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BIOSYSTEMATICS OF AEDES (NEOMELANICONION)

ANNUAL/FINAL REPORT

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The objective of the "Biosystematics of Aedes (Neomelaniconion)" project is to conduct a modern taxonomic study of this subgenus of mosquitoes by means of classical comparative morphological taxonomic procedures utilizing characteristics from both sexes and all stages in the life cycle.

Most specimens examined during the study were collected specifically for the project by the principal investigator on six collecting trips to Africa. Additional specimens were obtained through cooperators. Approximately 14,400 adult mosquitoes were collected in the field or reared in the laboratory and approximately 5,200 of these have associated larval and pupal skins. Most of this material consists of progeny rearings from eggs so that sexes and stages are unquestionably associated. Successful laboratory rearing techniques and forced mating techniques were developed. All adults reared for the project

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19. Abstract

and all associated larval and pupal skins have been prepared for study, and most of these specimens have been labeled with permanent, printed locality labels. Over 2,500 specimens of Neomelaniconion, including the primary types of 25 nominal species, were borrowed from existing museum collections. Preliminary pencil drawings of the immatures (23 species) and male genitalia (28 species) were prepaed, and final inked drawings of several species were prepared from these. Scanning electron micrographs of the eggs of 21 species of Neomelaniconion were prepared. As a result of this study, 32 species of Neomelaniconionare recognized. An abridged taxonomic treatment is included: this provides identification keys for the females, male genitalia and larvae of the species; brief descriptions of Neomelaniconion, the two major sections within it, and the species; and information on the distribution, variation, biology and relationships of the species. Three papers have been prepared for publication.

Contents

Statement of the Problem

The goal of the project "Biosystematics of Aedes (Neomelaniconion)" is to produce a modern taxonomic revision of this subgenus of mosquitoes. Neomelaniconion, which is primarily Ethiopian in distribution, has not been studied carefully, and so its species are poorly known. The absence of basic information on the number of species and on how to distinguish them severely hampers the acquisition and reporting of biological information about these mosquitoes. The result is that the distribution, bionomics, and disease vector potential of the different species remain unknown or uncertain.

Species of Neomelaniconion are believed to be involved in both the inter-epizootic maintenance and transmission of Rift Valley fever virus. A complete understanding of the natural history of this virus is not possible without better knowledge of these mosquitoes.

Background

As it is presently understood, the subgenus Neomelaniconion includes 28 nominal species, 24 of which are considered to be valid taxonomic species or subspecies (1-3). All except one of these currently recognized species are restricted to the Ethiopian Region. The exception is Aedes lineatopennis (Ludlow), which is considered to be widespread in both the Oriental and Australian regions.

The existing taxonomy of the subgenus Neomelaniconion dates back to Edwards's treatment of the group (under its former name Banksinella Theobald) in his catalog of the family Culicidae (4) and in his volume on Mosquitoes of the Ethiopian Region (5). Edwards's studies were based almost entirely upon adult mosquitoes, and characteristics of the immature stages were not considered. In the many decades since Edwards's brief taxonomic treatments of Neomelaniconion, there has been no comprehensive study of the group. Several additional species have been described (3, 6-10), immatures of a few species have been partially described or illustrated (7, 9, 11-17), one nominal species has been transferred to the subgenus (18), and two nominal species have been removed (19). Recently, Cornel (20) provided the first illustrations of the complete larval and pupal chaetotaxy of a species of Neomelaniconion.

In the absence of a comprehensive study of Neomelaniconion, the subgenus remains poorly and inadequately known. The immature stages, in particular, have been neglected. They have never been used to help define the

species of the group or to help place these species into a natural classification. In fact, to this day the immatures of nearly half the species of Neomelaniconion are completely unknown. Available keys to adults (5, 9, 15, 20) and larvae (11, 15) of Neomelaniconion are inadequate because they treat only a portion of the species now known or treat only the species of a restricted region.

Numerous arboviruses have been isolated from species of Neomelaniconion (21). The virus that causes Rift Valley fever, an important disease of domestic animals and humans in Africa and a potential international disease problem (22), is the most important of these. This virus has been isolated from field populations of three or more species of Neomelaniconion: circumluteolus (Theobald) in South Africa (23) and Uganda (24); lineatopennis in Kenya (25), South Africa (26), and Zimbabwe (27); palpalis (Newstead) in Central African Republic (28); and possibly luteolateralis (Theobald) in South Africa (29). Laboratory experiments have shown that the virus can be transmitted horizontally by yet another species of Neomelaniconion, unidentatus McIntosh (30). Studies of Rift Valley fever in Kenya have provided evidence that lineatopennis is a reservoir for the virus between epizootics, transmitting it transovarially from generation to generation (31). The identity of the Neomelaniconion species reported as lineatopennis in some of these studies is in doubt; in Kenya the species is probably mcintoshi Huang (3). The fact that Rift Valley fever virus has been isolated from several species of Neomelaniconion and is known to be transmitted horizontally or vertically by some of these mosquitoes underscores the importance of obtaining basic information on the systematics and biology of species of Neomelaniconion, for such information is critical to a complete understanding of the natural history of Rift Valley fever virus.

Approach to the Problem

A modern systematic study of Neomelaniconion, utilizing morphological characteristics from both sexes and all stages in the life cycle, will be undertaken in order to determine the number of species in the subgenus, the most reliable means of distinguishing these species from each other, the existence and nature of intraspecific variation, the geographic distribution of the species, and the evolutionary relationships of the species. The results of this study will be published in a monograph that will include: taxonomic descriptions of species and groups of species; identification keys for all stages in the life cycle; detailed drawings of the larva, pupa, and male genitalia of most species and of the adult morphology for selected species; photographs of

eggs; information on type specimens; synonymies; discussions of diagnostic characters, variation, and relationships; summaries of bionomics and medical importance; data on geographical distribution of the species, including lists of specimens examined and maps; and a bibliography.

Although the historically important specimens of Neomelaniconion currently held in museums will be examined, the bulk of the specimens studied will be collected specifically for the project. The collection, rearing, and preservation of material and the recording of field data will follow the procedures developed for the "Mosquitos of Middle America" project (32). Emphasis will be placed on collecting adult females from which eggs for progeny rearings can be obtained and on collecting the immature stages so they can be reared individually. Both progeny rearings and individual rearings associate the stages of a species, and progeny rearings associate the sexes unequivocally. Specimens collected in the field or borrowed from museums will be prepared for study using standard laboratory procedures for mosquitoes, in general following the methods of Belkin (19). Classical, comparative morphological taxonomic procedures will be emphasized, as outlined for mosquito systematics by Belkin (19) and Zavortink (33). The form of presentation and terminology used in the final monograph will follow Belkin (19) and Zavortink (34-36) in large part.

Results and Discussion

The accomplishments and results of the project "Biosystematics of Aedes (Neomelaniconion)" are described below.

FACILITIES

In addition to the Principal Investigator's laboratory of approximately 150 square feet of work space, two additional laboratories were acquired for the duration of the project. One of these, measuring 260 square feet, contained most of the equipment and supplies for the project and was the workplace of the taxonomic research specialist and scientific illustrator. The other laboratory, with 275 square feet total, included and inner room of 45 square feet and was utilized for rearing mosquitoes.

All major pieces of equipment for which funds were provided on the contract were acquired and utilized. All supplies, tools, and chemicals necessary for the collection and rearing of mosquitoes and the preparation of mosquito specimens for study were obtained.

STAFF

The following full-time and part-time staff were supported by the contract:

Thomas J. Zavortink, Principal Investigator (50% time during the academic year; 100% time for two months each of five summers)

Sandra S. Shanks, Taxonomic Research Specialist (100% time from May 1986 through November 1989; 20% time from February 1990 through April 1991)

Mary Ann Tenorio, Taxonomic Research Specialist (80% time from December 1989 through February 1991); Scientific Illustrator (Piecework, April 1987 to October 1991)

Sylvia Barr, Scientific Illustrator (Piecework, August to October 1991)

Both Sandra Shanks and Mary Ann Tenorio were fully trained in the procedures for rearing mosquitoes in the laboratory and in preparing mosquito specimens for scientific study. Both also became fully familiar with the operation of the personal computer acquired for the project and handled all correspondence, reports, manuscripts, and data analysis related to the project. Sandra Shanks also became fully trained in the procedures for collecting and rearing mosquitoes in the field.

COOPERATORS

The Principal Investigator was extremely fortunate in obtaining the cooperation of many individuals and institutions in Africa, Asia, Australia, Europe and North America during the "Biosystematics of Aedes (Neomelaniconion)" project. The project became, indeed, an international effort. A list of those individuals, with the institutions they represent, who helped with the research effort during the five years of the project follows.

James and Sanda Ashe, Watamu, Kenya, took the Principal Investigator to several collecting sites in coastal Kenya.

Y. Boulvert, Director, ORSTOM Center, Bangui, Central African Republic, provided vehicles and a chauffeur during the trip to Central African Republic, and authorized use of the ORSTOM field station at Bozo.

Maureen Coetzee, South African Institute for Medical Research, Johannesburg, South Africa, organized the Principal Investigator's field trip to South Africa, helped with the collection and rearing of Neomelaniconion, and provided lodging in her home.

Roger Cordellier, Chief, ORSTOM Medical Entomology Laboratory, Abidjan, Ivory Coast, arranged for transportation, lodging, laboratory facilities, and field help during the Principal Investigator's trip to Ivory Coast,

and provided access to ORSTOM field stations.

Anton Cornel, South African Institute for Medical Research, Johannesburg, South Africa, accompanied the Principal Investigator in the field in South Africa, helped with the collection and rearing of Neomelaniconion, and brought live eggs of Neomelaniconion from South Africa to San Francisco.

Jean-Paul Cornet, Institut Pasteur, Dakar, Senegal, facilitated the collecting of Neomelaniconion in Senegal and provided laboratory space.

George B. Craig, Jr., University of Notre Dame, Notre Dame, Indiana, allowed the Principal Investigator to utilize his staff, equipment, and supplies at the Vector Biology Laboratory, University of Notre Dame, in order to obtain electrophoretic data for several species of Neomelaniconion.

Peter S. Cranston, CSIRO Entomology, Canberra City, Australia, loaned specimens of Neomelaniconion from the Australian National Insect Collection and provided names and addresses of other possible collaborators in Australia.

F. Glyn Davies, Veterinary Research Laboratory, Kabete, Kenya, provided laboratory facilities, transportation, and field assistance during two collecting trips to Kenya.

S. D'Cruz, Department of Veterinary and Tsetse Control Services, Lusaka, Zambia, provided valuable help and transportation during the collecting trip to Zambia.

E. de Coninck, Musee Royal de L'Afrique Centrale, Tervuren, Belgium, loaned the museum's specimens of Neomelaniconion.

Robert Drews, California Academy of Sciences, San Francisco, California, suggested several collecting sites in coastal Kenya.

A. Ehouman, Director, Institut Pasteur, Ivory Coast, authorized provision of laboratory facilities, vehicles, chauffeurs, and field collectors during the trip to Ivory Coast.

Thomas P. Gargan, United States Army Medical Research Unit - Kenya, obtained egg clutches of Neomelaniconion, provided the Principal Investigator with advice and equipment for collecting soil samples, processed the samples collected to separate Aedes eggs, and sent specimens of Neomelaniconion from Kenya.

Bernard Geoffroy, ORSTOM, Montpellier, France, sent egg clutches and specimens of Neomelaniconion collected in Ivory Coast in 1986, made arrangements with Institut Pasteur and ORSTOM Center in Ivory Coast, Central African Republic and Senegal for joint field studies with the Principal Investigator in 1987 and 1988, and helped with the collecting of Neomelaniconion in those countries.

Alan Georges, Director, Institut Pasteur, Bangui, Central African Republic, provided laboratory facilities, lodging, field equipment, and field collectors during the trip to Central African Republic.

Jean-Paul Gonzales, Institut Pasteur, Dakar, Senegal, facilitated the collecting of Neomelaniconion in Senegal and arranged to have mosquito eggs shipped to San Francisco.

Scott Gordon, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Frederick, Maryland, provided some field equipment in Senegal and helped with the collection of Neomelaniconion.

Ralph Harbach, Walter Reed Biosystematics Unit, Walter Reed Army Institute of Research, Washington, D.C., arranged a loan of Neomelaniconion specimens from the National Museum of Natural History.

Bruce A. Harrison, Walter Reed Biosystematics Unit, Walter Reed Army Institute of Research, Washington, D.C., arranged a loan of Neomelaniconion specimens from the National Museum of Natural History.

Richard H. Hunt, Head, Department of Entomology, South African Institute for Medical Research, Johannesburg, South Africa, arranged for transportation, lodging, and laboratory facilities during the trip to South Africa, helped with the collecting and rearing of Neomelaniconion, and gave permission to study the Institute's collection of Neomelaniconion.

Peter Jupp, National Institute for Virology, Johannesburg, South Africa, gave permission to study the Institute's collection of Neomelaniconion, provided information on collecting sites in South Africa, and sent live eggs of Neomelaniconion from South Africa.

A. Kouasai, Minister of Scientific Research, Ivory Coast, provided authorization to conduct research in the country.

Steve Lindsay, London School of Hygiene and Tropical Medicine, England, provided the name and address of a possible collaborator in The Gambia.

Kenneth J. Linthicum, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Frederick, Maryland, sent live eggs of Neomelaniconion from Kenya.

Thomas M. Logan, United States Army Medical Research Unit - Kenya, provided field equipment and supplies used during the June 1990 collecting trip to Kenya.

L. Phil Lounibos, Florida Medical Entomology Laboratory, Vero Beach, Florida, obtained egg clutches of Neomelaniconion in Kenya during September 1986, and assisted the Principal Investigator in the field in Kenya during June 1990.

G. Nguerekata Mandata, High Commissioner of Research, Central African Republic, gave authorization to travel and conduct research on mosquitoes in Central African Republic.

Bruce McIntosh, Port Shepstone, South Africa, provided valuable information on collecting sites for South African Neomelaniconion, provided lodging and laboratory facilities at his home, and helped with the collecting of Neomelaniconion.

Rudy Meiswinkle, Veterinary Research Institute, Onderstepoort, South Africa, provided access to a collecting

area at one of the Institute's farms and provided lodging at his home.

J. Metz, Director, South African Institute for Medical Research, Johannesburg, South Africa, authorized provision of laboratory facilities, vehicles, lodging, and field assistance during the trip to South Africa.

Bernard Mondet, ORSTOM, Abidjan, facilitated the collection of Neomelaniconion in Ivory Coast.

F.N. Mungaba, Department of Veterinary and Tsetse Control Services, Lusaka, Zambia, provided valuable help and transportation during the collecting trip to Zambia.

Leonard E. Munstermann, University of Notre Dame, Notre Dame, Indiana, taught the Principal Investigator electrophoretic techniques and supervised the gathering of electrophoretic data for several species of Neomelaniconion, and assisted the Principal Investigator in the field in Kenya during June 1990.

F. Rodhain, Institut Pasteur, Paris, France, loaned specimens of Neomelaniconion.

Philippe Salles, Societie Industrial Central Africa, Mbaiki, Central African Republic, provided lodging and working space at the SICA headquarters and gave permission to travel and collect mosquitoes in logging areas under his control.

Michael W. Service, Liverpool School of Tropical Medicine, England, provided valuable notes on Neomelaniconion specimens in African and European museums and names and addresses of possible collaborators in Africa.

Brian Sharp, Research Institute for Diseases in a Tropical Environment, Durban, South Africa, provided information on collecting areas in the coastal portion of Natal and provided lodging at the Institute's house in Jozini.

Daniel Strickman, U.S. Army Medical Component, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand, provided live eggs of Neomelaniconion from Thailand.

A.W. Sweeney, Army Malaria Research Unit, Ingleburn, Australia, sent specimens of Neomelaniconion from Queensland.

Sabastian Talec, Bobenga Bouchia, Central African Republic, provided lodging, meals, and working space at his coffee plantation.

Madeline Thomson, Medical Research Council Laboratories, Fajara, Banjul, The Gambia, assisted in trying to obtain eggs of Neomelaniconion from The Gambia.

Bruce C. Townsend, British Museum (Natural History), London, England, loaned the museum's specimens of Neomelaniconion.

Trevlyn Webb, Lilayi Farm, Lusaka, Zambia, provided valuable field help and transportation during the collecting trip to Zambia.

Peter Whelan, Department of Health and Community Services, Darwin, Northwest Territory, Australia, sent live eggs of

Neomelaniconion from Australia.

Mark Wilson, Institut Pasteur, Dakar, Senegal, facilitated the collecting of mosquitoes in Senegal by providing field equipment and assistance with logistics.

Sangare Yaya, Institute of Tropical Ecology, gave permission to conduct field research and utilize the facilities at the Institute's field station at Tai, Ivory Coast.

ACQUISITION OF SPECIMENS

Loans from Museums. - Over 2,500 specimens of Neomelaniconion were borrowed from the following museums: Australian National Insect Collection, Canberra City, Australia; British Museum (Natural History), London, England; Institut Francais de Recherche Scientifique pour le Developpment en Cooperation, Montpellier, France; Institute Pasteur, Paris; Musee Royal de L'Afrique Centrale, Tervuren, Belgium; National Institute for Virology, Johannesburg, South Africa; National Museum of Natural History, Washington, D.C.; South African Institute for Medical Research, Johannesburg, South Africa.

The loan from the British Museum (Natural History) was particularly valuable because it included the types of the majority of the nominal species of Neomelaniconion and it included most of the Neomelaniconion specimens studied and identified by F.W. Edwards during the preparation of his volume on the Mosquitoes of the Ethiopian Region (5).

