained with the simultaneous use of meat and sweet bait.

With the systematic use of poisoned baits for 2-2½ months it is possible to attain the complete destruction of ants. With the distribution of baits every 25 days premises are disinfested within 7 months, whereas with an interval of 33-45 days for this about 14 months are required.

To reduce the period of combatting ants in places most frequently visited by them, for 1-2 days food baits are scattered — pieces of fish, meat, egg yolk, etc., creating so-called bait sites. Subsequently poisoned baits are placed at these sites.

Mechanical measures for protecting against ants consist of the following. The legs of tables or beds are placed in vessels filled with water, kerosene and other liquids. The liquids in these vessels must be periodically changed to prevent the formation of a film of dust over which the ants can easily crawl.

It has been established by laboratory investigations that dimethylphthalate, diethyltoluamide, diethylphthalate, diethyladipate, hexamide and formyltetrahydro-quinoline have a prolonged repellent effect on red house ants. The first two repellents under semi-industrial conditions provided protection for products against crawling ants for 3-4 weeks (Table 44).

Table 44. The composition and standard specifications of expenditure of poisoned food baits per m^2 of floor for destroying red house ants.

The proportion of the component parts of the poisoned baits, %						Number of operations (per year)	Single average expenditure of poisoned bait, g					Method of application
							medical and children's institutions		articles of food in living quarters			
insecticide	water	sugar	honey*	glycerine	sausage meat		flasks for penicillin	paper glasses	glasses	flasks	glasses	
Borax 3.5	31,5	38,0	7,0	20,0	—	16	1,5	8,8	7,0	0,3	1,75	Poisoned bait in packing is scattered in all premises which are infested with ants
Borax 3.5	64,5	25,0	7,0	—	—	48	1,5	8,8	7,0	0,3	1,75	
Borax 10.0	—	—	—	—	90,0	16	—	7,5	6,0	—	1,5	
Sodium fluoride 0.3 (or sodium fluosilicate)	66,7	26,0	7,0	—	—	48	0,03	—	—	0,13	—	

*Honey can be replaced by 1 mℓ of vanilla or 1.5 mℓ of pear essence. In this case the amount of water is respsctively increased by 6.8-6.9%.

Determining the effectiveness of exterminating measures. To establish the degree of infestation of premises (storehouses, institutions, rooms, apartments) before and after their treatment with insecticides pieces (1 g) of boiled sausage or other food products most preferred by ants are placed in open chemical test tubes and spread about the premises for 24 hours, after which the test tubes with the ants are closed with a cotton plug (they gnaw through cork); they are delivered to a laboratory and counted: the difference in the number of insects in the test tubes scattered about before and after treatment determine both the degree of infestation of the premises and also the effectiveness of the work carried out.

Garden and forest ants make their nests in the earth, under the bark of stumps, in the trunks of trees, under stones, in the cracks in walls and buildings. Outside the destruction of ant nests is best carried out in the evening, when the insects have congregated in the nests. A nest can be treated with DDT, hexachlorane and carbon disulfide, which are placed in a cup on a nest; the cups and the nest are covered with a cover pressed to the earth. If the nest can't be found, but the place where the ants come out can be, then it is possible to try to destroy them by dusting around the assumed nest with preparations of DDT, hexachlorane, pyrethrum and others. In certain cases the places where the ants come out are surrounded with sheets of sticky paper. The nest itself is flooded with boiling water, kerosene, alkali solution, and carbon bisulfide.

To prevent the ants from crawling into premises their routes of infiltration are found and treated on the outside with insecticides.

If the routes of ant infiltration into premises are numerous, then the external walls. window frames and a band of the plot (a width of 1 m) around the house are treated with insecticides.

CHAPTER XXX

FLIES AND THEIR CONTROL

The Morphologico-Ecological Characteristics of Flies

Flies belong to the suborder of brachycerous, dipterous insects of the order Diptera (two-winged). This most highly organized suborder, Diptera, includes about 70 families, the representatives of which are widespread all over the earth.

Flies pass in their individual development through four phases metamorphosis: the egg, larva, pupa, and adult insect.

The body of adult flies is separate into three sections – the head, thorax and abdomen. On the sides of the head are located complex, compound eyes, on the parieted section – three simple eyes. On the anterior surface of the head are the antennae and oral organs. In omnivorous flies the oral organs are of the licking-sucking type, the proboscis is soft, retractable, terminating with massive sucking lobes. The surface of these lobes is furrowed with pseudotracheae (chitinous tubules open to the outside), through which liquid food is filtered and enters the oral aperture. In the proboscis are an oral cavity and a pharynx, behind which is situated the salivary gland duct.

In flies of the blood-sucking species the oral organs are of the piercing-sucking type; the proboscis is hard, chitinized, protruding sharply forward; inside are situated the piercing setae.

The thorax of the fly consists of three basic divisions - the pro-, meso- and metathorax. To the mesothorax there are attached the middle pair of legs and the wings. The front and rear pairs of legs are attached to the pro- and metathorax, the halters are situated on the latter.

On the sides of the thorax above the base of the first pair of legs are located the prothoracic spiracles; above the base of the rear pair of legs somewhat to the rear are the metathoracic spiracles.

The upper surface of the thorax is called the mesodorsum; the anterior section of the mesodorsum usually has a triangular shape; it is called the scutellum. The legs of flies consist of the coxa (attached to the thorax), the trochanter, the femur, the tibia and a five-segment tarsus. On the latter segment there is situated a pair of claws, under which are sticky suckers - the pulvilli, thickly covered with hairs. Thanks to the pulvilli flies can move along vertical surfaces.

The venation in flies of various groups is different. In determining individual species of flies the configuration of the medial vein (the fourth from the top, the longitudinal vein), in particular, is important.

The abdomen of the higher flies consist of four segments (rings); its latter segments form the genital appendages - the copulative organ of the male and the ovipositor of the female.

The head, thorax, abdomen, and the legs of flies on the outside are usually covered with bristles and hairs (Fig. 27).

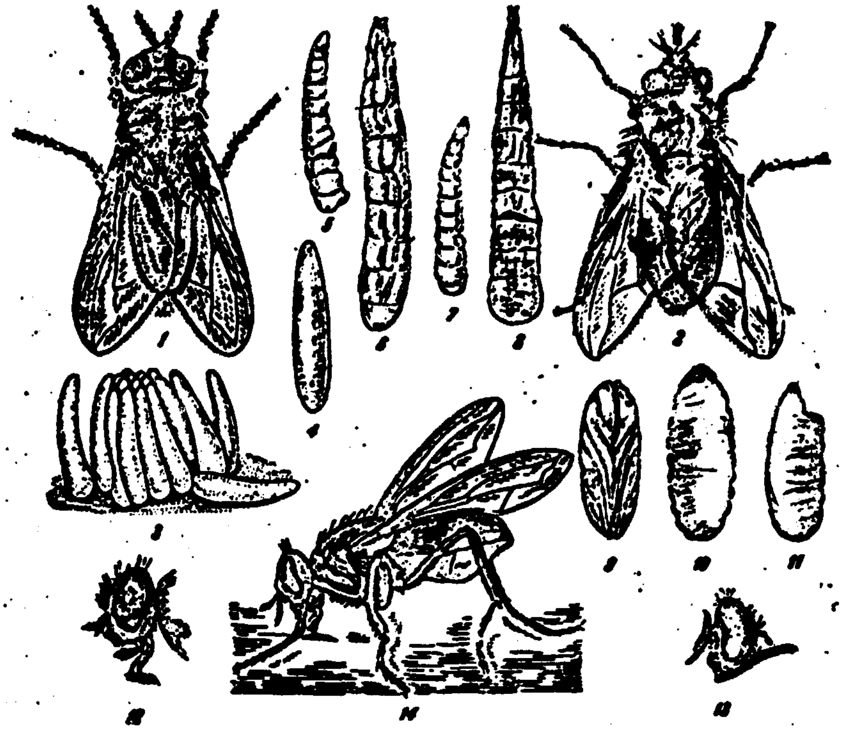


Fig. 27. 1 – house fly; a) medial vein of the wing; 2 – stable fly: a) medial vein of the wing; b) scutellum; 3 – eggs of the house fly; 4 – egg of the stable fly; 5-6 – larvae of house fly; 7-8 – larvae of stable fly; 9 – pupa of house fly; 10-11 – puparia of the house fly; 12 – head of a house fly; 13 – head of a stable fly.

Majority of flies are oviparous. There are also viviparous species of flies giving birth to live larvae (for example, the flies of the family Sarcophagidae, many species of the genus Musca), or prepupae (the family Hippoboscidae – blood-suckers).

Fly eggs are whitish-gray in color, sometimes yellowish, mainly oval-cylindrical in shape. From the egg stage I larvae hatch; they are usually worm-like in shape. The body of fly larvae, excluding the head, consists of 13 segments. The larvae move with the help of craicller prolegs located on the abdominal segments in muscoid species. The posterior end of the body is composed of the 8th and 9th (displaced on the lower side of the abdomen) and 10th abdominal segments. On 8th abdominal segment in the larvae of muscoid flies are the posterior spiracles, around which is located a system of coneshaped outgrowths, the maximum number of which attains 15. The number, configuration, and dimensions of the outgrowths vary for larvae of different groups (L. S. Zimin).

During its development the larva molts 3 times: accordingly three stages of the larval phase are distinguished. In stage I larvae the first pair of spiracles is absent; in stage II and III larvae they are located on each side of the first thoracic segment. The posterior stage I and II larvae have two posterior spiracles; stage III larvae have three spiracular slits, the shape and location of which vary in different species of larvae.

The pupae of the higher flies have a false cocoon (puparium), formed by the hardening of the last molted skin of the stage III larvae.

The peculiarities of feeding and the mode of life of flies are distinguished by their great variety. Many species of flies are known which live in natural habitats not inhabited by man. Many species of flies are synanthropic[1]; they live at populated sites connected with food products, human excrement, household waste materials, etc. In accordance with ecology among the peculiarities of larva and adult fly nutrition of synanthropic flies there can be distinguished: a) obligate-synanthropic species capable of multiplying only in a human habitat, mainly in accumulations of waste material, in particular in the feces and urine of man and also in human excrement scattered over the surface of the ground (for example, house, blue carrion, market flies); b) optional-synanthropic species capable of multiplying in cultivated and "wild" habitats in isolated groups and also in accumulations of waste materials (for example, house, green-bottle and gray flesh flies, etc.) (M. N. Sukhov). Along with synanthropic flies in rural populated places, especially in pastures there are numerous flies of synbovilic [Translator's Note: symbiotic or synbovine][2] species connected with domestic animals and their excretions, frequently leading a parasitic mode of life. The making of the division of the group of synbovilic flies was proposed by Gregor and Povolny.

Of great epidemiological significance (as carriers of infections and human infestators) are the synonthropic species of flies belonging to the family Muscidae (true flies – the main representatives of this family – house, market [musca sorbens], greater house, lesser house flies, etc.); Calliphoridae (bluebottle, green flesh flies); Sarcophagidae (gray flesh flies).

Among the synbovilic species of flies of greatest epizootiological significance as carriers of infections and infestators of domestic cattle are the individual blood-sucking (for example, stable flies) and blood-licking species belonging to the family of true flies. The negative role of gadflies in animal husbandry – sheep bot-, warrble, horse bot-, and also individual species of gray flesh flies (Wohlfahrtia flies), the larvae of which are parasites of domestic animals, and sometimes of man is great.

In populated places usually the greatest numbers are attained by house flies (Musca domestica L.). The house fly is a universally widespread species, represented by two forms: the northerm form (Musca domestica domestica L.), encountered in the temperate and northern latitudes and the southern form (Musca domestica vicina Macq.) widespread in the USSR in Transcauscasia, on the southern coast of the Crimea, in the Amur Region, and in Central Asia (L. S. Zimin).

The general body color of the house fly is grayish-brown. The pronotum has four narrow brown bands. The abdomen underneath and on the sides is yellow. The media vein is curved toward the leading edge of the wing. Its dimensions are 6-7.5 mm. The larvae of the stage III house fly is yellowish-white in color, brilliant with the body thickened toward the posterior end. The eighth abdominal segment is around the rear spiracles, as in the majority of Muscidae larvae of the genera Musca, Muscina and several others - without large coneshaped outgrowths; the spiracular slits frequently spiral in a serpentine manner and are thin.

House flies are an endophilic species. They fly in closed premises and live in them. However, especially in the south, they are constantly encountered in the open air - on rubbish, excrements and other waste materials.

Along with house flies at populated sites there also occur numerous lesser house flies (genus Fannia), greater house flies (Muscina stabulans Flln). In the south of Kazakhstan, in the Central Asian republics and Transcaucasus there are encountered market flies (Musca sorbens Wd). Of the synbovilic species of flies attacking man in rural populated places, there can be numerous blood-sucking stable flies (Stomoxys calcitrans L.).

Almost universally widespread are blue spring flies (Protophormia terrae-novae R. D.), green flesh flies (genus Lucilia, in particular Lucilia sericata Mg.). In the forest and forest-steppe zones of the European part of the USSR, and of Western Siberia there are encountered blue carrion flies - Calliphora uralensis Vill. Everywhere in the temperate climatic belt there are widespread, but more abundant in the southern regions, the flies of the family Sarcophagidae, in particular Coprosarcophaga haemorrhoidalis Flln. (B. B. Rodendorf).

The imagoes of all species of flies with the exception of the blood-sucking stable fly are omnivorous: they eat the food of man (especially the endophilic house fly), and also the excrements of man and domestic animals, domestic waste materials, etc. Flies (house, market) are also attracted by perspiration, purulent excrement, human blood. Market flies intensively attack people, landing in the eyes, festering wounds, etc., feeding in their excrement.

During one sucking act a female house fly can absorb up to 0.008 mℓ of liquid food, and in 24 hours up to 20 mg of food (B. L. Shura-Bura).

House flies are able to feed every 10-15 minutes, until their intestines are filled with food. They feed repeatedly even before the end of digestion of food in the intestine. Food consumed by a fly goes from the pharynx into the esophagus and from the latter into the crop. If the crop of a fly is overfilled, then the insect is observed to perform something like the belching of food.

From the crop the food enters the midcrop usually called the stomach, then into the hind-gut. Flies defecate every 5-15 minutes. The release of excrement and belching frequently occur when they are on food products.

Of great importance for the viability of flies is temperature. The lower threshold of activity of the imago of a house fly (northern subspecies) is about 9-10°; normal feeding occurs at 15°, oviposition at 17-18°. The zone of optimum temperatures is within the limits of from 25-26° (V. P. Derbeneva-Ukhova).

House flies frequently fly back and forth from their feeding and oviposition sites in the open air (trash cans, latrines, manure piles) into premises and conversely.

Within the limits of populated sites house flies migrate mainly to a distance of up to 200-300 m; from dumps and garbage disposal sites the mass dispersion of flies is possible to distances of up to 3-6 km and more (A. S. Gorodetskiy).

Under laboratory conditions at a temperature of 20-24° when fed milk and carbohydrates house, market, greater house, blue spring flies live about 30-45 days. Certain authors were able to maintain a house fly culture up to 121 days. In an anabiotic state (at a temperature lower than 7-8°) flies are able to live for up to 5-6 months.

The fertility of flies varies; it is lower for viviparous forms. The majority of oviparous species of flies is distinguished by their great fertility. Thus, female house flies during their life can oviposit more than 600 eggs; female C. uralensis – over 1200 eggs.

The development of synanthropic flies occurs in putrescent waste materials of diverse origin, which are for the fly larvae not only the source of food, but also the living environment. Consequently, the larvae of individual species of flies are adapted to existence under the specific conditions of temperature, humidity, and substratum, in which their development occurs. Due to this the breeding sites of flies can be very diverse and depend (taking into account the specific peculiarities of the insects) on the climatic conditions and the methods employed at a given site for collecting, storing, and neutralizing of various, putrescent, organic waste materials (M. N. Sukhova).

