MOSQUITOES of Medical Importance

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By Richard H. Foote and David R. Cook

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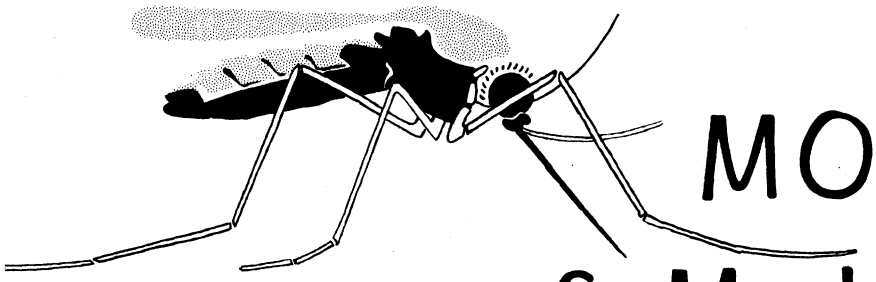


MOSQUITOES of Medical Importance

By Richard H. Foote and David R. Cook,[1] *entomologists,*
Entomology Research Division, Agricultural Research Service

Success in controlling arthropod-borne diseases during military operations is frequently dependent on the rapidity with which a situation can be correctly evaluated. This, in turn, depends on having or quickly obtaining an accurate picture of the populations of potential vectors of disease in the area under consideration, for the disease rate prevalent under normal conditions is not necessarily an index of the disease rate that may quickly develop. An important step in the assessment of the disease potential of an area is the rapid separation and identification of mosquitoes of primary medical importance. This task is frequently difficult or impossible, even for experienced taxonomists, unless adequate literature is at hand. Publications that fill this need have been generally lacking in the past. This situation has resulted in delays and errors in the activation of measures to protect troops and civilian populations.

Because of the lack of suitable guides for the entomological phases of preventive medicine during World War II, the Office of the Surgeon General, Department of the Army, began exploring ways and means of providing Medical Department personnel with concise and accurate guides to the medically important arthropods likely to be encountered in any part of the world where military operations might be necessary. Mosquitoes, being the most important insects from a military standpoint, received primary consideration. After a careful study of the problems entailed and the type of reference material needed by military preventive-medicine units in the field, it was decided to develop a series of pictorial keys that would aid in identifying the medically important mosquitoes of selected geographic regions. The task of developing these keys was assigned to the Insect Identification Division of the former Bureau of Entomology and Plant Quarantine in 1950. The work was supported by a transfer of funds from the Department of Defense to the Department of Agriculture. Under this program over 60 pictorial keys to medically important mosquitoes were developed.

Meanwhile, experiences of military preventive-medicine personnel during the Korean war contributed further evidence as to the needs of field units for reference materials. It was therefore decided to enhance the usefulness of the pictorial keys by supplementing summarized information about mosquito-borne diseases and by adding further details about the species of mosquitoes of medical importance. This handbook consists of the pictorial keys and the supplemental information. Although designed primarily for use of the Military Establishment, this publication should also prove useful to persons concerned with public-health programs. Furthermore, the information on those species that are vectors of the encephalitides makes evident the inseparable nature of medical and veterinary entomology.

The pictorial keys were designed to eliminate from consideration all species that are not medically important and those that are not known to be present in a region. The number of species requiring critical study is thus reduced. These keys can be used effectively by persons having a minimum of taxonomic training.

Published information pertaining to the biology and medical importance of the mosquitoes included in the keys has been summarized for each region and provides easily accessible data useful in the identification of vectors, their distribution, the diseases they carry, and the relative importance of the different vector species. The handbook is accordingly arranged in three sections. In the first section the diseases are described, in the second the geographic distribution and the relative medical importance of the disease-transmitting mosquitoes are given, and in the last section, entitled "Notes on the Medically Important Species," is summarized the published information pertaining to the bionomics, relation to disease, and recorded distribution for each species.

[1] Resigned August 28, 1953. Present address: Department of Biology, Wayne University, Detroit, Mich.

MOSQUITO-TRANSMITTED DISEASES

The diseases transmitted to man by mosquitoes include malaria, yellow fever, dengue, the encephalitides, and filariasis. Their importance, distribution, and epidemiology are described here.

MALARIA

Malaria is an acute, intermittent, febrile disease that sometimes persists in individuals for several years. It is prevalent between latitude 45° N. and 40° S. around the world and is responsible for more deaths per year than any other arthropod-transmitted disease.

Malaria is a collective term referring in humans to a group of four infections, each caused by a different species of Protozoa belonging to the genus *Plasmodium*. These species and the infections they cause are as follows:

1. *P. vivax*.—This species has the widest distribution of all the human malaria parasites. It causes benign tertian or *vivax* malaria, characterized by a fever every 48 hours due to a periodic maturation of parasites in the blood. Relapses are common.

2. *P. falciparum*.—This species tends to predominate in tropical and subtropical regions. It causes malignant tertian, subtertian, or aestivo-autumnal malaria, which produces febrile attacks usually every 48 hours. Relapses are rare.

3. *P. malariae*.—This parasite is distributed around the world between about latitude 53° N. and 30° S. It is responsible for quartan malaria, which is characterized by attacks of fever every 72 hours and persistent infections, possibly lifelong, which have been reported to cause relapses up to 60 years after the initial infection.

4. *P. ovale*.—This is a relatively rare species found in isolated areas of South America, certain parts of Africa, and the Orient.[2] It is widely distributed throughout western Africa, but its occurrence in the eastern part is spotty. It is responsible for *ovale* malaria, which is similar to *vivax* malaria, with febrile attacks at 48-hour intervals and subsequent relapses.

Chronic cases of *falciparum*, *vivax*, or *malariae* infections, but predominantly *falciparum*, may develop into a particularly dangerous complication of malaria known as blackwater fever. This is accompanied by a breakdown of large numbers of red blood cells in a short time, with hemoglobin in the urine. The subsequent physiological imbalance may result in a 25- to 50-percent death rate.

The four malaria infections are invariably transmitted among humans by mosquitoes belonging to the genus *Anopheles*. Female mosquitoes draw up the parasites along with human blood while they feed. Parasites enter the gut of the mosquito, undergo a series of developmental stages, and eventually invade her salivary glands. The female injects these parasites along with her saliva at a subsequent feeding.

If conditions are such that sufficient numbers of infected and susceptible persons are in close proximity to highly anthropophilic[3] vectors in which the parasites have matured, malaria transmission will usually occur. The severity of this transmission is classified as endemic, hyperendemic, or epidemic, depending on the abundance and proximity of the participating elements, the length of the transmission season, and other factors.

Only 85 of the approximately 400 species of *Anopheles* have definitely been incriminated in malaria transmission. They are included in the pictorial keys and discussed in detail in the other two sections of this handbook. The physiological factors that allow only the *Anopheles* species to carry human plasmodia are not well understood. Even less is known about the conditions that enable these parasites to mature efficiently in some species of *Anopheles* and not in others. Although our epidemiological knowledge concerning these differences has increased rapidly during the last three decades, the absence of malaria from some areas where known vectors abound even today remains largely unexplained.

References: *67, 246*.[4]

YELLOW FEVER

Epidemiologically the two principal forms of this disease are classical urban yellow fever and jungle yellow fever. Both are caused by the same mosquito-transmitted, filterable virus. The virus is picked up by the female mosquito with her blood meal and undergoes multiplication for 1 to 3 weeks in her body. The time required for this process depends in part on the temperature and humidity prevailing in the mosquito's habitat. At the end of this time the infection is transmissible to other hosts, and the mosquito remains infective during the remainder of her life.

The virus causes certain pathological and physiological changes in the liver of its mammal host, and a lifelong immunity is imparted upon recovery. When infected persons enter an area, about 2 to 3 weeks usually elapse before additional cases appear. This corresponds to the incubation period in the mosquito. The virus appears in the blood of an infected person for only the first 3 to 5 days after he has been bitten.

Classical urban yellow fever is principally an epidemic disease. It is transmitted by *Aedes aegypti*, a ubiquitous urban mosquito that breeds in artificial containers of all kinds close to human habitations. The disease is usually introduced by infected people into seacoast communities that have dense, nonimmune populations, and it is here that yellow fever appears in its most severe form.

Jungle yellow fever, although caused by the same virus, is epidemiologically very different from the classical type. It is primarily a disease of forest mammals, especially monkeys, and is transmitted by mosquitoes that live in forest environments and prefer monkey blood to that of man. It is always tropical in distribution. Forest mammals do not appear to form a reservoir, since, as in man, the virus disappears from their blood soon after they have been bitten by infected mosquitoes.

In eastern Africa this disease is typically that of forest-

[2] The Orient, as used in this handbook, includes the following regions: Afghanistan and West Pakistan, India and Ceylon, East Pakistan and Assam, South China, Formosa, Burma, Indochina, Thailand, Malaya, Sunda Islands, and Philippine Islands.

[3] For definitions of certain terms used in this handbook, see the Glossary, p. 151.

[4] These italic numbers refer to References, p. 143.

inhabiting monkeys. A monkey-to-monkey transmission cycle is believed to be maintained by *Aedes africanus* and possibly *A. vittatus*. These mosquitoes breed in tree holes and plant containers and inhabit the forest canopy. However, at ground level, especially in plantation areas, the principal vector is *Aedes simpsoni*. This species feeds on infected monkeys either outside or just within the forest, but, unlike *africanus* or *vittatus*, feeds on man as well, acting as a transmitter in the monkey-to-man cycle. *Aedes metallicus*, *A. luteocephalus*, *A. furcifer*, and *A. taylori* may act in much the same capacity as *simpsoni* to spread yellow fever from monkey to man. *A. aegypti* is believed by some workers to play a minor role in this activity.

In South America, jungle yellow fever is even more incidentally a disease of humans than in Africa. There appears to be no mosquito such as *simpsoni* to effect a monkey-to-man cycle. Therefore, all the human disease is contracted by people who work within the forest and come in contact with the canopy haunts of the vectors by climbing trees for various purposes or by those who cut timber and bring the vectors to the ground. It is primarily a disease of young men; women and children are rarely affected, because they seldom frequent the forests. *Haemagogus albomaculatus*, *H. equinus*, *H. spegazzinii falco*, *H. s. spegazzinii*, *H. capricornii*, *Aedes leucocelaenus leucocelaenus*, and *A. l. clarki* are the principal vectors of jungle yellow fever in Central and South America.

Since immunity to yellow fever is so strong and lasting, it is used to determine the distribution of the disease. Large areas of South America and Africa have been surveyed. Endemic areas in which the disease has occurred in the past have been delimited by the discovery of immunity in persons who have never had yellow fever vaccine.

Reference: *246*.

DENGUE

The virus causing dengue is similar in particle size to that of yellow fever. All 10 strains now known belong to 1 of 2 distinct immunological types, Hawaiian or New Guinea. All strains produce similar symptoms. The virus causes an acute illness accompanied by fever, and it is present in greatest concentration in the patient's blood during the first 24 hours. Immunity to any one strain lasts for the rest of the person's life.

Aedes aegypti, *A. albopictus*, and members of the *A. scutellaris* group transmit the disease in nature. Recent laboratory and epidemiological observations show that *Aedes polynesiensis*, a member of the *scutellaris* group, may be an important vector of dengue in Tahiti, Manua (American Samoa), and the Marquesas Islands. Experiments have shown that *scutellaris* itself is probably the vector of a jungle type of dengue in New Guinea, and possibly other members of the *scutellaris* group are capable of transmitting the disease elsewhere. The virus has been transmitted experimentally from one monkey to another by means of infected mosquitoes, and several species of monkeys are apparently susceptible to dengue. As far as is known dengue has no animal reservoir; it is transmitted directly from man to man by the mosquitoes mentioned above. The virus requires an incubation period of at least 8 days in the body of the mosquito before it can be transmitted in virulent form to susceptible persons. The mosquito is then able to transmit dengue for the remainder of its life.

Because the virus is present in monkey or human blood for such a short time, transmission of endemic dengue takes place only in areas that can supply *Aedes* vectors throughout the year. Dengue is endemic or epidemic in various regions of the South and Southwest Pacific; Hawaii; northern and eastern Australia; New Guinea; Indonesia; India; the countries bordering the South China Sea; Japan; much of tropical Africa and along the Nile Valley to the Delta; the countries bordering the northern shore of the Mediterranean; and some areas between latitude 10° N. and 10° S. in the Western Hemisphere, notably Trinidad. Our knowledge of the exact distribution of the disease in many parts of the world is still sketchy and inadequate. Epidemics, which have occurred in many of the regions mentioned, are believed to be due to the importation of the virus into areas containing large numbers of nonimmune people.

References: *246, 256, 289, 297, 356*.

THE ENCEPHALITIDES

The encephalitides include all the diseases caused by encephalitis and certain other closely related viruses and all are mosquito borne. Most of these viruses are relatively small, being about 15mμ to 30 mμ. They attack various parts of the central nervous system. Apparently humans are only incidental hosts of these viruses. Little is known about the natural reservoirs, overwintering characteristics, or exact mode of transmission of many of them.

Encephalitis Viruses

Western Equine Encephalitis.—The principal endemic region of this virus, where animals are the host, comprises all States west of the Mississippi River; also Wisconsin, Illinois, Indiana, Kentucky, Mississippi, Alabama, and Florida; and parts of Canada adjacent to these States. Recently this virus has been reported from Florida, Alabama, Tennessee, Kentucky, North Carolina, New Jersey, Michigan, and Illinois. The largest epidemic occurred in 1941 in Minnesota, North Dakota, and Canada.

Studies of natural infections and occurrences of the disease in the presence of large numbers of infected mosquitoes point to *Culex tarsalis* as the primary vector. This virus also is found in Argentina and possibly Peru and central Chile, but the vector in those countries is not known. Antibodies from domestic and wild birds and mammals have been isolated in nature, and mites from such animals have been shown to harbor the virus. Since *tarsalis* prefers these wild animals and birds as hosts, man is only incidentally infected. The virus appears to be maintained in nature chiefly by a bird-*tarsalis*-bird transmission.

St. Louis Encephalitis.—This virus appears sporadically in the Midwestern and Southwestern United States and has been reported in an almost continuous belt across the United States. It has endemic areas in Nevada, California, Oregon, and Washington. A large epidemic occurred in St. Louis in 1933 and a smaller one in 1937. Epidemiological studies there involved *Culex pipiens*, but the virus has only been isolated from mosquitoes in the Western United States. Considerable evidence indicates that *Culex tarsalis* is probably the primary vector of St. Louis encephalitis in the United States. Antibodies to this virus have been found in chickens and wild birds, and it has been isolated from chicken and wild-bird mites, indicating that this virus, like the western strain, probably has an animal reservoir from

which man is accidentally infected by mosquitoes whose hosts are not normally man. Recent investigations indicate that St. Louis encephalitis virus might have infected humans in Trinidad.

Eastern Equine Encephalitis.—This virus is found throughout eastern Canada and the Eastern and Southern United States east of the Mississippi River, and it has spread into Nebraska, Missouri, Arkansas, Louisiana, Texas, Mexico, Panama, Brazil, Dominican Republic, Cuba, and Trinidad. Encephalitis cases believed to be of the eastern equine type were noted in the lower Rio Grande Valley in 1941, and additional cases have been recorded in Michigan, Wisconsin, Missouri, and Arkansas.

Major outbreaks occur in horses and pheasants. Only two epidemics affecting humans have been recorded, one in Massachusetts in 1938 and one in Louisiana in 1947. Eastern equine encephalitis virus has been isolated many times from *Culiseta melanura*, indicating that this species may be the principal vector, although the available evidence indicates that other species may be involved. Wild birds are important in the dissemination of the virus, since antibodies frequently have been isolated from them. Pheasants are particularly suspected and domestic fowl are presumed to be reservoirs, since the virus has been isolated from their parasites.

California Encephalitis.—This virus has been recovered from *Aedes dorsalis* and *Culex tarsalis* in the central valley area of California. It has produced clinically inapparent infections in humans, horses, and other mammals in this area. The role of these mosquitoes in transmission is not exactly known.

Venezuelan Equine Encephalitis.—This virus is found in Panama, Trinidad, Venezuela, Ecuador, Colombia, and Argentina. In Espinal, Colombia, mild human infections were observed, although the extent to which this virus causes disease in humans is not known. In the laboratory it is highly infectious. In Venezuelan equine as well as eastern equine encephalitis, many mosquito species have been suspected of transmitting the virus. Available evidence indicates that *Mansonia titillans* is a vector. Few studies have been made of animal reservoirs of this virus.

Japanese Encephalitis.—Epidemics of Japanese encephalitis affecting large numbers of humans have occurred in Japan, Okinawa, Korea, and Guam. There is evidence of widespread infection in Malaya and Borneo, and the presence of this disease in India, eastern China, Burma, Thailand, Indochina, Formosa, Sumatra, and Java is suspected. Japanese and American workers have reported positive sera from the Philippines. The virus has been reported from Australia, but recent serological work indicates that Murray Valley virus is probably the agent there instead.

Abundant evidence exists that, at least in Japan, *Culex tritaeniorhynchus* is the important vector. The appearance of this mosquito in large numbers is usually followed by an increase in disease incidence, and naturally infected mosquitoes always appear at critical times during the course of an epidemic. In Russia the virus has been isolated from a mixture of *tritaeniorhynchus* and *Culex pipiens*. *C. tritaeniorhynchus* has been incriminated in other areas, such as Korea, Formosa, and Okinawa, by presumptive evidence alone, and at least in Okinawa no conclusive field investigations of the possible vector have been completed. In China *pipiens* alone has yielded this Japanese virus in nature. A blackbird, swift, and dove were found to have antibodies associated with an epidemic that occurred in Guam in 1947 and 1948, but the vector in that island is not known; *tritaeniorhynchus* does not appear there. In Malaya the virus has been isolated from four fatal human cases, but so far the vector is not known in that country. A form similar to the Japanese strain has recently been found in Indochina; its vector is likewise unknown.

Murray Valley Encephalitis.—This virus, apparently limited to Australia, is related to the Japanese, West Nile, and St. Louis encephalitis viruses. It has received little field study and its vector is not known, but *Culex annulirostris* and several other species are the most strongly suspected mosquitoes. Higher percentages of water birds harbor antibodies than any other bird or mammal species tested, although domestic land fowl also carry immunity. The large migratory-bird population in Australia is believed to carry the virus from its northern endemic centers southward to New South Wales and northern Victoria during years of heavy rainfall.

Other Mosquito-Borne Viruses

Epidemiological investigations of the following viruses from South America and Africa have not progressed far enough for positive identifications of vectors or animal reservoirs.

Bwamba.—This virus causes a disease with fever, headache, malaise, and conjunctivitis lasting for 4 or 5 days. It appears most commonly in eastern Belgian Congo, Uganda, western Kenya, and northern Tanganyika, and antibodies have been found in natives in Northern and Southern Rhodesia. Its mode of transmission is unknown.

Ilhéus.—This is a virus related to the West Nile, Japanese, and St. Louis encephalitis viruses. It has been observed in the Ilhéus area of Brazil and in Trinidad, where neutralizing antibodies have been found in humans. In both localities the virus has been isolated from mixtures of various species of mosquitoes, in which *Aedes serratus* and *Psorophora ferox* have predominated.

Rift Valley.—This virus in man causes a self-limited disease, with fever, severe headache, and other symptoms from which the patient recovers in several days. It is primarily a disease of sheep, cattle, and other animals in the Rift Valley and neighboring areas of Africa. An extremely high incidence of infection occurs in laboratory personnel who work with this virus. The principal vector suspects are *Aedes deboeri demeilloni*, *A. tarsalis*, and *Eretmapodites* spp., the virus having been isolated from wild-caught females.

Sindbis.—This virus is related antigenicly to eastern, western, and Venezuelan equine encephalitis viruses and has appeared in Egypt and Anglo-Egyptian Sudan. No information is yet available on its symptomatology, but antibodies to the virus have been detected in man, domestic animals, and birds. Human infections are frequent. It has been experimentally transmitted by *Culex pipiens* and *C. univittatus*.

West Nile.—This virus was first isolated from the blood of a woman with mild fever in the West Nile district of Uganda. It has been observed in Egypt, Israel, Kenya,

Belgian Congo, and Sudan. Antibodies in humans have been found in many parts of India. The virus is related antigenicly to those causing St. Louis, Murray Valley, and Japanese encephalitis and dengue and yellow fever. In a highly endemic area in Egypt no deaths or frank cases of encephalitis were attributed to it. The West Nile virus causes primarily an early-childhood disease, which is most prevalent during the summer. Nonmigratory birds and mosquitoes appear to form the primary cycle, and man and domestic animals are incidentally infected. In Egypt *Culex univittatus* is probably the most important vector. The virus has caused a self-limited and nonfatal disease in over 100 patients in Israel, most of them children.

In the widespread search for immunity to yellow fever, the following mosquito-borne viruses have been isolated from the blood of natives in Africa and the Americas. Little is known about their ability to produce disease symptoms in man. For additional details of distribution, see the discussions under the heading "Encephalitis" in the next section of this handbook.

Anopheles "A."—*Anopheles boliviensis* is the only vector of this virus that is reported with certainty. It is a South American virus, but its exact distribution is not known.

Anopheles "B."—*Anopheles boliviensis*, *Haemagogus spegazzinii*, *Aedes leucocelaenus*, and *Sabethes* sp. have been incriminated in the transmission of this virus. The distribution of this South American virus is not known with certainty.

Bunyamwera.—This virus has been isolated from mixed *Aedes* species in east Africa, and antibodies in humans have been found in Kenya, Uganda, Tanganyika, Belgian Congo, and possibly Egypt.

Ntaya.—This virus has been isolated in eastern Africa from pools of mosquitoes in which *Culex* spp. predominated.

Semliki Forest.—Antibodies to this virus have been found in some asymptomatic natives in Tanganyika and Uganda. *Eretmapodites grahami* and mosquitoes closely related to *Aedes abnormalis* are the suspected vectors.

Uganda S.—This virus has been isolated from pools of *Aedes* spp., in which *A. longipalpis* and *A. ingrami* predominated. Neutralizing human antibodies have been found in Kenya, Belgian Congo, and Tanganyika.

Wyeomyia.—*Wyeomyia melanocephala* appears to be the important species in the transmission of this virus. The distribution of this South American virus is not known.

Zika.—*Aedes africanus* is the suspected vector of this virus. Human antibodies have been discovered in Egypt, Belgian Congo, Tanganyika, and India, and the virus has been recovered from human blood in Nigeria.

References: *39, 43, 58, 109, 117, 153, 154, 156, 246, 257, 270, 274, 278, 281, 299, 325–327, 355, 356.*

FILARIASIS

Initial symptoms of filariasis last a week or 10 days and consist of regional inflammations, with fever, swelling, and stiffness. From 3 months to a year after these symptoms subside, a second phase usually starts with swelling in various lymph glands. In later stages elephantiasis sometimes occurs after repeated attacks. Caused by a wholesale stoppage of lymph flow over large parts of the body, elephantiasis results in the enlargement of the lower extremities, scrotum, and breasts, sometimes to extreme proportions.

Filariasis is caused by nematodes belonging to the superfamily Filaroidea. As adults these nematodes live, usually in pairs, in the lymphatic vessels, lymph nodes, and connective tissues of their human host. Sexually mature female worms in these locations produce embryonated eggs that hatch. The resulting larvae, or microfilariae, migrate to the peripheral blood, where they are picked up by mosquitoes as they feed. They penetrate the gut wall of the mosquito, undergo extensive morphological changes, and migrate to the proboscis, from which they emerge and enter the intact skin or the bite puncture of the person bitten at a subsequent feeding of the mosquito. They migrate in various paths to the lymphatics and connective tissues of their human host, where they eventually transform to adults and initiate another cycle.

Periodic filariasis is caused by *Wuchereria bancrofti* and *W. malayi*. The numbers of microfilariae of these two species alternately increase and decrease in the peripheral blood. This periodicity takes place every 24 hours, the greatest number of microfilariae occurring between 8 p. m. and 2 a. m. The mosquitoes that transmit periodic filariasis are those that are most active during the hours when microfilariae are most abundant in the peripheral blood of infected persons.

A nonperiodic filariasis occurs in certain areas of the Pacific. It is caused by a filaria that some workers have named *Wuchereria pacifica* and which is morphologically identical to *bancrofti*. Its exact taxonomic status has not been settled.

Although the life cycles of *malayi* and *bancrofti*, the symptoms they cause, and their adult stages are essentially alike, there are distinct morphological differences between their respective microfilariae. Diagnosis depends on their identification in the peripheral blood. Another important difference between the two species lies in their respective vectors. *W. malayi* is transmitted principally by *Mansonia* (subgenus *Mansonoides*) and *Anopheles* mosquitoes, whereas *bancrofti* is transmitted by various species of *Anopheles*, *Culex*, and *Aedes*.

References: *65, 162, 246, 321.*

GEOGRAPHICAL DISTRIBUTION AND RELATIVE MEDICAL IMPORTANCE OF DISEASE-TRANSMITTING MOSQUITOES, BASED ON PICTORIAL KEYS

In this study the world has been divided into 35 rather arbitrary geographical regions, because so much variation exists from one region to the next in the diseases transmitted by mosquitoes and in the kinds and distribution of these vectors. The extent of each region has been defined in part by the number of medically important species that could be conveniently included in a single-page pictorial key.

The following information has been given for each region:

1. The countries and/or parts of countries included there.
2. A brief description of the physical geography and outstanding features of temperature and rainfall.
3. The distribution of malaria and the distribution and

relative importance within the region of each of the important vectors included in the keys.

4. A list, compiled from the literature and personal communications, of all the *Anopheles* species reported from the region.

5. Discussions of yellow fever, dengue, the encephalitides, and filariasis, including their vectors.

making the keys, and discussions of that disease and its vectors are limited to the text, except when vectors of filariasis are also vectors of any of the other four diseases, for example *Anopheles sinensis* in North Europe and North Asia. A species was selected as important when it had been reported in the literature by unquestionable evidence as a vector in a region or in regions bordering it. A large number

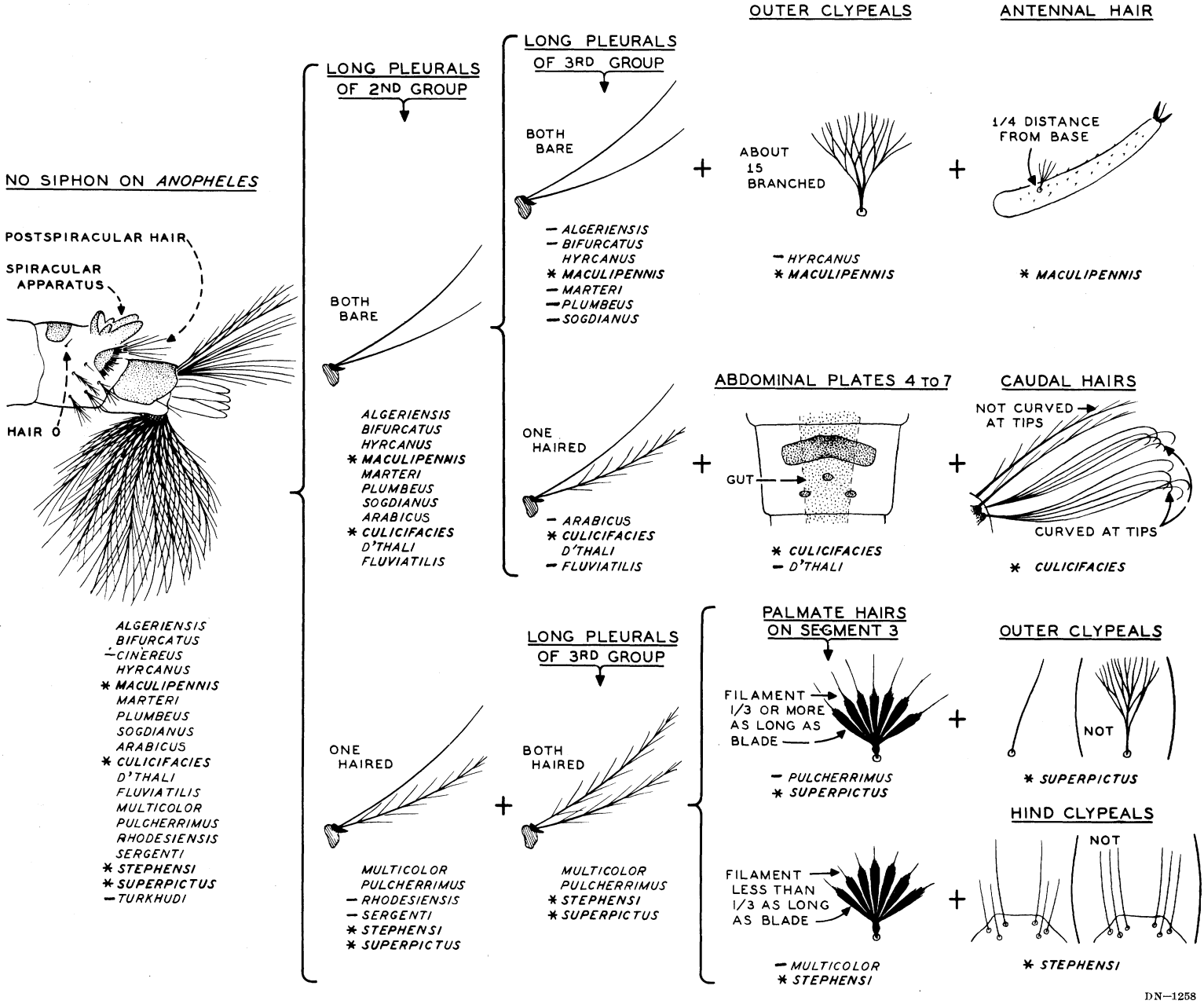


FIGURE 1.—Amplified part of key to Iranian *Anopheles* larvae.

One key to larvae and one to adults have been included for each region. All species of mosquitoes known to live in a given region were considered in the preparation of the keys. The species to be illustrated were selected on the basis of their importance in the transmission of the militarily important diseases malaria, yellow fever, dengue, and the encephalitides. Filariasis, therefore, was not considered in

of mosquito species incriminated from time to time in disease transmission are excluded from the keys, because they do not meet these criteria or because control of the particular disease does not necessarily depend on vector control. The subspecies are not always distinguished in the keys, primarily because of lack of space. In some regions they are not known.

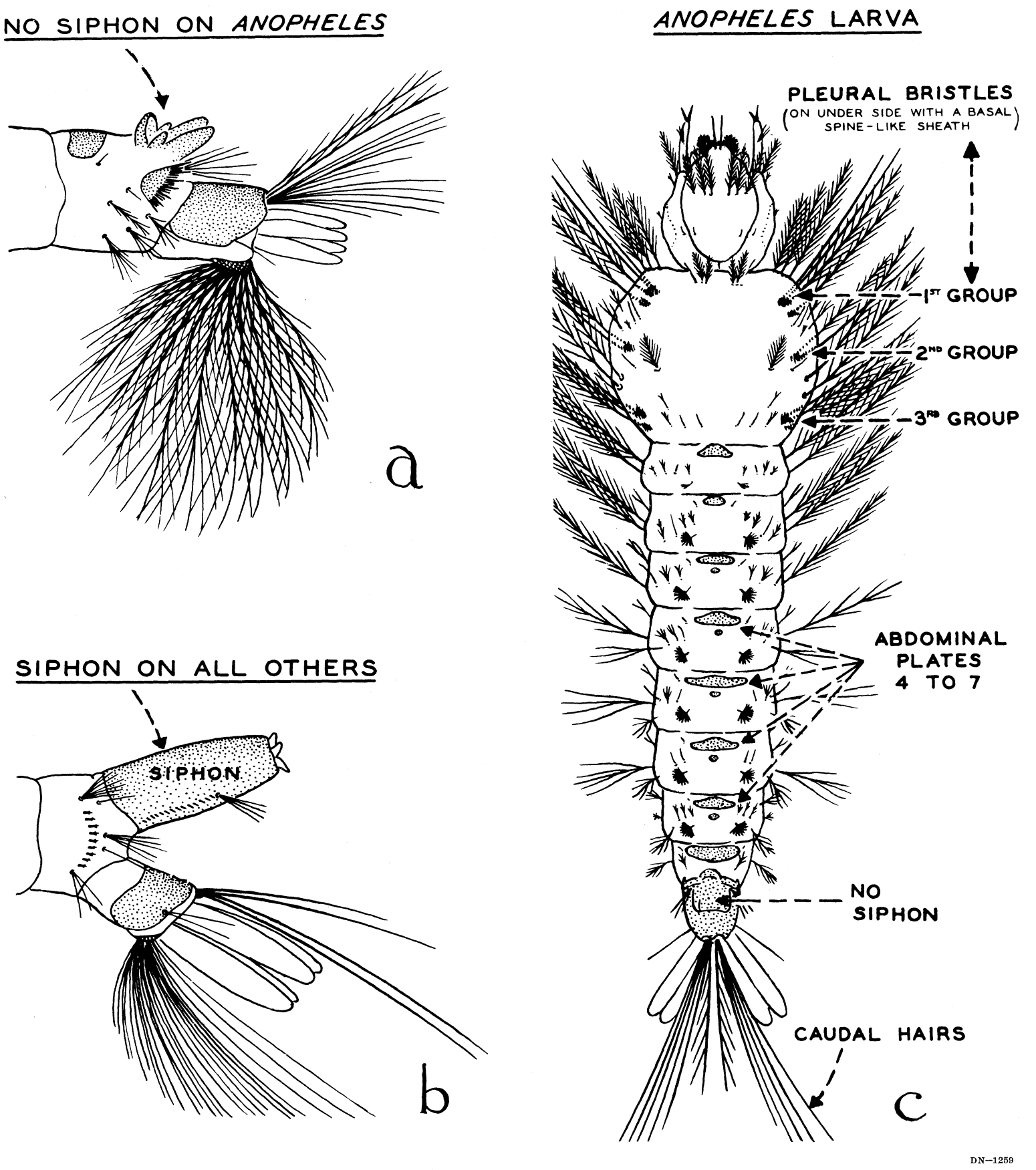


FIGURE 2.—Larval characters for use with the keys: *a*, Terminal abdominal segments of an *Anopheles* larva; *b*, terminal abdominal segments of a non-*Anopheles* larva, showing the siphon; *c*, top view of an *Anopheles* larva.

The following instructions should be read carefully before any attempt is made to identify specimens.

DIRECTIONS FOR USE OF THE KEYS

In order to demonstrate the technique for using the illustrated keys, a part of the Iranian larval key has been amplified, as shown in figure 1. The larval characters used in figure 1 and throughout the illustrated keys are shown in figure 2.

In order to use figure 1 to identify a larva, the specimen must be from Iran. If it lacks a siphon (see fig. 2, *a* and *b*) and its terminal abdominal segments resemble those shown in figure 1, column 1, under the heading "no siphon on *Anopheles*," it is an *Anopheles* larva. The *Anopheles* species known or thought to be in Iran are listed at the bottom of this column. The medically important species are designated by asterisks (*). The minus signs (−) indicate those species in each column that are not listed in the succeeding column, because they lack the combination of characters shown there.

In figure 1, column 2, under the heading "long pleurals of 2nd group" (see also fig. 2, *c*),[5] two possible choices are shown. If both long pleurals on the larva are bare, it belongs to one of the species listed under "both bare." If one of the long pleurals is haired, the larva belongs to one of the six species listed under "one haired." If both are haired, the larva is eliminated from further consideration, since larvae of all the medically important species in which this study is concerned happen to have one or both of the long pleurals of the second group bare.

If both long pleurals of the second group are bare, see figure 1, column 3. Two bracketed choices are given. If one of the long pleurals of the third group is haired and one is bare, it must belong to one of the four species listed under the second choice.

Be sure to follow specifically the directions implied by the brackets. The unbracketed key character labeled "long pleurals of 3rd group both haired" at the bottom of column 3 applies **only** to larvae possessing one haired second-group pleural (see bottom of col. 2). If it had had two haired second-group pleurals, it would have been eliminated from further consideration, since the key shows no larva with a combination of both second-group pleurals bare and both third-group pleurals haired.

If the larva has both second-group pleurals bare (see fig. 1, col. 2) and one third-group pleural haired (see col. 3), note the key characters in column 4. The plus (+) sign is an indication to continue as if a bracket were present. If abdominal plates 4 to 7 on the specimen conform to those in figure 1, column 4, the larva is one of the two species listed below "abdominal plates 4 to 7." If it possesses the curved caudal hairs shown in figure 1, column 5, under "caudal hairs," the specimen is *Anopheles culicifacies*. Thus it has been identified as a medically important species, because it has all the characters indicated in the key, and at the same time it has been separated from all other mosquitoes found in the region.

A specimen of *Anopheles sergenti*, a species that is dropped from the key as medically **unimportant** in Iran, can be run through the key as follows: Since the **larva** lacks a siphon, it is therefore an *Anopheles*. See the choice of characters in figure 1, column 2. As one of the long pleurals of the second group is bare and one is haired, refer to the bottom of column 3. Because the larva has one of the long pleurals of the third group bare, this character does not correspond to the only illustration provided. Therefore, the larva is rejected from further consideration, and the species is not medically important in the region treated by the key.

Accordingly, any species of *Anopheles* in Iran may be run through the key and either identified as medically important or dropped entirely from consideration at whatever point it fails to agree with the stated character or choice of characters.

Although geographical variation in species has been accounted for to the greatest possible extent, the user of these keys should be cautioned that **all** variation has not been illustrated in the keys. The entire range of variation of most of the species is not adequately known. It should also be understood that the illustrations usually depict the typical appearance. For distributional and biological data that might help to confirm the identification, consult the section of the text describing the specific region and also the description of the particular species in the last section of this handbook. Since many species have not been available for direct study, they are presented on the basis of the literature alone. An attempt has been made to verify the taxonomic characters of each of these species by correspondence with authorities familiar with them.

NORTH AMERICA

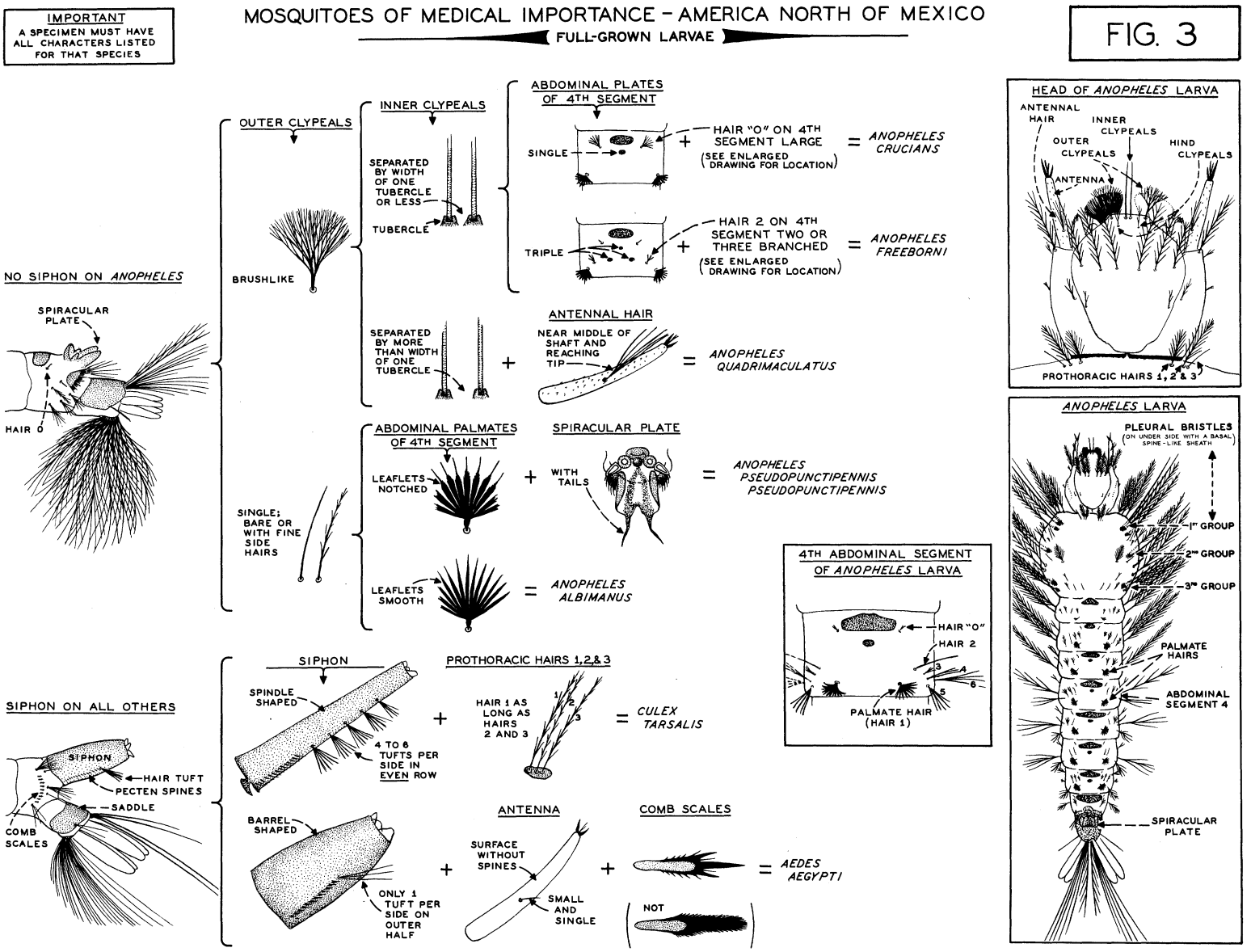
America North of Mexico

(Figs. 3 and 4)

Physical Features.—The territory covered by the accompanying keys (figs. 3 and 4) extends from the North Pole to the southern border of the United States along the Mexican border and the Gulf of Mexico, and from the Bering Strait to the eastern edge of Greenland. It includes Greenland, Alaska, Canada, and the continental United States. The principal western mountains forming the Continental Divide are the Rockies and the Alaska Range, which extend from the Arctic Ocean to New Mexico. Between these mountains and the Pacific Ocean are the Sierra Nevadas and Cascades in the United States. Except in scattered localities this west coast has no coastal plain. The Great Plains adjoin the eastern edge of the Rockies for most of their length. In northern Canada the Barren Grounds and Laurentian Plateau extend eastward, the latter to the Atlantic Ocean. A vast fertile lowland between central Saskatchewan and Hudson Bay extends south to the Gulf of Mexico. This is drained to the Gulf by the Mississippi-Missouri river system and to the Atlantic by the St. Lawrence. The only uplands in this region are the Ozarks and the Ouachitas in the South Central States. The Appalachians, including the White Mountains, and the Adirondacks comprise the main eastern highlands of the United States, the east coast of which is a narrow sandy plain, widening in the southeast corner to cover almost the entire peninsula of Florida.

Along the west coast the climate is moderate but becomes arid in the desert area of the Southwestern United States. From 20 to 40 inches of rain fall over the central plains; much of the south, southeast, and east coasts receive up to 60 inches, sometimes more. Eighty-five percent of Greenland, a great island basin encircled by a mountain chain,

[5] The first group of pleural bristles is not used in identifying larvae of Iranian *Anopheles*.



is covered with an icecap, with only the southwest coastal part suitable for limited agriculture.

Reference: *301.*

Malaria.—This disease is almost nonexistent in America north of Mexico. It became intense and widespread in the Eastern United States with the importation of slaves and the onset of the Revolutionary War, persisted throughout much of the settling of the West, and by 1850 had been reported from every State except North Dakota, Montana, Idaho, Wyoming, Utah, and Nevada. From its original focus in the Carolinas it spread slowly north and west, but since 1933 it has declined steadily. Reports of the United States Public Health Service indicate that malaria is no longer a medical problem, except for cases brought back to the States. These cases can serve as centers of infection under favorable conditions. Only 25 new indigenous cases were reported in 1952. Malaria control is limited to the treatment of areas in the immediate vicinity of each new case.

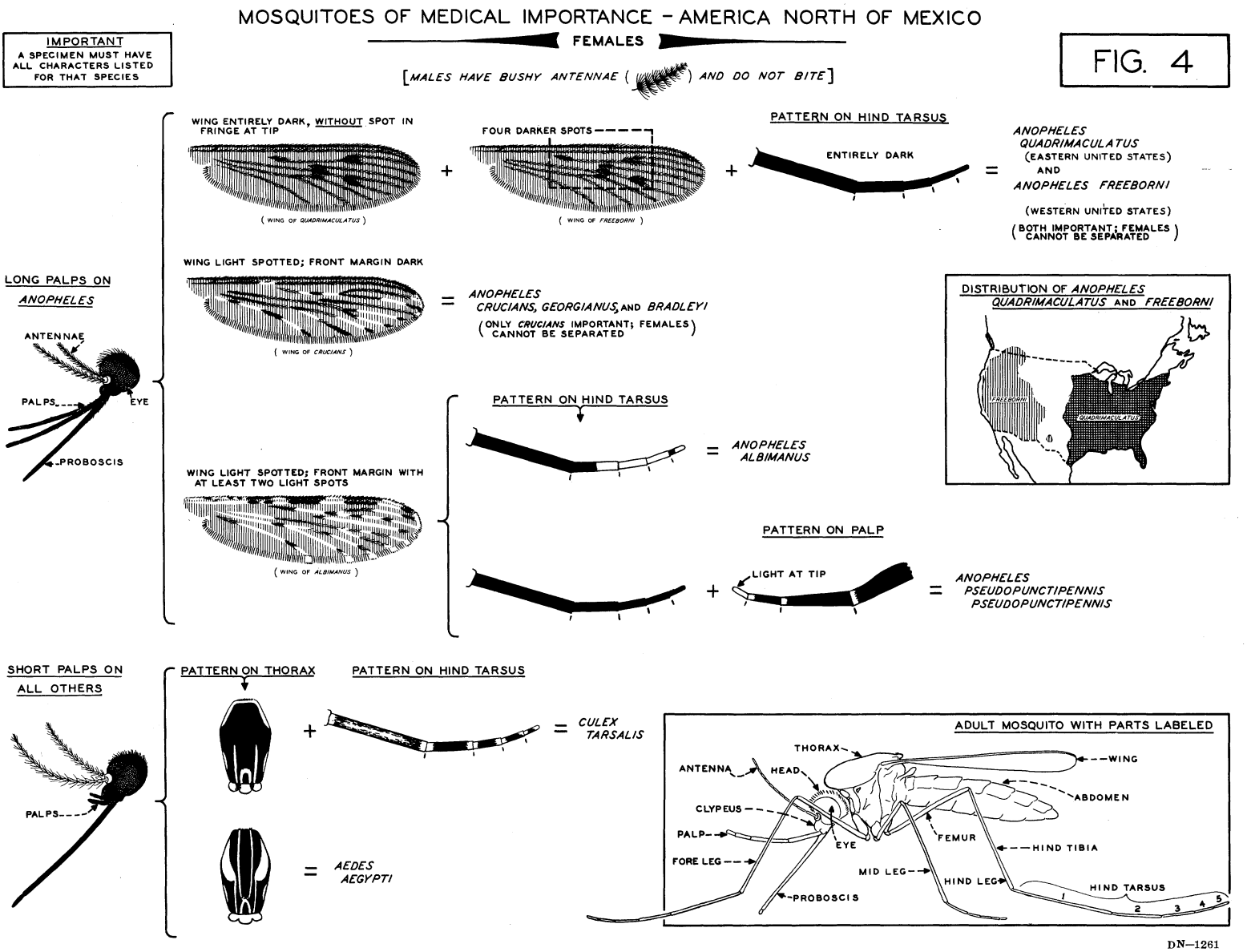
In Canada before 1880 malaria had become endemic along the north shores of Lake Ontario, Lake Erie, and the Canadian side of Lake St. Clair but not above the summer isotherm of 70° F. At one time it was reported to have become endemic in certain parts of the Western Provinces, but no malaria has been reported from Canada for several decades.

The little malaria in the temperate regions is almost all caused by *Plasmodium vivax*. *Plasmodium falciparum* is associated with a larger number of cases in the subtropical regions, and *P. malariae*, although present, has never contributed to the incidence of malaria to any important extent.

In the entire area east of the Great Plains, including the Mississippi River basin, *Anopheles quadrimaculatus* has been responsible for most cases of malaria. It is the Nearctic species most fond of human blood, and its ubiquitous breeding and house-entering habits make it North America's most important vector. This species has become especially important in the Tennessee Valley Authority area, where the construction of large bodies of water has provided ideal breeding places for it. Although the anophelines responsible for malaria in Canada have never been determined, evidence points to *quadrimaculatus* as the probable vector there.

Anopheles crucians is especially abundant along the Atlantic coastal plain. Evidence for its incrimination in malaria transmission in the United States is conflicting, because *quadrimaculatus* is also present over most of the same area, but *crucians* is definitely suspected because of its anthropophilic tendencies, high density, and tendency in some areas to enter human habitations.

Farther west but overlapping the range of *crucians*, *Anopheles pseudopunctipennis pseudopunctipennis* has a



northward distribution from Mexico. In the United States its importance is not exactly known, since few transmission studies have been made specifically of it. However, it is a vector of prime importance south of the Mexican border, and without doubt it could be an important vector in the United States under favorable circumstances.

In the Western United States and extreme southwestern Canada *Anopheles freeborni* is believed to be the principal vector. It shows about the same degree of anthropophilism as *quadrimaculatus* and is probably responsible for much of the malaria within its range. It is definitely a seasonal mosquito and survives the winter as an adult. The females feed intermittently during this period and may carry malaria from one person to another inside heated houses.

Studies indicate that *Anopheles punctipennis* may be a vector of malaria in California. This species has not been included in the keys for lack of conclusive evidence of its ability to transmit disease.

Anopheles albimanus, the chief vector of malaria in the Caribbean area, is included in the keys because of its potential rather than actual importance. Like *pseudopunctipennis*, its role in the United States has been little studied, but it probably does not contribute much to malaria transmission in this country. Its exact range in the United States is not known.

References: *41, 67, 71, 113, 129, 146.*

Anopheles Species [6] in America North of Mexico

†*albimanus*
atropos
barberi
bradleyi
**crucians*
earlei
**freeborni*
georgianus
occidentalis
perplexens
pseudopunctipennis franciscanus
†*pseudopunctipennis pseudopunctipennis*
punctipennis
**quadrimaculatus*
walkeri

Yellow Fever.—This disease occurred at one time in America north of Mexico, but it has not been reported since 1905. *Aedes aegypti*, its principal vector in many other parts of the world, is included in the keys only because of its potential importance, since the disease is no longer a medical problem here.

Haemagogus equinus was collected from two localities in the vicinity of Brownsville, Tex., in 1955. This mosquito is a good laboratory vector of yellow fever, but the virus has never been recovered from it in nature. Since *equinus* is

[6] Species marked with an asterisk (*) are recorded as vectors of malaria in this region and their medical importance is discussed in the accompanying text. Those marked with a dagger (†) are not recorded as vectors of malaria in this region but are important elsewhere. For information on the latter vectors, see the description of the particular species in the last section of this handbook.

probably of little or no importance in the United States, it is not included in the keys.

References: *331, 349.*

Dengue.—The last extensive epidemic of this disease in the United States occurred in 1922 and 1923 and was preceded by a considerable increase in the abundance of *Aedes aegypti.* This outbreak was centered in Texas and Louisiana, where 500,000 to 600,000 cases were reported. An epidemic occurred in Florida in 1936. A few cases are reported every year throughout the Southeastern States.

References: *162, 256.*

Encephalitis.—Several strains of this disease occur in the United States and parts of Canada. Western equine, eastern equine, and California encephalitis viruses have caused much injury to livestock, and these three, together with St. Louis encephalitis virus, incidentally have attacked humans throughout the United States. For the distribution of these viruses, see the preceding section. Epidemiological evidence points most strongly to *Culex tarsalis* as the vector of western equine virus. This mosquito has been incriminated as the vector of St. Louis encephalitis virus as well. Several mosquito species have been found infected in nature with the eastern equine strain, but studies have not yet definitely pointed out a specific vector of this virus.

References: *200, 257.*

Filariasis.—This disease was probably introduced into the United States by slaves from endemic centers in Africa. The only known focus of infection in America north of Mexico was found in 1915 in Charleston, S. C. The disease persisted for several years but is now believed to have disappeared entirely.

Reference: *159.*

MIDDLE AMERICA

West Indies

(Fig. 5)

The West Indies, which include the Bahamas, the Greater Antilles, and the Lesser Antilles, extend from Florida to the north coast of Venezuela. They separate the Gulf of Mexico and the Atlantic Ocean from the Caribbean Sea. The Greater Antilles on the west end of the chain include Cuba, Jamaica, Hispaniola, and Puerto Rico, and the Lesser Antilles include principally the Leeward and Windward Islands and Trinidad.

BAHAMA ISLANDS

Physical Features.—The Bahamas consist of about 700 islands and numerous reefs and cays. This island group stretches for 750 miles east of Florida and parallel to Cuba. Mangrove swamps and ponds are abundant throughout the islands. The Bahamas have a subtropical climate, with mild winters and an annual mean rainfall of about 50 inches. The rainy season is from May to October.

Reference: *301.*

Malaria.—This disease is not present in the Bahamas.

Reference: *67.*

CUBA AND JAMAICA

Physical Features.—Cuba has a greater land area than all the other islands in the West Indies combined. It stretches 700 miles in an east-west direction and has largely level or gently rolling ground suitable for large-scale agriculture. Cuba has three mountain ranges. The highest is located on the south shore at the east end of the island; the other two lie in the center and on the west end. The low coast, containing marshes and bottlenecked bays, is margined by numerous coral islands and keys. The climate is temperate, with two seasons, a rainy period from May to October and a cool, dry season from November to April. The rainfall averages about 50 inches annually and increases inland.

Jamaica lies 90 miles south of Cuba and is predominantly mountainous, the main range running in an east-west direction. A few alluvial plains extend along the south and west coasts, which have many fine bays.

Reference: *301.*

Malaria.—Epidemics rather than endemics characterize this disease in Cuba, whereas the reverse is largely true in Jamaica. Malaria is present chiefly in the low-lying plains and is seldom encountered above 1,000 feet.

In Cuba *Plasmodium vivax* and *P. falciparum* transmit malaria almost to the exclusion of *P. malariae.* In Jamaica *falciparum* by far outnumbers other species, and *malariae* accounts for up to 10 percent of malaria; *vivax* is almost nonexistent.

Anopheles albimanus, the most important vector in the Caribbean area, is the principal vector in Cuba and Jamaica. It is primarily a species of the coastal lowlands, and its numbers decrease rapidly with an increase in altitude. The abundance of *albimanus* is closely correlated with the intensity of malaria in these islands.

The role of *Anopheles crucians* has not been evaluated thoroughly, but it is strongly suspected of being a vector, at least in Cuba.

Neither *Anopheles aquasalis* nor *A. bellator* is found in Cuba or Jamaica.

Reference: *67.*

HISPANIOLA

Physical Features.—Hispaniola is composed of two political independencies, Haiti in the western one-third and the Dominican Republic in the eastern two-thirds. The island itself lies in the main chain of the West Indies just east of Cuba. It is predominantly mountainous, with several wooded ranges that enclose deep fertile valleys where most of the people live. Its coastal lowlands have an average annual temperature of about 77° F., with little seasonal change. There are two main rainy periods, one from April to June and the other in October and November.

Reference: *301.*

Malaria.—Hispaniola has the highest malaria rate in the West Indies. In the Dominican Republic periods of high endemicity alternate with several years of lower intensity.

The principal parasite is *Plasmodium falciparum. Plasmodium vivax* and *P. malariae* cause the remaining cases; *vivax* is predominant in most localities.

As in the other islands, *Anopheles albimanus* is the most important vector. Since it prefers low coastal areas where the rain makes temporary sunlit pools, it is most numerous during and shortly after the rainy season. The endemic malaria transmitted by this species is not so severe as that supported by many other vectors, notably *Anopheles darlingi* in South America.

If *Anopheles crucians* is found in Hispaniola, it must be a rare mosquito. It has been reported from both Cuba and Puerto Rico, but its role in Hispaniola has not been evaluated. It is probably not an important vector in this island.

Neither *Anopheles bellator* nor *A. aquasalis* is found in Hispaniola.

References: *67, 292.*

MOSQUITOES OF MEDICAL IMPORTANCE — WEST INDIES

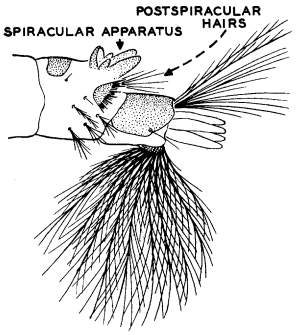
[AREA INCLUDED: BAHAMAS, GREATER ANTILLES, AND LESSER ANTILLES]

FIG. 5

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

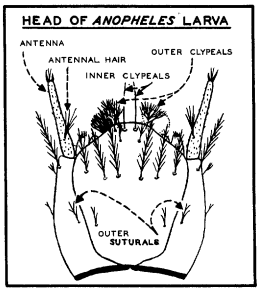
SIPHON ABSENT

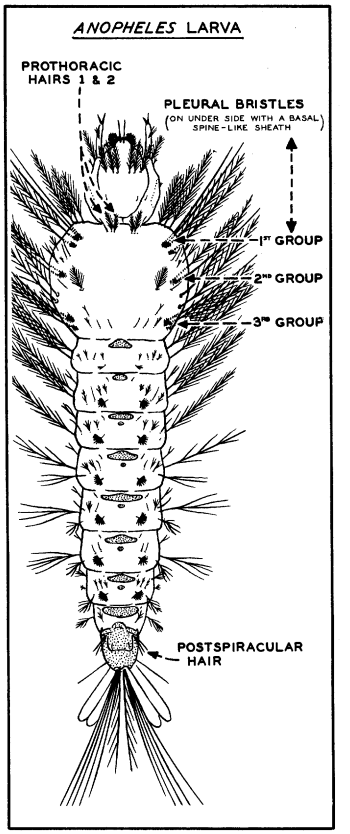


PROTHORACIC HAIR 1 — OUTER CLYPEALS

- SINGLE + BRUSHLIKE = *ANOPHELES CRUCIANS*
- BRANCHED FROM BASE + NOT = *ANOPHELES AQUASALIS*

OUTER CLYPEALS





OUTER SUTURALS — POSTSPIRACULAR HAIR

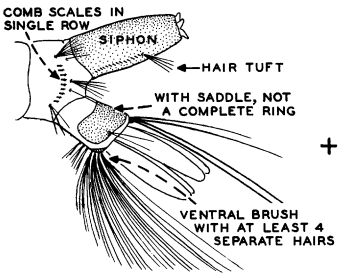
- BRANCHED FROM SIDES — SINGLE + BRANCHED = *ANOPHELES BELLATOR*

PROTHORACIC HAIRS 1 & 2

- BRANCHED + BASES FUSED = *ANOPHELES ALBIMANUS*

SIPHON PRESENT,

PLUS ALL CHARACTERS LISTED BELOW



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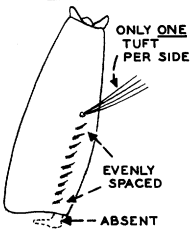

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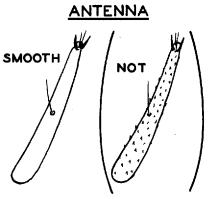

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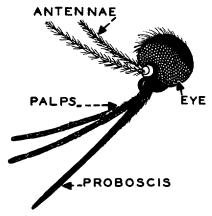
= *AEDES AEGYPTI*

FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

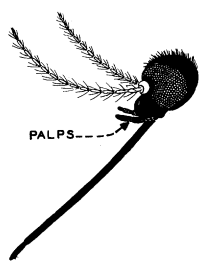
PALPS LONG



PATTERN ON HIND TARSUS

- SEGMENT 5 DARK AT BASE — PATTERN ON PALP = *ANOPHELES ALBIMANUS*
- PATTERN ON 2ND SEGMENT OF HIND TARSUS — DARK AREA 1/3 OR MORE AS LONG AS SEGMENT = *ANOPHELES AQUASALIS AND RANGELI* (ONLY *AQUASALIS* IMPORTANT; FEMALES CANNOT BE SEPARATED)
- SEGMENT 5 ALL DARK = *ANOPHELES BELLATOR*
- ALL DARK — PATTERN ON PALP = *ANOPHELES CRUCIANS*

PALPS SHORT



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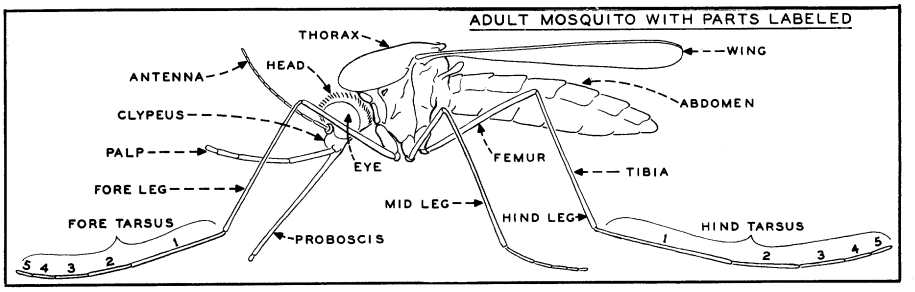
PATTERN ON THORAX

= *AEDES AEGYPTI*



PUERTO RICO

Physical Features.—Puerto Rico is the easternmost and smallest of the Greater Antilles. A central mountain range extends across its entire length; additional mountains are in the northeast and southeast. The coastal plain along the northern shore is about 10 miles wide; that on the south is narrower because of the abrupt rise of the mountains. The rainfall, scarcer on the south and west coasts than on the north and east, averages about 60 inches annually, with little seasonal variation in temperature.

