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INTERRELATIONSHIP BETWEEN AURAL FIELDS OF INSECTS AND PLANTS AND ELECTRICAL FIELDS OF ATMOSPHERE

by

P. I. Gulyayev, V. I. Zabotin
V. A. Gordiyenko

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

FTD-ID(RS)T-1700-77 6 October 1977

MICROFICHE NR: FTD-77-C-001290

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English pages: 14

Source: Nervnaya Sistema, Nr 12, Izd-vo Leningradskogo Universiteta, 1971, pp. 138-143.

Country of origin: USSR
Translated by: Marilyn Olaechea
Requester: FTD/ETCK
Approved for public release; distribution unlimited.

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Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
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З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*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.

GREEK ALPHABET

Alpha	Α	α	α	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Υ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

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INTERRELATIONSHIP BETWEEN AURAL FIELDS OF INSECTS AND PLANTS AND ELECTRICAL FIELDS OF ATMOSPHERE

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The idea that flying insects might have a constant electrostatic charge was expressed by Kalmus (1948), but was never experimentally confirmed by him. In his study Edwards (1962) experimentally analyzed this fact, studied the triboelectric phenomena of insects, and posed the problem of the effect on their behavior of the electrical charge and field which develop about them. It was shown that the sign of the charge is not constant and depends on the physicochemical properties of the surface from which the insects take off.

This problem was discussed in a monograph by A. S. Presman (1968) from the standpoint of the interaction of insects by means of these fields and their interaction with fields of geophysical origin.

Yet in all of the above mentioned studies a continuous electrostatic field was studied. We have shown that the wings of insects, the feathers of birds, and the fur of animals, which are almost always triboelectrically charged, create electromagnetic vibrations in the space around them during mechanical movement. We posed the problem of the informational and kinetic value of these phenomena (Gulyayev, Zabotin, Shlippenbakh, 1969). Aurograms (recordings of these vibrations in the electrical field) were also obtained under conditions of the natural habitat of the animals in areas far removed from large industrial complexes and populated points, where the level of electromagnetic interference was minimal. This freed us of the necessity of screening the research subjects.

The methods of registering these electroaurograms differed from those discussed by us in preceding studies (Gulyayev, Zabotin, Shlippenbakh, 1968, 1969), since, in addition to the aura sensor and tape recorder, we also used a very sensitive microphone and movie camera. The aurogram was recorded on magnetic tape with subsequent oscillographic processing in the laboratory.

The figure (A) shows the "background" of the recording, taken in a forest with no insects nearby. The "background" represents a combination of the natural noise of the aura sensor, the noise of the magnetic tape, and the signals of the aural field of remote objects comparable to this noise. The maximal amplitude of the "background" was on the order of 3 mV. The forest vegetation provided a reliable screen from electric interference of the low-frequency range perceived by the aura sensor. High-frequency fields (for example, fields of radio stations) are not reliably screened by the forests, although the aura sensor is insensitive to them. The fact that plants are good (if not ideal) screens for the electrical component of low-frequency fields, is indicated by the fact that in the presence of industrial noise sources near the recording area (for example, an electrical transmission line), the noise disappears behind bushes and trees. A sudden increase in the noise background was noted during gusts of wind (only one case).

The figure (B) shows an aurogram created by a swarm of mosquitoes. Striking the outside wall of a four-place canvas tent caused the mosquitoes, which usually accumulate in large numbers inside the tent, to become alarmed and fly in the form of an even, exceptionally tightly knit group. This "aural electrical chorus" of mosquitoes could only be registered by the contactless aural method. Standard contact methods of electrical measurement could not be used here. The observed amplitudes at times reached 50 mV at a frequency of 440 Hz.

The aurogram of the group of mosquitoes develops as a result of the combination of a large number of individual aurograms from each mosquito. The insects, which were distributed almost evenly throughout the space of the tent, flew in different directions. The frequencies, phases, amplitudes, and signs of the aural oscillations created by them were different and changed constantly in a random manner. Based on the relationship between the frequency components (but not on the absolute value of frequencies) the aurograms of the mosquito group resemble electroencephalograms (EEG) of the human brain. The presence of slow and fast waves and "shafts" is reminiscent of the form of the EEG alpha-rhythm. The relatively constant frequency of the aurogram of the mosquito swarm (440 Hz) resembles the constant alpha-rhythm frequency.

The EEG analogy is based on the fact that the EEG is also the result of the combination of the many potentials of the nerve cells of the brain, which have different frequencies, phases, amplitudes, signs, and are chaotically arranged in relation to the lead surfaces of the electrodes (Gulyayev 1960).

The aurogram of the mosquito group represents a model of an assembly of charged bodies or particles in random motion and in electromagnetic interaction within a limited space. We can assume that in the physicial plasma the shape of the vibrations of the electrical field will be similar to the shape of the aurogram of the mosquito group.