House fly larvae are adapted to development in the most diverse substances. Thus, the females of this species oviposit in accumulations in the first place of solid waste materials (in trash cans and in dumps), in the dung of domestic animals, vegetable waste, etc. Frequently, especially in the south, house fly development occurs in human excrements – in accessible material removed from latrine cesspools, in dumps, in drying impurities and other waste materials with a degree of moisture of from 65 to 80%, but not more. The preimaginal phases of the house fly (especially the eggs and larvae) are thermophilic. At a temperature of 20-30° the egg phase lasts respectively from 25 to 10 hours, the larval phase from 9 to 5 days, the pupa phase from 10 to 5 days. The shortest periods of metamorphosis including larval development of about 3 days were observed at a temperature of 36°.

In trashcans, in rubbish dumps, in meat and fish waste larvae also develop, in the first place blue spring, green flesh, greater house flies, etc. The larvae of these species are more aquaphilic than house fly larvae, their development is possible in a substrate with a degree of humidity of up to 85-87%.

It is necessary to consider that everyday household rubbish when it is deposited in trashcans and open pits adapted for the joint collection of solid waste material and slop is usually one of the basic sources of fly breeding at populated sites. It has been calculated that in regions with a hot climate in 100 g everyday household rubbish (calculated according to air-dry weight), there can develop over 600 larvae of the southern house fly; in regions with a temperate climate - over 150 larvae of the northern subspecies of house fly, 130 larvae of the blue spring fly, etc. Tremendous numbers of house flies and flies of exophilic species can also develop in dumps where everyday household rubbish is deposited.

Accumulations of manure, especially pig and horse manure are breeding sites not only of house flies, but also of greater house flies, and individual species of gray flesh flies. In cow dung mixed with putrescent plants stable fly larvae develop. Accumulations of bird excrement, in particular pigeon droppings (T. O. Teterovskaya) can be the site of mass development of flies of the genus Fannia.

From the dung of domestic cattle there hatch mainly synbovilic pasture species of flies, many of which are blood-licking or blood-sucking (Lyperosia, Haematobia of various species, Musca autumnalis Deg., etc.).

Fly larvae are usually concentrated in the surface layers of accumulations of solid waste material to a thickness of 20-25-35 cm. In those cases, when in the accumulations of the substrate a high temperature (higher than 40-44°), develops the larvae are in the very surface (colder) layers of the waste material, sometimes not deeper than 2-5 cm. A temperature of a substrate higher than 55-60° is lethal for fly larvae. In accumulations of solid waste material, in which a high temperature does not develop, the fly larvae are usually situated throughout the whole thickness of the substrate (A. S. Gorodetskiy, M. N. Sukhova, D. I. Grechko and V. P. Morozova).

A significant source of fly breeding at populated sites where there are no sewer systems can also be human excrement. Thus, aquaphilic larvae of blue carrion flies can be developed in accumulations of feces in latrines with the humidity of the substrate within the limits of from 76 to 94% - with an optimum close to 84-89%. The development of the less aquaphilic larvae of the greater house, the lesser house, blue flesh flies is also possible in fecal pits of latrines, but with the humidity of the feces not over 87-90%; finally, with the humidity of the excrement not more than 78-80% in fecal pits and in excrement dumps especially in the south, along with the larvae of other species there can develop house fly larvae.

In accumulations of liquid waste material (in cesspools, in dumps) fly larvae are usually concentrated in the surface, oxygen-richer layers of the substrate.

Human excrement strewn over the soil in the temperate climatic belt and the south is one of the main breeding sites of grey flesh flies of various species, in the southeastern regions - of the market fly, in the south - of the southern house fly.

Depending mainlv on the temperature of the living environment the development of fly larvae of individual species terminates in different periods. In accumulations of solid waste material, in which with putrefaction a temperature develops up to 36-42° the development of house fly larvae is completed in 3-4 days and at a temperature of the substratum of 20-25° within 7-9 days.

In the fecal pits of latrines, where the temperature of the excrement in the summer time in the temperate climatic zone does not exceed +19 and +24° the development of the larvae of blue carrion flies and house flies occurs within 14-7 days; in the southern regions, where the temperature of the substrate in summer reaches 28-30° the development of fly larvae (house, gray flesh) is completed within 4-5 days.

In excrement left on the soil, particularly in Central Asia, with the temperature of the feces varying during the day from 20 to 40° the development of fly larvae is completed within 2-3 days.

Fly larvae (prepupae) and pupae which have completed their development are less thermophilic and aquaphilic than the larvae. The prepupae usually migrate from the waste materials into the soil, where for the most part at a depth of up to 6-10 cm they pupate. The pupation of larvae frequently occurs in dried sections of the waste material, in clumps of paper, and rags, in the cracks between boards, in the recesses between bricks of receptacles for waste material, etc. Over packed, asphalted soil in seeking suitable sites for pupation the prepupae can crawl a distance of up to 3-6-10 m and more from the waste material.

In the temperate climatic zone the development of house fly pupae lasts about 5-7 days, of the blue carrion fly – about 7-10 days.

In Central Asia the development of the pupae of house and market flies is completed in the warm season within 4-5 days, of gray flesh flies – within 5-6 days.

Upon emerging from the puparia the cuticles of young flies are soft and unpigmented; the ptilinum protrudes, the wings are crumpled.

Only after a lapse of $1\frac{1}{2}$ to 2 hours after emerging from the puparium does the fly acquire the ability to fly. Young flies having hatched from the puparia can crawl distances of up to 50-70 cm upwards over loosened soil. Whereas to get over layers of tamped earth (with a thickness of more than 10 cm) they are not able (Ye. S. Smirnov).

The development of ovaries in the females of the majority of synanthropic species of flies at an air temperature of 22-26° is completed within 5-6 days. The female flies usually begin oviposition at an air temperature not lower than 17°. Under favorable temperature conditions house flies can live and multiply indoors during winter; in cold premises imagoes of this species can pass the winter in an inactive state. In an anabiotic state in barns, in accumulations of vegetable residua, etc., mature blue spring flies, greater house flies, blue flesh flies and many other species of flies can hibernate. Insects become active again in spring, in the period, when the maximum air temperature rises above 10°.

The hibernation of the larvae (and the pupae in the south) of house flies and also many exophilic species of flies (blue carrion, green flesh, gray flesh, market flies, etc.) occurs in the ground (under waste materials and with a radius around them of up to 5 m and more), in putrescent accumulations of waste material. Hibernating larvae and pupae can be found at a depth of up to 50 cm from the surface of the soil or waste material.

The emergence of the majority of species of flies wintering in the larval and pupal phases usually occurs (depending upon the climatic conditions) in March-April, in the period, when the average daily temperature of the soil or waste material in the places, where they are congregating, is for approximately ten days located at a level of 11-14°. In the southern regions fly breeding is also possible outside in the winter months.

The maximum number of the house fly population is observed in the temperate climatic belt in July-August; the blue spring flies, greater house flies – in May-June; blue carrion, green flesh flies – in August-September.

In regions with a hot dry climate (for example, in Central Asia) the flight curve of the southern house fly, and also of many exophilic flies has two peaks; in June-August due to the high temperature of the air and of the surface layers of the soil, and also due to the deficiency of humidity the depression of these species occurs. Whereas southern house flies, greater house flies, green and gray flesh flies predominate here in number in the spring-summer period, and market flies — in August-September and sometimes in October.

The Epidemiological Significance of Flies

The number of diseases the specific[3] carriers of which are flies is relatively small. To this number there belong individual diseases of animals and man of protozoal etiology (trypanosomiasis), which are widespread chiefly in tropical countries (for example, sleeping sickness), the specific carriers of which are blood-sucking flies of the genus Glossina RD; from helminthiasis — telasiosis of large cattle, transmitted by flies of the genera Musca and Lyperosia. The frequent alternate contact of flies with the putrescent waste material escreted by man and animals makes possible the mechanical transmission by them of the pathogenic agents of diverse etiology to food products, articles, vegetation surrounding man, and also to the mucous membranes and wounds of man.

B. L. Shura-Bura presented a list including more than 120 micro-organisms of diverse nature to man and animals; these have been detected by many authors in investigating naturally infected flies (cholera, typhoid fever, dysentery, gastroenteritis, poliomyelitis, and also tuberculosis, leprosy, diptheria, glanders, epidemic conjunctivitis and many others).

Especially great is the significance of flies of the coprobiont species (coming into contact with human excrement) in propagating intestinal infections of man, in the first place dysentery, and also typhoid fever, paratyphoid, cholera, etc., causing to a considerable degree seasonal increases in the disease incidence of these infections during the warm season (A. O. Govard, Ye. N. Pavlovskiy, L. V. Gromashevskiy and many others).

The possibility of the dissemination of massive doses of dysentery microbes by house flies and flies of exophilic, coprobiont species C. uralensis, M. stabulans, C. haemorrhoidalis, Fannia was confirmed by the data of the laboratory experiments and the results of the bacteriological investigations of flies caught at foci of intestinal diseases.

But house flies because of their endophilia in all climatic zones are the greatest danger as carriers of dysentery and other intestinal infections.

Dysentery and typhoid fever microbes are able to survive in the intestines of "wild" flies up to 2-3 days, in the intestines of flies sterilly cultivated in the laboratory – up to 5 days.

Many authors both domestic and foreign have established that successful control of synanthropic flies can bring about a reduction and can even prevent the seasonal rise in the disease incidence of intestinal infections, in the first place of dysentery (V. N. Bychkov-Oreshnikov, M. A. Dykhno, A. M. Klechetova and K. D. Kondashova, Ye. N. Pavlovskiy, Z. F. Petrov, M. N. Sukhova, V. D. Timakov, N. I. Fedorova-Talashcno, Verhoestraete, Puffer and others).

It is necessary to consider that the significance of synanthropic flies in the transmission of dysentery and other intestinal diseases is different in regions located in different climatic zones and differing in the degree of communal development and the level of sanitary culture of the population, the presence of bacillus carriers, etc. In the southern regions, where the intensity of insect reproduction is higher and their active period is more prolonged, the role of flies as carriers of dysentery is more significant than in regions with a temperate climate and in the northern regions.

The ways of propagating dysentery as well as other facultative-transmissive intestinal infections are diverse. Besides flies, other factors can also play an important role in their transmission - water, daily contact. Thus cases of an increase in the disease incidence with them in winter and in summer in the absence of flies cannot be viewed as contradicting the fly theory of propagating intestinal infections. Prophylaxis of these latter should be studied completely taking into account all possible ways of transmitting these diseases. It is necessary to add that the control of flies is a strict necessity in the prophylaxis of dysentery, typhoid fever, poliomyelitis and other infections and invasions, transmitted via the alimentary tract both in the Soviet Union and in foreign countries.

Along with the pathogenic agents of intestinal infections of bacillary etiology flies of the coprobiont species are also able to spread cysts of pathogenic protozoa - Entamoeba histolytics, Entamoeba coli, Giardia intestinalis, etc., and also the eggs of parasitic worms - ascarides, trichinae, dwarf tapeworms, taeniae (V. P. Pod'yapol'skaya and M. P. Gnedina and others).

Within the last 20 years the definite importance of flies of coprobiont species in spreading the virus of poliomyelitis was shown.

Poliovirus was isolated form spontaneously infected flies (house and exophilic species, mainly from the family Calliphoridae). S. A. Akberdin, N. N. Sheremet'yev also isolated from flies enteroviruses of the Coxsachie and ECHO group.

Poliomyelitis virus is retained in the organism of synanthropic flies (the house fly, and also flies of exophilic species) for from 2 to 21 days (Ye. N. Levkovich and M. N. Sukhova, N. N. Sheremet'yev). N. N. Sheremet'yev indicates the possibility of short-term reproduction of poliovirus in the organism of the house fly, and also of a number of flies of exophilic species.

Inasmuch as in diseases of an adenovirus nature the pathogenic agent in considerable numbers is excreted with the feces of an infected person and is detected in the secretion of mucous membrane of the eye and nose, its propagation is also possible by synanthropic coprobiont species of flies, attacking man, in the first place house and market flies. A. L. Belyayev, M. N. Sukhova, T. O. Teterovskaya demonstrated the survival and the isolation in the external environment in the course of 3-4 weeks of adenoviruses of type 3 and to a lesser degree of type 7a with the experimental infection of the imagoes of house and market flies. In the organism of the experimental flies and in wash-offs from the surface of objects contaminated by them during the indicated periods there was noted the periodical increase and decrease in the titer of adenoviruses.

The cited facts make it possible to draw a conclusion about the definite adaption (possible short-term reproduction) of individual pathogenic agents of virus origin in the organism of flies of the investigated coprobiont species.

As a result of the investigations conducted in Turkmenia there was demonstrated the spontaneous carriage by market and house flies of adenoviruses including the third type (A. L. Belyayev, M. N. Sukhova, V. A. Starodubskay, T. O. Teterovskaya).

Besides the infections transmitted by the alimentary tract the importance, in particular, of M. sorbens in the transmission of eye diseases is great.

The role of market flies as carriers of acute epidemic Koch-Weeks conjunctivitis is great (L. S. Zimin, V. G. Mekhanikova, L. F. Paradoksov, M. N. Sukhova, Gaud, Lourrent, Taurre and others).

The improvement of the sanitary condition of the populated sites of the Central Asian republics during the years of Soviet power, the application for 10 years of DDT and hexachlorane in combatting synanthropic Diptera made it possible to achieve a sharp (in individual places up to several hundreds of times) reduction in the number of market flies. As a result, for example, in the majority of cities of Turkmenia there were almost stopped the high rises in the disease incidence of epidemic conjunctivites existing here earlier in the autumn period of the year; the annual disease incidence in individual cities, for example in Krasnovodsk, was decreased as compared to that observed in 1951-1952 by up to 10 times.

In appraising the epidemiological role of flies it is also necessary to consider that house and market flies can play an essential role in the propagation of the mycobacteria of tuberculosis and the pathogenic agent of leprosy. Stable flies can be mechanical transmitters of tularemia infection (V. P. Romanova). Under experimental conditions there was also demonstrated the possibility of the transmission by them of anthrax and dermal leishmaniasis (A. A. Shtakel'berg).

It is also necessary to consider the negative role of flies as causative agents of myiasis. Myiasis are diseases caused by the introduction and the stay of fly larvae in tissues and cavities of the living organism of a vertebrate host. Among the myiases there are distinguished obligate and facultative species (Ye. N. Pavlovskiy). Obligate myiases mainly in domestic cattle, and sometimes in man are caused by the larvae mainly of synbovilic species of flies leading an exclusively parasitic form of life. In the USSR – there are larvae of the Wohlfahrtia fly, and also of gadflies – botflies, warble flies and horse botflies.

The causative agents of facultative myiases having a random character, can be larvae mainly in the flesh, and also coprobiont nonparasitic species of flies. Well-known are cases of facultative skin tissue and cavity myiases caused by the larvae of the house fly, L. sericata, Calliphora. There have also been described intestinal myiases caused by the larvae of the house fly, blue flesh fly, cheese skipper and others, with which infected persons can manifest typhoid symptoms.

As was shown, flies cause considerable harm to the health of man as carriers of pathogenic agents of infections and invasions of various etiology. Furthermore, individual species of flies (house, market) can deprive adults and especially children of rest. Therefore, the destruction of these insects has especially great significance.

Measures for Combatting Flies

At the basis of fly control there have to be placed sanitary measures preventing the possibility of the development of these insects. Accordingly there has to be provided good order at populated points, an efficient organization in a hygienic and entomological respect of collection at these points, systematic removal and neutralization of putrescent organic waste material. As a supplement to the sanitary-prophylactic measures it is necessary to destroy the eggs, larvae, pupae (in the first place), and also mature flies with the help of chemical and mechanical means (V. I. Vashkov, M. N. Sukhova).

Sanitary measures. Especially important in an epidemiological respect is the prevention of the possibility of flies breeding in human excrement. For this purpose the most efficient is the equipping of populated points with sewerage systems. In regions without sewerage systems it is necessary to set up regular latrines including impenetrable cesspools and possibly with well-sealed surface parts. The doors of the latrines have to be snugly assembled and self-closing. The windows, air vents, and ventilation holes should be screened with metal screens with a mesh of 1.5 mm^2.