Reference: *301.*

Malaria.—Although this disease is practically absent from the central mountainous part of Puerto Rico, it is widespread on the south and east coasts.

Plasmodium vivax infections are prevalent during the first half of the year and *P. falciparum* during the second half.

As a result of irrigation, which was needed because of the light rainfall, *Anopheles albimanus* has excellent breeding grounds. This mosquito is present the year around. It appears in small numbers through the dry season and increases to a low peak of abundance at the beginning of the rainy season and to relatively large numbers at the height of the rainy season in October, November, or early December. It is the only vector of malaria in Puerto Rico that requires extensive control measures.

Anopheles aquasalis and *A. bellator* are not present in Puerto Rico.

References: *67, 276.*

LESSER ANTILLES

Physical Features.—The Leeward Islands extend southeast from Puerto Rico to the Windward Islands and consist principally of the Virgin Islands, Guadeloupe, St. Eustatius, Saba, St. Martin, Antigua, St. Kitts, Nevis, and Montserrat. The last four islands are part of the volcanic chain of the Lesser Antilles and the others are of coral limestone. Nearly all the islands are immensely fertile, with a rainy season from August to January; the annual rainfall is 40 to 60 inches.

The Windward Islands continue the submerged mountain chain south and east and consist principally of Martinique, Dominica, St. Lucia, St. Vincent, and Grenada. All the islands have mountainous backbones, with extremely fertile valleys and some level land. The temperature is equable, with little seasonal variation, but the rainfall is rather variable.

Trinidad lies 10 miles north of Venezuela's Orinoco Delta and is geologically a part of the South American mainland. It is crossed from east to west by three low ranges of hills covered largely by virgin forests. The indented coast is swampy. The principal rainy period lasts from June to December, with 50 to 120 inches of rainfall annually.

Reference: *301.*

Malaria.—As in most of the Caribbean area, malaria is primarily a coastal disease in the Leeward and Windward Islands and in Trinidad.

Plasmodium falciparum malaria predominates, and *P. vivax* is a parasite of secondary importance. *Plasmodium malariae* accounts for few cases in most localities. The disease is rarely found above 1,000 feet.

In most of the islands except Grenada, St. Lucia, Martinique, and Trinidad, *Anopheles albimanus* is the principal vector, and its distribution is closely associated with malaria. Its habits are essentially the same as in the Greater Antilles.

Anopheles aquasalis is found in Trinidad and north to Antigua and is the only vector in many of the islands within this range. It is almost entirely a coastal species and appears to prefer brackish water, though it is not restricted to this habitat. Its ability to transmit malaria to man is probably limited by its zoophilism.

Anopheles bellator is largely restricted to Trinidad, where it transmits an out-of-doors malaria, principally in the county of St. Andrew. This species is unusual in that its larvae grow in epiphytic bromeliads (see p. 115) in cacao plantations.

Anopheles homunculus, a species not included in the keys, is found in the Aripo Valley of Trinidad, where it contributes to "bromeliad malaria" transmission.

Anopheles crucians is not present in the Lesser Antilles.

References: *67, 86.*

Anopheles Species in the West Indies

**albimanus*	*maculipes*
†*albitarsis*	*mediopunctatus*
apicimacula	*neomaculipalpus*
**aquasalis*	*nimbus*
atropos	†*oswaldoi*
**bellator*	†*pseudopunctipennis*
**crucians*	*pseudopunctipennis*
†*darlingi*	†*punctimacula*
eiseni	†*quadrimaculatus*
grabhamii	*rangeli*
**homunculus*	†*vestitipennis*

See footnote 6, p. 10.

Yellow Fever.—Positive mouse-protection tests have been performed in Cuba, Jamaica, and Puerto Rico, but no outbreaks of urban yellow fever have been recorded in the West Indies since 1914, when cases were reported from Trinidad. Personnel of the Regional Virus Laboratory of the Rockefeller Foundation found cases of jungle yellow fever in Trinidad early in January 1954, and over 100 human cases and many monkey deaths were observed during that year. Evidence of a specific mosquito vector was not obtained, but the virus was isolated from pools of mosquitoes containing species of *Haemagogus* collected at ground level. Since 1954 an islandwide immunization campaign has been carried on in Trinidad, and measures have been undertaken against *Aedes aegypti* on a large scale.

References: *7, 8, 13, 19, 20, 108, 109, 256.*

Dengue.—In the Bahamas and Jamaica dengue has never been reported. However, in Cuba and Hispaniola the disease is endemic in nonimmune persons, and small local outbreaks have occurred. Southward the disease becomes more intense and is prevalent in most of the Lesser Antilles. Both types of dengue are present in Trinidad, and surprisingly high rates of immunity to this disease have been found in humans there. In all these areas *Aedes aegypti* is the widely distributed vector.

References: *7, 8, 13, 19, 20, 109, 256.*

Encephalitis.—This disease is not present in most of the West Indies. Eastern equine encephalitis virus attacks animals in Cuba and both animals and humans in the lower valley of the Yaque del Norte in northwestern Dominican Republic. The only two known fatal cases of Venezuelan equine encephalitis in humans occurred in Americans in Trinidad. Little is known of the epidemiology of this disease, and the vector is not known with certainty. Recent investigations do not show any activity of the Venezuelan virus in Trinidad. However, St. Louis encephalitis virus infections have probably occurred in that island, and serum from one donkey has given a positive reaction to the eastern equine virus. In Trinidad two strains of Ilhéus virus have been isolated from wild-caught forest mosquitoes, among which large numbers of *Psorophora* and *Aedes* species were present. High immunity rates were found in humans in the low, heavily forested areas of the island.

References: *43, 109, 246, 257.*

Filariasis.—*Culex pipiens quinquefasciatus* is present throughout most of the West Indies and is the principal vector of *Wuchereria bancrofti* wherever that parasite is found. Thorough studies have been made in some islands, but none in others. The disease is not a public-health problem in Cuba, Hispaniola, or Jamaica.

In Puerto Rico, where more intensive studies have been made, infection rates up to 13 percent have been found. *C. p. quinquefasciatus* is most numerous in the hot, moist coastal areas; it is rare at altitudes above 2,000 feet and in the hot, dry south and southwest. There are no endemic centers in Puerto Rico and the smaller islands, because people move so freely from one locality to another.

Wuchereria bancrofti has been present in St. Croix for several years. St. Thomas, 40 miles away, has little or no filariasis where *quinquefasciatus* is abundant. Infectious stages of the parasite have been observed in this mosquito the year around in St. Croix, where up to 25 percent of the females have been found infected. In St. Croix *Wuchereria bancrofti* completes its development to the infectious stage in *Anopheles albimanus*, but that mosquito is not regarded as an efficient vector of filariasis.

In Antigua filariasis incidence has been estimated at about 38 percent in the native population, being highest in the central clay area, lowest in the northeast, and intermediate in the southwest volcanic area.

References: *166, 266–269, 300, 306, 323.*

Mexico

(Figs. 6 and 7)

Physical Features.—Triangular Mexico has a 2,000-mile northern frontier along the boundaries of California, Arizona, New Mexico, and Texas. Gradually narrowing, the country extends south to Guatemala, where its east coast swings northeastward to form the peninsula of Yucatan, which partially separates the Gulf of Mexico from the Caribbean Sea. Both of these bodies of water bound Mexico on the east; the entire west coast fronts the Pacific Ocean. Lying immediately west of Mexico proper is the narrow peninsula of Lower California, separated from Mexico by the Gulf of California.

Three-fourths of Mexico is covered by mountain ranges. The two most important are the roughly parallel Sierra Madre Oriental and Sierra Madre Occidental. The former is an extension of the Continental Divide and runs southward near the east coast from the northern border to below the level of Mexico City; the latter extends southward near the west coast. Each range is separated from its bordering water by coastal strips never exceeding 200 miles in width. Between these ranges is the central plateau or highlands, with broken mountains and deep valleys. From an altitude of about 4,000 feet in northern Coahuila and Chihuahua, these highlands rise to 8,000 feet in the interior farther south. The narrowest part on the isthmus is high and contains the Sierra Madre del Sur range, which extends into Guatemala close to the east coast.

Throughout Mexico the rainy season lasts from June through September. The Lower California coasts, Sonora, Sinaloa, and northern Tamaulipas are driest and depend on irrigation for agriculture. Farther south in the tropical jungle of Tabasco in the inner curve of the Yucatan Peninsula, the rainfall reaches 120 inches annually. All coastal lowlands and the mountainous country up to 3,000 feet in most of the Yucatan Peninsula are hot and tropical; from 3,000 to 6,000 feet in the central highlands the climate is more seasonal; and the area above 6,000 feet, containing many of Mexico's principal cities, has hot days and cold nights.

Reference: *301.*

Malaria.—The dry Northern States of Lower California, Sonora, Chihuahua, Coahuila, Durango, and Zacatecas have little malaria. The arid country supports little mosquito breeding, except in a limited way along the more verdant river courses, where the disease is occasionally endemic, with annual rates of almost 50 per 100,000 in some populations. In the highland States to the south—Aguascalientes, Guanajuato, Querétaro, Mexico, and Tlaxcala—there is a slightly higher rate of endemic malaria. The States of Hidalgo, Puebla, and Morelos and the western coastal region report extremely high rates. Along the gulf coast south and east from Tamaulipas malaria incidence increases considerably, and the States of Tabasco, Campeche, and Yucatan are highly malarious, as is the more inland San Luis Potosí. The same is generally true of the Pacific coast, with Jalisco and Michoacán lightly malarious and an area of Oaxaca heavily so.

Most malaria in Mexico is caused by *Plasmodium vivax*; *P. falciparum* and *P. malariae*, the former the more abundant, cause most of the remaining cases.

In the Xochimilco-Mixquic area of the valley of Mexico just south of Mexico City, *Anopheles aztecus* is the important if not the sole vector of benign malaria. This area is almost 7,500 feet above sea level. The species is commonly found in houses, bites man freely, and can be readily infected in the laboratory. It has been responsible for over a thousand cases of malaria annually. It has been found in various localities throughout central Mexico, but its importance there has not been studied adequately.

Anopheles pseudopunctipennis pseudopunctipennis is another highland species, appearing in the absence of other *Anopheles* species during the dry season in the highlands of Mexico. It is a dangerous vector, probably accounting for most of the malaria in Lower California and along the Pacific slopes of Mexico. With *aztecus*, it transmits all malaria in the Mexican highlands. The closely related *Anopheles pseudopunctipennis franciscanus* is found in Lower California and extreme northwest Mexico, but it is not an important species. Past records of nontransmission probably refer to that variety rather than to typical *pseudopunctipennis pseudopunctipennis.*

Anopheles albimanus is found on both the gulf and Pacific coasts of Mexico. It is present along the gulf coast from the United States border to Quintana Roo, and it is responsible for the high rate of endemic malaria there. Along the Pacific side its range extends northward from Central America to Sonora.

The range of *Anopheles darlingi* extends from South America to the lower part of Mexico, at least as far north as Tabasco. In Central and South America it is particularly dangerous and probably contributes greatly to the endemic malaria in extreme southern Mexico.

Anopheles freeborni, the principal vector in the Western United States, extends its range south into the north-central plateau of Mexico and Lower California. In these two areas south of the border it probably plays some part in malaria transmission, although it is replaced by *pseudopunctipennis pseudopunctipennis* to the south.

The range of *Anopheles crucians* extends south from the United States into Tamaulipas and beyond. It is restricted to the gulf side of Mexico, where it is suspected as a vector because of its anthropophilic tendencies.

Like *crucians*, *Anopheles quadrimaculatus* also is found in northeast Mexico, but its range is much more limited. Knowledge of its role in malaria transmission is confused by the presence of *albimanus.*

References: *41, 67, 110, 334, 335.*

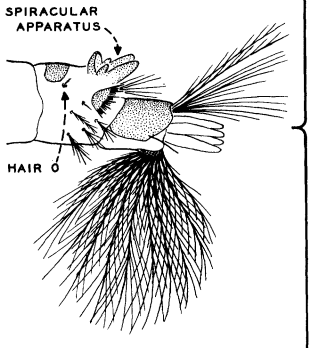
MOSQUITOES OF MEDICAL IMPORTANCE —— MEXICO

FULL-GROWN LARVAE

FIG. 6

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

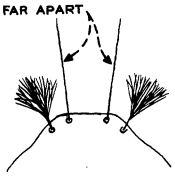
SIPHON ABSENT



OUTER CLYPEALS

INNER CLYPEALS

FAR APART

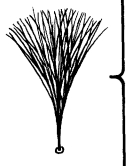


PALMATES ON 2ND ABDOMINAL SEGMENT

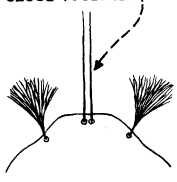
MODERATELY DEVELOPED = *ANOPHELES QUADRIMACULATUS*

POORLY DEVELOPED = *ANOPHELES AZTECUS*

15 OR MORE BRANCHED



CLOSE TOGETHER



PROTHORACIC HAIR 1

OR

HAIR "0" ON 4TH ABDOMINAL SEGMENT

NOT

= *ANOPHELES CRUCIANS*

HAIR "0" ON 4TH ABDOMINAL SEGMENT

OR

NOT

= *ANOPHELES FREEBORNI* AND *PUNCTIPENNIS*

(ONLY *FREEBORNI* IMPORTANT; LARVAE CANNOT BE SEPARATED)

WITH SHORT SIDE HAIRS

SPIRACULAR APPARATUS

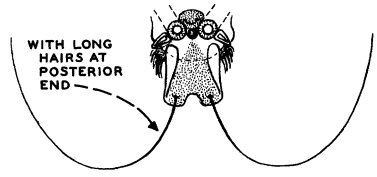
WITH SHORT HAIRS AT POSTERIOR END

PROTHORACIC HAIRS 1 & 2

HAIR 1 BRANCHED FROM SIDES; BASES FUSED

= *ANOPHELES ALBIMANUS*

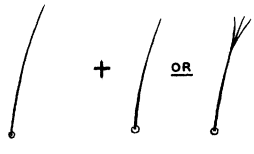
WITH LONG HAIRS AT POSTERIOR END



= *ANOPHELES DARLINGI*

PROTHORACIC HAIR 1 **SPIRACULAR APPARATUS**

BARE + OR +

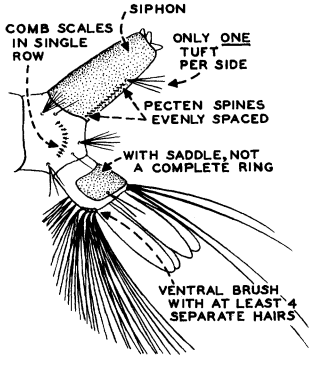


PROJECTIONS AT POSTERIOR END

= *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

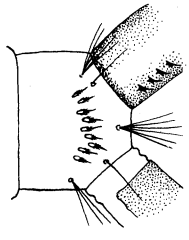
SIPHON PRESENT,

PLUS ALL CHARACTERS LISTED BELOW



ABDOMINAL SEGMENT 8

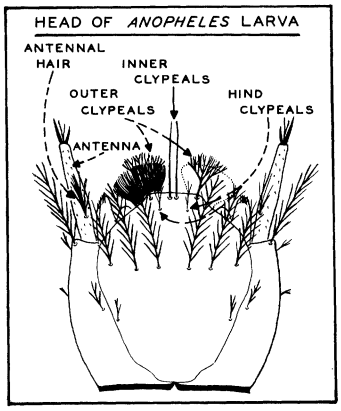
COMB SCALES NOT ON A PLATE; SURFACE BARE

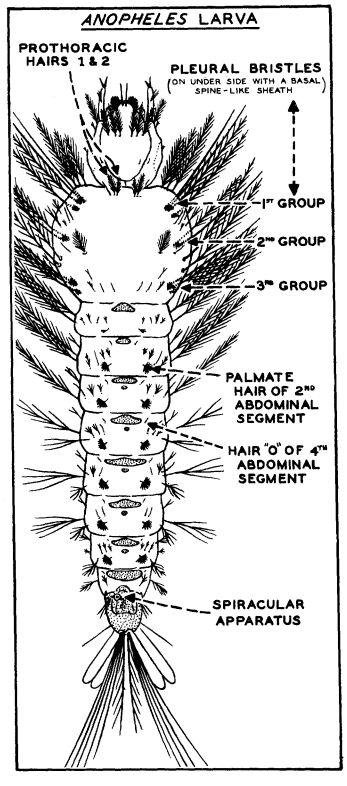


ANTENNA **COMB SCALES**

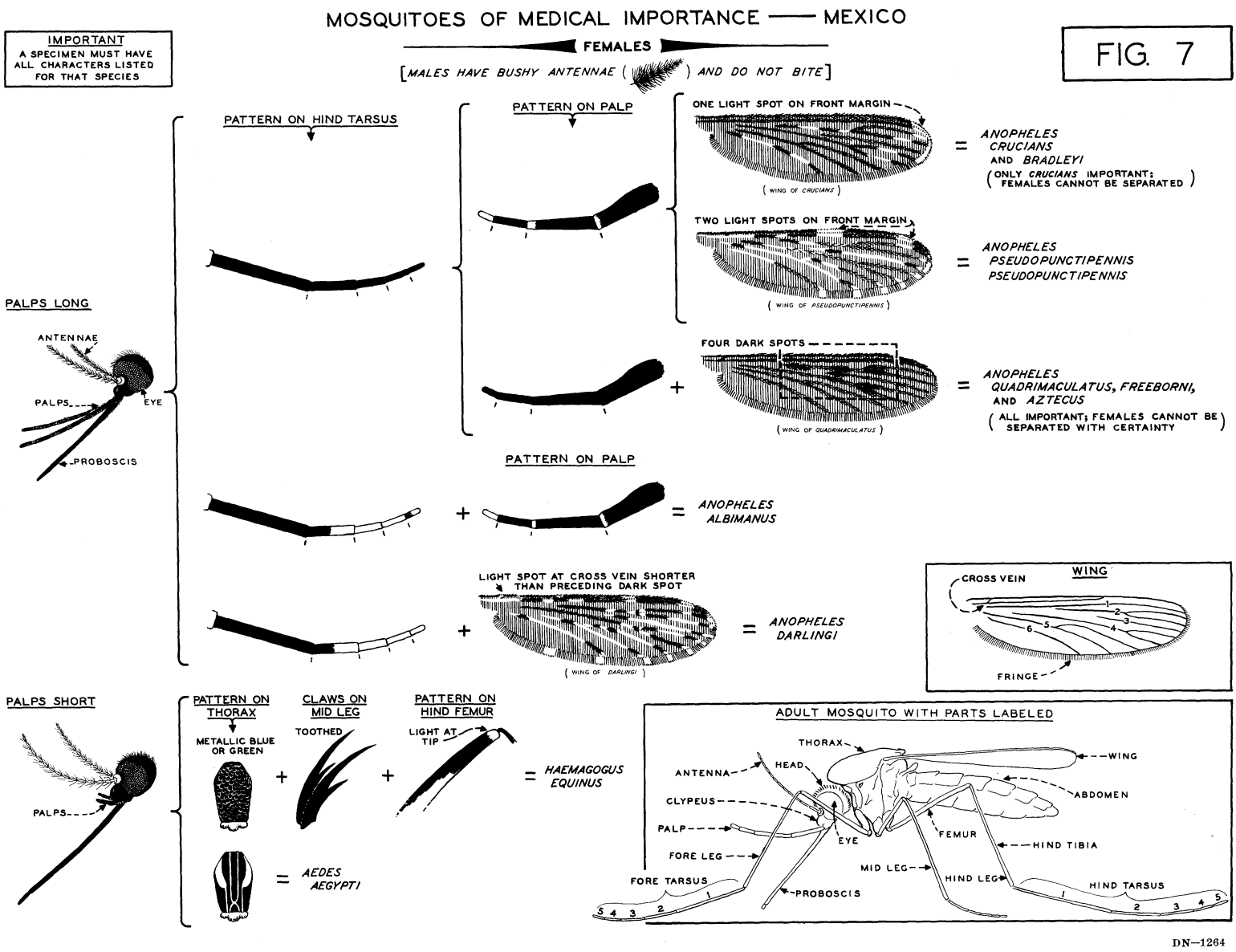
SMOOTH + = *AEDES AEGYPTI*

WITH SMALL SPINES + = *HAEMAGOGUS EQUINUS*





471779 O—59——2



Anopheles Species in Mexico

**albimanus*
apicimacula
†aquasalis
argyritarsis
atropos
**aztecus*
barberi
bradleyi
†crucians
†cruzi
**darlingi*
eiseni
evansae
fausti
**freeborni*
gabaldoni
hectoris
†homunculus
intermedius
neivai
neomaculipalpus
occidentalis
parapunctipennis guatemalensis
parapunctipennis parapunctipennis
pseudopunctipennis franciscanus
**pseudopunctipennis pseudopunctipennis*
†punctimacula
punctipennis
†quadrimaculatus
rondoni
†vestitipennis
walkeri
xelajuensis

See footnote 6, p. 10.

Yellow Fever.—No classical urban yellow fever has been known in Mexico since 1910–20. *Aedes aegypti* is present, probably in small numbers, in port areas into which the disease can be introduced. Jungle yellow fever has not yet been reported in humans, but mouse-protection tests have revealed positive monkey sera in Chiapas. Authorities agree that jungle yellow fever might extend into the tropical rain forest of the gulf coast from Central America (see p. 20).

Haemagogus equinus and potentially susceptible monkeys are present in a continuous belt of tropical rain forest extending northward on the gulf side. This mosquito is found in deciduous forest, mangrove, and thorny scrub as far north as Brownsville, Tex. *Haemagogus mesodentatus mesodentatus* and *H. m. gorgasi* are dominant species in the tropical rain forest. The range of the former extends along the gulf slope as far north as southeastern San Luis Potosí, that of the latter along the Pacific slope to southern Sinaloa near Mazatlán. All three *Haemagogus* species are good laboratory vectors of yellow fever, but none have been found with natural infections.

Sabethes chloropterus, an inhabitant of tropical rain and deciduous forests on the gulf and Pacific slopes, probably

maintains sylvan yellow fever during seasons that are unfavorably dry for the *Haemagogus* species.

References: *132, 155, 256, 330.*

Dengue.—This disease occurs throughout Mexico, but only a few cases are reported every year.

Reference: *256.*

Encephalitis.—The virus of western equine encephalitis may appear along the Rio Grande in the northernmost parts of Mexico. As far as is known no humans have contracted the disease. Eastern equine encephalitis virus attacks both animals and man along the gulf coast to about latitude 20° N. Its exact distribution in this area is uncertain. *Culex tarsalis*, the suspected vector of both viruses, is present in Mexico.

References: *200, 257.*

Filariasis.—No information is available.[7]

Central America

(Figs. 8 and 9)

Physical Features.—Central America includes British Honduras, Guatemala, Honduras, Salvador, Nicaragua, and Costa Rica. British Honduras, the northernmost country in Central America, is about 170 miles long, with an indented and swampy eastern coast on the Caribbean Sea. Most of the northern half is tropical, low, and flat, but high grasslands and the Maya and Cockscomb Mountains rise in the southeast. A dry season from mid-February to mid-May alternates with a rainy season, which brings most of the 80 inches of rainfall annually.

To the west is Guatemala, which touches both the Caribbean Sea and the Pacific Ocean. It is crossed from east to west near its southern border by the Sierra Madre range, with peaks from 11,000 to 13,000 feet. Several ranges that enclose high plateaus above 4,000 feet extend northward from the Sierra Madre. The Pacific slopes are steep and the coast is narrow, but to the north and west the slopes decrease more gradually in altitude. The coastal plains and the entire Petén Department below 1,500 feet are hot and humid. Uplands from 3,500 to 10,000 feet are subtropical to temperate. A rainy season from May to October brings most of the 45 inches of rain annually on the plateau and part of the 200 inches in some lowland sections.

Honduras to the south and east of Guatemala also touches both the Caribbean and the Pacific and is almost entirely mountainous except for the narrow coasts, river valleys, and the "mosquito coast" between the Patuca and Coco Rivers in the northeastern corner. Honduras is crossed by the Cordillera, the main mountain range that rises to 7,000 feet in the higher southern part near Salvador. These mountains send off spurs northward to enclose highlands and fertile valleys. In the tropical coastal lowlands in the north the climate is hot and humid with heavy rains, but farther south and higher the climate is more seasonal, with a rainy season from May to December.

Salvador has a 170-mile Pacific coastline and is bounded by land on the other sides. From east to west the country is crossed by two volcanic ranges rising to almost 8,000 feet. Between these ranges is a 2,000-foot plateau, which contains the principal cities and cultivated areas. The Lempa River Valley north of the mountains is an area of tropical savannas flanked by Honduras highlands. About 70 inches of rain fall annually, most of it in a rainy season from May to October. As in other Central American countries, the climate is tropical in the lowlands and more temperate in the mountains and plateaus.

Nicaragua has a swampy, key-fringed, 350-mile Caribbean coast and 200 miles of Pacific shoreline. The Cordillera traverses the country from northwest to southeast, rising to 7,000-foot peaks. Several long spurs branch out in a northeast direction and slope gradually to the wide Caribbean lowlands. West of the principal mountain divide an extensive depression contains the large lakes Managua and Nicaragua. Between these lakes and the Pacific Ocean is a narrow chain of low volcanoes (2,000 to 4,000 feet). The tropical eastern Caribbean lowlands receive almost 200 inches of rain annually and the more temperate western highlands about 60 inches, mostly from May to December.

Costa Rica straddles the isthmus. It has a 630-mile Pacific shore and a 130-mile Caribbean coast, which is marshy, alluvial, and lined by lagoons. From northwest to southeast the Cordillera cuts across the country in several nearly parallel ranges, which enclose at 3,000 to 5,000 feet a fertile basin containing three-fourths of the white population. The jungles of the Caribbean coast receive about 120 inches of rain annually, whereas the Pacific coast is cooler and drier. The mountain plateau has dry (December to April) and rainy seasons.

Reference: *301.*

Malaria.—Throughout the countries of Central America malaria is a dangerous disease. It is the predominant disease in low, moist tropical areas. The extensive mountainous backbone of the isthmus connecting Mexico with South America restricts this lowland area to the Pacific and Caribbean coasts. Malaria is also present in some highland areas but is not common above 4,000 to 5,000 feet.

Except in Salvador and Honduras, *Plasmodium vivax* is the predominant parasite, *P. falciparum* is next in importance, and *P. malariae* is the least common. *P. malariae* is important and abundant only along the Pacific slope of Costa Rica.

Anopheles albimanus is present along both the Pacific and Caribbean coasts and has been found inland in Guatemala at an altitude of 4,500 feet, a considerable deviation from its normal habitat of low tropical areas. In Costa Rica it is the dominant species, especially in the lowlands, and it has been observed at elevations of 2,500 feet in drying riverbeds. It is one of the most important vectors in the Caribbean area.

Anopheles darlingi is prevalent throughout almost all the Central American countries. The adults feed readily on man and are often taken in large numbers in houses. In South America this is one of the most important vectors of malaria, and it contributes greatly to endemic malaria in Central America as well.

Anopheles pseudopunctipennis pseudopunctipennis has been collected in all the Central American countries. It is not so important in Costa Rica as in the highlands of Guatemala farther north, where it consistently enters habitations and bites man readily.

Anopheles punctimacula is widely distributed in all the Central American countries. The adults visit human habitations in large numbers and have been observed feeding on animals.

Anopheles vestitipennis is a comparatively rare mosquito. Nevertheless, at certain times and places in British Honduras it probably plays a role in malaria transmission because of its habit of entering houses and biting man.

References: *67, 209, 292.*

[7] Signifies the disease is not present or it may occur in a region, but no records of it have been found in the literature.

MOSQUITOES OF MEDICAL IMPORTANCE — CENTRAL AMERICA

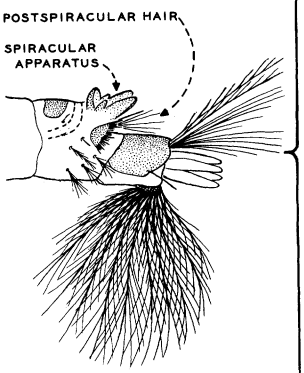
[EXCLUDING PANAMA]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 8

FULL-GROWN LARVAE

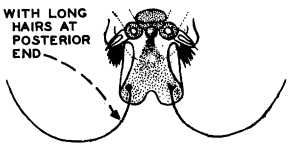
SIPHON ABSENT



PALMATE HAIRS

LEAFLETS SMOOTH

SPIRACULAR APPARATUS



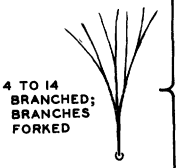
= *ANOPHELES DARLINGI*

PROTHORACIC HAIRS 1&2

= *ANOPHELES ALBIMANUS*

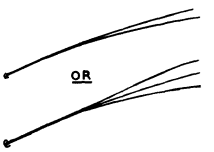
LEAFLETS NOTCHED

OUTER CLYPEALS



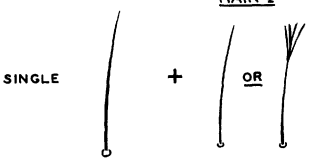
LATERAL HAIRS OF ABDOMINAL SEGMENTS 4 & 5

= *ANOPHELES PUNCTIMACULA*



= *ANOPHELES VESTITIPENNIS* AND *GABALDONI*
(ONLY *VESTITIPENNIS* IMPORTANT; LARVAE CANNOT BE SEPARATED)

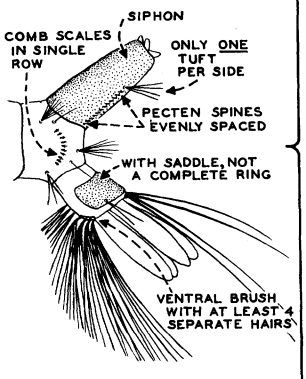
PROTHORACIC HAIR 1



= *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

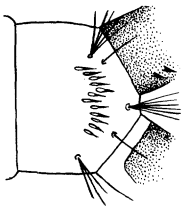
SIPHON PRESENT,

PLUS ALL CHARACTERS LISTED BELOW

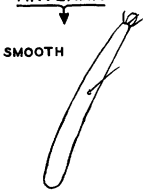


ABDOMINAL SEGMENT 8

COMB SCALES NOT ON A PLATE: SURFACE BARE

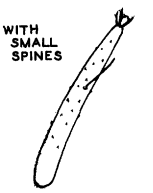


ANTENNA

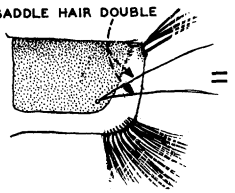


COMB SCALES

= *AEDES AEGYPTI*

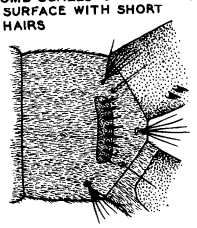


SADDLE

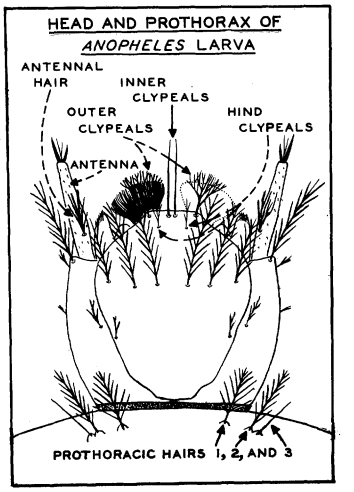


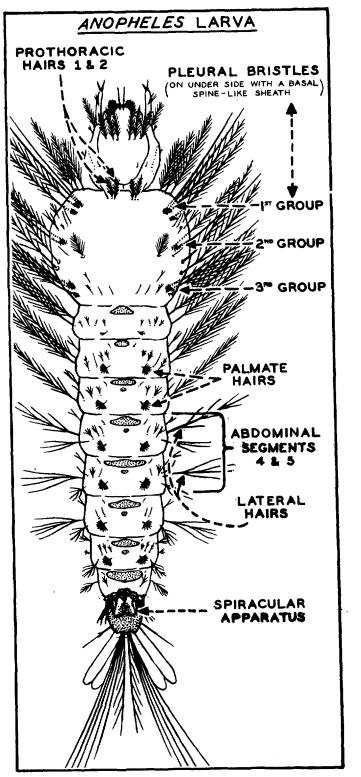
= *HAEMAGOGUS EQUINUS*

COMB SCALES ON A PLATE; SURFACE WITH SHORT HAIRS



= *HAEMAGOGUS SPEGAZZINII FALCO*





DN—1265

MOSQUITOES OF MEDICAL IMPORTANCE — CENTRAL AMERICA

[EXCLUDING PANAMA]

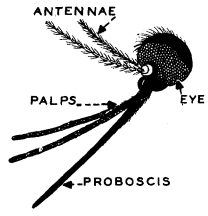
FEMALES

[*MALES HAVE BUSHY ANTENNAE* () *AND DO NOT BITE*]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

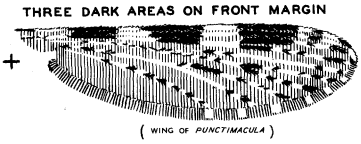
FIG. 9

PALPS LONG



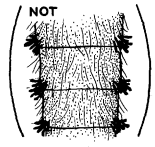
PATTERN ON HIND TARSUS

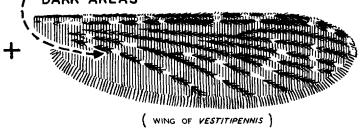
+ THREE DARK AREAS ON FRONT MARGIN



+ LIGHT SCALES ON LOWER HALF OF WING YELLOWISH (NOT WHITE) = *ANOPHELES PUNCTIMACULA*

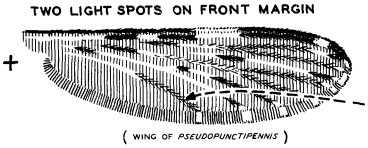
ABDOMINAL SEGMENTS

+ LATERAL SCALE TUFTS ABSENT (NOT ) + VEIN 6 WITH NUMEROUS LIGHT AND DARK AREAS



= *ANOPHELES VESTITIPENNIS*

+ TWO LIGHT SPOTS ON FRONT MARGIN

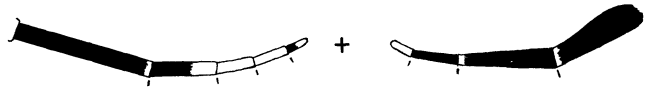


+ LOWER PART OF VEIN 6 ENTIRELY DARK = *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

+ LIGHT SPOT AT CROSS VEIN SHORTER THAN PRECEDING DARK SPOT

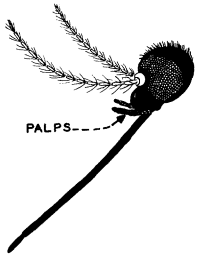
= *ANOPHELES DARLINGI*

PATTERN ON PALP



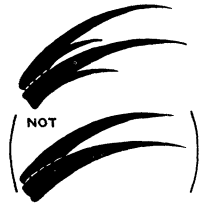
= *ANOPHELES ALBIMANUS*

PALPS SHORT



PATTERN ON TOP OF THORAX

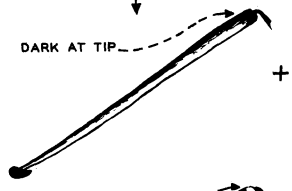
METALLIC BLUE OR GREEN

+ 

PATTERN ON MID LEG

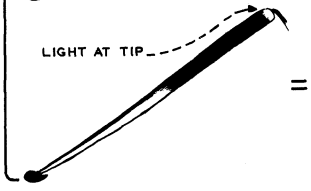
PATTERN ON HIND FEMUR

DARK AT TIP



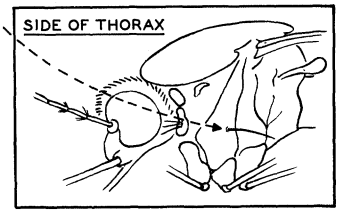
+ ONE OR MORE STERNOPLEURAL SETAE PRESENT (SEE ENLARGED DRAWING FOR LOCATION) = *HAEMAGOGUS MESODENTATUS* AND *SPEGAZZINII FALCO* (ONLY *SPEGAZZINII FALCO* IMPORTANT; FEMALES CANNOT BE SEPARATED)

LIGHT AT TIP



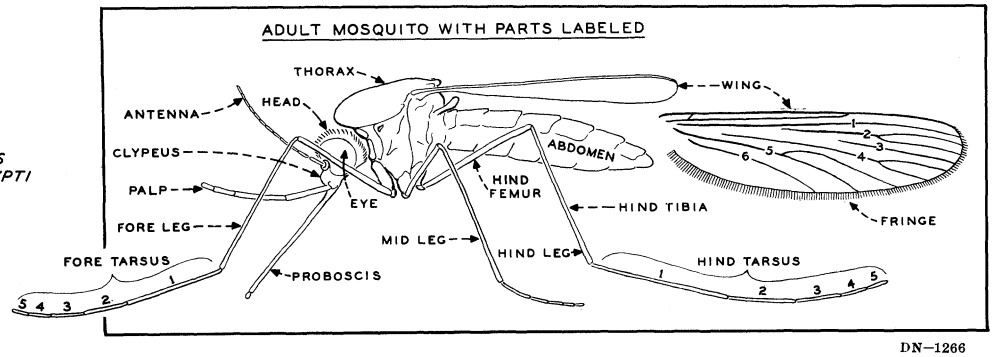
= *HAEMAGOGUS EQUINUS*

SIDE OF THORAX



= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1266

Anopheles Species in Central America

**albimanus*
†albitarsis
anomalophyllus
apicimacula
†aquasalis
argyritarsis
†bellator
†crucians
†cruzi
**darlingi*
eiseni
evansae
gabaldoni
hectoris
†homunculus
intermedius
kompi
neivai
neomaculipalpus
†oswaldoi
parapunctipennis guatemalensis
parapunctipennis parapunctipennis
**pseudopunctipennis pseudopunctipennis*
**punctimacula*
triannulatus
**vestitipennis*
zelajuensis

See footnote 6, p. 10.

Yellow Fever.—Urban yellow fever, transmitted by *Aedes aegypti*, was common in Central America prior to 1925. From 1925 to 1948 the Central American countries were free of the disease, but from 1948 to 1951 a wave of jungle yellow fever swept northward through Panama (see p. 23), and from 1951 to 1954 it invaded Costa Rica, Nicaragua, and Honduras. This disease is not known to occur in Guatemala. In the first three countries cases of jungle yellow fever were reported in the tropical rain forest of the Caribbean slope, where wild monkey hosts support the disease.

Haemagogus spegazzinii falco is one of the most commonly encountered vectors of yellow fever under suspicion, but its range extends northward only to the north coast of Honduras east of the Ulúa Valley. *Haemagogus equinus*, a species ranging from Panama to Texas, is also suspected. More recently *Haemagogus mesodentatus mesodentatus* and *H. m. gorgasi* have been implicated in yellow fever transmission. All these *Haemagogus* species have transmitted yellow fever virus in the laboratory, but none have been found naturally infected.

Sabethes chloropterus is believed to transmit the virus from one monkey host to another during dry periods that are unfavorable for other mosquitoes.

References: *132, 330, 349.*

Dengue.—This disease is apparently not present in Guatemala, Salvador, or British Honduras, but cases of dengue appear farther south. The presence of endemic dengue in Honduras is in considerable doubt, but sporadic cases thought to be of this disease have occurred there and in El Salvador. The extent of dengue in Nicaragua and Costa Rica is in dispute. *Aedes aegypti* is the vector wherever the disease appears in Central America.

References: *6, 9, 10, 12, 15, 17, 256.*

Encephalitis.—No information is available on the distribution of the encephalitis viruses in Central America.

Reference: *257.*

Filariasis.—*Wuchereria bancrofti* is present in an endemic focus around Limón, Costa Rica. Surveys have shown this parasite to be present in as high as 15 percent of the native populations in certain areas of the Caribbean coast and considerably less (1 percent) along the Pacific. *Culex pipiens quinquefasciatus*, the probable vector, is present in all these areas.

Reference: *74.*

Panama

(Figs. 10 and 11)

Physical Features.—Panama is 450 miles long and connects the North and South American Continents. It varies from 32 to 113 miles in width between the Caribbean Sea on the north and the Pacific Ocean on the south. Its heavily indented southern coast is a narrow lowland fringed with numerous keys and islands, where tides rise as high as 20 feet. The Caribbean side, bordered by narrow lowlands, has much weaker tides. The isthmus is traversed from east to west by several almost parallel mountain ranges, which rise to over 11,000 feet near the border of Costa Rica. In the center of Panama at the Panama Canal Zone, these mountains descend to 1,500–200 feet but rise to the east in the Cordillera de San Blas and the Serranía del Darién ranges, which are very close to the northern Caribbean coast and extend into Colombia.

The climate is tropical and subtropical except in a few high upland areas. The Caribbean side of the mountains receives up to 150 inches of rain annually, most of which comes in the wet season from mid-May to mid-December, but the Pacific side receives only about 70 inches per year.

The Canal Zone is a strip of land, 40 miles wide, lying across the center of Panama in a northwest to southeast direction. The climate there is tropical, with higher rainfall on the Caribbean than on the Pacific side.

Reference: *301.*

Malaria.—As in Central America, malaria in Panama is widespread and important. It is practically absent from the higher mountains, but along the coast and in the Canal Zone itself malaria is still highly endemic in spite of consistent control measures.

Most malaria in Panama is caused by *Plasmodium vivax*. *Plasmodium falciparum* and *P. malariae* are responsible for the remaining cases; the former parasite is the more common.

Anopheles albimanus is probably the most important vector of malaria in Panama, as in most of the Caribbean area. It is abundant throughout the year, but during the dry season it is mostly restricted to large bodies of water. When the rise of water level during the rains causes protective vegetation to break up, *albimanus* tends to seek coastal breeding places.

Anopheles pseudopunctipennis pseudopunctipennis is one of the most common mosquitoes in Panama. Despite its prevalence it is not regarded as an important species in that country. The larvae are most abundant during the dry season and inhabit drying stream beds in open, sunlit locations. This mosquito is present well into the rainy season, but heavy rain in these areas flushes the larvae out of breeding places and the adults become scarce.

Anopheles albitarsis is a dangerous species in parts of South America and for this reason is included in the keys. No records exist of *albitarsis* females attacking man in Panama, even in the immediate vicinity of intense larval populations. This species may be composed of several races, a possible explanation for its zoophilism in some areas of this country. It is usually found breeding during the last half of the dry season in a restricted area of the western arm of Gatun Lake.

Anopheles oswaldoi is a rare mosquito, but it is believed to be an important vector in several areas of Panama. Breeding in well-shaded, fresh-water jungle pools, it does not commonly come in contact with man. The females will occasionally bite and transmit a certain amount of malaria to man when the latter invades their jungle haunts.

Anopheles aquasalis is present only on the Caribbean side of Panama and commonly breeds in salt-marsh water, although the larvae have been found in fresh water as well.

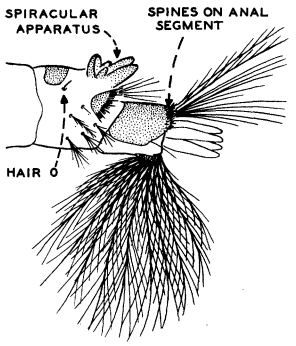
MOSQUITOES OF MEDICAL IMPORTANCE — PANAMA

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

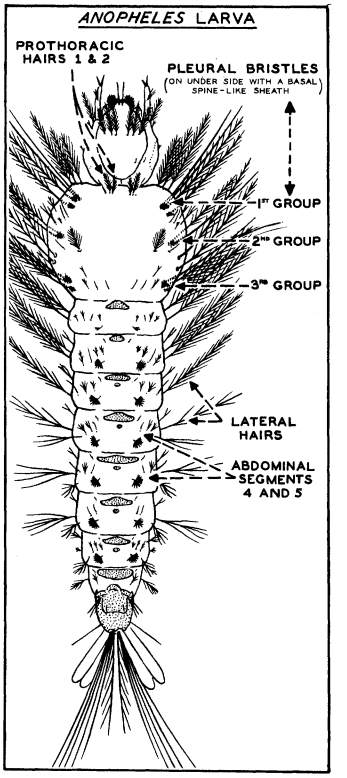
FULL-GROWN LARVAE

FIG. 10

SIPHON ABSENT

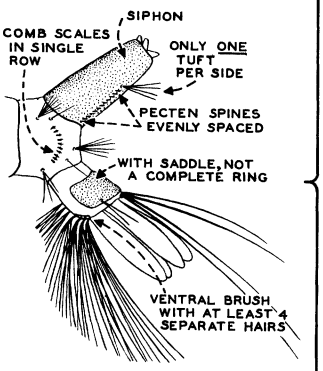


- **OUTER CLYPEALS** — **PROTHORACIC HAIR 1**
  - BARE + OR = *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*
- **PROTHORACIC HAIR 1** — **INNER CLYPEALS** (WITH SHORT HAIRS)
  - BRANCHED FROM BASE; LEAFLETS WIDE AND FLATTENED + WIDELY SEPARATED = *ANOPHELES ALBITARSIS*
- **PROTHORACIC HAIRS 1 AND 2** (WITH SHORT HAIRS)
  - BRANCHED FROM SIDES + BASES FUSED = *ANOPHELES ALBIMANUS*
- **OUTER CLYPEALS** (WITH LONG HAIRS)
  - MAIN STEM FORKED = *ANOPHELES OSWALDOI*
  - MAIN STEM SINGLE = *ANOPHELES AQUASALIS*
- **LATERAL HAIRS OF ABDOMINAL SEGMENTS 4 AND 5** — **SPINES ON ANAL SEGMENT** — **ANTENNA**
  - BRUSHLIKE + SINGLE + POINTED / NOT + VENTRAL SPINE BLUNT = *ANOPHELES PUNCTIMACULA*

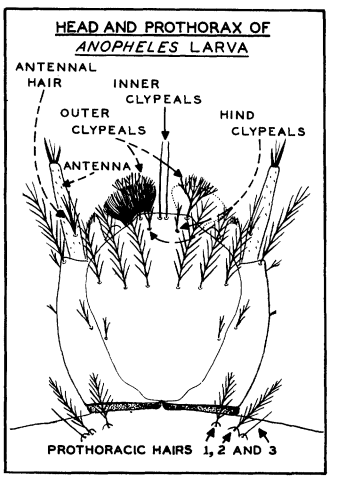


SIPHON PRESENT,

PLUS ALL CHARACTERS LISTED BELOW



- **ABDOMINAL SEGMENT 8**
  - COMB SCALES NOT ON A PLATE; SURFACE BARE — **ANTENNA**
    - SMOOTH — **COMB SCALES**
      - + LENGTH OF SIPHON FOUR TIMES WIDTH AT BASE = *AEDES LEUCOCELAENUS CLARKI*
      - = *AEDES AEGYPTI*
    - WITH SMALL SPINES + **SADDLE** (SADDLE HAIR TWO BRANCHED) = *HAEMAGOGUS EQUINUS*
  - COMB SCALES ON A PLATE; SURFACE WITH SHORT HAIRS = *HAEMAGOGUS SPEGAZZINII FALCO*



DN—1267

MOSQUITOES OF MEDICAL IMPORTANCE — PANAMA

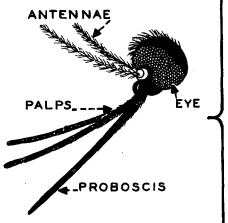
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

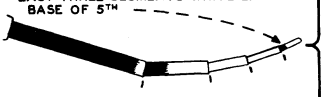
FIG. 11

PALPS LONG



PATTERN ON HIND TARSUS

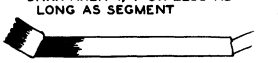
LAST THREE SEGMENTS WHITE EXCEPT BASE OF 5TH



PATTERN ON PALP

PATTERN ON 2ND SEGMENT OF HIND TARSUS

DARK AREA 1/4 OR LESS AS LONG AS SEGMENT



= *ANOPHELES OSWALDOI*

DARK AREA 1/3 OR MORE AS LONG AS SEGMENT

= *ANOPHELES AQUASALIS, ANOMALOPHYLLUS,* AND *STRODEI*
(ONLY *AQUASALIS* IMPORTANT; FEMALES CANNOT BE SEPARATED)

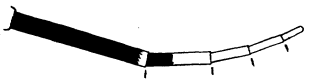
+ LIGHT SPOT AT CROSS VEIN LONGER THAN PRECEDING DARK SPOT

(WING OF *ALBIMANUS*)

= *ANOPHELES ALBIMANUS*

ABDOMINAL SEGMENT 1

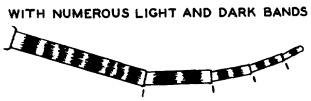
LAST THREE SEGMENTS ENTIRELY WHITE



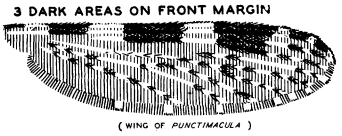
+ WITH ROWS OF WHITE SCALES ON VENTRAL SIDE

= *ANOPHELES ALBITARSIS*

WITH NUMEROUS LIGHT AND DARK BANDS

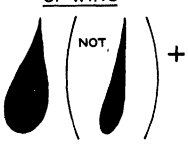


+ 3 DARK AREAS ON FRONT MARGIN



(WING OF *PUNCTIMACULA*)

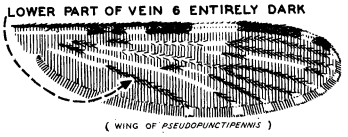
+ SCALES AT BASE OF WING



+ LIGHT SCALES ON LOWER HALF OF WING YELLOWISH = *ANOPHELES PUNCTIMACULA*

ALL DARK

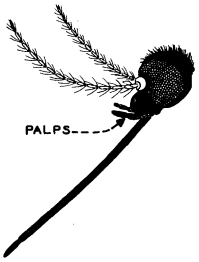
+ LOWER PART OF VEIN 6 ENTIRELY DARK



(WING OF *PSEUDOPUNCTIPENNIS*)

= *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

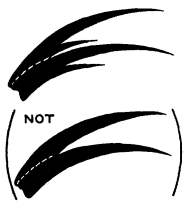
PALPS SHORT



PATTERN ON TOP OF THORAX

METALLIC BLUE OR GREEN

+ CLAWS ON MID LEG



PATTERN ON HIND FEMUR

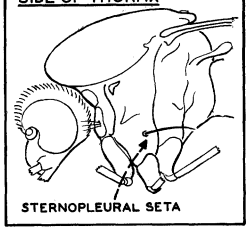
DARK AT TIP

+ ONE OR MORE STERNOPLEURAL SETAE PRESENT (SEE ENLARGED DRAWING FOR LOCATION) = *HAEMAGOGUS SPEGAZZINII FALCO*

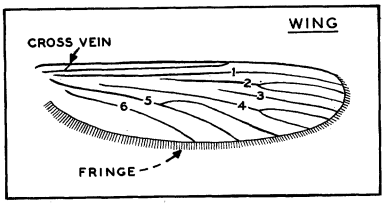
LIGHT AT TIP

= *HAEMAGOGUS EQUINUS*

SIDE OF THORAX



WING



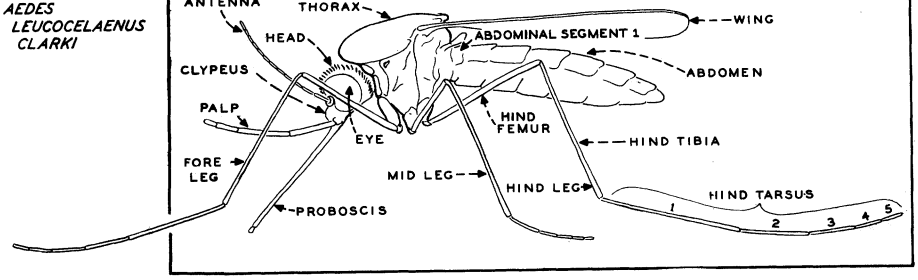
PATTERN ON SIDE OF THORAX

+ 

= *AEDES LEUCOCELAENUS CLARKI*

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1268

In spite of the large numbers present in some localities, this species is not attracted to man in this country.

Anopheles punctimacula is regarded by many workers as a malaria vector in Panama. Evidence for this is somewhat conflicting. The females are often abundant in areas where malaria is hyperendemic and where other known vectors are absent, but many times no infections can be demonstrated in wild-caught mosquitoes under these circumstances.

Anopheles darlingi may have some importance in Panama, because it is an efficient vector over most of its range.

References: *45, 67, 291, 292, 296.*

Anopheles Species in Panama

**albimanus*	*maculipes*
†*albitarsis*	*mediopunctatus*
anomalophyllus	*neivai*
apicimacula	*neomaculipalpus*
†*aquasalis*	*nimbus*
argyritarsis	**oswaldoi*
†*bellator*	*parapunctipennis*
braziliensis	*peryassui*
†*crucians*	**pseudopunctipennis pseudopunctipennis*
†*cruzi*	**punctimacula*
†*darlingi*	*rangeli*
eiseni	*squamifemur*
evansae	*strodei*
fausti	*triannulatus*
grabhamii	†*vestitipennis*
†*homunculus*	*xelajuensis*
kompi	

See footnote 6, p. 10.

Yellow Fever.—The difficulties encountered in the construction of the Panama Canal and the conquest of yellow fever gave rise to one of the most significant chapters in the history of arthropod-borne diseases. Classical yellow fever, transmitted by *Aedes aegypti*, is now practically extinct in Panama because of careful and persistent control measures. Jungle yellow fever, on the other hand, was discovered in 1932 in eastern Panama and may have been present there for a number of years. An outbreak causing five deaths occurred in the Pacora district in 1948, and soon afterward an epidemic was noted proceeding from east to west. It swept through the tropical rain forest on the Caribbean slope. In July and August 1949 it reached the Chagres district, and in April and June 1951 the disease reached Almirante and began to invade Costa Rica (see p. 20).

Haemagogus equinus, *H. spegazzinii falco*, and *H. mesodentatus mesodentatus* are primarily arboreal mosquitoes. All of them live in the tropical rain forest of the Caribbean slope, and all have transmitted yellow fever virus in the laboratory, although none have been found with natural infections.

Aedes leucocelaenus clarki is common in the rain forest, and naturally infected mosquitoes of this species from South America have been able to transmit the virus in the laboratory.

Sabethes chloropterus is believed to transmit the virus on both the Caribbean and Pacific slopes during times of the year that are too dry for the maintenance of other species.

References: *132, 155, 330.*

Dengue.—In 1933 three small outbreaks of dengue occurred at low altitudes near the coast of Panama at the end of the rainy season when artificial containers used by *Aedes aegypti* were filled. No substantial number of cases have been reported since this time.

Reference: *21.*

Encephalitis.—The virus of eastern equine encephalitis is present in central Panama, and doubtful human cases of the disease were recorded in 1946. Nothing is known about the vectors.

Reference: *257.*

Filariasis.—No information is available.

SOUTH AMERICA

Northwest South America

(Figs. 12 and 13)

Physical Features.—Northwest South America includes Venezuela, Colombia, Ecuador, and Peru. They form an arc around the northwest corner of the South American Continent. Venezuela has a north coast along the Caribbean Sea. The Orinoco River rises in the forested southeast Guiana Highlands, flows northwest, north, and east through the center of the country, and forms a wide, swampy delta opposite Trinidad. Most of the north-central part of Venezuela consists of some tropical jungle and the llanos, an area of savannas. A spur of the Andes, the Cordillera Oriental, runs from east to west across Venezuela near the coast. Seaward from this range is the low, tropical coast. The rainy season in Venezuela lasts from May to November.

The eastern three-fourths of Colombia consists of humid, torrid plains. The western fourth contains three great mountain chains, which reach northward from Ecuador, one peak being almost 19,000 feet high. The valleys between these mountains contain most of the country's population and agriculture. Savannas coextensive with those of Venezuela lie directly east of the Cordillera Oriental. All the southern half of Colombia east of the mountains is densely forested. The alluvial coasts are rain soaked.

Ecuador, the smallest of the four countries, fronts on the Pacific Ocean. The central north-south Andes chain consists of two parallel ranges of extremely high (up to 20,500 feet), active and inactive volcanoes. About 60 percent of the country's population lives in a 7,500- to 9,000-foot tableland between these mountain ranges. A western agricultural lowland lies between the Pacific and the Andes, and an eastern jungle and savanna lowland are in the Amazon basin.

Peru is the southernmost of the four countries and has a 1,400-mile Pacific coast. The 10- to 40-mile-wide coastal strip receives less than 2 inches of rain annually, but almost all river valleys and deltas are intensively cultivated. About 60 percent of Peru's native population lives in large upland basins of the Andes at altitudes of 10,000 feet and over. The land descends eastward from these uplands into the jungle of the upper Amazon basin known as the Montaña, which is low, humid, and covered by lush vegetation and savannas.

References: *301, 349.*

Malaria.—Throughout Ecuador and the coastal areas of Colombia *Plasmodium falciparum* predominates, although *P. vivax* and *P. malariae* are present in smaller numbers. Elsewhere in Colombia and throughout Venezuela and Peru *vivax* is the principal parasite. In Venezuela *malariae* is sometimes abundant.