Collecting trips. - The following six collecting trips, with a combined duration of 39 weeks, were supported by the Contract:

1) Kenya, 2 June - 3 July 1986, T.J. Zavortink;
2) Kenya and Zambia, 3 Nov 1986 - 1 Jan 1987, T.J. Zavortink and S.S. Shanks;
3) Ivory Coast, 8 June - 23 July 1987, T.J. Zavortink and B. Geoffroy;
4) South Africa, 2 Feb - 4 Apr 1988, T.J. Zavortink;
5) Senegal and Central African Republic, 11 Aug - 7 Oct 1988, T.J. Zavortink and B. Geoffroy; and
6) Kenya, 16-29 Jun 1990, T.J. Zavortink and L.P. Lounibos.

Over 12,700 adult mosquitoes were collected during these trips or reared in the laboratory at the University of San Francisco from eggs obtained in the field. Approximately 4500 of these adults have associated larval and pupal skins. Adults of 25 species of Neomelaniconion were obtained and the larvae and pupae of 23 of these were associated with the adults through individual or progeny rearings.

Gifts from Cooperators. - Several species of Neomelaniconion were reared from eggs sent to the Principal

Investigator by cooperators in Australia, Ivory Coast, Kenya, South Africa, and Thailand. Approximately 1700 adults, nearly 700 of which have associated larval and pupal skins, were reared from these eggs. Among the species reared were three Neomelaniconion not collected on the field surveys conducted by the Project staff. Adults of all three species are associated with their immature stages through individual or progeny rearings.

LABORATORY REARING

A great deal of difficulty was encountered in rearing larvae of Neomelaniconion, particularly species in the Forest Section. Very often the larvae grew slowly, experienced high mortality, and produced small, weak adults. As a consequence, during the first three years of the contract, a great deal of time and effort had to be devoted to developing a rearing procedure that would increase survival of the immatures and produce robust adults. After much experimentation, a very successful rearing method was developed. With this method, larval growth is rapid, larval survival is high (sometimes 100%), and the adults reared are large and robust and do not shrivel when killed and pinned for taxonomic study.

The following conclusions about the rearing of Neomelaniconion larvae were reached: 1) larvae of all species of Neomelaniconion grow faster, survive better, and become larger if they are reared in alkaline water, and, for species in the Forest Section of Neomelaniconion, it is essential that the rearing water be alkaline; 2) larvae of all species of Neomelaniconion benefit from the addition of dried leaves of angiosperm trees or shrubs (or extracts of such leaves) to the rearing medium, and, for species of the Forest Section, it is essential that dried leaves or their extracts be used; 3) larvae of all species of Neomelaniconion benefit from the addition of very small amounts of sand to the rearing containers; and 4) powdered tropical fish food (TetraMin brand) is superior to liver powder or yeast as a larval food.

The success of the rearing method that was developed was due, in large part, to using water from a local natural lake. The importance of this water was that it was alkaline, pH 8.4, and strongly buffered, so that its hydrogen-ion concentration scarcely changed when larvae were reared in it and when leaves and larval food were added to it. Even after seven to nine days, at which time all larvae have usually pupated, the lake water used for rearing was still alkaline, its pH having dropped only to 8.2. After the water was collected from the lake, it was filtered through cloth to remove larger planktonic organisms, sterilized in an

autoclave, and stored in glass bottles for use in the laboratory.

The complete egg-hatching and larval rearing procedure developed for all species of Neomelaniconion is as follows: 1) the oviposition vials with eggs are placed in a humid chamber at 25°C for 24 to 48 hours; 2) the oviposition vials with eggs are filled with a solution of 0.01% nutrient broth in sterilized lake water in the late afternoon (1600-1700 hours) and incubated at 25°C; 3) early the following morning (0800-0900 hours), small larvae are transferred from the oviposition vials to plastic rearing cups with 350 ml sterilized lake water, a small piece (5 to 9 cm long) of dried grass leaf (Hordeum species, family Gramineae), a short section (3 to 4 cm long) of dried tule stem (Scirpus species, family Cyperaceae), a small piece (5 to 15 cm^2) of dried bigleaf maple leaf (Acer macrophyllum, family Aceraceae), and a very small amount (0.1 to 0.2 gm) of sterile sand, and reared with aeration at 25°C; 4) on the next (second) morning, a single drop of Avitron Liquid Vitamin Supplement (for pet animals) is added; 5) on the second or third day, and usually every day thereafter, larvae are fed a slurry of powdered TetraMin tropical fish food; 6) if larvae are numerous (more than 20), they are moved to rearing pans that hold a larger volume of water when they have developed to large second to small fourth instar size; at this time the pieces of grass and tule may be discarded, but an additional piece of maple leaf and more sand are added if larvae are moved to a pan; 7) if larvae have been fed adequately, pupation usually starts on the sixth or seventh day, depending upon the species, and is completed within two more days.

The dried grass leaf and dried tule stem used in step 3 and the vitamins used in step 4 were not essential for larval development, but they enhanced larval survival. A weak solution of Lipton tea may be used in place of the piece of bigleaf maple leaf used in step 3. However, California black oak (Quercus kelloggi, family Fagaceae) leaves were not a suitable substitute for the bigleaf maple leaves because they turned the water acid, and Norway maple (Acer platanoides) leaves were not usable because an oily substance that seemed to be toxic to larvae leached from them. While some leaf matter was essential for survival of most larvae in the Forest Section of Neomelaniconion, too much leaf can be as deleterious as too little. Liver powder may replace the TetraMin as the larval food in step 5. Larvae developed faster (about one day less to pupation) when fed liver powder, but did not become as large. Baker's yeast was not a suitable larval food for species in the Forest Section because it makes the water acid, but it can be used for species in the Savanna Section, which seem to be less

affected by hydrogen-ion concentration.

The Principal Investigator learned force-mating techniques for mosquitoes at the Vector Biology Laboratory, University of Notre Dame, during periods of study there in January 1988 and July 1989. Experimentation with several species of Neomelaniconion in the Savanna Section has shown that these mosquitoes can be force-mated successfully. Four species - circumluteolus, luteolateralis, mcintoshi, and unidentatus were maintained through two or three generations in the laboratory. Of these, circumluteolus was the best candidate for a laboratory animal; adults can be force-mated easily, females feed readily on human blood, lay eggs readily on crumpled laboratory tissue moistened with distilled water, and are long-lived. At 25°C, females can complete a gonotrophic cycle every three days and can lay as many as 12 clutches of eggs. The three other species were more difficult to maintain because they were harder to mate (mcintoshi, unidentatus), less inclined to feed on human blood (unidentatus), required some unknown ovipositional stimulant (luteolateralis, unidentatus), or lived for a shorter period of time (unidentatus).

The force-mating technique developed for Neomelaniconion is as follows: 1) adults are held for two to seven days after eclosion and are provided with a source of carbohydrate (sucrose solution or moistened raisin) during this time; females may be offered a blood meal, but relatively few will feed; 2) males are anesthetized with ether only as long as it takes to knock them down (about 30 seconds); 3) anesthetized males are impaled on minuten pins inserted into wooden applicator sticks, with the minuten entering the thorax of the mosquito in the lower left sternopleural area and exiting through the scutum; 4) the head and hind legs of the impaled males are removed with forceps; 5) decapitated males are held over moistened towels for several minutes while they recover from the anesthesia; 6) females whose abdomens are distended by feeding on carbohydrate or blood are anesthetized with ether for three or four minutes; 7) an anesthetized female is placed on its back on a large rubber eraser so that its genital segments extend over the edge of the eraser; 8) a decapitated male impaled on a minuten pin is held so that its ventral surface is up and is maneuvered into position so that the cerci of the female extend between the sidepieces of the genitalia of the male; if the male is one that displays a strong mating response, then it will clasp the female with movements of its claspers and sidepieces and insert its aedeagus into the genital atrium of the female. Copulation is brief, lasting only 10-15 seconds, and during this time the female is held so firmly by the male that it can be picked up, suspended only by the genitalia of the male. Males that readily mate can be mated to more than one female.

Males that do not mate should be tried several times over a period of several minutes before being discarded. Steps 3, 4, 7, and 8 of the force-mating technique are performed at 10 to 20 times magnification under a stereoscopic microscope.

Force-mating techniques were used to obtain hybrids between several species in the Savanna Section. In some instances, F_2 hybrids and/or backcrosses of the F_1 hybrids to one or both parental species were produced. Progeny were reared from each of the following crosses (the female parent in each cross is listed first): *circumluteolus* x *luteolateralis*; *circumluteolus* x *mcintoshi*; *circumluteolus* x *unidentatus*; *mcintoshi* x *circumluteolus*; *mcintoshi* x *luteolateralis*; *unidentatus* x *circumluteolus*; *unidentatus* x *luteolateralis*; *unidentatus* x *mcintoshi*; (*circumluteolus* x *luteolateralis*) F_2; (*mcintoshi* x *circumluteolus*) F_2; (*mcintoshi* x *luteolateralis*) F_2; (*unidentatus* x *mcintoshi*) F_2; *circumluteolus* x (*circumluteolus* x *luteolateralis*); (*circumluteolus* x *luteolateralis*) x *circumluteolus*; (*circumluteolus* x *luteolateralis*) x *luteolateralis*; *circumluteolus* x (*mcintoshi* x *circumluteolus*); (*mcintoshi* x *circumluteolus*) x *circumluteolus*; and (*mcintoshi* x *luteolateralis*) x *luteolateralis*.

PREPARATION OF SPECIMENS FOR STUDY

All specimens collected and reared for the Project have been prepared for taxonomic study. Approximately 14,400 adult mosquitoes were double mounted on points. Approximately 5200 sets of associated larval and pupal skins and 3000 whole larvae and male genitalia were permanently mounted on microscope slides. Most of these specimens have been labeled with permanent, printed locality labels. Approximately 3900 additional reared adult mosquitoes were frozen for possible use in electrophoretic studies.

IDENTIFICATION

All specimens of *Neomelaniconion* borrowed from museums and collected and reared for the Project have been identified to species. The species represented and their country of origin can be found in the Taxonomic Study section.

Numerous other species of mosquitoes were collected in Africa during field surveys by the Principal Investigator. Many of these are ground-pool breeding species collected as larvae or pupae in habitats where *Neomelaniconion* were sought. Some are container breeding species collected as immatures and reared. However, the bulk of the species are represented by adults only, which were collected in habitats where adult *Neomelaniconion* were sought. Most of the species collected in Kenya, Senegal, South Africa, and Zambia have been provisionally identified. Most collected in Central

African Republic and Ivory Coast remain to be sorted and identified.

A list of the non-Neomelaniconion species collected and identified is:

Aedes (Aedimorphus)
- alboventralis (Theobald) Zambia
- argenteopunctatus (Theobald) Senegal
- bevisi (Edwards) South Africa
- cumminsii (Theobald) Kenya, South Africa, Zambia
- dalzieli (Theobald) Ivory Coast, Zambia
- dentatus (Theobald) Kenya, South Africa
- domesticus (Theobald) group Ivory Coast
- eritreae Lewis Kenya
- fowleri (Charmoy) ?Ivory Coast, Zambia
- hirsutus (Theobald) Kenya, South Africa, Zambia
- microstictus Edwards South Africa
- minutus (Theobald) Ivory Coast, ?Kenya, Senegal
- ochraceus (Theobald) Kenya, Senegal, Zambia
- quasiunivittatus (Theobald) Kenya, Zambia
- tarsalis (Newstead) Senegal, ?South Africa
- veeniae McIntosh South Africa
- vittatus (Bigot) Kenya, Senegal

Aedes (Albuginosus)
- haworthi Edwards Kenya
- marshallii (Theobald) South Africa
- ngong van Someren Kenya
- stokesi (Evans) Ivory Coast

Aedes (Diceromyia)
- furcifer (Edwards) Senegal
- taylori Edwards Senegal

Aedes (Finlaya)
- fulgens (Edwards) Kenya, South Africa
- ingrami Edwards Central African Republic
- longipalpus (Gruenberg) Ivory Coast

Aedes (Mucidus)
- grahami (Theobald) Ivory Coast
- mucidus (Karsch) Ivory Coast, Zambia
- sudanensis (Theobald) Kenya, Zambia

Aedes (Ochlerotatus)
- caballus (Theobald) South Africa
- juppi McIntosh South Africa

Aedes (Pseudarmigeres)
- kummi Edwards Ivory Coast
- michaelikati van Someren Kenya

Aedes (Skusea)
- pembaensis Theobald Kenya

Aedes (Stegomyia)
- aegypti (Linnaeus) Kenya, Senegal, Zambia
- africanus (Theobald) Central African Republic
- apicoargenteus (Theobald) Central African Republic

bromeliae (Theobald) Kenya, Senegal
calceatus Edwards Kenya
deboeri Edwards Kenya
demeilloni Edwards South Africa
heischi van Someren Kenya
ledgeri Huang South Africa
lilii (Theobald) Ivory Coast
luteocephalus (Newstead) Senegal
metallicus (Edwards) Kenya, Senegal, South Africa
neoafricanus Cornet, Valade & Dieng Senegal
simpsoni (Theobald) South Africa
soleatus Edwards Kenya
strelitziae Muspratt South Africa
unilineatus (Theobald) Senegal

Coquillettidia (Coquillettidia)
fuscopennata (Theobald) South Africa
microannulata (Theobald) South Africa

Culex (Culex)
antennatus (Becker) Kenya
decens Theobald Kenya
duttoni Theobald Kenya
grahami Theobald Senegal
perfuscus Edwards Kenya, Senegal
pipiens Linnaeus Kenya, South Africa
poicilipes (Theobald) Senegal
quinquefasciatus Say Kenya, South Africa
simpsoni Theobald Kenya
sitiens Wiedemann Kenya
?striatipes Edwards Zambia
thalassius Theobald Kenya, Senegal
theileri Theobald South Africa
tritaeniorhynchus Giles Senegal
univittatus Theobald South Africa, Zambia
vansomereni Edwards Kenya
weschei Edwards Senegal

Culex (Culiciomyia)
macfiei Edwards Senegal
nebulosus Theobald Senegal

Culex (Eumelanomyia)
adersianus Edwards Kenya
albiventris Edwards Ivory Coast
horridus Edwards South Africa
rima Theobald Senegal
wigglesworthi Edwards South Africa

Culex (Lutzia)
tigripes De Grandpre & De Charmoy Ivory Coast, Kenya, Senegal, Zambia

Culiseta (Allotheobaldia)
longiareolata (Macquart) South Africa

Culiseta (Theomyia)
fraseri (Edwards) Central African Republic

Eretmapodites

chrysogaster Graham Senegal
?dracaenae Edwards Ivory Coast
?grahami Edwards Ivory Coast
leucopus Graham group Ivory Coast
oedipodeios Graham group Ivory Coast
quinquevittatus Theobald Kenya, South Africa
silvestris Ingram & De Meillon South Africa
silvestris conchobius Edwards Kenya
subsimplicipes Edwards Kenya

Ficalbia
uniformis (Theobald) Kenya

Mansonia (Mansonioides)
africana (Theobald) Kenya

Mimomyia (Mimomyia)
mimomyiaformis (Newstead) Kenya

Toxorhynchites (Toxorhynchites)
brevipalpis Theobald Kenya
brevipalpis conradti Gruenberg Ivory Coast
erythrurus (Edwards) Ivory Coast
phytophagus Theobald Ivory Coast
viridibasis (Edwards) Senegal

Uranotaenia (Pseudoficalbia)
nivipous Theobald South Africa
ornata Theobald Ivory Coast
shillitonis Edwards Senegal

ILLUSTRATION

Preliminary pencil drawings of the larva and pupa of 23 species of Neomelaniconion were prepared, corrected for the modal number of branches in each seta, and checked for accuracy. Final inked drawings of the larva and pupa of five species were prepared.

A preliminary pencil drawing of the male genitalia of 28 species of Neomelaniconion was prepared and checked for accuracy. A final inked drawing of the male genitalia of six species was prepared.

Scanning electron micrographs of the eggs of 21 species of Neomelaniconion were prepared.

TAXONOMIC STUDY

Specimens representing 21 of the previously described species of Neomelaniconion were collected by the Principal Investigator or received for the Project through cooperators. The species, and the countries from which they were obtained,

are:

Aedes (Neomelaniconion)
albicosta (Edwards) Kenya
albothorax (Theobald) Kenya
aurovenatus Worth South Africa
bergerardi Pajot & Geoffroy Central African Republic
bolensis Edwards Senegal
carteri Edwards Central African Republic
circumluteolus (Theobald) Central African Republic, Ivory Coast, Kenya, South Africa
crassiforceps Edwards Central African Republic
fuscinervis (Edwards) Central African Republic, Ivory Coast
jamoti Hamon & Rickenbach Central African Republic, Ivory Coast, Senegal
linealis (Taylor) Australia
lineatopennis (Ludlow) Thailand
luridus McIntosh South Africa
luteolateralis (Theobald) South Africa
maculicosta Edwards Ivory Coast
mcintoshi Huang Kenya, Senegal, South Africa, Zambia
palpalis (Newstead) Central African Republic
pogonurus (Edwards) Central African Republic
punctocostalis (Theobald) Ivory Coast
taeniarostris (Theobald) Central African Republic, Ivory Coast
unidentatus McIntosh Kenya, South Africa

In addition, seven undescribed species were collected by the Principal Investigator. These species, with their geographical origins, are:

Aedes (Neomelaniconion)
species 1 Central African Republic, Ivory Coast
species 2 Ivory Coast
species 3 Central African Republic, Ivory Coast
species 4 Ivory Coast
species 5 Central African Republic
species 10 Ivory Coast
species 11 Central African Republic, Ivory Coast

In addition to these 28 species of Neomelaniconion collected by or for the Project, four additional valid species of Neomelaniconion were represented in material borrowed from museums. These species are:

Aedes (Neomelaniconion)
bequaerti Wolfs Zaire, Zambia
ellinorae Edwards Kenya
flavimargo Edwards Kenya
species 6 The Gambia, Liberia

Most of the 32 taxonomic species recognized by the Principal Investigator as a result of study supported by the Contract are known in both sexes and all stages. The exceptions are: pogonurus and species 4 unknown in the female sex; flavimargo unknown in the male sex; bequaerti, ellinorae, flavimargo, pogonurus and species 4 unknown in the larval and pupal stages; and bequaerti, bolensis, ellinorae, flavimargo, pogonurus, species 4 and species 6 unknown as eggs.