In public latrines the floors and walls should be of cement, concreted, etc. It is expediently to consolidate cesspools – sink drainage and latrines, because in feces with moisture higher than 92-94% there is a sharp reduction in the development of synanthropic species of flies having epidemiological significance. It is necessary to consider that outside sink drainage pits should be intended only for the collection of slops. They should consist of a cesspool and a surface part with a cover and a grid for separating out the solid waste material. The grid should not less frequently than once a day be completely cleared of everyday household rubbish which has accidently accumulated on it. Cesspools for public latrines are made of stone, brick, reinforced concrete, wood; the covers for clearing cesspools should have tightly fitted double covers. In 1-2 story buildings without sewerage systems within the limits of the I-II-III climatic regions the best arrangement consists luftclosets [air closets] or (within the limits of all regions) pudrclosets [powder closets]. After using a pudrcloset it is necessary to completely cover the impurities with dry peat, or garden dirt and to subsequently neutralize them in compost piles in areas removed from the farmstead.

It is necessary to consider that with the proper arrangement and utilization of luftclosets and pudrclosets fly breeding in them is impossible.

Cesspools of outhouses and luftclosets should be surrounded with asphalted, concreted sites to a distance of 1.5 m from the edge of the installations. The premises of the latrines and the area surrounding them should be washed daily and disinfected with chlorinated lime.

The removal of slop and sewerage from the cesspools of outhouses (cleaning them right down to the bottom) should be carried out not less frequently than once in 2 months, the cleaning of cesspools of luftclosets in apartment buildings should be carried out 1-2 times per year. It is necessary to consider that the overfilling of cesspools increases the possibility of flies breeding in them.

The neutralization of household-fecal sewage going from sewer-equipped homesteads to purification installations prevents the possibility of the breeding of synanthropic flies having epidemiological significance (M. N. Sukhov).

In nonsewer-equipped regions the neutralization of liquid waste materials in sanitation fields by the soil method with the dumping of the impurities in designated sections in accordance with sanitation standards and plowing the deposited waste materials under within 24-48 hours completely satisfies the entomological requirements.

It is absolutely impermissible in a sanitation respect, in particular from entomological indications, to set up dumping grounds for liquid waste materials or to spread the excrement over the soil.

Everyday household rubbish in dwellings, public and industrial premises, and in places where people sojourn should be deposited in buckets or in tanks with tightly fitting covers, preferable with pedal locks, which it is necessary to thoroughly clean daily.

For the complete prevention of the possibility of flies breeding in everyday household rubbish it is necessary to have a properly organized rubbish collection system taking in every apartment; at present this is being carried out in many cities of the Soviet Union. According to this method following specially worked out routes and graphs of the streets (depending upon local conditions 1 or 2 times per day) rubbish trucks or specially adapted motor vehicles, in which the tenants dump their waste materials, which are then taken to neutralization or utilization sites. In the apartment rubbish collection system there are no collections of everyday household rubbish outside homesteads (there are only receptacles for outside, street purposes).

In many populated places at the present time there is conducted the collection of garbage for cattle feed. With proper organization this system is completely efficient for entomological purposes. It is necessary that the garbage be collected in special buckets equipped with tightly fitting covers, and it is necessary to transport it daily in special containers to the livestock farms.

In a planned transport system for clearing populated places from everyday household rubbish it is necessary to properly organize the temporary storage of solid waste material in standard portable metallic receptacles with a capacity of 50-100 ℓ or in containers of 0.4 m^3 and more, emptied daily or every other day, with subsequent washing or at least mechanical cleaning of the bottom and walls of the receptacles. Depending upon local conditions it is permissible to set up stationary rubbish receptacles — wooden tightly assembled or iron boxes without a bottom, but with covers. In accordance with the minimum periods of development of eggs and larvae of flies cleaning of the boxes is necessary not less frequently than once every 3-4 days at sites located in the temperate climatic belt and not less frequently than once every 2-3 days in hot climates.

In order to prevent the migration of the larvae into the soil, the portable receptacles and stationary boxes should be placed on asphalted or concreted sites (to a radius of up to 1.5 m from the edges of the receptacles). According to hygienic evidence (including entomological evidence) it is impermissible to set up joint receptacles for the collection of slop and everyday household rubbish; it is also impermissible to deposit rubbish in closed barns, because with these methods the complete cleaning of these structures is impossible and considerable fly breeding is inevitable.

Transportation intended for moving waste material (trucks, wagons), should be washed and disinfected daily.

Neutralization methods for everyday household rubbish should be varied taking into account local conditions, using mainly biothermal methods. The most correctly according to sanitary-entomological evidence is the composting of solid waste material. The neutralizing of everyday household rubbish not infested with fly larvae can be carried out both in ground piles and also in trenches, but it is absolutely necessary to cover the waste material with a layer of dirt or other composting materials to a thickness of not less than 10 cm. Rubbish infested with fly larvae, especially in southern regions, should be neutralized in trenches, covering the waste material with mulching materials (rush matting, empty cement bags, etc.) or tamping them with earth, in order to prevent the migration of the larvae, mature flies on the surface of the soil. It is also permissible to set up improved dumps in which the waste material must be levelled out, covered with earth or construction debris and tamped with excavating equipment.

The prevention of fly breeding in manure is achieved by thoroughly cleaning the premises for domestic cattle and birds and by the immediate removal of waste material to a neutralization site. Neutralization of manure is carried out by biothermal methods – in dung pits or compost pits.

At private dwellings the neutralization of manure, like all organic waste material, collected at the household should be carried out by composting on a plot somewhat removed from the household. To avoid the development of fly larvae each portion of the waste material placed in the pile should be immediately covered with a layer of garden earth or other composting materials with a thickness of about 10 cm. In regions with a dry hot climate in accordance with the stacking of the compost pile it is expedient to smear the edges with fresh dung or a mixture of dung with clay. The dense crust forming inhibits oviposition by flies and the development of larvae in the substrate.

Disinfestational measures in combatting synanthropic flies. In conjunction with the sanitary-prophylactic measures it is necessary to carry out disinfestational antifly measures. It is necessary to consider that in the last few years these methods and tactics have changed in many respects. Thus, if from the 50's of the current century for combatting mature house flies the impregnation of the internal walls of premises has been widely accepted (food enterprises, medical and children's institutions, etc.) with DDT preparations, the external walls of the outbuildings of all sanitary-outside installations for destroying the imagoes of the house fly and flies of exophilic species were treated with preparations of DDT and hexachlorane, then, if one were to proceed from contemporary data, these tactics cannot be considered to be correct. This method does not provide stable positive results with insufficient development at populated sites. It is ineffective, especially in the summertime with respect to populations of house flies, in which within the limits of the USSR there has developed to a greater or lesser degree an expressed specific resistance to insecticides of the chlorinated hydrocarbon group. With the introduction into disinfestational practice of organophosphorous preparations, in particular chlorophos even greater application in imago control has been obtained by insecticidal baits. In recent years there has also been expanded the assortment of highly effective larvicides, in particular those from the group of organophosphorous compounds and the chlorinated terpenes.

All these new data making it possible to considerably improve the quality of disinfestational antifly measures must be considered in organizing practical operations at sites.

When planning destructive operations for combatting flies the methods and tactics of their execution should be varied depending upon the epidemiological situation, the natural conditions, the state of communal development and the sanitary cleanliness of the cities and inhabited points.

It is natural, that at populated sites with sewerage systems with the systematic removal of everyday household rubbish from each apartment or with complete cleaning of portable receptacles not less frequently than once every 2-3 days it is sufficient only to destroy individual flies flying into the premises, mainly house flies with the help of fly-swatters, fly-paper, etc.

In sections of populated sites, where toilets are not connected to a sewer system (with the exception of properly operated luftclosets and pudrclosets, and also of outhouses, where the moisture content of the fecal matter in cesspools is higher than 92-94%) and where the removal of solid waste material is haphazard of decisive importance in the successful execution of fly control is the destruction of the preimaginal phases of development of these insects with the help of chemical agents.

By applying larvicides there are simultaneously destroyed the complexes of synanthropic species of flies developing in limited breeding sites of a specific type. Thus, for example, the use of larvicides in everyday household waste material makes it possible to sharply limit everywhere the number of populations of house, greater house, blue spring flies, etc.

But to avoid the unnecessary expenditure of chemical poisons and manpower in the planning of delarvational operations it is necessary with the help of sanitary measures to try to obtain maximum localization of the sites of waste material accumulation, mainly in receptacles.

In order to ensure the success of delarvational operations it is necessary to consider the degree of humidity of the waste materials, their mass and temperature.

The destruction of fly larvae in liquid waste materials (with a moisture content higher than 75-80%) is attained with relative ease by the use of liquid preparations and disinfecting powders. The formation of an insecticidal film on the surface of waste materials leads to asphyxia in the larvae; and for normal breathing the fly larvae are forced to ascend to the very surface layers of the substrate, which inevitably entails the coating of their spiracles with the insecticide. In using larvicides liquid preparations are sprayed evenly, disinfecting powders are applied to the surface of the substrate being subjected to delarvation.

The destruction of fly larvae and pupae in accumulations of solid waste material with a moisture content lower than 75-80% (everyday household rubbish, manure, dried human excrement) and also in soil is attained with considerably greater difficulty, because in these substrates, especially when in them a high temperature is not developed, the larvae can live at a depth of up to 10-15 cm and more from surface. Thus, for the delarvation of solid waste material and also soil it is more expediently to use insecticides possessing a fumigational effect, applying them as far as possible in the form of emulsions and solutions. In order to provide the optimum rates of expenditure of the insecticidal liquid (taking into account the mass of the waste material being treated) it is necessary to use from 2 to 5 liters (depending upon the insecticide applied) for treating 1 m^2 of surface of waste materials or soil with a thickness of the substrate layer of not more than 30-50 cm, in accumulations of rubbish and manure - 10-12 ℓ per m^3.

The rates of expenditure of insecticides in the delarvation of liquid waste materials (with a moisture content higher than 80%) are lower than when treating solid waste materials, usually not more than 200-500 mℓ of working fluid or 300 g of disinfecting powder per m^2 of substrate surface being treated. The necessary number of delarvations of liquid waste materials is also usually $1\frac{1}{2}$ to 2 times less than for solid wastes. However at sites with a dry hot climate (for example, in Central Asia, Transcaucasus) in the summertime with the drying of fecal matter in the cleaned out latrines, the delarvations of the cesspools should be conducted, following the conditions accepted for the destruction of fly eggs and larvae in solid waste materials.

In applying larvicides, one should consider the available source material about the fact that the simultaneous effect of one and the same preparation on the preimaginal phases and the imago, in particular M. domestica (Decker, Bruce and others) is unsuitable, because this promotes the more rapid development of resistance to this insecticide.

Of the synthetic insecticides belonging to the organophosporous group of compounds, there are highly effective larvicides in the first place trichlorometaphos-3 applied in combatting the preimaginal phase of flies at a concentration of 0.1% (I. V. Gvozdevo). High larvicidal qualities are also manifested by carbophos (T. V. Yerofeyeva, Ye. V. Shnayder). Chlorophos is also an active larvicide. However, inasmuch as it is at present the main insecticide for destroying populations of house flies which are resistant to DDT and hexachlorane it should not be applied as a larvicide. This can be allowed only in the exceptional case when there is a complete absence of other larvicides.

Wofatox can be used for combatting the preimaginal phases of flies, however, in view of the toxicity of this preparation there must be observance of especially careful measures of precaution and then only in the case of the absence of other effective preparations.

Larvicides from the organophosphorous group of compounds are highly effective (due to the positive temperature coefficient) in places with a hot climate. Along with this they are also completely active in places with a temperate climate.

Of the group of chlorinated terpenes as larvicides there are very effectively applied 2-5% aqueous working emulsions prepared from 65% concentrates of polychloropinene and polychlorocamphene (T. V. Yerofeyeva). Also produced by industry are 50% solutions of polychlorpinene in diesel fuel which must be emulsified beforehand. As emulsifiers it is necessary to use naphthalysol or a 25% emulsion of DDT. The main mixtures are prepared at a ratio of 1:1 for each ingredient. For operations there are applied 2% (by polychloropinene) aqueous emulsions of the indicated mixtures. Aqueous emulsions of polychlorocamphene, polychloropinene and its mixtures are applied for the delarvation of both liquid and solid waste materials.

In populations of house flies resistant to hexachlorane there is observed a cross resistance to the chlorinated terpenes, in the first place to polychloropinene, which manifests itself especially sharply in regions with a hot climate. Therefore polychloropinene is not recommended for application in the southern regions, especially in Central Asia and Transcaucasus. Because the mixtures of polychloropinene with diesel fuel and napthalysol, and also with DDT are distinguished by higher insecticide activity than pure polychloropinene, their application is desirable, especially in combatting populations of house flies which are resistant to hexachlorane, in particular in the temperate climatic belt.

Hexachlorane preparations (emulsions, disinfecting powders), in view of the widespread, significant resistance to their effect within the USSR, should be applied only in liquid waste materials (with a moisture content higher than 80%) for destroying fly larvae of exophilic species sensitive up to now to the insecticides of the chlorinated hydrocarbon group.

Along with the synthetic insecticides as larvicides it is necessary to apply 10% aqueous emulsions of creolin, 10% emulsions of a mixture of unpurified carbolic acid with napthalysol, the vat residues of dischloroethane, etc. Also very effective is the use of green oil. In private households the inhabitants should be advised to treat their toilet dredgings with kerosene.

It is necessary to simultaneously carry out a search for new larvicidal preparations from local insecticidal raw materials.

To increase the productivity of delarvational operations it is necessary to make maximum use of mechanized apparatuses — high-angle sprayers on motor vehicles, motor liquid sprayers (MRZh-2), and also sprayers used in agriculture (DUK, LSD-2 and others). For the delarvation of soil there can be used spray-washing machines used in establishments conducting public and communal cleaning.

In conjunction with delarvational measures it is also necessary to destroy mature flies. The most effective preparation applied in the USSR for combatting in the first place mature house flies resistant to chlorinated hydrocarbons is chlorophos (V. I. Vashkov and Ye. V. Shnayder).

It is very significant that chlorophos along with its expressed toxic, fumigational, contact effect also possesses a sharply expressed intestinal effect with respect to insects. Moreover chlorophos does not possess a repellent property with respect to flies. This makes it possible to apply it as an intestinal poison in baits, which is one of the most effective, convenient and economical methods of destroying mature flies.

The more potent intestinal effect of baits with chlorophos (as is also the case with other intestinal poisons) as compared to the purely contact effect of the preparation is undoubtedly less conducive to the formation of populations of house flies resistant to this insecticide. The tactics also correspond more to the ecology of the house fly. With primary impregnation of the walls of buildings with insecticidal preparations the short-term contacts of these insects with insufficiently toxic doses of the poison are inevitable and as a result there is the selection of individuals capable of detoxication, which can lead to the resistance to insecticides of the given population.

As an intestinal poison chlorophos is applied in the form of liquid, and also solid (granulated) baits.

Liquid baits with chlorophos can be obtained with the use of insecticidal chlorophos fly-paper, tablets, and also directly in solutions.

It is necessary to consider that considerably more effective fly-paper and also solutions of chlorophos are prepared with ammonium carbonate (T. A. Bolotova). According to I. V. Gvozdeva with the addition of ammonium carbonate to chlorophos a new compound which is a product of the hydrolysis of chlorophos (possibly, DDVP) possessing up to 20 times more toxic intestinal effect on flies than chlorophos.

For manufacturing insecticidal chlorophos paper (directly in disinfectional establishments) there can be used unglued cardboard and other sorts of unglued paper. For manufacturing pure chlorophos fly-paper impregnation of all sorts of paper is carried out with 3-4% solutions of chlorophos, and cardboard – with a 1% solution. Moreover to the chlorophos solution first heated to 10° there is added 5% sugar. In preparing insecticidal chlorophos paper with ammonium carbonate paper of all sorts is impregnated with 1-2% aqueous solutions of chlorophos, carbon – with a 0.5% solution, in which there is additionally dissolved dry ammonium carbonate at a rate to obtain respectively 0.5-1-2% solutions of the last preparation (sugar is not added). For obtaining good fly-paper it is necessary that all the insecticidal liquid be absorbed in the paper (cardboard) without a residue. For treating 1 kg of wrapping paper or cigarette mouthpiece paper there is required approximately 2.2 ℓ insecticide solution, for treating cardboard 2.1 ℓ. Paper cut in strips is soaked in enameled bathtubs, buckets, basins, pots for 24 hours, cardboard – for 48 hours (after 12 and 24 hours respectively the paper or cardboard is turned over). Then it is dried in sheds on wooden grids or under canopies; it is cut and stamped. The stamp operates at a rate of marking of one sheet of flypaper with dimensions of 10 × 10 cm. The period of effect of chlorophos-impregnated flypaper (with pure chlorophos and with an admixture of ammonium carbonate) in premises – in regions with a temperate climate up to 20 days, in regions with a hot dry climate up to 12-15 days. Outside premises the effective period of treated flypaper is in all cases 12-15 days.