The southeastern jungle of Venezuela is sparsely populated but represents one of the country's large centers of endemic malaria. *Anopheles darlingi* is the vector in this area and in recent years has moved near the coast. Another endemic center is found at altitudes up to 3,280 feet on the southeastern savanna plateau of Venezuela. An additional endemic center in northwestern Venezuela is characterized by large epidemics attributed to *Anopheles albimanus*, especially during periods of heavy rain. This species breeds heavily in flooded ricefields, and in the vicinity of Maracay it is restricted

MOSQUITOES OF MEDICAL IMPORTANCE — NORTHWEST SOUTH AMERICA

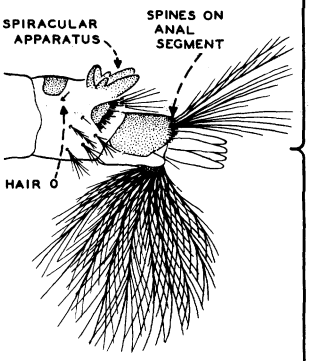
[AREA INCLUDED: VENEZUELA, COLOMBIA, ECUADOR, AND PERU]

FIG. 12

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

SIPHON ABSENT



OUTER CLYPEALS + **PROTHORACIC HAIR 1**

- BARE + OR = *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

WITH LONG HAIRS — **OUTER CLYPEALS**

- MAIN STEM FORKED = *ANOPHELES OSWALDOI*
- MAIN STEM SINGLE = *ANOPHELES AQUASALIS, BENARROCHI, AND NUNEZ-TOVARI* (ONLY *AQUASALIS* IMPORTANT; LARVAE CANNOT BE SEPARATED WITH CERTAINTY)

WITH SHORT HAIRS — **PROTHORACIC HAIR 1** + **PROTHORACIC HAIRS 1 AND 2**

- BASES FUSED = *ANOPHELES ALBIMANUS*

SPIRACULAR APPARATUS

- WITH LONG HAIRS AT POSTERIOR END = *ANOPHELES DARLINGI*

INNER CLYPEALS + **PROTHORACIC HAIRS 1**

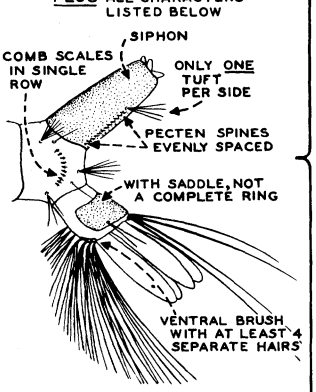
- WIDELY SPACED + DISTANCE BETWEEN BASES OF HAIRS APPROXIMATELY SAME AS THEIR LENGTHS = *ANOPHELES ALBITARSIS*

LATERAL HAIRS OF ABDOMINAL SEGMENTS 4 AND 5 + **PLEURALS OF 1ST GROUP** + **SPINES ON ANAL SEGMENT**

- BRUSHLIKE + SINGLE + ALL SINGLE + POINTED (NOT) = *ANOPHELES PUNCTIMACULA*

SIPHON PRESENT,

PLUS ALL CHARACTERS LISTED BELOW



ABDOMINAL SEGMENT 8

COMB SCALES NOT ON A PLATE; SURFACE BARE — **ANTENNA** + **SADDLE**

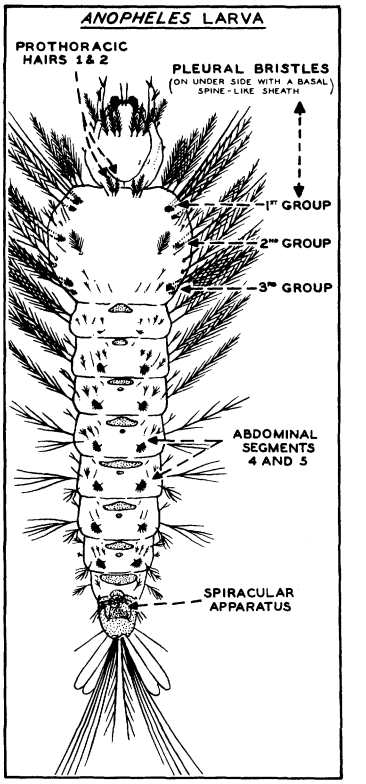
- WITH SMALL SPINES + SADDLE HAIR TWO BRANCHED + LENGTH OF SIPHON TWO TIMES WIDTH AT BASE = *HAEMAGOGUS EQUINUS*

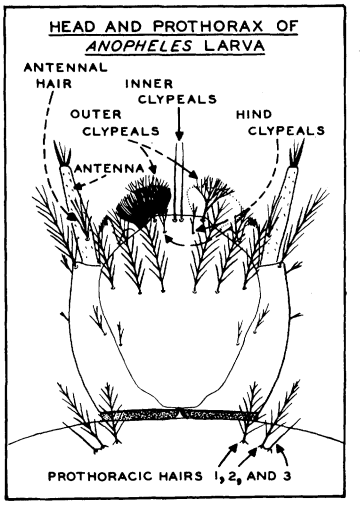
COMB SCALES

- SMOOTH = *AEDES LEUCOCELAENUS*
- = *AEDES AEGYPTI*

COMB SCALES ON A PLATE; SURFACE WITH SHORT HAIRS

- = *HAEMAGOGUS SPEGAZZINII SPEGAZZINII, SPEGAZZINII FALCO,* AND *CAPRICORNII* (ALL IMPORTANT; ONLY MALES CAN BE SEPARATED)





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MOSQUITOES OF MEDICAL IMPORTANCE — NORTHWEST SOUTH AMERICA

[AREA INCLUDED: VENEZUELA, COLOMBIA, ECUADOR, AND PERU]

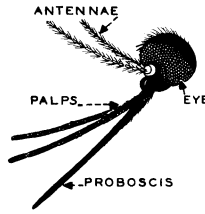
FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

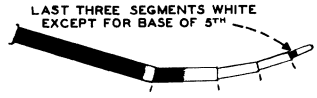
FIG. 13

PALPS LONG



PATTERN ON HIND TARSUS

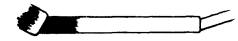
LAST THREE SEGMENTS WHITE EXCEPT FOR BASE OF 5TH



PATTERN ON PALP

PATTERN ON 2ND SEGMENT OF HIND TARSUS

DARK AREA 1/4 OR LESS AS LONG AS SEGMENT



= *ANOPHELES OSWALDOI*

DARK AREA 1/3 OR MORE AS LONG AS SEGMENT

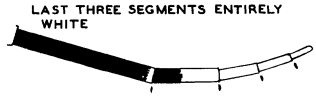
= *ANOPHELES AQUASALIS* AND RELATIVES

+ LIGHT SPOT AT CROSS VEIN LONGER THAN PRECEDING DARK SPOT

= *ANOPHELES ALBIMANUS*

(WING OF *ALBIMANUS*)

LAST THREE SEGMENTS ENTIRELY WHITE



LIGHT SPOT AT CROSS VEIN SHORTER THAN PRECEDING DARK SPOT

(WING OF *DARLINGI*)

+ **ABDOMINAL SEGMENTS** — LATERAL SCALE TUFTS PRESENT

= *ANOPHELES DARLINGI*

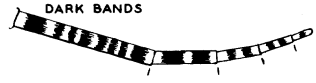
LIGHT SPOT AT CROSS VEIN LONGER THAN PRECEDING DARK SPOT

(WING OF *ALBITARSIS*)

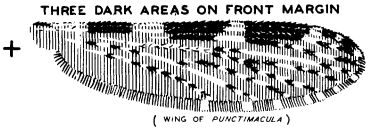
+ **ABDOMINAL SEGMENT 1** — WITH ROWS OF WHITE SCALES ON VENTRAL SIDE

= *ANOPHELES ALBITARSIS*

WITH NUMEROUS LIGHT AND DARK BANDS



+ THREE DARK AREAS ON FRONT MARGIN



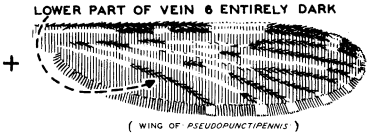
(WING OF *PUNCTIMACULA*)

+ **SCALES ON BASAL HALF OF WING**

+ LIGHT SCALES ON LOWER HALF OF WING YELLOWISH = *ANOPHELES PUNCTIMACULA*

ALL DARK

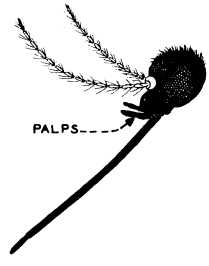
+ LOWER PART OF VEIN 6 ENTIRELY DARK



= *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

(WING OF *PSEUDOPUNCTIPENNIS*)

PALPS SHORT

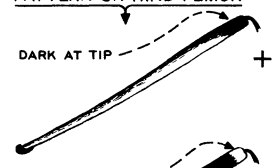


PATTERN ON THORAX — METALLIC BLUE OR GREEN

CLAWS ON MID LEG

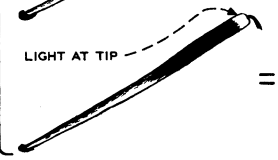
PATTERN ON HIND FEMUR

DARK AT TIP



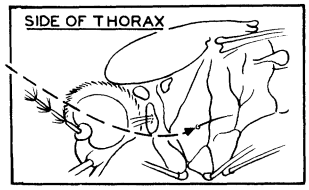
+ ONE OR MORE STERNOPLEURAL SETAE PRESENT (SEE ENLARGED DRAWING FOR LOCATION) = *HAEMAGOGUS SPEGAZZINII SPEGAZZINII, SPEGAZZINII FALCO,* AND *CAPRICORNII* (ALL IMPORTANT; ONLY MALES CAN BE SEPARATED)

LIGHT AT TIP



= *HAEMAGOGUS EQUINUS, ANDINUS,* AND *PANARCHYS* (ONLY *EQUINUS* IMPORTANT; FEMALES CANNOT BE SEPARATED)

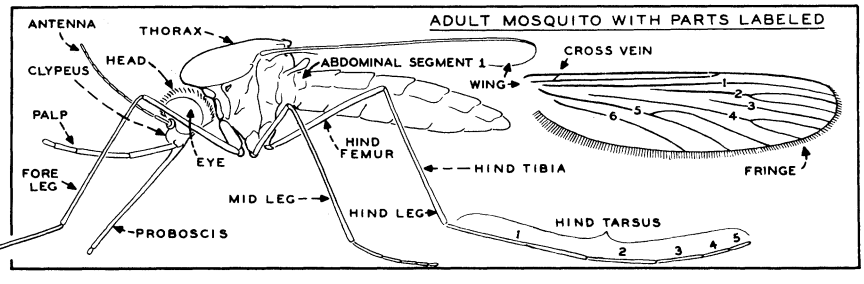
SIDE OF THORAX



= *AEDES LEUCOCELAENUS*

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



solely to this habitat. It is progressing farther and farther inland along the main highways. *A. darlingi* is present still farther inland throughout this area, and a great deal of malaria occurs throughout its range in the absence of *albimanus*. *Anopheles pseudopunctipennis pseudopunctipennis* transmits malaria in the valleys of the western Andes. *Anopheles aquasalis*, a coastal species, plays a role in malaria transmission along the southern part of the Paria Peninsula directly west of Trinidad, but elsewhere in Northwest South America it appears to be unimportant. *Anopheles albitarsis* is believed to be an important vector in parts of Venezuela, but the extent of its range has not yet been adequately determined.

Colombia's southeastern flatland has a large amount of malaria for its scattered population. This is carried by *darlingi*, whose range extends northward into Panama and westward into the low mountain valleys. *A. albimanus* inhabits the Pacific coastal flatlands, but malaria incidence is lower there than in the northern coastal area, where it is present with not only *darlingi* but *Anopheles punctimacula* as well. In the Cauca Valley in the west-central mountains *punctimacula* is the only vector in the presence of high malaria incidence. This area represents the greatest single malaria problem with which *punctimacula* has ever been associated. In the upper Magdalena Valley to the north and east *pseudopunctipennis* plays an important part in malaria transmission. *Anopheles oswaldoi*, primarily a forest mosquito, is believed to be important in several places in Panama, and it is included in the keys because it may be important in Colombia as well.

The distribution of malaria in Ecuador is little known. East of the Andes the vector is probably *darlingi*. *A. p. pseudopunctipennis* is the principal mosquito in several mountain valleys in this country, where it is the principal vector associated with epidemic and highly endemic malaria. *A. albimanus* reaches its southernmost range on the Pacific side of the continent in Ecuador. Near the coast at Guayaquil extremely high spleen rates, presumably due to the activity of *albimanus*, have been found.

In Peru, largely a mountainous country, *pseudopunctipennis* is the most important vector. It is present not only in the higher mountain valleys where most of the country's population lives but in the lower coastal areas as well. This species has been found as high as about 7,000 feet in the presence of endemic malaria, and it is responsible for occasional epidemics at these altitudes. The other important vector in Peru, *punctimacula*, is restricted to coastal areas and is found from sea level to about 2,500 feet along the west slope of the Andes. It is associated with the irrigation of sugarcane and rice. *A. darlingi* is the vector in the flatlands east of the Peruvian border, but little is known about its importance directly to the west.

References: *59, 67, 100, 292, 296.*

Anopheles Species in Northwest South America

acanthotorynus
**albimanus*
**albitarsis*
annulipalpis
apicimacula
**aquasalis*
argyritarsis argyritarsis
argyritarsis sawyeri
bambusicolus
†*bellator*
benarrochi
boliviensis
braziliensis
†*crucians*
†*cruzi*
cruzi laneanus
**darlingi*
eiseni
evansae
fluminensis
gilesi
gomezdelatorreyi
guarao
†*homunculus*
kompi
lanei
lutzi
maculipes
mattogrossensis
mediopunctatus
neivai
neomaculipalpus
nimbus
nuneztovari
oiketorakras
**oswaldoi*
parvus
peryassui
pseudomaculipes
pseudopunctipennis bifoliata
pseudopunctipennis levicastilloi
**pseudopunctipennis pseudopunctipennis*
pseudopunctipennis rivadeneirai
**punctimacula*
punctipennis
rangeli
rondoni
shannoni
squamifemur
thomasi
triannulatus davisi
triannulatus triannulatus
vargasi
†*vestitipennis*

See footnote 6, p. 10.

Yellow Fever.—Epidemics of urban yellow fever, normally supported by *Aedes aegypti*, no longer occur in Northwest South America because that species is no longer present. The disease has been reported from nearly all the coastal areas of this region in the past. Jungle yellow fever, on the other hand, occurs in a large part of this region, especially at lower altitudes. Mouse-protection tests performed before 1940 were positive in all four countries. There are continual sporadic outbreaks, each affecting considerable numbers of people.

Of all the *Haemagogus* species that can be vectors, *H. spegazzinii falco* is the most important in this region. *Haemagogus spegazzinii spegazzinii*, *H. capricornii*, and *H. equinus*, as well as *Aedes leucocelaenus*, have been taken in much smaller numbers. For details on the biology and importance of these species, see the next section of this handbook.

References: *40, 140, 141, 220, 230, 256, 313.*

Dengue.—In 1942 and 1943 a disease resembling dengue occurred along the Magdalena River in Colombia, but its vector was never actually determined. Sporadic cases, thought to be dengue, are reported every year. Although dengue has occurred in Venezuela in the past, no cases have been reported since 1920. The disease has never been reported from Peru.

References: *11, 14, 23, 26, 256.*

Encephalitis.—The virus of Venezuelan equine encephalitis has been found in an endemic area that includes parts of Venezuela, Colombia, the western half of Ecuador, and Trinidad. It is highly infectious, especially to man, but the extent to which this virus is responsible for the disease in man and animals is not known. Doubtful human cases in Ecuador and confirmed human cases at Espinal, Colombia, were recorded in 1951 and 1952, respectively. No vector has been definitely implicated. A large area of central Peru is believed to contain animals infected with western equine encephalitis virus. For additional information, see page 3.

References: *246, 257.*

Filariasis.—No information is available.

Brazil and the Guianas

(Figs. 14 and 15)

Physical Features.—Brazil and the Guianas comprise about one-half the total area of South America. Most of Brazil lies south of the Equator and has approximately 4,600 miles of Atlantic coastline. Brazil is essentially a vast central plateau bordered by lowlands, the largest of which is the Amazon basin in the northern half. The Guiana Highlands form its northern rim. The basin, which extends into eastern Colombia, Ecuador, and Peru, has uniform high

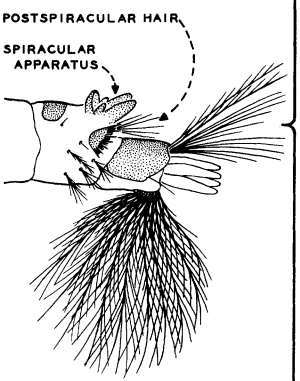
MOSQUITOES OF MEDICAL IMPORTANCE — BRAZIL AND THE GUIANAS

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

FIG. 14

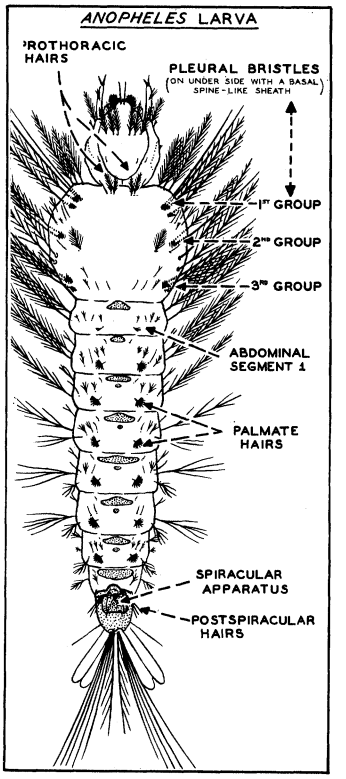
SIPHON ABSENT



PROTHORACIC HAIR 1

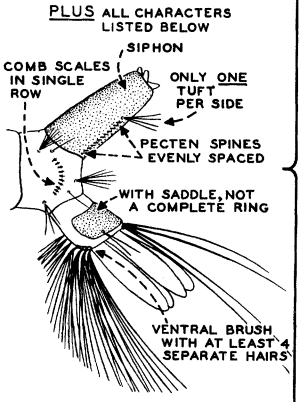
- BRANCHES FLATTENED; RISING FROM BASE
  - OUTER CLYPEALS: WITH SHORT HAIRS + INNER CLYPEALS: WIDELY SEPARATED + PROTHORACIC HAIRS 1: DISTANCE BETWEEN BASES OF HAIRS APPROXIMATELY SAME AS THEIR LENGTHS = *ANOPHELES ALBITARSIS*
  - WITH LONG HAIRS; MAIN STEM SINGLE = *ANOPHELES AQUASALIS* AND RELATIVES (ONLY *AQUASALIS* IMPORTANT; ONLY MALES CAN BE SEPARATED)
  - PALMATE HAIRS: WITH LONG HAIRS; MAIN STEM FORKED + LEAFLETS SMOOTH (NOT) = *ANOPHELES OSWALDOI*
- BRANCHES HAIRLIKE; RISING FROM BASE + SPIRACULAR APPARATUS: WITH LONG HAIRS AT POSTERIOR END = *ANOPHELES DARLINGI*
- BRANCHES HAIRLIKE; RISING FROM SHAFT
  - OUTER SUTURALS: BRANCHED + PROTHORACIC HAIRS 1 AND 2: BASES FUSED = *ANOPHELES ALBIMANUS*
  - BARE; OVER ONE-HALF AS LONG AS INNER CLYPEALS
    - POSTSPIRACULAR HAIRS: DOUBLE = *ANOPHELES BELLATOR*
    - SINGLE + ABDOMINAL SEGMENT 1: PALMATES PRESENT = *ANOPHELES HOMUNCULUS, CRUZI,* AND *ANOPLUS* (ONLY *HOMUNCULUS* AND *CRUZI* IMPORTANT; LARVAE CANNOT BE SEPARATED)

ANOPHELES LARVA



SIPHON PRESENT,

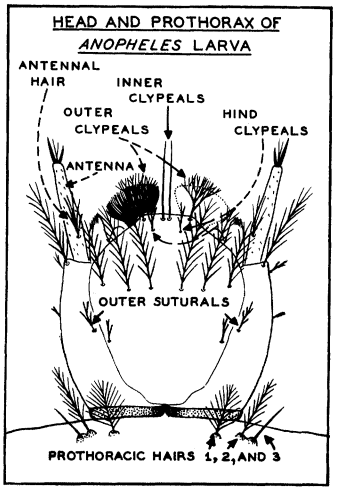
PLUS ALL CHARACTERS LISTED BELOW



ABDOMINAL SEGMENT 8

- COMB SCALES NOT ON A PLATE; SURFACE BARE
  - ANTENNA: SMOOTH
    - COMB SCALES: + SIPHON: HAIR TUFT TWO BRANCHED = *AEDES LEUCOCELAENUS*
    - = *AEDES AEGYPTI*
  - ANTENNA: WITH SHORT SPINES = *HAEMAGOGUS EQUINUS*
- COMB SCALES ON A PLATE; SURFACE WITH SHORT HAIRS = *HAEMAGOGUS SPEGAZZINII SPEGAZZINII, SPEGAZZINII FALCO,* AND *CAPRICORNII* (ALL IMPORTANT; ONLY MALES CAN BE SEPARATED)

HEAD AND PROTHORAX OF *ANOPHELES* LARVA



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MOSQUITOES OF MEDICAL IMPORTANCE - BRAZIL AND THE GUIANAS

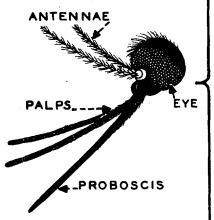
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FEMALES

[*MALES HAVE BUSHY ANTENNAE* () *AND DO NOT BITE*]

FIG. 15

PALPS LONG

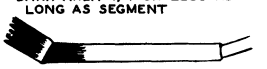


PATTERN ON HIND TARSUS

PATTERN ON PALP

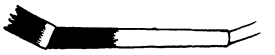
PATTERN ON 2ND SEGMENT OF HIND TARSUS

DARK AREA 1/4 OR LESS AS LONG AS SEGMENT



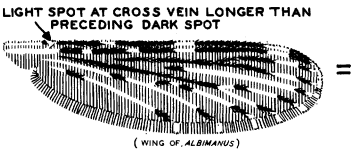
= *ANOPHELES OSWALDOI* AND *ININII*
(ONLY *OSWALDOI* IMPORTANT; FEMALES CANNOT BE SEPARATED)

DARK AREA 1/3 OR MORE AS LONG AS SEGMENT



= *ANOPHELES AQUASALIS* AND RELATIVES
(ONLY *AQUASALIS* IMPORTANT; ONLY MALES CAN BE SEPARATED)

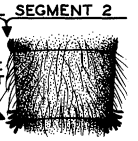
+ LIGHT SPOT AT CROSS VEIN LONGER THAN PRECEDING DARK SPOT



= *ANOPHELES ALBIMANUS*

ABDOMINAL SEGMENT 2

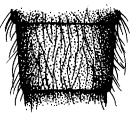
LATERAL SCALE TUFTS PRESENT



+ LIGHT SPOT AT CROSS VEIN SHORTER THAN PRECEDING DARK SPOT

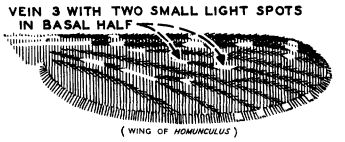
= *ANOPHELES DARLINGI*

LATERAL SCALE TUFTS ABSENT

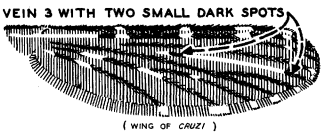


+ **ABDOMINAL SEGMENT 1** WITH ROWS OF WHITE SCALES ON VENTRAL SIDE

= *ANOPHELES ALBITARSIS*



= *ANOPHELES HOMUNCULUS*

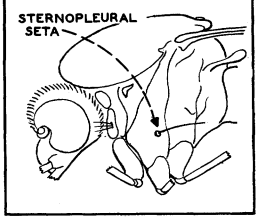


= *ANOPHELES CRUZI*

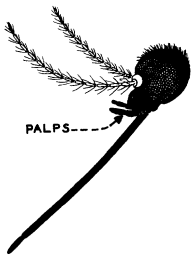
+ 

= *ANOPHELES BELLATOR*

SIDE OF THORAX



PALPS SHORT

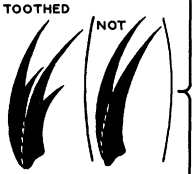


PATTERN ON THORAX

METALLIC BLUE OR GREEN

CLAWS ON MID LEG

TOOTHED NOT



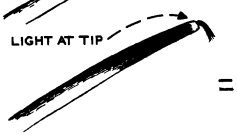
PATTERN ON HIND FEMUR

DARK AT TIP

+ ONE OR MORE STERNOPLEURAL SETAE PRESENT (SEE ENLARGED DRAWING FOR LOCATION)

= *HAEMAGOGUS CAPRICORNII, SPEGAZZINII SPEGAZZINII, SPEGAZZINII FALCO,* AND *ALBOMACULATUS*
(ALL IMPORTANT EXCEPT *ALBOMACULATUS*; FEMALES CANNOT BE SEPARATED)

LIGHT AT TIP

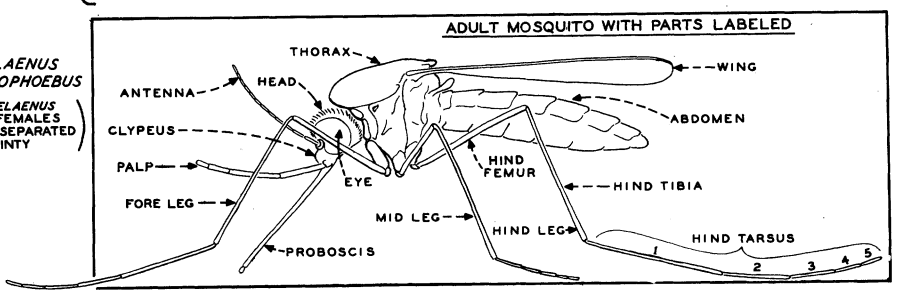


= *HAEMAGOGUS EQUINUS*

= *AEDES LEUCOCELAENUS* AND *LEUCOPHOEBUS*
(ONLY *LEUCOCELAENUS* IMPORTANT; FEMALES CANNOT BE SEPARATED WITH CERTAINTY)

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1272

temperatures and is the world's largest area of tropical climate and forest. It has an annual rainfall of about 60 inches. Much of the land near the coast and the poorly drained flood plain of the Paraguay River constitute another area of tropical rain. The Mato Grosso is the central Brazilian highland separating the Amazon from the Río de la Plata. This rolling upland is interrupted by several mountain ranges as high as 9,000 feet. It has a tropical climate, with alternate wet (summer) and dry seasons. In the southernmost Brazilian States the weather is humid and subtropical. Near to and parallel with the east coast is the Serra do Mar, which rises in peaks to almost 10,000 feet and forms a barrier to inland traffic.

British Guiana, Surinam (Netherlands Guiana), and French Guiana lie side by side directly north of Brazil. All have rather similar physical features. The 5- to 30-mile-wide coastal belt across all three countries is the only cultivated area. To the south an extensive upland contains most of the mineral and forest wealth. The Guiana Highlands along the northern border of Brazil have densely wooded plateaus and occasional savannas. The two wet seasons in the Guianas, one from April to mid-August and one from mid-November to February, are much less pronounced in the interior than on the coast, and trade winds from the northeast prevail from October to July.

Reference: *301.*

Malaria.—New World malaria reaches its greatest intensity in Brazil and the Guianas. In the Guianas and the entire Amazon River basin it is transmitted throughout the entire year. Its curve of intensity shows little annual fluctuation. From the southern edge of the Amazon basin south to about latitude 22° S., malaria occurs in a single pronounced annual peak in the first half of the year and is transmitted over a long period. In the rest of Brazil malaria occurs in two peaks, one rather pronounced and occurring during March and April and the other considerably lower and occurring in September, October, and November.

Plasmodium falciparum malaria predominates in northern Brazil. *Plasmodium vivax* is a more important parasite than *P. malariae* in the north, the latter predominating in the vicinity of São Paulo. Coastal malaria in British Guiana is caused by *falciparum*, and *vivax* predominates inland; the reverse is true in French Guiana and Surinam.

The most efficient vector of New World malaria, *Anopheles darlingi*, is widespread throughout the four countries, principally in the lowlands some distance from the coast, but it is also present in areas as high as 1,000 feet above sea level. This species is not found in areas having heavily acid waters or in brackish water along the coast. It is estimated that malaria would become a relatively unimportant disease in South America with the disappearance of *darlingi*.

Anopheles aquasalis is a coastal brackish-water mosquito that rarely is found more than 10 to 12 miles inland. It plays a prominent role in malaria transmission in several coastal localities of Brazil. Under certain conditions it is surprisingly zoophilic and feeds readily on domestic animals, a possible reason for its lack of importance in many areas.

Anopheles albimanus has a limited coastal distribution in the Guianas. For this reason it is limited in its importance, although it is an efficient vector where it appears in large numbers.

Anopheles albitarsis is important in several places in Brazil. The most important is near the Sergipe and Bahia coasts, where it has been found infected in highly malarious areas. This endemic center extends southward along the coastal plain where, in Espíritu Santo, the typical species is present, and it is as important as *darlingi* and *aquasalis*, which also are found there.

Anopheles oswaldoi has not been adequately studied. It is a jungle mosquito and bites man out of doors. Since man seldom enters its haunts, this mosquito may not play an important role in malaria transmission in Brazil and the Guianas.

A particularly interesting association of man and malaria-bearing mosquitoes is that provided by *Anopheles homunculus*, *A. cruzi*, and *A. bellator*. These three species breed in epiphytic bromeliads, which are parasitic plants growing on the limbs of the tall immortelles that shade cacao plantations. Not only do they transmit malaria by entering the houses of the plantation workers but they commonly bite out of doors as well. They transmit a large amount of malaria along the central and southern coasts of Brazil. In several localities near Santa Catarina, Pananá, and São Paulo, *cruzi* and *bellator* are the most abundant *Anopheles* species and will attack man both night and day.

Anopheles gambiae, the most important vector of malaria in tropical Africa, was introduced at one time into northeastern Brazil. This species is not included in the keys, because it has not reappeared since its eradication in 1943.

References: *67, 111, 296.*

Anopheles Species in Brazil and the Guianas

acanthotorynus
**albimanus*
**albitarsis*
annulipalpis
anoplus
antunesi
apicimacula
**aquasalis*
argyritarsis argyritarsis
argyritarsis sawyeri
argyrothorax
bambusicolus
**bellator*
benarrochi
boliviensis
bonnei
braziliensis
canorii
**cruzi*
**darlingi*
eiseni
evandroi
evansae
fluminensis
galvaoi
gilesi
**homunculus*
ininii
intermedius
kompi
lanei
lutzi
maculipes
mattogrossensis
mediopunctatus
minor
neivai
neomaculipalpus
nigritarsis
nimbus
noroestensis
nuneztovari
**oswaldoi*
parvus
peryassui
pictipennis
†*pseudopunctipennis*
pseudopunctipennis
pseudotibiamaculatus
†*punctimacula*
rachoui
rangeli
rondoni
sanctielii
shannoni
squamifemur
thomasi
tibiamaculatus
triannulatus davisi
triannulatus triannulatus

See footnote 6, p. 10.

Yellow Fever.—Jungle yellow fever appears from time to time in sporadic outbreaks in humans throughout most of Brazil and the Guianas. Mouse-protection tests show that immunity to this disease is widespread in humans. Urban yellow fever, borne by *Aedes aegypti*, is rare in this region, but *aegypti*-borne epidemics may start with the introduction of jungle yellow fever into urban areas.

Haemagogus spegazzinii spegazzinii and *H. s. falco* account for almost 80 percent of the *Haemagogus* mosquitoes in Brazil. The latter is probably the more common of the two in the Guianas, although investigations have shown that *Haemagogus albomaculatus* may also be important there. *Haemagogus equinus* is an important vector of jungle yellow fever in Central America, and although reports of its presence in British Guiana, Surinam, and parts of Brazil are conflicting, it is included in the keys because of its potential importance.

Aedes leucocelaenus has been found in 18 of the 20 Brazilian States, but it is most common in the south. In northern Brazil it is a less important vector than *spegazzinii*.

References: *40, 127, 173, 218, 219, 256, 313.*

Dengue.—This disease, transmitted by *Aedes aegypti*, is largely confined to the coastal areas of the Guianas. An outbreak of 36 cases was reported in 1936 and 10 in 1943, mostly in newcomers. Dengue appears to be definitely endemic in these countries. There have been no large epidemics since 1920. A few cases of dengue have been reported from parts of Brazil bordering the Amazon River.

References: *2–5, 16, 24, 256.*

Encephalitis.—Two unconfirmed human cases of St. Louis encephalitis were diagnosed in 1952 in Paramaribo, Surinam. Antibodies were found in the immediate families and in domestic and wild animals. The virus of eastern equine encephalitis was found in animals in Peçanha, Brazil, in 1944. It is not known how any of these cases originated. The Ilhéus virus was first isolated from animals in the Ilhéus area of the Brazilian coast. The vector is not known.

Reference: *257.*

Filariasis.—In Georgetown, British Guiana, and Paramaribo, Surinam, *Culex pipiens quinquefasciatus* has been found naturally infected with *Wuchereria bancrofti*. In the former locality up to 7.4 percent of *quinquefasciatus* mosquitoes have been found infected. According to a clinical survey, almost the entire colored population is subject to infection. Outside these two centers little is known of the occurrence and distribution of filariasis. A study at Belém, a city at the mouth of the Amazon in the State of Pará, showed that *quinquefasciatus* far outnumbered other mosquitoes and was the principal vector of *bancrofti* in the native population.

References: *80, 225, 288.*

Lower South America

(Fig. 16)

Physical Features.—Lower South America comprises all continental South America south of Brazil and Peru and includes Bolivia, Paraguay, Uruguay, Argentina, and Chile. Bolivia and Paraguay are the only countries in South America without seacoasts. Most of the Bolivians live in the Temperate Zone on an intermountain plateau at an average altitude of 12,000 feet. It is located between the three main ranges of the Andes, which cut across western Bolivia from northwest to southeast. The eastern three-fourths of the country is principally tropical lowland, covered in the northern half with the dense forest of the Amazon basin and with savannas and scrub in the more arid southeast Chaco. These lowlands rise westward into the higher subtropical Yungas. The Chaco area also extends into Paraguay and Argentina.

The western half of Paraguay is entirely covered with arid, torrid grasslands and hardwood forests. The fertile lowlands east of the Paraguay River support most of the country's population. A northeastern highland area separates this country from Brazil.

Most of Uruguay is rolling grassland. The irregular, lagoon-filled coastline faces south. Between it and the interior is a fertile alluvial plain. Most of the population is concentrated in the southern half of the country.

Argentina is a 2,300-mile-long triangle at the southern tip of the continent. The northwest end contains the semiarid Gran Chaco, which extends north into Paraguay. The alluvial lowlands in the north and northeast receive about 60 inches of rain annually, the country's highest precipitation. Rainfall gradually decreases westward across the plains of the 400-mile-wide pampas. The slopes of the Andes receive the least rain of all this area. Patagonia stretches north from the cape about 1,000 miles in bleak, windswept plateaus.

Chile averages about 110 miles in width and extends south from Peru between the western border of Argentina and the Pacific Ocean. The Andes rise from within a short distance of the coast to some of the highest peaks in the world on the Chile-Argentine border. In the lower half of Chile this mountain chain decreases in altitude. The adjacent coastline is tortuous, with numerous offshore islands extending to the cape. The northern part is very dry. Central Chile is a 600-mile-long fertile plain containing about 90 percent of the country's population. Dense forests cover much of the southern part.

Reference: *301.*

Malaria.—In the southern two-thirds of Bolivia, the northern one-fourth of Argentina, and all of Paraguay, endemic malaria is widespread and shows two annual peaks of intensity. The first of these is the highest and occurs in March and April, although in northernmost Argentina the disease may appear as early as January. Along the Argentina coast an interesting situation arises where the maximum density of *Anopheles* occurs from December to March, but maximum malaria occurs in June and July. The second peak of malaria intensity is much lower and usually occurs in September, October, and November. The southernmost extension of malaria on the Atlantic coast is Córdoba, Argentina, and on the Pacific a point just south of Iquique, Chile, although the disease has not appeared in the latter country for many years.

In Bolivia and Argentina *Plasmodium vivax* is responsible for most of the malaria. At higher altitudes in Bolivia *Plasmodium malariae* may be a problem, but elsewhere it is sporadic. In almost all areas where malaria is present *Plasmodium falciparum* is not so important a parasite as *vivax*.

Anopheles pseudopunctipennis pseudopunctipennis is present in the high mountain valleys of Bolivia and northern Argentina. It is by far the most important vector in this region. In Bolivia it has been found in the presence of malaria at an altitude of about 9,000 feet, and in almost all localities within its range it transmits malaria efficiently.

Anopheles darlingi, the region's most efficient vector, invades only the vast plains of northern Bolivia, where it causes rather large epidemics.

Anopheles albitarsis is found in the Andean foothills. It is not always infected when in the presence of severe malaria, but it should be regarded as a potential vector.

Anopheles aquasalis is a coastal species, appearing as far south as northern Argentina and Uruguay. It is an important vector in Brazil and probably transmits malaria in Lower South America as well.

References: *42, 50, 67, 226, 304, 349.*

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

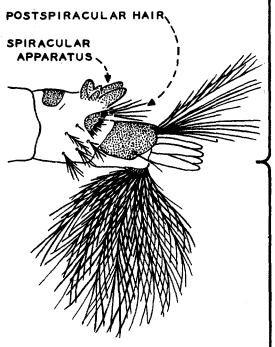
MOSQUITOES OF MEDICAL IMPORTANCE — LOWER SOUTH AMERICA

[AREA INCLUDED: BOLIVIA, PARAGUAY, URUGUAY, ARGENTINA, AND CHILE]

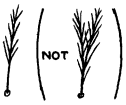
FIG. 16

FULL-GROWN LARVAE

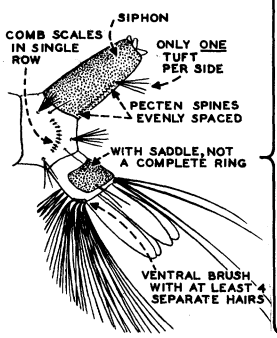
SIPHON ABSENT



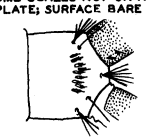
PROTHORACIC HAIR 1

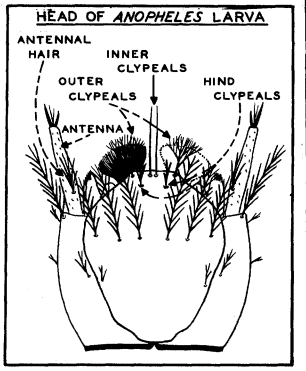
- OUTER CLYPEALS: WITH SHORT HAIRS  + INNER CLYPEALS: WIDELY SEPARATED  + PROTHORACIC HAIR 1: DISTANCE BETWEEN BASES OF HAIRS APPROXIMATELY SAME AS THEIR LENGTHS  = *ANOPHELES ALBITARSIS*
- INNER CLYPEALS: WITH LONG HAIRS  + MAIN STEM SINGLE  (NOT) = *ANOPHELES AQUASALIS*
- SPIRACULAR APPARATUS: WITH LONG HAIRS AT POSTERIOR END  = *ANOPHELES DARLINGI*
-  OR = *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

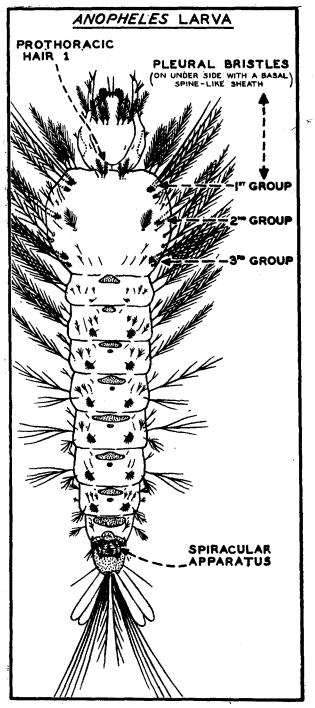
SIPHON PRESENT, PLUS ALL CHARACTERS LISTED BELOW



ABDOMINAL SEGMENT 8

- COMB SCALES ON A PLATE; SURFACE WITH SHORT HAIRS  = *HAEMAGOGUS SPEGAZZINII* AND *CAPRICORNII* (BOTH IMPORTANT; ONLY MALES CAN BE SEPARATED)
- COMB SCALES NOT ON A PLATE; SURFACE BARE 
  - COMB SCALES  = *AEDES AEGYPTI*
  - SADDLE: SADDLE HAIR TWO BRANCHED  = *AEDES LEUCOCELAENUS LEUCOCELAENUS*

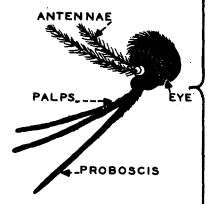




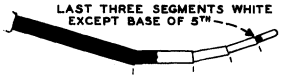
FEMALES

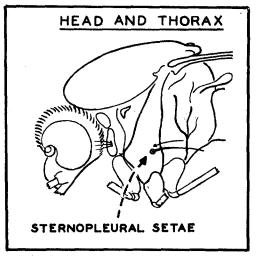
[*MALES HAVE BUSHY ANTENNAE*  *AND DO NOT BITE*]

PALPS LONG

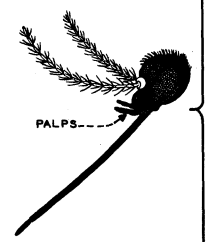


PATTERN ON HIND TARSUS

- LAST THREE SEGMENTS ENTIRELY WHITE 
  - LIGHT SPOT AT CROSS VEIN SHORTER THAN PRECEDING DARK SPOT  = *ANOPHELES DARLINGI*
  - LIGHT SPOT AT CROSS VEIN LONGER THAN PRECEDING DARK SPOT  + ABDOMINAL SEGMENT 1: WITH ROWS OF WHITE SCALES ON VENTRAL SIDE  = *ANOPHELES ALBITARSIS*
- LAST THREE SEGMENTS WHITE EXCEPT BASE OF 5TH  + PATTERN ON PALP  = *ANOPHELES AQUASALIS* AND RELATIVES (ONLY *AQUASALIS* IMPORTANT; FEMALES CANNOT BE SEPARATED)
- ALL DARK  = *ANOPHELES PSEUDOPUNCTIPENNIS PSEUDOPUNCTIPENNIS*

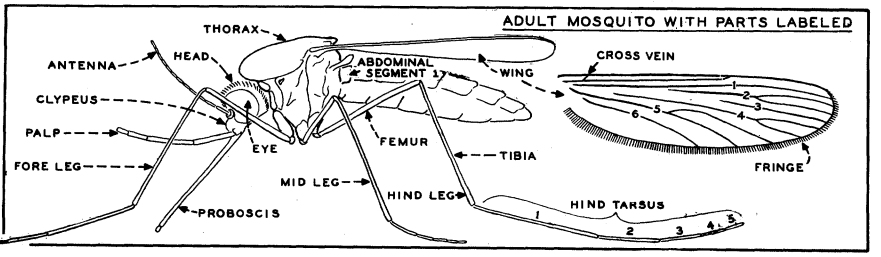


PALPS SHORT



PATTERN ON THORAX

- METALLIC BLUE OR GREEN  + CLAWS ON MID LEG  (NOT) + STERNOPLEURAL SETAE PRESENT (SEE ENLARGED DRAWING FOR LOCATION) = *HAEMAGOGUS SPEGAZZINII, CAPRICORNII,* AND *ALBOMACULATUS* (ONLY *SPEGAZZINII* AND *CAPRICORNII* IMPORTANT; FEMALES CANNOT BE SEPARATED)
-  = *AEDES LEUCOCELAENUS LEUCOCELAENUS*
-  = *AEDES AEGYPTI*



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Anopheles Species in Lower South America

†*albimanus*
**albitarsis*
annulipalpis
antunesi
apicimacula
**aquasalis*
argyritarsis
bambusicolus
boliviensis
bustamentei
**darlingi*
eiseni eiseni
eiseni geometricus
evansae
fluminensis
lanei
lutzi
maculipes
mattogrossensis
mediopunctatus
minor
nigritarsis
nimbus
noroestensis
nuneztovari
†*oswaldoi*
parvus
peryassui
pictipennis
pseudomaculipes
pseudopunctipennis neghmei
pseudopunctipennis noei
pseudopunctipennis patersoni
**pseudopunctipennis pseudopunctipennis*
†*punctimacula*
rangeli
rondoni
shannoni
triannulatus davisi
triannulatus triannulatus

See footnote 6, p. 10.

Yellow Fever.—Jungle yellow fever has five endemic centers in Bolivia, 1 in the department of La Paz and 4 in the department of Santa Cruz. Isolated cases are commonly encountered outside these areas. It has never been reported from July to October in this country, but when it is present it is always associated with an increase in population of *Haemagogus* species. Little is known of the distribution of this disease in other countries of this region, although positive mouse-protection tests show immunity to yellow fever in northern Argentina and Paraguay. *Aedes leucocelaenus leucocelaenus* is found in northern Argentina and may be responsible for the yellow fever there.

References: *60, 256.*

Dengue.—This disease appeared in southern Paraguay and in the northwest corner of Argentina in 1916, but its extent and importance there and elsewhere in the region are little known. *Aedes aegypti* is common over much of the region and is the vector of this disease.

References: *22, 25, 256.*

Encephalitis.—Unconfirmed cases of western equine encephalitis have been discovered in central Chile, and a large area of central Argentina contains animals infected with the virus. In the latter country human cases of western equine encephalitis have been tentatively diagnosed, but no virus has been isolated from them. The vector of western equine encephalitis in these two countries is not known.

Reference: *257.*

Filariasis.—No information is available.

AFRICA

Northwest Africa

(Figs. 17 and 18)

Physical Features.—The countries included in Northwest Africa are Río de Oro, Canary Islands, Madeira, French and Spanish Morocco, Algeria, Tunisia, Libya, and northern French West Africa south to latitude 15° N. Río de Oro is a barren desert tract with low hills, its entire west coast fronting the Atlantic Ocean. It is inhabited by nomadic tribes, and agriculture is practiced little or not at all.

The Canary Islands and Madeira are entirely of volcanic origin and comprise several islands off Northwest Africa in the Atlantic. They are mountainous, with high plains, deep valleys, and deserts. The climate is mild, with little seasonal change, and the rainy period is from October to February.

Northern French Morocco is primarily a broad, fertile valley, bounded on the north by the Atlantic Ocean and on the south by the Atlas Mountains, which consist of three parallel ranges, some peaks of which rise to over 13,000 feet. The Atlantic coast is dissected by many streams originating in the Atlas Mountains. This country has an equable Mediterranean climate.

Spanish Morocco is a mountainous country bordering the Mediterranean Sea. It represents the northernmost reaches of the Sahara Desert and contains oases watered by rivers flowing southward from the Atlas range. It has rainfall ranging from 30 inches annually to less than 10 inches in the east and southeast.

Algeria has a rocky northern coast along the Mediterranean, and the Atlas Mountains extend across its entire northern area, with a few lowlands near the coast receiving up to 50 inches of rain annually. High, semiarid, lake-filled plateaus farther south separate these mountains from the Saharan Atlas, a range that marks the northern limit of the Sahara Desert. The Sahara comprises the rest of Algeria to the south.

Tunisia lies across the Mediterranean just south and west of Sicily. In the northern half are continuations of the Atlas and Saharan Atlas Mountains. An arid plateau extends southward and is divided from the Sahara Desert proper by an east-west depression containing shallow salt lakes.

Libya is largely desert but has a Mediterranean coast containing a string of coastal oases receiving up to 15 inches of rain per year. The southern limit of Libya extends deep into the Sahara.

French West Africa is composed of a series of extremely dry, low to moderately high tablelands and includes a large part of the Sahara Desert proper.

Reference: *301.*

Malaria.—Malaria in Northwest Africa is periodic and is regulated by the rather cyclical rainfall of the region. A few years of abundant rainfall may provide extensive anopheline breeding places, after which the marshy areas usually dry up and there is little malaria transmission. Epidemic malaria occurs not only in the wetter coastal areas but in the Saharan oases as well.

Although both *Plasmodium falciparum* and *P. malariae* are present along the coast, the former species usually predominates. Little is known of the distribution of the parasites in malarious oases.

Anopheles labranchiae labranchiae is the principal vector of malaria in all the countries of this region. Along the Barbary coast from Tripolitania to Morocco this species breeds in the fresh and saline waters of rivers and marshes. Because of these breeding places in both wet and dry seasons, malaria is ever present, especially near large streams. Libya represents the easternmost limit of the range of *labranchiae*, and it is an area where rainfall diminishes far below the point necessary to maintain the species, which is not an oasis breeder.

Anopheles sergenti and *A. multicolor* transmit malaria in the desert oases, where nomads always have heavy infections and where endemic malaria is permanent. The former is the more important species. It usually breeds in very slowly moving water, such as seepages, and is found from Algeria eastward to Suez. *A. multicolor*, on the other hand, inhabits all kinds of brackish-water collections exposed to the sun,

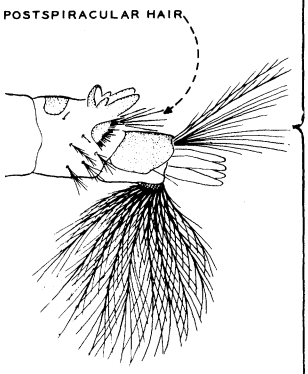
MOSQUITOES OF MEDICAL IMPORTANCE — NORTHWEST AFRICA

[AREA INCLUDED: RIO DE ORO, CANARY ISLANDS, MADEIRA, FRENCH AND SPANISH MOROCCO, ALGERIA, TUNISIA, LIBYA, AND NORTHERN FRENCH WEST AFRICA]

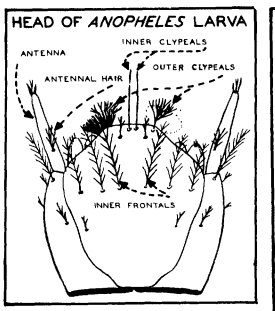
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

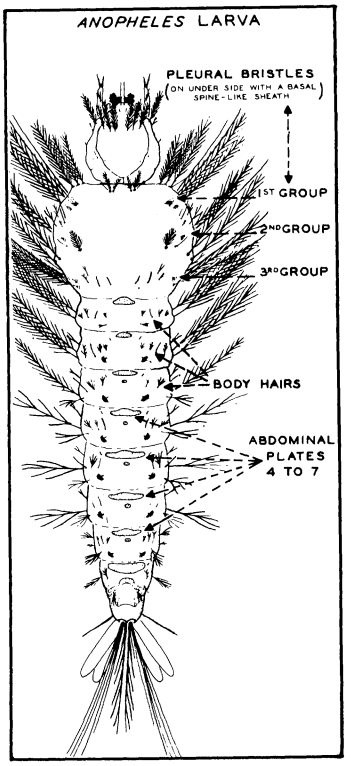
FIG. 17

FULL-GROWN LARVAE

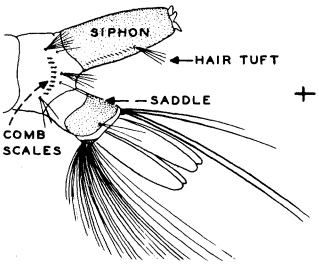


LONG PLEURALS OF 3RD GROUP
- ONE HAIRED
  - LONG PLEURALS OF 2ND GROUP
    - = *ANOPHELES D'THALI*
    - = *ANOPHELES SERGENTI*
- BOTH BARE + OUTER CLYPEALS (NOT) + ANTENNAL HAIR (NOT) = *ANOPHELES LABRANCHIAE* AND RELATIVES
  (ALL NOT IMPORTANT BUT LARVAE CANNOT BE SEPARATED - SEE KEY TO EGGS BELOW)
- BOTH HAIRED
  - LONG PLEURALS OF 2ND GROUP
    - BOTH HAIRED = *ANOPHELES HISPANIOLA*
    - ONE HAIRED + OUTER CLYPEALS (OR / NOT)
      - INNER FRONTALS
        - DARK SPOTS AT BASES = *ANOPHELES MULTICOLOR*
        - NO DARK SPOTS AT BASES = *ANOPHELES SUPERPICTUS*

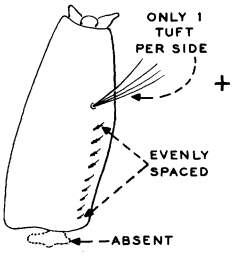




SIPHON ON ALL OTHERS

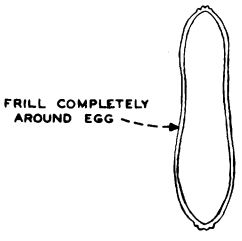


SIPHON + ANTENNA + BODY HAIRS + COMB SCALES

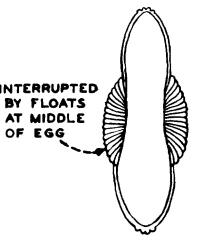


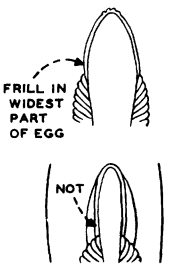
- COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)
- ANTENNA: SMOOTH / NOT
- BODY HAIRS: SINGLE TO 4 BRANCHED / NOT
- COMB SCALES / NOT
- = *AEDES AEGYPTI*

EGGS



OR





FLOATS
- AT LEAST 1/3 AS LONG AS EGG + PATTERN ON TOP = *ANOPHELES LABRANCHIAE LABRANCHIAE* AND *MACULIPENNIS SICAULTI*
- LESS THAN 1/4 AS LONG AS EGG, OR ABSENT = *ANOPHELES SACHAROVI* AND *PLUMBEUS*
  (*A. PLUMBEUS* BREEDS ONLY IN TREE HOLES AND ARTIFICIAL CONTAINERS AND IS NOT AN IMPORTANT VECTOR OF MALARIA)

MOSQUITOES OF MEDICAL IMPORTANCE — NORTHWEST AFRICA

[AREA INCLUDED: RIO DE ORO, CANARY ISLANDS, MADEIRA, FRENCH AND SPANISH MOROCCO, ALGERIA, TUNISIA, LIBYA, AND NORTHERN FRENCH WEST AFRICA]

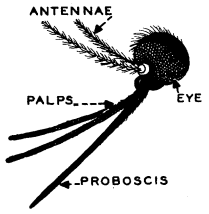
FEMALES

[*MALES HAVE BUSHY ANTENNAE* () *AND DO NOT BITE*]

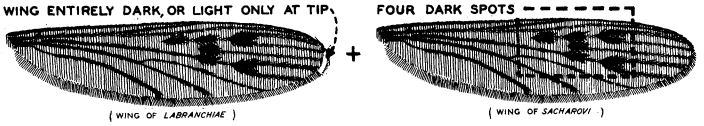
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 18

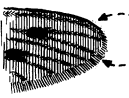
LONG PALPS ON *ANOPHELES*



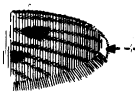
WING ENTIRELY DARK, OR LIGHT ONLY AT TIP + FOUR DARK SPOTS



FRINGE AT WING TIP

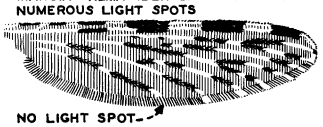


= *ANOPHELES SACHAROVI*



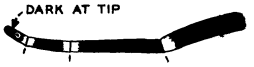
= *ANOPHELES LABRANCHIAE* AND RELATIVES (ALL NOT IMPORTANT BUT ADULTS CANNOT BE SEPARATED - SEE KEY TO EGGS)

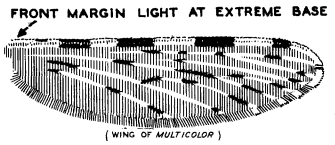
4 OR MORE LIGHT SPOTS ON FRONT MARGIN - REMAINDER OF WING WITH NUMEROUS LIGHT SPOTS



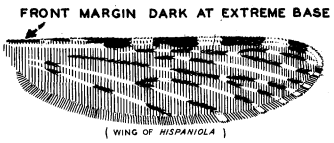
PATTERN ON PALP

DARK AT TIP



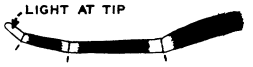


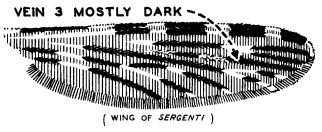
= *ANOPHELES MULTICOLOR*



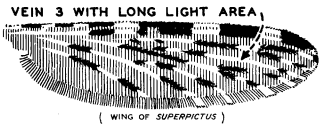
= *ANOPHELES HISPANIOLA*

LIGHT AT TIP



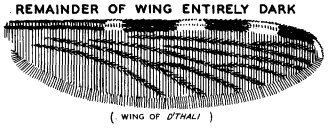


= *ANOPHELES SERGENTI*

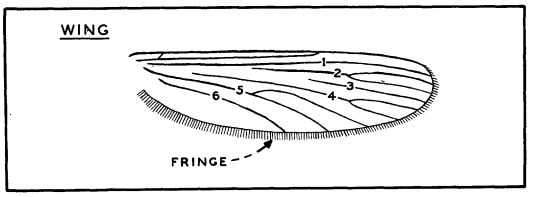


= *ANOPHELES SUPERPICTUS*

4 LIGHT SPOTS ON FRONT MARGIN — REMAINDER OF WING ENTIRELY DARK

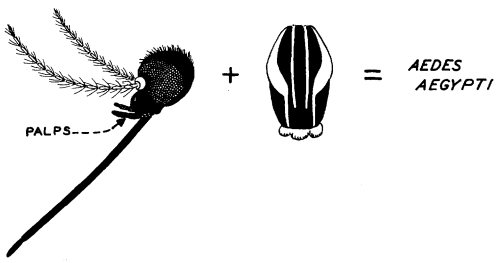


= *ANOPHELES D'THALI*

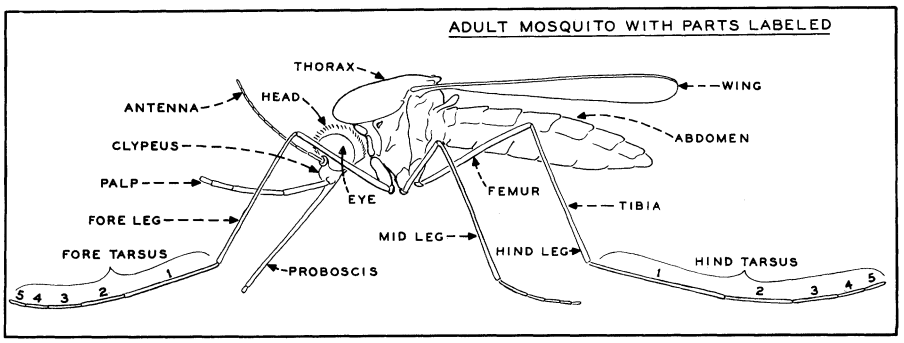


SHORT PALPS ON ALL OTHERS

PATTERN ON THORAX



= *AEDES AEGYPTI*



DN—1275

and therefore it thrives throughout dry areas, where rapid evaporation concentrates soil salts in breeding places.

Anopheles sacharovi, another important vector of the *maculipennis* group, is not known to live in Northwest Africa, but its distribution and medical importance nearby justify its inclusion in the keys.

Anopheles hispaniola is found in Algeria, Tunisia, and Morocco north of the southernmost Atlas range. It transmits malaria in the lowlands and in the high valleys at altitudes up to 8,000 feet. Not much is known of the importance of this species in Northwest Africa, but it is believed to have been an accessory vector in a severe epidemic in the department of Constantine in northern Algeria. In Tenerife, Canary Islands, it is the only *Anopheles* species in the presence of intense malaria.

Anopheles superpictus is found in Northwest Africa, but its role in this region is not well known. It breeds in mountainous areas here as it does elsewhere in the Mediterranean region.

Anopheles d'thali has a range from Algeria as far east as Suez. Its importance in the transmission of malaria in Northwest Africa is not known, but it is included in the keys because it is an effective vector in Sinai.

References: *67, 75, 94.*

Anopheles Species in Northwest Africa

algeriensis
broussesi
†*claviger claviger*
coustani tenebrosus
coustani ziemanni
†*d'thali*
†*fluviatilis*
†*gambiae*
**hispaniola*
hyrcanus
†*labranchiae atroparvus*
**labranchiae labranchiae*
†*maculipennis*
marteri
melanoon melanoon
†*melanoon subalpinus*
**multicolor*
†*plumbeus*
†*sacharovi*
**sergenti*
**superpictus*

See footnote 6, p. 10.

Yellow Fever.—This disease has apparently never been reported in Northwest Africa except where tropical jungles border its southernmost rim (see p. 46).

Reference: *256.*

Dengue.—This disease is very lightly endemic in the Canary Islands and along the Mediterranean and Atlantic coasts to the inland mountains, but no epidemics have been reported since 1900. *Aedes aegypti* is the only known vector in Northwest Africa. This domestic species breeds in all kinds of artificial containers close to man's habitations.

References: *256, 311.*

Encephalitis.—No information is available.