Twenty-six of the 28 species collected by or for the Project have both sexes and the larvae and pupae associated by means of progeny rearings. The exceptions are pogonurus and species 4, which were collected in the male sex only. Females of many species in the Forest Section of Neomelaniconion are extremely variable, and progeny rearings have been invaluable in documenting the range of variation in these species.

During the course of the Project, the primary types (either holotypes, lectotypes, or syntypes) of 25 of the 28 previously described nominal species of Neomelaniconion were studied. These were:

Aedes (Neomelaniconion)
- albicosta (Edwards)
- albothorax (Theobald)
- aurovenatus Worth
- bequaerti Wolfs
- bolensis Edwards
- carteri Edwards
- chrysothorax (Theobald)
- circumluteolus (Theobald)
- crassiforceps Edwards
- ellinorae Edwards
- flavimargo Edwards
- fuscinervis (Edwards)
- linealis (Taylor)
- lineatopennis (Ludlow)
- luridus McIntosh
- luteolateralis (Theobald)
- maculicosta Edwards
- mcintoshi Huang
- monotrichus Edwards
- pallida (Theobald)
- palpalis (Newstead)
- pogonurus Edwards
- punctocostalis (Theobald)
- taeniarostris (Theobald)
- unidentatus McIntosh

The three nominal species whose types were not seen are:

Aedes (Neomelaniconion) aureus Gutsevich, bergerardi Pajot & Geoffroy and jamoti Hamon & Rickenbach. Paratypic or topotypic specimens of the latter two species were studied by the Principal Investigator, so there are no questions about either the validity or identity of these species.

Examination of types revealed two important and unsuspected synonymies. Aedes circumluteolus and mcintoshi, two of the commonest and most widespread species of Ethiopian Neomelaniconion, are actually junior subjective synonyms of albothorax and pallidus, respectively. Aedes albothorax of authors in East Africa is a distinct but unnamed species. The Principal Investigator believes it would cause confusion to synonymize circumluteolus with albothorax and to describe as new and change the name of albothorax of authors, so a proposal requesting conservation of the names albothorax and circumluteolus in their accustomed usage will be submitted to the International Commission on Zoological Nomenclature. The Principal Investigator also believes it would be a mistake to synonymize mcintoshi with pallidus. The species in question was known as lineatopennis until Huang (3) concluded that it was distinct and named it mcintoshi in 1985. If mcintoshi were synonymized with pallidus, then this would be the second name change for this important species in less than a decade. In order to circumvent this name change, another proposal requesting conservation of the name mcintoshi will be submitted to the International Commission on Zoological Nomenclature.

As a result of the taxonomic study of Neomelaniconion supported by the Contract, the following nomenclatorial and taxonomic changes should be made in our knowledge of the subgenus, as summarized in the revision of the group by Edwards (5) and in the Catalog of the Mosquitoes of the World (1) and its first supplement (2): 1) aureus should be synonymized with lineatopennis; 2) bolensis should be transferred from Edwards's forest group to the Savanna Section; 3) linealis should be resurrected from synonymy with lineatopennis; 4) maculicosta should be resurrected from synonymy with carteri; 5) monotrichus should be synonymized with punctocostalis; 6) pallidus should be removed from synonymy with albothorax and suppressed in favor of mcintoshi; and 7) eight new species should be described in the Forest Section.

An abridged taxonomic treatment of Neomelaniconion is included in this report as Appendix 1. This abridgment: 1) presents all taxonomic decisions made by the Principal Investigator; 2) provides identification keys for the females, males and larvae of the species; 3) gives brief descriptions of the subgenus, the two major subdivisions of the subgenus, and all the species; 4) summarizes the known

distribution of each species; 5) gives information on the relationships of the species; and 6) provides information on variation and biology.

The methodology used in this study was primarily that of classical, comparative morphological taxonomy, as outlined by Belkin (19) and Zavortink (33), and the classification erected is evolutionary. During the course of the study, the uses of alternate sources of data, namely electrophoretic data on cellular enzymes and crossing data from laboratory hybridizations, and the use of an alternate methodology, namely phylogenetic analysis using parsimony, were explored. It was concluded that all of these approaches could contribute greatly to an understanding of the systematics of Neomelaniconion, but that none could be pursued due to lack of sufficient time and funding.

COMMUNICATION OF RESULTS OF RESEARCH

Summaries of the research completed on the Contract were presented at the Annual Meetings of the American Mosquito Control Association at Boston in 1989 and at Lexington in 1990.

Three papers for publication were prepared. One of these, the first in the list below, has been accepted for publication in Mosquito Systematics, and the other two will be submitted to the Bulletin of Zoological Nomenclature as soon as the first is published. A list of these three papers follows.

Zavortink, T.J.

1991(?1992). Bleaching of adult mosquitoes with daylight and its bearing on nomenclature in Aedes (Neomelaniconion) (Diptera: Culicidae). Mosq. Syst., 23: in press.

?1992. Banksinella luteolateralis var. albothorax Theobald, 1907, and Banksiella luteolateralis var. circumluteola Theobald, 1908 (currently Aedes albothorax and A. circumluteolus; Insecta, Diptera): proposed conservation of the specific names by the replacement of the holotype of A. albothorax by a neotype. Bull. Zool. Nomencl.

?1992. Aedes (Neomelaniconion) mcintoshi Huang, 1985 (Insecta, Diptera): proposed conservation of the specific name. Bull. Zool. Nomen.

Conclusions

All conclusions of the comparative morphological taxonomic study of Neomelaniconion are presented in the Abridged Taxonomic Treatment (Appendix 1). Thirty-two species are recognized, eight of which are undescribed. Two names (aureus, monotrichus) are relegated to synonymy, and three (linealis, maculicosta, pallidus) are resurrected from synonymy.

The names albothorax and pallidus are senior subjective synonyms of circumluteolus and mcintoshi, respectively. Proposals to conserve the names albothorax, circumluteolus and mcintoshi in their accustomed usages have been prepared and will be submitted to the International Commission on Zoological Nomenclature.

Neomelaniconion is particularly difficult taxonomically because of the limited number of good taxonomic characters and the extremely great amount of intraspecific variability.

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Appendix 1.

Abridged Taxonomic Treatment

Subgenus NEOMELANICONION Newstead

1907 (1 Feb.). Neomelaniconion Newstead, in Newstead, Dutton and Todd, 1907:31. TYPE SPECIES: Neomelaniconion palpale Newstead, 1907:31; monobasic and original designation.
1907 (23 Feb.). Banksinella Theobald, 1907:469. TYPE SPECIES: Culex luteolateralis Theobald; monobasic.

Description: Females with eyes broadly separated; frontal tuft well developed; vertex and occiput of head with narrow, curved decumbent scales and numerous erect scales; proboscis 0.9-1.4 length of forefemur; palpus short, 0.18-0.25 length of proboscis, 3- or 4-segmented; acrostichal bristles of scutum usually developed; dorsocentral bristles present; scutum and scutellum with narrow, curved scales only; sides of scutum usually with conspicuous stripe of white to yellow or golden yellow scales; paratergite normally bare; anterior and posterior pronotum sparsely scaled, the scales narrow, curved; lower mesepimeral bristles normally 1-several; prealar knob without scales; tarsi of legs unbanded; hindclaws toothed or simple; tergum I of abdomen extensively scaled; laterotergite usually scaled; terga II-VII with basolateral light-scaled patches and sometimes with light-scaled basal bands; segment VIII completely retracted; cercus exserted, long and slender or moderately long and moderately broad; spermathecae 3. Males often quite unlike females and not easily associated with them except by rearing; palpus longer than proboscis, 4-segmented, segment 4 upturned and with numerous long hairs; lower mesepimeral bristles normally absent; claws of mid- and hindtarsus enlarged, unequal; terga with long lateral hairs; terga without basolateral light-scaled patches. Male genitalia long, conspicuous, not retracted; tergum IX not divided, with poorly defined, shallowly separated, setose lobes; coxite long, with long, narrow basal tergomesal lobe bearing 2 (1-3) short, stout spiniform setae and 1, 2 hairs at apex, without apical lobe; coxite usually without membranous strip mesally; mesal surface of coxite usually with conspicuous spiniform setae; basal mesal lobe poorly developed, largely hidden by basal tergomesal lobe; stylus subapical on coxite; stylus short to moderately long, without lobes or arms, but with inner edge expanded in many species; stylus with single apical spiniform; aedeagus narrow, parallel-sided or nearly so, enlarged at base and apex, complex, comprised of a pair of strongly sclerotized, longitudinally ridged plates bearing apical teeth, and a more weakly sclerotized dorsal flap represented by a pair of median plates at apex tergally and a pair of triangular expansions laterally; proctiger complex, paraproct with single, strongly sclerotized apical process and with strongly

sclerotized, irregularly ridged sclerite fused to its sternal edge; cercal setae not developed. Pupae with weakly to strongly developed cuticular facets on ocular plate; seta 8-C at level of trumpet base; trumpet short to moderately long, its tracheoid indistinct to distinct; seta 10-C of metanotum caudomesad to caudolaterad of seta 11-C; 11-C moderately long, usually single; abdomen with setae 2,3-I widely separated; seta 3-I weakly developed, 2-10b beyond base; seta 1-II moderately strong, 3-21b, usually closer to midline than seta 1-I; seta 5-II far cephalad and laterad on segment; seta 2-III-V mesad of seta 1 of corresponding segment and usually near caudal edge of segment; female cercal lobe prominent, conical; paddle midrib strongly developed; marginal spicules of paddle short, inconspicuous. Larvae with head setae 5,6-C strongly developed, approximated (6-C closer to 5-C than to 7-C), single or multiple; setae 12,13-C approximated, removed from cephalic border; mental plate triangular, usually with 14-20 narrow teeth on each side of median tooth; antenna short to moderately long, straight to slightly incurved, strongly spiculate; seta 1-A usually multiple, inserted at or basad of middle; integument of thorax and abdomen without spicules; thorax with tracheal trunks usually conspicuously dilated; setae 1-3-P without common basal plate; meso- and metapleural tubercles moderately large, with series of teeth at apex laterally; abdomen with seta 6-I,II strongly developed, 1-5b (1-6); seta 6-III strongly developed, usually single or double (1-4b); seta 6-IV-VI similar to 6-III or slightly to conspicuously weaker and shorter; seta 12-I not developed; comb scales in irregular single or partly double row, usually 8 (5-10), each scale thorn-shaped, with fringe of short denticles and single long apical spine; seta 1,2-VIII approximated, sometimes with common basal plate; siphon short to moderately long, index 1.7-5.2; acus strongly developed, usually attached; pecten teeth usually 11-22 (7-23), usually with 1,2 strong ventral denticles at base, usually yellow to light brown; distal 1-4 pecten teeth usually more widely spaced and sometimes simple and/or stronger and/or longer and/or darker; seta 1-S small, inserted within pecten or distad of it; accessory setae of siphon not developed; anal saddle usually incomplete, without conspicuous enlarged spicules caudally; acus usually not developed on saddle; seta 1-X usually single or double; seta 2-X usually 6-15b; seta 3-X single; ventral brush usually with 6 pairs (6,7 pairs) of setae, the distal on a poorly developed grid, the proximal 0-4 setae detached; anal gills 4, lanceolate, dorsal and ventral subequal, usually moderately long to long, 1.7-4.4 times length of saddle. Eggs narrowly to broadly fusiform, their greatest diameter at anterior 0.38-0.50; outer chorion thin, membranous, translucent, weakly adherent, with circular, oval, polygonal, or irregular tubercles; inner chorionic reticulum indistinct or distinct at ends of egg; micropylar collar low; micropyle indistinct, trilobed; dehiscence subapical, oblique, complete or incomplete.

Distribution: Most species of Neomelaniconion occur in sub-Saharan Africa, but one species occurs in the Oriental and southern Palearctic regions, and one occurs in the Australian Region.

Remarks: Neomelaniconion is a moderately large subgenus of 32 species. Unlike many other subgenera of Aedes, Neomelaniconion is unquestionably monophyletic since several unique derived characteristics are shared by all species presently included in the subgenus.

Most female Neomelaniconion can be distinguished at a glance from virtually all other aedine mosquitoes by having a conspicuous white to yellow or golden yellow stripe on each side of the scutum and by having dark tarsi. In those few instances where appearance alone is not sufficient to distinguish them, then females can be recognized by the conspicuous frontal tuft between their widely separated eyes and the possession of 1 or more lower mesepimeral bristles. Male Neomelaniconion can usually be recognized by their long palpus with the last obvious segment upturned and hairy and their long, exserted genitalia. The male genitalia are easily recognized by several unique or unusual characteristics, among them being: the long narrow basal tergomesal lobe bearing 2 (1-3) short, stout spiniform setae; the poorly developed basal mesal lobe that is largely hidden beneath the basal tergomesal lobe; the usually completely sclerotized mesal surface of the coxite that bears spiniform setae; the subapical stylus; and the uniquely shaped aedeagus and paraproct.

The immatures of Neomelaniconion are very similar to those in several other subgenera of ground-pool breeding Aedes in Section B of the tribe Aedini (see below), and it is not known what, if any, characteristics of the larvae and pupae are diagnostic. Pupae of Neomelaniconion appear to be distinguished from those of these other subgenera by the following combination of characters: the position of seta 10-C, which is caudolaterad to caudomesad of seta 11-C; the wide separation of setae 2,3-I; the development and branching of seta 3-I, which is weak, short and 2-10 branched beyond its base; the position of seta 2-III-V, which is far mesad of seta 1 of the corresponding segment and usually near the caudal edge of segment; and the presence of weakly to strongly developed cuticular facets on the ocular plate. Larvae of Neomelaniconion can perhaps be distinguished from those in related subgenera by the following combination of characters: setae 5,6-C of head approximated; setae 1-3-P of prothorax not arising from a common basal plate; comb scales of segment VIII in an irregular single or partly double row, usually 8 (5-10) in number, each scale thorn-shaped, with fringe of short denticles and single long apical spine; the absence of accessory setae on the siphon; the yellowish to light brown pecten teeth that usually have 1 or 2 strong ventral denticles at base; the large but usually incomplete anal saddle; seta 3-X long and simple; the ventral brush (setae 4-X) usually with 6 or 7 pairs of setae and the proximal 0-4 setae detached; and the usually

conspicuously dilated tracheal trunks in the thorax.

I have found the dilated thoracic tracheal trunks to be very useful in separating living or freshly killed Neomelaniconion larvae from other ground pool breeding Aedes in Africa. However, since features of the tracheal system are not normally described by systematists, it is not known if this characteristic is of value in separating Neomelaniconion from the subgenera that are related to it. It is worth noting that all but two species of Neomelaniconion have dilated thoracic tracheal trunks. The two exception are species 1 and species 11, which have their tracheal system otherwise modified for their benthic existence. In these species the tracheal trunks in the siphon, abdomen and thorax are very slender and are, in fact, not appreciably larger than the tracheae that extend into their extremely long anal gills.

Edwards (1932:130) considered the form of the aedeagus of male Aedes to be of fundamental importance in dividing the genus into two major groups. Belkin (1962:325-326) expanded Edwards's system and applied it to all genera that he included in his tribe Aedini. Neomelaniconion obviously belongs to Belkin's Section B of the tribe: the proctiger of the male genitalia is without cercal setae; the aedeagus is complex, being comprised in large part of a pair of conspicuously ridged and toothed plates; and seta 12-I of the larva is not developed. Section B includes 22 other subgenera of Aedes in addition to Neomelaniconion, and also includes the genera Armigeres, Eretmapodites, Heizmannia, Udaya, and Zeugnomyia. The majority of these 28 generic and subgeneric taxa included in Section B are container breeding mosquitoes. Only five taxa in addition to Neomelaniconion breed in fresh-water habitats on or in the soil. These are the subgenera Aedes, Aedimorphus, Edwardsaedes, Paraedes and Verrallina of the genus Aedes. All five of these subgenera share many similarities with Neomelaniconion, particularly in the immature stages, and it seems reasonable to seek the closest relatives of Neomelaniconion from among them. Indeed, Edwards (1932:172) considered Neomelaniconion (as Banksinella), which at that time included also the species now placed in Edwardsaedes, to be closest to Aedimorphus, and Mattingly (1961:45) considered Neomelaniconion (including Edwardsaedes) to have marked affinities with Aedes sensu stricto (which then included Verrallina) and Paraedes. At this moment I favor the subgenus Aedes as the most closely related taxon. However, since Aedimorphus is poorly known in Africa, where it reaches its greatest diversity, it is possible that some member of this subgenus is indeed the nearest relative of Neomelaniconion. It should be noted that there can be no final resolution of the relationships of Neomelaniconion, or of any other Section B aedine for that matter, until the homologies of the various components of the phallosome and proctiger of these insects are worked out. This will require a careful, comparative morphological study of the genitalia of most, if not all, of the 28 included taxa.

Edwards (1941:201, 202, 207) divided the Ethiopian species

of Neomelaniconion into two groups on the basis of whether the abdominal terga of females were basally banded or not. Additional characters discovered during the present study support this division. The names Edwards used for these divisions, the forest group and the savannah group, are employed here but altered slightly to the Forest Section and the Savanna Section. These sections are "natural" in the sense of being assemblages of species that share numerous characteristics. However, a preliminary phylogenetic analysis of the species using the principle of parsimony and using Aedes (Aedimorphus) vexans as an outgroup indicates that the Forest Section is paraphyletic.