Chlorophos tablets "fly-killer" are prepared in commerical quantities. They are placed on saucers, plates, placed on sheets of unglued paper with dimensions of 10 × 10 cm and drenched with 40-50 mℓ of sweetened water.

Insecticidal chlorophos paper and chlorophos tablets are disseminated on objects by workers of sanitary-epidemiological and disinfectional establishments; they are sold by the commericial-pharmaceutical network. They are used for destroying flies in public dining enterprises, in food stores and other food enterprises, in medical and children's institutions, and also in living and auxiliary premises.

Dishes with flypaper, tablets are set in places with the greatest concentration of flies, in particular on window sills, varying the amount of bait depending upon the intensity of fly infestation in the premises. In food enterprises, if there are many flies in them, it is better to use chlorophos flypaper at night in artificial light; in children's institutions the flypaper should be placed in such a way that the children cannot reach it.

When using baits with chlorophos food products must be covered.

In the summertime, especially in regions with a hot dry climate, it is neccessary as broadly as possible liquid baits with chlorophos in animal husbandry premises, at sites for the transportation and neutralization of waste material, placing several pieces of flypaper in one pan or plate. In order to prevent the rapid evaporation of water, it is best to soak in the dishes, pieces of motor vehicle coverings folded in several layers, pieces of cotton fabric, sacking, newsprint, wood shavings, middlings, etc., covering them from above with 8-10 leaves and more of chlorophos paper. The enumerated materials should be moistened respectively with $2\frac{1}{2}$ to 3 and more glasses of water so that liquid completely soaks through them.

In cases, when at sites there are no insecticidal chlorophos or paper or tablets, in combatting mature flies inside and outside premises it is possible to use solutions of chlorophos with attractant substances. It is most expedient for this purpose to apply 0.5% aqueous solutions of chlorophos, in which there is dissolved dry ammonium carbonate until there is obtained 0.5% aqueous solutions with respect to this last preparation; it is also possible to use fly-attracting substances - sugar, fodder molasses, outside premises - blood obtained from a slaughter house, and others. The indicated solutions are poured into saucers and trays. In the insecticidal liquid there is placed unglued paper or rags, or shavings or middlings are poured, etc. The surface of the materials moistened with the insecticidal bait, should be from 200 to 400 cm^2 and more. It is necessary to renew baits prepared from a mixture of chlorophos with ammonium carbonate in premises once in 10-12 days, in the open air - once a week; mixtures chlorophos with sugar, molasses should be renewed once in 5-7 days.

With a considerable concentration of flies in premises it is also necessary to use aerosols, which are obtained by burning aerosol paper impregnated DDT and chlorophos and aerosol pots and bombs with DDT, etc., also are applied.

In regions with a moist climate it is also expedient to use insecticidal baits, for example wood shavings impregnated with a mixture of chlorophos with castor oil and sugar (100 g of shavings take 0.4 g of chlorophos, 10 g of castor oil, 5 g of sugar).

Workers at disinfestational establishments occupied with the distribution and dissemination of baits with chlorophos should enlist the help of their colleagues in other enterprises and establishments, the members of house committees, sanitary activists, and also the broad layers of the population.

With insufficient cleaning of populated sites in cases of considerable infestation with flies in premises in summer chlorophos should be applied in the form of a contact poison and sprayed randomly in 2-3% aqueous solutions on sections which are the favorite landing places of flies (windows, doors electric wires, ceilings, etc.), in food stores, in public eating places, in animal husbandry premises and others. The rate of expenditure of chlorophos, and the number of treatments vary depending upon the type of surfaces.

In spring and autumn in the case of considerable fly reproduction especially of exophilic species of flies mixtures of preparations of

DDT and hexachlorane one should be used to impregnate surface of external walls of outdoor sanitary installations, the external walls of animal husbandry premises and other places where flies concentrate in the open air.

In regions endemic to the outbreak of acute epidemic conjunctivitis in April-May and August-September depending upon the climatic conditions for the purpose of destroying the imagoes of market flies in undeveloped sections of populated sites there is conducted the impregnation of the external walls of premises, fences, etc., with mixtures of DDT and hexachlorane preparations. These measures should be when necessary combined with measures for combatting blood-sucking diptera - mosquitoes, sand flies, etc. In applying contact insecticides to the surface of walls of buildings it is necessary to get maximum use out of mechanized equipment.

Along with the application of insecticides for destroying mature flies in premises one should use fly swatters, sticky paper, sticky tapes.

In order to prevent infestation by flies, especially in food enterprises, medical and children's establishments the windows and when necessary the doors should be equipped with metal screens with a mesh size of 1.5 mm^2.

Of great importance is the destruction of hibernating flies. To prevent the prepupae from going into hibernation it is necessary in autumn to carry out especially through treatment of waste material and soil with larvicides. In spring the destruction of the fly larvae and pupae wintering in the soil and waste material should be executed in accordance with the given entomological observations. Mature flies wintering in premises should be destroyed with the help of fly swatters or insecticidal chlorophos paper.

Table 45. Larvicides for destroying fly larvae in the liquid contents of latrine cesspools and slop pits.

Name of the preparations	Form, concentration of the applied preparation and its method of preparation	Expenditure per m^2 of surface of waste material and the number of treatments per month
Creolin	10% aqueous emulsion (1 kg of preparation is combined with water to make 10 ℓ)	1.5-2 and the number of treatments is 3-5 times per month
Naphthlysol	The same	The same
Unpurified carbolic acid	Without dilution	" "
Unrefined oil	The same	3-4 ℓ and the number of treatments is 3-10 times per month
A mixture of unpurified carbolic acid with naphthalysol	10% aqueous emulsion (900 g of unpurified carbolic acid are mixed with 100 g of naphthlysol and water is added to make 10 ℓ)	3-4 ℓ with the number of treatments up to 10 times per month
Green oil - the by-product of oil processing	Without dilution	1.5-2 ℓ with the number of treatments 2 times per month
Chlorinated lime with the chlorine content not less than 25%	The lumps are ground up and applied in dry form	1 kg and the number of treatments is 10-15 times per month
12% HCCH disinfecting powder	In dry form	300 g and the number of treatments is 4-5 times per month
	2% aqueous suspension (for preparing 1 bucket of a working suspension there are taken 2 kg of disinfecting powder and water is added to make 10 ℓ)	500 mℓ and the number of treatments is 4-5 times per month
25% HCCH disinfecting powder	In dry form	150-200 g and the number of treatments is 4-5 times
15% HCCH emulsion	2% aqueous emulsion (1.5 kg of factory emulsion and water added to make 10 ℓ)	500 g and the number of treatments is 3-5 times

Table 45 (Continued).

Name of the preparations	Form, concentration of the applied preparation and its method of preparation	Expenditure per m^2 of surface of waste material and the number of treatments per month
Polychloropinene (65% concentrate)	5% aqueous emulsion (770 g of concentrate and water added to make 10 ℓ)	200 g and the number of treatments is 3-5 times
A mixture of a 50% s solution of polychloropinene in diesel fuel with naphthalysol or DDT (25% emulsion)	2% aqueous emulsion (of polychloropinene). To 400 g of a 50% solution of PChP (polychloropinene) in diesel fuel, while mixing, there are added 400 g of naphthalysol or 400 g of DDT emulsion. The mixture is complemented with water to make 10 ℓ	200 mℓ and the number of treatments is 3-5 times
Chlorophos	2% aqueous solution (200 g of chlorophos complemented with 10 ℓ of water)	200 mℓ and the number of treatments is 2-4 times
Trichlorometaphos-3 (30-50% concentrate)	0.1% aqueous emulsion (30 or 20 g of TChMP-3 (trichlorometaphos) complemented with 10ℓ of water)	0.5 ℓ per point and the number of treatments is 1 1/2 to 2 times per month in the temperate climate belt; 2-3 times in a hot climate
Wofatox disinfecting powder (2.5% metaphos disinfecting powder)	Applied in disinfecting powder form	100-200 g and the number of treatments is 6-8 times
Kerosene	1) Without dilution	0.5 ℓ per point and the number of treatments is 2-3 times per month (in regions with a temperate climate)
	2) Water-soap emulsion (500 g of kerosene complemented with 4ℓ of soapy water)	4 ℓ per pound and the number of treatments is 4 times per month in regions with a dry hot climate

Table 46. Insecticides for destroying mature flies.

Name of the preparation	Form, concentration of the applied preparation and the method of its preparation for application	Method of application	Objects subjected to treatment	Expenditure per unit of surface or volume	Number and periods of treatment
A mixture of DDT and HCCH emulsions	There are taken 2 parts by weight of 25% DDT emulsion and 1 part by weight of 15% HCCH emulsion. 2% aqueous emulsion (800-1600 g of mixture complemented with water to make 10 ℓ)	Surfaces subjected to treatment uniformly	Sections of external walls, premises, fences, outside sanitary installations	Per m^2 of plastered, pasted with wall-paper, wooden and other surfaces there is applied 100 mℓ of liquid containing 2-4 ℓ of the technical preparation	In spring and in autumn one time; in summer depending upon local conditions
A mixture of DDT and HCCH disinfecting powders	There are taken 2 parts by weight of 10% DDT disinfecting and 1 part by weight of 1[illegible]% HCCH disinfecting powder. 2% aqueous suspension (2 kg of mixture complemented with water to make 10 ℓ)	The same	The same	The same	The same
Technical DDT	Aerosol. The preparation is pulverised and weighed samples are prepared taking into account the cubic volume of the premises	The preparation is spread on metal sheets and slightly heated on an electric stove, oil stove or spirit-lamp covered beforehand with asbestos	Children's establishments and living quarters	0.5 g/m^2	In proportion to the accumulation of flies in the premises

Table 46 (Continued).

Name of the preparation	Form, concentration of the applied preparation and the method of its preparation for application	Method of application	Objects subjected to treatment	Expenditure per unit of surface or volume	Number and periods of treatments
Aerosol cylinders containing DDT, DDVP	Aerosol	Activate the cylinder and fill the closed premises with the aerosol	Medical establishments, living quarters, food enterprises	On 100 m^3 the cylinder is activated for 50 seconds. The action time of the cylinder is calculated at 14 minutes, i.e., enough to treat 1630 m^3 of premises. After treatment the valve is released and the cylinder is stored until the next treatment	The same
DDT aerosol paper	Aerosol. Filter or thick paper is impregnated with a 7% solution of saltpeter, dried for 24 hours, and then impregnated with a 12% DDT solution in benzene, dichloroethane or some other organic rapidly evaporating solvent. Then dried.	Pieces of paper are burned without permitting them to flame	Medical establishments, living quarters, food enterprises	0.5 g/m^3	In proportion to the accumulation of flies in the premises
Chlorophos	A 2-3% aqueous solution (200 g of chlorophos or 400 ml of 50% mother liquor of chlorophos are dissolved in 10 l of water)	The surface of the objects being subjected to selective treatment are treated uniformly	In well ventilated industrial and living premises	50-100 ml depending upon the nature of the surface being treated	Not less frequently than once every 20-25 days in a temperate climate, not less frequently than once every 15-20 days in a hot climate

Table 46 (Continued).

Name of the preparation	Form, concentration of the applied preparation and the method of its preparation for application	Method of application	Objects subjected to treatment	Expenditure per unit of surface or volume	Number and periods of treatment
Insecticidal chlorophos paper	Sheets of insecticidal chlorophos paper with dimensions of 10 x 10 cm	They are placed on baking sheets and 40 m ℓ of water are added per sheet	They are placed inside the premises of food enterprises, at foci of intestinal infections and in the open air	1 sheet per 10-20 m^2 floor area, 5-6 sheets in outdoor; sanitary, installations	Adding additional water when necessary 1 sheet is used for 10-15 days
Liquid insecticidal baits with chlorophos	To a 1% aqueous solution of chlorophos there is added 3-5% fodder molasses or barley malt	The surfaces of objects being treated are treated uniformly	Sheds at markets: fences, external walls of premises for cattle, floor sections	100 m ℓ /m^2	6-10 times per month
Chlorophos aerosol paper	Aerosol. Filter paper treated with an aqueous solution containing 10% chlorophos and 7% saltpeter at a rate of 1 ℓ per 5 m^2 of paper. Dried for 24 hours	In well ventilated industrial and living premises	Inside living quarters at foci of intestinal infections	0.1-0.2 g/m^3	In proportion to the accumulation of flies in the premises
Fleacide	Applied without dilution	Sprayed into the air	Children's and medical establishments foci of intestinal infections	6-8 g/m^3	The same
Pyrethrum	Powder	Sprayed into the air	The same	4-5 g/m^3	The same

Table 47. Insecticides for destroying fly larvae and pupae in solid waste material and in soil

Name of the preparation	Form, concentration of the applied preparation and the method of its preparation for application	Expenditure per m^2 of surface with a thickness of the layer of waste material from 30-50 cm*	Number of treatments per month
Creolin	10% aqueous emulsion (1 kg of creolin is complemented with water to make 10 ℓ)	From 2-5 ℓ	6-9 times
Napthalysol	20% aqueous emulsion (2 kg of napthalysol are complemented with water to make 10 ℓ)	From 2-5 ℓ	8-10 times
A mixture of unpurified carbolic acid with napthalysol	10% aqueous emulsion	From 2-5 ℓ	8-10 times
Green oil	Without dilution	From 2-3 ℓ	2-4 times
Polychloropinene (65% concentrate)	2% aqueous emulsion (300 g of concentrate are complemented with water to make 10 ℓ)	From 2-4 ℓ	3-4 times
Polychlorocamphene (65% concentrate)			
A mixture of a 50% solution of polychloropinene in diesel fuel with napthalysol or with a 25% DDT emulsion	Aqueous emulsion (of polychloropinene)	From 2-4 ℓ	3-4 times
Chlorophos	0.5% aqueous solution (50 g of chlorophos or 100 mℓ of a 50% chlorophos solution are complemented with water to make 10 ℓ)	From 2-4 ℓ	3-4 times
Trichlormetaphos-3 (30% or 50% concentrate)	0.1% aqueous emulsion (30-20 g of 30 or 50% concentrate of trichlormetaphos-3 respectively are complemented to make 10 ℓ)	From 3-4 ℓ/m^2	2-3 times

Table 47 (Continued).

Name of the preparation	Form, concentration of the applied preparation and the method of its preparation for application	Expenditure per m^2 of surface with a thickness of the layer of waste material from 30-50 cm*	Number of treatments per month
2.5% wofatox disinfecting powder	In the form of disinfecting powder and aqueous suspension (100-200 g of disinfecting powder 10 ℓ water	100-200 g of disinfecting powder 2-5 ℓ of aqueous suspension of the disinfecting powder ..	8 times

*In accumulations of waste material in all cases the expenditure of the working fluid is 10-12 ℓ/m^3.

Special attention should be given to exterminating flies at foci of intestinal diseases, poliomyelitis, conjunctivites, tuberculosis and other infections transmitted by flies. The main problem in carrying out both the current and also the concluding disinfestation is the one-time, rapid destruction of all flies located in the apartment of a diseases person.

For this (before carrying out disinfestation) with closed windows and doors, not allowing the flies to escape from the premises, fast-acting insecticides are used – pyrethrum preparations (fleacide, pyrethrum disinfecting powder), aerosol bombs, DDT pots. Subsequently, in the premises chlorophos is applied as a contact poison, and also set out for the fly population are insecticidal chlorophos paper and sticky tapes; the use of fly swatters is also recommended; etc. Simultaneously there are treated with larvicides waste material in receptacles, the surrounding soil, a schedule is set up for the timely removal of waste material (Table 45, 46, 47).