Filariasis.—Little is known about the distribution of this disease in Northwest Africa. Some early observations in Tunis implicated *Anopheles algeriensis* as the vector of *Wuchereria bancrofti*, but later work demonstrated that *Culex pipiens quinquefasciatus* is the true mosquito host.

References: *302, 305.*

Egypt

(Figs. 19 and 20)

Physical Features.—About 96 percent of Egypt is nonarable desert, where nomadic tribes roam. The remaining 4 percent is contained in a narrow strip of land representing the Nile River Valley. The Nile Delta area, which is about 8,500 square miles, is called Lower Egypt and contains not only one of the world's greatest concentrations of human population but immense cotton-growing areas as well. Upper Egypt lies south of the delta. Most of its cities and towns are situated within the strip of fertile land that is 1 to 10 miles wide on either side of the river. Since rainfall is scarce, the economy of the agricultural area bordering the Nile is regulated by the level of the river, which is controlled by its headwaters in Anglo-Egyptian Sudan and Uganda. Floods on the Nile usually take place in August and September and are partially controlled by an immense irrigation and dam system.

Immediately west of the Nile Valley a dry area containing scattered oases merges with the Libyan Desert, a part of the Sahara. In southwestern Egypt large outcroppings of rock reach as high as 6,200 feet. Large depressions are characteristic of the northwestern parts.

The territory east of the Nile is part of the Arabian Desert and is bisected by ravines leading to the Red Sea. A range of mountains borders the eastern edge of Egypt along its Red Sea coast. In places these mountains reach above 6,000 feet. Sinai, a triangle of land extending into the Red Sea between Egypt and Israel, is practically uninhabited and has rugged 8,000-foot mountains.

Reference: *301.*

Malaria.—Malaria is mildly endemic over all Egypt. In spite of the concentration of people in the Nile Valley, there is little indication of intense malaria there.

Malaria caused by *Plasmodium malariae* is almost entirely absent in the delta area but is common in the oases; whereas malaria caused by *P. vivax* is almost entirely absent from the oases.

Anopheles pharoensis and *A. multicolor* transmit most of the malaria in Egypt. The former species, though less abundant than *multicolor*, is more widely distributed. It is the most important vector in the Nile Delta, breeding there in immense numbers and transmitting most of the malaria. The adults enter houses and are most active in evening and morning twilight. The larvae very seldom appear in the absence of abundant vegetation and are found largely in swamps, ricefields, and their drainage and supply systems.

A. multicolor is less common in northern than in southern Egypt, where it breeds principally in oases. The adults readily enter houses and bite by night. The larvae live in small shallow pools, such as stagnant or flowing drains, unused wells, and in stagnant desert water. The amount of malaria actually transmitted by this mosquito in Egypt is not exactly known.

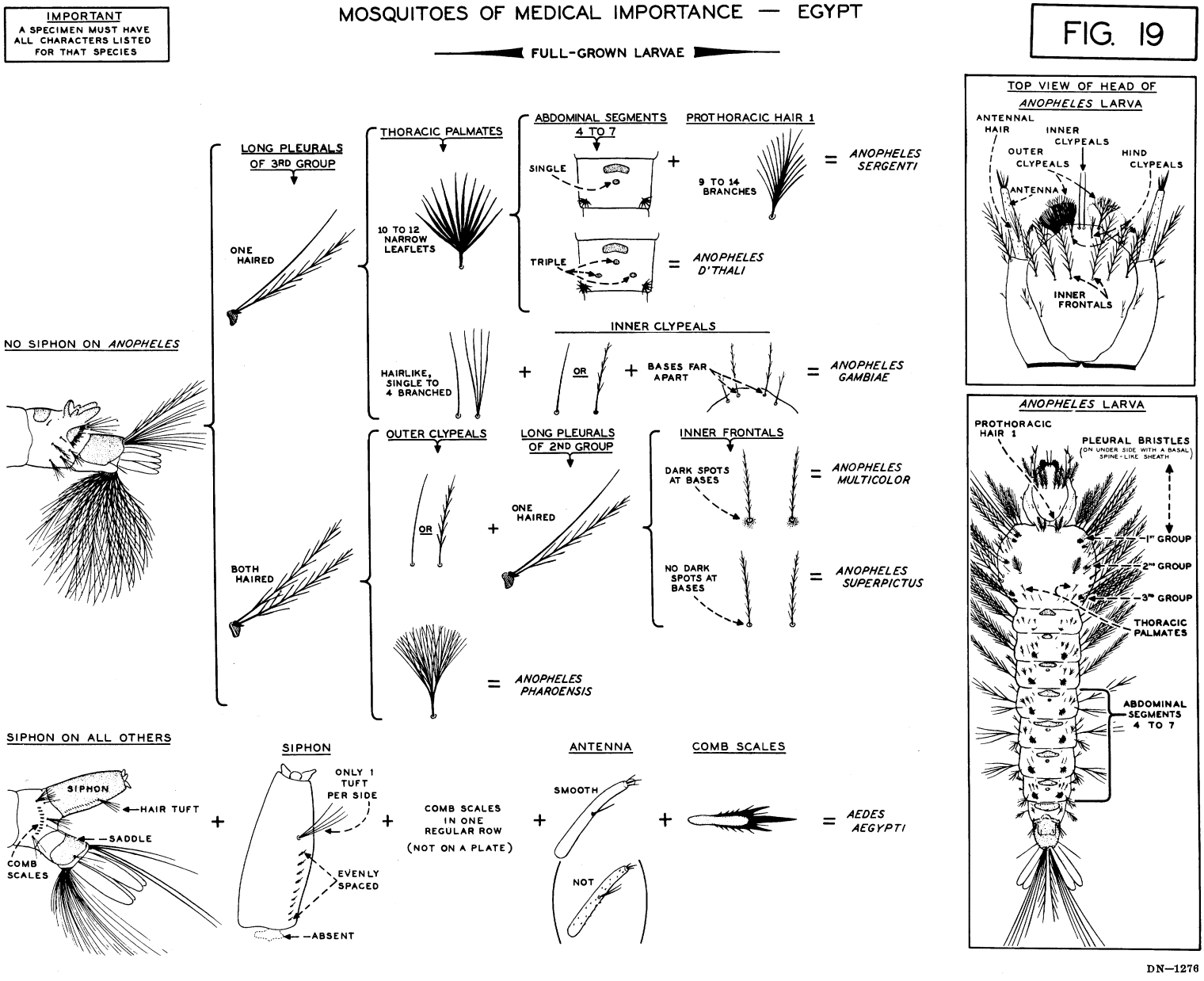
Anopheles sergenti appears throughout the country in stagnant, slow-moving water filled with vegetation and is the most important oasis mosquito. It is rare in the Nile Delta but is well adapted to the desert climate and, with *multicolor*, maintains infections that are always found in desert-inhabiting people. The adults readily enter houses at night to feed on man. This species is a proved vector in some areas of Egypt and Israel.

Strong epidemiological evidence points to *Anopheles d'thali* as an important vector in Sinai, where it bites viciously after dark inside human habitations. The larvae have been found in a wide variety of aquatic locations, including stagnant and fresh water.

Anopheles superpictus is included in the keys because of its potential ability to transmit malaria, although it has never been shown to do so in Egypt. It is usually associated with hill or mountain country, where the larvae prefer freshwater habitats and where the adults bite readily inside houses.

Anopheles gambiae, the most important vector of malaria in all tropical Africa, is no longer present in Egypt, having been eradicated from the Nile Valley. Since it easily adapts itself to conditions in that area and since it might be reintroduced, it is included in the keys.

References: *67, 205, 216, 350.*



Anopheles Species in Egypt

algeriensis
claviger
coustani tenebrosus
**d'thali*
†*gambiae*
†*hispaniola*
hyrcanus
marteri
**multicolor*
**pharoensis*
†*pretoriensis*
†*rhodesiensis rhodesiensis*
rhodesiensis rupicolus
†*rufipes*
†*sacharovi*
**sergenti*
**superpictus*
turkhudi

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Egypt, although positive mouse-protection tests in humans have been obtained since 1940 along the Red Sea coast.

Reference: *256.*

Dengue.—This disease is normally endemic in Egypt and flares out from time to time in epidemics. A large outbreak occurred in Cairo in 1937, eventually affecting most of the Nile Valley, even though it was concentrated in the Cairo area. *Aedes aegypti* was presumed to be the sole vector at that time. This species is intensely domestic and lives in all kinds of artificial containers close to man's habitations.

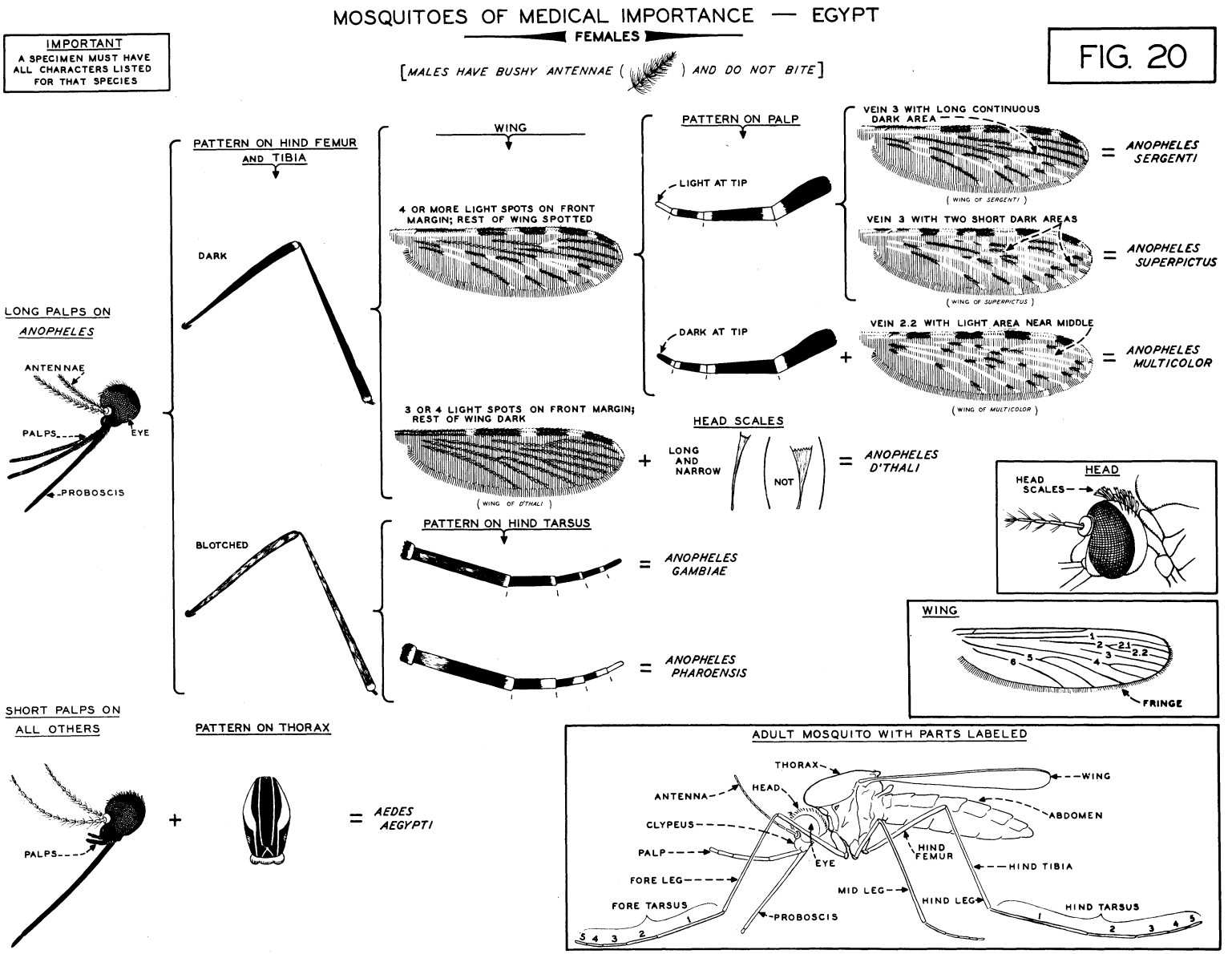
References: *256, 311.*

Encephalitis.—West Nile virus is widely disseminated along the Nile River, according to surveys. It is also present in the Nile Delta area. In neither of these localities are frank cases of encephalitis seen. This disease usually attacks children during the summer months. The virus has been isolated from *Culex antennatus*, mixed pools of *C. pipiens* and *C. univittatus*, and from *univittatus* alone. The last-named mosquito is believed to be the important vector, since it feeds primarily on birds, which are probably the natural reservoir of the virus. For additional information, see page 4.

Sindbis virus was discovered in the Nile Delta, but its symptomatology has not yet been studied. This virus has been transmitted experimentally by *pipiens* and *univittatus*. For additional information, see page 4.

Humans have been found to possess immunity to Bunyamwera, Uganda S, Zika, and Semliki Forest viruses along the lower Nile River. Little is known about their transmission.

References: *257, 325, 326.*



Filariasis.—Little is known of the distribution and extent of this disease in Egypt. In the Cairo area, where *Culex pipiens quinquefasciatus* does not appear, a study revealed that 5.4 percent of *C. pipiens pipiens* were naturally infected. Experiments showed that *Wuchereria bancrofti* reached the infectious stage in the proboscis of that mosquito in about 14 days.

References: *203, 298.*

Anglo-Egyptian Sudan

(Figs. 21 and 22)

Physical Features.—Anglo-Egyptian Sudan is essentially a vast plain surrounded on three sides by mountains, the Marras on the west and south and the Ethiopian highlands and the Etbai range on the east. In southernmost Anglo-Egyptian Sudan, which contains park savannas and patches of tropical forest, rainfall reaches 50 inches annually. Northward the length of the rainy season and the amount of precipitation gradually decrease. In the northwestern quarter of the country is a part of the Libyan Desert, where precipitation north of latitude 18° N. is negligible. In the northeastern corner is the Nubian Desert, a sandstone plateau intersected by many steep-walled wadies.

The Nile River originates in Anglo-Egyptian Sudan and is formed by the union of the White Nile and Blue Nile Rivers near Khartoum. The country's main agricultural center is located immediately north of Khartoum. It is irrigated by dams and lakes of various Nile tributaries. The Kordofan plateau south and west of Khartoum consists of an undulating surface with isolated mountain ranges reaching an altitude of about 4,000 feet.

Reference: *301.*

Malaria.—*Plasmodium malariae* is rarely encountered in Anglo-Egyptian Sudan. In the southern part *Plasmodium falciparum* is the important parasite. Elsewhere *Plasmodium vivax* or *falciparum* is equally common or *vivax* is slightly more prevalent.

Anopheles gambiae, the most important vector of malaria in Anglo-Egyptian Sudan, as in all Africa, is widely distributed in the southern and central parts of the country and along the Nile from Uganda to Egypt. It breeds in a wide variety of places, principally in small pools at least partially exposed to direct sunlight. Because such accumulations of water as those in footprints and hoofprints and irrigation and drainage ditches are commonly associated with man, and because *gambiae* constitutes a large proportion of mosquitoes

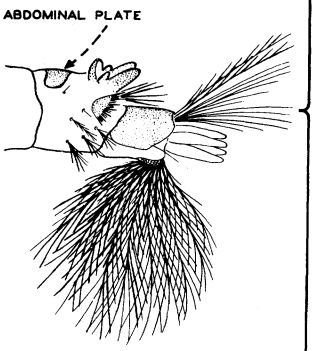
MOSQUITOES OF MEDICAL IMPORTANCE — ANGLO-EGYPTIAN SUDAN

FIG. 21

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

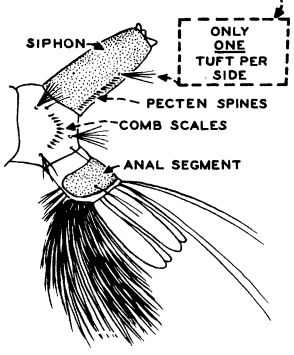
NO SIPHON ON *ANOPHELES*



ABDOMINAL PLATES 4 TO 7

- COVERING LESS THAN 1/2 OF SEGMENT
  - **LONG PLEURALS OF 3RD GROUP**
    - BOTH BARE + **OUTER CLYPEALS** (NOT) = *ANOPHELES NILI*
    - ONE HAIRED + **PROTHORACIC HAIR 1** (NOT) = *ANOPHELES GAMBIAE*
    - BOTH HAIRED + **OUTER CLYPEALS** (NOT) = *ANOPHELES RUFIPES*
- COVERING ABOUT 1/2 OF SEGMENT = *ANOPHELES FUNESTUS*

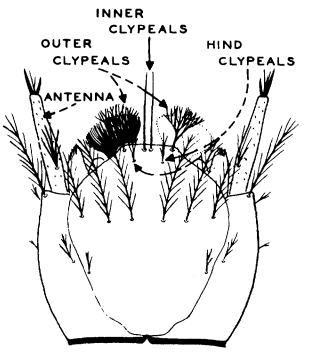
SIPHON ON ALL OTHERS +



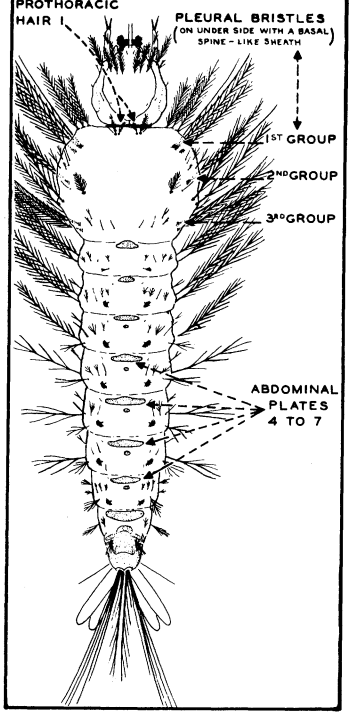
HEAD HAIR 6

- **COMB SCALES**
  - IN SINGLE EVEN ROW = *AEDES LUTEOCEPHALUS* AND *AFRICANUS* (ONLY *LUTEOCEPHALUS* IMPORTANT; LARVAE CANNOT BE SEPARATED)
- SINGLE
  - IN SINGLE EVEN ROW
    - **PECTEN SPINES**
      - = *AEDES AEGYPTI*
      - = *AEDES SIMPSONI*
  - IN SINGLE EVEN ROW + **TUFT OF SIPHON** ABOUT AS LONG AS WIDTH OF SIPHON = *AEDES METALLICUS*
  - IN IRREGULAR ROW + **HEAD HAIRS 4, 5 AND 6** (NOT) = *AEDES VITTATUS*
- **ANAL SEGMENT**
  - WITH HAIRED BRANCHES + (ABSENT) = *AEDES FURCIFER* AND *TAYLORI* (BOTH IMPORTANT; ONLY MALES CAN BE SEPARATED)

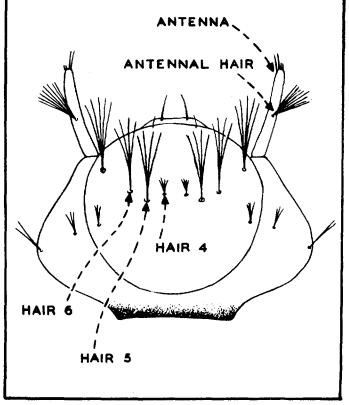
HEAD OF *ANOPHELES* LARVA



ANOPHELES LARVA



HEAD OF *AEDES* LARVA



MOSQUITOES OF MEDICAL IMPORTANCE — ANGLO-EGYPTIAN SUDAN

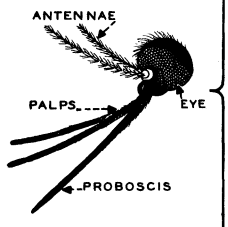
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FEMALES

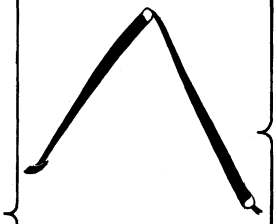
[MALES HAVE BUSHY ANTENNAE  AND DO NOT BITE]

FIG. 22

LONG PALPS ON *ANOPHELES*



PATTERN ON HIND FEMUR AND TIBIA



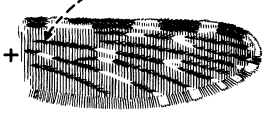
3 SHORT DARK SPOTS BEHIND MIDDLE MARGINAL SPOT

= *ANOPHELES RUFIPES*

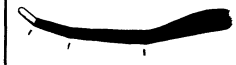
1 LONG DARK AREA BEHIND MIDDLE MARGINAL SPOT

PATTERN ON PALP

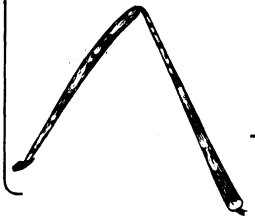
BASE OF VEIN 4 DARK



= *ANOPHELES FUNESTUS*

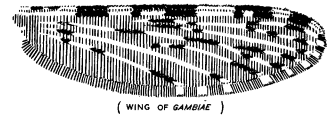


= *ANOPHELES NILI*



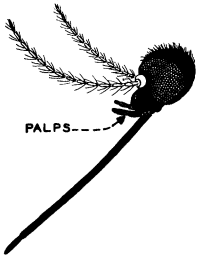
PATTERN ON HIND TARSUS

SPOTS IN FRINGE AT END OF EACH VEIN



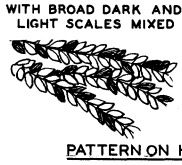
= *ANOPHELES GAMBIAE*

SHORT PALPS ON ALL OTHERS

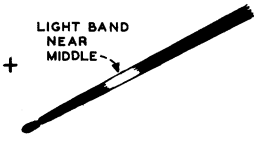


PATTERN ON THORAX

VEINS OF WINGS WITH BROAD DARK AND LIGHT SCALES MIXED



PATTERN ON PROBOSCIS LIGHT BAND NEAR MIDDLE



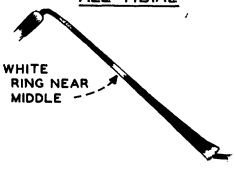
= *AEDES FURCIFER* AND *TAYLORI* (BOTH IMPORTANT; ONLY MALES CAN BE SEPARATED)

PATTERN ON HIND TARSUS

TOP VIEW OF ABDOMEN WITH WHITE BANDS

= *AEDES LUTEOCEPHALUS*

ALL TIBIAE



= *AEDES VITTATUS*

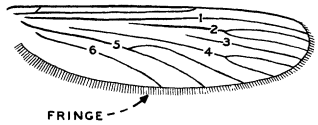
PATTERN ON HIND TARSUS

= *AEDES SIMPSONI*

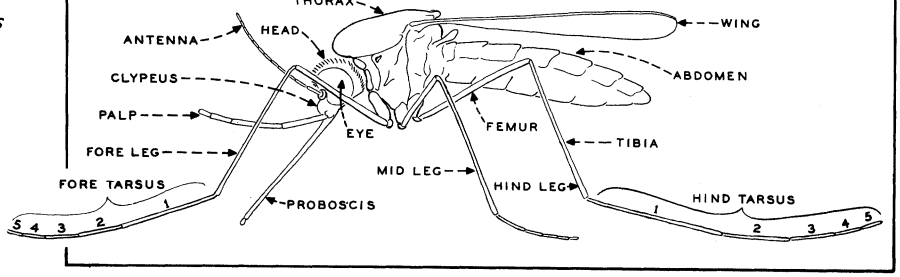
= *AEDES METALLICUS*

= *AEDES AEGYPTI*

WING



ADULT MOSQUITO WITH PARTS LABELED



caught indoors and feeding on man, control of this species is of prime importance in malaria eradication.

Anopheles funestus is the second most important vector. Its distribution is confined to many parts of southern and central Anglo-Egyptian Sudan and along the White Nile as far north as Jebelein. In contrast to *gambiae*, *funestus* breeds in rather permanent, clear water, such as swamps, lakes, edges of rivers, and seepage areas, almost always in association with vegetation and shade. The year-round character of its breeding and prevalence tends to associate *funestus* with endemic rather than with epidemic malaria, the latter being more characteristic of the more seasonal *gambiae* populations. The females of *funestus* readily enter houses and feed on man.

Anopheles nili is a subsidiary vector and varies markedly in its habits. It breeds in the marginal vegetation of rivers and streams, and population densities are usually correlated with the seasonal rise and fall of river systems. The adults vary from area to area in their house-haunting habits, but naturally infected females have been found in native dwellings, where the species is important if it appears in large numbers.

Anopheles rufipes has been found in many localities in this country, especially along the White Nile. It usually breeds in stagnant and semistagnant pools in partial shade. This species is important only where it appears in large numbers. In most localities it is scarce and is often found resting out of doors.

References: *67, 122, 352.*

Anopheles Species in Anglo-Egyptian Sudan

brohieri	**nili*
cinereus	*obscurus*
coustani coustani	†*pharoensis*
coustani ziemanni	†*pretoriensis*
**funestus*	*rhodesiensis rupicolus*
**gambiae*	*rivulorum*
implexus	**rufipes*
leesoni	*sergenti macmahoni*
maculipalpis	*squamosus squamosus*
marshallii gibbinsi	*symesi*
marshallii marshallii	*turkhudi*
multicolor	*wellcomei*

See footnote 6, p. 10.

Yellow Fever.—This disease has not attacked humans in Anglo-Egyptian Sudan for several years, but jungle yellow fever is present across the southern third of the country. This disease is typically that of forest-inhabiting monkeys. The monkey-to-monkey transmission cycle is believed to be maintained by *Aedes vittatus* and possibly by *A. africanus*, mosquitoes that breed in tree holes and plant containers, inhabit the forest canopy, and prefer monkey to human blood. However, at ground level, especially in plantation areas, the principal vector is *Aedes simpsoni*, which also breeds in plant containers. *A. simpsoni* feeds on infected monkeys either outside or just within the forest and, having a wide host preference, feeds on man as well, transmitting the virus in a monkey-to-monkey cycle. *Aedes metallicus*, *A. luteocephalus*, *A. furcifer*, and *A. taylori* are believed to act in much the same capacity as *simpsoni* in spreading yellow fever from monkey to man. *Aedes aegypti* has been included in the keys, since it is universally responsible for the presence of urban yellow fever. This species is prevalent only at certain times and localities.

References: *231–233, 256, 351.*

Dengue.—Epidemics of dengue have occurred along the valley of the Nile, but little is known about the status of this disease.

Reference: *256.*

Encephalitis.—West Nile virus occurs throughout the central southern half of Anglo-Egyptian Sudan (see also p. 36). Sindbis virus has been transmitted experimentally by *Culex pipiens* and *C. univittatus*. Its symptomatology and distribution have not yet been studied. For additional information on this virus, see page 4.

In the east-central part of the country immunity to Japanese and St. Louis viruses has been demonstrated. However, it is believed that these two viruses do not actually appear anywhere in Africa. Incidence of immunity to them is low. Furthermore, they are very closely related antigenicly to West Nile virus, which is commonly encountered in Africa.

References: *257, 325, 326.*

Filariasis.—*Anopheles gambiae* transmits *Wuchereria bancrofti* in the Nuba Mountains and in the southern part of Anglo-Egyptian Sudan between latitude 4° and 6° N. and west of longitude 30° E.

Reference: *311.*

Eritrea, the Somalilands, and Ethiopia

(Figs. 23 and 24)

Physical Features.—Eritrea has an excessively hot, arid Red Sea coast, which is narrowed in the north by the rather abrupt rise of a 3,000- to 7,000-foot north-central plateau. In the extreme northwest this plateau descends to the arid Sudan Desert. The central uplands are considerably cooler and wetter than the coastal areas.

French Somaliland consists mostly of stony desert, with isolated plateaus and highlands. It has a deeply indented coast opposite the southwest corner of Arabia. The climate is torrid, most of the area receiving only 2 to 10 inches of rain annually.

British Somaliland has a torrid coastal plain in the northeast, a mountain range about 8,000 feet high in the northwest, and an arid plateau in the south along the borders of Ethiopia and Somalia (Italian Somaliland). The entire country is extremely hot and dry, with rain adequate for agriculture only in the northern foothills.

Somalia (Italian Somaliland) is a broad, arid lowland sloping eastward to the Indian Ocean from the Ethiopian Ogaden Plateau. It has a dry tropical climate with two short rainy periods, one in March and April and the other in October and November, averaging less than 20 inches of rain annually.

Ethiopia, the largest of the countries in this region, is an almost isolated mountain plateau rising from the White Nile lowland in the west. Mountains in the northern parts are over 15,000 feet high. They descend into flat highlands to the east and south. The Rift Valley, a large steep-walled depression running from French Somaliland to the center of the southwestern border at Lake Rudolph, is bounded on the south by mountains that gradually descend to the semiarid Ogaden Plateau. The Danakil Desert is in the northeast corner. Areas of this country up to 5,500 feet are constantly hot and arid or semiarid, such as the Rift Valley and around Ogaden and Danakil, whereas areas from 5,500 to 8,000 feet contain most of the population and receive from 25 to 80 inches of rain annually. Above 8,000 feet the temperatures are comparatively low and the rainfall is abundant.

Reference: *301.*

Malaria.—This disease is present in varying amounts in almost all watered areas of this region. Because of gradual increases in elevation over much of this territory the temperature does not change abruptly, so that vectors become gradually adapted to climatic changes when their populations increase. Malaria, therefore, appears in mildly endemic and epidemic form in some areas up to 7,000 feet.

MOSQUITOES OF MEDICAL IMPORTANCE — ERITREA, THE SOMALILANDS, AND ETHIOPIA

[AREA INCLUDED: ERITREA, FRENCH SOMALILAND, BRITISH SOMALILAND, SOMALIA, AND ETHIOPIA]

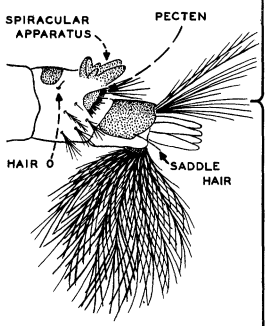
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

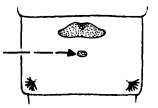
FIG. 23

PLATES ON 5TH SEGMENT

NO SIPHON ON *ANOPHELES*



SINGLE



BOTH HAIRED

LONG PLEURALS OF 3RD GROUP

ONE HAIRED

LONG PLEURALS OF 2ND GROUP

BOTH BARE

PROTHORACIC HAIRS 1 AND 2

NOT

= *ANOPHELES GAMBIAE*

ONE HAIRED

ANTENNA

PATCH OF LONG SPINES

SADDLE HAIR

OR

= *ANOPHELES RHODESIENSIS* AND *RUPICOLUS*
(ONLY *RHODESIENSIS* IMPORTANT; LARVAE CANNOT BE SEPARATED)

CLYPEAL HAIRS

BOTH BARE

LONG PLEURALS OF 2ND GROUP

ONE HAIRED

PALMATE HAIRS ON 5TH SEGMENT

SHOULDERS SLOPING

= *ANOPHELES CHRISTYI*

SHOULDERS NEARLY SQUARE

= *ANOPHELES PRETORIENSIS*

WITH SIDE HAIRS

3 TO 7 BRANCHED FROM MIDDLE

PECTEN SPINES

WITH LARGE TEETH

= *ANOPHELES PHAROENSIS*

WITH SIDE HAIRS

BRUSHLIKE

= *ANOPHELES RUFIPES*

INNER CLYPEALS

BOTH BARE

WITH LONG HAIRS ON INNER SIDE

= *ANOPHELES NILI*

COVERING ABOUT 1/2 OF SEGMENT

DOUBLE; SOMETIMES ABSENT

HIND EDGE NOT DARKENED

= *ANOPHELES FUNESTUS*

TRIPLE

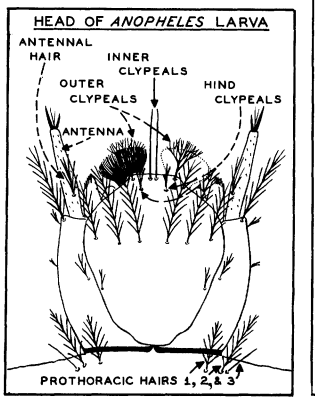
PROTHORACIC HAIRS 1 AND 2

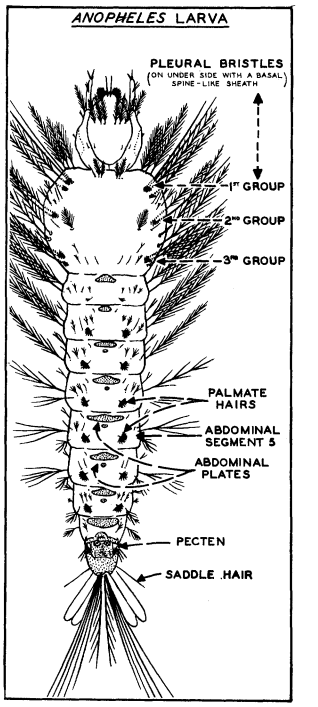
BASAL TUBERCLES CLOSE TOGETHER OR FUSED

= *ANOPHELES ADENENSIS*

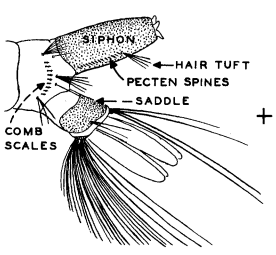
BASAL TUBERCLES FAR APART

= *ANOPHELES D'THALI*

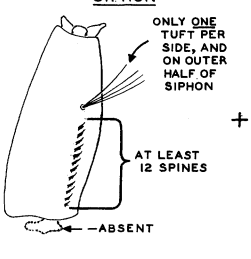




SIPHON ON ALL OTHERS



SIPHON



COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)

ANTENNA

SMOOTH

NOT

COMB SCALES

PECTEN SPINES

= *AEDES AEGYPTI*

= *AEDES SIMPSONI*

= *AEDES AFRICANUS*

DN—1280

MOSQUITOES OF MEDICAL IMPORTANCE — ERITREA, THE SOMALILANDS, AND ETHIOPIA

[AREA INCLUDED: ERITREA, FRENCH SOMALILAND, BRITISH SOMALILAND, SOMALIA, AND ETHIOPIA]

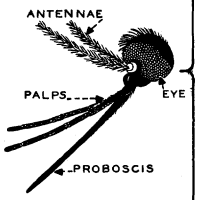
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 24

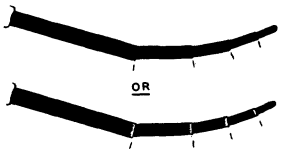
FEMALES

[MALES HAVE BUSHY ANTENNAE  AND DO NOT BITE]

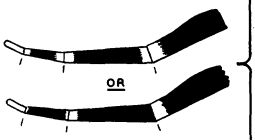
LONG PALPS ON *ANOPHELES*



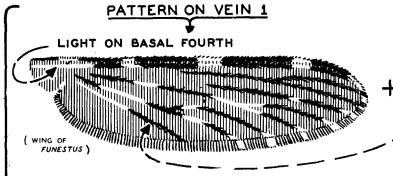
PATTERN ON HIND TARSUS

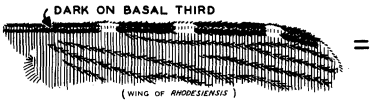


PATTERN ON PALP



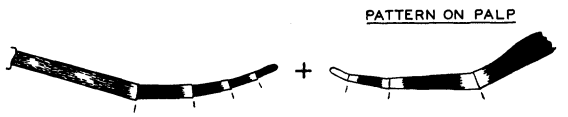
PATTERN ON VEIN 1

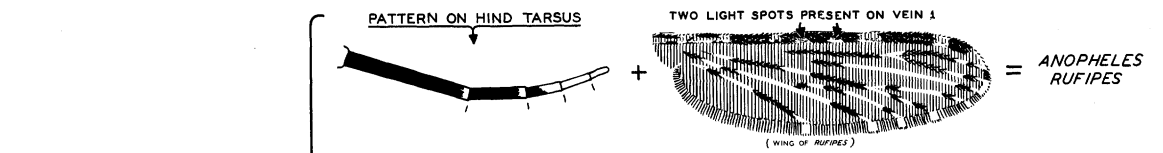


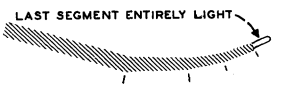


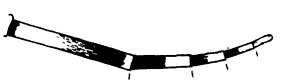

= *ANOPHELES NILI*


= *ANOPHELES D'THALI*

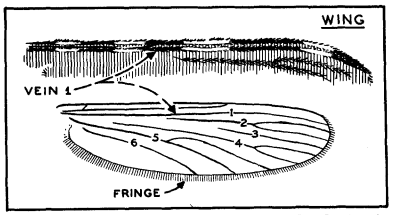




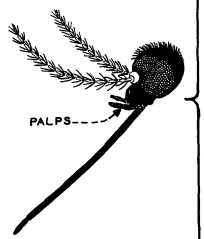



= *ANOPHELES PHAROENSIS*

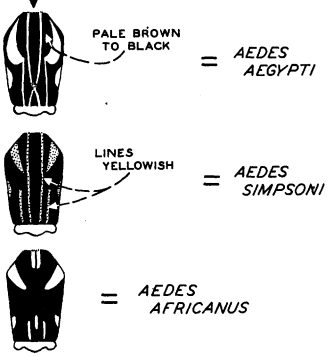

= *ANOPHELES PRETORIENSIS*

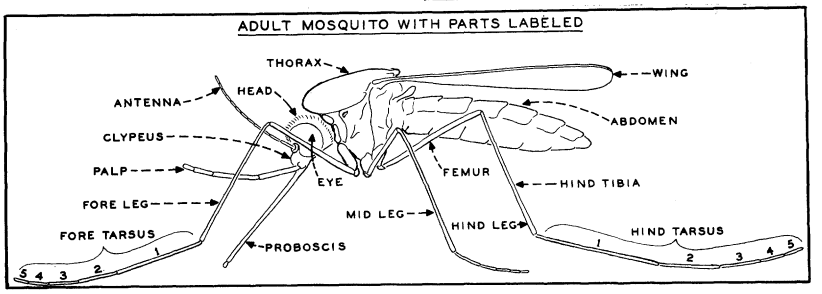


SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX





DN—1281

The rather steep slopes in the north above 6,000 feet do not support the disease for the same reason. At altitudes over 4,000 feet the cycle of transmission is seasonal. Below this level in the eastern area the disease is confined to the courses of the larger rivers and is hyperendemic as well as epidemic.

Plasmodium falciparum and *P. vivax* are the most common parasites. In western Ethiopia *falciparum* predominates. *Plasmodium malariae* is scarce throughout the entire region.

Anopheles gambiae is responsible for most of the malaria at high altitudes. This species tends to spread during the breeding season and seeks higher and higher altitudes as populations increase. This expansion results in epidemics, because people are exposed to fresh attacks of malaria in areas where they have little immunity. This species, which breeds in all kinds of manmade water containers, is a dangerous vector because of its proximity to man.

Anopheles funestus inhabits large rivers at low altitudes, especially in very dry areas where lack of rain causes a seasonal lowering of water levels and leaves residual pools suitable for breeding. The malaria supported by this mosquito is less endemic than that transmitted by *gambiae*. Where *funestus* predominates as a vector it transmits malaria rather consistently.

Anopheles christyi is an eastern African highland species that sometimes appears in large numbers. It is strongly suspected as a vector in the Uganda highlands and is included in the keys because of its potential importance in Ethiopia and Somalia.

Anopheles adenensis is thought to be widespread in Eritrea. It is a close relative of the very effective Indian vector *Anopheles culicifacies*, and for this reason it is implicated in transmission wherever *culicifacies* is found. However, direct evidence of its ability as a vector is difficult to find in the literature. Its role in any local malaria transmission should be carefully evaluated.

Anopheles pharoensis is present but normally scarce in Ethiopia. The rate of natural infection there and in other areas is extremely variable. In some localities it has a high infection rate, in others none at all. It has been included in the keys because it has been implicated in transmission in such widely separated localities as Egypt, southern Nigeria, Kenya, Uganda, and Madagascar.

Anopheles pretoriensis is regarded by some workers as an important vector in Ethiopia, although the evidence is not certain. It is anthropophilic to some extent but is rarely found inside houses in that country.

Anopheles rufipes is found in Ethiopia but is too scarce to be important in malaria transmission, especially when *gambiae* and *funestus* are present.

Anopheles rhodesiensis also is found in Ethiopia and probably in Somalia, but throughout most of its range it is generally not a domestic species. However, it has been found from time to time with a low rate of natural infection and is believed to be a secondary vector under favorable conditions.

Anopheles nili is generally scarce in dry areas. It prefers breeding in or near large rivers. The numbers of adults collected in houses are correlated with the water level. This species has not been found with natural infections in Ethiopia but is included in the keys because of its potential importance in that country.

The importance of *Anopheles d'thali* in Ethiopia is in doubt. However, near Aiscia, Ethiopia, it was the only *Anopheles* species found definitely associated with malaria by the local people. It has been found in dwellings at Diredawa, Ethiopia, and in small numbers in tents in British Somaliland, and it is suspected of being a vector in northern Ethiopia.

References: *67, 73, 258.*

Anopheles Species in Eritrea, the Somalilands, and Ethiopia

†*adenensis*
amutis
ardensis
†*christyi*
cinereus
coustani coustani
coustani ziemanni
dancalicus
demeilloni
**d'thali*
erythraeus
funestus confusus
**funestus funestus*
**gambiae*
garnhami
gingeroi
harperi
kingi
leesoni
longipalpis
maculipalpis
marshallii marshallii
†*nili*
obscurus obscurus
†*paludis*
†*pharoensis*
**pretoriensis*
**rhodesiensis rhodesiensis*
rhodesiensis rupicolus
†*rufipes*
sergenti macmahoni
squamosus cydippis
squamosus squamosus
turkhudi
wellcomei

See footnote 6, p. 10.

Yellow Fever.—Clinical yellow fever has seldom been reported from Eritrea, the Somalilands, and Ethiopia, but the endemic zone, as proposed by the World Health Organization Commission on Yellow Fever, includes almost all this region. In Eritrea positive mouse-protection tests performed since 1940 indicate an immunity in children under 14 years of age. The Somalilands are apparently free of yellow fever. In Ethiopia along the Anglo-Egyptian Sudan frontier one case of yellow fever has been reported; however, others probably occur there from time to time but not elsewhere in that country.

Aedes aegypti transmits a small amount of yellow fever in the port cities of this region. *Aedes simpsoni* and *A. africanus*, which are forest mosquitoes, are probably the only other important vectors. Their relative importance has not been evaluated.

References: *256, 311.*

Dengue.—Sporadic cases of this disease occur in Eritrea, principally from April to June and from October to December. The incidence of dengue in Somalis is lower than in Ethiopians and Europeans. It is endemic in the Somalilands. In French Somaliland it is known as obock and massawa fever. In Ethiopia sporadic outbreaks of endemic dengue have been reported from Diredawa, Harar, and the western highlands.

References: *256, 311.*

Encephalitis.—No information is available.

Filariasis.—Cases of this disease are sporadic in several areas and are thought to be introduced from other parts of Africa. Filariasis is probably not indigenous to the Somalilands and Ethiopia.

Reference: *311.*

West Africa

(Figs. 25 and 26)

Physical Features.—West Africa includes Gambia, Portuguese Guinea, Sierra Leone, Liberia, Gold Coast, Nigeria, and all French West Africa below the northern border of Senegal and latitude 15° N. Four well-defined climatic zones extend across this region from Gambia to French Equatorial Africa. From south to north they include (1) a 10- to 60-mile-wide coast with swamps and mangrove, (2) a 50- to 100-mile-wide belt of dense tropical forest with thick undergrowth and few clearings, (3) hilly country with deciduous forests merging with park and high grass savannas, and (4)

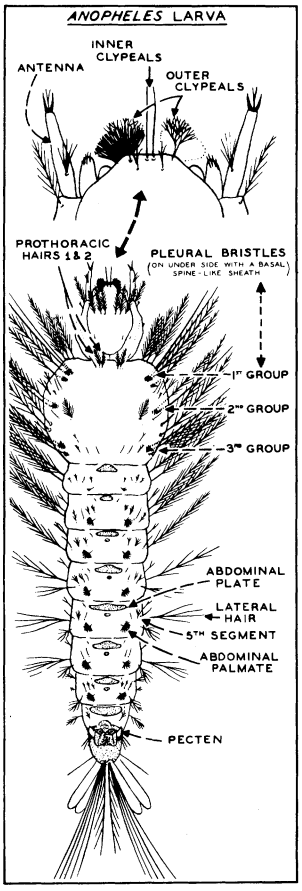
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

MOSQUITOES OF MEDICAL IMPORTANCE — WEST AFRICA

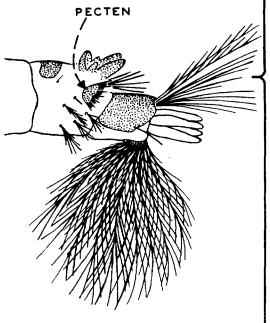
[AREA INCLUDED: GAMBIA, PORTUGUESE GUINEA, SIERRA LEONE, LIBERIA, GOLD COAST, NIGERIA, AND SOUTHERN FRENCH WEST AFRICA]

FULL-GROWN LARVAE

FIG. 25



NO SIPHON ON *ANOPHELES*



LONG PLEURALS OF 3RD GROUP

BOTH HAIRED

CLYPEAL HAIRS — BOTH BARE + LONG PLEURALS OF 2ND GROUP — ONE HAIRED + PALMATE HAIRS ON 5TH SEGMENT — NOT = *ANOPHELES PRETORIENSIS*

WITH SIDE HAIRS — 3 TO 7 BRANCHED FROM MIDDLE = *ANOPHELES RUFIPES RUFIPES* AND *RUFIPES INGRAMI* (BOTH IMPORTANT; LARVAE CANNOT BE SEPARATED)

WITH SIDE HAIRS — BRUSHLIKE + PECTEN SPINES — WITH LARGE TEETH = *ANOPHELES PHAROENSIS*

BOTH BARE + INNER CLYPEALS — WITH LONG HAIRS ON INNER SIDE = *ANOPHELES NILI*

ONE HAIRED, ONE BARE AND SPINE-LIKE = *ANOPHELES BRUNNIPES*

ONE HAIRED, ONE BARE AND HAIR-LIKE

PROTHORACIC HAIRS 1 AND 2

SHAFTS SLENDER — BASAL TUBERCLES ABSENT

PECTEN — LONG AND SHORT SPINES MIXED = *ANOPHELES GAMBIAE*

ALL SPINES ABOUT EQUAL IN LENGTH = *ANOPHELES MELAS*

ANTENNA — SPICULES EVENLY DISTRIBUTED

PLATES ON 5TH SEGMENT — COVERING ABOUT 1/2 OF SEGMENT = *ANOPHELES FUNESTUS*; ABSENT

COVERING LESS THAN 1/2 OF SEGMENT + OUTER CLYPEALS — STOUT AND BLUNT = *ANOPHELES MOUCHETI NIGERIENSIS*

SHAFTS THICKENED — BASAL TUBERCLES PRESENT AND CLOSE TOGETHER

DENSE PATCH OF SPICULES AT BASE

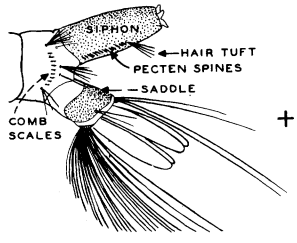
OUTER CLYPEALS — BARE AND HAIRLIKE — LATERAL HAIRS ON 5TH SEGMENT — 2 TO 4 BRANCHED = *ANOPHELES HARGREAVESI*; 6 TO 9 BRANCHED = *ANOPHELES HANCOCKI* AND *MARSHALLII* (ONLY *HANCOCKI* IMPORTANT; LARVAE SEPARATED WITH DIFFICULTY)

OUTER CLYPEALS — WITH FINE SIDE HAIRS = *ANOPHELES RHODESIENSIS*

OUTER CLYPEALS — BARE, STOUT, AND BLUNT = *ANOPHELES DOMICOLUS*

OUTER CLYPEALS — WITH STOUT BRANCHES = *ANOPHELES MOUCHETI MOUCHETI*

SIPHON ON ALL OTHERS



+

SIPHON — ONLY ONE TUFT PER SIDE, AND ON OUTER HALF OF SIPHON — AT LEAST 12 SPINES — ABSENT

+ COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE) +

ANTENNA — SMOOTH; NOT + COMB SCALES +

PECTEN SPINES = *AEDES AEGYPTI*; = *AEDES SIMPSONI*

DN—1282

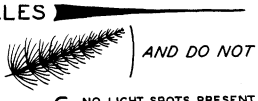
MOSQUITOES OF MEDICAL IMPORTANCE — WEST AFRICA

[AREA INCLUDED: GAMBIA, PORTUGUESE GUINEA, SIERRA LEONE, LIBERIA, GOLD COAST, NIGERIA, AND SOUTHERN FRENCH WEST AFRICA]

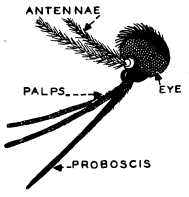
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 26

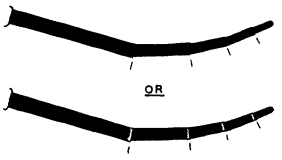
FEMALES

[*MALES HAVE BUSHY ANTENNAE*  *AND DO NOT BITE*]

LONG PALPS ON *ANOPHELES*

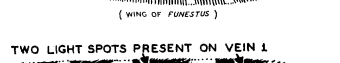


PATTERN ON HIND TARSUS



PATTERN ON PALP

NO LIGHT SPOTS PRESENT ON VEIN 1 + VEIN 3 DARK ON BASAL HALF = *ANOPHELES FUNESTUS*



TWO LIGHT SPOTS PRESENT ON VEIN 1 = *ANOPHELES BRUNNIPES*

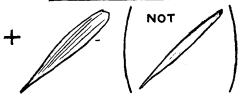
AT LEAST FOUR LIGHT SPOTS PRESENT ON FRONT MARGIN; REMAINDER OF WING DARK + = *ANOPHELES RHODESIENSIS*

= *ANOPHELES NILI*

PATTERN ON PALP

= *ANOPHELES MOUCHETI MOUCHETI* AND *MOUCHETI NIGERIENSIS* (BOTH IMPORTANT; FEMALES CANNOT BE SEPARATED WITH CERTAINTY)

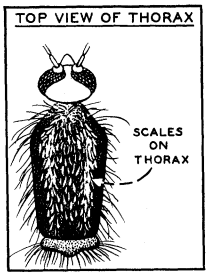
SCALES ON THORAX

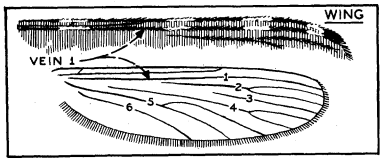


= *ANOPHELES HARGREAVESI*

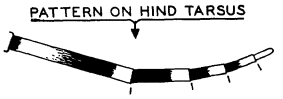
= *ANOPHELES DOMICOLUS*

= *ANOPHELES GAMBIAE* AND *MELAS* (BOTH IMPORTANT; FEMALES CANNOT BE SEPARATED WITH CERTAINTY)



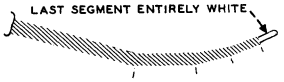


PATTERN ON HIND TARSUS

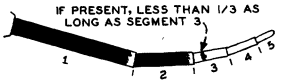


= *ANOPHELES PHAROENSIS*

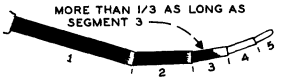
= *ANOPHELES PRETORIENSIS*



+  = *ANOPHELES HANCOCKI*

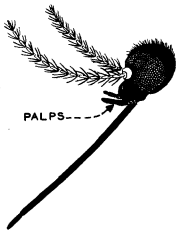


+  = *ANOPHELES RUFIPES INGRAMI*



= *ANOPHELES RUFIPES RUFIPES*

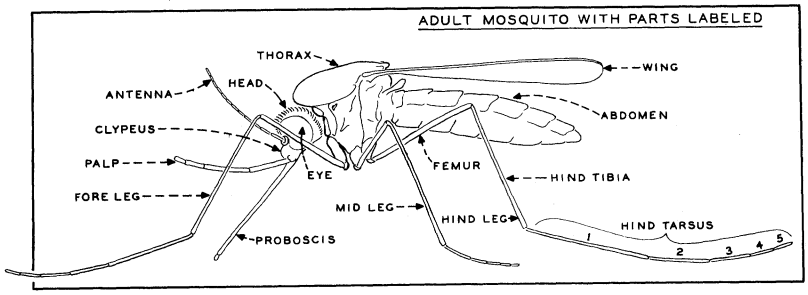
SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX

+ LINES WHITE = *AEDES AEGYPTI*

+ LINES YELLOWISH = *AEDES SIMPSONI*



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the southernmost part of the Sahara Desert. All the countries in West Africa, except Senegal and Gambia, contain at least the first two zones, Nigeria is the only one that has all four, and French West Africa is largely desert, except for French Guinea, Ivory Coast, and Dahomey, all of which extend to the coast. Senegal and Gambia in the westernmost part of this region are flat and monotonous. Vegetation is concentrated in the river basins and in the Casamance.

The dry season in West Africa is caused by a dry, hot harmattan blowing south from the Sahara from November to April. The wet season is brought by a monsoon blowing north from the Gulf of Guinea from May to October. The inches of rain each zone receives annually are as follows: Zone 1 about 170, zone 2 from 55 to 170, zone 3 from 40 to 55, and zone 4 less than 25 in some areas.

Reference: *301.*

Malaria.—Highly intense malaria with spleen rates of 70–90 percent occurs in the southern parts of most of these countries in West Africa. This disease is particularly dangerous in the coastal strip (zone 1), which contains vast mangrove swamps, and along the courses of large rivers. In zone 2, which extends inland for 100 to 150 miles, a high, dense, tropical forest tends to inhibit the breeding of malaria vectors. Spleen rates are slightly lower than on the coast. The distribution of malaria in zone 3 is seasonal, but transmission continues through most of the year. In zone 4 the northern parts of the countries, which contain dry savannas merging into semideserts, support a distinctly seasonal malaria that closely corresponds to that in the summer rainy season.

In most of the tropical rain forest malaria caused by *Plasmodium falciparum* predominates. *Plasmodium malariae* cases are less numerous over most of the region. *Plasmodium ovale* and *P. vivax* have been reported as uncommon, although widely distributed. However, recent work in West Africa suggests that *vivax* is extremely rare or even absent in this region and that most previous reports of *vivax* should be assigned to *ovale.*

Anopheles gambiae breeds in all kinds of water-holding depressions in the ground and is closely associated with man. It is one of the most efficient vectors of all the *Anopheles* species and is almost always associated with high parasite rates wherever it is abundant. It is widely distributed over entire West Africa and is responsible for most of the malaria there, both in rural and urban locations. It is the mosquito of the rainy season, reaching its population peak in June, July, and August, and almost completely disappearing in February and March.

Anopheles funestus is characteristically associated with large bodies of water, especially along river courses, and transmits malaria most efficiently during the first half of the dry season. Together with *gambiae*, which is common early in the rainy season, *funestus* helps to carry the year-round malaria found near the coast and along the large river courses.

Anopheles melas is the third most important transmitter in the region. It is a brackish-water breeder, with a particular preference for *Avicennia* mangrove swamps. These swamps are flooded by high spring tides and are important breeding places because of the flat, peaty soil. Because *melas* larvae can withstand sudden changes in salinity and because the species is almost as effective a vector as *gambiae* itself, it easily maintains most of the highly endemic, strictly coastal malaria. Several other species of *Anopheles* may have some importance in West Africa but are not nearly so effective in maintaining malaria as *gambiae*, *funestus*, and *melas.*

Anopheles hancocki is a subsidiary vector in parts of Ivory Coast and Haute-Volta. In Liberia this anthropophilic species is generally endophilic, but in Sierra Leone it bites man out of doors only.

Anopheles domicolus represented 25 percent of all anophelines caught indoors in northern Nigeria, and in parts of French West Africa and Haute-Volta it was found to be highly infected and a subsidiary vector.

Anopheles hargreavesi is of considerable importance in Nigeria. It is common in native huts and bites man freely out of doors. Because of its more uniform distribution and greater abundance, it may be a more important vector under certain conditions than *gambiae*, especially at Itowolo, Nigeria.

Anopheles rufipes rufipes and *A. r. ingrami* have represented up to 70 percent of all mosquitoes found in houses, as determined by studies in certain parts of northern Haute-Volta. They are believed to be the principal vectors there.

Anopheles moucheti nigeriensis is of some importance near Lagos, Nigeria. The typical form, *Anopheles moucheti moucheti*, is included in the keys because of its importance elsewhere.

Anopheles brunnipes is included in the keys because it has been found with high salivary infection rates during the winter in nearby Belgian Congo. It is not regarded as an important vector in French West Africa.

Another secondary vector, *Anopheles nili*, is very common in Liberia, Sierra Leone, and French West Africa. Its breeding is associated with large streams, and the adults are often found indoors.

Anopheles pharoensis is largely a swamp breeder. Dissections indicate that this species varies considerably in its natural infectivity. It is found infected in some localities in French West Africa and southern Nigeria, whereas in other nearby localities the tests have been entirely negative for malaria. This species is a vector of secondary importance.

Anopheles pretoriensis does not frequent houses. It is included in the keys because it is infected in other parts of its range and because it is often associated with *gambiae.*

Anopheles rhodesiensis is included in the keys because of its importance outside West Africa. This species does not frequent houses in this region, but it has been found with high natural infection rates.

References: *67, 167, 259, 260.*

Anopheles Species in West Africa

africanus
barberellus
brohieri
brumpti
†*brunnipes*
cavernicolus
cinctus
coustani coustani
coustani tenebrosus
coustani ziemanni
**domicolus*
dureni
flavicosta
freetownensis
**funestus*
**gambiae*
**hancocki hancocki*
hancocki masseguini
**hargreavesi*
implexus
jebudensis
leesoni
maculipalpis
marshallii
**melas*
minutus
†*moucheti moucheti*
**moucheti nigeriensis*
†*nili*
obscurus nowlini
obscurus obscurus
†*paludis*
**pharoensis*
†*pretoriensis*
†*rhodesiensis*
rivulorum rivulorum
**rufipes ingrami*
**rufipes rufipes*
smithii
squamosus squamosus
wellcomei

See footnote 6, p. 10.

Yellow Fever.—Small outbreaks of classical urban yellow fever have been reported at irregular intervals from the cities and towns of West Africa. *Aedes aegypti* has been responsible for these epidemics, one of which occurred in 1946 in

southwestern Nigeria. Jungle yellow fever is endemic and has been a constant problem, accounting for all yellow fever cases that are reported. It is restricted to the belt of tropical forest crossing the region from west to east, and numerous positive mouse-protection tests have been performed throughout this area. The monkey-to-monkey vector has not yet been determined. The only *Aedes* species so far implicated with any certainty is *simpsoni*. For further information, see pages 2, 3, 40, 43, and 53.

References: *92, 232, 234, 256.*

Dengue.—There is little active dengue in West Africa. Most of the cases have been reported from the coasts of Nigeria and coastal French West Africa. The last outbreak occurred in Dahomey in 1947.

References: *256, 311.*

Encephalitis.—Very little information is available about encephalitis in West Africa. The Zika virus has been isolated from humans at Afikpo, Nigeria, but nothing is known about its etiology.

Reference: *257.*

Filariasis.—Definite records are available of transmission of *Wuchereria bancrofti* by *Anopheles gambiae* and *A. funestus* in the plantation districts of Sierra Leone. These two species are the prime vectors of filariasis in that country. *A. gambiae* has been found with natural infections at Roberts Field, Liberia, where up to 8.4 percent of the natives have been found with filariasis and several cases of elephantiasis have been observed. In the coastal Marshall Territory of Liberia, *Anopheles melas* and *gambiae* appear to be the most important vectors. *Anopheles hancocki* females were also found with natural infections. *A. gambiae* is believed to be the principal vector during the rainy season and *melas* during the dry season and the beginning of the rainy season. Farther north at Dakar, French West Africa, filariasis is rare, and although it is present in the Northern Territories of the Gold Coast, the vector there is not known.