In the figure (C) we see an aurogram representing the flight of a large horsefly (Tabanidae, species Tabanus), flying near an aura sensor located in a forest. The amplitude reached 20 mV and above, the frequency of the main cone - 150 Hz. The sign of the horsefly charge was not determined. The change in amplitude is explained by the change in distance to the probe during flight. The frequency did not change, since the flight speed and, consequently, the rate at which the wings were flaped, remained unchanged, while the Doppler effect was small to vanishing because of the light speed of propagation of the aural field. Aurograms and phonograms were recorded simultaneously. Here the aural sensor and the microphone were placed quite close together, and the one-track recording on the tape recorder was taken by many successive switchings of the tape recorder input - first to the aura sensor then to the microphone. The microphone was of the MD-47 design, which we perfected, with a built-in transistor amplifier and separate power supply. It was also electrically shielded by a sound-transmitting casing of a metallic fiber - a screen with cell dimensions of several microns.

We learned that the law of change in amplitude of sonic oscillations is different than the law of change in the amplitude of aural oscillations. The amplitude of aural oscillations decreases in inverse proportion to the square, sonic oscillations - to the first degree of the distance between the receiver and the source. Therefore, in the immediate vicinity of the insect the amplitude of the aural field is relatively greater than the amplitude of the sonic field; at a distance from the insect - vice versa. This fact has the following informationl value. For certain insects only signals concerning events which occur at short distances are important. Distant sounds for such insects represent the noise background of the habitat. Yet the aural signal is significant in the immediate vicinity for predator and prey, to warn of collisions in swarms, and when landing on a plant or animal. From this standpoint the absence of an auditory organ in some insects - the bumblebee, for example - becomes understandable. If, however, insects are capable of perceiving both the sonic and aural fields simultaneously, then the difference in the change of amplitudes in these vibrations with distance acquires great informational significance. The simultaneous perception of vibrations in the electrical field and sonic vibrations makes it possible to precisely determine the distance and simultaneously the rate of movement at a given moment for any predator or prey (based on the Doppler effect for sound).

The aural field of insects has not only an informational, but also a kinetic value (Gulyayev, Zabotin, Shlippenbakh, 1969). Depending on the sign of the charge, insects are either attracted or repelled from one another and from predators. Insects change the sign of charge in selecting a takeoff surface.

The figure (D) shows atmospherics* recorded in the middle of the mouth of a river (on a boat).

[FOOTNOTE: Atmospherics are electrical signals in the atmosphere caused by individual thunderstorm discharges of lighting and solar radiation. END FOOTNOTE]

Electrical fields of geophysical origin are constantly active factors in the medium, and create an electrical landscape. The maximal amplitude reaches 40 mV or above, frequency is undetermined. In "auditory" recording these are clicking, crackling, and humming sounds, similar to the sounds of a campfire. The nature of the sounds is the same in both clear and overcast weather but is different for day and night. All this can be of significance in the space and time orientation of animals in the earth's biosphere.

As we have already reported in the preceding articles, the aural electrical field is created by two sources.

The first source is the internal electrical field generated by the active organs within the body of the animal.

The second source is the total electric charge of the body surface.

Remember that in insects the triboelectric component exceeds the magnitude of all others to such a degree that we cannot distinguish them. Consequently, in insects we registered the low-frequency component of the aural field which develops from the mechanical vibrations of their wings, which have a triboelectric charge.

We must also consider the third source of the aural field - induction of charges by the electrical landscape. Experiments have shown that when plants move (bushes and tree branches) there arise aural oscillations in time with the movements of parts of the plant. The sources of the electrical oscillations are either the fields which are inherent in the plants themselves and develop within them as the result of activity, or changes in the atmospheric fields in which the plants are found and whose parameters they change by their mechanical motion. However, in the last case it is simpler to say that the oscillations of the electrical field are created by charges induced by the field of the electrical landscape on the conducting surfaces of plants. In the figure (E) we see an aurogram of the microphone effect of a young birch tree whose trunk has been struck by a long pole. An analogous effect was observed in the shaking of branches and rustling of the leaves on them. To verify that this was not the microphone effect of the pole alone, the experiment was conducted so that the distance between the pole and the aura sensor did not change, just the distance to the plant. Here the effect diminished regularly with distance.

We notice the isomorphic nature of the individual peaks on the aurogram (see figure E) corresponding to the individual mechanical blows to the trunk. We must detemine whether or not the nature of the peaks is a species or geobotanical indicator. For this purpose an investigation is being planned to study the effect of all possible factors, including random factors, on the shape of the aurogram representing the microphone effect of plants.

In plants the triboelectric charge is apparently absent, since they are grounded and have sufficient conductivity. The electrical aural fields generated by individual plants interact. It is possible that this factor is the information channel which acts between plants. The aural fields of the plants can play a role in biocoenosis (phytocoenosis) (Gulyayev, Zabotin, Shlippenbakh, 1968).