Neomelaniconion is taxonomically challenging for a variety of reasons. One of these is the extreme sexual dimorphism of many of the species, particularly those in the Forest Section. For example, four of the known species of Neomelaniconion have conspicuous light patches on the wings of females, but not on those of the males. In some species the development of the pleural scale patches is similar in both sexes, but in other species with conspicuous scale patches in the females, the pleuron of the male is nearly devoid of scales. And, none of the species with conspicuous light markings on the proboscis and hindtibiae of females have such markings in the males. There are many other instances of sexual dimorphism involving the number of pleural bristles, dentition of the hindclaws, and banding of the abdominal terga. Because of the extreme sexual dimorphism, oftentimes it is not possible to associate males and females collected in the field in those regions where several species are sympatric.

An additional feature of Neomelaniconion that makes the group difficult for the taxonomist is the paucity of taxonomic characters. Numerous structures that one would logically expect to show clear-cut specific differences in a group the size of Neomelaniconion provide no useful taxonomic characters at all. In the male genitalia, the aedeagus provides no taxonomic characters other than the subtle difference in dentition that marks the sections. The basal tergomesal lobe and basal mesal lobe are similarly developed in all species, although the basal tergomesal lobe of one species differs from the others in having one rather than two spiniform setae. In the larvae, the comb scales are virtually monomorphic throughout the subgenus. The sclerotized parts of the larvae - the antenna, head, siphon and anal saddle - provide few characters. And, the chaetotaxy is very similar in all species except the highly modified larvae of species 1 and species 11. The general absence of interspecific variation is particularly troublesome in the Savanna Section, where the larvae and male genitalia of many species appear to be indistinguishable.

Another reason why Neomelaniconion is extraordinarily difficult is the tremendous amount of intrapopulational variation that is present in those very characters that are of value in distinguishing females of the species, especially in the Forest Section. In those species that usually have conspicuous light

markings on the proboscis and hindtibiae, the markings are often small and inconspicuous and are sometimes even absent. The extent of light-scaling on the wing is extremely variable: in those species with lines of light scales on the wing veins, the length of the lines varies and the light scales are sometimes completely absent on the more posterior veins; in those species with patches of light scales, the patches vary in size, in color, and in how far they extend posteriorly on the wing, and the apical patch is sometimes reduced to just one or two light scales or may even be absent. In those species in the Forest Section that usually have toothed hindclaws in the females, such teeth are sometimes absent from the claws of one or both hindlegs. The bulk of the Neomelaniconion examined during this study consists of reared progeny series, and all of the variations mentioned can occur even in the offspring of a single female.

As just noted, females of species in the Forest Section are unusually variable and, as described above, sexual dimorphism is extreme in this group also. The very characters that vary in their development in females are, for the most part, the same ones that differ in their development in the two sexes. While I do not know the genetic basis for either of these types of variation, I cannot help but think there is some relationship between them. I think it is significant that in at least two of the subgenera related to Neomelaniconion, Edwardsaedes and Verrallina, there is also extreme interspecific variation in females and marked sexual dimorphism (Belkin, 1962:410, 413).

KEYS TO SPECIES

FEMALES
(pogonurus and species 4 unknown)

1. Terga II-VI without basal light-scaled bands 2
   Some or all of terga II-VI with basal light-scaled bands 18

Forest Section

2(1). Wing with subcostal and apical light-scaled patches . . 3
   Wing without light-scaled patches 5

3(2). Scutum mostly yellow-scaled; posterior surface of midfemur and anterior and posterior surfaces of hindfemur mainly dark-scaled or at least the scales appearing dark at some angles of observation . . . . . species 1, species 11
   Disc of scutum mainly dark-scaled; posterior surface of midfemur and anterior and posterior surfaces of hindfemur white-scaled to apex ventrally 4

4(3). Costal vein partly to nearly completely yellowish-scaled in basal 0.5-0.6; postspiracular scales usually present . .

. . . . . punctocostalis
Costal vein usually dark-scaled in basal 0.5-0.6; postspiracular scales absent or few (1-5) . . maculicosta

5(3). Costal vein with scattered light scales in basal 0.75; vein Cu with light scales extending from base to basal part of Cu_2 . . . . . flavimargo
Costal vein without light scales or with scattered light scales restricted to basal 0.5; vein Cu usually entirely dark-scaled or light-scaled only at very base 6

6(5). Wing veins entirely dark-scaled; scutum mainly dark-scaled, without complete light-scaled lateral stripe . . . . . fuscinervis
Wing vein R and sometimes vein Cu light-scaled at base; scutum with conspicuous light-scaled lateral stripe . . 7

7(6). Claws of hindtarsus simple 8
Claws of hindtarsus toothed 14

8(7). Hindtibia with patch, line or streak of yellowish scales in middle dorsally 9
Hindtibia dark-scaled in middle dorsally 11

9(8). Proboscis shorter than forefemur, dark-scaled; disc of scutum with scattered yellow scales, without distinct yellow-scaled inner dorsocentral line . . . . species 2
Proboscis longer than forefemur, usually with submedian ventral patch or incomplete to complete band of light scales; disc of scutum without scattered yellow scales, either mainly yellow-scaled or with distinct yellow-scaled inner dorsocentral line 10

10(9). Scutum mainly yellow-scaled . . . . . bergerardi
Disc of scutum dark-scaled with distinct yellow-scaled inner dorsocentral line . . . taeniarostris, species 3

11(8). Lateral scutal stripe narrow to moderately broad, usually whitish to cream-colored or very pale yellowish; disc of scutum dark-scaled or with scattered light scales 12
Lateral scutal stripe moderately broad to broad, yellow-scaled; disc of scutum with scattered yellow scales or with distinct yellow-scaled inner dorsocentral line 13

12(11). Proboscis with long ventral streak or very broad incomplete to complete band of cream-colored scales . . . . . ellinorae
Proboscis dark-scaled or with patch or streak of mixed dark and indistinctly lighter scales in middle ventrally . . . . . jamoti

13(11). Proboscis with pale-scaled patch in middle ventrally; disc of scutum with distinct yellow-scaled inner dorsocentral line . . . . . crassiforceps
Proboscis dark-scaled; disc of scutum with scattered yellow scales or with weakly developed, incomplete yellow-scaled inner dorsocentral line . . . species 6

14(7). Hindtibia dark-scaled in middle dorsally; disc of scutum entirely dark-scaled; lateral scutal stripe narrow, sometimes incomplete, white or cream-colored to very pale yellowish . . . . . bequaerti
Hindtibia light-scaled in middle dorsally; disc of scutum with indistinct to distinct yellow-scaled inner dorsocentral line; lateral scutal stripe broad, yellow-scaled 15

15(14). Proboscis with pale-scaled patch in middle ventrally . 16
Proboscis dark-scaled 17

16(15). Claws of hindtarsus usually stout, strongly pigmented, with long, stout tooth . . . . . carteri
Claws of hindtarsus slender, weakly pigmented, with short triangular tooth . . . . . species 10

17(15). Claws of hindtarsus evenly curved, usually with short triangular tooth . . . . . palpalis
Claws of hindtarsus abruptly curved beyond long, slender tooth, the distal portion of claw subparallel with tooth . . . . . species 5

Savanna Section

18(1). Acrostichal bristles not developed 19
Acrostichal bristles present 21

19(18). Costal fringe white-scaled in apical 0.3-0.4 of wing; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M mostly whitish . . . . . albicosta
Costal fringe dark-scaled; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M dark 20

20(19). Abdominal sterna usually completely to nearly completely dark-scaled; anterior surface of hindfemur white-scaled in basal 0.2-0.4; lower mesepimeral bristles usually 3-5 (2-7) . . . . . albothorax
Abdominal sterna usually completely to nearly completely white-scaled to pale yellow-scaled; anterior surface of hindfemur white-scaled in basal 0.5; lower mesepimeral bristle usually 1 (0-2) . . . . . circumluteolus

21(18). Claws of hindtarsus simple 22
Claws of hindtarsus toothed 25

22(21). Scutum mainly pale yellow-scaled; veins R_1, R_{4+5} and 1A pale yellow-scaled . . . . . aurovenatus
Disc of scutum mainly dark-scaled; veins R_1, R_{4+5} and 1A dark-scaled 23

23(22). Plume scales on veins Rs, R_{2+3}, R_2, R_3 and M dark; abdominal terga III-VI with basal bands of light scales prolonged medially, subtriangular in shape . . linealis
Plume scales on veins Rs, R_{2+3}, R_2, R_3 and M pale; abdominal terga III-VI with basal bands of light scales straight, concave or convex medially, not conspicuously prolonged 24

24(23). Vein R light-scaled from base to considerably beyond base of Rs or to near level of base of R_{4+5}; pleural scale patches very small to absent, the upper mesepimeral patch usually with 3 or fewer scales . . lineatopennis
Vein R light-scaled from base to slightly beyond base of Rs; pleural scale patches moderately large, the upper mesepimeral patch usually with 10 or more scales . . . . . mcintoshi

25(21). Vein R light-scaled almost to apex of R_1 . . . . . luteolateralis
Vein R light-scaled only to near base of Rs or to near level of base of R_{4+5} 26

26(25). Lateral scutal stripe very pale yellow to brownish yellow or yellow; vein R light-scaled from base nearly to base of Rs . . . . . luridus
Lateral scutal stripe yellow to golden yellow; vein R light-scaled from base to beyond base of Rs or even to level of base of R_{4+5} 27

27(26). Pleural scale patches moderately large to large; anterior surface of hindfemur white-scaled in basal 0.5-0.6 or white-scaled to apex ventrally . . . . . unidentatus
Pleural scale patches small; anterior surface of hindfemur dark-scaled or inconspicuously pale-scaled in basal 0.7 . . . . . bolensis

MALE GENITALIA
(flavimargo unknown)

1. Tips of longest teeth at apex of aedeagus meeting or nearly meeting on midline 2
Tips of longest teeth at apex of aedeagus widely separated 20

2(1). Stylus with obvious hairs 3
Stylus without hairs 9

3(2). Coxite with dense masses of long bristles on sternal and tergolateral surfaces 4
Coxite without dense masses of long bristles 5

4(3). Stylus much enlarged apically, with dense mass of hairs; apical projection of coxite large, with many hairs; basal tergomesal lobe with 1 spiniform seta . . . . pogonurus
Stylus subparallel-sided to near apex, then abruptly narrowed, with relatively few (6-8) hairs; apical projection of coxite very small, with only 2-4 hairs; basal tergomesal lobe with 2 spiniform setae . . . . . crassiforceps

5(3). Basal mesal surface of coxite with relatively few (7-12) setae; apical projection of coxite with few (4-8) hairs . . . . . n. sp. #5
Basal mesal surface of coxite with dense mass of setae; apical projection of coxite with numercus (12-16) hairs 6

6(5). Spiniform setae on mesal surface of coxite 5-8; 1 or more rows of hairs present immediately tergad of spiniform setae 7
Spiniform setae on mesal surface of coxite 3,4; no rows of hairs present tergad of spiniform setae 8

7(6). Spiniform setae on mesal surface of coxite very strongly developed, becoming thicker beyond their bases, the distance between some of them at their widest parts less than their diameters . . . . . palpalis
Spiniform setae on mesal surface of coxite strongly developed, not or only very slightly thicker beyond their bases, the distance between them greater than their diameters . . . . . bequaerti

8(6). Area of dense setae on basal mesal surface of coxite oblique to long axis of coxite, the setae in basal portion of area far tergad of those in distal portion of area; alveoli of setae in basal portion of area of dense setae on basal mesal surface of coxite touching . . . . . carteri
Area of dense setae on basal mesal surface of coxite nearly parallel to long axis of coxite, the setae in basal portion of area not or only slightly tergad of those in distal portion of area; alveoli of setae in basal portion of area of dense setae on basal mesal surface of coxite separated . . . . . n. sp. #10

9(2). Stylus with many conspicuous spicules 10
Stylus without spicules 13

10(9). Spiniform setae on mesal surface of coxite numerous (20-30), in dense clump; setae of basal mesal surface of coxite moderately dense . . . . . n. sp. #3
Spiniform setae on mesal surface of coxite fewer (5-17), widely spaced; setae of basal mesal surface of coxite sparse 11

11(10). Some (3,4) spiniform setae on mesal surface of coxite conspicuously stronger and longer than others; apicomesal portion of sternal surface of coxite without bristles . . . . . n. sp. #2
No spiniform setae on mesal surface of coxite conspicuously stronger and longer than others; apicomesal portion of sternal surface of sidepiece with few to numerous moderately to strongly developed bristles 12

12(11). Apicomesal portion of sternal surface of coxite with relatively few moderately developed bristles . . . . . n. sp. #6
Apicomesal portion of sternal surface of coxite with numerous moderately to strongly developed bristles . . . . . fuscinervis

13(9). Mesal surface of coxite without thickened spiniform setae; inner edge of stylus very conspicuously expanded and spiniform of stylus very long, slender, curved . . . . . taeniarostris
Mesal surface of coxite with obvious, thickened spiniform setae; inner edge of stylus usually not conspicuously expanded, or, if it is, then spiniform of stylus shorter, stouter, nearly straight 14

14(13). Inner edge of stylus very conspicuously expanded; stylus abruptly narrowed to slender apex not much broader than alveolus of its spiniform . . . n. sp. #1, n. sp. #11
Inner edge of stylus not or only slightly expanded; if slightly expanded, then stylus not abruptly narrowed to slender apex 15

15(14). Spiniform setae on mesal surface of coxite few (2-7), widely spaced, from conspicuously protuberant alveoli; coxite broad to far beyond middle, then abruptly narrowed, its mesal margin strongly concave where coxite narrows 16
Spiniform setae on mesal surface of coxite more numerous (10-18), closely spaced, in clump or 2 or 3 rows, their alveoli not conspicuously protuberant; coxite gradually narrowing from base to apex, its mesal margin nearly

straight to slightly concave beyond middle 18

16(15). Spiniform setae on mesal surface of coxite 2; apical projection of coxite very broad, with setae restricted to outer half of sternal surface; basal mesal surface of coxite with dense mass of setae where coxite narrows . . . . . bergerardi

Spiniform setae on mesal surface of coxite 4-7; apical projection of coxite narrow to moderately broad, with setae distributed over entire sternal surface; basal mesal surface of coxite without dense mass of setae 17

17(16). Apical projection of coxite narrow, pointed; 2 or 3 strongly developed setae on mesal surface of coxite basad of spiniform setae; apex of stylus broad, irregular, jagged . . . . . jamoti

Apical projection of coxite moderately broad, rounded; no strongly developed setae on mesal surface of coxite basad of spiniform setae; apex of stylus narrow, simple . . . . . ellinorae

18(15). Tergum IX with 4-9 bristles on each side; apical projection of coxite with 1 moderately strong to strong bristle . . . . . punctocostalis

Tergum IX with 2-8 hairs on each side; apical projection of coxite without bristle, but with several hairs 19

19(18). Spiniform setae on mesal surface of coxite in moderately dense clump; more sternal spiniform setae 2.0 times length of tergal ones; apical projection of coxite moderately large; setae on basal mesal surface of coxite moderately dense . . . . . maculicosta

Spiniform setae on mesal surface of coxite more spread out; more sternal spiniform setae 1.0-1.3 times length of tergal ones; apical projection of coxite small; setae on basal mesal surface of coxite sparse . . . . . n. sp. #4

Savanna Section

20(1). Basal mesal surface of coxite without rows of hairs tergad of bristles on mesal edge; spiniform setae on mesal surface of coxite in dense clump, usually arising from slightly convex area, usually so numerous and closely spaced that they cannot be counted accurately . . . albicosta, bolensis, luteolateralis, unidentatus

Basal mesal surface of coxite with 1 or more rows of hairs tergad of bristles on very mesal edge, many of these hairs rather abruptly curved beyond their bases toward apex of genitalia; spiniform setae on mesal

surface of coxite not in dense clump arising from slightly convex area, usually spaced far enough apart that they can be counted accurately 21

21(20). Spiniform setae on mesal surface of coxite relatively numerous (13-23), conspicuous, as thick as or thicker than largest bristles on basal mesal edge of coxite; basal mesal surface of coxite with relatively small area of setae that does not extend onto tergomesal surface of coxite or that extends only slightly onto it, there being 1 or 2 rows of hairs tergad of bristles on mesal edge of coxite . . . . . aurovenatus, circumluteolus, linealis, lineatopennis, luridus

Spiniform setae on mesal surface of coxite relatively few (4-13), relatively inconspicuous, not thicker than largest bristles on basal mesal edge of coxite; basal mesal surface of coxite with relatively large area of setae that extends far onto tergomesal surface of coxite, their being 4-7 rows of hairs tergad of bristles on mesal edge of coxite 22

22(21). Coxite abruptly narrowed distally, its mesal margin strongly concave where coxite narrows . . albothorax

Coxite narrowing more gradually from base, its mesal margin slightly concave where coxite narrows to nearly straight . . . . . mcintoshi

LARVAE
(bequaerti, ellinorae, flavimargo, pogonurus, species 4 unknown)

1. Setae 5,6-C single 2
Setae 5,6-C 2-7b 10

Forest Section

2(1). Seta 4-C far forward on head capsule 3
Seta 4-C relatively close to setae 5,6-C 7

3(2). Seta 1-S inserted within pecten 4
Seta 1-S inserted at end of or distad of pecten 6

4(3). Head capsule, siphon, and anal saddle strongly pigmented, predominantly brown . . . . . species 5

Head capsule, siphon, and anal saddle weakly pigmented, predominantly yellow to light brown 5

5(4). Apical 2-4 pecten teeth enlarged, simple, often more strongly pigmented than more basal teeth . . . . palpalis

Apical 2-3 pecten teeth enlarged, usually toothed, concolorous with more basal teeth . . . . . crassiforceps

6(3). Seta 4-C moderately far forward on head capsule; seta 1-S moderately strong . . . . . bergerardi
Seta 4-C very far forward on head capsule; seta 1-S weakly developed . . . . . carteri, species 10

7(2). Seta 1-S inserted within pecten 8
Seta 1-S inserted at end of or distad of pecten 9