References: *104, 143, 164, 190, 250, 345.*

West-Central Africa

(Figs. 27 and 28)

Physical Features.—West-Central Africa includes the Cameroons, French Equatorial Africa, and Belgian Congo. The Cameroons and French Equatorial Africa have an alluvial coast on the west and south. A belt of dense tropical forest, contiguous with that in Nigeria and eastern Africa and extending north to latitude 5° N., covers the littoral plain, the subcoastal highland slopes, and the low swampy areas of the southeast Congo basin. In this forest abundant rainfall and high temperatures vary little from day to day or from year to year. The center of French Equatorial Africa north of the forest belt contains open savannas, with isolated clumps of forest along the rivers. This area is dry between December and March and wet from April to September. A semiarid sandy desert, which has hot days and cold nights, lies between the savanna area and the northeastern Tibesti Massif, a range of mountains almost 11,000 feet high.

The outstanding physical feature of Belgian Congo is the valley of the Congo River, a flat depression in the central African plateau, which is covered by the tropical-forest belt spreading south and east from French Equatorial Africa. Extensive swamplands lie at the junction of the Congo and Ubangi Rivers along the western border. Highlands of 6,000 to 7,000 feet form the Uganda frontier. Mt. Ruwenzori, which is about 16,000 feet high, overlooks the Katanga plateau in the southeast corner. Except in the highest parts of Belgian Congo, the temperature is always close to 80° F., with very small daily and annual changes. Annual rainfall is about 80 inches, most of which occurs in a 7- to 9-month period. The invigorating eastern and southeastern highlands are savannas, with forests along the rivers.

Reference: *301.*

Malaria.—The belt of tropical rain forest, covering the southern third of French Equatorial Africa and almost the entire Congo basin, has highly endemic malaria, which is transmitted throughout most of the year. Spleen rates in this area range from 70 to 90 percent. In the east-central Ubangi-Shari highlands of French Equatorial Africa malaria has a highly marked seasonal distribution, clearly corresponding to the rainy season. In the northern parts of the Cameroons and French Equatorial Africa malaria incidence becomes even more seasonal. Southeast of the Congo basin in the Katanga highlands the disease is seasonal, with spleen rates of 50 to 70 percent. Similar conditions prevail in extreme southern French Equatorial Africa.

In western Belgian Congo *Plasmodium vivax* infections are about as numerous as those of *P. malariae*. *Plasmodium falciparum* is the predominant parasite in the east, *malariae* is next in abundance, and *vivax* is encountered least. *Plasmodium ovale* is scarce in this area.

Throughout the rain-forest belt and in many other localities *Anopheles gambiae* is the predominant vector. It is the most efficient malaria transmitter in Africa. This factor, together with its habit of breeding in all types of small water-containing depressions close to man's habitations, makes it the most dangerous vector in this region. It breeds in immense numbers throughout the rainy season.

Anopheles melas, originally described as a variety of *gambiae*, is a brackish-water breeder that prefers *Avicennia* mangrove swamps, although it breeds prolifically outside such areas along the coast. The larvae are able to withstand rather large changes in salinity, so that high tide floods in the spring do not disturb their breeding places. This species is nearly as efficient a vector as *gambiae*, and in areas where it is abundant it may transmit a malaria of extremely high endemicity.

Anopheles funestus, the second most abundant vector in this region, inhabits large bodies of water, and as summer rains decrease this species appears in large numbers, especially along the main water courses. Because *gambiae* is prevalent during the rainy season and *funestus* is abundant afterward, malaria is transmitted during almost the entire year. In higher areas *gambiae* is the most prevalent species. Even though these three *Anopheles* species transmit most of the malaria in West-Central Africa, several other vectors of varying importance play minor roles in its transmission and are discussed here.

Anopheles moucheti moucheti has often been reported as the most prevalent mosquito found in houses in Belgian Congo, at times far outnumbering *gambiae* and other mosquitoes. Parasite rates in this species have almost always been low and account for the relatively low endemic malaria in many parts of Belgian Congo, where the principal vectors are scarce or absent.

The adults of *Anopheles brunnipes* have been observed in large numbers inside houses in Leopoldville. During the winter in this locality salivary infection rates of up to 4 percent have been found. Little is known of the biology of this species, but it is highly possible that *brunnipes* plays a part in winter malaria.

Anopheles nili has variable habits and breeds at the edges of large rivers. The predominance of adults caught in human habitations is directly correlated with the rise and fall of the rivers in which it breeds. Because of its house-haunting habits it is regarded as a secondary vector of some importance.

471779 O—59——4

MOSQUITOES OF MEDICAL IMPORTANCE — WEST-CENTRAL AFRICA

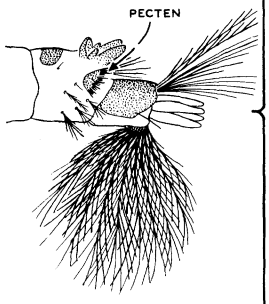
[AREA INCLUDED: CAMEROONS, FRENCH EQUATORIAL AFRICA, AND BELGIAN CONGO]

FULL-GROWN LARVAE

FIG. 27

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

NO SIPHON ON *ANOPHELES*



LONG PLEURALS OF 3RD GROUP

BOTH HAIRED

- CLYPEAL HAIRS: BOTH BARE + LONG PLEURALS OF 2ND GROUP: ONE HAIRED → PALMATE HAIRS ON 5TH SEGMENT: SHOULDERS SLOPING = *ANOPHELES CHRISTYI*
- CLYPEAL HAIRS: WITH SIDE HAIRS, 3 TO 7 BRANCHED FROM MIDDLE = *ANOPHELES RUFIPES RUFIPES*
- PALMATE HAIRS ON 5TH SEGMENT: SHOULDERS NEARLY SQUARE = *ANOPHELES PRETORIENSIS*
- CLYPEAL HAIRS: WITH SIDE HAIRS, BRUSH-LIKE + PECTEN SPINES: WITH LARGE TEETH = *ANOPHELES PHAROENSIS*

BOTH BARE

- CLYPEAL HAIRS: BARE, CLOSE TOGETHER, BRUSH-LIKE = *ANOPHELES PALUDIS, SYMESI, AND COUSTANI* (ONLY *PALUDIS* IMPORTANT; LARVAE CANNOT BE SEPARATED)
- WITH LONG HAIRS ON INNER SIDE, BARE = *ANOPHELES NILI*

ONE HAIRED, ONE BARE AND SPINE-LIKE

= *ANOPHELES BRUNNIPES*

PROTHORACIC HAIRS 1 AND 2

SHAFTS SLENDER, BASAL TUBERCLES ABSENT

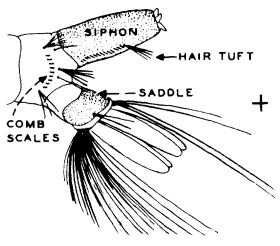
- PECTEN: LONG AND SHORT SPINES MIXED = *ANOPHELES GAMBIAE*
- PECTEN: ALL SPINES ABOUT EQUAL IN LENGTH = *ANOPHELES MELAS*

ONE HAIRED, ONE BARE AND HAIR-LIKE

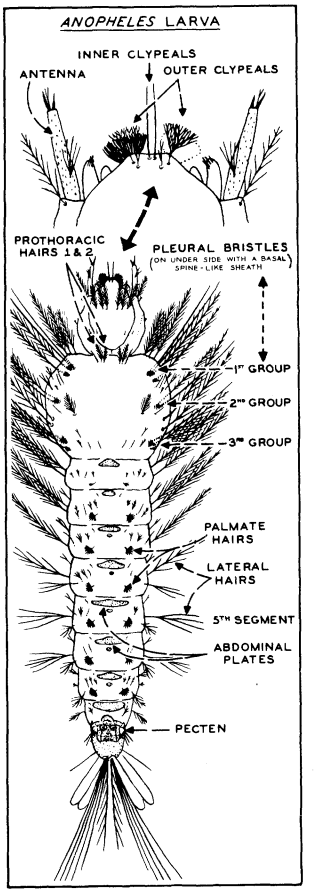
SHAFTS THICKENED, BASAL TUBERCLES PRESENT AND CLOSE TOGETHER

- ANTENNA: SPICULES EVENLY DISTRIBUTED + PLATES ON 5TH SEGMENT: COVERING ABOUT 1/2 OF SEGMENT + HIND EDGE OF PLATE NOT DARKENED = *ANOPHELES FUNESTUS*
- DENSE PATCH OF SPICULES AT BASE; LATERAL HAIRS ON 5TH SEGMENT:
  - OUTER CLYPEALS: BARE AND HAIRLIKE = *ANOPHELES HARGREAVESI*
  - 2 TO 4 BRANCHED; OUTER CLYPEALS: WITH FINE SIDE HAIRS = *ANOPHELES RHODESIENSIS*
  - OUTER CLYPEALS: WITH STOUT BRANCHES = *ANOPHELES MOUCHETI MOUCHETI*
  - 6 TO 8 BRANCHED + PECTEN SPINES: NOT = *ANOPHELES HANCOCKI*

SIPHON ON ALL OTHERS



+ SIPHON: ONLY ONE TUFT PER SIDE, AND ON OUTER HALF OF SIPHON; AT LEAST 12 SPINES; ABSENT
+ COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)
+ ANTENNA: SMOOTH / NOT
→ COMB SCALES:
  - PECTEN SPINES: = *AEDES AEGYPTI*
  - PECTEN SPINES: = *AEDES SIMPSONI*
  - = *AEDES AFRICANUS*



DN—1284

MOSQUITOES OF MEDICAL IMPORTANCE - WEST-CENTRAL AFRICA

[AREA INCLUDED: CAMEROONS, FRENCH EQUATORIAL AFRICA, AND BELGIAN CONGO]

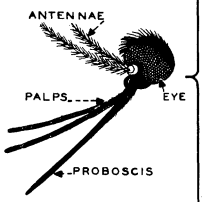
FIG. 28

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

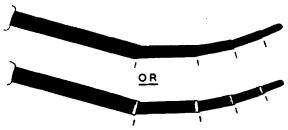
FEMALES

[MALES HAVE BUSHY ANTENNAE () AND DO NOT BITE]

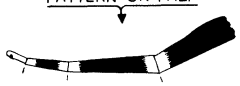
LONG PALPS ON *ANOPHELES*



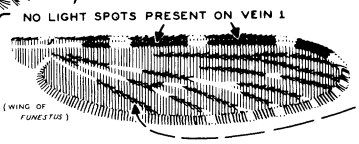
PATTERN ON HIND TARSUS



PATTERN ON PALP



NO LIGHT SPOTS PRESENT ON VEIN 1



+ DARK ON OUTER HALF OF VEIN 6 = *ANOPHELES FUNESTUS*

TWO LIGHT SPOTS PRESENT ON VEIN 1

= *ANOPHELES BRUNNIPES*

= *ANOPHELES NILI*

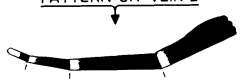
+

AT LEAST FOUR LIGHT SPOTS ON FRONT MARGIN; REMAINDER OF WING DARK

= *ANOPHELES RHODESIENSIS*

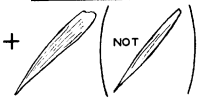
PATTERN ON VEIN 1

PATTERN ON VEIN 1



= *ANOPHELES CHRISTYI*

SCALES ON THORAX

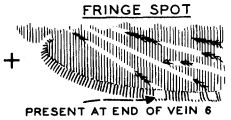


= *ANOPHELES HARGREAVESI*

+ 

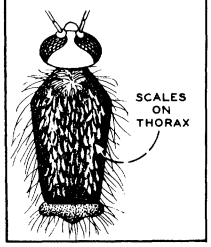
= *ANOPHELES MOUCHETI MOUCHETI*

FRINGE SPOT

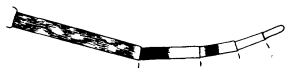


= *ANOPHELES GAMBIAE* AND *MELAS*
(BOTH IMPORTANT; ADULTS CANNOT BE SEPARATED WITH CERTAINTY)

TOP VIEW OF THORAX

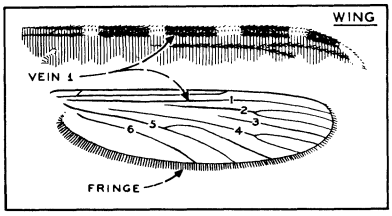


= *ANOPHELES PHAROENSIS*



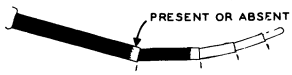
= *ANOPHELES PRETORIENSIS*

WING



= *ANOPHELES RUFIPES RUFIPES*

PATTERN ON FRONT MARGIN OF WING



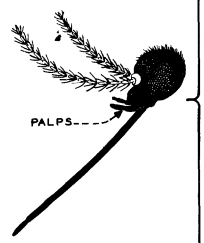
AT LEAST FOUR LIGHT SPOTS PRESENT

= *ANOPHELES HANCOCKI*

ONLY TWO LIGHT SPOTS PRESENT

= *ANOPHELES PALUDIS*

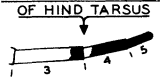
SHORT PALPS ON ALL OTHERS



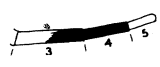
PATTERN ON THORAX

= *AEDES AEGYPTI*

SEGMENTS 3, 4, AND 5 OF HIND TARSUS

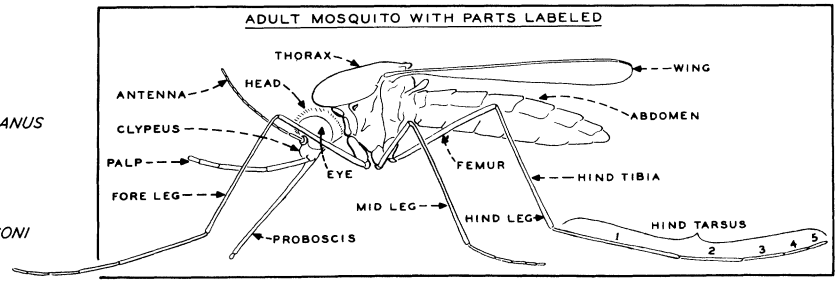


= *AEDES AFRICANUS*



= *AEDES SIMPSONI*

ADULT MOSQUITO WITH PARTS LABELED



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Anopheles paludis readily enters houses in Belgian Congo, where resting females have been found with gut and salivary gland infections. It is not common, but it is probably important as a secondary vector.

The remaining *Anopheles* species presented in the keys all are found in West-Central Africa, sometimes in large numbers. According to available records, none of these mosquitoes are normally infected or associated with man in this region, but elsewhere they have been implicated in malaria transmission at one time or another and are potentially important. These *Anopheles* species and the areas of their potential or actual medical importance include *rufipes rufipes*, Anglo-Egyptian Sudan, Haute-Volta; *rhodesiensis*, Sierra Leone; *pretoriensis*, Transvaal, Southern Rhodesia; *pharoensis*, French West Africa, Egypt, southern Nigeria, Uganda; *christyi*, Uganda; *hancocki*, Ivory Coast, Haute-Volta, Uganda; and *hargreavesi*, Nigeria.

References: *67, 260.*

Anopheles Species in West-Central Africa

ardensis
argenteolobatus
berghei
**brunnipes*
†*christyi*
cinctus
cinereus
concolor
coustani caliginosus
coustani coustani
coustani tenebrosus
coustani ziemanni
demeilloni
distinctus distinctus
distinctus ugandae
dureni
faini
**funestus*
**gambiae*
garnhami garnhami
†*hancocki*
†*hargreavesi*
implexus
keniensis
kingi
leesoni
lloreti
longipalpis
maculipalpis
marshallii gibbinsi
marshallii marshallii
marshallii mousinhoi
marshallii pitchfordi
**melas*
michaeli
mortiauxi
**moucheti moucheti*
natalensis multicinctus
natalensis natalensis
**nili*
obscurus nowlini
obscurus obscurus
**paludis*
†*pharoensis*
†*pretoriensis*
†*rhodesiensis*
rivulorum rivulorum
rodhaini
†*rufipes rufipes*
seydeli
smithii rageaui
squamosus cydippis
squamosus squamosus
symesi
theileri
vanhoofi
vinckei
walravensi schwetzi
wellcomei

See footnote 6, p. 10.

Yellow Fever.—Numerous cases of jungle yellow fever have been reported from West-Central Africa, and immunity to this disease is apparently rather widespread. Although *Aedes aegypti*, *A. simpsoni*, and *A. africanus* are considered to be the important vectors in this region, no studies have been completed on their respective roles in transmission. For additional information, see pages 2 and 3.

References: *256, 311.*

Dengue.—This disease is endemic throughout most of this region. Although active cases appear from time to time, they are not numerous.

References: *256, 311.*

Encephalitis.—In the extreme northern part of Belgian Congo, West Nile antibodies have been found in humans, and in an area of the Congo River to the south tests have been positive for neutralizing antibodies to West Nile virus. It is not known how this virus is spread in Belgian Congo.

Reference: *257.*

Filariasis.—The distribution of mosquito-borne filariasis is not well known in West-Central Africa. *Culex pipiens quinquefasciatus* is widely distributed in the lower Congo Valley at Matadi, where it transmits *Wuchereria bancrofti.* Filariasis and elephantiasis are widespread in the native population at Douala, Cameroons, where the vector is not known.

References: *134, 295, 338.*

East-Central Africa

(Figs. 29 and 30)

Physical Features.—East-Central Africa includes Kenya, Uganda, Tanganyika, and Zanzibar and associated islands in the Indian Ocean. The northern three-fifths of Kenya is arid, receiving from 5 to 20 inches of rain per year. This semidesert country rises from the low, marshy coast toward the Ethiopian highlands. Southern Kenya contains most of the population and agriculture, because it has a moderate altitude and a subtropical climate, with 40 to 50 inches of rain annually. The western half of Kenya is traversed from north to south by the Rift Valley, lined on either side by towering peaks. The extreme western slopes of the interior highland descend gradually to the shores of Lake Victoria.

The Rift Valley forms the western frontier of Uganda. Savanna tablelands to the east and north are topped by a high mountain range along the Kenya frontier. In the savanna area the rainfall averages from 40 to 55 inches annually in two rainy seasons, one from March to May and the other from September to November.

The 10- to 40-mile-wide eastern coastal strip of Tanganyika rises to a central plateau of about 4,000 feet and descends to the shores of Lake Tanganyika in the west. Mountains over 15,000 feet high border Kenya in the north, and mountains of about 9,000 feet are a part of the southern highlands. The Rift Valley extends southward to separate Tanganyika from Belgian Congo. Two-thirds of Tanganyika, including most of the plateau, has less than 40 inches of rain and no ground water. The most densely settled areas are the northern half of the coast above 4,000 feet, the shores of Lakes Tanganyika and Victoria, and some of the major river valleys, all of which have between 40 and 60 inches of rain annually.

Zanzibar is a low limestone island with a tropical monsoon climate. From April to June it receives up to 60 inches of rain; from December to March it is hot and dry. The island is very fertile, and almost all the land is under cultivation.

Reference: *301.*

Malaria.—Zanzibar, Pemba, nearly all Uganda, the extreme southern part of Kenya, and that part of Tanganyika in the north under 5,000 feet and its east coast proper are intensely malarious, partly because of the high rainfall brought by monsoons from the southeast. Spleen rates in these areas range from 70 to 100 percent. In the northeast quarter of Kenya malaria is rather confined to watercourses and is truly hyperendemic only along the large rivers. All Kenya's central area, most of which is over 6,000 feet, and the southern highlands of Tanganyika over 5,000 feet are almost devoid of malaria. In these mountainous areas at altitudes over 4,000 feet, endemic malaria is transmitted for 4 to 6 months depending on the altitude, with occasional epidemic outbursts. The intervening periods are almost completely free of this disease. A small sharp outbreak of malaria has been recorded at 8,600 feet in central Kenya. At this altitude malaria is rare, and when present it can be transmitted for only a very short time.

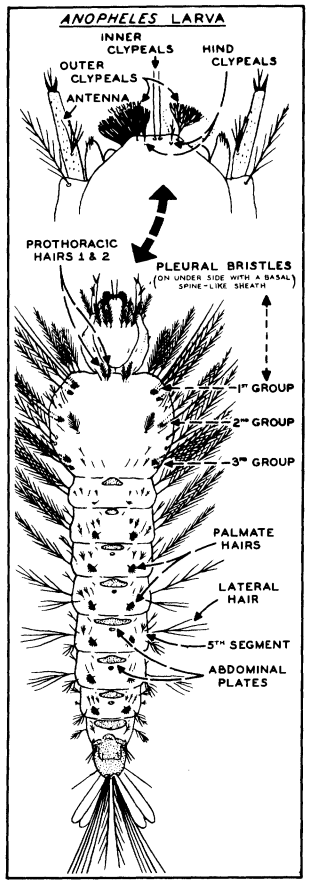
MOSQUITOES OF MEDICAL IMPORTANCE - EAST-CENTRAL AFRICA

[AREA INCLUDED: KENYA, UGANDA, TANGANYIKA, AND ZANZIBAR]

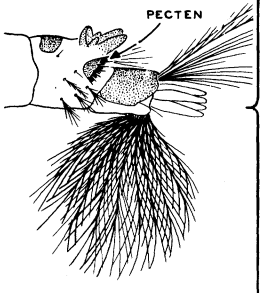
FULL-GROWN LARVAE

FIG. 29

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES



NO SIPHON ON *ANOPHELES*



LONG PLEURALS OF 3RD GROUP

BOTH HAIRED

CLYPEAL HAIRS: BOTH BARE + LONG PLEURALS OF 2ND GROUP: ONE HAIRED
- PALMATE HAIRS ON 5TH SEGMENT: SHOULDERS SLOPING = *ANOPHELES CHRISTYI*
- SHOULDERS NEARLY SQUARE = *ANOPHELES PRETORIENSIS*

HIND CLYPEALS: WITH SIDE HAIRS, 3 TO 7 BRANCHED FROM MIDDLE + BARE = *ANOPHELES RUFIPES RUFIPES*

HIND CLYPEALS: WITH SIDE HAIRS, BRUSHLIKE = *ANOPHELES PHAROENSIS*

BOTH BARE

INNER CLYPEALS: WITH LONG HAIRS ON INNER SIDE = *ANOPHELES NILI*

ONE HAIRED

PROTHORACIC HAIRS 1 AND 2: SHAFTS SLENDER, BASAL TUBERCLES ABSENT = *ANOPHELES GAMBIAE*

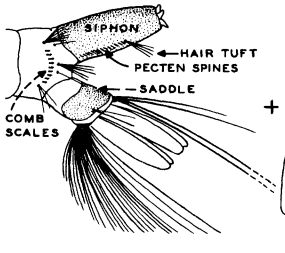
PROTHORACIC HAIRS 1 AND 2: SHAFTS THICKENED, BASAL TUBERCLES PRESENT AND CLOSE TOGETHER

ANTENNA: SPICULES EVENLY DISTRIBUTED + PLATES ON 5TH SEGMENT: COVERING ABOUT 1/2 OF SEGMENT, SOMETIMES PRESENT = *ANOPHELES FUNESTUS*

ANTENNA: DENSE PATCH OF SPICULES AT BASE

LATERAL HAIRS ON 5TH SEGMENT:
- 2 TO 4 BRANCHED
  - INNER CLYPEALS: BARE AND HAIRLIKE = *ANOPHELES HARGREAVESI* AND *HARPERI* (ONLY *HARGREAVESI* IMPORTANT; LARVAE SEPARATED WITH DIFFICULTY)
  - WITH FINE SIDE HAIRS = *ANOPHELES RHODESIENSIS*
  - WITH STOUT BRANCHES = *ANOPHELES MOUCHETI MOUCHETI*
- 6 TO 8 BRANCHED
  - INNER CLYPEALS: BARE AND HAIRLIKE = *ANOPHELES HANCOCKI* AND *MARSHALLII* (ONLY *HANCOCKI* IMPORTANT; LARVAE SEPARATED WITH DIFFICULTY)
  - STOUT, BLUNT AT TIP = *ANOPHELES DOMICOLUS*

SIPHON ON ALL OTHERS



SIPHON: ONLY ONE TUFT PER SIDE, AND ON OUTER HALF OF SIPHON; AT LEAST 12 SPINES; ABSENT

COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)

ANTENNA: SMOOTH; NOT

COMB SCALES:
- PECTEN SPINES: = *AEDES AEGYPTI*
- PECTEN SPINES: = *AEDES SIMPSONI*
- = *AEDES AFRICANUS*

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MOSQUITOES OF MEDICAL IMPORTANCE - EAST-CENTRAL AFRICA

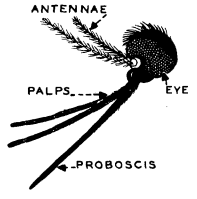
[AREA INCLUDED: KENYA, UGANDA, TANGANYIKA, AND ZANZIBAR]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

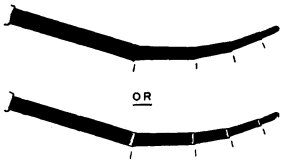
FIG. 30

FEMALES

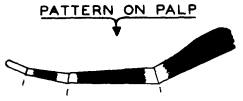
[MALES HAVE BUSHY ANTENNAE  AND DO NOT BITE]

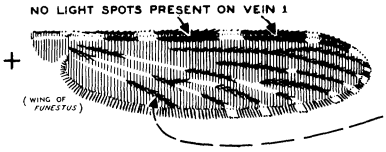


PATTERN ON HIND TARSUS



PATTERN ON PALP



+ 

+ VEIN 6 DARK ON OUTER HALF = *ANOPHELES FUNESTUS* AND *MACMAHONI* (ONLY *FUNESTUS* IMPORTANT; LARVAE CANNOT BE SEPARATED)

= *ANOPHELES NILI*

+ 

= *ANOPHELES RHODESIENSIS*

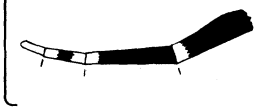
= *ANOPHELES DOMICOLUS*

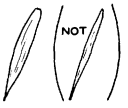
PATTERN ON VEIN 1

PATTERN ON PALP

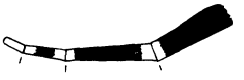
= *ANOPHELES CHRISTYI*

SCALES ON THORAX

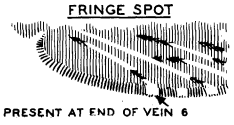


+ 

= *ANOPHELES HARGREAVESI*

+ 

= *ANOPHELES MOUCHETI MOUCHETI*

+ FRINGE SPOT 

= *ANOPHELES GAMBIAE*

PATTERN ON HIND TARSUS

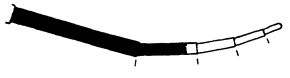
+ 

= *ANOPHELES PRETORIENSIS*

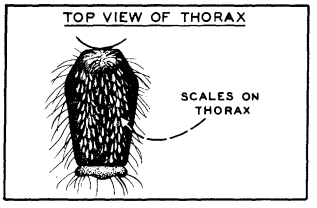
LAST SEGMENT ENTIRELY LIGHT 

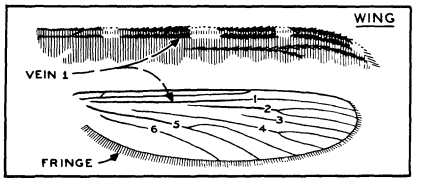
= *ANOPHELES PHAROENSIS*

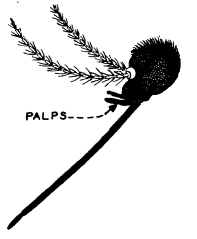
= *ANOPHELES RUFIPES RUFIPES*



= *ANOPHELES HANCOCKI*



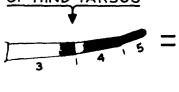




PATTERN ON THORAX

= *AEDES AEGYPTI*

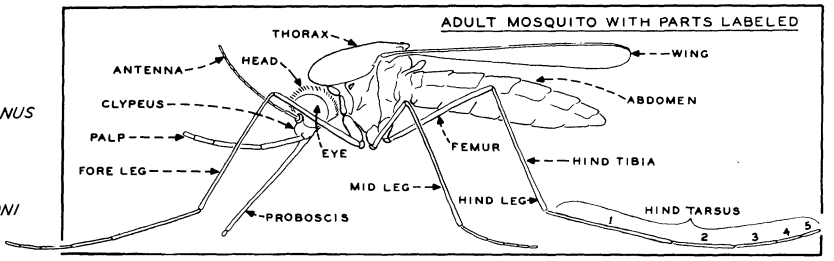
SEGMENTS 3, 4, AND 5 OF HIND TARSUS

+ 

= *AEDES AFRICANUS*

+ 

= *AEDES SIMPSONI*



DN—1287

Plasmodium falciparum predominates over East-Central Africa and is almost always found in epidemics. *Plasmodium malariae* is not nearly so abundant. *Plasmodium ovale* is believed to be indigenous to this region, but it is not common.

Anopheles gambiae, here as elsewhere in tropical Africa, is widespread and the principal vector. Because it breeds in manmade depressions in the ground, it is a mosquito of the rainy season. It is responsible for most of the malaria transmitted at high altitudes and was the vector in the epidemic recorded at 8,600 feet in Kenya (see above).

Anopheles funestus, the second most important vector in Africa, is as important in the highlands of northern Kenya as anywhere on the continent. This mosquito supports hyperendemic malaria along large rivers, where *gambiae* is scarce or entirely absent because of lack of rain. The natural infection rates of *funestus* are normally lower than those of *gambiae*; therefore, the malaria transmitted by it is slightly less intense. Although these two species together are by far the most important, other species also serve as vectors at times and in localities where populations of *gambiae* and *funestus* are low.

One of these, *Anopheles christyi*, has been implicated as a vector in the Kigezi highlands of Uganda. In this particular locality cattle are scarce, so that the normally zoophilic *christyi* is forced to seek human blood. Over most of its range it is not regarded as a vector at all.

Anopheles hancocki, a secondary vector of some importance in Uganda, commonly bites man and rests indoors. It has sometimes been found with a high infection rate.

Anopheles moucheti moucheti, a vector whose role in transmission is not exactly known, breeds in Uganda in quiet or flowing, shaded, clean water. In Belgian Congo it has been observed indoors feeding on man and often has been found with a low natural infection rate.

Anopheles pharoensis is found naturally infected in certain parts of Uganda, but in closely adjoining areas the tests for malaria are always negative. Since it is a secondary vector in French West Africa, it may be important on account of its large numbers in the ricegrowing area of Kenya.

Six additional *Anopheles* species have been implicated as vectors in various parts of their range outside East-Central Africa. Their ranges overlap this region or extend through it, and because these species appear in large numbers at various times and places, they have been included as potentially important vectors in the keys. The *Anopheles* species and the areas in which each has been implicated in malaria transmission include *domicolus*, French West Africa, Haute-Volta; *hargreavesi*, Nigeria; *nili*, Belgian Congo, Liberia, Sierra Leone, French West Africa; *rufipes rufipes*, Anglo-Egyptian Sudan, Haute-Volta; *rhodesiensis*, Sierra Leone; and *pretoriensis*, Ethiopia, Somaliland, Southern Rhodesia, Transvaal.

References: *67, 160, 260.*

Anopheles Species in East-Central Africa

ardensis
brohieri
**christyi*
cinereus
coustani coustani
coustani tenebrosus
coustani ziemanni
demeilloni
distinctus ugandae
†*domicolus*
funestus confusus
**funestus funestus*
**gambiae*
garnhami basilewskyi
garnhami garnhami
**hancocki*
†*hargreavesi*
implexus
keniensis
kibena
kingi
leesoni
longipalpis
lovettae
machardyi
maculipalpis
marshallii gibbinsi
marshallii marshallii
**moucheti moucheti*
natalensis multicinctus
natalensis natalensis
†*nili*
njombiensis
obscurus obscurus
†*paludis*
**pharoensis*
†*pretoriensis*
†*rhodesiensis*
rivulorum
†*rufipes rufipes*
sergenti macmahoni
squamosus cydippis
squamosus entebbiensis
squamosus squamosus
symesi
wellcomei erepens
wellcomei wellcomei
wilsoni

See footnote 6, p. 10.

Yellow Fever.—The Virus Research Institute at Entebbe, Uganda, has been instrumental in elucidating the epidemiology of jungle yellow fever in East-Central Africa. *Aedes aegypti*, *A. simpsoni*, and *A. africanus* transmit yellow fever in a manner similar to that described for Anglo-Egyptian Sudan (p. 40). Most of the mouse-protection tests performed in Uganda, western Kenya, and northern Tanganyika have been negative. For further information, see page 2.

References: *150, 238, 256, 311.*

Dengue.—This disease appears infrequently in East-Central Africa. It is endemic throughout most of the region. Occasionally it appears in epidemic form, especially along the coast.

References: *38, 256, 311.*

Encephalitis.—Rift Valley fever has been reported from Kenya and Uganda. West Nile encephalitis virus is occasionally encountered in both of these countries. Because Japanese and St. Louis encephalitis viruses are closely related antigenicly to the West Nile virus and because the first two have a low incidence of positive serologies, it is believed that they actually do not occur in Africa at all. In addition to West Nile encephalitis virus, antibodies to the following viruses have been found in animals in Uganda: Ntaya, Zika, Bunyamwera, Uganda S, Semliki Forest, and Bwamba. The same viruses are also present in northern Tanganyika, but their exact distribution has not yet been studied thoroughly.

References: *246, 257.*

Filariasis.—Filariasis is endemic along much of the coast of East-Central Africa. A large endemic center in Tanganyika, south of Lake Victoria, includes almost 30 percent of the native population, and a smaller center at the head of Lake Nyasa presents another acute problem. *Wuchereria bancrofti* is found in all cases of mosquito-borne filariasis in Tanganyika, but the vectors have not been determined with certainty. Both *Culex pipiens quinquefasciatus* and *Anopheles gambiae* may be involved. Elsewhere in East-Central Africa filariasis is not known to occur.

References: *99, 112, 158, 201.*

Madagascar and Adjacent Islands

(Figs. 31 and 32)

Physical Features.—Madagascar, about 1,000 miles long, is the fourth largest island in the world. It has a deeply eroded grassland plateau, with ranges as high as 9,500 feet. The weather is warm and rainy there from October to April and dry and cool from May to September. The low western shore on the Indian Ocean is bordered by numerous islands and coral reefs; on the east the steep, wet, densely forested slopes are bordered by a narrow strip of swamps and lagoons. The southern and southwestern parts of the country are semiarid, with less than 15 inches of rain annually.

The Comoro Islands, a volcanic archipelago between northern Madagascar and the African mainland, are mountainous, densely forested, and very fertile. Their climate is much like that of Madagascar.

MOSQUITOES OF MEDICAL IMPORTANCE — MADAGASCAR AND ADJACENT ISLANDS

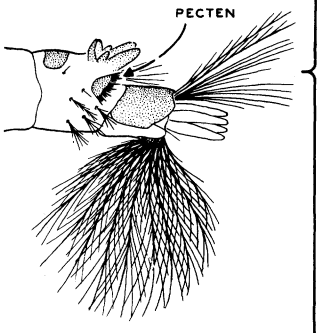
[AREA INCLUDED: MADAGASCAR, COMORO ISLANDS, SEYCHELLES, MAURITIUS, AND REUNION]

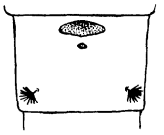
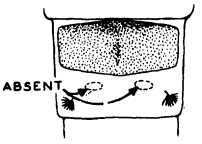
FIG. 31

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

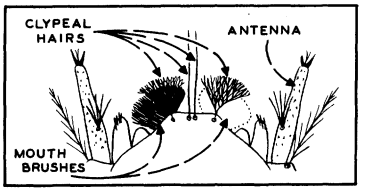
FULL-GROWN LARVAE

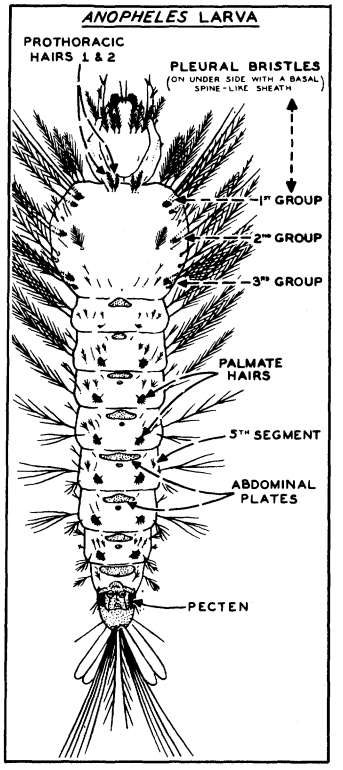
NO SIPHON ON *ANOPHELES*



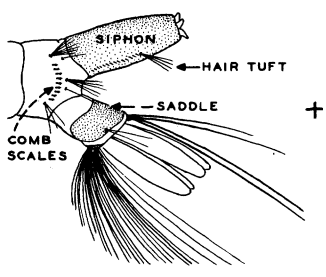
- LONG PLEURALS OF 3RD GROUP
  - ONE HAIRED, ONE BARE AND HAIR-LIKE
    - PLATES ON 5TH SEGMENT
      - 
      - PROTHORACIC HAIRS 1 AND 2
        - BASAL TUBERCLES PRESENT + PECTEN (NOT) = *ANOPHELES HANCOCKI*
        - BASAL TUBERCLES ABSENT = *ANOPHELES GAMBIAE*
      - 

        = *ANOPHELES FUNESTUS*
  - ONE HAIRED, ONE BARE AND SPINE-LIKE = *ANOPHELES BRUNNIPES*
  - BOTH HAIRED
    - CLYPEAL HAIRS
      - WITH SIDE HAIRS, BRUSH-LIKE = *ANOPHELES RUFIPES RUFIPES*
    - WITH SIDE HAIRS, 3 TO 7 BRANCHED FROM MIDDLE + PECTEN SPINES (WITH LARGE TEETH) = *ANOPHELES PHAROENSIS*
    - BOTH BARE + ONE HAIRED
      - LONG PLEURALS OF 2ND GROUP
      - PALMATE HAIRS OF 5TH SEGMENT
        - SHOULDERS SLOPING = *ANOPHELES CHRISTYI*
        - SHOULDERS NEARLY SQUARE = *ANOPHELES PRETORIENSIS*





SIPHON ON ALL OTHERS



+ SIPHON
  - ONLY ONE TUFT PER SIDE, AND ON OUTER HALF OF SIPHON
  - AT LEAST 12 SPINES
  - ABSENT
- + COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)
- + ANTENNA
  - SMOOTH
  - NOT
- COMB SCALES
  - = *AEDES AEGYPTI*
  - = *AEDES ALBOPICTUS*

DN—1288

MOSQUITOES OF MEDICAL IMPORTANCE - MADAGASCAR AND ADJACENT ISLANDS

[AREA INCLUDED: MADAGASCAR, COMORO ISLANDS, SEYCHELLES, MAURITIUS, AND REUNION]

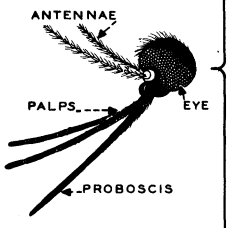
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 32

FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

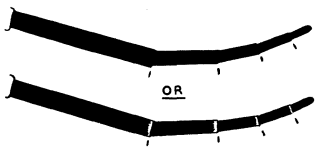
LONG PALPS ON *ANOPHELES*

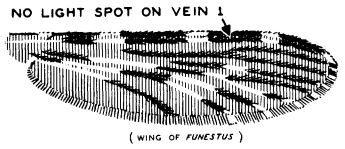


PATTERN ON HIND TARSUS

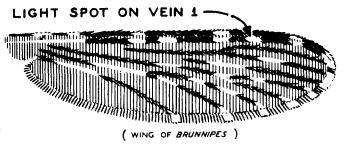
LAST SEGMENT DARK

PATTERN ON HIND TARSUS



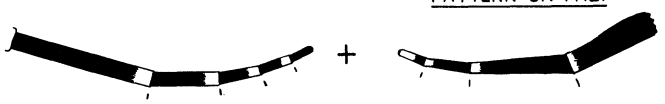


= *ANOPHELES FUNESTUS*



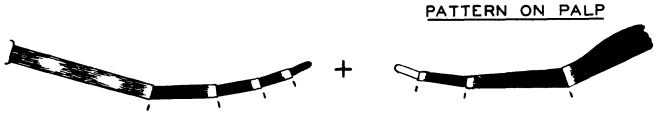
= *ANOPHELES BRUNNIPES*

PATTERN ON PALP



= *ANOPHELES CHRISTYI*

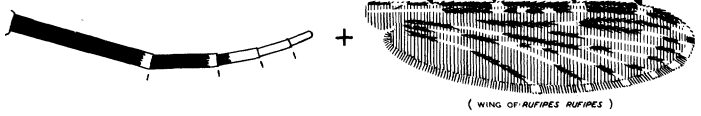
PATTERN ON PALP



= *ANOPHELES GAMBIAE*

LAST SEGMENT LIGHT

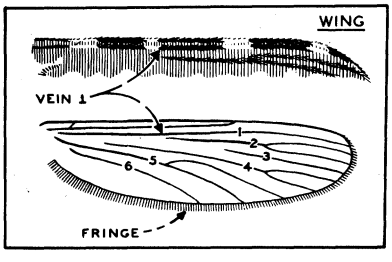
= *ANOPHELES PHAROENSIS*



= *ANOPHELES RUFIPES RUFIPES*

= *ANOPHELES HANCOCKI*

= *ANOPHELES PRETORIENSIS*

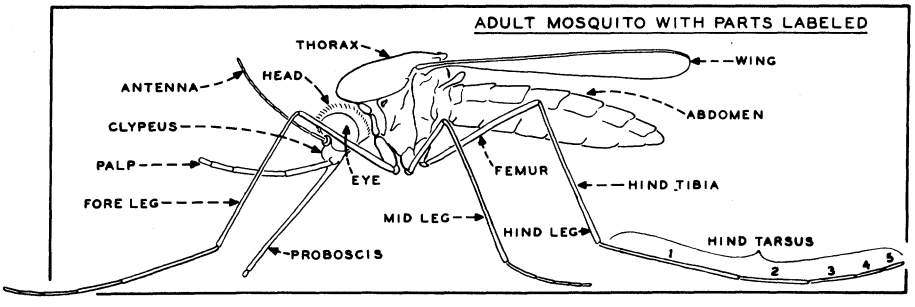


SHORT PALPS ON ALL OTHERS

PATTERN ON THORAX

= *AEDES AEGYPTI*

= *AEDES ALBOPICTUS*



DN-1289

The approximately 30 Seychelles, lying 700 miles northeast of Madagascar, are subjected to southeast winter trade winds from May to November and northwest summer monsoons. The rainfall averages about 90 inches annually, with the heaviest precipitation between November and April.

Mauritius, 500 miles east of Madagascar, has a reef-fringed coastal plain rising abruptly in three mountain ranges on the southeast, west, and north. These mountains enclose a central plateau. From 75 to 175 inches of rain fall annually on the windward coast and about 40 inches on the leeward side. Tropical cyclones are frequent.

Réunion is of volcanic origin. It has interior uplands and narrow valleys between the steep mountainsides. The rainfall ranges from 28 to 160 inches annually.

Reference: *301.*

Malaria.—Except for the central mountains and arid southwest corner, malaria is highly endemic over most of Madagascar. Abundant mosquito breeding places and year-round malaria transmission occur on the wet east coast, but the disease is seasonal elsewhere and its distribution patchy. The indigenous population is very susceptible in the numerous valleys of the central plateau, where the prevalence of malaria is closely associated with rainfall and mosquito abundance. Ricegrowing areas of the island are particularly dangerous.

Mauritius has reported complete eradication of its malaria. After 1865, when it was introduced to that island, this disease appeared in all areas below 1,400 feet nearly every year between December and June. Malaria is endemic in most of the Comoro archipelago and at low elevations in Réunion. The Seychelles are reported to be free of the *Anopheles* species and malaria.

In all these islands *Plasmodium falciparum* and *P. vivax* infections are equally abundant in native populations and account for nearly all cases; about 10 percent are *P. malariae* infections. *Plasmodium ovale* malaria is rare.

Anopheles gambiae is the principal malaria vector everywhere in this region. Particularly in Madagascar it is most subject to seasonal changes in temperature. It does not reach high altitudes there as in continental Africa. The gradual increases in elevation, such as the Ethiopian highlands, are completely lacking, and *gambiae* cannot overcome the sudden changes in temperature characteristic of the steep slopes of offshore localities.

Anopheles funestus plays a rather minor role as a malaria vector but is present along with *gambiae* in all islands where that species appears. In Madagascar *funestus* is known as *funestus imerinensis*, which is as effective a vector as typical *funestus*. It is not treated separately in the keys.

Only one female of *Anopheles rufipes rufipes* has ever been found infected with malaria in Madagascar. It is not regarded as a vector there but is included in the keys because of its importance elsewhere.

The role of *Anopheles pretoriensis* as a malaria vector is negligible in this region. In Southern Africa as high as 2 percent of this species has been found infected. It is generally considered to be rather anthropophilic. It is included in the keys because of its potential ability to transmit malaria in the islands.

Anopheles pharoensis, naturally infected in some areas and found to be negative in others, is very irregular in its ability to transmit the disease. In Madagascar it is a vector of minor importance, especially in the presence of *funestus* and *gambiae*.

Anopheles christyi, *A. hancocki*, and *A. brunnipes* are not known to be vectors in Madagascar but are included in the keys because of their ability to transmit malaria elsewhere.

References: *67. 105.*

Anopheles Species in Madagascar and Adjacent Islands

†*brunnipes*
†*christyi*
coustani coustani
funestus confusus
**funestus imerinensis*
fuscicolor fuscicolor
fuscicolor soalalaensis
**gambiae*
grassei
†*hancocki*
lacani
maculipalpis
marshallii (var. not known)
mascarensis
millotti
notleyi
obscurus obscurus
pauliani
**pharoensis*
†*pretoriensis*
radama
ranci roubaudi
†*rufipes rufipes*
squamosus cydippis
squamosus squamosus
theileri

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Madagascar or the neighboring islands. A few mouse-protection tests, all negative, have been performed.

Reference: *256.*

Dengue.—This disease has been reported from Madagascar, Mauritius, and the Comoro Islands. It is said to be endemic on the east coast and in the plateau areas of Madagascar, where a few cases are reported every year and irregularly spaced larger outbreaks occur from time to time. The last epidemic was at the northern tip of Madagascar in 1944. No information is available on dengue in the rest of the region. *Aedes aegypti* and *A. albopictus* are present in various parts of this region. They are believed to be the sole vectors wherever dengue occurs.

References: *256, 311.*

Encephalitis.—No information is available.

Filariasis.—This disease is well established throughout Mauritius and attacks humans living along streams and in urban areas that have open drains. In some localities up to 9 percent of the human population has been found with microfilariae of *Wuchereria bancrofti*, especially during cool weather. *Anopheles gambiae* and *A. funestus* are believed to be the important vectors in the island.

Reference: *142.*

Southern Africa

(Figs. 33 and 34)

Physical Features.—Southern Africa consists of the African mainland south of the Belgian Congo and Tanganyika. It includes Angola, Northern and Southern Rhodesia, Nyasaland, Mozambique, South-West Africa, Bechuanaland, and the Union of South Africa.

Angola has a narrow coastal lowland. The northern half of this country has an unhealthy tropical climate. The vast, jumbled inland plateau, with an average altitude of 6,000 feet, slopes gently eastward to the plains of the Congo and Zambezi Rivers. It receives up to 60 inches of rain per year, mostly from September to April.

Most of Northern Rhodesia, at an altitude of 3,000 to 5,000 feet, has a subtropical climate, with moderate winters and extremely hot summers in the river valleys. The rolling uplands are savannas; the extensive lowlands in the south in Barotseland are covered with tall grass and are poorly drained. The average annual rainfall is 50 inches in the north and from 25 to 30 inches in the south.

Southern Rhodesia lies on the African plateau at an elevation of 2,000 to 5,000 feet. Only the low forested veldt on the northern fringe and in the southeast corner is below 2,000 feet. The highest ranges in the country are located along the Mozambique border and are almost 8,500 feet. They receive up to 40 inches of rain annually. The three seasons

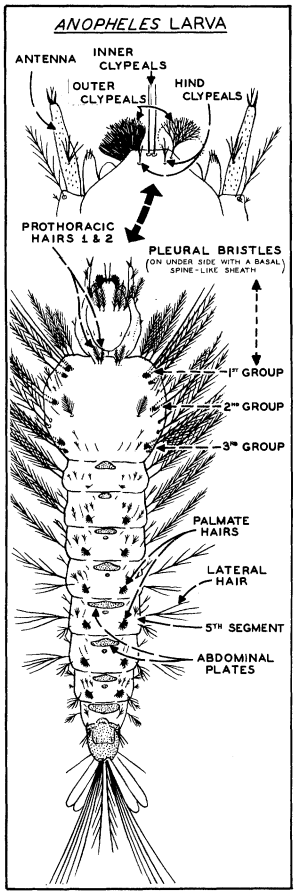
MOSQUITOES OF MEDICAL IMPORTANCE – SOUTHERN AFRICA

[AREA INCLUDED: ANGOLA, NORTHERN AND SOUTHERN RHODESIA, NYASALAND, MOZAMBIQUE, SOUTH-WEST AFRICA, BECHUANALAND, AND THE UNION OF SOUTH AFRICA]

FULL-GROWN LARVAE

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 33



LONG PLEURALS OF 3RD GROUP

BOTH HAIRED

CLYPEAL HAIRS

BOTH BARE + LONG PLEURALS OF 2ND GROUP: ONE HAIRED

PALMATE HAIRS ON 5TH SEGMENT

THREAD-LIKE = *ANOPHELES PRETORIENSIS*

BLUNT = *ANOPHELES LISTERI*

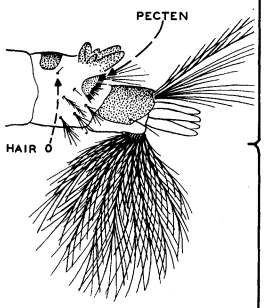
WITH SIDE HAIRS; 3 TO 7 BRANCHED FROM MIDDLE = *ANOPHELES RUFIPES RUFIPES* AND *RUFIPES INGRAMI* (BOTH IMPORTANT; LARVAE CANNOT BE SEPARATED)

WITH SIDE HAIRS; BRUSHLIKE + PECTEN SPINES: WITH LARGE TEETH = *ANOPHELES PHAROENSIS*

BOTH BARE + CLYPEAL HAIRS: WITH LONG HAIRS ON INNER SIDE; BARE = *ANOPHELES NILI*

ONE HAIRED; ONE BARE AND SPINE-LIKE = *ANOPHELES BRUNNIPES*

NO SIPHON ON *ANOPHELES*



PROTHORACIC HAIRS 1 AND 2

SHAFTS SLENDER; BASAL TUBERCLES ABSENT

PECTEN: LONG AND SHORT SPINES MIXED = *ANOPHELES GAMBIAE*

ALL SPINES ABOUT EQUAL IN LENGTH = *ANOPHELES MELAS*

ONE HAIRED; ONE BARE AND HAIR-LIKE

SHAFTS THICKENED; BASAL TUBERCLES PRESENT AND CLOSE TOGETHER

ANTENNA: SPICULES EVENLY DISTRIBUTED + PLATES ON 5TH SEGMENT: COVERING ABOUT 1/2 OF SEGMENT; SOMETIMES PRESENT + HIND EDGE OF PLATE NOT DARKENED = *ANOPHELES FUNESTUS FUNESTUS* AND *FUNESTUS FUSCIVENOSUS* (BOTH IMPORTANT; LARVAE CAN-NOT BE SEPARATED)

DENSE PATCH OF SPICULES AT BASE

OUTER CLYPEALS

BARE AND HAIRLIKE

LATERAL HAIRS ON 5TH SEGMENT

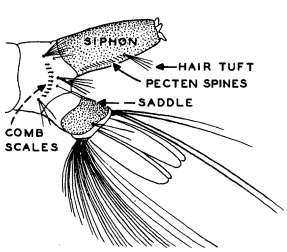
2 TO 4 BRANCHED = *ANOPHELES HARGREAVESI*

6 TO 9 BRANCHED = *ANOPHELES HANCOCKI* AND *MARSHALLII* (ONLY *HANCOCKI* IMPORTANT; LARVAE SEPARATED WITH DIFFICULTY)

WITH FINE SIDE HAIRS = *ANOPHELES RHODESIENSIS*

SHORT, BLUNT AT TIP = *ANOPHELES DOMICOLUS*

SIPHON ON ALL OTHERS



SIPHON: ONLY ONE TUFT PER SIDE, AND ON OUTER HALF OF SIPHON; AT LEAST 12 SPINES; ABSENT

COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE)

ANTENNA: SMOOTH; NOT

COMB SCALES

PECTEN SPINES = *AEDES AEGYPTI*

= *AEDES SIMPSONI*

MOSQUITOES OF MEDICAL IMPORTANCE — SOUTHERN AFRICA

[AREA INCLUDED: ANGOLA, NORTHERN AND SOUTHERN RHODESIA, NYASALAND, MOZAMBIQUE, SOUTH-WEST AFRICA, BECHUANALAND, AND THE UNION OF SOUTH AFRICA]

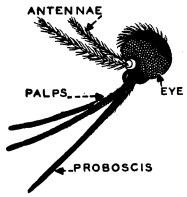
FIG. 34

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FEMALES

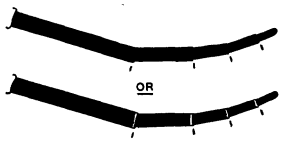
[MALES HAVE BUSHY ANTENNAE  AND DO NOT BITE]

LONG PALPS ON *ANOPHELES*



PATTERN ON HIND TARSUS

PATTERN ON PALP



NO LIGHT SPOTS ON VEIN 1

VEIN 6 DARK ON OUTER HALF

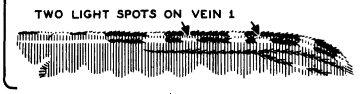
FRONT MARGIN WITH LIGHT SPOT IN BASAL THIRD

= *ANOPHELES FUNESTUS FUNESTUS*

FRONT MARGIN DARK ON BASAL THIRD

= *ANOPHELES FUNESTUS FUSCIVENOSUS*

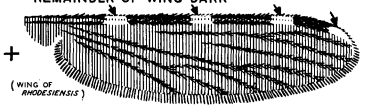
TWO LIGHT SPOTS ON VEIN 1



= *ANOPHELES BRUNNIPES*

= *ANOPHELES NILI*

AT LEAST FOUR LIGHT SPOTS ON FRONT MARGIN; REMAINDER OF WING DARK

+ 

= *ANOPHELES RHODESIENSIS*

AT LEAST FOUR LIGHT SPOTS ON FRONT MARGIN

+ 

= *ANOPHELES LISTERI*

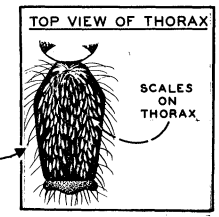
+ 

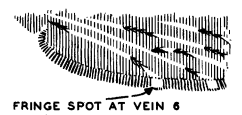
TWO LIGHT SPOTS ON VEIN 1

SCALES ON THORAX

= *ANOPHELES HARGREAVESI*

TOP VIEW OF THORAX



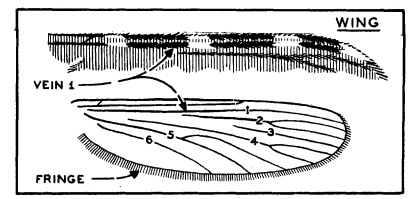
+ 

= *ANOPHELES GAMBIAE* AND *MELAS*
(BOTH IMPORTANT; ADULTS CANNOT BE SEPARATED WITH CERTAINTY)

FRINGE SPOT AT VEIN 6

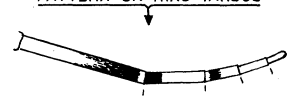
= *ANOPHELES DOMICOLUS*

WING



PATTERN ON HIND TARSUS

LAST SEGMENT ENTIRELY LIGHT



= *ANOPHELES PHAROENSIS*

+ 

TWO LIGHT SPOTS ON VEIN 1

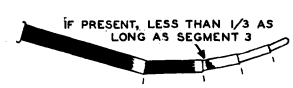
= *ANOPHELES PRETORIENSIS*

+ 

ONLY ONE LIGHT SPOT ON VEIN 1

= *ANOPHELES HANCOCKI*

IF PRESENT, LESS THAN 1/3 AS LONG AS SEGMENT 3



+ 

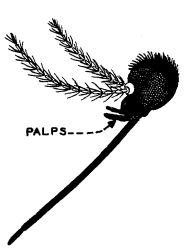
TWO LIGHT SPOTS ON VEIN 1

= *ANOPHELES RUFIPES INGRAMI*

MORE THAN 1/3 AS LONG AS SEGMENT 3

= *ANOPHELES RUFIPES RUFIPES*

SHORT PALPS ON ALL OTHERS

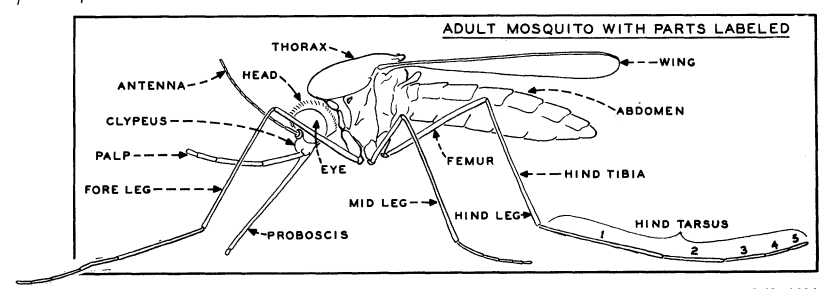


PATTERN ON THORAX

+ LINES WHITE = *AEDES AEGYPTI*

+ WHITE SCALES = *AEDES SIMPSONI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1291

include hot dry weather from September to November, a rainy season from November to March, and generally cool weather from May to August.

Nyasaland lies in the Rift Valley and is flanked by high savanna-covered plateaus at elevations of 3,500 to 8,000 feet. The temperature in the valley is 120° F., but in the milder uplands the temperature ranges from 40° to 95° F. The annual rainfall averages about 40 inches. The southeast part of Nyasaland is low and marshy.

Mozambique is a flat lowland, which rises gradually in the west to an undulating 800- to 2,000-foot plateau, with the highest parts in the north and along the edge of the Rift Valley. Monsoons bring 40 to 60 inches of rainfall per year to the northern edge of the coastal plain, mostly between December and April. Southern Mozambique is cooler and drier. Commercial agriculture is practiced only along the northern river valley.

South-West Africa has an arid coastal plain contiguous with that in Angola. This rises abruptly to an interior 2,500-foot plateau, which is bordered by northern mountains of 8,500 feet. The dry southern and eastern parts of the country contain many salt-water depressions.

Bechuanaland is an interior 3,000-foot plateau, the entire southern part of which is desert. Most of the northern part has a subtropical climate. Lake Ngami and the Okovanggo River basin in the northwest are the country's largest marshy areas.

The interior of the Union of South Africa is a vast rolling plateau 2,000 to 6,000 feet high, bounded by a series of high parallel mountain ranges extending from Cape Town around the southern edge of the country to Mozambique. The southern part of the Union of South Africa has winter rains, but elsewhere there are summer rains, except in the extreme northern and western parts, which are arid.

Reference: *301.*

Malaria.—The distribution of this disease is patchy in the Rhodesias, Nyasaland, and Mozambique. The areas of hyperendemic malaria, which are rarely above 4,500 feet, with spleen rates of 50 to 100 percent, are located along the Mozambique coast, in the valley of the Zambezi to Lake Natal, and in parts of both Transvaal and Natal. Latitude 31° S. represents the southernmost limit of the disease in Southern Africa. In the grassy uplands of the Rhodesias and Mozambique malaria is seasonal. Apparently no information is available about the distribution or intensity of the disease in Angola, but the extreme northern parts of South-West Africa have endemic centers. The vast expanses of extremely dry countryside to the south support little malaria.