* *
*

In the course of this account we have repeatedly indicated the necessity of conducting disinfestational antifly measures taking into account the phenomenon of specific resistance of house flies to insecticides. To prevent this phenomenon it is necessary to apply insecticides in accordance with the ecology of the flies. In particular, there was noted the expediency of using in combatting mature flies poisoned baits with the introduction of insecticides attracting insects and highly toxic to them. Regular (not less frequently than once every 2-3 years) appraisal of the sensitivity of local populations of house flies to the insecticides being applied is a necessity. Timely replacement of insecticidal preparations should when possible prevent the formation of fly populations with hereditarily secured resistance to individual groups of chemical poisons.

These determinations are carried out by the local application (with micropipettes or microloops) of solutions of test insecticides in acetone or in ethyl alcohol on the midback of female house flies. Changing the concentration of the solutions of the preparations determines the LD_{50} of the test insecticide for the investigated fly population.

On the basis of control works conducted in various climatic zones of the Soviet Union it may be concluded, that in cases when the LD_{50} for DDT, hexachlorane and polychloropinene at an air temperature of 24-26° exceeds with local application on a female 6-10 μg, the sensitivity of the insects of the test population to the given preparations has been weakened. The application of these insecticides at an air temperature exceeding 22° in combatting house flies of a given population is inexpedient. In those cases, when the LD_{50} with local application on a female house fly of solutions of polychloropinene in acetone at a temperature of 24-26° exceeds 15-20 μg it is necessary to stop using mixtures of this insecticide with diesel fuel, napthalysol, DDT in combatting the preimaginal phases of house flies under local conditions. In this case it is necessary to use larvicides from the organophosphorous group of compounds, phenols, cresols.

Chlorophos is completely effective with respect to house flies in cases, when the LD_{50} with local application of this preparation on a female of the natural population being tested varies at a temperature of 24-26° from 0.2 to 1.5 μg and more. It is necessary to note that the application of chlorophos for 8 years in mytishchi (Moscow oblast), its use during the course of 5 years in Tashkent with the above described tactics of carrying out of the exterminating operations did not promote the appearance in the enumerated cities of tolerance in the local populations of house flies to this preparation (T. A. Bolotova, I. V. Gvozdeva, K. S. Zairov, Yu. N. Misnik, S. I. Novikov, M. N. Sukhova).

As is evident from what has been said, measures for combatting flies present a rather complicated problem requiring appropriate organization and subsequent control. These latter should be carried out by sanitary-epidemiological stations, sanitary-epidemiological branches of regional hospitals, and in the big cities by disinfestational stations. The responsible executors in realizing antifly measures according to the division of sanitary-prophylactic operation are development administrations, cleaning establishments, administrations of housing-communal service of the local executive committees of the Councils of deputies of workers, enterprises of the food industry and public nutrition, sovkhozes, kolkhozes, medical-prophylactic establishments, house owners, etc. Exterminating measures are carried out by the appropriate disinfestational establishments in conjunction with communal service workers, and also the population itself.

Operations for combatting flies should be conducted according to a general plan which is part of the overall schedule of measures of the sanitary-epidemiological service on reducing diesel incidence of intestinal infections.

In a plan for combatting flies there are specified concrete measures for developing and for the sanitary purification of individual sections of populated sites, the insecticides to be applied at these sites, the volume, methods, periods of execution of exterminating measures, control observations; responsible executors are designated for each division of the operation.

Measures for combatting flies should be conducted at all populated points, but especially intensively in sections with increased disease incidence with intestinal and other infections transmitted by these insects. It is necessary to carry out antifly measures during the whole year, and in planning the work it is necessary to consider the individual seasons, and also the local climatic and economic peculiarities.

Calculating the Number of Synanthropic Flies and the Possibility of the Maximum Reduction of the Number of These Insects at Populated Sites

The collecting and the calculation of the number of mature flies are carried out using traps with baits attracting these insects, and by active collection with nets and test tubes.

As traps in closed premises sticky paper is used, outside — fly catching nets, using fermenting dough and yeast as bait. It is also expediently to carry out the calculation of the number of flies using insecticidal chlorophos paper prepared with ammonium carbonate. In a deep plate there are placed 6 sheets of chlorophos flypaper with an overall area of 60 × 60 cm; it is filled with 300 ml of water and placed for a day at a calculation point (inside or outside). After twenty-four hours the dead flies are removed and counted.

At monotypic sites according to the character of development and the methods of carrying out the disinfestational operations there are placed not less than two fly trap nets baited with chlorophos flypaper. The number of calculation points inside for catching mainly house flies should exceed the number of calculation points outside by not less than 5 times in each section respectively.

On the basis of obtained calculation materials there are compiled: 1) curves of the seasonal dynamics of the number of house flies (according to the calculation data in the premises), 2) curves of the seasonal dynamics of the number of predominant synanthropic flies of exophilic species (according to calculation data in monotypic traps outside). These curves compare with the course of meteorological elements, the seasonal distribution of infections transmitted by flies. Based on the data for calculating the number of flies, the seasonal indices of the number of insects are calculated. The seasonal index of the number of mature flies is considered the average number of flies of one species (or the total populations of various species) caught in one catching period in one trap, considering the total amount of traps and calculations conducted during the periods of vital activity of insects (M. N. Sukhova).

The calculation of the number of preimaginal phases is carried out either visually, or for scientific and practical purposes by test sampling at the main fly breeding sites, every ten days if possible. Samples are taken taking into account the temperature of the substrate; under laboratory conditions the humidity of the investigated waste material and soil is determined. Each sample is taken twice (in two vessels). From one the larvae are removed by the flotation method.[4] The larvae and pupae found in the second vessel are kept until hatching. The hatched adult flies, and also the fixed larvae are identified according to the species and counted. Proceeding from the total number of samples taken from monotypic biotopes during the season, a calculation is carried out of the population density of 100 g of air-dry substrate with the preimaginal phases of flies (the index of the number of preimaginal phases) (M. N. Sukhova and T. V. Yerofeyeva).

It is necessary to consider that synanthropic flies are definite indirect indices of the state of the sanitary decontamination of populated points from putrescent waste material. High index numbers for example, of blue spring flies indicate insufficient decontamination of populated points in the first place from everyday household rubbish; the presence of market flies, individual species of gray flesh flies indicated direct fecal contamination of the soil. Finally, high index numbers for house flies indicate contamination of the area of populated sites with waste material of the most diverse origin (M. N. Sukhova).

On the other hand, a maximum reduction in the number of synonthropic flies with a small volume of disinfestational measures testifies to good (in a sanitary-entomological respect) decontamination of populated sites from putrescent organic waste material.

By the maximum reduction in the number of individual species of flies one should understand a reduction in the number of their populations to the extreme minimum, at which seasonal rises in the number of these insects are excluded and accordingly the possibility of disease transmission by the transmissive path. This is observed, when the seasonal index numbers of imagoes of house flies according to the calculation data with sheets of sticky paper in premises do not exceed 2-5, and the seasonal indices of the total population of exophilic species of flies (according to the calculation data in traps outside) are not more than 10-20; seasonal index numbers of preimaginal phases in waste material do not exceed 1.0; in soil not more than 0.1 (Table 48). It is completely sound to pose a question about the complete destruction over large territories of individual highly specialized obligate-synanthropic species, for example, such as blue carrion and market flies. (Destruction of the house fly as a species a more difficult problem is due to the great ecological plasticity of this species).

However, the problem of the maximum reduction of the number of house flies, just like flies of the facultative-synanthropic species, reducing their number at populated sites to individual specimens is completely accessible of solution and absolutely necessary.

Table 48. Quantitative criteria for appraising the quality of operations in combatting flies (according to M. N. Sukhova and T. V. Yerofeyeva).

a) Appraisal of the degree of encounterability of synanthropic flies at populated sites

Species of insects and method of collection	Encounterability of nature flies (in seasonal index numbers)		
	weak	moderate	high
House flies (according to the calculation data in premises on tapes of sticky paper)	5-2 and below	10-5	10 and above
Total population of synanthropic flies (according to calculation data outside premises fly trap nets)	20-10 and below	30-20	30 and above

b) Appraisal of degree of infestation of soil and waste material with fly larvae and pupae

Substrate	Population density of the substrate (index numbers of preimaginal phases)		
	weak	moderate	high
Waste material	1 and below	5-1	5 and above
Soil	0.1 and below	1.0-0.1	1.0 and above

Footnotes

[1]The word "synanthropic" derives from the Greek words συν – together and [illegible] – man.

[2]The term "synbovilic" is broadly understood here in a general connotation of being connected with domestic animals. [Editor's note: it could derive from syn and bovine, i.e., synbovine.]

[3]According to Ye. N. Pavlovskiy, specific ones are those arthropod carriers, in the organism of which there occurs the reproduction of pathogenic agents of infection or infestation.

[4]The waste material is flooded with a saturated solution of table salt at a ratio of 1:2 by volume. The larvae coming to the surface of the liquid are washed in cold water, then flooded with boiling water and subsequently fixed in 80% ethanol.

C H A P T E R XXXI

COCKROACHES AND THEIR CONTROL

Cockroaches belong to the family Blattidae order Blatodea order Orthoptera. In living quarters there are encountered the common [German] [red] (Blatella germanica) and the oriental [black] cockroach (Blatta orientalis) (Fig. 28, 29). There are also other species of cockroaches – the American cockroach (Periplaneta americana), the Indo-Australian cockroach, Polyphaga soussurer and others. A total of more than 2000 species.

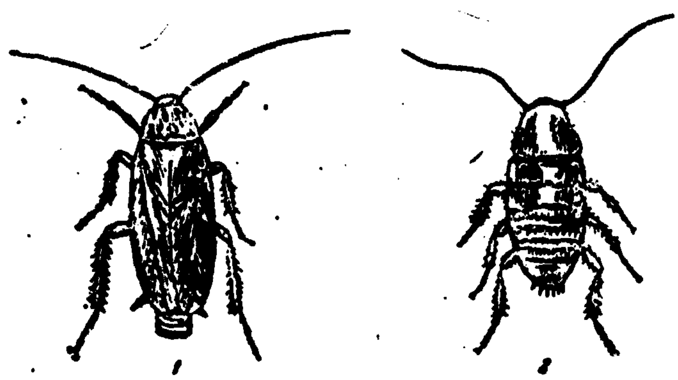


Fig. 28. The common [red] cockroach (German cockroach). Blatella germanica. 1 – female with cocoon; 2 – larva.

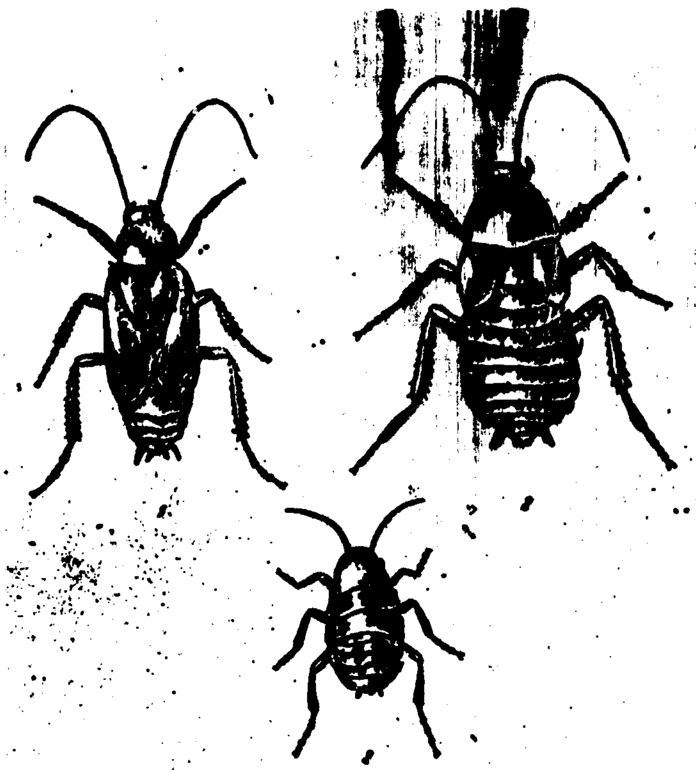


Fig. 29. The oriental [black] cockroach Blatta orientalis. 1 - male; 2 - female; 3 - larva.

Morphologico-Ecological Characteristics of Cockroaches

Common [German or red] cockroaches, or Prussians are distinguished by their yellowish-brown color; their length is 11-13 mm. The females are considerably larger than the males. The cockroach body is flattened, oval in shape. On the head is a pair of long many-segment antennae, compound, faceted and a pair of simple eyes. The oral organs of the cockroach are of the gnawing type. The male and female common cockroaches have wings: the front, narrow ones play an elytroid role, the second pair - folded - are located under the first. Cockroaches do not fly but use their wings for jumping from heights. The legs of cockroaches are well developed. With the help of special attachments on the tarsi - suckers - they can crawl along vertical surfaces. The abdomen consists of 10 segments. In the abdominal integument there are glands secreting an unpleasant odor; there are also well-developed cerci serving as olfactory organs.

The impregnated female cockroach lays from 28 to 67 eggs in a special cocoon (capsule), which according to its development emerges from the posterior end of the abdomen. During her whole life the female lays up to 4 such capsules. She carries the capsule with her for 15-40 days, depending upon the temperature, and lays it, when the larvae are ready to hatch. After 30 minutes white larvae emerge from the cocoon; within 6 hours their color changes to the usual brown color. The larva passes through 6 molts. The total duration of development depends on external conditions: with insignificant moisture, a sufficient amount of food and a temperature of 30° this process is completed in $2\frac{1}{2}$ months, at 22° the complete development of the larvae is completed in 4-8 months, at 20° it takes about 6 months, and with lower temperatures 10-12 months.

The optimum temperature for the development of common and oriental cockroaches is 25-30°; with a decrease in the temperature to 4° the insect is almost motionless, and at -5° it dies.

Favorable conditions for the life of the cockroach are warmth, humidity and an abundance of food; thus the favorite sites where cockroaches are found can be kitchens, bakeries, dining rooms, breweries and other food enterprises. Cockroaches easily penetrate from premises infested by them through cracks in doors, floors, walls, along water lines and gas pipes and power-supply lines and move into neighboring living quarters.

Common cockroaches can be encountered in considerable numbers on steamers and ships, where they in most cases are scattered all over the vessel. The main sites infested by them are food-preparation sites, and the main mass of the insects is localized in galleys and bakeries. Under the conditions of these biotopes common cockroaches find the optimum possibilities for existence and development, namely a favorable temperature regime in combination with optimum humidity and a large variety of food. Cockroaches are also concentrated in cupboards, dishwashers and warm, food pantries. It is possible to encounter them in corridors connecting food preparation sites, behind pipelines, behind electric lines, near heating equipment. In galleys cockroaches nest behind stoves, in cabinets with dishes, around washers and under them, in corners of walls and ceiling. In bakeries they are concentrated near places where dough is prepared, near stoves and underneath meat cutting blocks.

From the food preparation sites cockroaches spread all over the vessel into the cabins. On the lookout for water and food or favorable microclimatic conditions common cockroaches sometimes crawl into other adjacent premises. Such infestation is observed usually with mass reproduction. The first stage of their migration is into toilets, bathrooms, showers. Here they concentrate mainly behind pipelines.

The food of cockroaches is very diverse: black bread, boiled potatoes, carrot, sugar beets, sugar syrup, flour products, grain, leather, leather bindings, boots, cotton, silk, wool, paper, glue, animal corpses, insects, people, defecation, oil and other fats. Cockroaches are voracious, they crawl over food products, over dishes, dirty rubbish buckets, spittoons, toiletseats in latrines and with their feces soil the household surroundings. Hard foods they crack with their oral organs and dissolve with secreted saliva. To the absence of food red cockroaches are not sensitive: they can starve for 30-40 days, and their larvae from 9 to 22 days. Cockroaches are active at night, and during the day hide in cracks; in twilight they begin to crawl from their refuges and go out looking for food.

As a result of the prolonged application of such insecticides as DDT, hexachlorane, the gamma-isomer, dieldrin and others, cockroaches have produced a resistance to them.