8(7). Siphon short, index 2.0-2.4 . . . . . maculicosta
Siphon moderately long, index 2.4-2.9 . . . . . species 2

9(7). Anal saddle complete . . . . . punctocostalis
Anal saddle incomplete . . . . . species 3

10(1). Anal gills very long, with conspicuous dark tracheae; siphon with slender tracheae 11
Anal gills not unusually long, without conspicuous tracheae; siphon with broad tracheae 12

11(10). Setae 5,6-C subequal in length and strength; seta 6-IV,V long, strong; siphon index 3.3-4.1 . . . . . species 1
Seta 5-C conspicuously longer and stronger than 6-C; seta 6-IV,V short, moderately strong; siphon index 4.2-5.2 . . . . . species 11

12(10). Seta 1-S inserted within pecten 13
Seta 1-S inserted at end of or distad of pecten . . . 14

13(12). Siphon index 3.2-4.0; antenna darker than antennal prominence; seta 13-C strongly developed, long . . . . . taeniarostris
Siphon index 2.5-3.0; antenna lighter than or concolorous with antennal prominence; seta 13-C weakly developed, short . . . . . jamoti

14(12). Siphon index 1.7-1.8 . . . . . species 6
Siphon index greater than 2.4 15

15(14). Antenna weakly pigmented, nearly colorless at its base . . . . . fuscinervis
Antenna moderately to strongly pigmented, tan to brown 16

Savanna Section

16(15). Ventral brush usually with 14 setae (13,14) . albicosta
Ventral brush usually with 12 setae (10-13) 17

17(16). Mental plate with 9-11 teeth on each side of median tooth; siphon bent dorsad subapically . . . bolensis
Mental plate with 16-19 (16-20) teeth on each side of median tooth; siphon not bent dorsad subapically . .18

18(17). Setae 1,2-VIII without common basal plate; seta 1-VIII shorter than 0.33 length of saddle . . . aurovenatus
Setae 1,2-VIII with common basal plate; seta 1-VIII longer than 0.50 length of saddle 19

19(18). Seta 6-IV,V usually double (single, double); integument of frontoclypeus with weakly developed polygonal sculpturing visible at 100 magnifications . albothorax
Seta 6-IV,V usually single (single, double); integument of frontoclypeus smooth at 100 magnifications . . . . . circumluteolus, linealis, lineatopennis, luridus, luteolateralis, mcintoshi, unidentatus

Forest Section

Description: Females without basal band of light scales on abdominal terga II-VI. Males with tips of longest teeth at apex of aedeagus meeting or nearly meeting on midline. Pupae with strongly developed cuticular facets on ocular plate; trumpet not gradually broadened distad; setae 6,9-VII similar. Larvae with head setae 5,6-C single, and/or siphonal seta 1-S inserted basad of base of last pecten tooth, and/or antenna weakly pigmented and lighter than or concolorous with antennal prominence, and/or anal gills very long and with conspicuous dark tracheae. Eggs narrow to broad, length to width ratio 3.3-5.2; inner chorionic reticulum conspicuous at ends of egg.

Distribution: Apparently restricted to areas of tropical rainforest or dense gallery forest, primarily in west and central Africa (Senegal to Uganda and northern Zambia), but also along the coast in east Africa (Kenya).

Remarks: The Forest Section of Neomelaniconion consists of 21 species. Nineteen of these are found in west and central Africa and two are known only from coastal Kenya. The species are most reliably identified by the male genitalia and larvae. Females of many of the species are extremely variable, with the result that not all individuals can be identified. Several groups of species can be recognized on the basis of correlated characteristics of females, male genitalia and larvae. These groups are: 1) bequaerti, carteri, crassiforceps, palpalis, pogonurus, species 5 and species 10; 2) ellinorae and jamoti; 3) flavimargo, maculicosta, punctocostalis and species 4; 4) fuscinervis and species 6; and 5) species 1 and species 11. The four remaining species, bergerardi, taeniarostris, species 2 and species 3, appear to be isolated. In some localities, specimens of as many as eight or nine species have been collected. Species of the section are so sexually dimorphic that it is not possible to associate the sexes except by means of individual or progeny rearings.

Eight of the 21 species recognized in the Forest Section

are undescribed. Numerous other undescribed species undoubtedly exist, particularly in areas of high rainfall with rich biotas, such as Sierra Leone, Liberia and Cameroon. One of the species recognized (maculicosta) is resurrected from synonymy. One new synonymy (monotrichus with punctocostalis) is made as a result of associating males and females through progeny rearings.

Aedes (Neomelaniconion) bequaerti Wolfs

1947. Aedes (Banksinella) bequaerti Wolfs, 1947:40-41. TYPE: Holotype male, Kimilolo River, near Elizabethville, Shaba Province, Zaire (MRAC).

Description: Female with scales on vertex of head and sides of scutum white or cream-colored to very pale yellowish; proboscis subequal in length to forefemur, dark-scaled; lateral scutal stripe narrow, sometimes incomplete; disc of scutum completely dark brown-scaled; pleural scale patches large, white to silvery white; postspiracular scales few (2-8); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia dark-scaled in middle dorsally; claws of hindtarsus slender, evenly curved, with short triangular tooth; costal vein dark-scaled; vein R usually with creamy white scales in basal 0.15-0.25; vein Cu dark-scaled. Male genitalia very similar to palpalis, perhaps distinguished by shape of spiniform setae on mesal surface of coxite, which are not as thickened beyond their bases. Larva unknown.

Distribution: Aedes bequaerti is known only from the Katanga region in southern Zaire and adjacent northern Zambia.

Remarks: The only significant variation noted in the few females of bequaerti studied involves the base of vein R, which may have only a few pale scales instead of a line of creamy white scales. The affinities of bequaerti are not definitely resolved. The male genitalia are very similar to those of palpalis, but the adults are similar to jamoti and ellinorae in size, color, and vestiture. Females do, however, have toothed hindclaws, and in this regard they are also like palpalis.

Aedes (Neomelaniconion) bergerardi Pajot & Geoffroy

1971. Aedes (Neomelaniconion) bergerardi Pajot and Geoffroy, 1971:269-272. TYPE: Holotype male, Botambi Forest, near Botambi village, Ombella-M'Poko, Central African Republic (IERT).

Description: Female with scales on vertex of head and sides of scutum yellow; proboscis longer than forefemur, with

median pale-scaled patch beneath or incomplete to complete pale-scaled band; lateral scutal stripe broad; disc of scutum mainly yellow-scaled, some dark brown scales among acrostichal and dorsocentral bristles; pleural scale patches moderately large, dingy white to yellowish; postspiracular scales absent or few (1); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia with long streak of yellowish scales dorsally; claws of hindtarsus simple; costal vein dark-scaled; vein R with cream-colored scales in basal 0.35; vein Cu pale-scaled in basal 0.25-0.40. Male genitalia with coxite broad to far beyond middle, very abruptly narrowed apically, its basal mesal surface with dense mass of setae where coxite narrows, its mesal surface with 2 stout spiniform setae from protuberant alveoli, its apical projection very large and with setae restricted to outer half of sternal surface; stylus slender, pointed, without hairs or spicules. Larva in general similar to carteri, but seta 4-C not as far forward on head capsule and seta 1-S stronger; 0 or 1 apical pecten tooth enlarged.

Distribution: Aedes bergerardi is known from only the region of tropical rainforest southwest of Bangui, Central African Republic.

Remarks: The male genitalia of bergerardi are very distinctive. The female is similar to taeniarostris and difficult or perhaps even impossible to separate from individuals of taeniarostris that have the scutum largely yellow-scaled. The larva appears to be closest to carteri.

Aedes (Neomelaniconion) carteri Edwards

1936. Aedes palpalis var. carteri Edwards, 1936:52. TYPE: Holotype male, Lagos, Lagos State, Nigeria (BM).

Description: Female similar to palpalis, differing as follows: scales on vertex of head and sides of scutum golden yellow; proboscis usually with small to large median pale-scaled patch beneath or incomplete to complete, median pale-scaled band; inner dorsocentral yellow-scaled line sometimes incomplete anteriorly; hindtibia with large patch or broad incomplete band of yellowish scales dorsally in middle; claws of hindtarsus usually stout, strongly pigmented, with long, stout tooth. Male genitalia in general similar to palpalis, but differing as follows: basal mesal surface of coxite with very dense mass of setae, the mass oblique to long axis of coxite; mesal surface of coxite with 3 or 4 spiniform setae and without hairs dorsad of spiniform setae. Larva in general similar to palpalis, but differing primarily in having seta 1-S arising beyond last pecten tooth; apical 1-3 pecten teeth enlarged, usually concolorous with more basal teeth.

Distribution: Specimens of carteri from Central African Republic, Nigeria and Zaire have been examined during this study. Edwards's (1941:210) records of carteri from Ghana and Liberia undoubtedly refer to the similar species 10, which occurs west of the Dahomey gap. The record of carteri from Uganda by Haddow et al. (1951:226) requires confirmation since the specimens may be palpalis. The Central African Republic specimens collected by me were from a region of tropical rainforest.

Remarks: Females of carteri and palpalis are in general similar, but can be distinguished by markings on the proboscis and hindtibia and by the development of the claws of the hindtarsus. Male genitalia and larvae of the two species are easily separated. The species have been collected sympatrically in Central African Republic, but carteri was far less abundant. Aedes carteri is similar in all stages to species 10, which occurs west of the range of carteri in Ghana, Ivory Coast and possibly Liberia.

Aedes (Neomelaniconion) crassiforceps Edwards

1927. Aedes (Banksinella) crassiforceps Edwards, 1927:352-353. TYPE: Holotype male, Stanleyville, Haut Zaire, Zaire (MRAC).

Description: Female very similar to palpalis, differing as follows: proboscis with small to moderately large median pale-scaled patch beneath; pleural patches slightly larger; hindtibia dark-scaled in middle dorsally; claws of hindtarsus simple. Male genitalia with coxite very broad basally, gradually narrowing to apex, its tergolateral and sternal surfaces with dense masses of long bristles, its basal mesal surface with few setae, its mesal surface with 4-6 spiniform setae, all but 1 of which are very small and inconspicuous, its apical projection very small and with only 2-4 hairs; stylus subparallel-sided to near apex, then abruptly narrowed, with few (6-8) hairs. Larva very similar to palpalis, possibly distinguished by having the apical 2-3 pecten teeth of the siphon enlarged, but usually toothed and concolorous with more basal teeth.

Distribution: Aedes crassiforceps is known from only regions of rainforest in Central African Republic and Zaire.

Remarks: Aedes crassiforceps is a rare species, or at least a rarely collected species. The male genitalia are very distinctive. The female is very similar to palpalis but can be separated by the characters given in the description. The larva of crassiforceps is also very similar to that of palpalis. The males and females of crassiforceps have been associated by rearing progeny from a single female of the species collected in Central African Republic. The female questionably associated

with the holotype male of crassiforceps by Edwards and described by him (1941:212) is actually the forest-inhabiting form of jamoti with yellow-scaled scutal stripes.

Aedes (Neomelaniconion) ellinorae Edwards

1941. Aedes (Banksinella) ellinorae Edwards, 1941:212-213. TYPE: Lectotype male, Gede, Coast Province, Kenya (BM; selection of Mattingly, 1956:40).

Description: Female in general similar to jamoti, differing as follows: scales on vertex of head and sides of scutum creamy white to very pale yellowish; proboscis subequal to forefemur, with long ventral streak or very broad incomplete to complete band of cream-colored scales; disc of scutum dark-scaled; pleural scale patches white; vein Cu dark-scaled. Male genitalia similar to jamoti, differing primarily in the broader, rounded apical projection of the coxite and the slender, simple apex of the stylus. Larva unknown.

Distribution: Known only from the Kenya coast north of Mombasa.

Remarks: On the basis of both male genitalic and female characteristics, ellinorae appears to be closely related to jamoti. Females are separated primarily by the markings of the proboscis, as noted above. I was not able to collect this species on any of three separate visits to the vicinity of the type locality along the Kenya coast.

Aedes (Neomelaniconion) flavimargo Edwards

1941. Aedes (Banksinella) flavimargo Edwards, 1941:209. TYPE: Lectotype female, Gede, Coast Province, Kenya (BM; selection of Mattingly, 1956:40).

Description: Female very similar to punctocostalis, differing as follows: costal vein with scattered cream-colored scales in basal 0.75, without light-scaled patches; vein R with cream-colored scales in basal 0.55; plume scales whitish in middle portion of wing. Male and larva unknown.

Distribution: This species is known from only the original type series collected at Gede in the forested region along the Kenya coast.

Remarks: Edwards (1941:209) considered flavimargo to be very similar to taeniarostris. However, I believe the species is instead closely related to punctocostalis. Females of these two species are very similar, but can be distinguished by the

characters given above. There are only two specimens of flavimargo in the British Museum collection now, and neither possesses hindtarsi, so the dentition of the hindclaws is actually unknown. I did not find this species on any of my three visits to the type locality.

Aedes (Neomelaniconion) fuscinervis Edwards

1914. Banksinella fuscinervis Edwards, 1914:73-74. TYPE: Holotype male, Accra, Eastern Region, Ghana.

Description: Female with scales on vertex of head and sides of scutum yellow and dark brown; proboscis longer than forefemur, dark-scaled or with some indistinct pale scales in middle ventrally; lateral scutal stripe not developed to weakly developed, narrow, incomplete near scutal angle; disc of scutum dark brown-scaled with scattered yellow scales; pleural scale patches large, white to creamy white; postspiracular scales absent or few (1-7); posterior surface of midfemur white-scaled to near apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to near apex ventrally or anterior surface white-scaled in basal 0.5; hindtibia dark-scaled in middle dorsally; claws of hindtarsus simple; wing entirely dark-scaled. Male genitalia with coxite broad basally, slightly tapered toward apex, its basal mesal surface with setae sparse, its mesal surface with 5-17 short, slender, widely spaced spiniform setae, its apical projection small, with many setae, its apicomesal sternal surface with numerous bristles; stylus broadest in middle, apex slender, with spicules. Larva in general like jamoti, differing primarily in position of seta 1-S at end of or distad of pecten; siphon index 2.4-3.2; pecten teeth 15-18 (13-19), apical 1-2 (1-3) enlarged, sometimes simple.

Distribution: Specimens of fuscinervis have been seen by me from Central African Republic, Ghana, Ivory Coast, Liberia and Nigeria. The record of fuscinervis from The Gambia by Mattingly (1963:169-170) is erroneous. In Ivory Coast, this species was collected commonly in gallery forest in regions of savanna woodland, but it occurred also, with lower frequency, in regions of tropical rainforest. In Central African Republic it was found only in tropical rainforest.

Remarks: Females of fuscinervis differ from all other species of Neomelaniconion in the absence of light scales on the wing and the much reduced amount of pale scaling on the sides of the scutum. They can be easily confused with small individuals of Aedes (Aedimorphus) cumminsii. Aedes fuscinervis is similar in most respects to species 6, but that species has moderately broad, yellow-scaled scutal stripes. The larva of fuscinervis resembles larvae of species in the Savanna Section by having head setae 5,6-C branched and siphonal seta 1-S arising at the end of

or distad of the pecten.

Aedes (Neomelaniconion) jamoti Hamon & Rickenbach

1954. Aedes (Banksinella) jamoti Hamon and Rickenbach, 1954:932-934. TYPE: Holotype male, Bobo Dioulasso, Volta-Noire, Burkina (IERT).

Description: Female with scales on vertex of head and sides of scutum whitish to cream-colored, very pale yellow or yellow; proboscis longer than forefemur, dark-scaled or with patch or streak of mixed dark and indistinct light scales on underside in middle; lateral scutal stripe narrow to moderately broad; disc of scutum dark-scaled or with scattered light scales; pleural scale patches large, white, silvery white or yellowish; postspiracular scales absent to few (1-6); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia dark-scaled in middle dorsally; claws of hindtarsus simple; costal vein dark-scaled; vein R with mixed dark and whitish to cream-colored scales in basal 0.20-0.30; vein Cu dark-scaled, with a few light scales at base, or partly light-scaled in basal 0.3. Male genitalia with coxite broad to far beyond middle, abruptly narrowed apically, its basal mesal surface with setae sparse, its mesal surface with 4-7 spiniform setae from conspicuously protuberant alveoli, its apical projection slender, pointed, with hairs on entire sternal surface; stylus slender, its apex broad, irregular, jagged; stylus without hairs or spicules. Larva with head mainly yellowish to light brown; antenna lighter than or concolorous with antennal prominence; seta 4-C close to 5,6-C; setae 5,6-C multiple; seta 13-C weakly developed and short to moderately developed and moderately long; siphon index 2.5-3.0; seta 1-S weakly developed, inserted within pecten; pecten teeth 18-22 (16-23), apical 2 (1-4) teeth enlarged, often simple and more strongly pigmented than more basal teeth; anal saddle incomplete; anal gills normal.

Distribution: Aedes jamoti is known from Burkina, Central African Republic, Ivory Coast, Nigeria, Senegal and Zaire. In Ivory Coast I collected this species only in gallery forests in regions of savanna woodland. In Central African Republic the species was found not only in this habitat, but also in tropical rainforest.

Remarks: Specimens of jamoti from regions of savanna woodland have whitish to cream-colored or very pale yellow scutal stripes, whereas those from regions of tropical rainforest in Central African Republic and Zaire have yellow scutal stripes. Edwards (1941:212) described the forest-inhabiting form with yellow scutal stripes, but provisionally considered it to be the female of crassiforceps. Females of jamoti are similar to those

of bequaerti. Both are large, somber insects with their scutal stripes narrow and, except as noted above, whitish to cream-colored or very pale yellow in color and with their pleural scale patches large and usually white to silvery white. Females of these species can be separated by the claws of the hindtarsus, which are simple in jamoti, toothed in bequaerti. The male genitalia of jamoti are distinctive in shape and can be easily separated from those of bequaerti. Aedes jamoti is probably most closely related to ellinorae. Females of ellinorae are also large, dark mosquitoes with narrow, creamy white to very pale yellowish scutal stripes and large, white pleural scale patches. Females of jamoti and ellinorae can be separated by the color of the proboscis, which is dark in jamoti, but with cream-colored scales in the middle in ellinorae. The male genitalia of ellinorae are similar to those of jamoti, but readily distinguishable.