Plasmodium falciparum is often found in epidemics, but *P. vivax* appears at least as frequently; *P. malariae* and *P. ovale* are rare.

Anopheles gambiae finds ideal breeding sites in the northwest part of Southern Africa, where man makes many natural depressions in the hard soil. However, *gambiae* as the principal vector is restricted to highland areas in other parts of Southern Africa. There it supports endemic, hyperendemic, and epidemic malaria almost to the exclusion of *Anopheles funestus* (see below). *A. gambiae* will infiltrate into many upland areas during the breeding season and then completely disappear during the winter.

A. funestus, on the other hand, normally inhabits larger bodies of water than does *gambiae*, and the malaria it transmits is less intense on account of the relatively more stable mosquito population. Furthermore, in Southern Africa it is responsible for most of the malaria transmitted at lower altitudes. Hyperendemic malaria occurs in areas where *funestus* is the dominant species, but this hyperendemicity is generally slightly lower than that supported by *gambiae*. Several morphological varieties of *funestus* are found in Southern Africa. The best known of these, *fuscivenosus*, appears in Southern Rhodesia and is probably as effective a vector as the type form.

Anopheles listeri is suspected as a possible vector in South-West Africa. It is widely distributed in this country. The females often enter houses and feed on man. Because of its endophilism and anthropophilism this mosquito may be a vector. It is only potentially important, since its exact role in transmission is not known.

Anopheles melas reaches its extreme southern distribution on the north coast of Angola, where it is associated principally with *Avicennia* mangrove. In this area it is an extremely effective vector and as important as *gambiae*.

Anopheles pretoriensis is normally a wild mosquito and almost never found indoors. In Southern Rhodesia and the Transvaal it is found naturally infected out of doors, but no information is available on the nature of the parasites or how they are obtained by the mosquito.

Eight additional species of *Anopheles* are found in various parts of this region, sometimes in large numbers, but none of them have been implicated in malaria transmission in any of the countries discussed above. They have been included in the keys because of their known importance elsewhere and their possible importance in this region. The *Anopheles* species and the areas in which they are important include *brunnipes*, Belgian Congo; *domicolus*, northern Nigeria, French West Africa; *hancocki*, Uganda, Ivory Coast, Haute-Volta; *hargreavesi*, Nigeria; *nili*, Belgian Congo, Liberia, French West Africa, Sierra Leone; *pharoensis*, Egypt, French West Africa; *rhodesiensis*, Sierra Leone; *rufipes rufipes*, Anglo-Egyptian Sudan, Haute-Volta; and *r. ingrami*, Sierra Leone.

References: *67, 259, 260.*

Anopheles Species in Southern Africa

ardensis
argenteolobatus
austenii
†*brunnipes*
cameroni
cinereus
costalis
coustani caliginosus
coustani coustani
coustani tenebrosus
coustani ziemanni
demeilloni
distinctus distinctus
†*domicolus*
funestus confusus
**funestus funestus*
**funestus fuscivenosus*
**gambiae*
garnhami
†*hancocki*
†*hargreavesi*
implexus
jacobi
leesoni
**listeri*
longipalpis
maculipalpis
marshallii marshallii
marshallii musinhoi
marshallii pitchfordi
**melas*
michaeli
moucheti moucheti
natalensis multicinctus
natalensis natalensis
†*nili*
njombiensis
obscurus obscurus
paludis
†*pharoensis*
**pretoriensis*
†*rhodesiensis*
rivulorum rivulorum
ruarinus
†*rufipes ingrami*
†*rufipes rufipes*
seydeli
squamosus cydippis
squamosus squamosus
symesi
tchekedii
theileri
vinckei
walravensi milesi
walravensi walravensi

See footnote 6, p. 10.

Yellow Fever.—Clinical cases of this disease have never been reported from Nyasaland, Northern Rhodesia, Southern Rhodesia, Union of South Africa, South-West Africa, or Bechuanaland. Endemic centers of yellow fever have been found in the Barotse Province of Northern Rhodesia and

Balovale district. *Aedes simpsoni* is believed to be the principal vector in these two centers. It probably behaves in much the same way as in Anglo-Egyptian Sudan (p. 40). In the Lake Ngami area of northern Bechuanaland another endemic center has been uncovered. The vectors there are not known with certainty. Angola has reported no clinical cases of yellow fever since 1900. Persons living there have positive immunization tests only near the Congo border. In Mozambique yellow fever is not known to occur. For additional information, see pages 2 and 3.

References: *256, 311.*

Dengue.—In Southern Africa dengue has been reported only from Mozambique and the Union of South Africa. In Mozambique the disease is endemic, but no major outbreak has been reported since 1924. In the Union of South Africa dengue is epidemic along the Natal coast, with occasional outbreaks. *Aedes aegypti* transmits dengue in this coastal area.

References: *256, 311.*

Encephalitis.—The West Nile and some newly described encephalitis viruses are present in Southern Africa. Few observations have been made on their epidemiologies. For further information about mosquito-borne encephalitides, see pages 3–5.

References: *257, 311.*

Filariasis.—No information is available.

EURASIA

North Europe and North Asia

(Figs. 35 and 36)

Physical Features.—This region of North Europe and North Asia includes North Europe, the Union of Soviet Socialist Republics (U. S. S. R.), Mongolia, Manchuria, northern China, Korea, and Japan. It is bounded on the south by the following countries: Spain, Italy, Yugoslavia, Rumania, Turkey, Iran, Afghanistan, India, East Pakistan, Assam, Burma, and China at about latitude 28° N. The southern border includes most of the shoreline of the Caspian Sea and the northern shore of the Black Sea. Ireland and western France form the westernmost extension of this region and the western edge of the Bering Sea and Bering Strait the easternmost limit.

North Europe and North Asia are separated from the countries to the south by a series of high mountain ranges. Lower mountains cover much of the southern half of this region and merge with the relatively low northern coastal plain in northern France, Belgium, Netherlands, Denmark, Germany, and the northeastern shore of the U. S. S. R. The Carpathians form an inland mountain circle around the eastern border of Hungary, enclosing an upper part of the Danube River basin. A relatively low, flat area extends northeastward across all Europe from Gdansk (Danzig) to the Black Sea and includes the vast steppes surrounding Moscow. The Caucasus Mountains, extending from northwest to southeast between the Black and the Caspian Seas, mark the approximate southern border of Asia between these two bodies of water. Extensive ranges lie along the western border of Norway from north to south, through the northern three-fourths of England and Scotland, and along the eastern margin of the U. S. S. R. from the Arctic Circle to about latitude 50° N. The northern border of Asia is relatively low, with vast expanses of tundra and permafrost. A large series of east-west mountain ranges extend southward across the center of Mongolia and Siberia from Afghanistan in the southwest to the Sea of Okhotsk in the northeast. Another mountain mass, roughly oval in shape, is in the western half of China north of the Himalayan range. A partially submerged mountain chain lies in the Pacific Ocean east of the continent and forms the Kamchatka Peninsula, Japan, and the Kuriles.

Europe, open to the Gulf Stream and the North Atlantic Drift, has an unusually mild winter for the high latitudes, but the effect of these warm currents disappears at the Urals and beyond. Only the northernmost parts of Scandinavia, Finland, and North Asia are subarctic. The northern and western plains and steppes have temperate westerlies, although summer and winter temperatures differ considerably. In the southern and eastern parts the climate is regulated by monsoon systems, which bring cool, dry winds blowing outward from the center of the continent in the winter and hot, moist winds blowing toward its center in the summer.

Reference: *301.*

Malaria.—*Plasmodium vivax* is the principal cause of malaria in the Temperate Zone across North Europe and North Asia, *P. falciparum* tends to dominate in the more southern subtropical area, and *P. malariae* is sporadic and usually accounts for fewer cases than either of the others.

Anopheles messeae, one of the members of the *Anopheles maculipennis* complex, is widespread north of the Alps and inhabits great inland river valleys and large marshes. In North Europe it rarely bites man. It is a vector of malaria only in parts of Hungary where dense human populations live close to large marshy areas. However, in the U. S. S. R. it is the most widely distributed and important *Anopheles* species, and because of the immense area included in its range, it is one of the most important, if not the most important, vector in the *maculipennis* group. The northern and eastern limits of the range of the *maculipennis* group in North Asia are represented by the northern and eastern limits of the range of *messeae*. This species does not extend south of Caucasia. There are no *Anopheles* species or malaria in Iceland.

In all western Europe north of the Alps malaria is endemic in only one small area consisting of the North Sea Coast Provinces of North Holland, Friesland, Zeeland, and German East Friesland. This endemic *Plasmodium vivax* malaria appears in epidemic waves about 20 years apart and is carried by *Anopheles labranchiae atroparvus*. Its larvae are found in slightly brackish coastal waters, and the adults inhabit warm shelters throughout the winter. The species transmits a great deal of so-called winter house malaria, presumably because the numerous children are the most persistent carriers of malaria. Outside of this area *atroparvus* is not known to be a malaria vector, except in southwest U. S. S. R. on the Black Sea coast between the Bug and Danube River Deltas. The species over much of its range is greatly attracted to stable animals. The easternmost limit of the distribution of malaria in the Black Sea area corresponds to the easternmost limit of the range of *atroparvus*.

Anopheles labranchiae labranchiae is not represented at all in North Europe, but its egg is illustrated in the key, because this species does inhabit the northern parts of Italy and Spain close to the borders of France.

Anopheles melanoon melanoon has been reported from Transcaucasia just south of the Caucasus Mountains but is not believed to contribute to endemic malaria anywhere in its range. *Anopheles melanoon subalpinus* has been reported from Switzerland, Hungary, and in large numbers from the lowlands of Transcaucasia on the southern shore of the Caspian Sea. In the vicinity of Lenkoran and the Sefid Rud River Delta it is the dominant and often the only member of the *maculipennis* complex, and it is the principal vector of a severe malaria. The female hibernates near its source of food and, like *atroparvus*, feeds throughout the winter. This mosquito is not found north of Caucasia.

Anopheles maculipennis has never been reported from England but is widely distributed in continental Europe, ap-

MOSQUITOES OF MEDICAL IMPORTANCE – NORTH EUROPE AND NORTH ASIA

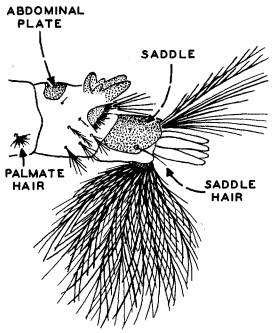
[AREA INCLUDED: NORTH EUROPE, THE U.S.S.R., MONGOLIA, MANCHURIA, NORTHERN CHINA, KOREA, AND JAPAN]

FIG. 35

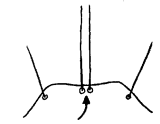
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

NO SIPHON ON *ANOPHELES*



INNER CLYPEALS

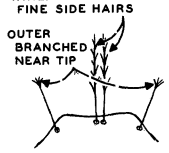


BASES CLOSE TOGETHER

CLYPEALS

INNER BARE OR WITH FINE SIDE HAIRS

OUTER BRANCHED NEAR TIP



FRONTALS

WITH LONG SIDE HAIRS + SADDLE HAIR (AT MARGIN OR BEYOND; NOT) = *ANOPHELES CLAVIGER*

BARE = *ANOPHELES PLUMBEUS*

INNER BARE

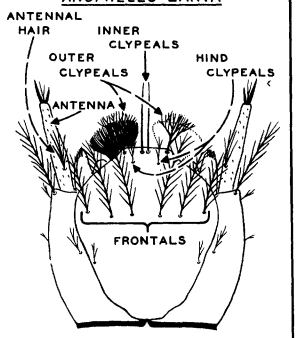
OUTER BRUSH-LIKE

ANTENNAL HAIR

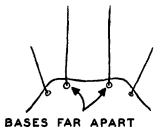
AT ABOUT MIDDLE OF SHAFT, LONG = *ANOPHELES SINENSIS*

AT BASAL THIRD OF SHAFT, SHORT = *ANOPHELES MACULIPENNIS* AND RELATIVES (LARVAE CANNOT BE SEPARATED; SEE CHART OF EGGS BELOW)

TOP VIEW OF HEAD OF *ANOPHELES* LARVA



BASES FAR APART



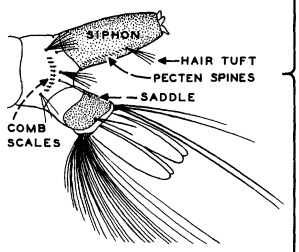
OUTER CLYPEALS

BARE + ABDOMINAL PLATES 4 TO 7 (SMALL; NOT) + PALMATES ON SEGMENTS 2 & 3 (PALMATES ON SEGMENT 2 SMALLER THAN ON SEGMENT 3; SEGMENT 2; SEGMENT 3) = *ANOPHELES SUPERPICTUS*

WITH FINE SIDE HAIRS + PALMATES ON SEGMENT 1 (WELL DEVELOPED; NOT) = *ANOPHELES PATTONI*

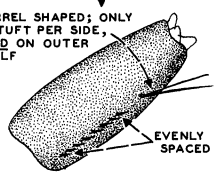
BRUSH-LIKE = *ANOPHELES PULCHERRIMUS*

SIPHON ON ALL OTHERS



SIPHON

BARREL SHAPED; ONLY 1 TUFT PER SIDE, AND ON OUTER HALF



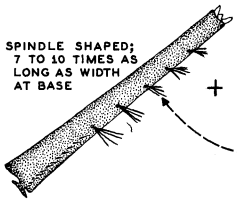
EVENLY SPACED

+ COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE) + ANTENNA (SMOOTH; NOT)

COMB SCALES = *AEDES AEGYPTI*

COMB SCALES = *AEDES ALBOPICTUS*

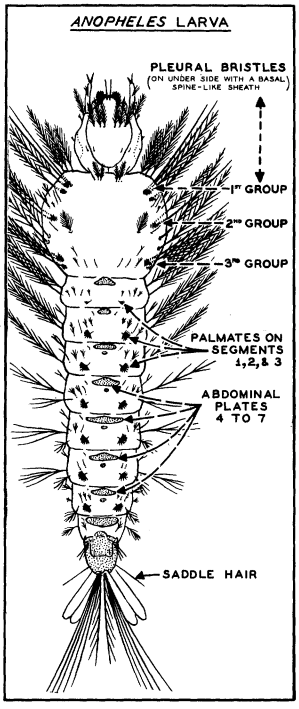
SPINDLE SHAPED; 7 TO 10 TIMES AS LONG AS WIDTH AT BASE



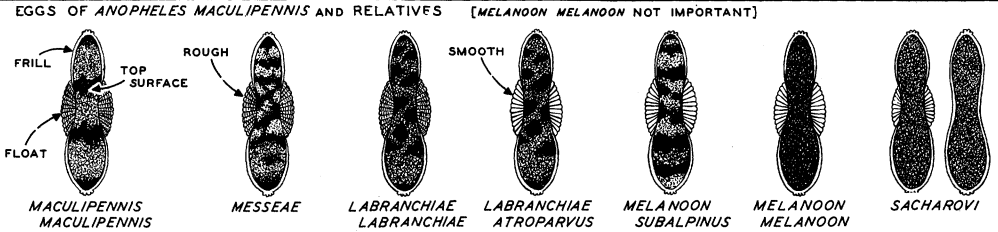
+ 5 OR 6 TUFTS PER SIDE IN EVEN ROW

COMB SCALES	PECTEN SPINES	
(NOT POINTED)	(NOT)	= *CULEX TRITAENIORHYNCHUS*

ANOPHELES LARVA



EGGS OF *ANOPHELES MACULIPENNIS* AND RELATIVES [*MELANOON MELANOON* NOT IMPORTANT]



MACULIPENNIS MACULIPENNIS | *MESSEAE* | *LABRANCHIAE LABRANCHIAE* | *LABRANCHIAE ATROPARVUS* | *MELANOON SUBALPINUS* | *MELANOON MELANOON* | *SACHAROVI*

MOSQUITOES OF MEDICAL IMPORTANCE – NORTH EUROPE AND NORTH ASIA

[AREA INCLUDED: NORTH EUROPE, THE U.S.S.R., MONGOLIA, MANCHURIA, NORTHERN CHINA, KOREA, AND JAPAN]

FIG. 36

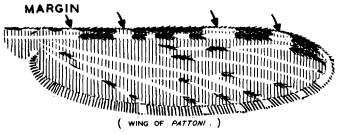
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FEMALES

[MALES HAVE BUSHY ANTENNAE () AND DO NOT BITE]

PATTERN ON WING

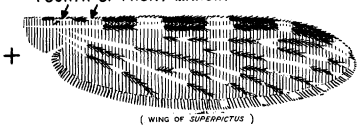
AT LEAST FOUR LIGHT SPOTS ON FRONT MARGIN



(WING OF *PATTONI*)

PATTERN ON HIND TARSUS

ONE OR TWO LIGHT SPOTS ON BASAL FOURTH OF FRONT MARGIN



(WING OF *SUPERPICTUS*)

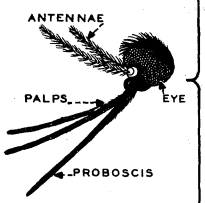
= *ANOPHELES SUPERPICTUS*

HIND FEMUR AND TIBIA ENTIRELY DARK

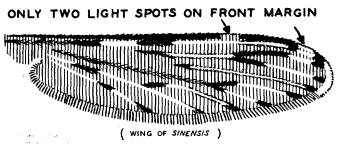
= *ANOPHELES PATTONI*

= *ANOPHELES PULCHERRIMUS*

LONG PALPS ON *ANOPHELES*



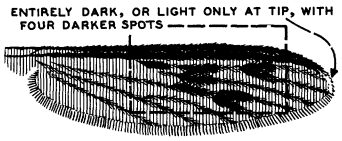
ONLY TWO LIGHT SPOTS ON FRONT MARGIN



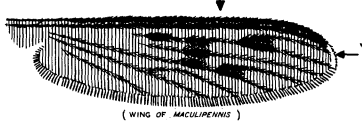
(WING OF *SINENSIS*)

= *ANOPHELES SINENSIS*

ENTIRELY DARK, OR LIGHT ONLY AT TIP, WITH FOUR DARKER SPOTS



FRINGE AT WING TIP



YELLOWISH SPOT

(WING OF *MACULIPENNIS*)

= *ANOPHELES MACULIPENNIS* AND RELATIVES
(NOT ALL IMPORTANT; ADULTS CANNOT BE SEPARATED)

ALL DARK

(WING OF *SACHAROVI*)

= *ANOPHELES SACHAROVI*

ENTIRELY DARK, WITHOUT DARKER SPOTS

(WING OF *CLAVIGER*)

+

TOP VIEW OF HEAD

TUFT OF WHITE SCALES

PALP

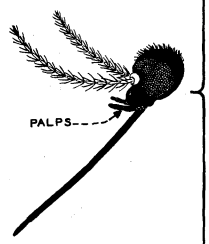
END SEGMENT NOT MORE THAN 1/2 AS LONG AS NEXT, AND SAME COLOR

= *ANOPHELES CLAVIGER*

END SEGMENT ABOUT 3/4 AS LONG AS NEXT, AND SAME COLOR

= *ANOPHELES PLUMBEUS*

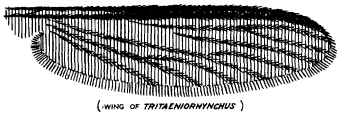
SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX

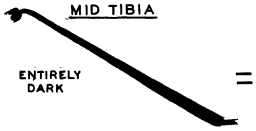
+ PROBOSCIS

+ ENTIRELY DARK, WITHOUT LIGHT SCALES



(WING OF *TRITAENIORHYNCHUS*)

+ MID TIBIA



ENTIRELY DARK

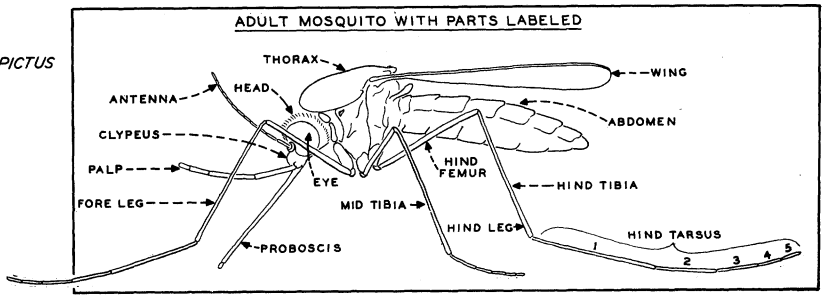
= *CULEX TRITAENIORHYNCHUS*

+ SCALES BROAD AND YELLOWISH (NOT WHITE)

= *AEDES ALBOPICTUS*

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



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pearing as far north as southern Sweden and as far east as the plains of western Siberia. The eastern boundary of its range is generally the Urals. It lives primarily in mountainous country and is found only in the hilly parts of flatter areas. In Europe it is not known as a vector at all, but it is the chief or sole vector, maintaining a high rate of transmission, in Caucasia and Transcaucasia, where it often hibernates, like *atroparvus* and *subalpinus*, in warm shelters and may be responsible for some cases of winter house malaria in this area. In Transcaucasia *maculipennis* may consist of local races, since several egg varieties have been described.

Anopheles sacharovi is not found in Europe proper north of the Alps. It is largely restricted to the Mediterranean area in the west, but eastward its range swings slightly north. It is common throughout most of Transcaucasia, along the western littoral of the Caspian Sea, Daghestan, throughout the less arid parts of Turkestan, and in Sinkiang Province, China. The larvae are often found in brackish or saline water. This mosquito is a dangerous vector throughout most of its range. However, in the lower part of the Amu Darya Valley it is present in large numbers in the complete absence of malaria. Reasons for this are not well understood. Extensive cattle breeding may divert this mosquito from man.

Anopheles claviger is a widely distributed mosquito. Its range extends from England and Denmark through North Europe and North Asia and into Siberia as far east as the Yenisei River. It is common in central Asia and is prevalent in Caucasia on the Black Sea coast. It is an effective vector only in the southern part of its range and then only where it breeds in spring water in the mountainous areas close to large human populations. It has maintained a mild endemic malaria in the suburbs of Baku, where it breeds in abandoned wells.

Anopheles plumbeus is distributed throughout North Europe, and its range extends as far east as Tadzhikistan. Since it breeds in tree holes, it is primarily a forest mosquito and rarely has high enough populations to maintain malaria. However, in the forested areas east of the Black Sea coast, it has transmitted malaria, although insignificantly. This species is included in the keys because of its potential importance.

Anopheles pulcherrimus is restricted to North Asia (see p. 132). It inhabits chiefly low land and is common in the flat valleys of the large rivers. It is most commonly encountered in central Asia, especially in the lower part of the Murgab Valley, where it breeds in tremendous numbers, building up populations early in the year. It is able to maintain severe endemics in the absence of other vectors. In most of its range it is a vector of malaria to some extent.

Anopheles superpictus, which is absent from Europe north of the Alps, is restricted largely to the Mediterranean. However, it is found abundantly along the west Caspian seacoast and is very common eastward throughout the mountainous and hilly areas of central Asia. Like *pulcherrimus*, it is able to maintain heavy endemics in the absence of other vectors, especially in many localities of Turkmenistan.

Anopheles sinensis, the eastern representative of the *A. hyrcanus* group, is restricted to eastern Asia and the Orient. The northwest limit of its range is represented by a line drawn across Asia from the northern Assam-Burma connection with China to the northeast border of Manchuria. Its range covers all the territory east of this, including Japan. In the Ussuri area and the lowlands of northern China it is the only *Anopheles* species, and in the latter area it is able to maintain rather severe endemic malaria. In Japan and Korea it is the principal vector of malaria.

Anopheles pattoni, another eastern Asian mosquito, is common in the hilly areas of northern China. It is the chief vector in southern Manchuria, Hopeh, Shantung, Shansi, Shensi, northern Szechwan, and eastern Kansu. This species has not definitely invaded the Japanese islands.

References: *67, 122, 125, 175, 223, 262, 264.*

Anopheles Species [8] in North Europe and North Asia

aitkenii
algeriensis
chodukini
**claviger*
†*fluviatilis*
gigas baileyi
gigas simlensis
hyrcanus
koreicus koreicus
koreicus var. *hisaoe*
**labranchiae atroparvus*
†*labranchiae labranchiae*
lewisi
lindesayi japonicus
lindesayi lindesayi
†*maculatus*
**maculipennis*
marteri
melanoon melanoon
**melanoon subalpinus*
**messeae*
moghulensis
**pattoni*
**plumbeus*
**pulcherrimus*
pullus
**sacharovi*
**sinensis*
sineroides
**superpictus*
yatsushiroensis

Yellow Fever.—Outbreaks of yellow fever in temperate regions probably represent introductions from tropical regions, where this disease is believed to have originated as jungle yellow fever. Epidemics were reported in Europe during the 18th century in port cities of France and England and were probably borne by *Aedes aegypti*. Yellow fever has never been reported from the Orient.

Reference: *316.*

Dengue.—The distribution of dengue is discontinuous in North Europe and North Asia. A few cases are reported from southern Austria each year, and a small epidemic occurred in Vienna in 1941. An important endemic center surrounds the Black Sea and extends in a wide belt across Caucasia to encompass the Caspian Sea, beyond which it reaches to the western border of China and is continuous northward to about latitude 54° N. It is assumed that *Aedes aegypti* is the vector in this area.

Dengue also occurs along the Asian coast opposite Sakhalin and along the Yellow and East China Sea coasts of China, and it extends well inland. It is probably not a military problem in Korea.

Epidemics of dengue in the Nagasaki, Sasebo, and Osaka-Kobe areas of Japan occurred in 1942, recurred every summer for several years, and ended in 1945. This was one of the largest series of epidemics ever recorded in the temperate region, almost 200,000 people having been affected. *Aedes aegypti* and *A. albopictus* were the vectors of this eastern Asia dengue. Both are found over much of this area and are known vectors of the disease elsewhere.

References: *171, 256, 310, 348.*

Encephalitis.—Human cases of Japanese encephalitis, some of them unconfirmed, have been reported in an area extending from Sakhalin to Hankow in eastern China. For additional details, see page 4.

Reference: *257.*

Filariasis.—The distribution of filariasis in this region is not completely known, but Japan, South Korea, the Yangtze River basin, and other parts of coastal China are known centers of infection. Among the large number of mosquitoes that have been experimentally infected with *Wuchereria ban-*

[8] Species marked with an asterisk (*) are recorded as vectors of malaria and/or filariasis in this region and their medical importance is discussed in the accompanying text. Those marked with a dagger (†) are not recorded as vectors of malaria and/or filariasis in this region but are important elsewhere. For information on the latter vectors, see the description of the particular species in the last section of this handbook.

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crofti in Japan, *Culex pipiens pallens* and *Aedes togoi* are outstanding. Filariasis parasites mature rapidly in these two species, which are especially domestic and are commonly found with infectious stages of *bancrofti* in nature. *A. togoi* and possibly *pallens* have been found to transmit *Wuchereria malayi* in the Japanese islands not more than about 80 miles south of Tokyo. This parasite is present in almost pure form in a focus entirely isolated from the closest centers of infection of *malayi*. *A. togoi* breeds close to houses in concrete rainwater reservoirs in this area.

Filariasis caused by *malayi* and *bancrofti* is present in most of the coastal provinces of China and along most of the Yangtze River and its delta, where *Anopheles sinensis* is probably the most important vector of both of them. Filariasis is an important disease in the country villages of the Woosung district, where *sinensis* is commonly found with natural infections. *Culex tritaeniorhynchus* may be a minor vector from mid-July to mid-August in central China, where it is endophilic, but in the Shanghai area it is not common. *Armigeres obturbans* is one of the most common domestic mosquitoes of the lower Yangtze Valley and may transmit some filariasis, since it has been found with a low rate of natural infection.

In the Shanghai area *Culex pipiens pallens* is one of the most important vectors of *bancrofti*, but *pallens* has a low susceptibility to infection with *malayi*. Attempts have been made to infect a number of mosquitoes in the Shanghai area with filarial parasites. Field and laboratory observations suggest that the following species are not vectors in nature there: *Culex bitaeniorhynchus*, *C. fuscanus*, *C. pallidothorax*, *C. vexans* var. *nipponii*, and *Aedes albopictus*.

References: *40, 123, 177–182, 184–187, 208, 227, 342, 343.*

Spain and Portugal

(Fig. 37)

Physical Features.—Spain comprises most of the Iberian Peninsula. This country is roughly triangular in shape and is bounded largely by water. The Galician Mountains in the extreme northwest extend along the northern border. Along the steep, rocky shores of the Bay of Biscay, which has the highest rainfall in Spain, is another range, the Cantabrian. These mountains merge with the high Pyrenees, which divide Spain from France. The entire southeast coast on the Mediterranean Sea consists of many beaches, lagoons, and marshes and has hot, dry summers and wet winters. The extreme southern part of the peninsula contains the highest mountains in Spain, the Sierra Nevadas. A massive plateau, having a Temperate Zone climate, covers most of the interior. Lowlands are in the vicinity of Valencia, Murcia, and Alicante on the Mediterranean coast. The principal fertile river valleys in the interior are in Old Castile, New Castile, and Aragon.

Portugal's entire west coast faces the Atlantic Ocean and is generally level and sandy except for numerous rocky bays in the north. A series of northeast to southwest mountain ranges extend inland from the eastern border and cover most of the northern half of the country. The extreme north, which is relatively undeveloped and very cold in winter, is divided by the Tagus River from the southern half, which is flatter and more arid. Algarve is a subtropical coastal strip. Lisbon, situated at about the southern third of Portugal, has a mean annual temperature of about 60° F. and an annual rainfall of about 60 inches.

Reference: *301.*

Malaria.—No information is available on the *Plasmodium* species in Spain and Portugal.

By far the most important vectors of malaria in these countries are *Anopheles labranchiae labranchiae* and *A. l. atroparvus*. The former mosquito is restricted to the southeast corner of Spain. Since its range covers a much smaller area than that of *atroparvus*, it may be said to be less important than that species. In that area it appears in the almost complete absence of other *Anopheles* species, and it transmits a malaria with a much higher endemicity than in other parts of the country. The larvae live in numerous habitats, including fresh water of ricefields and streams and brackish coastal marshes. The females enter houses in large numbers to engorge on human blood. It is believed that the malaria transmitted by this species will not disappear so long as *labranchiae* remains.

In contrast to *labranchiae*, often stated to be a vector of intense malaria, *atroparvus* is a vector of extensive malaria, being the most widespread mosquito in Spain and Portugal. The larvae typically are found in brackish water along the coast and also in fresh water farther inland. The adults may feed on sheltered animals but prefer the blood of man. They are responsible for winter house malaria. The most malarious part of Spain is the northwest part of Cáceres at the southwest end of the central mountain range near Portugal. Here *atroparvus* is the only known mosquito. It has been found with a low rate of infection, but its large numbers here, as elsewhere, account for its importance. In Portugal only the ricegrowing areas of the Sado River in the south, the Tagus River in the center, and the Mondego River in the north have malaria in a highly endemic or hyperendemic form. These areas normally support large populations of *atroparvus*.

Anopheles hispaniola appears throughout the southern half of the peninsula and has been implicated as a vector by presumptive evidence. The larvae prefer clear, sunlit water in either small pools or slow streams, nearly always in association with *Spirogyra*. Little is known of the biting habits of the females.

References: *28, 67, 76, 336.*

Anopheles Species in Spain and Portugal

algeriensis	*melanoon melanoon*
†*claviger*	†*melanoon subalpinus*
**hispaniola*	†*messeae*
hyrcanus	†*multicolor*
**labranchiae atroparvus*	†*plumbeus*
**labranchiae labranchiae*	*portucaliensis*
†*maculipennis*	†*sergenti*
marteri	†*superpictus*

See footnote 6, p. 10.

Yellow Fever.—*Aedes aegypti* is the only known disease vector of the nonanopheline mosquitoes in Spain and Portugal. It transmits urban yellow fever and proliferates in close proximity to man, breeding in all kinds of artificial containers. Although this disease was last reported in 1890, its vector is included in the keys because the disease might be reintroduced and because large numbers of *aegypti* mosquitoes are present, especially in the port cities. This species is widely distributed in Spain and Portugal.

References: *32, 36.*

Dengue.—Likewise transmitted by *Aedes aegypti*, dengue is present but has an extremely low endemicity, principally in southern Spain. For this reason it does not appear in current disease statistics. Most Portuguese authorities believe that it never entered Portugal. Its vector is widespread in both countries.

References: *32, 36, 256.*

Encephalitis.—No information is available.

Filariasis.—No information is available.

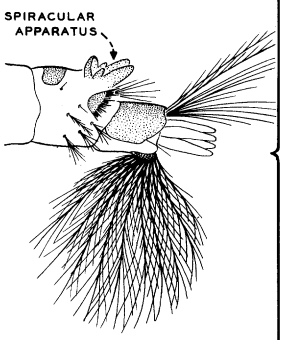
IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

MOSQUITOES OF MEDICAL IMPORTANCE - SPAIN AND PORTUGAL

FIG. 37

FULL-GROWN LARVAE

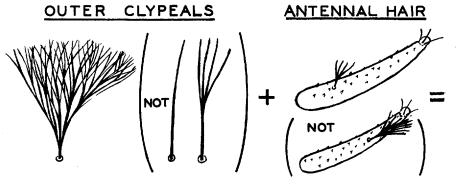
NO SIPHON ON *ANOPHELES*



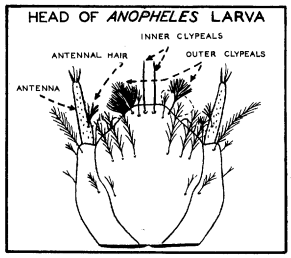
LONG PLEURALS OF 2ND GROUP

BOTH HAIRED = *ANOPHELES HISPANIOLA*

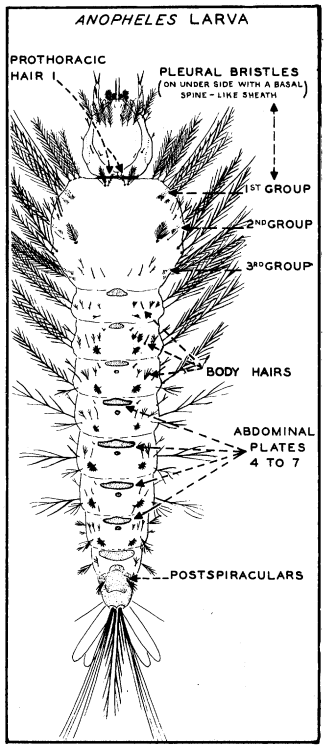
BOTH BARE + OUTER CLYPEALS (NOT) + ANTENNAL HAIR (NOT) = *ANOPHELES LABRANCHIAE* AND RELATIVES (LARVAE CANNOT BE SEPARATED - SEE KEY TO EGGS BELOW



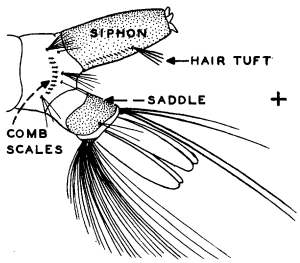
HEAD OF *ANOPHELES* LARVA



ANOPHELES LARVA



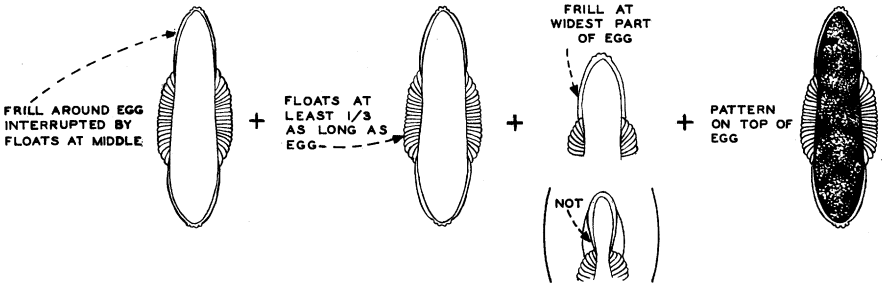
SIPHON ON ALL OTHERS



SIPHON: ONLY ONE TUFT PER SIDE; SHORT AND EVENLY SPACED; ABSENT +

ANTENNA + BODY HAIRS: SINGLE TO 4 BRANCHED (NOT) + BASE OF LONG PLEURALS OF 3RD GROUP = *AEDES AEGYPTI*

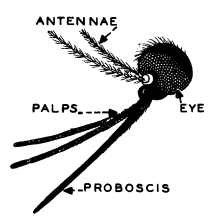
EGGS



FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

LONG PALPS ON *ANOPHELES*



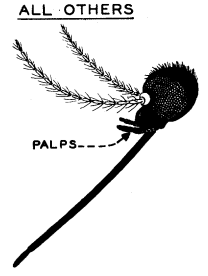
WITH NUMEROUS LIGHT SPOTS + PATTERN ON PALP + MIDDLE MARGINAL SPOT 2 TIMES AS LONG AS SPOT BEHIND IT = *ANOPHELES HISPANIOLA*

(WING OF *HISPANIOLA*)

WING ENTIRELY DARK OR LIGHT ONLY AT TIP + FOUR DARK SPOTS = *ANOPHELES LABRANCHIAE* AND RELATIVES (ADULTS CANNOT BE SEPARATED - SEE KEY TO EGGS ABOVE

(WING OF *LABRANCHIAE*)

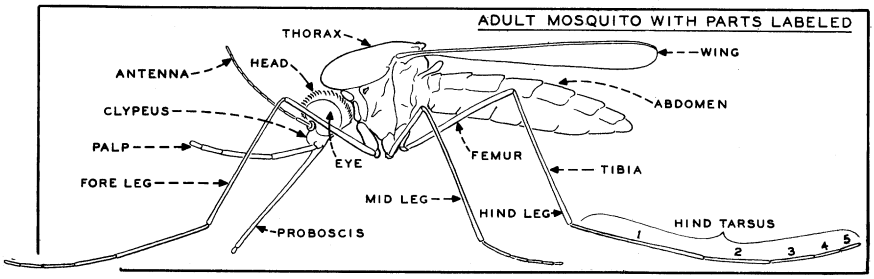
SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX

+ = *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1294

Italy, the Balkans, and Adjacent Islands

(Fig. 38)

Physical Features.—Italy, extending for 600 miles into the Mediterranean Sea, is separated from France, Switzerland, and Austria by the Alps. The high Maritime and Graian Alps on the French frontier are contiguous with the volcanic Apennine range, the backbone of the peninsula, which extends the length of the country. Farther south these mountains split off into plateaus, encircling lowlands and extensive marshes. The Po River basin, situated between the Alps and the Apennines, is one of the country's most fertile areas and has a continental climate with marked changes in season. The Pontine Marshes on the west coast near Rome are additional lowlands. The east coast is much drier than the west, which is wet and lined with islands.

Sicily, Sardinia, and Corsica are large mountainous islands in the Mediterranean Sea. Sicily, the largest of these, is a continuation of the Apennines. It is drained by intermittent streams. Sardinia, the second largest, has a lowland in the southwest. Corsica is a jumble of short mountain chains, with a rocky coast. The climate of all three tends to be hot in the summer but mild during the rest of the year.

The Balkans include Yugoslavia, Albania, Rumania, Bulgaria, and Greece. Yugoslavia, lying at about the same latitude as Italy, is separated from that country by the Adriatic Sea. Off the western coast of Yugoslavia are the islands of Dalmatia, which have a mild, equable climate. The Danube and its tributaries form a large fertile basin in the northeast quarter, where most of the population and agriculture are centered. The Dinaric Alps are in the remainder of the country. Continental cold winters and hot summers prevail, although Macedonia and Montenegro support such subtropical crops as citrus, figs, and olives.

Albania fronts on the Adriatic Sea. In its eastern two-thirds, most of which is over 3,000 feet, is a southward extension of the Dinaric Alps from Yugoslavia. These mountains have a continental climate and considerable extremes of temperature and moisture. Most of their rivers are dry during the summer. The western third is more fertile, having large alluvial plains and a low, rather humid coast, with 40 to 80 inches of rain annually.

The Carpathian Mountains extend in a southeast direction from the U. S. S. R. through the center of Rumania, then swing abruptly westward as the Transylvanian Alps to the border of Yugoslavia. The plateau of Transylvania at about 1,000 to 1,600 feet lies north and west of these mountains. In Rumania south of the Transylvanian Alps is the northern half of the Danube River basin. In the entire eastern fourth of the country from north to south are the low valleys of Danube tributaries flowing from the north. The Danube turns northward in southeast Rumania to form an extensive delta, much of which is low marsh. The climate varies from occasional severe drought in the summer to cold and windy in the winter. The rainfall averages 17 to 30 inches annually, and most of the area is rather fertile.

The Balkan Mountains, extending from east to west across central Bulgaria, mark the southern boundary of the fertile Danube River basin and form the northern boundary of the Maritsa River basin, Bulgaria's other principal agricultural area. South of this great valley lie the Rhodope Mountains, which cover most of the southern part of the country. The climate is mainly continental, with hot summers and long cold winters, although the numerous river valleys are slightly more protected.

Greece, in the southernmost part of the Balkan Peninsula is irregularly shaped and has a rocky, indented coastline and hundreds of small outlying islands in the Aegean Sea and the Sea of Crete. It is predominantly mountainous, with a southern extension of the Dinaric Alps from Yugoslavia and Albania throughout its length. The few lowlands are located in northern Macedonia, Thrace, and Thessaly and are the principal agricultural areas. The rainfall is usually heaviest in the west and decreases in the east. The climate is largely Mediterranean. The principal population centers are on the southern coast and in the islands.

Crete, the largest of the Greek islands, is very mountainous and its coasts are rocky. The climate is mild, and rainfall is much higher in the western than in the eastern part.

Cyprus is the third largest Mediterranean island, with two mountain ranges, one along the north coast and one parallel to it in the center. Between these two ranges is the country's principal agricultural area. An average rainfall of 21 inches occurs, mostly from October to March.

Reference: *301.*

Malaria.—This disease is most intense in Italy and Greece. Approximately 68 percent of the population of Greece lives within endemic areas, and general or local epidemics occur every 2 to 5 years in Macedonia, Thrace, and Epirus.

Plasmodium vivax and *P. falciparum* are the only malaria parasites causing infections in Italy and the Balkans. In Sardinia and elsewhere in this region *Plasmodium vivax* infections are common in infants, whereas *falciparum* infections tend to predominate in all other age groups.

Anopheles labranchiae atroparvus, one of the region's most abundant mosquitoes, is not always associated with the transmission of malaria. It is distributed throughout the northern mainland of Italy, northern Yugoslavia, northern Bulgaria, and most of Rumania, but its importance is not known with certainty, except in parts of Rumania where it is an important vector. This mosquito tends to be a coastal form but also breeds inland, where it seeks warm winter shelters in which to feed.

Anopheles labranchiae labranchiae, principally a western Mediterranean mosquito, is centered geographically in Sicily, from which it spreads west, south, and east. In Sicily, Corsica, and Sardinia this mosquito breeds in both brackish and fresh water. It is an extremely important vector, because it uses those breeding habitats that are universally present in spite of seasonal changes. It is the principal vector in Elba, where malaria has existed for several years. However, in Italy it is strictly a brackish-water coastal species, appearing south of latitude 43° N. It transmits a severe endemic malaria, which varies in intensity with the rainfall. *A. l. labranchiae* has been reported from the west coast of Yugoslavia, but so far its importance there is not known with certainty. This beachhead represents the easternmost limit of its range.

Anopheles sacharovi, likewise principally a brackish-water breeder, is found with *labranchiae* in Italy, Sardinia, and Corsica. In the northern part of its range it is much scarcer and transmits much less malaria than *labranchiae*, but it is still the most important vector in the Po River Delta and along the Adriatic coast. The range of *sacharovi*, unlike that of *labranchiae*, extends from Spain far to the east of Italy. It is a common and dangerous vector in the southern half of Yugoslavia, a southern area of Rumania, and in all the Balkan Peninsula south of these countries. It is the most important vector in Greece. It breeds in early and middle summer in brackish marshes close to the sea, and it transmits most of the malaria in Greece and along the low Dalmatian coast, where the intensity of malaria is closely associated with the abundance of this species.

The range of *Anopheles superpictus* closely parallels that of *sacharovi*, and *superpictus* is second in importance only to that species. Like *sacharovi*, its range reaches its western limit in Italy and Spain, but it is not important in these countries at all. *A. superpictus* is essentially a foothill-stream breeder and appears slightly later than *sacharovi*. These two species together transmit malaria from early

MOSQUITOES OF MEDICAL IMPORTANCE – ITALY, THE BALKANS, AND ADJACENT ISLANDS

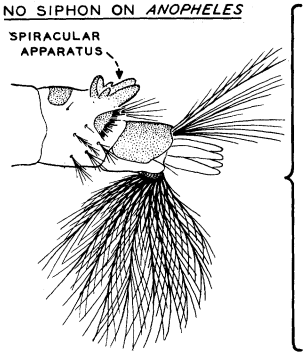
[AREA INCLUDED: ITALY, SICILY, SARDINIA, CORSICA, YUGOSLAVIA, ALBANIA, RUMANIA, BULGARIA, GREECE, CRETE, AND CYPRUS]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FIG. 38

FULL-GROWN LARVAE

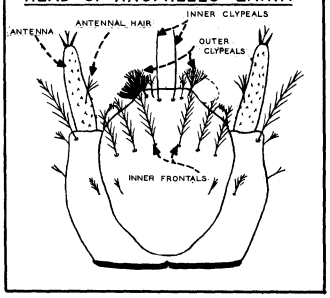
NO SIPHON ON *ANOPHELES*



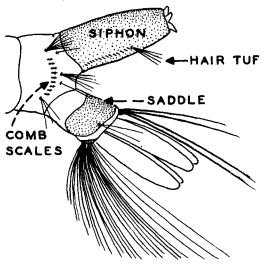
LONG PLEURALS OF 2ND GROUP: BOTH BARE + OUTER CLYPEALS: NOT + ANTENNAL HAIR: NOT = *ANOPHELES MACULIPENNIS* AND RELATIVES (LARVAE CANNOT BE SEPARATED – SEE CHART OF EGGS BELOW)

LONG PLEURALS OF 3RD GROUP: ONE HAIRED + BOTH HAIRED + INNER FRONTALS: NO DARK SPOTS AT BASES = *ANOPHELES SUPERPICTUS*

HEAD OF *ANOPHELES* LARVA

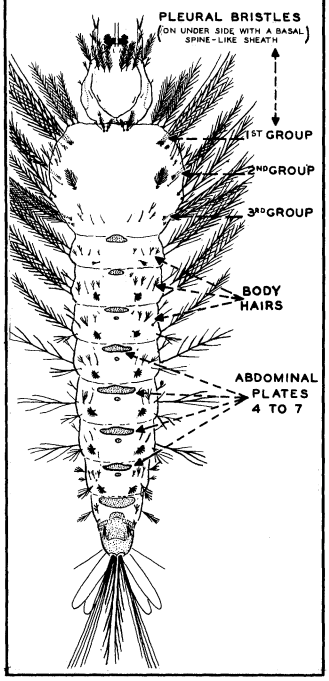


SIPHON ON ALL OTHERS

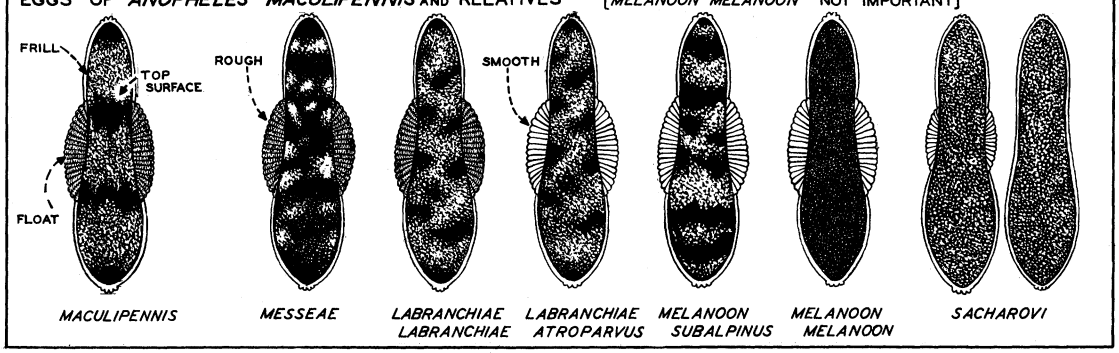


SIPHON: ONLY 1 TUFT PER SIDE / EVENLY SPACED / ABSENT + ANTENNA: SMOOTH / NOT + BODY HAIRS: SINGLE TO 4 BRANCHED / NOT + COMB SCALES: / NOT = *AEDES AEGYPTI*

ANOPHELES LARVA



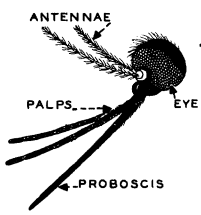
EGGS OF *ANOPHELES MACULIPENNIS* AND RELATIVES [*MELANOON MELANOON* NOT IMPORTANT]



FEMALES

[*MALES HAVE BUSHY ANTENNAE* ( ) *AND DO NOT BITE*]

LONG PALPS ON *ANOPHELES*



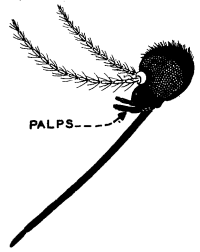
WING ENTIRELY DARK, OR LIGHT ONLY AT TIP (WING OF *MACULIPENNIS*) + FOUR DARK SPOTS (WING OF *SACHAROVI*)

FRINGE AT WING TIP: ALL DARK = *ANOPHELES SACHAROVI*

YELLOWISH SPOT = *ANOPHELES MACULIPENNIS* AND RELATIVES (ADULTS CANNOT BE SEPARATED – SEE CHART OF EGGS ABOVE)

WING WITH NUMEROUS LIGHT SPOTS (WING OF *SUPERPICTUS*) + PATTERN ON PALP: LIGHT AT TIP + VEIN 3 WITH LONG LIGHT AREA = *ANOPHELES SUPERPICTUS*

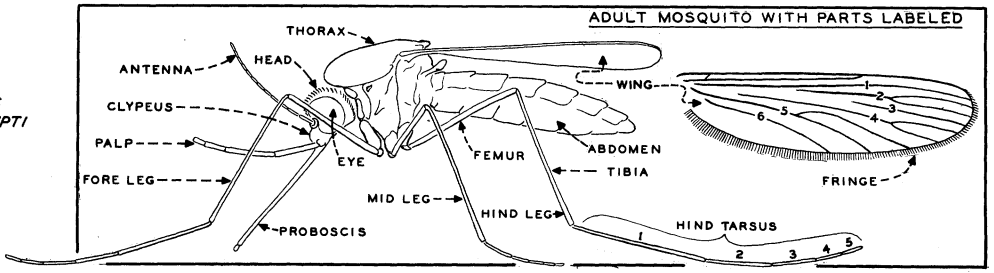
SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



spring to late fall. Although *superpictus* is of secondary importance, it maintains an extremely high rate of endemic malaria in Cyprus. It is also an important vector in southern Bulgaria. Its population peak in Greece usually occurs in September.

Anopheles messeae is widespread over Asia and is important in the transmission of malaria wherever cattle or other domestic animals are not present. The Balkans represent the southwesternmost limit of its range. There it is important only above the Danube Delta in eastern Rumania and in those parts of the Danube Valley where animal husbandry is not practiced and in the vicinity of "Lake Malik" in Albania. In the last-named locality it maintains malaria at a rather low level and is always diverted from man when animal blood meals are available. It hibernates in cold, foodless shelters.

Anopheles maculipennis is not considered to be a species of primary importance, although it is common to both the Iberian and Italian peninsulas, where it breeds in a wide variety of water collections. It is included in the keys because it maintains mildly endemic malaria in Macedonia in the absence of domestic animals, and, with *messeae*, it transmits endemic malaria in villages at "Lake Malik" on the Albania-Yugoslav frontier. Since its habits are comparable to those of *messeae*, this species is potentially able to transmit the disease elsewhere in the Balkans as well.

Neither *Anopheles melanoon melanoon* nor *A. m. subalpinus* is regarded as important. The former is restricted to southern Italy, and the latter appears in northern Italy and throughout the Balkans.

References: *35, 67, 72, 236, 237.*

Anopheles Species in Italy, the Balkans, and Adjacent Islands

algeriensis
atheniensis
†*claviger*
hellenicus
†*hispaniola*
hyrcanus
**labranchiae atroparvus*
**labranchiae labranchiae*
**maculipennis*
marteri marteri
melanoon melanoon
†*melanoon subalpinus*
**messeae*
†*multicolor*
†*plumbeus*
**sacharovi*
†*sergenti*
**superpictus*
turkhudi

See footnote 6, p. 10.

Yellow Fever.—No information is available.

Dengue.—This disease has a very low endemicity in Italy and Yugoslavia, but it appears in sporadic form along the Dalmatian coast, in Albania, and in Greece, where there have been at least two serious epidemics. The first, in the islands of Syros and Crete, occurred in 1881. In 1927 and 1928 an epidemic of dengue that swept Greece resulted in 1½ million cases and was marked by unusual severity. There have been few records of dengue since 1929. *Aedes aegypti*, the urban vector of dengue, is widely distributed throughout Greece.

References: *29, 30, 33, 256.*

Encephalitis.—The presence of western equine encephalitis virus has been suspected in humans and horses in Sicily. No detailed investigations have been carried out to determine the vector.

Reference: *257.*

Filariasis.—No information is available.

The Near East

(Figs. 39 and 40)

Physical Features.—The Near East includes Turkey, Syria, Lebanon, Israel, Jordan, and Iraq. Turkey consists of a partly wooded coastal strip backed by high mountain ranges that enclose high steppelike uplands, with an average altitude of 2,500 feet. These uplands are semiarid, with severe snowy winters and hot, dry summers. The southeast part of the country is largely desert. The west and south coasts have an equable Mediterranean climate, with 20 to 30 inches of rain annually. The eastern Black Sea coast receives up to 100 inches of rain annually.

Syria is mostly desert except for the Tigris and Euphrates Valley. The northwest part consists of mountains and valleys of the Anti-Lebanon range. They extend southward along the Lebanon border to the southwestern Hauran plain, just north of which is an irrigated area that surrounds Damascus. Although the annual rainfall is extremely low in the eastern part, the coastal and mountain areas of the west receive considerable precipitation.

Lebanon is separated from Syria by the Anti-Lebanon range. Near the coast another series of mountains, the Lebanons, extend southward, on one side of which is a Mediterranean coastal plain and on the other a high, fertile valley, the Bekaa.

The State of Israel lies directly south of Lebanon, with its western border entirely on the Mediterranean. Its sandy, level coastal plain has a dry, subtropical climate with winter rains. Parallel with the coast and the Anti-Lebanon and Lebanon Mountains is a central highland, which has cool, dry summers and cold, rainy winters.

In the western half of Jordan is a distinctive depression containing the Jordan River and the Dead Sea, the latter more than 1,000 feet below sea level. The mountains slope gradually eastward from this depression and merge with the Syrian Desert. About 85 percent of the population lives in the western 5 percent of the country, which has hot, dry summers and mild, cool, wet winters. The Jordan Valley supports a growth of subtropical cultivated plants.

Highlands in northeastern Iraq rise to above 10,000 feet. In the western half is a part of the vast Syrian Desert and in the east the fertile valley of the Tigris and Euphrates Rivers, in which lie most of the productive areas and the major population centers. The lowest reaches of these two rivers run through an alluvial plain containing marshes, large lakes, and canals.

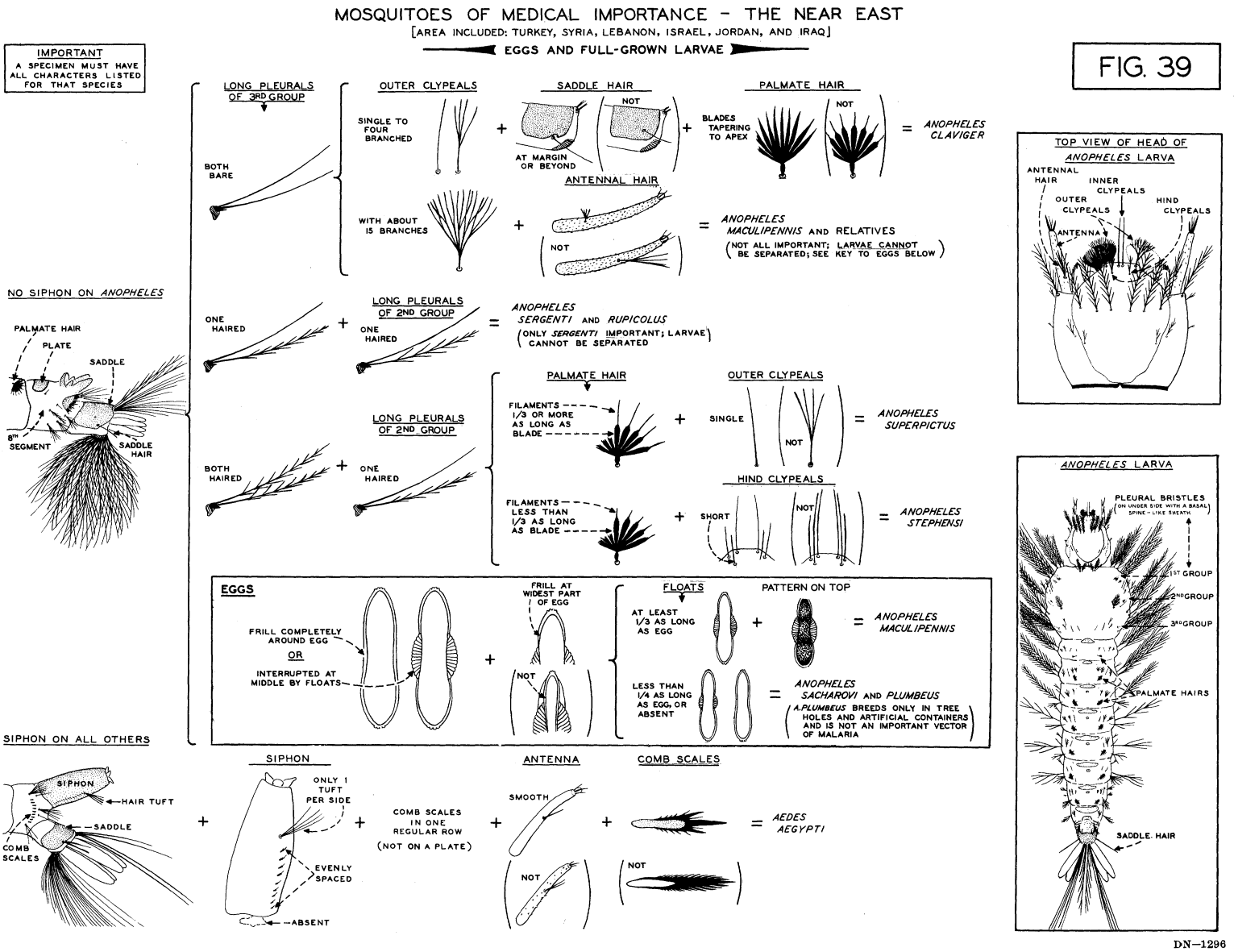
Reference: *301.*

Malaria.—The south and west coasts of Turkey, as well as scattered areas along the Black Sea coast, have a high rate of endemic malaria. Some part of every province in this country is malarious.

Plasmodium vivax, *P. malariae*, and *P. falciparum* infections are almost equally divided in the Near East, with any one of the parasites predominating in certain areas.

Throughout the Near East *Anopheles sacharovi*, *A. superpictus*, and *A. maculipennis* are the principal vectors. In Turkey *sacharovi* is not restricted to brackish water near the coast but is widespread over most of the country except in the arid southeast part of the Anatolian plateau, where there is relatively little or no malaria. Farther east and south in Lebanon, Syria, Israel, and Iraq this species forsakes its brackish-water habitat and becomes an entirely fresh-water mosquito. It is responsible, with *superpictus*, for the intense malaria along the east coast of the Mediterranean, the valley between the Lebanon and Anti-Lebanon ranges, and farther east and south where periodic flooding of the Tigris and Euphrates creates extensive breeding areas near Basra. Elsewhere in the Near East *sacharovi* is present in smaller numbers and contributes its share of transmission.