The process of development of the oriental cockroach is similar with the development of the common cockroach. A week after mating oviposition begins in the form of egg capsules with up to 16 eggs in one capsule. In approximately 2-5 days female oviposits her cocoon in a warm place, from which at 20° within 6 months, and at 30° within $2\frac{1}{2}$ months larvae hatch. The period of maturation depends on temperature and can be extended for up to a year. The larva molts 6 times. Complete development of the larva is achieved within 4-9 months. The time of complete development from the egg to the mature stage is from 269 days to 5 years. One female from April up to September can oviposit up to 128 individuals. The food of the oriental cockroaches is the same that of the common cockroach.

The American cockroach has dimensions of 26-32 mm with a red-brown color; the elytra and wings exist in both sexes; in Soviet Union it is sometimes transported from tropics.

The cockroaches inhabiting houses in Central Asia (Schelfordella tartara) are brownish-yellow in color; their elytra are rust-brown in color with a whitish maginal area.

The cockroach (Polyphaga saussurei) lives in the burrows of gerbils, in old cemeteries and in barns coming into contact with domestic animals having contact with man. In many places of Central Asia it also lives in the living quarters of man himself.

Under the influence of ionizing radiation there have been established on large larvae of the common cockroach both in males and females sterilizing doses (3200 R) and lethal doses (6400-9600 R). With a dose of 3200 R there is observed a reduction in the number of eggs deposited and a decrease in their viability. There are also noted certain changes in the ovaries and testes.

The Epidemiological Significance of Cockroaches

Cockroaches transmit pathogenic agents of various infections (about 40) not only mechanically on their tarsi and body integuments, but they can also infect food with their excretions. According to source material cockroaches can transmit TB bacillus, B. proteus vulgaris, the intestinal bacillus B. pyogenes aureus, Staphylococcus aureus, Staphylococcus albus, Sarcine, subtilis molds, B. anthracis, pathogenic agents of salmonellosis, poliomyelitis, the virus of lymphocytic choriomeningitis, the pathogenic agent of scarlet fever, measles, 6 species of protozoa, 12 species of helminthiasis and others. The bacilli of Friedländer, diphtheria, typhoid fever, cholera, leprosy, sporogenes, tetanus, glanders, pneumoccoci, staphylococci and Escherichia coli pass through the intestines of cockroaches (oriental and common) without visible changes. After consuming the excrement of persons infected with cholera cockroaches can excrete with their feces Vibrio comma for 79 hours, and then upon getting into a moist medium remain virulent for up to 16 hours. Bacilli of typhoid fever can be detected in the intestines of the insect for a period of 23 days.

After consuming 0.02--0.1 g of human excrement containing Salmonellae, the latter are detected in the feces of cockroaches for a week. Salmonallae were extracted from the intestines of a black cockroach caught in a hospital ward, where patients were located because of an outbreak of salmonellosis.

After feeding the common cockroach saccharose, broth or a mixture of skim milk, an extract of yeast and saccharose containing bacteria of murine typhus for a period of 11 days the initial culture was extracted from the excrement of the cockroach.

Leprosy bacilli were extracted from common cockroaches inhabiting leper colonies. It has also been established that after feeding oriental [black] cockroaches the sputum of persons infected with tuberculosis along with the feces of the insects there were excreted the mycobacteria of tuberculosis, which were completely virulent and when injected into guinea pigs caused the death of the latter.

Cockroaches infected through their food with the bacillus of anthrax can excrete the latter with their feces for 30 days and with a prolonged stay in the intestines of a cockroach the bacteria of anthrax multiply and their virulence is increased.

Plague microbes preserve their virulence in the intestines of a cockroach for 24 hours; the mycobacteria of tuberculosis are excreted in large numbers for 9 days.

It has also been established that oriental [black] cockroaches can be infected with cysts of Amoeba dysenteriae. Upon consuming these cockroaches kittens became ill with amebic dysentery.

According to G. V. Epstein and Ye. V. Ekzemplyarskaya with the introduction of a suspension of the mycobacteria of human tuberculosis into the body cavity of oriental cockroaches there is observed the secretion of perivisceral liquid corresponding to protective phagocytic reaction, which begins within 4 hours and lasts for 3 months, and in certain cockroaches an increase in the number of tuberculosis mycobacteria occurs. With the infection of cockroaches by feeding the mycobacteria of tuberculosis are excreted with their feces for more than 3 months. It has been noted that in the first period both in the perivisceral liquid and also in the feces of cockroaches the number of tuberculosis increased, which was confirmed by calculating the introduced micro-organisms and their number after a month. On the basis of this the authors came to the conclusion that in the organism of cockroaches the reproduction of tuberculosis mycobacteria occurs.

Measures for Combatting Cockroaches

The methods of combatting cockroaches and also other insects include carrying out prophylactic and exterminating measures. One of the most important prophylactic measures is the maintenance of cleanliness in order to deprive cockroaches of their food and places for shelter. It is necessary to thoroughly cover food products, to clean up kitchen waste material and food residue. In kitchen premises and at enterprises for public dining all seams and cracks (in the floor, in walls) should be carefully sealed, and drains and ventilation openings should be screened with fine-mesh screen.

Exterminating measures are divided into chemical, mechanical and physical.

The basic measure in combatting cockroaches is the creation of barrier zones by treating with chemical preparations (powder and liquid forms) sites infested by them. Because it is not always possible to treat their reproduction sites, their breeding sites in premises are treated. Cockroaches heading out to look for food and water are forced to crawl through the protective zones, as a result of which they are poisoned and die. Poisonous substances (most frequently in the form of disinfecting powders) are not only applied to the surfaces of floors, tables, and cupboards, but also in liquid form they are also introduced with the help of paint brushes or special sprayers into cracks serving as hiding places for cockroaches. For destroying oriental cockroaches there are treated mainly the baseboards and cracks in floors, which serve as breeding sites. For impregnating surfaces liquid preparations are used. Surfaces treated in the manner acquire insecticidal properties for a more or less prolonged period of time.

Of the chemical preparations there are applied DDT, hexachlorane, its gamma-isomer, chlorophos, metaphos, strobane, chlordane, dieldrin, trichlorometaphos-3 sodium fluoride, borax, boric acid and others. All the enumerated preparations are toxic to people, therefore when working with them it is necessary to observe precautionary measures. It is necessary to see that they do not get into food products. Before setting about disinfestation, it is necessary to remove from the premises or to thoroughly isolate food, food products, dishes and so on. The treatment of food enterprises is carried out after the end of a working day; it is even better to do this before a holiday and to remove the preparation residue in the morning before the beginning of work. Kitchens in dwellings are treated in the evening, and after treating it is not recommended that they be used before cleaning up the preparations in the morning.

The preparations are atomized on the surface of floors, behind baseboards, in cracks and openings, along water lines and sewer pipes, on surfaces of cupboards and cabinets turned towards walls, and on the lower parts of tables, stands and shelves. Also subjected to dusting are ventilation vents, gas pipes, etc.

When cleaning up the residues of the powders of DDT, hexachlorane, sodium fluoride and other preparations are carefully removed; insects are swept up and burned. Implements, equipment, dishes and other objects located in the premises are thoroughly cleaned and washed.

A study of the repellent properties of 7 insecticides: DDT, chlordane, lindane (the gamma-isomer of hexachlorane), dieldrin, heptachlor, allethrin, pyrethrum extract showed that with increased dosages the enumerated insecticides with the exception of DDT possess weak repellent properties. The DDT even in insignificant quantities possessed high repellent properties. In the usually applied doses not one of the remaining insecticides showed repellent or attractant properties.

In an investigation of the tissues of cockroaches poisoned with DDT 2 days before their death it was established that the amount of glucose, glycogen, fat and water composed respectively 38, 27, 83 and 84% of the normal amount; the same decrease was found in cockroaches poisoned with strobane, respectively 43, 44, 92 and 69%; analogous data were obtained in a study of metaphos with the distinction that the amount of fat in insects poisoned with metaphos did not decrease. Apparently, the reduction in carbohydrates and fats occurred as a result of a great amount of muscular work. Death ensued as a result of exhaustion: the fact that the fat reserves during poisoning with metaphos were untouched can be explained by the more rapid advent of paralysis than with poisoning with DDT and strobane. In insects poisoned with dieldrin the content of glucose, glycogen and fat was approximately the same as in control insects. This is explained by the fact that in its action mechanism dieldrin differs from DDT, strobane and metaphos. The content of water in insects poisoned with DDT, strobane, metaphos and dieldrin was respectively 84, 70, 88 and 68% from that found in the control (Clark and others).

A study of the sites of DDT metabolism, injected into the blood stream of the oriental cockroach showed that the preparation exists in the digestive tract, the gonads, the fat bodies, the malpighian vessels, thoracic muscles of adult male and female cockroaches in which various doses of the preparation were introduced. In both sexes the greatest quantities of DDT were detected in the digestive tract, thoracic muscles, fat bodies and in discarded tissues (in molting). The same broad distribution of DDT was detected in nymphs (males and females) of the last stage in which the preparation was introduced.

Metabolism of DDT in DDE occurs, apparently, in all the mentioned tissues, although in certain of them in more limited dimensions. For adult males and females DDE was detected in the largest quantity in the fat bodies, the digestive tract and the external integuments.

In common and American cockroaches Agosin found a new microsomal enzyme transforming DDT into Keltan [Kelthane] a compound very close to it and, possibly, constituting a mixture of several enzymes. A similar enzyme was also detected in house flies.

The DDT and hexachorane are used in forms of dusts (disinfecting powders) containing 10% DDT and 5-6% hexachlorane, at a dose of 20-35 g/m^2 of surface.

As was shown above, treating surfaces with DDT preparations ensures good effect. An even higher effect is achieved with the use of the gamma-isomer of hexachlorane. In individual cases a 2% DDT emulsion with a mineral oil is used, but because it soils and leaves spots it has not found broad application. It is necessary to treat not only the surfaces visited by cockroaches, but also implements, fissures and their other nesting sites. In insects coming into contact with DDT or hexachlorane preparations paralysis ensues within 4-5 hours with their subsequent death within 2-4 days.

With hexachlorane pencils streaks are applied with intervals of 4-7 cm around cracks, holes in walls, stoves, in places where pipes enter.

Inasmuch as hexachorane possesses a strong odor of mold, which is persistent and is absorbed by products, the latter acquire an unpleasant taste and odor, thus it should be applied at food producing enterprises only in extreme cases and in very limited quantities.

Recently for combatting cockroaches the gamma-isomer of hexachlorane has been recommended. With respect to common cockroaches the gamma-isomer is more effective in disinfecting powder form. With respect to its toxic properties for cockroaches it is higher than chlordane disinfecting powder by $2\frac{1}{2}$ times, it is more effective than DDT by 18 times and sodium fluoride by 160 times (Table 49).

Table 49. The dependence of the insecticidal effect of the gamma-isomer and other preparations on the method of their application on Blatella germanica (according to Neiswander).

Insecticide	Amounts of preparation (g/m^2), providing the death of 50% of the cockroaches		
	spraying a surface	dusting a surface with disinfecting powder	dusting in a chamber
Gamma-isomer	2.8	0.8	0.2
Chlordane	1.7	2.0	0.6
DDT	40.0	15.0	2.5
Sodium fluoride	-	130.0	40.0

The gamma-isomer of hexachlorane when administered to a cockroach in combination with the alpha-isomer of the same compound is less effective than when it is used separately.

Thus, the available data show that with the introduction of isomers of hexachlorane there is noted a certain antagonistic effect of the alpha- and delta-isomers with respect to the gamma isomers.

With application on a surface at a rate of 2.5 g/m^2 the most promising was dieldrin, the activity of which on a surface was preserved for 29 weeks, for it in the order of decreasing time of effective there follows the gamma-isomer of hexachlorane (3-6 weeks), diazinon, chlordane and DDVP.

Because of the fact that at a number of places on the earth the common cockroach has become resistant to DDT, chlordane, and dieldrin, broad distribution has been acquired by the organophosphorus compounds, which were also effective with respect to resistant populations however not one of them provides such a long-range effect as takes place with the use of the chlorinated hydrocarbons. Although organophosphorous insecticides have been applied in a number of countries for a long time, nonetheless there still has not been noted the development to them of resistance among cockroaches on a wide scale, with the exception of the appearance of a population of common cockroaches resistant to diazinon in Kentucky (USA), where this population continues to remain susceptible to malathion. Other cases of the development of resistance among cockroaches to organophosphorous compounds under practical conditions have not been noted.

Of the preparations recommended by various authors - disinfecting powders with pyrophyllite filler - 1% diazinon, 4% dicapthan, 4% ronnel and 4% malathion (carbophos) - the most effective was diazinon. Oil and aqueous solutions of the enumerated preparations showed highly effective results. The latter indicates that these forms of application of the given preparations more active than disinfecting powders. Furthermore, there are data about the fact that cockroaches avoid deposits of disinfecting powders of DDT, hexachlorane and look for passages not dusted with disinfecting powder; in the absence of such places they pass through the dusted surfaces. Of great significance is the size of the dust particles. The most effective are disinfecting powders the particles of which pass through a sieve with a 200 mesh.

Concerning the advantages of oil solutions there attests also the fact that 1% solutions or emulsions of baytex when they are used against common cockroaches provided effective results for a period of 90 days. In contrast to 3% baytex disinfecting powder was very effective only for 30 days. Diazinon in the form of a 2% disinfecting powder remained highly effective for 3 months. During combined treatment with disinfecting powder and emulsion (solution) good results were also observed. For example, 2% diazinon disinfecting powder with 2% malathion (carbophos) emulsion or with 0.5% emulsion of the same diazinon provided the best results as compared to those, which were observed with the use of only disinfecting powder or only solution. Highly effective was wofatox disinfecting powder; with its three-time application with weekly intervals at a rate of 3 g/m^2 the complete destruction of common cockroaches is attained.

In contrast to the organophosphorous insecticides sevin (carbamate) in the form of a 5% suspension provided destruction of 95-100% of the cockroaches during the period of the observations (60 days), but with the use of the emulsion at the same concentration the results were ineffective.

During a study of organophosphorus preparations from the point of view of their residual activity it was established that this latter varies depending on the character of the treated surface. Laboratory experiments showed that baytex emulsion with a rate of expenditure of 1 g/m^2 was ineffective for common cockroaches with a 3-hour exposure a week after the treatment of painted metal and asphalt tiles, but on masonite and unpainted metal its application provided complete destruction of the insects.

At the same dosage DDVP when sprayed is effective on all surfaces, with the exception of unpainted metal, whereas as a result of the application of diazinon there was provided complete destruction of insects on all 4 surfaces. The DDVP caused the destruction of 94% of the insects at rate of expenditure of 2 g/m^2 on asphalt tiles 2 weeks after treatment as compared to the death of 6% of the insects with the use of 0.5 g/m^2; however on unpainted metal plates with an increase in the rate of expenditure from 0.5 to 2 g/m^2 the results were not improved.

The degree of effectiveness of many organophosphorous compounds is directly connected with the completeness of the coverage by the preparation of the surface being treated. In treating certain surfaces (wallpaper, plastering, etc.) with organophosphorus compounds their discoloration is observed after the drying of the applied insecticide. Dicapton should be applied with caution especially on alkaline surfaces and also when spraying of oil solutions around floors of asphalt or vinyl tiles. Drops falling on these surfaces cause their softening and damage them.

Piperonyl butoxide is also toxic to cockroaches; with the application of 0.157 μg of tagged preparation their death was noted. The cockroaches absorbed about 88% within 3 days: about 50% of the radioactive parts could be detected in their excretions in the course of 7 days. The greatest numbers of radioactive parts per unit of weight were contained in the brain, the thoracic ganglion, the anterior segment of the intestines, the posterior segment of intestines and the Malpighian vessels. Schmidt and Dahm consider that these tissues and organs take part in the destruction of the radioactivity of piperonyl butoxide in female cockroaches.

Susceptible common cockroaches and other species of these insects can be destroyed completely with a 3% emulsion or solution of chlordane, or a 0.5% solution, or a 1% disinfecting powder of dieldrin. The application of all the above-mentioned preparations in dwellings or on food objects should be selective (selective treatment of surfaces) using the disinfecting powder for treating baseboards, along water line pipes and other places infested by cockroaches, and also their routes of movement.