Aedes (Neomelaniconion) maculicosta Edwards

1936. Aedes palpalis var. maculicosta Edwards, 1936:52. TYPE: Holotype female, Lagos, Lagos State, Nigeria (BM).

Description: Female with scales on vertex of head and sides of scutum pale yellow; proboscis slightly longer than forefemur, with incomplete to complete median pale-scaled band; lateral scutal stripe moderately broad to broad; disc of scutum mainly dark brown-scaled, with scattered yellow scales and very weakly developed inner dorsocentral line; pleural scale patches moderately large, dingy white to yellowish; postspiracular scales absent to few (1-5); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia with cream-colored to yellow scales dorsally in median patch or long streak; claws of hindtarsus simple; costal vein usually dark-scaled in basal 0.5, with small to moderately large subcostal and apical light-scaled patches, the subcostal patch sometimes represented also on veins Sc, R_1, R_{2+3}, R_{4+5}, M, and the apical on R_1, R_2; vein R with creamy-white scales in basal 0.4 and sometimes additionally in narrow or incomplete line to subcostal patch; vein Cu with light scales at base or extending from base to basal part of Cu_2. Male genitalia with coxite broad basally, narrowed distally, its basal mesal surface with moderately dense setae, its mesal surface with moderately dense clump of short and long spiniform setae, its apical projection moderately large, narrow and with relatively few hairs; stylus slightly expanded along inner edge, narrow at apex, without hairs or spicules. Larva with head mainly yellowish to light brown; antenna lighter than antennal prominence; seta 4-C close to 5,6-C; setae 5,6-C single, abruptly pointed; seta 13-C weakly developed, short; siphon index 2.0-2.4; seta 1-S weakly developed, inserted within pecten; pecten teeth 16-18 (15-19); apical 2 (1-3) teeth enlarged, apex of last tooth

usually extending beyond apex of siphon; anal saddle narrowly incomplete; anal gills normal.

Distribution: Aedes maculicosta is known to occur in Ivory Coast and Nigeria. The record of maculicosta from Mozambique by Pereira (1958) is undoubtedly erroneous. In Ivory Coast all collections of this species made by me were from gallery forests in regions of savanna woodland.

Remarks: Aedes maculicosta is one of four species of Neomelaniconion with light-scaled costal patches in the female. The development of these patches is extremely variable in all four of these species, and may vary even on the two wings of the same specimen. The patches vary in size and color and in how far they extend posteriad on the wing onto other veins. In maculicosta the apical wing patch is sometimes absent. The male genitalia of maculicosta are quite different from those of the other species with spotted wings in the female and provide unequivocal identification of the species. The affinities of maculicosta appear to be with punctocostalis, flavimargo and species 4.

Aedes (Neomelaniconion) palpalis (Newstead)

1907. Neomelaniconion palpale Newstead, in Newstead, Dutton and Todd, 1907:31. TYPE: Holotype male, Basoko, Haut Zaire, Zaire (BM).

Description: Female with scales on vertex of head and sides of scutum light yellow to yellow; proboscis longer than forefemur, usually completely dark-scaled; lateral scutal stripe broad; disc of scutum dark brown-scaled with narrow to moderately broad yellow-scaled inner dorsocentral line; pleural scale patches moderately large, white to dingy white or yellowish; postspiracular scales absent or few (1-4); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia usually with patch or streak of cream-colored scales in middle dorsally; claws of hindtarsus slender, evenly curved, usually with short triangular tooth; costal vein dark-scaled; vein R with creamy white scales in basal 0.30-0.35; vein Cu usually dark-scaled, sometimes with a few light scales at base. Male genitalia with coxite broad basally, abruptly narrowed apically, its basal mesal surface with dense mass of setae, its mesal surface with row of 5-8 long, sharp spiniform setae that are thicker beyond their bases and 1 or more rows of hairs dorsad of spiniform setae, its apical projection moderately large and with numerous (12-16) hairs; stylus with many hairs distally, its apex broad, rounded. Larva with head mainly yellowish to light brown; antenna concolorous with or lighter than antennal prominence; seta 4-C far forward on head capsule; setae 5,6-C single,

abruptly pointed; seta 13-C weakly developed, short; siphon index 2.3-3.1; seta 1-S weakly developed, inserted within pecten; pecten teeth 14-17 (14-21), apical 2-4 teeth enlarged, simple, often more strongly pigmented than more basal teeth; anal saddle incomplete; anal gills normal.

Distribution: I have examined specimens of palpalis from Central African Republic, Uganda and Zaire. The species was recorded from southern Sudan by Lewis (1945:2, 12). The record of palpalis from southern Zaire by McIntosh (1971:332) is erroneous, as the female specimens described by him are bequaerti. The record of palpalis from The Gambia by Mattingly (1963:169-170) is also erroneous, as the species recorded by him is actually species 6. In Central African Republic the species was common in gallery forests in regions of savanna woodland and in tropical rainforest.

Remarks: Females of palpalis, like females of most species of Neomelaniconion, are quite variable, and some specimens simply cannot be identified by means of keys. Most of the material available for study was collected by me in Central African Republic, and is unequivocally identified by association with males in progeny series. Some females of palpalis have light or mixed light and dark scales on the underside of the proboscis. Some have the light-scaled patch or streak in the middle of the hindtibia reduced to only a few light scales or completely lack the light scales. Most females of palpalis have toothed hindclaws, but again there is variability, and some individuals have simple hindclaws. It is worth noting that males of palpalis always have simple hindclaws. The male genitalia of palpalis are very similar to, and perhaps indistinguishable from, those of bequaerti. This latter species is, though, easily distinguished from palpalis on colorational features. Edwards (1941:209-210) described palpalis as having the hindtibia dark in the middle and separated the species in his key on this basis. As noted above, while some specimens of palpalis lack light scales in the middle of the hindtibia, most do have a light-scaled patch or streak in this position.

Aedes (Neomelaniconion) pogonurus Edwards

1936. Aedes pogonurus Edwards, 1936:52. TYPE: Holotype male, Stanleyville, Haut Zaire, Zaire (BM).

Description: Female unknown. Male genitalia with coxite apparently broad basally and gradually narrowing toward apex, its tergolateral and sternal surfaces with dense masses of long bristles, its basal mesal surface without setae, its mesal surface with 3 spiniform setae, its apical projection large, with many hairs; basal tergomesal lobe of coxite with 1 spiniform seta; mesal surface of coxite membranous; stylus bulbous

apically, with dense mass of hairs. Larva unknown.

Distribution: Aedes pogonurus is known from only regions of tropical rainforest in Central African Republic and Zaire.

Remarks: In so far as I know, only three males of pogonurus have ever been collected: the holotype from Zaire, a male from Central African Republic collected by Bernard Geoffroy, and another male collected from there by me. The genitalia of all three of these males are the same and are, perhaps, the most distinctive in the subgenus. Noteworthy genitalic characters unique in Neomelaniconion are the presence of only one spiniform seta on the basal tergomesal lobe of the coxite and the membranous mesal surface of the coxite. Edwards (1941:211) considered several females of Neomelaniconion from Stanleyville collected by Mouchet to belong to pogonurus. I have seen at least some of these specimens and consider them to be palpalis, although those with particularly well-developed light-scaling on the proboscis and hindtibia may be another species, and could actually be females of pogonurus. The numerous hairs on the swollen apex of the stylus of the genitalia suggest a relationship with papalis and carteri.

Aedes (Neomelaniconion) punctocostalis Theobald

1909. Banksinella punctocostalis Theobald, 1909:14-15. TYPE: Holotype female, Obuasi, Ashanti, Ghana (BM).
1936. Aedes monotrichus Edwards, 1936:52. TYPE: Holotype male, Onitsha, Anambra State, Nigeria (BM).

Description: Female similar to maculicosta but differing as follows: band on proboscis usually complete, conspicuous, yellow-scaled; pleural scale patches larger, denser, creamy-yellow; postspiracular scales usually present, in small to moderate-sized patch; light scales in middle of hindtibia usually in incomplete band, conspicuous, yellow; costal vein partly to nearly completely yellowish-scaled in basal 0.5-0.6; costal patches larger, yellowish, often extending farther posteriorly on wing to veins Cu_1 and R_{4+5}; vein R with yellowish scales in basal 0.45; vein Cu with light scales extending from base to basal part of Cu_2. Male genitalia with tergum IX bearing 4-9 long bristles on each side; coxite gradually tapered from base to apex, its basal mesal surface with moderately dense setae, its distal mesal surface with numerous, closely spaced, short spiniform setae, its apical projection small, with 1 bristle; stylus slender, without hairs or spicules. Larva in general similar to maculicosta, but apex of ventral surface of siphon with enlarged spicules; seta 1-S inserted at end of or beyond pecten; apical 1,2 pecten teeth enlarged, last tooth not extending beyond apex of siphon; anal saddle complete.

Distribution: I have examined specimens of punctocostalis from Ghana, Ivory Coast, Liberia, Nigeria and Zaire. All specimens collected by me in Ivory Coast were from regions of tropical rainforest.

Remarks: Aedes punctocostalis is one of the most distinctive species in the subgenus and can be readily identified as females, male genitalia or larvae. The larva is the only one in the subgenus with a complete anal saddle. Edwards (1936:52) described the male of punctocostalis as monotrichus. I have associated the sexes of punctocostalis by means of progeny rearings, and can state unequivocally that males of monotrichus are conspecific with females of punctocostalis. At the time he described monotrichus, Edwards (1936:52) considered females collected at Lagos by Philip to belong to this species. I have identified only two species in Philip's material, punctocostalis and carteri, and believe that the specimens erroneously considered to be females of monotrichus by Edwards were actually carteri.

Aedes (Neomelaniconion) taeniarostris Theobald

1909. Banksinella taeniarostris Theobald, 1909:13-14. TYPE: Syntype females, Obuasi, Ashanti, Ghana (BM).
1909. Banksinella chrysothorax Theobald, 1909:13. TYPE: Syntype male, Obuasi, Ashanti, Ghana (BM).

Description: Female with scales on vertex of head and sides of scutum pale yellow to yellow; proboscis much longer than forefemur, with submedian ventral patch or incomplete to complete band of cream-colored or yellowish scales; lateral scutal stripe broad; disc of scutum dark brown-scaled, with narrow to moderately broad yellow-scaled inner dorsocentral line; pleural scale patches moderately large, white to cream-colored or yellowish; postspiracular scales usually absent (0-3); posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia usually with patch, line or streak of yellowish scales in middle dorsally; claws of hindtarsus simple; costal vein dark-scaled; vein R with creamy white to yellowish scales in basal 0.35-0.40; vein Cu with light scales in basal 0.10-0.60. Male genitalia with coxite broad to near apex, its basal mesal surface with relatively few setae, its mesal surface without conspicuous spiniform setae, its apical projection small, but with many hairs; stylus conspicuously expanded along inner edge, abruptly narrowed at apex, with very long, slender, curved spiniform, without hairs or spicules. Larva with head mainly light brown; antenna usually darker than antennal prominence; seta 4-C close to 5,6-C; setae 5,6-C multiple; seta 13-C strongly developed, long; siphon index 3.2-4.0; seta 1-S moderately strong, inserted within pecten; pecten teeth 14-18 (14-20), apical 1-3 teeth

enlarged; anal saddle incomplete; anal gills normal.

Distribution: I have examined specimens of taeniarostris from Central African Republic, Ghana, Ivory Coast, Nigeria, and Zaire. The species has been reported also from Uganda by Haddow et al. (1951:226). In both Central African Republic and Ivory Coast, this species was collected in regions of tropical rainforest and in gallery forests in regions of savanna woodland. Also, in both these countries taeniarostris was one of the commonest species of Neomelaniconion encountered.

Remarks: The male genitalia and larva of taeniarostris are among the most distinctive in the Forest Section. Females are apparently indistinguishable from those of species 3, and are quite similar to several other species as well, so that identification of them can be difficult, if not impossible. It is perhaps worth repeating that the hindtarsal claws of female taeniarostris are simple and this serves to separate the species from some of the other common species of Forest Section Neomelaniconion, such as carteri, palpalis and species 10, which have toothed hindclaws in the female. As is the case with several other species of Neomelaniconion, females are extremely variable. All specimens of taeniarostris from Central African Republic and Ivory Coast reared by me are progeny series, so females are unquestionably identified through association with males. If I did not know the identity of many of these reared females, I would not suspect that they are taeniarostris. I would have misidentified them as other species or perhaps considered them to represent undescribed species. Particularly noteworthy variations in the very characteristics that are important in identifying female Neomelaniconion that have been seen in taeniarostris follow: the proboscis usually has a noticeable incomplete to complete submedian band or submedian ventral patch of light scales, but in some females the number of light scales is reduced to a very few that form a tiny, inconspicuous ventral spot. The disc of the scutum is usually dark brown-scaled with narrow to moderately broad yellow-scaled inner dorsocentral lines. The inner dorsocentral lines can be very weakly developed and incomplete, though, so that the disc is predominantly dark-scaled. At the other extreme of variation, the scutum can be almost completely yellow-scaled. In one small progeny series from Central African Republic, three of four females have the scutum nearly entirely yellow-scaled; the fourth is normal. The hindtibia usually has a conspicuous patch, line or streak of yellowish scales dorsally in the middle, but it can be completely dark-scaled in this area. And finally, the light-scaling of wing veins R and Cu can be conspicuously less or more than indicated in the description above. In another small progeny series from Central African Republic, vein R is light-scaled for 0.75 of its length in all three females reared.

Aedes (Neomelaniconion) species 1

Description: Female similar to maculicosta, but differing as follows: band on proboscis usually complete, conspicuous, cream-colored to yellowish; disc of scutum mainly yellow-scaled, some dark brown scales among acrostichal and dorsocentral bristles; pleural scale patches small to moderately large; posterior surface of midfemur and anterior and posterior surfaces of hindfemur mainly dark-scaled or at least the scales appearing dark at some angle of observation; costal vein partly light-scaled in basal 0.5-0.6; costal patches small to large; vein Cu light-scaled from base to basal part of Cu_2. Male genitalia with coxite gradually tapered from base to apex, its basal mesal surface with few setae, its mesal surface with dense clump of spiniform setae, its apical projection very slender; stylus conspicuously expanded along inner edge, abruptly narrowed to slender apex, without hairs or spicules. Larva with head mainly yellowish to light brown; antenna concolorous with or lighter than antennal prominence; seta 4-C forward of 6-C; seta 5-C 2-4b, subequal to 6-C; seta 6-C 2,3b; seta 13-C moderately strong, moderately long; seta 6-IV,V long, strong, single; siphon index 3.3-4.1; seta 1-S moderately strong, inserted beyond pecten; pecten teeth 8-13, all teeth similar in size, usually simple or some with 1 or 2 minute barbs; anal saddle incomplete; anal gills very long, with conspicuous dark tracheae.

Distribution: This undescribed species is definitely known from only Central African Republic and Ivory Coast. A single female from Zaire is provisionally placed with this species, but it may represent species 11. In Ivory Coast this species was collected in gallery forest in regions of savanna woodland and in regions of tropical rainforest. In Central African Republic it was collected only in tropical rainforest.

Remarks: Species 1 and species 11 are noteworthy in having spotted wings, like maculicosta and punctocostalis, in the females, and in having extremely long anal gills with conspicuous, large, dark tracheae in the larvae. The modified larvae of these species are unlike the larvae of any other known African species of Aedes, but are similar to other species of Aedes in the subgenera Ochlerotatus and Verrallina from other geographic regions. The male genitalia of species 1 and species 11 are apparently indistinguishable and are actually very similar to those of bolensis, a species in the Savanna Section. Abdominal terga VI and VII of species 1 and species 11 are sometimes banded, and in this respect these species also resemble those in the Savanna Section.

Aedes (Neomelaniconion) species 2

Description: Female with scales on vertex of head and

sides of scutum yellow to golden yellow; proboscis shorter than forefemur, dark-scaled; lateral scutal stripe broad; disc of scutum dark brown-scaled with numerous scattered yellow scales; pleural scale patches moderately large, cream-colored to pale yellowish; postspiracular scales 1-3; posterior surface of midfemur white-scaled to apex ventrally; anterior and posterior surfaces of hindfemur white-scaled to apex ventrally; hindtibia with patch or long streak of yellowish scales dorsally in middle; claws of hindtarsus simple; costal vein with some pale scales scattered in basal 0.1-0.2; vein R with cream-colored to pale yellowish scales in basal 0.30-0.35; vein Cu with light scales in basal 0.3. Male genitalia very similar to fuscinervis, differing primarily in the enlargement of 3 or 4 spiniform setae on mesal surface of coxite and the absence of bristles on apicomesal portion of sternal surface of coxite. Larva very similar to maculicosta, differing mainly in the longer siphon (index 2.4-2.9); pecten teeth 13-17 (12-18), apical 2-4 elongate, sometimes simple, apex of last tooth usually not extending beyond apex of siphon.

Distribution: Species 2 was collected in tropical rainforest at the Station D'Ecologie Tropicale, near Tai, Guiglo Prefecture, in western Ivory Coast.

Remarks: The affinities of species 2 are enigmatic. Females resemble palpalis in habitus, but differ from that species in having simple hindclaws. In the key to females, species 2 runs to the vicinity of bergerardi, taeniarostris and species 3, but it differs from all these species in possessing a shorter, dark-scaled proboscis, and more diffuse yellow-scaling on the disc of the scutum. The genitalia of males of species 2 are similar enough to fuscinervis and species 6 to suggest a close relationship. The larva, on the other hand, is very similar to that of maculicosta. Adding to the uncertainty about its affinities if the sculpturing of the inner chorion of the egg, which is unique in the subgenus: species 2 is the only Neomelaniconion with the inner chorion of the middle portion of the egg sculptured; all other species in the Forest Section have the sculpturing restricted to the ends of the egg.