The very significant role of atmospheric precipitation in the earth's biosphere has been recognized for a long time. We know that drops of rain, which are charged, also create oscillations of the electrical field because of their charge and the change in the electrical landscape during motion in the electrical fields of the earth. This can be experimentally demonstrated using our aural method. In a screened chamber a drop of liquid falling in front of the aura sensor probe creates vibrations by its charge. The value and sign of the charge can be changed at will. An uncharged particle falling in front of the probe in the absence of a stationary electrical field in the chamber does not cause electrical oscillations. If, however, a stationary field is created in the chamber, then an uncharged particle passing near the probe creates field vibrations . This experiment convinces us at a glance that the drop only acquires its charge when acted upon by the field at the moment of separation from the drop former, and if it is in flight, then no action on the part of the field can create an additional charge on it.

We carried out a vast program of studies for the purpose of determining whether or not effects revealed under laboratory conditions occur in the same manner under the natural conditions of the habitat of the animals. Here an interesting fact was observed: Our instruments successfully registered the signals of the variable electrical fields of animals and plants under conditions where there were no screening chambers, provided that the place where the study was conducted was at a sufficient distance from electrical industrial objects, electrical lines, populated areas, etc. Below is a list of objects from which aurograms were registered in the natural environment of the living subjects:

1) Hoseflies, bumblebees, all kinds of flies, beetles, bees, grasshoppers, ants, butterflies, moths, horseflies, and other insects unknown to us, whose species were not determined. Here it was observed that the aural field in some types of mosquitoes had a lower intensity or none at all.

2) The tensed musculature of the arms, scratching of one nail against another, abruptedly running the hands through the hair, objects thrown past the sensor (pine cones, clods of dirt, heads of flowers), the ticking of a watch near the sensor, and the friction of

underwear against the skin.

3) Movement of the human body and arms in the electrical field of the atmosphere and at a distance of 5-10 m from the probe in a forest meadow. Here superslow field vibrations were registered.

Thus, it has again been experimentally proven that the aural fields of animals and plants exist under natural conditions - in their forest and meadow habitat - and are not artifacts associated with the use of screened chambers under labatory conditions. We have determined the role of the earth's electrical landscape as the source cf the aural field and have studied the problem of the interaction of the electrical aural fields of insects and plants with the electrical fields of the atmosphere.

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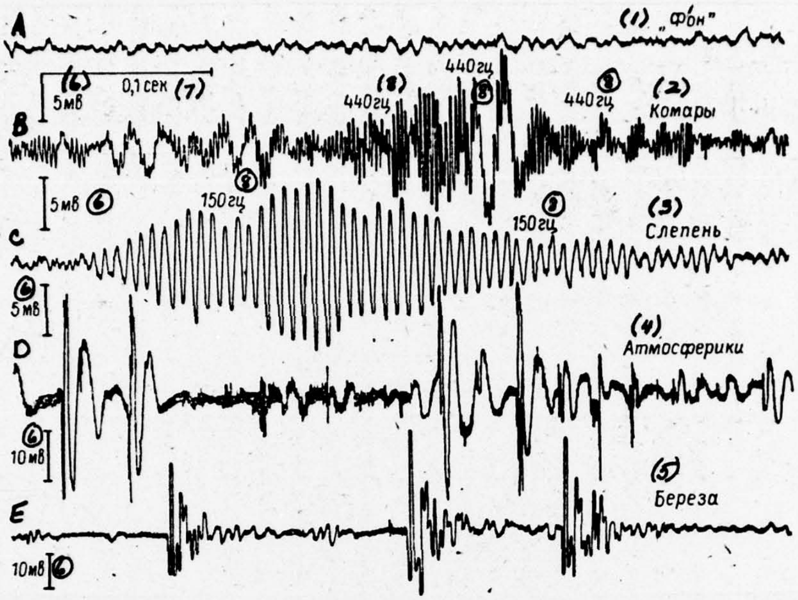

Figure.

Caption on next page.

Figure. Aurograms of insects, plants, and atmospherics. Karelia, 1969. A - "background" of aural recording under forest conditions and absence of flying insects in immediate vicinity of aura sensors. Recording conditions: probe - metal discs measuring 4 cm in diameter, frequency reproduction band 40-3500 Hz (at level of 0.7) with all processes associated with tape recording and oscillographic transcription onto photographic paper considered; B - aurogram of large swarm of mosquitoes in tent alarmed by striking the canvas walls from the outside. Recording conditions are the same; C - aurogram of flight of horsefly at a distance of approximately 25-50 cm from probe. Recording conditions the same; D - atmospherics registered from boat floating in middle of river, at 12:00 midnight. The probe - a pintle 50 cm long cross section 2.5 x 2.5 mm, other conditions the same; E - all signals of microphone effect of birch tree as a result of striking its trunk three times with a stick. The probe - a pintle 500 x 2.5 x 2.5 mm, installed on a 120-millimeter coaxial extender. Other conditions the same. KEY: (1) Background, (2) Mosquitoes, (3) Horsefly, (4) Atmospherics, (5) Birch tree, (6) mV, (7) s, (8) Hz.

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