Sodium fluoride is applied at a rate of 3-8 g/m^2 for treating their reproduction sites, and also the horizontal surfaces, along which cockroaches move toward food and water. Usually there are used powders containing 50-80% sodium fluoride, or mixtures consisting of the preparation and granulated sugar, or the preparation and flour at a ratio of 1:10-1:4. In dusting surfaces with sodium fluoride it is necessary to protect oneself from inhaling it, since this may cause severe irritation of the mucous membranes of the upper respiratory tract; in individual persons it causes coughing, sneezing and nasal haemorrhage. Before dusting with the powders it is necessary to remove all water from the premises, because having drunk water the poison is diluted in the intestines of the cockroaches, and this partially breaks it down and the number of cockroaches remaining alive is increased.

Pyrethrum is applied at a rate of 20 g/m^2.

Also recommended is the use of 1% anabasine-sulfate disinfecting powder with a chalk filler at a rate of 15 g of disinfecting powder per m^2. The removal of the disinfecting powder and the dead insects should be carried out on the day following the treatment.

Poisoned baits. As substances added to baits there are most frequently used organophosphorous compounds (chlorophos), borax, boric acid, and also sodium fluoride; the preparations are mixed with an attractant substance, in particular with flour and powdered sugar and others. Since only dehydrated borax caused the death of cockroaches, in preparating the mixtures the borax is first calcined, pulverized, sifted and mixed in equal parts with sugar. Baits of the following composition are also used: 1) borax 70-75 g, powdered sugar 30-25 g; 2) borax 50 g, pea flour 25 g, wheat starch 25 g; 3) borax 60 g, powdered sugar 20 g and wheat starch 20 g.

As poisoned baits there are used dough, dried bread and cereals of the following composition: 1) liquid pea gruel 200 g, borax 65 g, salicylic acid 35 g; 2) boric acid 10 parts, semolina 10 parts, water 70 parts, sugar 10 parts; 3) any sweet porridge 90 parts, boric acid 10 parts; 4) wheat siftings 90 parts, sugar 10 parts: 100 g of this food base is wet with 50 ml of 10% aqueous solution of chlorophos and thoroughly mixed.

The mixtures are scattered at night for several days in succession in places most frequently visited by cockroaches. On the following day the baits are gathered up and used again or are burned.

Baits containing 1% chlorophos are ineffective with respect to common cockroaches. According to B. L. Shura-Bura and A. Ya. Glazunova, after 4-5 distributions (for a period of 1-2 months) of the baits in the form of bread or corn flour containing 2% chlorophos the common cockroaches vanish completely or are encountered only as solitary individuals. As a result of the application of bait (granulated sugar, powdered sugar) containing 1% chlorophos the populations of American, brown and Australian cockroaches are effectively reduced. Analogous baits with 2% trichlorophone [chlorophos] provided the death of 75-95% of the American cockroaches in cow barns, whereas baits with 2% malthion (carbophos) gave poorer results (Table 50).

We give the LD_{50} in μg per 1 g of weight of the most toxic insecticides for Periplaneta americana when orally administered: 0.74 DDVP, 1.29 thiophos, 6.4 isolan, 6.6 endrin, 14.5 dieldrin, 16.4 heptachlor, 42.5 aldrin, 43 malathion (carbophos), 45.5

thiodan, 63 DDT, 130 chlordane and 134 toxaphene (Heller and others). Hence it is possible to draw the conclusion that with the use of insecticides in bait the greatest effectiveness is possessed by DDVP.

Table. 50. Rates of expenditure of preparations per m^2 of floor for combatting cockroaches

Preparation	Single average expenditure of preparation (g) in systematic disinfestation				Average expenditure (g) for a single operation	Method of application and concentration of working solutions
	Number per year	Cockroach infestation of a physical area				
		to 10%	to 25%	over 25%		
Chlorophos	4—6	1,5	2	2,5	8	3% aqueous solution for treating infested sites
5% chlorophos disinfecting powder	2—4	3	10	20	35	
10% DDT disinfecting powder	6—12	3	10	20	35	
25% DDT emulsion	6—12	4	6	12	20	2-3% aqueous working emulsion
Preparation-5	4—6	10	15	25	30	Without dilution
12% HCCH disinfecting powder	4—6	5	8	10	12	In a mixture with 10% DDT disinfecting powder (1:3)
15% HCCH emulsion	4—6	2	4	6	10	1.5-4% aqueous emulsion of a mixture of 15% HCCH emulsion and 25% DDT emulsion (1:2)
50-80% fluoride sodium disinfecting powder	6—8	5	10	15	20	
Pyrethrum	4—6	3	9	15	20	
1.5% aqueous aqueous solution of chlorophos and bait (1:1)	According to indications	3	5	8	—	Food baits with insecticides of intestinal action
Borax 70%, powdered sugar 30%	The same	3	5	8	—	The same
Borax 60%, powdered sugar 20%, wheat starch 20%	„ „	3	5	8	—	The same
Boric acid 10%, semolina 10%, sugar 10%, water 70%	„ „	3	5	8	—	The same

The application of attractants together with the insecticides increases the effectiveness of the latter. A hydrolyzate from the feathers of domestic birds (poultry) possesses attractant properties. Highly attractive is the sexual attractant of the American cockroach, which was isolated in its pure form and identified as 2,2-dimethyl-3-isopropylidenecyclopropylpropionate. It was possible to synthesize its hydrogenated form. From approximately 10,000 female cockroaches there was obtained 12.2 mg of pure attractant substance in the form of a yellow liquid with a characteristic odor. It brought about a reaction in males in the presence of a dose lower than 10^{-4} μg. As agents against cockroaches repellents have found limited application.

Traps. Among the mechanical assets belong traps, which are used in special cases; near cockroach breeding sites there is placed some kind of vessel with smooth walls; on its bottom there is placed food bait, and on the rim of the vessel there is placed a small board, the other end of which touches the floor, a table, etc. Cockroaches attracted by the bait climb up the small board, fall off and land on the bottom of the trap and then cannot escape from there. The trapped cockroaches are destroyed.

Gaseous agents (syanogen, sulfur dioxide, chloropicrin and others) are highly effective with respect to cockroaches, but their application must be considered inefficient, because the destruction of cockroaches in individual sites of the premises is ineffective and requires fumigation of the whole building.

Other agents and methods of combatting cockroaches. Sometimes cockroaches are subjected to freezing at a temperature of 7-10° below zero, scalding with boiling water or burning with a blow torch.

Besides the enumerated methods, there are also used the so-called "drying disinfecting powders" (silica gel, sorbent disinfecting powder) which destroy common cockroaches within an hour. Sorbent disinfecting powders damage the cuticle of the insect, because of which it loses moisture; furthermore, as a result of the damage to the cutile the crystalline particles of disinfecting powder combine with the lipoids and the insect dies. A study of silico-powder - aerosol and silica gel showed that after the insects crawl through the aerosol within a minute the common, eastern and American cockroaches died after 45, 180 and 270 minutes (males) and 95, 240 and 450 minutes (female). The loss in weight with death constituted 20, 19, 21 and 20%, 17 and 28% respectively. Both powders leave good films on wood, glass and other surfaces; common cockroaches also died on these dry films.

Silica gel also causes the death of bugs, fleas, ticks, lice, flies, but it is difficult to apply for these purposes. The preparation is not toxic to people. In treating premises for cockroaches it is necessary to leave a visible film and not to remove it until all the insects have disappeared.

Repellents are finding application, for example MGK, repellent R-11, tabutrex (1%) and others. It is possible with repellents to create a protective barrier around food products, which cockroaches do not transgress for a long time (for approximately 4 weeks).

It is possible to combat cockroaches by applying varnishes with insecticides on surfaces. The English firm "Shell" produces for sale "insecto-lac", which contains 4% dieldrin. An application of this preparation gives good results for 6 months with respect to susceptible strains of cockroaches; the death of over 90% is observed after a one-day exposure and complete destruction after a 3-day exposure. Other insecticides are also being introduced into varnishes.

For combatting cockroaches in small objects, for example, in carts for transporting food in insectariums dry ice is recommended. The object and the dry ice are covered with a nylon film. This method is not too promising and if it finds application, it will be only in exceptional cases.

C H A P T E R XXXII

MEASURES FOR PROTECTING PERSONNEL WORKING WITH INSECTICIDES

All insecticides are toxic both to warm-blooded animals (Table 51) and also to man. They can penetrate into the human organism through the mouth, skin and with inhaled air.

In Soviet Union the maximum permissible concentrations and doses (hygienic norms) are determined on the basis of experimental investigations and industrial observations conducted by scientific-research hygienic institutes and are confirmed by the Main State Sanitary Inspection Agency of the USSR. The data cited in Table 52 were examined by the Committee on the Regulation of Chemical Poisons and confirmed by the Main State Sanitary Inspection Agency of the Ministry of Public Health of the USSR.

Officially accepted at the American Conference of Hygienists in 1955 were the maximum permissible doses of aldrin and dieldrin in the air; they were 0.00025 mg/ℓ and for chlordane 0.002 mg/ℓ.

The most dangerous insecticides for man were considered to be those, which possess volatility, as, for example, methyl-bromide, chloropicrin, prussic acid, because they enter the organism through the respiratory organs, but this almost corresponds with the direct introduction of the preparation into the blood stream.

Table 51. The LD_{50} for female and male rats of organophosphorous insecticides and chlorinated hydrocarbons when orally administered and with application on the skin (according to Woyland).

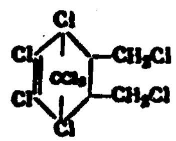
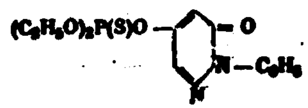
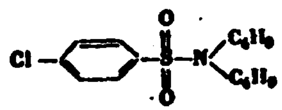
Insecticides	LD_{50} with oral introduction, mg/kg		LD_{50} with application on the skin, mg/kg	
	males	females	males	females
Aldrin	39	60	98	98
HCCH	200	—	500	—
Heptachlor	100	162	195	250
Guthion	13	11	220	220
DDA*	740	660	—	—
DDVP	80	56	107	75
DDE*	880	1 240	—	—
DDT	113	118	—	2 510
Delnov	43	23	235	63
Diazinon	108	76	900	455
Dicapton	400	330	790	1 250
Dilon	—	—	6 900	5 900
Dimethoate (rogor)	215	—	400	—
Dimetan	6,2	2,5	14	8,2
Di-Syston	6,8	2,3	15	6
Dieldrin	46	46	90	60
EPN	36	7,7	230	25
Isodrin	15,5	7,0	35	23
Kelthone	1 100	1 000	1 230	1 000
Co-rol	41	15,5	860	—
Gamma-isomer	88	91	1 000	900
Malothion	1 375	1 000	>4 444	>4 444
Methylporathion	14	24	67	67
Methyltrithion	98	120	215	>6 190
Methoxychlor	6 000	—	—	—
Perthane	>4 000	>4 000	—	—
Ronnel	1 250	2 630	—	—
TDE (DDD)	3 400	—	—	—
TEPP	1,05	—	2,4	—
Thiodan	43	18	230	74
Thiophos (parothion)	18	3,0	21	68
Toxaphene	90	80	1 075	780
Trichlorophone (chlorophos)	630	560	>2000	>2 000
Phenthion	215	245	330	330
Phosdrin	6,1	3,7	4,7	4,2
Phosphomidone	23,5	23,5	143	107
Chlorbezylate	1 040	1 220	—	—
Chlordone	335	430	840	690
Chlorthion	880	980	<4 500	4 100
Sehrodan	9,1	42	15	44
Endrion	17,8	7,5	—	15
Ethion	65	27	245	62

Table 52. Maximum permissible concentrations and doses established by the State Sanitory Inspection Agency of the Ministry of Public Health of the USSR (according to L. I. Medved').

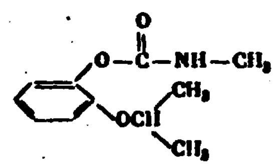
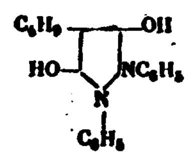
Insecticides	In air of working zone, mg/Tld	In water of reservoirs ml/Itd	In food products, mg/kg
Aldrin	0,00001	Not established	Not allowed
Allodon	0,0005	" "	Not established
HCCH	0,00005	" "	2 (temporarily)
Mixture of isomers HCCH	0,0001	0,02	1—1,5
Hexachlorobenzene	0,0009	0,05	Not established
Heptachlor	0,00001	Not established	Not allowed
DDT	0,001	0,2	Allowed in vegetables and fruits but not in milk and grain
DDD	Not established	Not established	7, in grain 3,5
Dinitroorthocresol	0,00005	" "	Not established
Dinitrorhodienebenzene	0,002	" "	" "
Dichloroethane	0,01	2,0	In grain 7; in flour 5
Dieldrin	0,00001	Not established	Not allowed
Carbophos	0,0005	0,05	Periods of treatment are regulated
Merouran (by mercury)	0,000005	Not established	Not allowed
Metophos	0,0001	0,2	Periods of treatment are regulated
Methylmercaptophos	0,0001	Not established	In fruits 0.7 (temporarily)
Methorychlor+thiophos	0,00003	" "	Not established
Arsenic and arsenous anhydrides	0,0003	0,05	Not allowed
Methorychlor	Not established	Not established	14
M-81 (dimethylmercapto-dithiophosphate)	0,0001	" "	0,5 (temporarily)
Napthalene	0,02	" "	Not established
Octomethyl	0,00002	" "	Not allowed
Ethylene oxide	0,01	" "	" "
Pentachloronitro-benzene	0,0005	" "	Not established
Perthane	Not established	" "	14, in grain 7
Polychloropinene	0,0002	0,2 (temporarily)	Not established
Preparotion	0,003	Not established	" "
Sevin	Not established	" "	5 (recommended)
Carbon bisulfide	0,01	1,0	Not allowed
Thiophos	0,00005	0,003	In the form of decomposition products 5, non-hydrolyzed not permitted
Phosphomide	0,0005	Not established	Not established
Chlorindone	0,00001	" "	Not allowed
Chlorten	0,0002	" "	Not allowed in fruits
Chloropicrin	Not established	" "	In grain 2; in flour 0
Hydrogen cyanide and salts of prussic acid (calculated for HCl)	0,0003	0,1	Not allowed
Carbon tetrachlorid	0,02	5,0	Not established