Aedes (Neomelaniconion) species 3

Description: Female apparently indistinguishable from that of taeniarostris. Male genitalia with coxite broad basally, narrowed apically, its basal mesal surface with moderately dense to dense setae, its mesal surface with dense clump of short to long spiniform setae, its apical projection moderately large, with many hairs; stylus expanded along inner edge, narrowed apically, with thin crest along distal outer edge, with numerous spicules. Larva in general similar to maculicosta, but differing as follows: setae 5,6-C long attenuate; siphon index 2.3-2.5;

seta 1-S inserted beyond pecten; apical 1, 2 pecten teeth enlarged, last tooth not extending beyond apex of siphon.

Distribution: I have collected species 3 in rainforest in Central African Republic and Ivory Coast. Some records of taeniarostris based on females could actually pertain to this species.

Remarks: The affinities of species 3 are obscure. Although females of species 3 are apparently indistinguishable from those of taeniarostris, the male genitalia and larvae of these species are so different that I doubt that they can be related. If male genitalic characters of species 3 are indicative of relationship, then they suggest an alliance with fuscinervis and similar species. If, on the other hand, larval features are the best for showing relationship, then species 3 is allied to maculicosta, punctocostalis, and species 2.

Aedes (Neomelaniconion) species 4

Description: Female unknown. Male genitalia most similar to punctocostalis, differing in the presence of only 2 hairs on each side of tergum IX; fewer hairs on basal mesal surface of coxite; longer spiniform setae on mesal surface of coxite; presence of several hairs on apical projection of coxite; stylus bent inward near apex. Similar also to maculicosta but differing in the less clumped and more uniformly long spiniform setae on mesal surface of coxite, the sparser setae on basal mesal surface of coxite, the smaller apical projection of coxite, and the slender, bent stylus. Larva unknown.

Distribution: Presently known from a single male from the Station D'Ecologie Tropicale, near Tai, Guiglo Prefecture, Ivory Coast. The region is tropical rainforest.

Remarks: Little can be said about this species because it is so imperfectly known. As noted above, the genitalia show similarities to both punctocostalis and maculicosta, so the species could be related to either or both of those species. Since both punctocostalis and maculicosta have light-scaled patches on the wings, it seems reasonable to expect the female of species 4 to be similarly colored.

Aedes (Neomelaniconion) species 5

Description: Female very similar to palpalis, but claws of hindtarsus abruptly curved beyond long, slender tooth, the distal portion of claw subparallel with tooth. Male genitalia in general similar to palpalis, but differing conspicuously in the absence of a dense mass of setae on the basal mesal surface of

the coxite; mesal surface of coxite with row of 3-5 spiniform setae; apical projection of coxite also with fewer (4-8) hairs. Larva very similar to palpalis, distinguished from it by the more strongly pigmented head, siphon, and anal saddle.

Distribution: This species is known at present from only a few specimens collected in the region of tropical rainforest southwest of Bangui, Central African Republic.

Remarks: Species 5 is undoubtedly related to palpalis, with which it occurs in Central African Republic. Females and larvae of these species are very similar. The genitalia of the males are very similar in some details, but strikingly different in others. It is tempting to hypothesize that the differences in the genitalia play some major role in the reproductive isolation of these sympatric species.

Aedes (Neomelaniconion) species 6

Description: Female very similar to jamoti, but with the following differences: scales on vertex of head and sides of scutum more distinctly yellow; proboscis dark-scaled beneath; lateral scutal stripe moderately broad to broad; disc of scutum dark brown-scaled with scattered yellow scales or weakly developed, incomplete yellow-scaled inner dorsocentral line; pleural scale patches white to creamy white. Male genitalia very similar to fuscinervis, differing in the fewer bristles on the apicomesal sternal surface of the coxite. Larva very similar to fuscinervis, differing in shorter siphon (index 1.7-1.8) and fewer pecten teeth (12-15 (12-18)).

Distribution: This species is known from only The Gambia and Liberia. The records of palpalis females and fuscinervis males from The Gambia by Mattingly (1963:169-170) refer to this species.

Remarks: I have not collected this species and have seen only a few museum specimens of rather poor quality. The species is undoubtedly related to fuscinervis, but differs conspicuously in having a moderately broad to broad stripe of yellow scales on each side of the scutum.

Aedes (Neomelaniconion) species 10

Description: Female very similar to carteri, but claws of hindtarsus more slender, weakly pigmented, with short, triangular tooth. Male genitalia very similar to carteri, differing primarily in position of dense mass of setae on basal mesal surface of coxite, the mass being parallel to long axis of coxite. Larva apparently indistinguishable from that of carteri.

Distribution: Species 10 is at present known definitely from only Ghana and Ivory Coast. Edwards's (1941:210) record of carteri from Liberia may refer to this species. In Ivory Coast this species was collected only in regions of tropical rainforest. The tongue of savanna woodland known as the Dahomey gap is most likely the geographic barrier separating species 10 and carteri.

Remarks: This species is so similar to carteri in all stages that there can be no doubt about their close relationship. The primary distinction between these species is the slight but constant difference in the position of the dense mass of setae on the basal mesal surface of the coxite of the male genitalia. This species was very common in Ivory Coast.

Aedes (Neomelaniconion) species 11

Description: Female very similar to species 1 and perhaps not distinguishable from it, but the few specimens available for study with proboscis band broader and with reduced light-scaling in basal 0.5 of costa. Male genitalia apparently indistinguishable from species 1. Larva in general similar to species 1, but differs as follows: seta 5-C 2b, longer and stronger than 6-C; seta 6-IV,V short, moderately strong; siphon index 4.2-5.2; seta 1-S weak; pecten teeth 12-14, proximal teeth toothed, apical 2,3 teeth enlarged, simple or barbed.

Distribution: Aedes (Neomelaniconion) species 11 is definitely known from Central African Republic and Ivory Coast. A single female from Zaire provisionally identified as species 1 may belong here. In both Central African Republic and Ivory Coast I collected this species only in tropical rainforest.

Remarks: Both Bernard Geoffroy and I collected the long-gilled larvae of this species among the leaves in the bottom of a densely shaded forest pool in Ivory Coast and reared them to adulthood, and both of us were surprised to find that the species was a Neomelaniconion. Species 11 is obviously related to the very similar species 1; the few distinctions between them are given above. For general comments about the variation in wing patches in those Neomelaniconion that are so marked, see maculicosta. In species 11 the apical wing patch may be absent or represented by only one scale.

Savanna Section

Description: Females with basal band of light scales on abdominal terga II-VI. Males with tips of longest teeth at apex of aedeagus widely separated. Pupae with weakly developed cuticular facets on ocular plate; trumpet gradually broadened

distally; seta 9-VII stronger and longer than seta 6-VII. Larvae with combination of head setae 5,6-C branched, siphonal seta 1-S inserted distad of base of last pecten tooth, antenna moderately to strongly pigmented and darker than antennal prominence, and anal gills not unusually long and without conspicuous dark tracheae. Eggs moderately broad to broad, length to width ratio 2.2-3.2; inner chorionic reticulum indistinct.

Distribution: Widespread in areas of savanna woodland, wooded steppe, grassland and semidesert scrub in north, east and southern Africa, although one species (circumluteolus) occurs also in areas of tropical rainforest in west and central Africa. Occurs also in the Oriental, Australian and southern Palearctic regions.

Remarks: The Savanna Section of Neomelaniconion consists of 11 species, nine of which are endemic to the Ethiopian Region. The species are most reliably identified as adult females. In those regions of Africa where two or three species occur sympatrically, characteristics of the male genitalia are also useful in distinguishing them. Larvae of most species are apparently indistinguishable. The relationships of the species are not obvious because of the mosaic pattern of distribution of taxonomic characters among the species.

None of the 11 species recognized in the Savanna Section is undescribed, although one (albothorax of authors) is without a valid name. One (bolensis) is transferred to the section from the Forest Section, and one (linealis) is resurrected from synonymy. One name (aureus) is reduced to synonymy with lineatopennis.

Aedes (Neomelaniconion) albicosta (Edwards)

1913. Banksinella luteolateralis var. albicosta Edwards, 1913:47-48. TYPE: Holotype female, Wangi, Coast Province, Kenya (BM).

Description: Female with scales on vertex of head and sides of scutum white; proboscis with long streak of pale or mixed pale and dark scales on underside; acrostichal bristles not developed; scales of disk of scutum tan to light brown, much lighter than dark brown to black scales on scutal angle; pleural integument dark brown to black; lower mesepimeral bristles usually 4-6 (3-6); pleural scale patches small to moderately large, white to dingy white; subspiracular scales broad, flat; posterior surface of mid- and hindfemora dark-scaled in apical 0.3-0.4; anterior surface of hindfemur dark-scaled or partly or entirely white-scaled in basal 0.2-0.4; claws of hindtarsus simple; costal fringe white-scaled in apical 0.3-0.4; vein R with creamy white scales from base to or nearly to base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M mostly whitish; veins

R_{4+5}, Cu1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with broad basal bands of white scales; abdominal sterna with mixed light and dark scales, the light scales usually particularly abundant on segments V, VI, creamy-white to tannish white. Male palpus with many long hairs on distal 0.5 of shaft, segment 4 long, thickened, with very numerous long hairs, those in middle of outer side shorter; coxite of genitalia gradually tapering from base to apex, its basal mesal surface without rows of hairs tergad of bristles on mesal edge, its mesal surface with dense clump of spiniform setae arising from slightly convex area. Larva distinguished from all other species of the section by the 14 setae in the ventral brush.

Distribution: Apparently restricted to the northern portion of east Africa. I have examined specimens from only Ethiopia, Kenya and Somalia. Edwards (1941:206) and Harris (1942:184) record the species from Tanzania and Lewis (1945:12) records it from southern Sudan. All localities in Kenya, Somalia, and Tanzania from which the species is recorded are coastal. The records from Ethiopia and Sudan are from inland areas.

Remarks: Aedes albicosta is the most distinctive species in the Savanna Section. Particularly noteworthy are the absence of acrostichal bristles, the large number of lower mesepimeral bristles, the white-scaled costal fringe of the distal part of the wing, the whitish plume scales of the wing, the setation of the male palpus, and the 14 setae in the ventral brush of the larva. Two other species, albothorax and circumluteolus, lack acrostichal bristles and have scutal markings similar to those of albicosta. However, in these species the costal fringe and plume scales of the wing are dark, the ventral brush of the larva usually has only 12 setae, and the genitalia differ in shape and development of specialized setae. The male genitalia of albicosta are apparently indistinguishable from those of bolensis, luteolateralis and unidentatus. The similarities in the genitalia of these species may not indicate relationship, but may indicate instead the primitive form of the genitalia for the Savanna Section.

Aedes (Neomelaniconion) albothorax (Theobald)

1907. Banksinella luteolateralis var. albothorax Theobald, 1907: 470-471. TYPE: Holotype female, Inkutu, The Gambia (BM). The holotype of albothorax represents the same species as circumluteolus, not albothorax of authors. To prevent confusing name changes, a proposal requesting that the type status of the holotype of albothorax be suppressed, that a neotype representing albothorax of authors from Lake Mbaratumu, Coast Province, Kenya, be designated, and that

the names albothorax and circumluteolus be placed on the Official List of Names in Zoology will be submitted to the International Commission on Zoological Nomenclature.

Description: Female with scales on vertex of head and sides of scutum white; proboscis with long streak of whitish scales on underside; acrostichal bristles not developed; scales on disc of scutum tan to light brown, much lighter than dark brown scales on scutal angle; pleural integument dark brown to black; lower mesepimeral bristles usually 3-5 (2-7); pleural scale patches small to moderately large, usually yellowish white to tannish white; subspiracular scales broad, flat, or some narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.3-0.5; anterior surface of hindfemur white-scaled in basal 0.2-0.4; claws of hindtarsus simple; costal vein completely dark-scaled; vein R with creamy white scales from base to or slightly beyond base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M dark; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with broad basal bands of creamy white to yellowish white scales; abdominal sterna usually completely to nearly completely dark-scaled. Male palpus with many long hairs on distal 0.25 of shaft, segment 4 long, slender, with very numerous long hairs; coxite of genitalia broad basally, abruptly narrowed distally, its basal mesal surface with large area of setae extending far onto tergomesal surface of coxite tergad of bristles on very mesal edge, its mesal surface with 4-13 widely spaced, slender spiniform setae. Larva possibly distinguished from other species in the section by the weakly developed polygonal sculpturing on the frontoclypeus in combination with the usually double (single, double) seta 6-IV,V.

Distribution: Aedes albothorax is apparently restricted to the central portion of east Africa. I have examined specimens from Kenya, Mozambique, southern Sudan, Tanzania, Uganda, and eastern Zaire. Edwards (1941:205) records the species from Malawi (as Nyasaland). All published records of albothorax from The Gambia in West Africa are based on the holotype, which, as noted above, is actually a specimen of circumluteolus.

Remarks: Females of albothorax and circumluteolus are very similar and can be easily confused. Both species lack acrostichal bristles and have the plume scales of the wing dark. In the region where these two species are sympatric, both have similar scutal markings, with the scales on the disc of the scutum tan to light brown or brown, and the lateral stripes white or whitish. Characters of value in separating albothorax and circumluteolus are: the pleural scale patches, which are smaller and more sparsely scaled in albothorax, larger and more densely scaled in circumluteolus; the anterior surface of the hindfemur, which is rather inconspicuously white-scaled in the basal 0.2-0.4 in albothorax, but more conspicuously white-scaled in the basal 0.5 in circumluteolus; and the sterna, which are usually, but not

always, dark-scaled in albothorax, and usually, but not always, white-scaled to pale yellowish-scaled in circumluteolus. Additionally, the lateral scutal stripes are apparently always white in albothorax, whereas they may be creamy white to slightly yellowish in circumluteolus. In spite of the close resemblance between females of these two species, the genitalia of the males are quite different. The genitalia of albothorax is, in fact, the most distinctive in the Savanna Section.

Aedes (Neomelaniconion) aurovenatus Worth

1960. Aedes (Neomelaniconion) aurovenatus Worth, 1960:312-313. TYPE: Holotype female, Ndumu, Natal, South Africa (SAIMR).

Description: Female with scales on vertex of head and sides of scutum yellowish white to pale yellowish; proboscis with streak of slightly lightened scales in middle of underside; acrostichal bristles present; scales on disc of scutum pale yellowish to tannish cream, much lighter than the blackish scales on scutal angle; pleural integument dark brown to blackish; lower mesepimeral bristles 2, 3; pleural scale patches small to absent, scales dingy white to brownish when present; subspiracular scales usually absent, broad, flat when present; posterior surface of mid- and hindfemora dark-scaled in apical 0.3-0.4, the scales basad of these only indistinctly lighter; anterior surface of hindfemur dark-scaled; claws of hindtarsus simple; costal fringe pale yellowish-scaled in apical 0.4; vein R with pale yellowish scales from base to near apex of R_1; plume scales on veins Rs and basal half of M pale; veins R_{4+5}, Cu_1, Cu_2 and 1A pale yellowish-scaled; abdominal terga with very broad basal bands of white scales; abdominal sterna dark-scaled. Male palpus with few hairs on distal 0.15 of shaft, segment 4 moderately long, with numerous long hairs; genitalia similar to those of circumluteolus, but with the apical projection of the coxite larger (both longer and wider). Larva possibly distinguished from other species of the section by the absence of a common basal plate for setae 1,2-VIII and seta 1-VIII shorter than 0.33 length of the anal saddle.

Distribution: Known at present from only the very northeastern portion of South Africa.

Remarks: Females are easily distinguished from all other species of the Savanna Section by the completely to nearly completely pale yellow-scaled scutum and the pale yellow scales on wing veins R_1, R_{4+5}, Cu1 and 1A. The costal fringe is pale-scaled in the distal part of the wing, and in this respect the species is similar to albicosta. The pleural scale patches are very small or even absent, and in this respect the species is similar to lineatopennis.

Aedes (Neomelaniconion) bolensis Edwards

1936. Aedes bolensis Edwards, 1936:52. TYPE: Holotype male, Bole, Northern Province, Ghana (BM).

Description: Female with scales on vertex of head and sides of scutum yellow to golden yellow; proboscis dark-scaled; acrostichal bristles present; scales on disc of scutum yellow to golden yellow along inner dorsocentral line, otherwise very dark brown, concolorous with scales on scutal angle; pleural integument dark brown to blackish; lower mesepimeral bristles 1-3; pleural scale patches small, white to dingy white except for yellow on psp and hypostigial area; subspiracular scales broad, flat and/or narrow, curved, white to dingy white or yellow; posterior surface of mid- and hindfemora dark-scaled in apical 0.2-0.5; anterior surface of hindfemur dark-scaled or pale-scaled in basal 0.7; claws of hindtarsus toothed; costal vein completely dark-scaled; vein R with creamy white to pale yellow scales from base to or nearly to level of base of R_{4+5}; many plume scales on veins Rs, R_{2+3}, R_2, R_3 and M white to pale yellow; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with narrow to moderately broad continuous or medially interrupted basal bands of white to dingy white scales; abdominal sterna mainly dark-scaled. Male palpus with a few long hairs on distal 0.1 of shaft, segment 4 moderately long, with numerous long hairs; genitalia similar to those of albicosta. Larva distinguished from all other species in the Savanna Section by the relatively few (9-11) teeth on each side of the mental plate and by the shape of the siphon, which is bent dorsad subapically.

Distribution: Aedes bolensis occurs to the north of the heavily forested areas in west and central Africa. I have seen specimens from Burkina, Central African Republic, Ghana and Senegal.