The ranges of *superpictus* and *sacharovi* overlap throughout almost the entire Near East. However, *superpictus* breeds in foothill streams; consequently, it develops later in the breeding season when riverbed pools form with the general lowering of water levels in hot weather. It is the prin-



cipal vector in the mountain ranges throughout this region and is the common species in the foothills surrounding Turkey, on the western Anatolian plain, and in the Lebanon and Anti-Lebanon Mountains, where malaria is not so severe as in the lowlands but where nevertheless it is an important disease.

A. maculipennis is almost always associated with low spleen and blood rates in the areas where it transmits malaria and must be present in large numbers in order to be an efficient vector. These characteristics are partly due to its high degree of zoophilism. The females can be rather easily diverted from feeding on man by using domestic animals as a barrier. The species is present in nearly all the foothill areas of the Near East and is often found with *superpictus*.

Anopheles sergenti is very similar to *superpictus* in breeding habits and ability to carry malaria, but it is much less important. In western Jordan *superpictus* is generally a late-season breeder, but *sergenti* appears even later, its larvae having been found as late as November in Jordan.

Anopheles claviger is principally an urban species. On the central plain and coastal areas of Syria and Lebanon it is locally important. Over most of its range it is a wild mosquito, but in parts of Turkey and in Israel, especially near Jerusalem, it breeds in water stored in underground cisterns during the hot weather and freely enters nearby houses for human blood meals. In other parts of its range *claviger* prefers animals for food. When they are not available, it will readily feed on man.

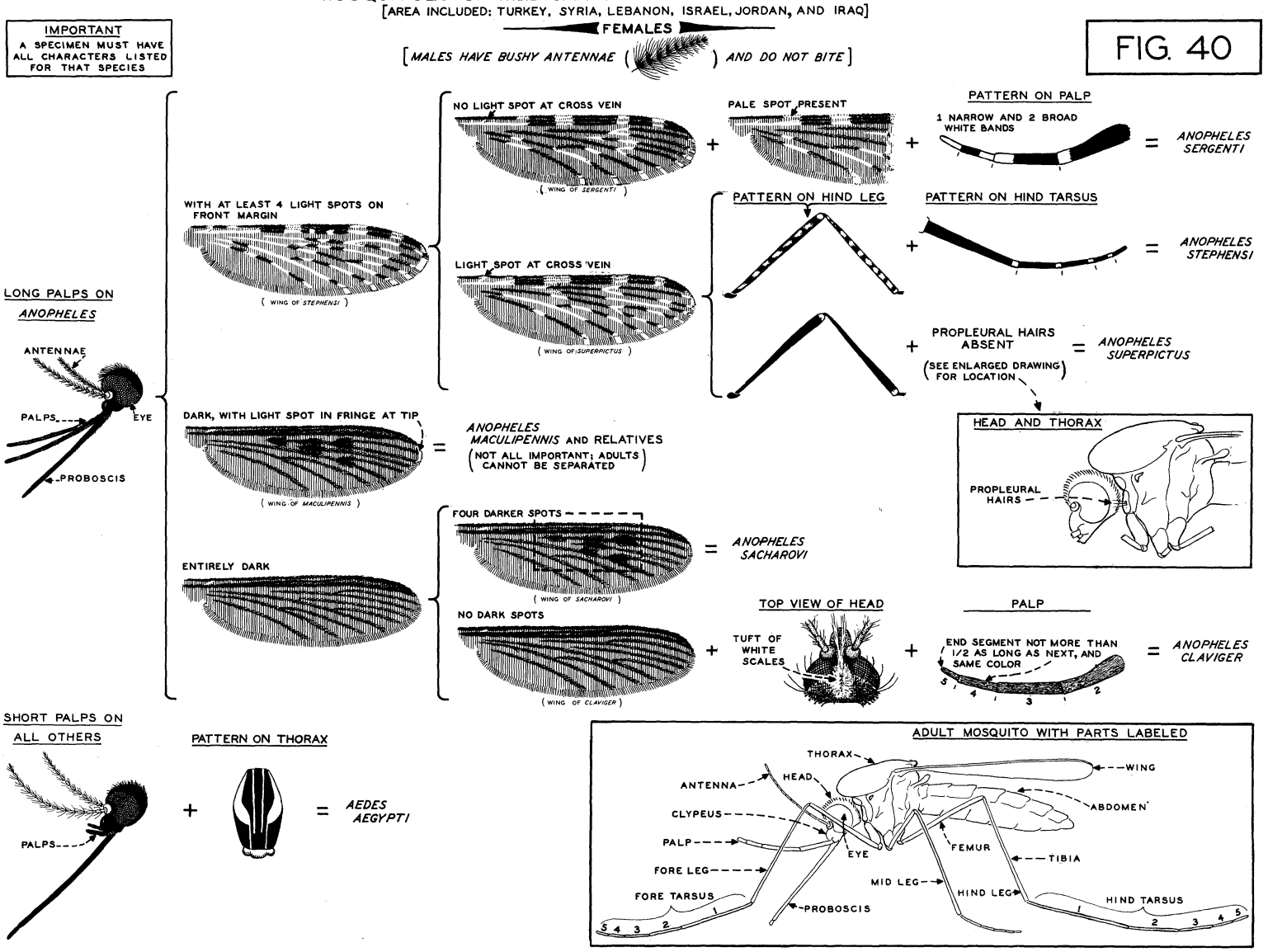
Anopheles stephensi is restricted to a small area in the southeastern part of Iraq. It is an urban mosquito, breeding in all kinds of water-holding receptacles close to man's houses and in small collections of ground water as well. It is an important vector in the alluvial plain of Iraq, where it flourishes in the date palm gardens.

References: *67, 118, 229, 239, 241, 265.*

Anopheles Species in the Near East

algeriensis
apoci
**claviger*
coustani coustani
coustani tenebrosus
†*culicifacies*
†*d'thali*
†*fluviatilis*
†*hispaniola*
hyrcanus
**maculipennis*
marteri marteri
marteri sogdianus
†*messeae*
†*multicolor*
†*pharoensis*
†*plumbeus*
†*pulcherrimus*
rhodesiensis rupicolus
**sacharovi*
**sergenti*
**stephensi*
**superpictus*
turkhudi telamali
turkhudi turkhudi

See footnote 6, p. 10.



Yellow Fever.—This disease is not present in the Near East.

Reference: *256.*

Dengue.—This disease is prevalent in Turkey along the Black Sea and the Mediterranean coasts. An epidemic affecting a large number of people occurred in 1928 and 1929 as a result of the 1927–28 epidemic in Greece, but there have been no further outbreaks. A small epidemic occurred in Hama, Syria, in 1940, but, as in Turkey, only sporadic cases have been reported since. Small epidemics occurred in Baghdad in 1921 and 1947, and the disease has been reported from both Israel and Jordan. In all these places *Aedes aegypti*, breeding in all sorts of artificial containers close to man, has been the vector.

References: *30, 34, 256.*

Encephalitis.—Over 100 cases, mostly in children, of a nonfatal disease caused by the West Nile encephalitis virus occurred in Israel in 1951 and again in 1952. The vector there is not known.

References: *58, 257.*

Filariasis.—A small focus of infection with *Wuchereria bancrofti* has been found in Lebanon. Since filariasis is not indigenous to the Near East, the cases are believed to have originated by contact with African troops during World War II. No vector has been named.

Reference: *70.*

Arabia

(Figs. 41 and 42)

Physical Features.—Arabia includes Saudi Arabia, Yemen, Aden, Oman, Kuwait, and the islands of Bahrein and Socotra. It is a large peninsula separated from Africa by the narrow Red Sea and the Gulf of Aden and from Iran by the Persian Gulf and the Gulf of Oman. Its highest mountains, rising to 9,000–12,000 feet, extend along the Red Sea coast. In the south they are continued in the so-called Jabal Akhdar and Kaur Mountains, which at their eastern ends rise to almost 10,000 feet. The interior plateau slopes gradually eastward to the coast. This plateau contains the north-central Syrian and An Nafud Deserts, between which are the vast deserts of Rub' al Khali and Bahr as Safi, which fill almost the entire southern third of the peninsula behind the mountains. West-central Arabia contains mountainous highlands, through which deep, eroded valleys extend from east to west.

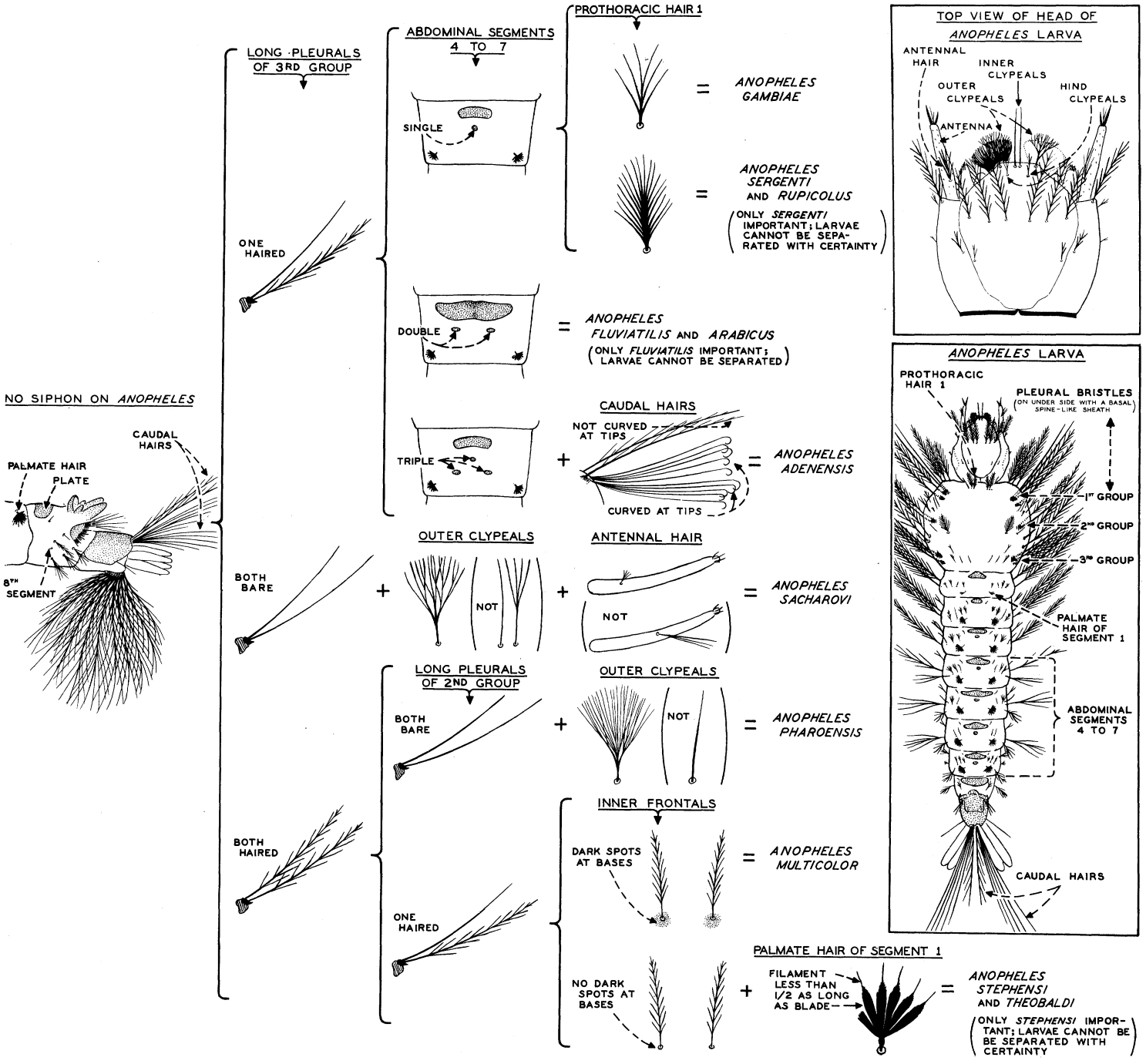
MOSQUITOES OF MEDICAL IMPORTANCE — ARABIA

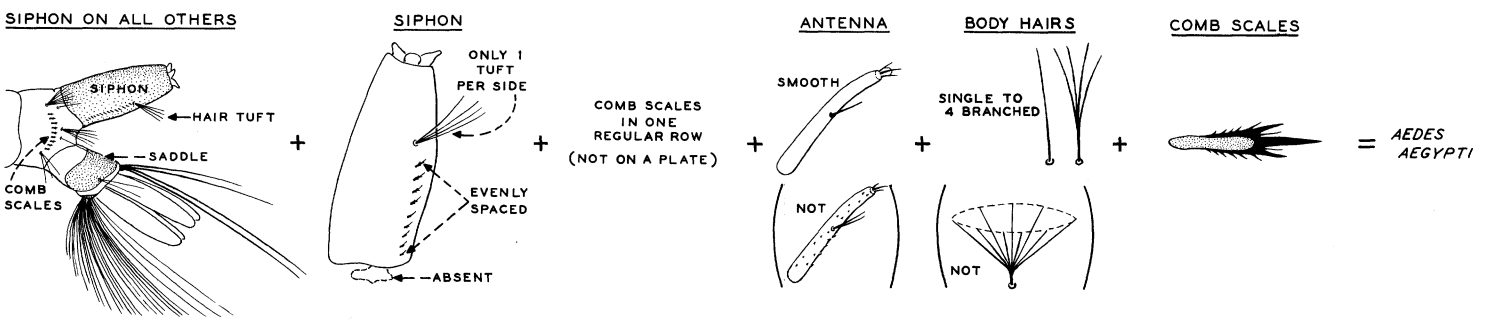
[AREA INCLUDED: SAUDI ARABIA, YEMEN, ADEN, OMAN, KUWAIT, AND BAHREIN AND SOCOTRA ISLANDS]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

FULL-GROWN LARVAE

FIG. 41





MOSQUITOES OF MEDICAL IMPORTANCE — ARABIA

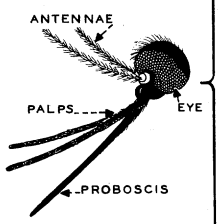
[AREA INCLUDED: SAUDI ARABIA, YEMEN, ADEN, OMAN, KUWAIT, AND BAHREIN AND SOCOTRA ISLANDS]

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

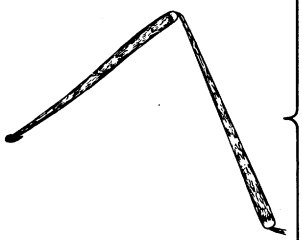
FEMALES

[*MALES HAVE BUSHY ANTENNAE* () *AND DO NOT BITE*]

FIG. 42

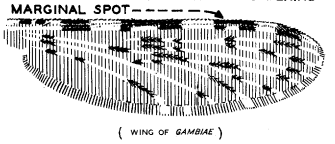


PATTERN ON HIND FEMUR AND TIBIA



PATTERN ON HIND TARSUS

ONE OR TWO SHORT DARK SPOTS BEHIND MARGINAL SPOT



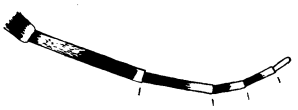
(WING OF *GAMBIAE*)

= *ANOPHELES GAMBIAE*

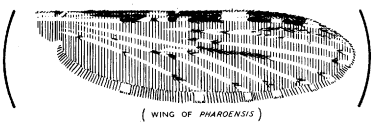
ONE LONG DARK SPOT BEHIND MARGINAL SPOT

(WING OF *STEPHENSI*)

= *ANOPHELES STEPHENSI*

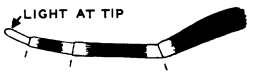


= *ANOPHELES PHAROENSIS*



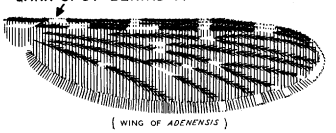
(WING OF *PHAROENSIS*)

PATTERN ON PALP



LIGHT AT TIP

NO LIGHT SPOT AT CROSS VEIN, BUT LIGHT SPOT IN BASAL THIRD WITH DARK SPOT BEHIND IT



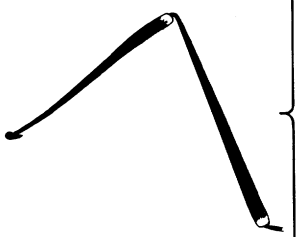
(WING OF *ADENENSIS*)

= *ANOPHELES ADENENSIS*

NO LIGHT SPOT AT CROSS VEIN, BUT LIGHT SPOT IN BASAL THIRD WITHOUT DARK SPOT BEHIND IT

(WING OF *SERGENTI*)

= *ANOPHELES SERGENTI*



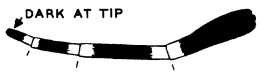
BASAL THIRD ENTIRELY DARK

(WING OF *FLUVIATILIS*)

= *ANOPHELES FLUVIATILIS* AND *ARABICUS*

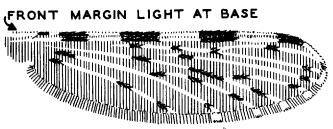
(ONLY *FLUVIATILIS* IMPORTANT; ADULTS CANNOT BE SEPARATED WITH CERTAINTY)

DARK AT TIP



+

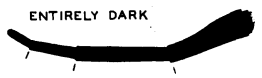
FRONT MARGIN LIGHT AT BASE



(WING OF *MULTICOLOR*)

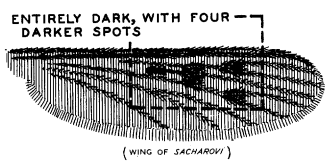
= *ANOPHELES MULTICOLOR*

ENTIRELY DARK



+

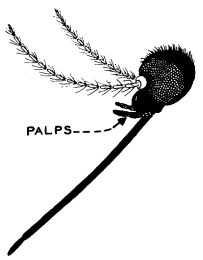
ENTIRELY DARK, WITH FOUR DARKER SPOTS



(WING OF *SACHAROVI*)

= *ANOPHELES SACHAROVI*

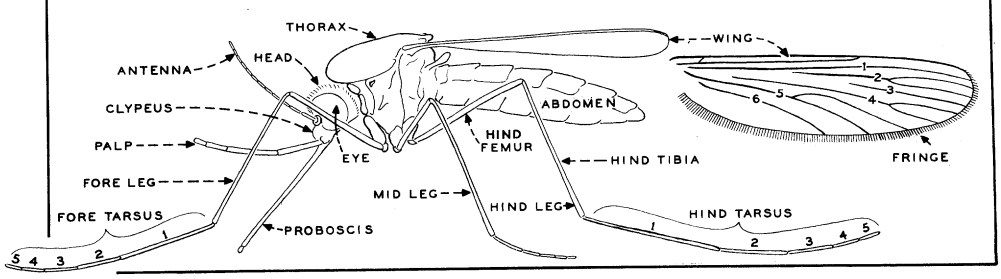
SHORT PALPS ON ALL OTHERS



PATTERN ON THORAX

= *AEDES AEGYPTI*

ADULT MOSQUITO WITH PARTS LABELED



DN—1299

Most of the interior has desert temperatures and a rainfall of about 4 inches annually. However, the mountainous highlands along the southern frontier where the principal agricultural areas are located, receive from 20 to 40 inches of rain per year in well-marked monsoon seasons. These areas contain approximately four-fifths of the country's population.

Reference: *301.*

Malaria.—It has been said that wherever there is man in Arabia there is water, and wherever there is water there is malaria. The most abundant mosquito in the Persian Gulf area is *Anopheles stephensi.* This species is essentially urban and is important throughout most of its range. It is an inland vector from Al Karj on the west to the coast on the east. It is also a vector in the Bahreins, where a hot, humid climate prevails and date plantations are watered by abundant warm, slightly brackish water. Malaria here accounts for almost one-fourth of the hospital admissions. It is almost equally divided among *Plasmodium falciparum*, *P. malariae*, and *P. vivax*. Muscat to the south, where *stephensi* is also a vector, is malarious, with high spleen and parasite rates in the human population the year round.

Anopheles fluviatilis, primarily a foothill species in the Orient, is the second most abundant mosquito along the Persian Gulf coast. Its actual importance in malaria transmission in Arabia has not been completely determined. Many of its previous records have been confused with those of *stephensi.* It has been included in the keys because of its importance in the Orient and because it is believed to transmit some malaria in Arabia.

Neither the distribution nor importance of *Anopheles multicolor* is known with certainty. This species is essentially an oasis mosquito and breeds in desert water of extremely high salinity. It is potentially able to carry malaria efficiently and is regarded as a vector throughout the deserts of Egypt and Northwest Africa.

Anopheles sergenti, another oasis breeder, has been recorded from various dry parts of Arabia. It is the only vector recorded from a well at Jabrin oasis, which was said to be abandoned at one time as an agricultural colony because of malaria. This species is common in the outskirts of Jeddah. Both *sergenti* and *multicolor* probably transmit a large amount of malaria in the interior deserts of Arabia.

Anopheles adenensis, originally described as a variety of the important Indian vector *A. culicifacies*, has been observed in large numbers in and about Aden and at Hodeida on the Red Sea coast of Yemen. It is definitely a vector at Hodeida and is probably important in other parts of this extremely arid coastland as well.

Anopheles gambiae, by far the most important malaria vector in continental Africa, has invaded various localities on the Red Sea coast and has migrated inland for some distance. Doubtlessly this species transmits malaria in the Jeddah-Mecca area. In a severe epidemic at Jeddah in 1950 it was found breeding prolifically in waste-water pools formed by a new city water-supply system. This species was said to have been carried to Jeddah by extensive pilgrim traffic.

Anopheles pharoensis is included in the keys because of its importance in Egypt and its discovery in Yemen. Its role in Arabia is not known. This species is of potential danger when it appears in large numbers in the presence of human malaria.

Anopheles sacharovi is the only member of the *maculipennis* complex that might be found in Arabia. It has never been recorded there, but its importance in other areas of its range necessitates its inclusion in the keys.

Anopheles d'thali has been suspected as a vector in Arabia, but the few available data are not conclusive.

References: *67, 206, 347.*

Anopheles Species in Arabia

**adenensis*	**multicolor*
apoci	†*pharoensis*
arabicus	†*plumbeus*
cinereus	†*pretoriensis*
†*coustani coustani*	†*pulcherrimus*
coustani tenebrosus	*rhodesiensis rupicolus*
†*d'thali*	†*sacharovi*
**fluviatilis*	**sergenti*
**gambiae*	**stephensi*
†*hispaniola*	†*subpictus*
hyrcanus	†*superpictus*

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Arabia.

Reference: *256.*

Dengue.—Dengue is present and lightly endemic in the Yemen and Muscat areas of Arabia, where it is known as oasis fever, a rather misleading term, since malaria and sandfly fever are also known by that name in various parts of the country. Dengue epidemics have not been reported, but the vector *Aedes aegypti* breeds in all kinds of artificial containers close to man's habitations.

References: *1, 256.*

Encephalitis.—No information is available.

Filariasis.—No information is available.

Iran

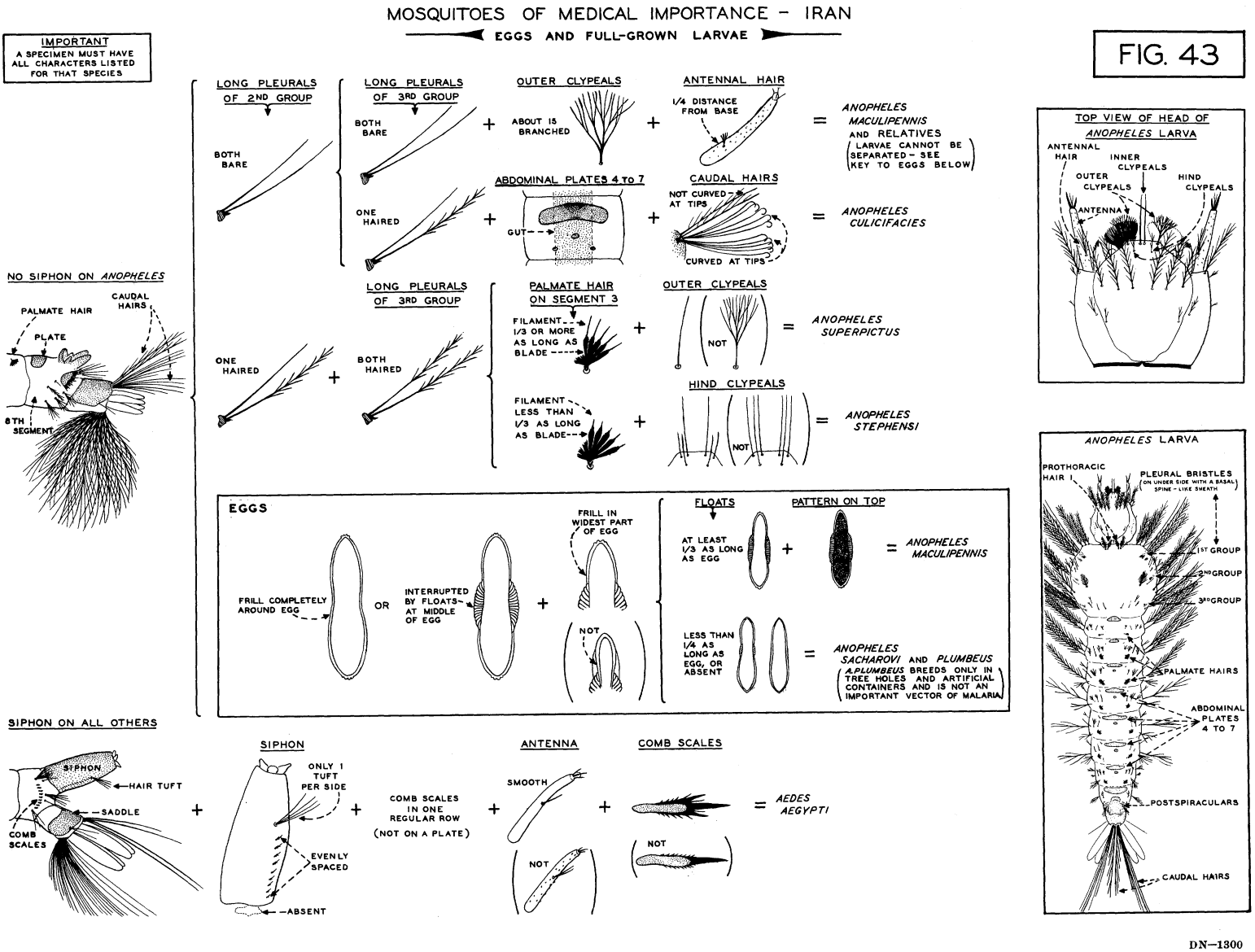
(Figs. 43 and 44)

Physical Features.—Iran lies along the southern border of the Asiatic mainland and forms a zoogeographical link between the Near East and the Orient. The country consists of a vast central plateau, with an average elevation of about 4,000 feet. This plateau is separated from the Caspian Sea by the Elburz mountain range, with peaks as high as 18,000 feet. Its western slopes dip to the Caspian, leaving a narrow coastal lowland. A wide series of mountain ranges comprise the western third of Iran. They are bounded on their western side by the broad fertile valley of the Tigris and Euphrates Rivers, which extends into western Iran. To the south a narrow coastal lowland borders the length of the Persian Gulf and the Gulf of Oman, part of the Arabian Sea. On the east more mountain ranges separate Iran from Afghanistan and West Pakistan. The salt desert of Dasht-i-Kavir is situated in the north-central and northeast area, and the Dasht-i-Lut, connected to it by a narrow arm, is a southward extension of this salt desert.

Rather low rainfall and high winds prevail over much of the country. The hot, dry summer monsoon from northwest India, alternating with winds blowing south from Siberia, causes extreme temperatures. Areas of highest rainfall, about 40 inches per year, are along the subtropical Caspian coast and in the northwest part, which contains Lake Urmia, the country's largest lake, whereas the interior deserts receive less than 5 inches of rain per year. The Persian Gulf coast has an extremely dry, hot summer.

Reference: *301.*

Malaria.—Highly endemic malaria exists in the low semitropical areas of the Caspian coast, the Persian Gulf coast, and the lower Tigris and Euphrates areas. Malaria is also endemic, but localized, in the widely scattered marshes of the central plain and in even drier areas, and it is mildly endemic in some localities on the highest northern plateaus. In such barren terrain as this country has, both man and mosquitoes are necessarily thrown together in the watered areas. Such



enforced coexistence presents ideal conditions for the maintenance and spread of malaria.

No information is available on the *Plasmodium* species in Iran.

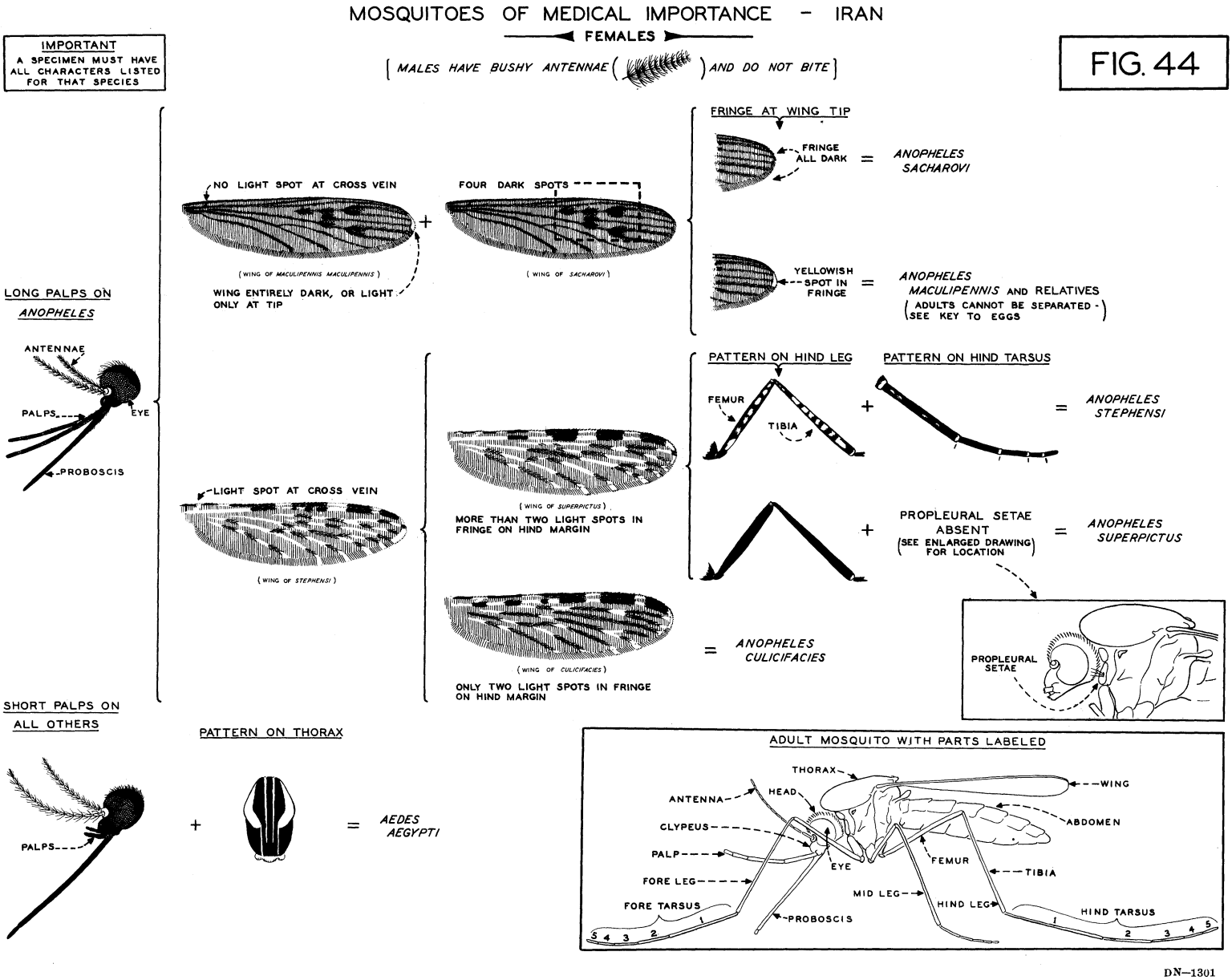
Anopheles superpictus and *A. sacharovi* are the two most prominent vectors in Iran. The former species is widely distributed but appears neither in the deserts nor in the southeast corner of the country. It is responsible for transmission of most of the malaria at elevations above 1,000 feet in all except the humid Caspian coastal area, where it does not enter houses and is considered to be a wild species. In drier areas the adults are always found in houses and the larvae breed in almost all available water collections. It is the most important vector in the intensely malarious west-central area.

A. sacharovi, on the other hand, is the principal vector in the most intensely malarious area of Iran, i. e., the Caspian coast. It is the predominant mosquito on the coastal plain, and its numbers as well as malaria incidence in this area increase markedly from July to November. This species inhabits ricefields and water used for irrigation and to a lesser extent the rivers, which tend to become slow and sluggish during the summer. Although *sacharovi* is found principally in the western half of Iran, its numbers are not so concentrated there as in coastal localities.

Anopheles maculipennis closely parallels *sacharovi* in distribution. It is concentrated in the Caspian area, and its range extends from the northwest part of Iran as far south as Abadan at the head of the Persian Gulf. It is apparently absent from the gulf coast and most of the interior, but it has been observed near the northeast border. *A. maculipennis* and *superpictus* often appear together, but the former is more characteristic of the lower valleys and tablelands. Its exact role in the transmission of malaria in Iran is not known, though it is a proved vector in some other parts of its range and is suspected as a vector of a mildly endemic malaria in northern Iran.

Anopheles stephensi has a more southern distribution than any of the other vectors. It is absent from the entire northern half of Iran but is responsible for the transmission of a great deal of malaria along the Persian Gulf coast and eastward. It is of great importance at Abadan, where it rests commonly in manmade shelters. It is characteristically an urban mosquito but also breeds rurally in various collections of water.

Anopheles culicifacies, like *stephensi*, is an extremely important vector of malaria in India and is largely restricted to areas east and south of the deserts. It has been found as far west as Bushire on the Persian Gulf coast. It breeds in cisterns, wells, and other large manmade containers and is



probably an important vector, although its exact status in malaria transmission in Iran needs more study.

References: *67, 106, 107, 144.*

Anopheles Species in Iran

algeriensis
apoci
cinereus
†*claviger*
**culicifacies*
†*d'thali*
†*fluviatilis*
hyrcanus
**maculipennis*
marteri marteri
marteri sogdianus
†*melanoon subalpinus*
moghulensis
†*multicolor*
†*plumbeus*
†*pulcherrimus*
†*rhodesiensis*
**sacharovi*
†*sergenti*
**stephensi*
†*subpictus*
**superpictus*
turkhudi

See footnote 6, p. 10.

Yellow Fever.—Yellow fever does not occur in Iran. The classical vector *Aedes aegypti* is present and common in most port cities, where there is a constant threat of this disease being introduced.

References: *18, 256.*

Dengue.—Dengue occurs in endemic form, with occasional outbreaks along most of the Persian Gulf coast and in the Caspian Sea area. In these two areas it is transmitted by *Aedes aegypti. Aedes albopictus* is not present in Iran.

Reference: *18.*

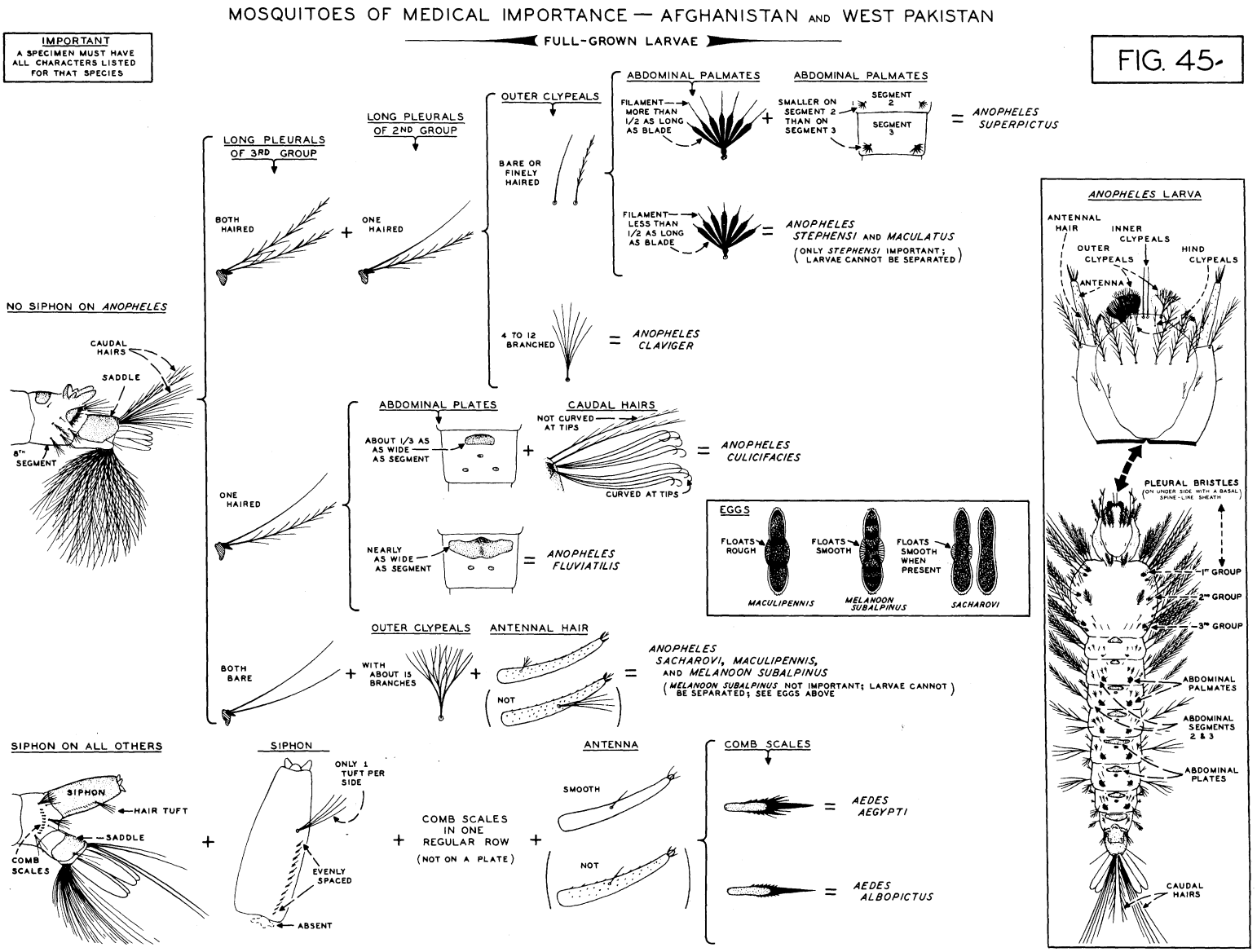
Encephalitis.—No information is available.

Filariasis.—No information is available.

Afghanistan and West Pakistan

(Figs. 45 and 46)

Physical Features.—Afghanistan is bordered on the west by Iran, on the south and east by West Pakistan, and on the north by the U. S. S. R. The Hindu Kush, a series of mountain ranges rising in the north to 25,000 feet, extends southward from the U. S. S. R. and covers almost all the northern half of the country. A belt of steppes separates these mountains from arid lowlands on the western frontier and from extensive desert areas in the southwest. A depression surrounding Jalalabad near the famed Khyber Pass, the gateway from Afghanistan through the eastern mountains to West Pakistan, has a subtropical climate. Rainfall ranges



annually from 10 inches in the steppes to less than 2 inches in the southwestern desert areas.

West Pakistan is separated from the U. S. S. R. by the Himalayas in the north and has a southern coast on the Arabian Sea. The Indus River, flowing the entire length of the country, divides the Thar, or Indian, Desert in the east from mountain ranges in the west. Semiarid and desert areas west and south of these mountains are contiguous with those in the southern parts of Afghanistan. Extremes of temperature, from 40° in the winter to 120° F. in the summer, prevail in this country. The rainfall ranges annually from 5 inches or less in the southwest to about 25 inches in the northeast. The northern tributaries of the Indus River are perennial, but those of the southwest are seasonal.

Reference: *301*.

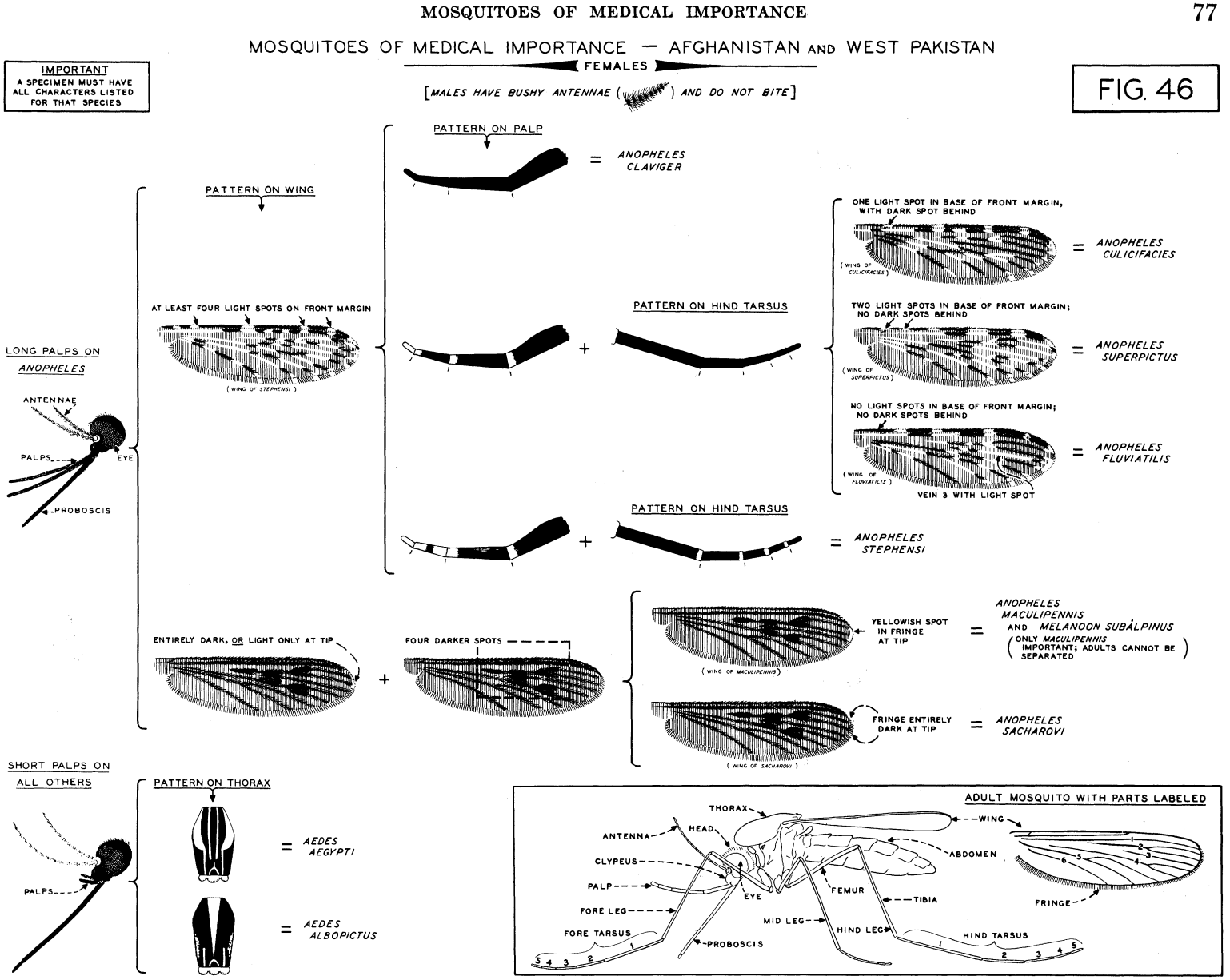
Malaria.—Malaria is endemic in most of Afghanistan. It is not an important disease in the arid southwestern areas of Afghanistan or in western Pakistan. In the steppes area traversing the center of Afghanistan malaria is more highly endemic, and in the northern mountainous areas of both countries the disease is prevalent even at levels above 5,000 feet. Most transmission occurs in September, when mosquito populations are at their peak.

Little is known of the distribution of the *Plasmodium* parasites in either country.

Anopheles superpictus is the important vector in the mountainous areas and has only one generation each year. The transmission period begins in July and reaches a peak in September. At lower altitudes the breeding of this highly anthropophilic mosquito starts in May, when a low degree of transmission begins.

Anopheles sacharovi is another important vector in the mountainous northern half of Afghanistan and in parts of West Pakistan. It commonly appears in the same areas as *superpictus*, but it is characteristically a mosquito of valleys and mountain plains rather than of higher mountain areas. For this reason it is a more important vector at lower altitudes than *superpictus*, especially in those eastern parts of Afghanistan having a moderate to subtropical climate. In most of its range it has but one generation each year.

Anopheles culicifacies, one of India's most important vectors, appears in northeastern West Pakistan and eastern Afghanistan. This species has been found with low natural infection rates and maintains an endemicity that increases in spring and early summer, almost disappears during the hotter months, then reappears in varying intensity in the autumn.



Anopheles fluviatilis, a mosquito of West Pakistan, transmits endemic malaria in a manner similar to *Anopheles minimus* in the Orient (see p. 83). Its occurrence in Afghanistan is not known with certainty.

Anopheles stephensi is the only medically important urban anopheline in both countries. Because the larvae live in all types of manmade water collections, the malaria transmitted by it is often localized and limited to urban centers. This species is extremely abundant, but it has not been found infected in nature in certain areas of Afghanistan.

Anopheles claviger also appears in the extreme northern mountains of Afghanistan, where it is believed to maintain malaria in the vicinity of mountain streams.

The roles of *Anopheles maculipennis* and *A. pulcherrimus* in the transmission of malaria in Afghanistan and West Pakistan are not well known. In certain parts of their respective ranges they are important vectors or suspected of being important vectors.

References: *67, 101, 235, 280.*

Anopheles Species in Afghanistan and West Pakistan

†*annularis*
**claviger*
**culicifacies*
†*d'thali*
**fluviatilis*
habibi
hyrcanus
lindesayi
†*maculatus maculatus*
maculatus willmori
†*maculipennis*
moghulensis
†*multicolor*
†*nigerrimus*
pallidus
†*pulcherrimus*
**sacharovi*
†*sergenti*
splendidus
**stephensi*
†*subpictus*
**superpictus*
turkhudi
vagus

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Afghanistan and West Pakistan.

Reference: *256.*

Dengue.—Dengue occurs at the head and mouth of the Indus River in several endemic areas, where both *Aedes aegypti* and *A. albopictus* are present. The distribution of *aegypti* extends farther east than that of *albopictus*, so that the former species is more likely to be a vector in West Pakistan. The disease has not been reported from Afghanistan, and neither vector has been recorded from there.

References: *256, 310.*

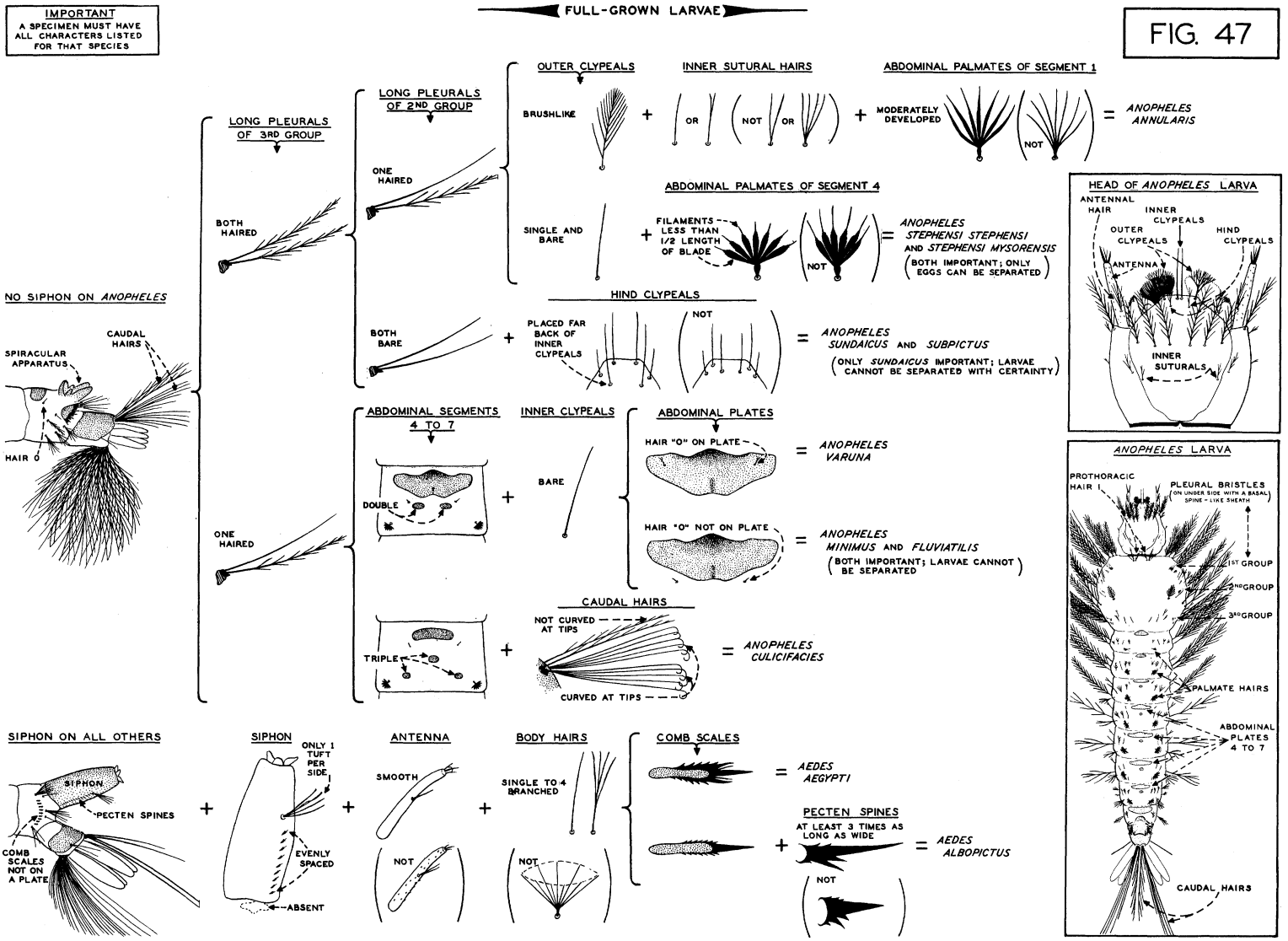
Encephalitis.—No information is available.

Filariasis.—No information is available.

MOSQUITOES OF MEDICAL IMPORTANCE — INDIA AND CEYLON

FULL-GROWN LARVAE

FIG. 47



DN—1304

India and Ceylon

(Figs. 47 and 48)

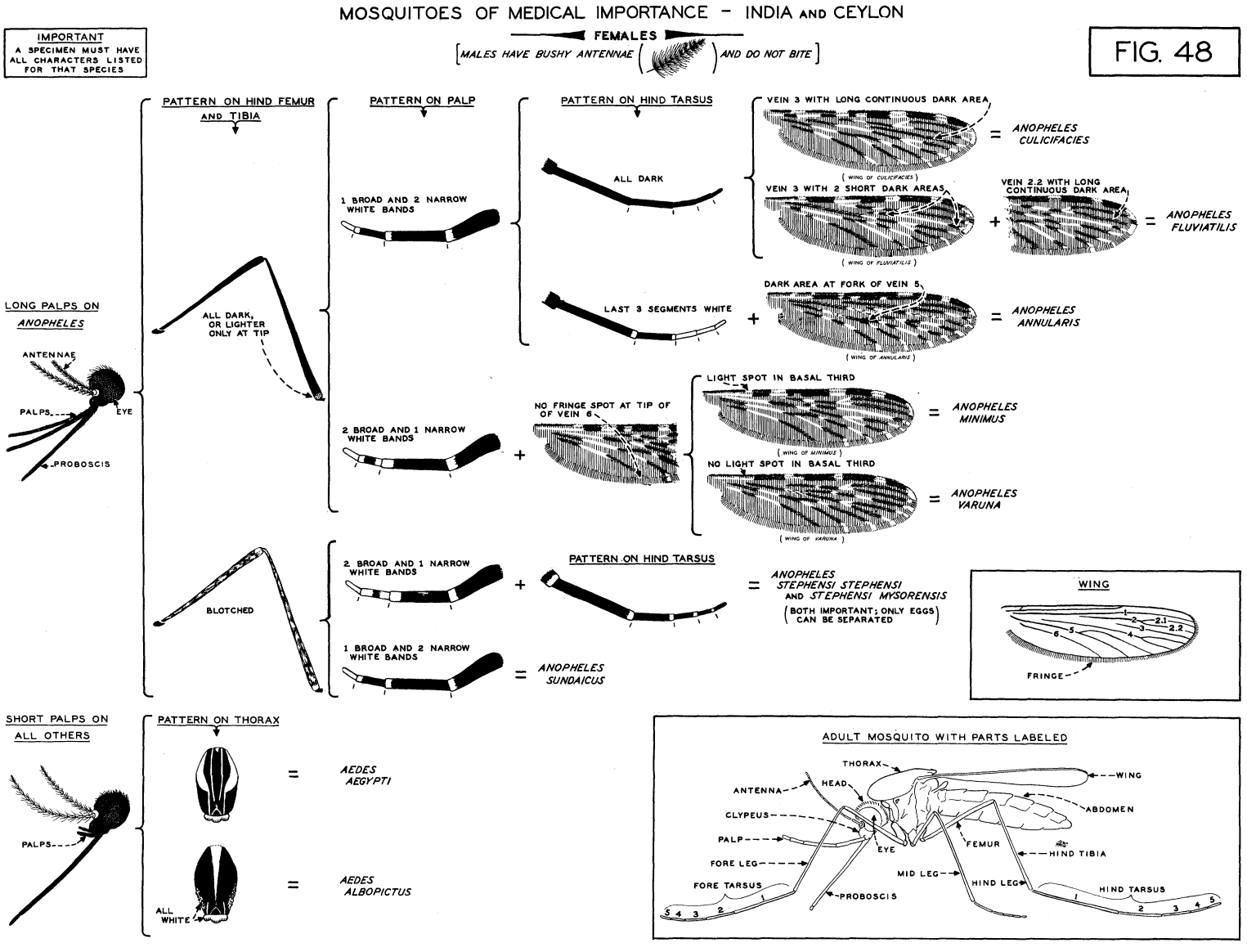
Physical Features.—India, isolated on the north from the rest of Asia by the highest mountain range in the world, the Himalayas, consists of three rather well-defined areas: (1) Hilly and mountainous country descending southward from the Himalayas; (2) an extensive agricultural area formed by the valley of the Ganges River and known as the United Provinces; and (3) the extensive plateau of peninsular India, with foothills and escarpments along the narrow western coast. The main rivers of peninsular India form broad deltas on the wide east coast. In the northwest corner is the extensive Thar Desert, which merges with swampy areas of the Kathiawar peninsula on the west coast. Daily annual variations in temperature are more marked in the northern and central than in the southern parts of the country. Southwest monsoons from June to September bring most of southwestern India's yearly 100 to 200 inches of rain. The effect of these winds decreases to the north and east, where periods of rain alternate with drought. A cool, dry period prevails from October to February and a hot, dry season with scorching winds from March to May.

Ceylon consists of a central mountain mass, 8,000 feet high, which is surrounded by a broad coastal plain with sandbars enclosing lagoons and marshes. The island has a small annual range of temperature, with heavy rains brought to the western mountain slopes by a southwest monsoon from June to September and to the eastern slopes by a northeast monsoon in October and November.

Reference: *301.*

Malaria.—This disease occurs practically everywhere in India and Ceylon except in the Himalayas. The vast plains and plateaus of the Ganges in the United Provinces and the central and peninsular parts of India are subject to a marked seasonal type, with a low or moderate endemicity. There are usually two peaks of prevalence, one in the spring and early summer and another in the autumn. Between these peaks the disease is almost completely absent from many parts of the area. Localized epidemics of high intensity occur from time to time in the northwest. They are associated with high rainfall and river flooding.

In the northern parts of India *Plasmodium vivax* is by far the most common parasite, whereas *P. falciparum* predominates in the south. *Plasmodium malariae* is common in southern India, and in wet areas in Ceylon it accounts for as many cases as *P. falciparum*.



DN—1305

The most important and widespread vector of malaria in central and peninsular India is *Anopheles culicifacies*. This species is also the most important, if not the only vector in Ceylon, but there it flourishes in periods of drought, breeding in small accumulations of water held over from river drying.

The foothill areas bordering the central plateau on both the east and west sides of peninsular India have a hyperendemic malaria supported by *Anopheles fluviatilis*. Here there are usually two periods of prevalence, one preceding and one following the monsoon rains. The breeding places of this mosquito may be completely washed out during the wet season, but transmission usually occurs during most or all the year.

The disease in the Himalayan foothills on the northeastern rim of India bordering Nepal and China has a similar periodicity. Its chief vector is *Anopheles minimus*. In contrast to conditions in southern India malaria in the north is absent during most of the year. *Anopheles varuna*, a close relative of *minimus* and *fluviatilis*, has been implicated as a vector of only occasional importance in east-central India, since it has been found naturally infected in widely scattered localities.

Anopheles stephensi stephensi is responsible for a considerable amount of malaria in urban areas, especially along the northern west coast and in the heavily populated Ganges plain. The real importance of this species lies in its ability to breed prolifically in artificial containers close to man. This urban malaria is extremely localized, because cities differ in their ability to cope with their malaria-control problems.

Anopheles stephensi mysorensis, usually considered to be of less importance than the type form, has been implicated as the chief rural carrier at Vizagapatnam, where rather high sporozoite rates have been encountered. Possibly some of the infection records given for the type form in the literature actually apply to *mysorensis*.

Anopheles sundaicus, typically a brackish-water breeder, appears from Calcutta southward to the middle of peninsular India along the east coast. It is responsible for periodic outbreaks of malaria, some of which may become rather severe in many localities. This malaria appears either in the spring or in the autumn, depending on whether local habitats are favorable for breeding. *A. sundaicus* is typically associated with cleared areas that have been embanked to protect them from the sea.

Anopheles annularis is not thought to be an important mosquito in India, but it sometimes is observed in extremely large numbers, among which infected specimens have been found. It is believed to play some part in the transmission of the malaria in Orissa.

References: *67, 101, 310.*

471779 O—59——6

Anopheles Species in India and Ceylon

†*aconitus*
aitkenii
annandalei
**annularis*
†*barbirostris*
barianensis
**culicifacies*
culiciformis
†*d'thali*
elegans
**fluviatilis*
gigas gigas
gigas refutans
gigas simlensis
insulaeflorum
jamesii
†*jeyporiensis candidiensis*
jeyporiensis jeyporiensis
karwari
leucosphyrus
lindesayi lindesayi
lindesayi nilgiricus
†*maculatus maculatus*
maculatus willmori
majidi
**minimus*
moghulensis
†*multicolor*
†*nigerrimus*
pallidus
pinjaurensis
†*pulcherrimus*
ramsayi
sintoni
splendidus
**stephensi mysorensis*
**stephensi stephensi*
†*subpictus*
**sundaicus*
†*superpictus*
†*tessellatus*
theobaldi
turkhudi
vagus
**varuna*

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in India and Ceylon.

Reference: *256.*

Dengue.—This disease is endemic throughout India. It is especially common after the rainy season in Bengal and Madras, but it is less so in western India and is practically unknown in the mountainous provinces along the northwestern frontier. It is carried by *Aedes aegypti* and *A. albopictus*; the former mosquito lives closer to man and is more universally distributed than the latter.