As minimum measures of precaution for personnel working with insecticides the following measures are recommended: 1) all workers should be acquainted with the toxic properties of the preparations, with which they are working; 2) the workers should be provided appropriate medical examinations, and also the means for rendering help in the case of accidents; 3) persons with cuts on the skin or skin irritations in places accessible to insecticides should not be allowed to work, inasmuch as such wounds, as is known, promote the penetration of the insecticides into the organism; 4) it is desirable that workers should locate under the effect of a preparation for not more than 4-5 hours during a working day, if this preparation is applied daily for a prolonged period of time; 5) when using insecticides it is not recommended that work be conducted without special apparel protecting the skin (robes, hats or hoods, rubber gloves, footwear and so forth), and respirators protecting the respiratory tract, or gauze dressings with a cotton lining covering the nose and mouth (in extreme case veil); in the case of the application of insecticides in the form of gases or aerosols type A gasmasks most reliably protect the respiratory tract; personnel occupied with the mixing of concentrates should furthermore be equipped with an impenetrable apron as a supplement to their protective clothing; 6) the protective clothes should be individually fitted and it should be washed weekly; in cleaning clothing contaminated with chlorinated hydrocarbons (if it has not been possible to remove the contamination using soap and water) it is desirable to rinse it in kerosene; in removing organophosphorous insecticides it is best to apply soda; 7) while working with insecticides smoking and eating must not be permitted; before eating it is necessary to wash the hands and to take other measures of precaution so that the insecticide does not get into the organism with the food; 8) of all the operations with insecticides the greatest danger is presented by work with concentrates, and in this type of operation it is recommended that when transferring concentrates from a large container to other vessels (small containers) pumps should be used; 9) when using organophosphorous compounds it is desirable that disinfectors work with them every other day; furthermore, in the course of a working day when spraying them it is necessary after each 45 minutes to go out into the fresh air (for 5-10 minutes), taking off the respirator; 10) during the treatment of premises with insecticides is not allowed the presence of extraneous persons, domestic animals and birds should not be permitted. To the treatment site the preparation is delivered in a closed container (glass jar with a screw-on cover or ground-glass stopper, etc); 11) it is desirable that the apparatus for spraying the insecticides have a long hose (1.5 m); 12) the packaged insecticides should have clearly compiled labels, in which there is indicated: a) name of the factory; b) name of the preparation, c) formula with a rundown of data on the concentration of the ingredients, d) recommended regions of application and, where necessary, a warning about undesirable types of use, e) basic measures of precaution, f) indication of danger, including a "symbol," characterizing highly toxic substances - "poison"; g) recommended measures in case of intoxication; h) disinfestational agents are stored in closed packages in uninhabited premises specially intended for chemical poisons; 13) empty is packing subjected to thorough cleaning, for this it is washed 2-3 times in water and preparation sticking to the walls is scraped; packing in which organophosphorous compounds are stored is additionally treated with a 5% solution of washing soda, and the solution is left in the packing overnight; the cleaning and washing of the packing is carried and wearing rubber gloves, but for disposing of the wash water a special temporary pit is made; 14) safe storage of empty or almost empty packing is provided; it should not be discarded and untrained people allowed to touch it; these people might use similar packing for storage of food products or drinking water, especially in places, where such packing is rarely encountered; 15) the packing of insecticides, the preparation of working solutions, suspensions, and grinding should be carried out under a hood in well ventilated premises using respirators, gloves and protective goggles or in the open air; 16) vessels and other articles used in transporting and preparing working mixture of disinfestational agents should be washed with soap and water and soda; in no case should they be used for preparing food for people and animals; 17) in all forms of disinfestational operations it is desirable to avoid manual labor; when necessary and disinfecting powders are scattered by hands, the hands should be protected by rubber gloves; 18) premises and articles treated with insecticides should be well ventilated until the disappearance of the sharp odor of the preparation; 19) at enterprises for public dining and in the food industry disinfestation is carried out after the end of the work day; from dishes and food products are removed from the premises; also the internal parts of cabinets, bins, shelves, packing and other objects intended for the storage of products are not treated; before beginning the treatment of a food preparation site it is necessary to carry out a thorough ordering of the premises, serving tables in the kitchens and other places, in which food products can be stored; it is not recommended that implements, table surfaces, cutting boards, scales and the internal parts of tables, cabinets and packing designated for storing articles be treated; the same precautions are followed before treating kolkhoz markets; 20) the workers should be provided with soap and other articles; at the end of the operations or during break-time the work clothes are removed, the face and hands are washed with warm water and soap and the buccal cavity is rinsed out with water; it is desirable after work to take a shower; 21) the workers should be periodically subjected to clinical medical examination; 22) if accidents occur first aid is given — with the appearance of the initial symptoms of poisoning (headache, weakness, nausea) the afflicted person is removed from the premises being treated, the work clothes are removed, the buccal cavity is rinsed out with water, first aid is rendered, and when necessary the person is hospitalized.

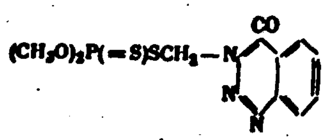
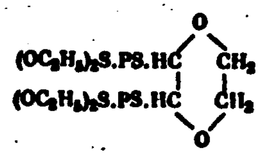
A list of certain insecticides used in combatting arthropods

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Allodon	5-6-bis-(chloromethyl)-1,2,3,4,7,7-hexachlorbicyclo-(2,2,1)-heptene-2 	Crystalline substance melting point 71-73°	750	It is applied both in combatting arthropod pests in agriculture and also insects having medical significance
American cyanamide 12503	C,O-diethy 1-O-(2-phenyl-6[2H] pyridozinonyl)-thiphosphate 	Crystalline substance melting point 87-88°		Recommended for the destruction of pests of agricultural plants
American cyanamide 12008	O,O-diethyl-S-(isopropylthio)-methyldithiophosphate $(C_2H_5O)_2P(=S)SCH_2SC_3H_7-i$			The same
Antiresistant	N,N-di-n-butyl-p-chlorobenzenesulfonamide 	White crystalline substance, melting point 33°	4,000	Applied together with DDT against pests, which have acquired resistance to the latter

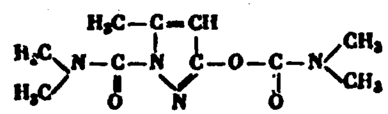
Continuation

Preparation and basic firms	Chemical name and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Bayer 38,920	6,7,8,9,10,10-hexachloro-1,5,5a,6,9a-hexahydro-3-methyl-6,9-methylene-2,4-benzodioxypine (chlorinated with a total chlorine content of 70%)	Brown liquid	120	Applied in combatting ants (also including the ant-solenopis paired)
Bayer 39,007	0-isopropoxyphenyl-N-methylcarbamate 	White crystalline power, melting point 91°	100	Promising for treating field, forage and vegetable cultures, for destruction of mosquitoes, flies, lice and other parasites in everyday life
Butazolidin	Na-salt 3,5-dioxy-1,2-diphenyl-4-n-butyl-butylpyrazolidine 			
Butoxy polypropylene glycol "Carbide" (registered under the name "Crog")	Butoxy polypropylene glycol $C_4H_9O(CH_2CHO)_xH$ (with CH_3 on CH)	Colorless liquid, vapor pressure 0.00[illegible] at 30°, specific gravity 0.990	9,100	Gives repellent properties to preparations, applied on dairy cattle against flies

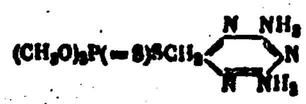
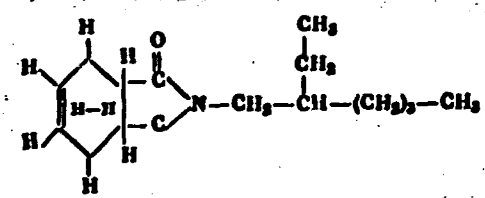
Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Vikan "Dow"	Sulfuryl fluoride SO_2F_2	Colorless, ordorless noninflammable gas, with a boiling point of 55.2°	Over 100	Fumigant for destroying insects in premises
Guzathion (bayer 17147, guthion)	0,0-dimethyl-S-(4-oxo-1,2,3-benzotriazine-3 [4H]-ylmethyl-dithiophosphate 	Brown waxy crystalline substance with a melting point of 73-74°	Nontoxic	Applied both in combatting orthropod pests of algricultrual plants and also in combatting insects having medical and veterinary significance
DOU-YeT-15	Amide-O-methyl-O-(2,4,5-trichlorophenyl)-thiophosphate $(CH_3O)(Cl_3C_6H_2O)P(=S)NH_2$	Analog of ronnel, a liquid	710	Applied in agriculture, veterinary medicice and sanitary practice
Delnav (Hercules-528, DEP, Navadel AC-528)	1,4-dioxanedithiol-2,3-S,S'-bis-(0,0-diethyl dithiophosphate) 	Technical product, brown liquid with a density of 1·5409	30-40	Applied in combatting arthropod pests of agricultural plants
Dibrom	0,0-dimethyl-1,2-dibromo-2,2-dichloroethyl-phosphate $(CH_3O)_2P(=O)OCHBr-CBrCl_2$	Liquid, index of refraction, 1·5083	250-430	Applied to destroy insects in agriculture, veterinary medicine and sanitary practice

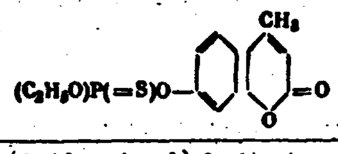
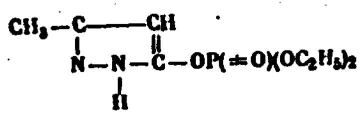
Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Di-Syston	0,0-diethyl-S(2-ethylmercaptoethyl)-dithiophosphate $(C_2H_5O)_2P(=S)SC_2H_4SC_2H_5$	Light-yellow liquid with a boiling point of 62° at 0.01 mm Hg	2.6-12.5	Applied only in combatting arthropod pest of agricultural plants
Dimethylane "Geigy" (registered as "Snilfly")	2-(N,N-dimethylcarbamyl)-3-methylpyrazolyl-5-N,N-dimethylcarbamats 	Melting point 68-71°. Boiling point 200-210° at 13 mm Hg		For combatting house flies in premises for dairy cattle and in other premises of farms; applied in the form of impregnated tapes
Lethane-60	Beta-thiocyanoethyllaurate $C_{11}H_{23}-COOCH_2CH_2SCN$	50% solution, oily liquid	500	50% solution of an ether of thiocyanotes of liquid acids containing from 10 to 19 atoms of carbon, applied for destroying pests of agricultural plants
Lethane-70	2,2'-dithiocyano-diethyl ether $SCNCH_2CH_2OCH_2CH_2SCN$	Liquid	90-500	Applied to destroying pests of agricultural plants and insects having sanitary and veterinary significance

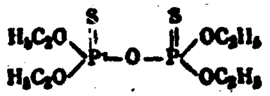
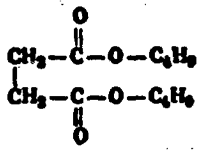
Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Menazon (PP-175)	0,0-dimethyl-S-(4,6-diamine-1,3,5-triazin-2-yl)-methyldithiophosphate 	Colorless crystals decomposing a. 160°	200-300	Applied to destroying pests of agricultural plants and arthropods having sanitary and veterinary significance
Meta-systox (methylmercaptophosdimethane, bayer 21/116)	0,0-dimethyl-O-(2-ethylmercaptoethyl)-thiophosphate and 0,0-dimethyl-S-(2-ethylmercaptoethyl)-thiophosphate $(CH_3O)_2P(=S)OC_2H_4SC_2H_5$ ⇅ $(CH_3O)_2P(=O)SC_2H_4SC_2H_5$	Liquid of pale-yellow color with a boiling point of 106° at 0.1 mm specific gravity - 1.28	40-200	Applied mainly for destroying pests of agricultural plants
264 "MGK" (registered as MGK-264)	N-(2-ethylhexyl)-bicyclo-[2,2,1]-5-heptene-2,3-dicarboximide 	Liquid with a boiling point of 158° at 2 mm Hg, specific gravity 1.05	2,800	Synergist for pyrethrin and allethrin; applied in the form of aerosols and liquids in spraying to destroy flies
Mipafax (isopestox pestox-XV)	Bis-(isopropylamide)-fluorophosphate $((CH_3)_2CHNH)_2P(-O)F$	Crystalline solid, melting point 60°, boiling point 120° at 2 mm Hg	50-80	Applied for destroying pests of agricultural plants. Possesses high systemic properties

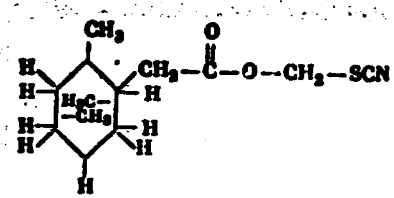
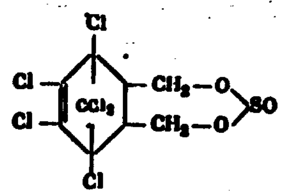
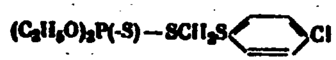
Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Paraoxon (E = 600, fosfakol, mintacol)	0,0-diethyl-0-(4-nitrophenyl)-phosphate $(C_2H_5O)_2P(=O)OC_6H_4NO_2$	Transparent oily liquid, boiling point point 169-170° at 1 mm Hg	3.5	Applied sometimes for destroying pests of agricultural plants with appropriate measures for protecting workers
Potasan (E = 834)	0,0-diethyl-0-(4-methyl-7-coumorin)-thiophosphate 	Pure substance, colorless, with mild aromatic odor with a melting point of 38°	15	Applied mainly for destroying pest of agricultural plants. Highly toxic to the colorado beetle and its larvae
Prolan, or DNP	1,1-bis-(4-chlorophenyl)-2-nitropropane $ClC_6H_4-CH(-CHNO_2-CH_3)-C_6H_4Cl$	Brownish, sticky, plastic, semisolid moss at room temper-	Less toxic than DDT	Enters into the composition of the insecticide dilon. Dilon is a mixture of two insecticides. Prolan 1 part and bulon 2 parts [-2-nitro-1,1-bis(r-chlorophenyl) butane]. Applied in combatting arthropods in agriculture, medicine and veterinary medicine
Pyrazoxon	0,0-diethyl-0-(3-methyl-5-pyrazolyl)-phosphate 	Yellowish liquid, density of 1,001	7.5	Applied to destroy pests of agricultural plants

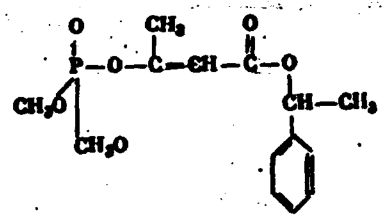
Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Propylyzom	Di-n-propyl-6,7-methylenedioxy-3-methyl-1,2,3,4-tetrahydronapthalene-1,2-dicarboxilate	Liquid with a specific gravity of 1.14-1.15, index of refraction 1.51-1.52	15,000	Synergist for pyrethrin, rotenone, allethrin and riania
Sulfotepp (dithione bladefum ASP 47 E = 393)	Tetraethyl-dithiopyrophosphate 	Liquid of pale-yellow color, boiling point 136-139°	5	Applied for destroying pests of useful plants
Tabatrex "Glenn Chemical"	Di-n-butylsuccinate 	Liquid with a boiling point of 108° at 4 mm Hg		Repellent against flies for treating cattle and premises

Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD_{50} when orally administered mg/kg	Note
Tanit "Hercules"	Minimum content of Isobornyl thiocyonoacetate is 82%, maximum content of the other active terpenes is 18% 	Liquid of amber color with a specific gravity of 1.1105	1600	Applied for treating cattle and in combatting parasites in everyday life
Thiodan	1,2,3,4,7,7-hexachlorobicyclo-(2,2,1)-2-heptene-5,6-bis-oxymethylene sulfite 	Light-brown crystalline substance, boiling point is 70-100°, has two isomers A and B	40-100	Possesses higher insecticide properties than DDT. Used for destroying flies and in agriculture
Trithion (Stauffer P-1303)	S-(4-chlorophenyl-thiomethyl)-O,O-diethyldithiophosphate 	Liquid of amber color density is 1.265	28-167	Used for destroying pests of agricultural plants (strong aphicide and acaricide)

Continuation

Preparation and basic firms	Chemical designation and formula	Physical properties	LD50 when orally administered mg/kg	Note
Phosphamidon .	0,0-dimethyl-0-[2-chloro-2-(N,N-diethylcarbamoyl-1-methylvinyl] phosphate $(CH_3O)_2PO.O.CCH_3):C.Cl.CON(C_2H_5)_2$	Liquid with boiling point of 162° at 1.5 mm Hg	16.8	Used for destroying pests of agricultural plants. possesses systemic properties. Strong aphicide acaricide, acts on thrips and others
Cyodrin "Shell"	0,0-dimethyl-0-[1-methyl-2(/1-phenylcarbethoxy phenylcarbethoxy)-vinyl]-phosphate 	Light liquid, boiling point is 135° at 0.3 mm Hg	125	Used to destroy parasites of domestic animals
Ecethin (bayer 23139, thimethone)	0,0-dimethly-S-morpholinocarbonollmethyl-dithiocophosphate $(CH_3O)_2P(-S)SC_2H_4SC_2H_5$	Colorless crystals with characteristic odor, melting point is 64-65°	25-225	Used for destroying pests of agricultural plants (aphicide). Can be used in veterinary medicine as a systemic insecticide

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ABSTRACT

(U) This book is intended for persons interested in the problems of disinfestation (extermination of insects). It contains descsiptions of contemporary insecticides from various groups of chemical compounds: the chlorinated hydrocarbons including those obtained by Diene synthesis, the chlorinated terpenes, organophosphorous insecticides, carbamates, vegetable insecticide including synthetic pyrethrins, fumigants and various other compounds used for exterminating arthropods; also described are the forms of application of the insecticides, their synergism and antagonism. Also covered are the biological methods of combatting insects, including attractants, repellents, physical and chemical methods of sterilization. The epidemiological significance of certain insects (fleas, lice, blood-sucking flies, ticks, bugs, sand flies, moths, ants, flies and cockroaches) and the measures for combatting them are also included in this book.