Remarks: Edwards (1936:52) described bolensis from a single male from Ghana. This specimen lacked basal bands on the abdominal terga, and so Edwards placed the species in his Forest Group. However, examination of females shows that the species is more properly placed in the Savanna Section. The basal bands on the abdominal terga of females of bolensis vary from being very narrow and interrupted medially, to being moderately broad and continuous across the midline. Females of bolensis and mcintoshi can be difficult to separate; in some instances the only reliable difference between the species is the dentition of the hindclaws, which are toothed in bolensis, simple in mcintoshi. The larvae and male genitalia of these two species are amply distinct.

Aedes (Neomelaniconion) circumluteolus (Theobald)

1907. Banksinella luteolateralis var. albothorax Theobald, 1907: 470-471. TYPE: Holotype female, Inkutu, The Gambia (BM). The holotype of albothorax represents the same species as circumluteolus, not albothorax of authors. To prevent confusing name changes, a proposal requesting that the type status of the holotype of albothorax be suppressed, that a neotype representing albothorax of authors from Lake Mbaratumu, Coast Province, Kenya, be designated, and that the names albothorax and circumluteolus be placed on the Official List of Names in Zoology will be submitted to the International Commission on Zoological Nomenclature.

1908. Banksiella luteolateralis var. circumluteola Theobald, 1908:107. TYPE: Holotype female, Transvaal, South Africa (BM).

Description: Female with scales on vertex of head and sides of scutum white to pale yellow, yellow, or golden yellow; proboscis dark-scaled; acrostichal bristles not developed; scales on disc of scutum tan to light brown along inner dorsocentral line, otherwise brown to dark brown and slightly lighter than or concolorous with dark brown scales on scutal angle; pleural integument light to dark brown; lower mesepimeral bristle usually 1 (0-2); pleural scale patches large, white to very pale yellowish; subspiracular scales broad, flat; posterior surface of mid- and hindfemora white-scaled to near apex, at least ventrally; anterior surface of hindfemur completely white-scaled in basal 0.5; claws of hindtarsus simple; costal vein completely dark-scaled; vein R with white to creamy white scales from base to to near base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M dark; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with moderately broad to broad basal bands of white to creamy white scales; abdominal sterna usually completely to nearly completely white-scaled to pale yellowish-scaled, sometimes mainly dark-scaled. Male palpus with many long hairs on distal 0.20-0.25 of shaft, segment 4 moderately long, with numerous long hairs; coxite of genitalia slightly broadened basally and narrowed distally, its basal mesal surface with 1 or 2 rows of hairs tergad of bristles on very mesal edge, its mesal surface with 17-23 conspicuous, thickened spiniform setae. Larva apparently indistinguishable from that of most species in the section.

Distribution: Aedes circumluteolus is very widespread in sub-Saharan Africa, including even areas of tropical rainforest. It appears to be absent, through, from the arid southwestern region of the continent. I have seen specimens from Central African Republic, Ethiopia, The Gambia, Ghana, Ivory Coast, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Sudan, Uganda, Zaire and Zambia. De Meillon (1947:116) records the species from Bechuanaland.

Remarks: As noted above, circumluteolus is a junior subjective synonym of albothorax and a proposal to conserve the current usage of both names will be submitted to the International Commission on Zoological Nomenclature.

Females of circumluteolus and albothorax are easily confused. The characters which are of value in separating them are given in the remarks for albothorax. Females of circumluteolus and mcintoshi are often confused, but there is no justification for this since they differ in numerous ways, as indicated in the description. The color of the lateral stripes on the scutum of circumluteolus females varies geographically. In west Africa the scales of these stripes are normally bright yellow, in east Africa they are yellowish white to white, and in South Africa they are pale yellow. The color of the scales on the abdominal sterna is also variable. All or nearly all of these scales are usually white to pale yellow, but in some individuals in the northern part of the range some or even most of them are dark.

Aedes (Neomelaniconion) linealis (Taylor)

1913. Pseudohowardina linealis Taylor, 1913:57-58. TYPE: Holotype female, Townsville, Queensland, Australia (ANIC).

Description: Female with scales on vertex of head and sides of scutum golden yellow; proboscis with long streak of pale scales or mixed pale and dark scales on underside; acrostichal bristles present; scales on disc of scutum dark brown to black, concolorous with scales on scutal angle; pleural integument dark brown to blackish; lower mesepimeral bristles usually 3-4 (3-5); pleural scale patches very small to small, dingy white, pale yellowish or very pale tannish; subspiracular scales broad, flat or narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.3-0.4; anterior surface of hindfemur inconspicuously pale-scaled in basal 0.4-0.5; claws of hindtarsus simple; costal vein completely dark-scaled; vein R with creamy white scales from base to base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M dark; veins R_{4+5}, Cu1, Cu_2 and 1A dark-scaled; abdominal terga with broad basal bands of pale yellowish scales, the bands prolonged medially, subtriangular; abdominal sterna completely dark-scaled or with mixed light and dark scales. Male palpus with many long hairs on distal 0.25 of shaft, segment 4 moderately long, slender, with numerous long hairs; genitalia apparently indistinguishable from those of lineatopennis. Larva apparently indistinguishable from that of most species of the section.

Distribution: Aedes linealis is known definitely only from Australia. I have seen specimens from Northern Territory and Queensland.

Remarks: Aedes linealis is resurrected from synonymy with lineatopennis. Although linealis is very similar to lineatopennis, it differs in several colorational characters that are comparable in magnitude to the colorational differences between the Ethiopian species of the Savanna Section. In linealis the lines of pale scales on wing veins R and Cu are shorter than in lineatopennis, the plume scales of the wing are dark, and the basal bands of the abdominal terga are prolonged medially and subtriangular in shape.

Aedes (Neomelaniconion) lineatopennis (Ludlow)

1905. Taeniorhynchus lineatopennis Ludlow, 1905:133-134. TYPE: Lectotype female, Camp Gregg, Luzon, Philippine Islands (USNM; selection of Knight and Hull, 1953).
1955. Aedes (Aedes?) aureus Gutsevich, 1955:320-321. TYPE: Syntype females, Kraskino, Primorsky Kray, Union of Soviet Socialist Republics (LU).

Description: Female with scales on vertex of head and sides of scutum golden yellow; proboscis usually dark-scaled, sometimes with long streak of inconspicuously pale scales on underside; acrostichal bristles present; scales on disc of scutum dark brown to black, concolorous with scales on scutal angle; pleural integument dark brown to blackish; lower mesepimeral bristles usually 2-3 (1-3); pleural scale patches absent to very small, usually dingy white to pale yellowish; subspiracular scales broad, flat or narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.1-0.4; anterior surface of hindfemur dark-scaled or inconspicuously pale-scaled in basal 0.5; claws of hindtarsus simple; costal vein completely dark-scaled; vein R with creamy white to yellowish scales from base to beyond base of Rs to near level of base of R_{4+5}, plume scales on veins Rs, R_{2+3}, R_2, R_3 and M pale; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with moderately broad to broad basal bands of creamy white to yellowish scales, the bands convex or emarginate medially; abdominal sterna completely dark-scaled or with mixed light and dark scales. Male palpus with few long hairs on distal 0.1-0.15 of shaft, segment 4 moderately long, slender, with numerous long hairs; genitalia apparently indistinguishable from those of circumluteolus. Larva apparently indistinguishable from that of most species in the section.

Distribution: Aedes lineatopennis occurs in the Oriental Region and southern Palearctic Region. I have seen specimens from Burma, southern China, India, Indonesia (Amboina, Celebes, Java, Kabaena, Sumatra, Sumba, Timor), Malaysia (peninsular and Sabah), Republic of the Philippines, Sri Lanka, Thailand and Vietnam. The species has also been reported from Bangladesh by Ahmed (1987:191), Korea by Tanaka et al. (1979:422), Nepal by

Joshi et al. (1965:138), the Ryukyu Islands by Toma and Miyagi (1986:79) and the Union of Soviet Socialist Republics by Gutsevich (1955:320-321; as aureus).

Remarks: I have not seen the type of aureus and have not, in fact, seen any specimens of lineatopennis from the northeastern part of the reported range of the species. Aedes aureus is reduced to synonymy with lineatopennis until it is demonstrated that it is actually specifically or subspecifically distinct.

Aedes lineatopennis is similar to mcintoshi from the Ethiopian Region and linealis from the Australian Region. The characters that distinguish lineatopennis from these species are presented in the remarks for mcintoshi and linealis.

Very few of the specimens of lineatopennis available for study are of research quality. Considerable variation has been observed in the material examined. One of two females from southern China examined has a broad median stripe of yellow or mixed yellow and dark scales on the dorsal surface of the abdomen. The single female from Sabah examined has unusually narrow scutal stripes. Some females from the Philippines have white-scaled abdominal sterna.

Aedes (Neomelaniconion) luridus McIntosh

1971. Aedes (Neomelaniconion) luridus McIntosh, 1971:327-329. TYPE: Holotype female, Bethulie (3 mi. W), Orange Free State, South Africa (NIV).

Description: Female with scales on vertex of head and sides of scutum pale yellow to yellow or brownish yellow; proboscis dark-scaled or with some pale scales ventrally; acrostichal bristles present; scales on disc of scutum yellowish-brown or reddish brown to brown, concolorous with scales on scutal angle; pleural integument light brown to brown; lower mesepimeral bristles 1-3; pleural scale patches large, usually yellowish white to pale yellow; subspiracular scales narrow, curved; posterior surface of mid- and hindfemora light-scaled to apex ventrally; anterior surface of hindfemur white-scaled in basal 0.6 or white-scaled to apex ventrally; claws of hindtarsus toothed; costal vein completely dark-scaled; vein R with yellowish scales from base nearly to base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M mainly yellowish; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with moderately broad to broad basal bands of yellowish scales, terga III or IV-VI with narrower apical bands of yellowish scales; abdominal sterna completely yellow-scaled. Male palpus with many long hairs on distal 0.2-0.25 of shaft, segment 4 moderately long, thickened, with very numerous long hairs; genitalia very similar to those of circumluteolus but differing in the usually more tapered shape of the coxite. Larva

apparently indistinguishable from that of most species in the Savanna Section.

Distribution: Aedes luridus is apparently restricted to South Africa. All specimens examined were from the Orange Free State.

Remarks: A distinctive species, the females characterized by the usually pale yellow scutal stripes, large patches of scales on the pleuron, toothed hind claws, and yellowish plume scales on the wings.

Aedes (Neomelaniconion) luteolateralis (Theobald)

1901. Culex luteolateralis Theobald, 1901:71-73. TYPE: Lectotype female, Durban, Natal, South Africa (BM; selection of Edwards, 1915).

Description: Female with scales on vertex of head and sides of scutum golden yellow; proboscis dark-scaled; acrostichal bristles present; scales on disc of scutum mainly dark brown to blackish, concolorous with scales on scutal angle; pleural integument dark brown to blackish; lower mesepimeral bristles 1-3; pleural scale patches absent or small, usually dingy white to yellowish; subspiracular scales narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.4-0.5; anterior surface of hindfemur dark-scaled; claws of hindtarsus toothed; costal vein completely dark-scaled or costal fringe pale-scaled at very apex of wing; vein R with creamy white to yellowish scales from base nearly to apex of vein R_1; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M yellowish; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled; abdominal terga with broad basal bands of yellowish scales; abdominal sterna completely dark-scaled. Male palpus with few long hairs on distal 0.1-0.15 of shaft, segment 4 short to moderately long, slender, with few long hairs; genitalia apparently indistinguishable from those of albicosta. Larva apparently indistinguishable from that of most other species in the section.

Distribution: Aedes luteolateralis is known from only lowland areas along the Indian Ocean in South Africa. All specimens seen by me are from Natal Province. McIntosh (1971:329) records the species from Coffee Bay in Transkei Province.

Remarks: A distinctive species, characterized in the female by the reduced pleural scaling, toothed hindclaws and the very long line of pale scales on vein R. Some specimens reared in the laboratory from eggs laid by a female force-mated to a sibling had reddish brown scutal stripes rather than golden yellow ones. It is not known if this variation, caused by

increased melanin production, occurs in nature.

Aedes (Neomelaniconion) mcintoshi Huang

1907. Banksinella luteolateralis var. pallida Theobald, 1907:470. TYPE: Syntype female, Inkutu, The Gambia (BM). A proposal requesting that the name pallida be suppressed for the purposes of the Principle of Priority and be placed on the Official Index of Rejected and Invalid Names in Zoology will be submitted to the International Commission on Zoological Nomenclature.

1985. Aede (Neomelaniconion) mcintoshi Huang, 1985:109-114. TYPE: Holotype male, Onderstepoort, Transvaal, South Africa (USNM).

Description: Female with scales on vertex of head and sides of scutum golden yellow; proboscis dark-scaled; acrostichal bristles present; scales on disc of scutum mostly dark brown to blackish, concolorous with scales on scutal angle; pleural integument brown to blackish; lower mesepimeral bristles usually 1-3 (1-4); pleural scale patches moderately large, usually white to yellowish white or dingy white; subspiracular scales sometimes golden, narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.3-0.4, or light-scaled to near apex ventrally; anterior surface of hindfemur dark-scaled, or at least appearing dark-scaled at some angle of observation; claws of hindtarsus simple; costal vein completely dark-scaled; vein R with creamy white to yellowish scales from base to or slightly beyond base of Rs; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M yellowish; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with narrow to moderately broad basal bands of creamy white to yellowish scales; abdominal sterna completely dark-scaled. Male palpus with many long hairs on distal 0.15-0.25 of shaft, segment 4 moderately long to long, slender, with numerous long hairs; genitalia in general very similar to those of albothorax, but with the coxite narrowing more gradually from its base and its mesal margin nearly straight or only slightly concave where coxite narrows. Larva apparently indistinguishable from that of most other species in the section.

Distribution: Aedes mcintoshi is widespread in sub-Saharan Africa, but appears to be absent from regions of tropical rainforest and from the very arid regions of southwestern Africa. I have examined specimens from Angola, Bechuanaland, Ethiopia, The Gambia, Kenya, Nigeria, Senegal, South Africa, Sudan, Tanzania, Zaire, Zambia and Zimbabwe. Edwards (1941:203) records the species (as lineatopennis) from Uganda, and McIntosh (1971:324) examined specimens from Mozambique and South-West Africa.

Remarks: Huang (1985) concluded that the African lineatopennis was specifically distinct from the true lineatopennis of the Oriental Region, and she described the African species as mcintoshi. In her haste to publish, she did not examine types of any of the other Ethiopian species of Neomelaniconion in the Savanna Section, and so she did not discover that the African species had already been named pallida by Theobald in 1907. Since the name mcintoshi has been used extensively by mosquito workers in South Africa and the United States, a proposal requesting conservation of the name will be submitted to the International Commission of Zoological Nomenclature.

Females of mcintoshi and lineatopennis are very similar, but can be separated on the basis of the larger pleural scale patches and the shorter line of pale scales on wing vein R in mcintoshi. Males of these two species can be separated easily by genital characters, as noted in the key. Aedes mcintoshi is, in fact, one of the few species in the Savanna Section that can be readily identified by the male genitalia. Several other African species in the Savanna Section, namely bolensis, luteolateralis and unidentatus, resemble mcintoshi. Females of all these species are dark, with yellow to golden yellow scutal stripes and pale plume scales on the wing. All three of these other species differ from mcintoshi, though, by having a longer line of pale scales on wing vein R and, more importantly, by having toothed hindclaws.

Aedes mcintoshi is rather uniform throughout it range except for populations from the extreme southern end of its distribution. Females from the Orange River drainage system in South Africa have white-scaled abdominal sterna and conspicuous white-scaling in the basal half of the anterior surface of the hindfemur, and some females from adjacent regions exhibit one or the other of these features. Only one population, from Villiers, in the Orange River watershed, is well known, and in this population the eggs are not as broad as in other populations of mcintoshi examined.

Aedes (Neomelaniconion) unidentatus McIntosh

1971. Aedes (Neomelaniconion) unidentatus McIntosh, 1971: 325-326. TYPE: Holotype female, Olifantsvlei, Johannesburg, South Africa (NIV).

Description: Female with scales on vertex of head and sides of scutum golden yellow; proboscis dark-scaled or with streak of mixed indistinctly paler and dark scales on underside; acrostichal bristles present; scales on disc of scutum mainly dark brown, concolorous with scales on scutal angle; pleural integument light to dark brown; lower mesepimeral bristles 1-3; pleural scale patches moderately large to large, usually yellowish white to dingy white; subspiracular scales yellow or

golden, usually narrow, curved; posterior surface of mid- and hindfemora dark-scaled in apical 0.3 or white-scaled to apex ventrally; anterior surface of hindfemur white-scaled in basal 0.5-0.6 or white-scaled to apex ventrally; claws of hindtarsus toothed; costal vein completely dark-scaled; vein R with creamy white scales from base to beyond base of Rs or level of base of R_{4+5}; plume scales on veins Rs, R_{2+3}, R_2, R_3 and M yellowish; veins R_{4+5}, Cu_1 and 1A dark-scaled; vein Cu_2 light-scaled at least basally; abdominal terga with broad basal bands of creamy white to yellow scales; abdominal sterna dark-scaled, with mixed light and dark scales, or mainly pale yellow-scaled. Male palpus with many long hairs on distal 0.2-0.25 of shaft, segment 4 moderately long to long, slender, with numerous long hairs; genitalia apparently indistinguishable from those of albicosta. Larva apparently indistinguishable from that of most other species in the Savanna Section.

Distribution: Aedes unidentatus appears to be restricted to areas of grassland and savanna at higher elevations in east and southern Africa. Specimens have been examined from Basutoland, Kenya, South Africa and Zimbabwe.

Remarks: Aedes unidentatus is most similar to bolensis. Females of unidentatus differ from those of bolensis by having larger pleural scale patches and the anterior surface of the hindfemur more conspicuously white-scaled in the basal half.

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