References: *256, 310.*

Encephalitis.—In several localities in West Pakistan and northwestern and central India, the following viruses have been found: West Nile, St. Louis, Murray Valley, Ilhéus, Zika, Ntaya, and Uganda S. Some of these are very closely related antigenicly, and interpretations of the findings are still being made. The presence of dengue may contribute toward misidentification of some of them. Japanese virus is probably present, but it has never been isolated. A study of the vectors of these viruses is still to be made.

Reference: *257.*

Filariasis.—The important centers of filariasis in India are (1) the lower parts of the Ganges River basin, (2) some seacoast areas in Bihar and Orissa on the northeast coast, and (3) Travancore State in the south. *Culex pipiens quinquefasciatus* is not present in the Punjab or is filariasis a medical problem. Farther southeast in the Central Provinces filariasis with elephantiasis is present in some restricted localities, but nearby localities are practically free of the disease.

There is only one parasite, *Wuchereria malayi*, which is transmitted by *Mansonia annulifera* and *M. uniformis*. *M. annulifera* is the chief vector because of its abundance and high rate of natural infection. Still farther southeast in Bihar and Orissa *Wuchereria bancrofti* also appears. This parasite is transmitted exclusively by *quinquefasciatus*, which is uniformly present in areas under rice cultivation. Investigations have shown up to 14 percent of these mosquitoes to be infected in such areas. In Bihar and on the seacoasts of Orissa *malayi* is the only parasite and *annulifera* its chief vector. Observations at Puri on the east coast indicate filariasis to be an important medical problem. Up to 27 percent of the human population harbors microfilariae and up to 34 percent of captured mosquitoes are infected. In two coastal areas of Travancore the principal parasite is *malayi* and its principal vector *annulifera*. Farther south in this State both parasites are found; *bancrofti* is transmitted exclusively by *quinquefasciatus*, which is principally urban, and *malayi* by *annulifera* and *uniformis*.

References: *192–194, 212–215, 290, 317, 318, 320.*

East Pakistan and Assam

(Figs. 49 and 50)

Physical Features.—East Pakistan, formerly the eastern part of Bengal, is a flat, low country, most of which rises hardly more than 300 feet above sea level; in the southeast the Chittagong Hills are over 3,000 feet high. East Pakistan lies largely in the immense fertile Ganges-Brahmaputra Delta, which consists of a confused network of waterways cutting across a vast alluvial tract. Rice comprises 85 to 90 percent of the country's agricultural output. Constant flooding of this low land is aided by an annual rainfall of 80 to 100 inches, principally caused by monsoons. The average temperature ranges annually from about 67° in January to 83° F. in May.

Assam is separated by high mountains from East Pakistan, the U. S. S. R., and Burma. In the northern half of the country is the broad agricultural valley of the lower half of the Brahmaputra; the southern part is largely hilly and has an east-west mountain range and the Surma River with its valley. Rainfall varies in different parts of the country: 75 to 85 inches fall annually in the central plateau area, 110 to 120 inches in the Brahmaputra Valley, 125 to 150 inches in the Surma Valley, and over 400 inches at one locality in the Khasi Hills. In the last-named area a rainfall of 900 inches, one of the world's heaviest annual precipitations, was once reported. Although the annual temperature range is rather great, much of the area is covered by dense tropical forests.

Reference: *301.*

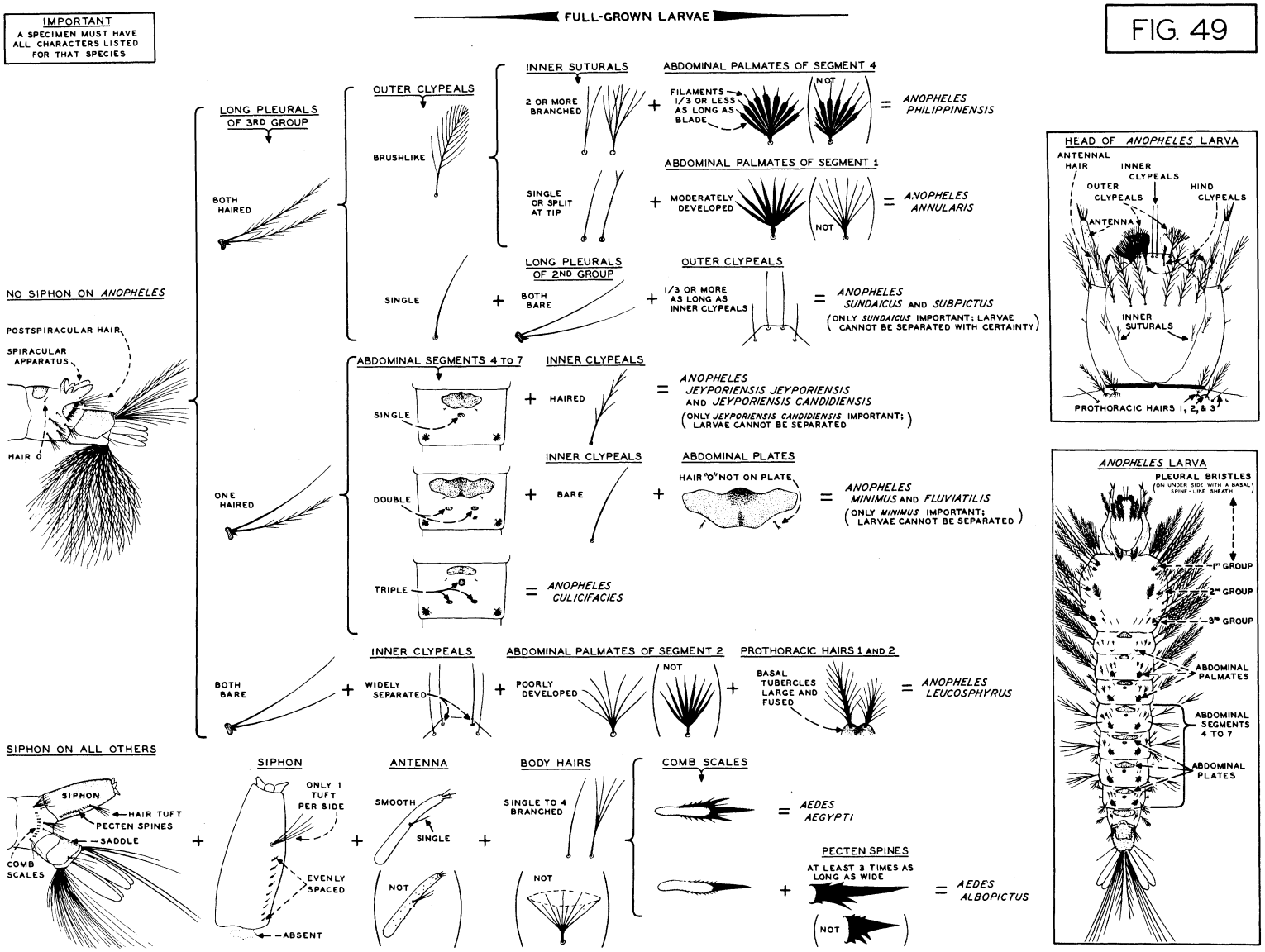
Malaria.—Although *Plasmodium falciparum* accounts for a large number of cases of malaria each year in East Pakistan and Assam, the exact distribution of *falciparum*, *P. vivax*, and *P. malariae* is not known with certainty.

Malaria is a most important problem in the mountainous parts of Assam. It occurs there in two periods, as it does in India, one before the rainy season and one afterward, closely corresponding to the peaks of mosquito incidence. During several months of the winter there is a malaria-free period in the foothill areas. *Anopheles minimus* breeds in clear, slowly running water and is the vector. Because rains flood out most of its breeding places, it is essentially a dry-season mosquito.

Anopheles jeyporiensis candidiensis is a vector along the East Pakistan-Burma border, and it has been found with natural infections in the vicinity of Chunati, in several localities near which it was the only species present. It is regarded as the vector of most of the premonsoon malaria in the hillocks of this border area.

Anopheles sundaicus breeds along the entire coastal area of East Pakistan in localities where the forest has been cleared and the land banked to prevent flooding by the ocean. It does not appear in mangrove areas in that country. It causes severe outbreaks in certain localities when it is abundant.

Anopheles philippinensis has been found with sporozoite rates as high as 2 percent in the western part of the Ganges Delta, where rivers are sluggish. Premonsoon malaria becomes evident as early as May and June, but the highly malarious months in this area are September, October, and November, just at the end of the rainy season when tanks and impoundments in the area offer optimum breeding con-



ditions. Throughout the dry season *philippinensis* breeds primarily in marshes and in rivers cut off from the main flow by a lowering of the water level.

Although extremely important in central India, *Anopheles culicifacies* is believed to be of comparatively little importance in East Pakistan or Assam. Since this species is common and dangerous throughout the United Provinces, it probably is of some importance in the lower reaches of the Ganges. The exact nature of the role played by *culicifacies* in this area is not known, but natural infections have always been comparatively low.

Anopheles annularis, apparently the only vector in the Goalpara District of Assam, is believed to transmit malaria at a low rate in this and other localities where it appears in large numbers. It is always found with very low natural infection rates and must be present in large numbers to be an effective transmitter.

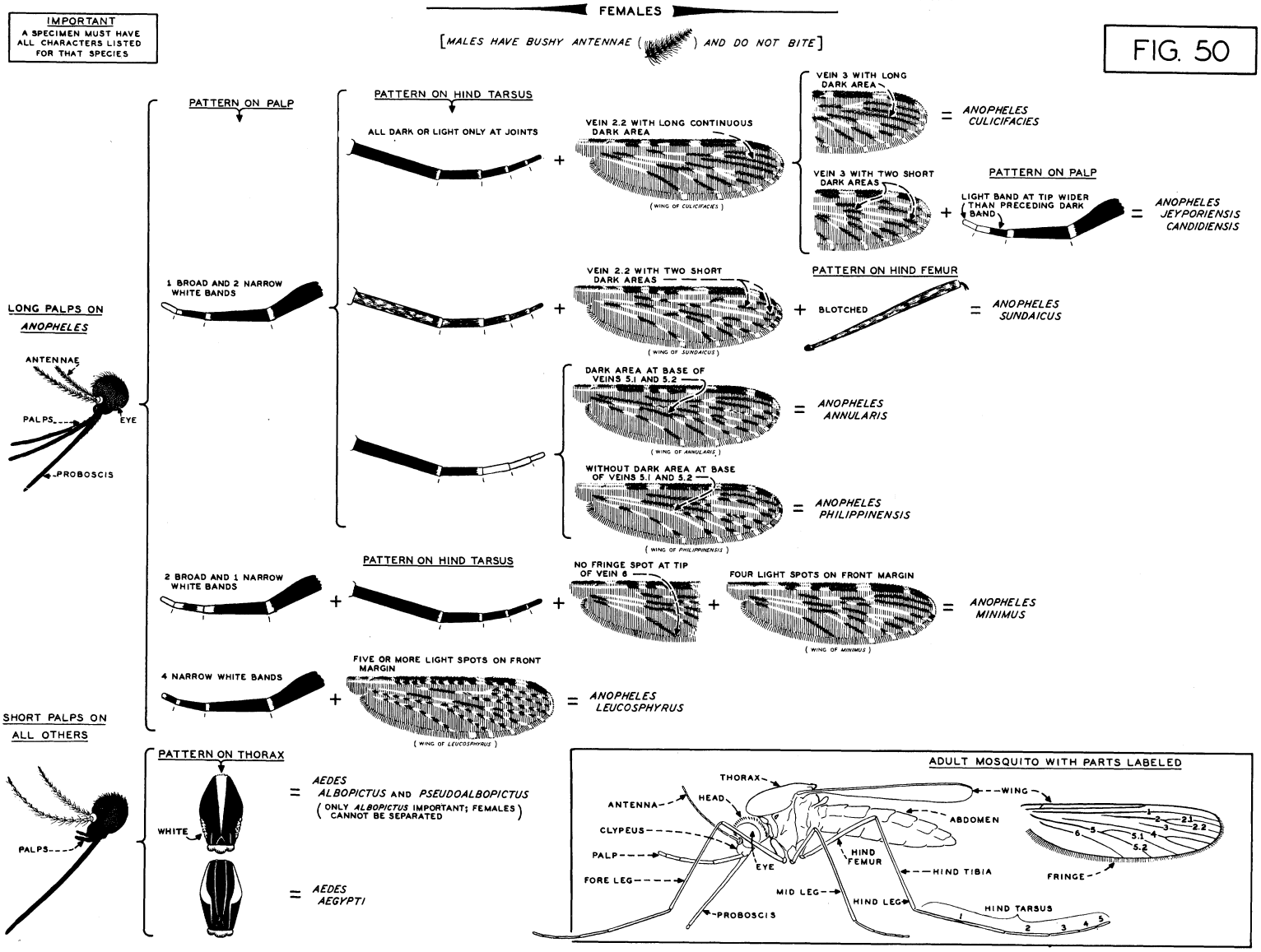
Anopheles leucosphyrus balabacensis, primarily a forest species, has been found with high infection rates several times of the year near Digboi, Assam. It transmits malaria in much of northern Burma during the rainy season and recently has been implicated as a possible vector along the East Pakistan-Burma frontier. Observations to determine the extent of its importance in this area are not yet complete. •

References: *67, 97, 101, 122, 242, 279, 310.*

Anopheles Species in East Pakistan and Assam

†*aconitus*
aitkenii aitkenii
aitkenii bengalensis
annandalei annandalei
annandalei interruptus
**annularis*
barbirostris ahomi
†*barbirostris barbirostris*
barianensis
**culicifacies*
†*fluviatilis*
gigas baileyi
gigas gigas
gigas simlensis
insulaeflorum
jamesii
**jeyporiensis candidiensis*
jeyporiensis jeyporiensis
karwari
†*kochi*
**leucosphyrus balabacensis*
lindesayi
†*maculatus*
majidi
**minimus*
†*nigerrimus*
pallidus
**philippinensis*
ramsayi
†*sinensis*
splendidus
†*stephensi*
†*subpictus*
**sundaicus*
tessellatus
theobaldi
†*umbrosus*
vagus
†*varuna*

See footnote 6, p. 10.



DN–1307

Yellow Fever.—This disease is not present in East Pakistan or Assam.

Reference: *256.*

Dengue.—Both of the principal vectors of dengue fever, *Aedes aegypti* and *A. albopictus*, are widely distributed in East Pakistan and Assam and are responsible for the heavy endemicity of the disease, especially in the Ganges Delta area east of Calcutta, where the disease has prevailed in an especially intense form. It is estimated that dengue can occur in epidemic form in any endemic area whether either or both vectors are present, especially among nonimmune persons. In East Pakistan and Assam dengue is especially prevalent just after the rainy season.

References: *256, 310.*

Encephalitis.—No information is available.

Filariasis.—Filariasis was introduced about 30 years ago into the tea-garden sections of the Pachhar district, lower Assam, where it is endemic in the small villages and where it has caused much elephantiasis.

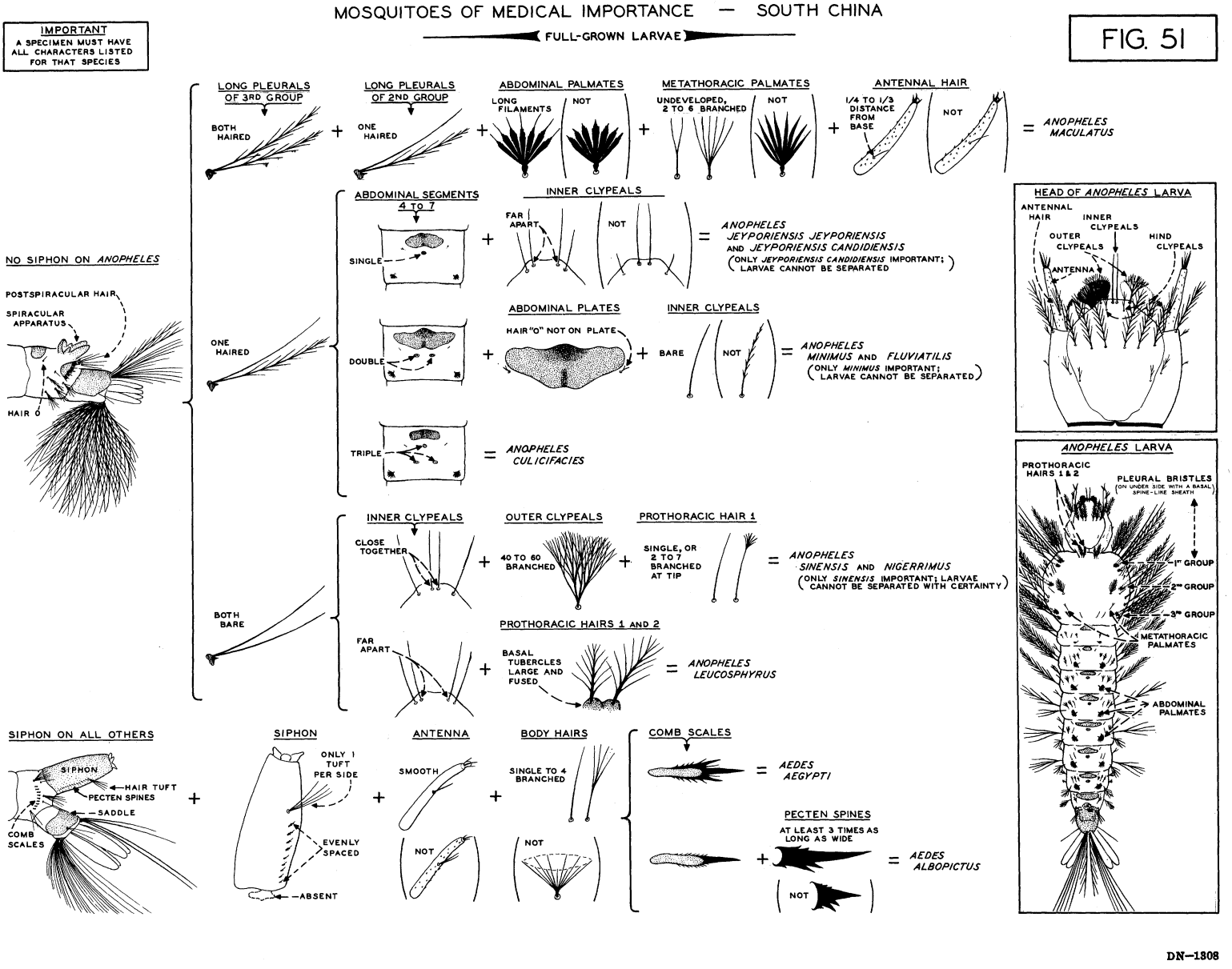
Both *Wuchereria bancrofti* and *W. malayi* are present in the native population, the former transmitted by *Culex pipiens quinquefasciatus*, the latter, causing most of the infections, by *Mansonia annulifera*, *M. uniformis*, and *M. indiana.* All these mosquitoes have been found with high rates of natural infection. Bancroftian filariasis has been found in rural areas in the Birbhum District of Bengal and is transmitted by *Anopheles philippinensis.* Wild-caught specimens of this mosquito have been found with infective larvae of *W. bancrofti.* It is not known whether *quinquefasciatus* is present in Bengal and Assam.

References: *195, 319.*

South China

(Figs. 51 and 52)

Physical Features.—The part of China treated here has a northern boundary that corresponds to the northern borders of the Provinces of Chekiang, Kiangsi, and Hunan, follows latitude 29° N. across the southern part of Szechwan, and ends at the northern extremity of Burma. This line corresponds to the northern limit of extension into China of a great part of the oriental mosquito fauna, even though there is a Palearctic element reaching south of it. Excepting Manchuria, the line divides the southern third from the northern two-thirds of the country. South China contains most of the country's mountains and also the plateaus of Yunnan and Kweichow in the southwest, the valleys of the West, North, and East Rivers, and a rather narrow coastal



plain in the southeast. The large island of Hainan lies off the coast in the South China Sea. The Ryuku Islands are also included in this region.

The climate of South China is regulated by monsoons and is subtropical, with mild winters and an annual rainfall of about 80 inches. About 90 percent of the total arable land in the extreme south is planted to rice, which is extensively cultivated and is double cropped.

Reference: *301.*

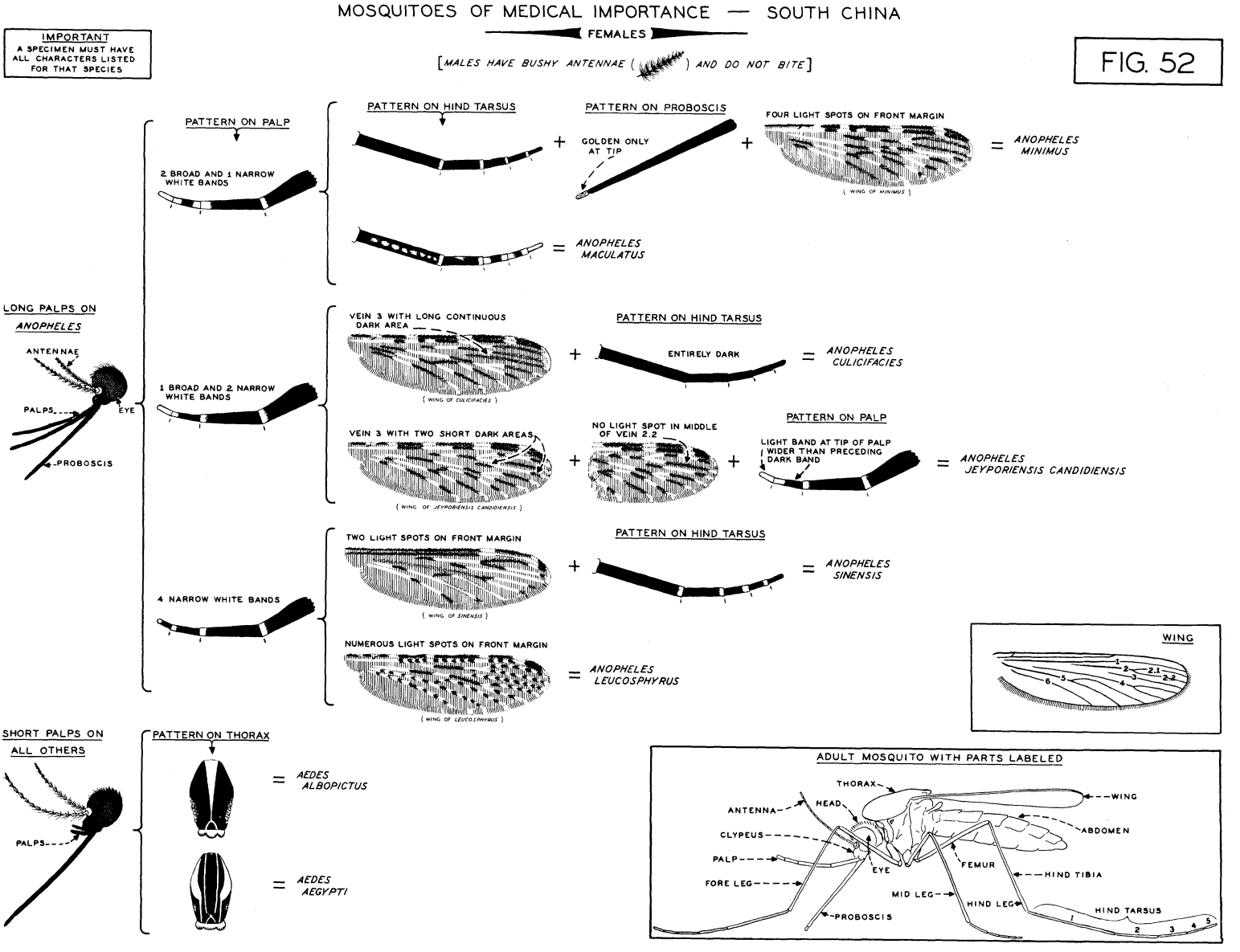
Malaria.—The areas of highest endemicity are southwest Yunnan and a coastal strip beginning at the lower Yangtze River and extending north to include Hainan. As in much of southeastern Asia, foothill malaria is one of the most serious problems in South China and is particularly intense in southwestern Yunnan.

During construction of the Burma Road and the Yunnan-Burma Railway, large numbers of fatal malaria cases caused by *Plasmodium falciparum* occurred among native laborers, and this disease has accounted for high morbidity and mortality rates in military campaigns throughout the area. *Plasmodium malariae* is a rather common and surprisingly prevalent parasite, but its distribution is sporadic.

Anopheles minimus and *A. jeyporiensis candidiensis* are the principal vectors of most foothill malaria in South China. During the dry season *minimus* tends to disappear, since most breeding places completely dry up, but populations in some localities are very large near the end of the rainy season and immediately afterward. It is such a prolific breeder in Yunnan that it has even been found in lowland plains at the edges of swamps and terraced ricefields. *A. j. candidiensis* is often found with *minimus* but it is not so abundant. It is found at the edges of seepages and fallow ricefields, and throughout South China where its numbers are large it is important, though slightly less so than *minimus*. This species is occasionally found with very high rates of natural infection. In the vicinity of Hong Kong, for example, 9 percent of wild-caught mosquitoes were infected.

Anopheles sinensis, a transmitter in the northern two-thirds of China, is the most important vector in the vast rice-growing areas of South China. In general, the species is most prevalent toward the end of summer monsoon rains. In South China, as elsewhere, *sinensis* is noticeably zoophilic, and natural infection rates are generally low. Therefore, in areas where this species transmits malaria, large populations of the mosquito must be present.

In Ceylon and throughout much of India *Anopheles culicifacies* is one of the outstanding malaria vectors. Its distribution in South China is restricted to Yunnan, where it reaches the easternmost limit of its range and where it has



been found at least once with relatively high natural infection rates. Because it is occasionally free of malaria parasites and because it is a rare mosquito, at least from July to February, compared with *minimus*, *candidiensis*, and *sinensis*, it is regarded as a secondary vector in this area.

Anopheles maculatus has been found throughout South China, but it is most often encountered in the western half, where it is the most common mosquito present. It is typically a stream and riverbed breeder. Its numbers are rather constant throughout the year, because its breeding places remain more or less intact throughout the dry season.

Little is known of the importance of *Anopheles leucosphyrus* in South China. It breeds in small shaded pools in forested areas of Yunnan, and since it is of some importance in northern Burma, it is included in the keys as a potential vector in South China.

References: *67, 84, 88, 122, 125, 310.*

Anopheles Species in South China

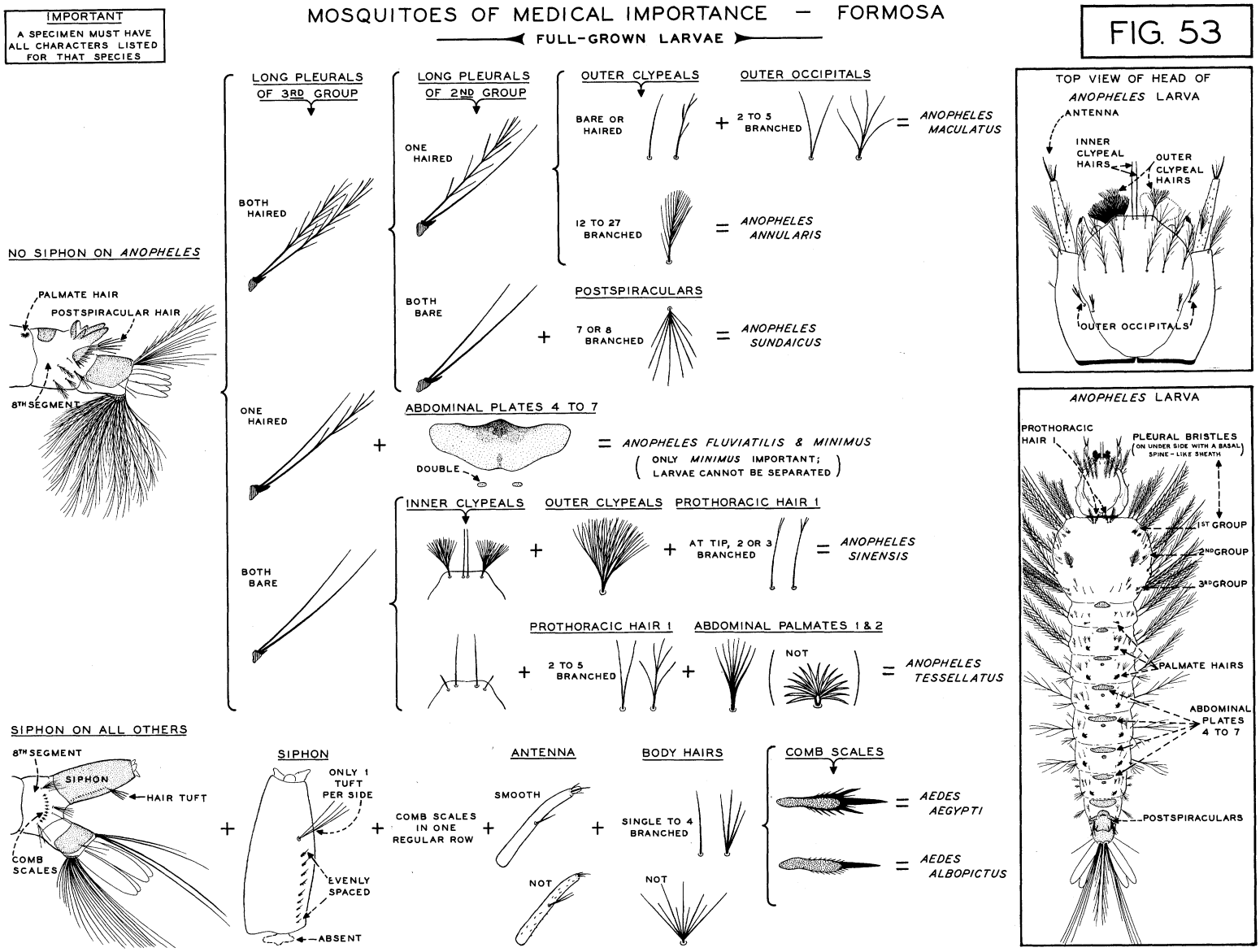
†*aconitus*
aitkenii aitkenii
aitkenii bengalensis
annandalei interruptus
†*annularis*
jamesii
**jeyporiensis candidiensis*
jeyporiensis jeyporiensis
karwari
†*kochi*
koreicus
kweiyangensis
†*leucosphyrus*
lindesayi lindesayi
lindesayi pleccau
**maculatus*
**minimus*
nigerrimus
ohamai
†*barbirostris*
**culicifacies*
†*fluviatilis*
gigas baileyi
gigas simlensis
philippinensis hainanensis
†*philippinensis philippinensis*
saperoi
**sinensis*
sineroides
sintonoides
splendidus
†*stephensi*
†*subpictus*
†*sundaicus*
†*tessellatus*
†*umbrosus*
vagus
†*varuna*

See footnote 8, p. 63.

Yellow Fever.—This disease is not present in South China.

Reference: *256.*

Dengue.—Endemic in various localities in South China, dengue occurs sporadically along the south and east coasts, extending beyond the northern border of Chekiang Province. The major foci appear to be port cities, where several epidemics have occurred in the past. Both *Aedes aegypti* and *A. albopictus* are present in South China. The former



species, more urban than the latter, has been found in the vicinity of Hong Kong, but its exact distribution elsewhere is not known. *A. albopictus* is extensively distributed in a large area near Shanghai, a locality where *aegypti* is absent.

References: *256, 310.*

Encephalitis.—Outbreaks of Japanese encephalitis occur in the various Provinces of eastern China from time to time. In many localities where it is believed to be present, no virus has ever been isolated, but 80 to 90 percent of the population in certain areas show immunity to this virus. Little is known about the vectors in this area.

Reference: *257.*

Filariasis.—Both *Wuchereria bancrofti* and *W. malayi* are found in the coastal areas of South China. Their distribution farther inland is not clearly known. Filariasis is centered in low rural areas around lakes and rivers and near the coast. In South China *Anopheles sinensis* transmits both parasites and accounts for a large number of malaria cases each year. *Culex pipiens quinquefasciatus* and *C. p. pallens* carry only *bancrofti*, and *Mansonia uniformis* is implicated in the transmission of *malayi* in certain areas. In Amoy the vectors are *sinensis* and *quinquefasciatus*, but they are less common there than in other parts of Fukien Province, where the incidence of the disease is considerably higher.

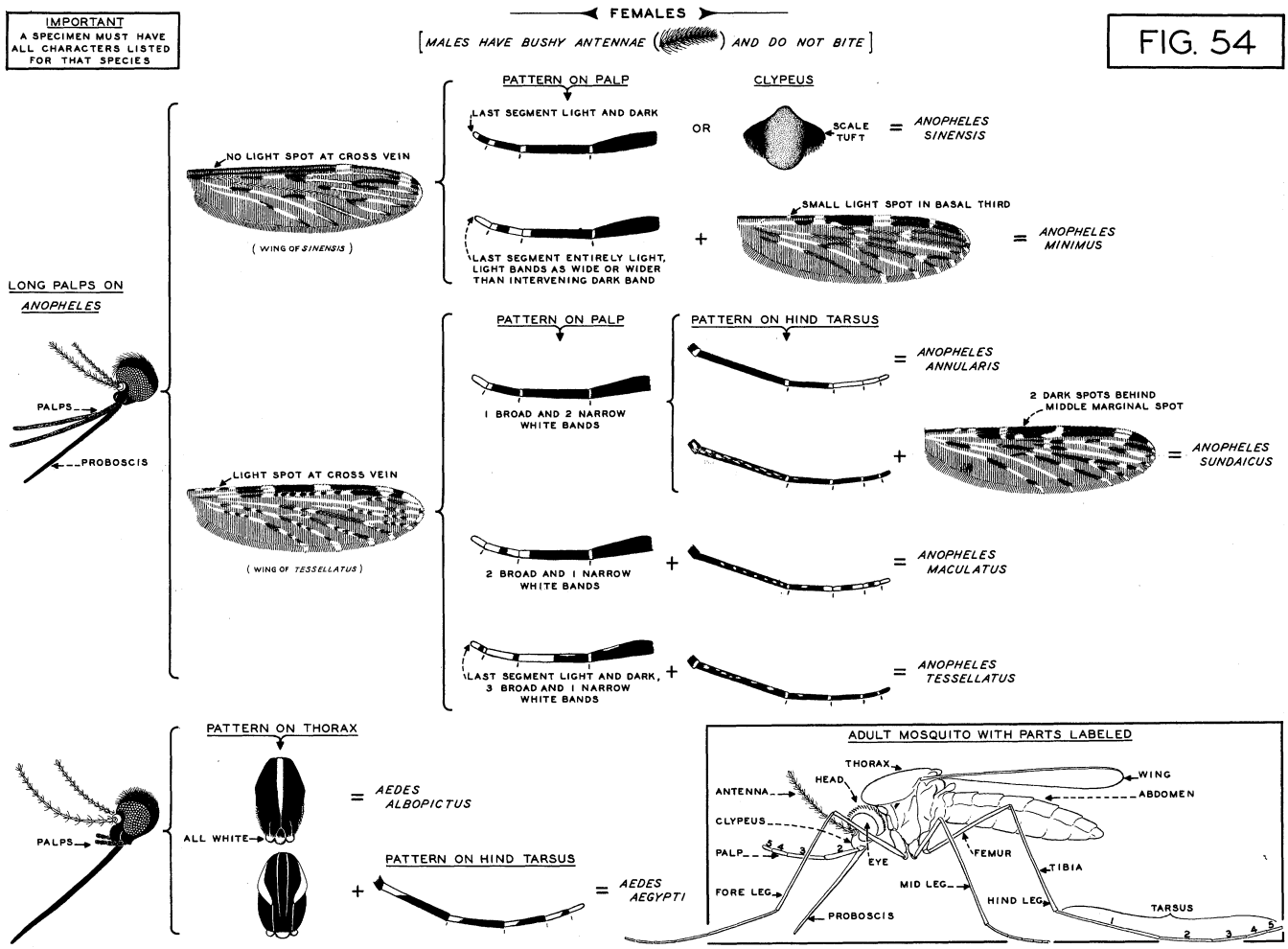
Natural infections have been found in *Anopheles minimus*, *A. jeyporiensis candidiensis*, and *C. p. quinquefasciatus* in the island of Hong Kong, where filarial infection in humans is rare, and in *Anopheles splendidus* and *sinensis* on the adjacent mainland. *Aedes togoi* has been experimentally infected with *bancrofti* and may be an important vector near Hong Kong.

References: *124, 126, 191, 198.*

Formosa

(Figs. 53 and 54)

Physical Features.—Formosa, which is separated from the mainland of China by the 100-mile-wide Formosa Strait, is an island 235 miles long, 90 miles wide, and 13,886 square miles in area. From north to south parallel mountain ranges form abrupt, precipitous banks and cliffs and rise in nearly 70 peaks above 10,000 feet. The west and southwest sides of these mountains descend gradually to form a broad alluvial plain that covers about one-third of the island, which has a nearly uniform topography. About 70 percent of the is-



land's population lives on this plain, where rice and sugarcane are the most important crops.

A southwest monsoon brings light rains to the southern part of the island in April and May and a rainy season from June to September; the rest of the year is relatively dry. A northeast winter monsoon brings rain to northern Formosa during the dry season in the south. Cool seasons in the island are well marked, but temperatures never become low enough to prevent year-round mosquito breeding except in the high mountains.

References: *85, 301.*

Malaria.—The principal malaria problem in Formosa is centered in the western and southwestern plains, where extensive cultivation of rice supports large mosquito populations. In addition, there is a small amount of malaria in the adjoining foothills.

The malaria is usually caused by *Plasmodium vivax*, even though most deaths are due to *P. falciparum*; *P. malariae* is rare in the island.

Alluvial-plain malaria is transmitted principally by *Anopheles sinensis*, which has two seasonal population peaks. The first occurs in February and March and is due to the second flooding of the first rice crop of the year. The second peak in September and October, caused by the flooding of the second crop, is usually slightly lower than the first. At Taipeh in northern Formosa two peaks also occur, the earlier one slightly later than in the south because of the later date of rice planting. *A. sinensis* is the most prevalent mosquito in the plains area. Because it is primarily zoophilic, it requires large human populations to maintain endemic malaria.

Three other alluvial-plain *Anopheles* species have been found infected with malaria parasites in nature. Their relative importance is not known with certainty. They are regarded as secondary vectors during the time of year when their numbers are large. The commonest of these, *Anopheles tessellatus*, breeds in pools formed by autumn rains in southern Formosa's sugarcane fields. Its peak of abundance is high in the fall and decreases as the pools dry out after the end of the rainy season. *Anopheles annularis* larvae are often found in sugarcane fields with *tessellatus* larvae. The peak of abundance of these two species occurs simultaneously in the fall. *Anopheles sundaicus* is found during the dry season because of its habit of breeding in small pools with sandy or stony bottoms, mainly along riverbeds. When these rivers are filled during the rainy season, breeding is reduced to a minimum. *A. sundaicus* has a low peak of abundance in the fall, corresponding to that of *sinensis*, in areas where it occasionally breeds in ricefields.

The larvae of *Anopheles minimus* live at the margins of small streams and irrigation canals, primarily in the foothills. The adults have two peaks of abundance, one about May and another in the autumn. Since *minimus* appears in relatively large numbers in houses and is normally found with a high rate of natural infection, it is the second most important vector in Formosa, transmitting most of the malaria in the foothills.

Anopheles maculatus, like the preceding species, breeds in foothill stream-bed pools in central and southern Formosa, reaching a dry-season population peak in April and May. In contrast to *minimus*, it has rarely been collected in houses there. It is included here as a potential vector because of its high natural infection rates.

References: *67, 85, 89, 310.*

Anopheles Species in Formosa

aitkenii bengalensis
**annularis*
†*barbirostris barbirostris*
barbumbrosus
fluviatilis
gigas baileyi
insulaeflorum
†*jeyporiensis candidiensis*
†*kochi*
†*leucosphyrus* (var. not known with certainty)
lindesayi lindesayi
lindesayi pleccau
†*ludlowi ludlowi*
**maculatus*
**minimus*
**sinensis*
splendidus
†*subpictus indefinitus*
**sundaicus*
**tessellatus*
vagus vagus
vulgaris

See footnote 6, p. 10.

Yellow Fever.—As in other areas of the Orient, no cases of yellow fever have been reported from Formosa. However, *Aedes aegypti* is common here and throughout adjacent islands, and its habits here as elsewhere are definitely urban.

References: *27, 256.*

Dengue.—This disease occurs in numerous epidemics, and sporadic cases appear in the southern part of the island. *Aedes aegypti* is undoubtedly responsible for most of the urban cases and *A. albopictus* for the more rural ones, since the latter mosquito tends to be less domestic in its habits.

References: *27, 256.*

Encephalitis.—Severe epidemics of Japanese encephalitis occur every year in Formosa. Little information is available regarding the distribution of the disease or the nature of the vectors. *Culex tritaeniorhynchus*, the vector of Japanese encephalitis virus elsewhere, is present in the island.

Reference: *257.*

Filariasis.—This disease is rare in natives in Formosa, and even in areas with the heaviest infections, mosquitoes are found with low parasite rates. *Wuchereria bancrofti* is the only parasite in the island, and it is transmitted only by *Culex pipiens quinquefasciatus.*

Reference: *344.*

Burma

(Figs. 55 and 56)

Physical Features.—Burma, which is roughly oval in shape, has a narrow, southern 400-mile arm along the west coast of Thailand, consisting of extensive inland mountain ranges and the narrow Tenasserim coast. An arc of mountains separates Burma from China on the east and from Assam and the Bay of Bengal on the west. These mountains are an extension of the Himalayas and rise to 20,000 feet in the extreme north. In the western half of Burma is the extensive valley of the Irrawaddy River. Its delta extends along most of the southern and southwestern coasts. Rice is the most important crop and is grown extensively for export throughout this region. The Arakan range separates the Irrawaddy Valley from the Bay of Bengal, leaving a narrow coastal strip. The eastern half of Burma consists of the Shan Plateau and the Karenni Hills, the latter cut into deep gorges by the tributaries and main course of the Salween River, which empties into the Bay of Bengal on the southeast coast.

Areas of highest rainfall, with 200 inches per year, are the Arakan and Tenasserim coasts. This rain is brought by a southwest monsoon from May to October. The dry zone is situated in the lee of the Arakan Yoma Mountains and receives about 25 to 40 inches of rain annually. November to February in Burma is cool and February to May hot, with little rain in either season.

Reference: *301.*

Malaria.—Malaria is an urgent medical problem in the foothills of Burma, where most cases are found. Malaria occurs principally in the mountain ranges in the north and extends southwest throughout the Arakan range, southeast through the Shan States, and along the Burma-Thailand border into the Malay Peninsula. Because of their immunity, natives in these areas appear to be less affected than immigrants.

Plasmodium falciparum, *P. vivax*, and *P. malariae* are found in this country, with *falciparum* predominating in most areas. Large numbers of cases of blackwater fever are admitted to hospitals in Burma.

Throughout the foothills of Burma *Anopheles minimus* is the most widespread and important vector. This mosquito breeds in clear, fresh water at the grassy edges of slowly running streams and is more distinctly anthropophilic than almost any other oriental malaria vector.

Anopheles jeyporiensis candidiensis is another foothill mosquito, inhabiting a large variety of fresh-water collections. It varies more in its anthropophilism from locality to locality than does *minimus*, but it has definitely been implicated in the transmission of premonsoon malaria along the Burma-East Pakistan border, where adults commonly are found in hillock country and avidly attack man.

Anopheles leucosphyrus balabacensis, principally a forest species, is a vector in central Burma during the rainy season and may also play a part in transmission farther south and west in the Arakan area. These three *Anopheles* species are the most important vectors in Burma, especially when they are abundant.

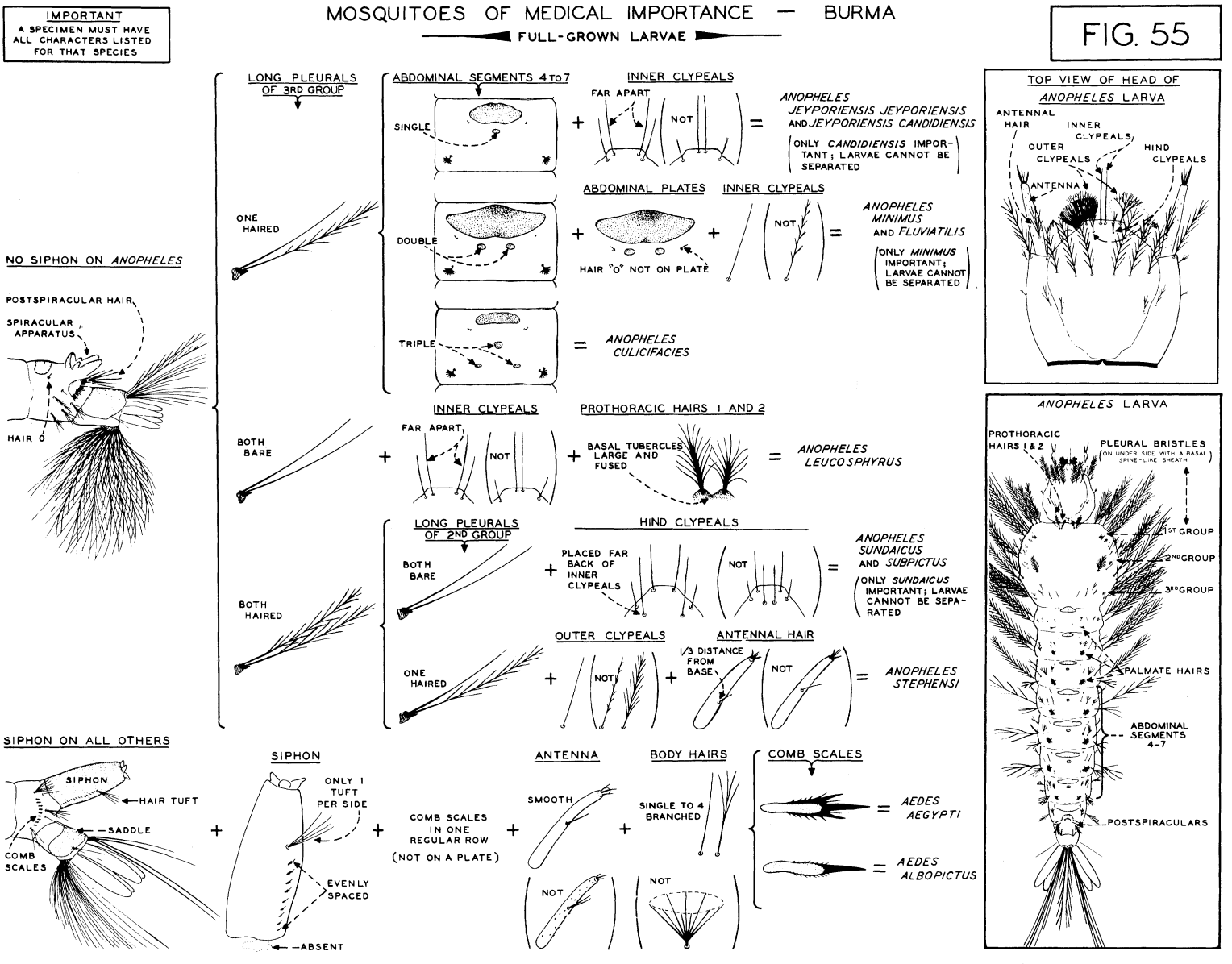
Anopheles sundaicus, a brackish-water coastal species, is found in many areas of the Burma coast, but never in association with mangrove. This vector tends to cause small epidemics at irregular intervals within restricted and isolated areas, especially along the Arakan seaboard. It is zoophilic to a large extent and may be easily deflected from feeding on man in this area by the presence of cattle. Very little malaria is found along the south Burma coast.

Anopheles stephensi, an extremely important vector in India and westward, has a range that extends into northern Burma. Since it has been found infected in nearby countries, it has been included as a potentially important vector. It is principally urban over most of its range.

Anopheles culicifacies, one of the most important transmitters of malaria in India, has been found infected in Minbu, upper Chindwin, the northern Shan States, and along the Ledo Road. Because it is an effective vector in other parts of its range and because it has been found with natural infections in Burma, this mosquito may be important.

On the northern point of Ramree, the largest island off the Arakan coast, *Anopheles annularis* has been implicated as the fresh-water vector on the basis of epidemiological evidence. This species is not included in the keys, because it is of such little importance, considering Burma as a whole.

References: *67, 97, 122, 240, 242, 310, 333.*



Anopheles Species in Burma

†*aconitus*
aitkenii
†*annularis*
†*barbirostris*
**culicifacies*
†*fluviatilis*
gigas baileyi
jamesii
**jeyporiensis candidiensis*
jeyporiensis jeyporiensis
karwari
†*kochi*
kyondawensis
**leucosphyrus balabacensis*
†*maculatus maculatus*
maculatus willmori
**minimus*
†*nigerrimus*
pallidus
†*philippinensis*
ramsayi
†*sinensis*
splendidus
†*stephensi*
†*subpictus subpictus*
**sundaicus*
†*tessellatus*
theobaldi
†*umbrosus*
vagus
†*varuna*

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Burma.

Reference: *256.*

Dengue.—Dengue fever in the past has been an important disease in southern Burma. At least one epidemic affecting a large number of persons has occurred. Dengue has never been recorded from the Shan States or the old Burma Road and does not occur in these areas. *Aedes aegypti*, the vector of classical yellow fever outside the Orient, is the most important vector of dengue in Burma. *Aedes albopictus* is probably widespread, but its importance in the transmission of dengue in Burma is not well known.

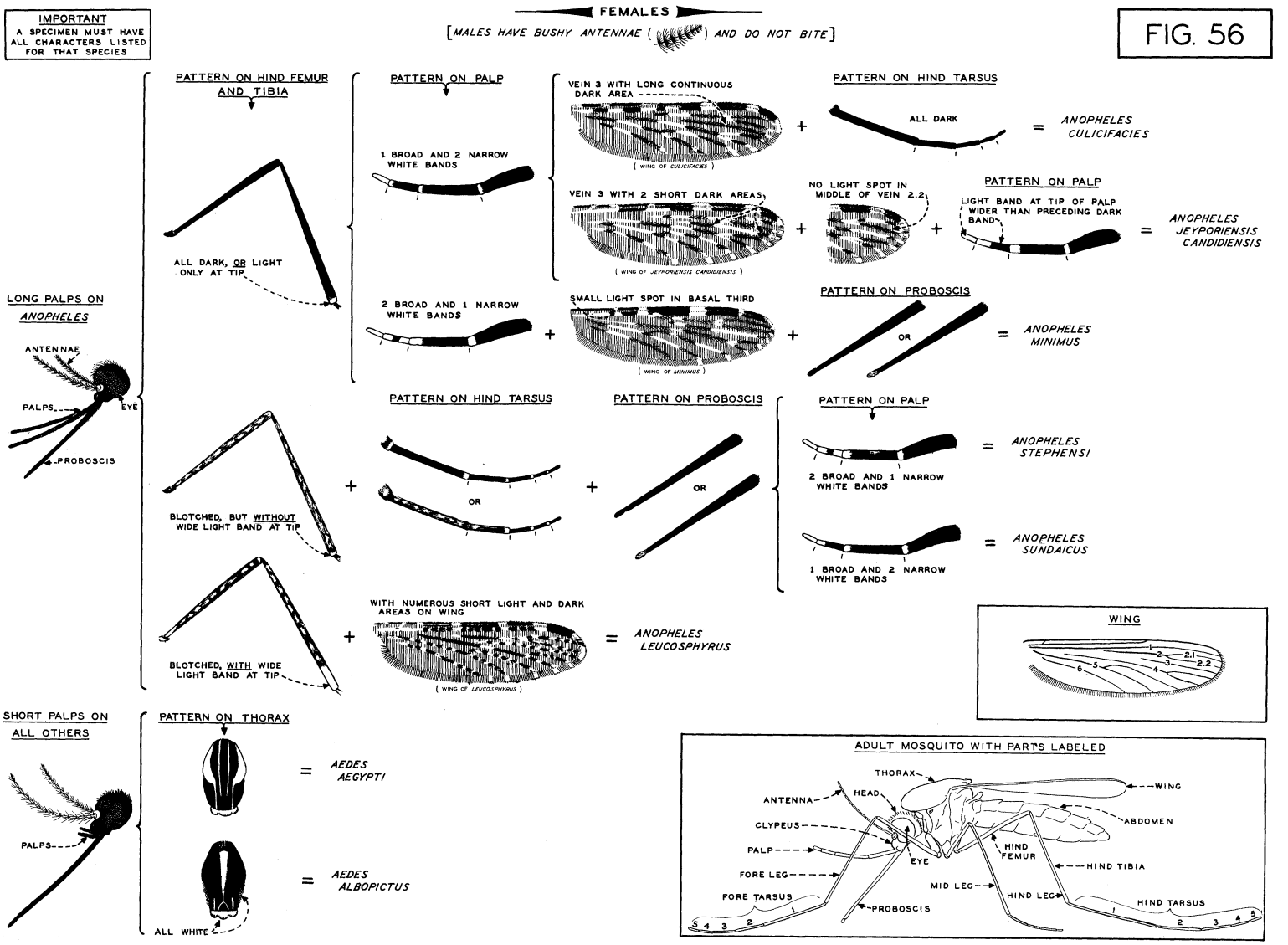
References: *122, 256, 310.*

Encephalitis.—Japanese encephalitis has been reported from the delta area of the Irrawaddy, but as far as is known no cases have occurred in humans, nor have any human sera been found with antibodies to the virus.

Reference: *257.*

Filariasis.—Although both *Wuchereria bancrofti* and *W. malayi* are present in Burma, the latter parasite predominates and causes a great deal of disease, especially along the Tenasserim and Arakan coasts and in Mandalay. The vectors of *malayi* are presumably members of the *Mansonia* subgenus *Mansonoides*, as elsewhere in the Orient.

Reference: *310.*



Indochina

(Figs. 57 and 58)

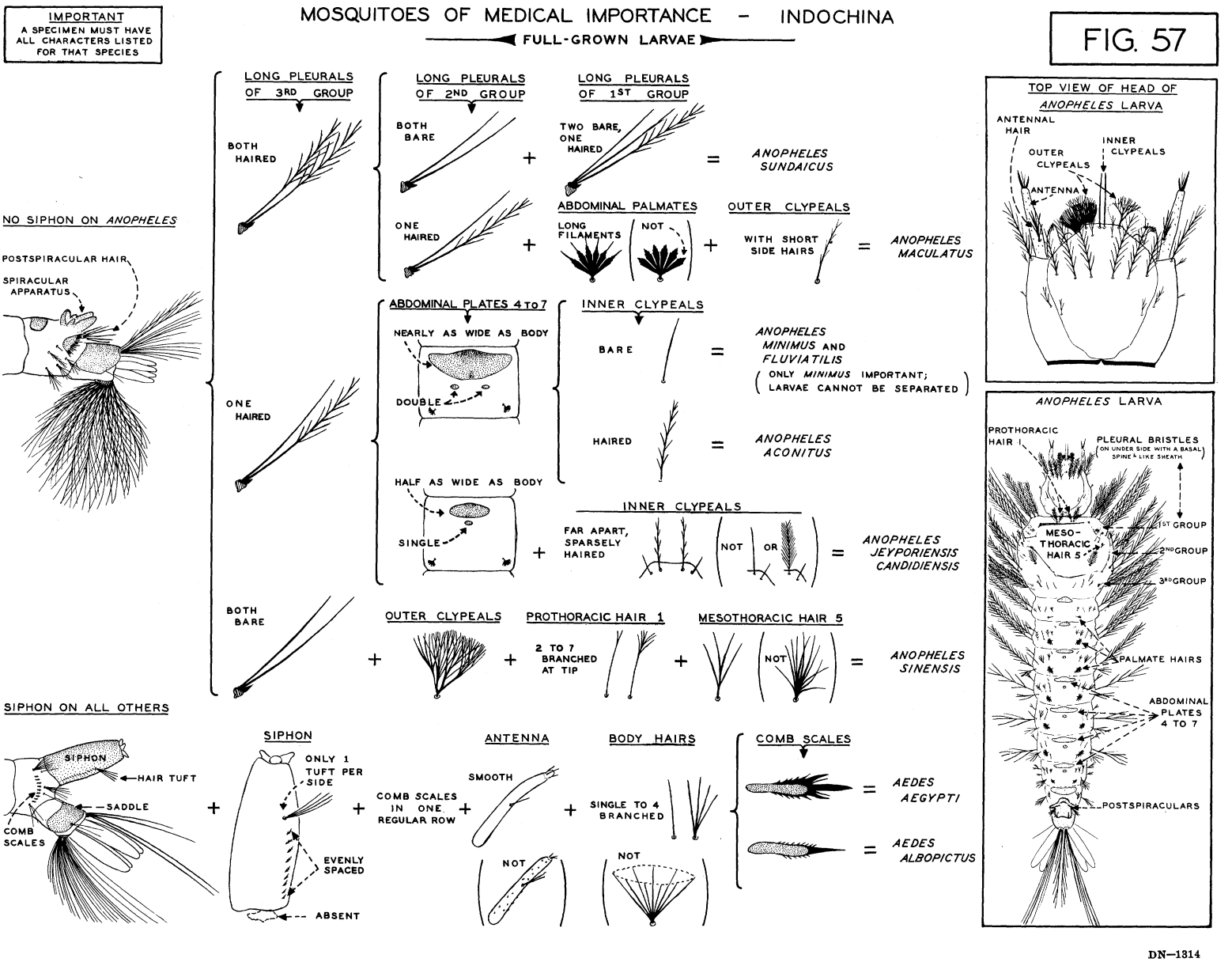
Physical Features.—Indochina is a crescent-shaped country on the southeast coast of Asia and is composed of the States of Vietnam, Laos, and Cambodia. Vietnam consists of Tonkin in the north, Cochin China in the south, and the long, narrow coastal strip of Annam between them. Tonkin's scattered northern mountains are thinly populated and steep walled, and its southern ricegrowing areas are the most extensive in Indochina. Annam extends for 800 miles between the Annamese Cordillera on the west and the South China Sea on the east. The Cordillera expands southward to form the Moi Plateaus in the lower end of Annam. Cochin China, another important ricegrowing area, is a flat alluvial plain irrigated by the Mekong River, which flows almost the entire length of Indochina and ends in an extensive delta on the south coast. The southwestern tip of Cochin China is expanded into the mangrove-covered Camau Peninsula. The kingdom of Laos consists of a northern area of wooded ranges and plateaus cut by narrow valleys and a southern area with arid, sparsely forested, limestone terraces. Cambodia, separated from the southeast border of Thailand by an extensive mountain range, is a flat alluvial plain like that of Cochin China, where rice is the principal crop.

Indochina has a tropical climate dominated by monsoons from the South China Sea. These winds bring high year-round temperatures to southern Vietnam and rain from May to October. Farther west, Cambodia receives 25 to 40 inches of rain annually, the summer floods of the Mekong providing a large part of the water needed for agriculture. In the north the climate is more seasonal, with cooler winters and precipitation up to 80 inches per year in Laos. A dry, cool season usually occurs from November to February and a hot season from February to May, after which rain again begins.

Reference: *301.*

Malaria.—The principal malaria problem exists in the foothills of all three States of Indochina. The disease is severe, and blackwater fever is present, especially in the mountains of Annam and Tonkin.

Plasmodium falciparum malaria predominates in many parts of Indochina, and *P. vivax* accounts for an equal number of cases in other parts. *Plasmodium malariae* rarely accounts for over 10 percent of the cases in any locality.



All malaria up to about 1,500 feet is transmitted chiefly by *Anopheles minimus*, by far the most important vector in Indochina. It is strongly anthropophilic and breeds not only in the moving water of streams but also in clear water at the edges of swamps, ricefields, and borrow pits.

Anopheles jeyporiensis candidiensis, another foothill species, is found in standing or running, grassy, clear water. Although it is slightly less anthropophilic than *minimus*, it plays an important part in the transmission of foothill malaria under certain conditions.

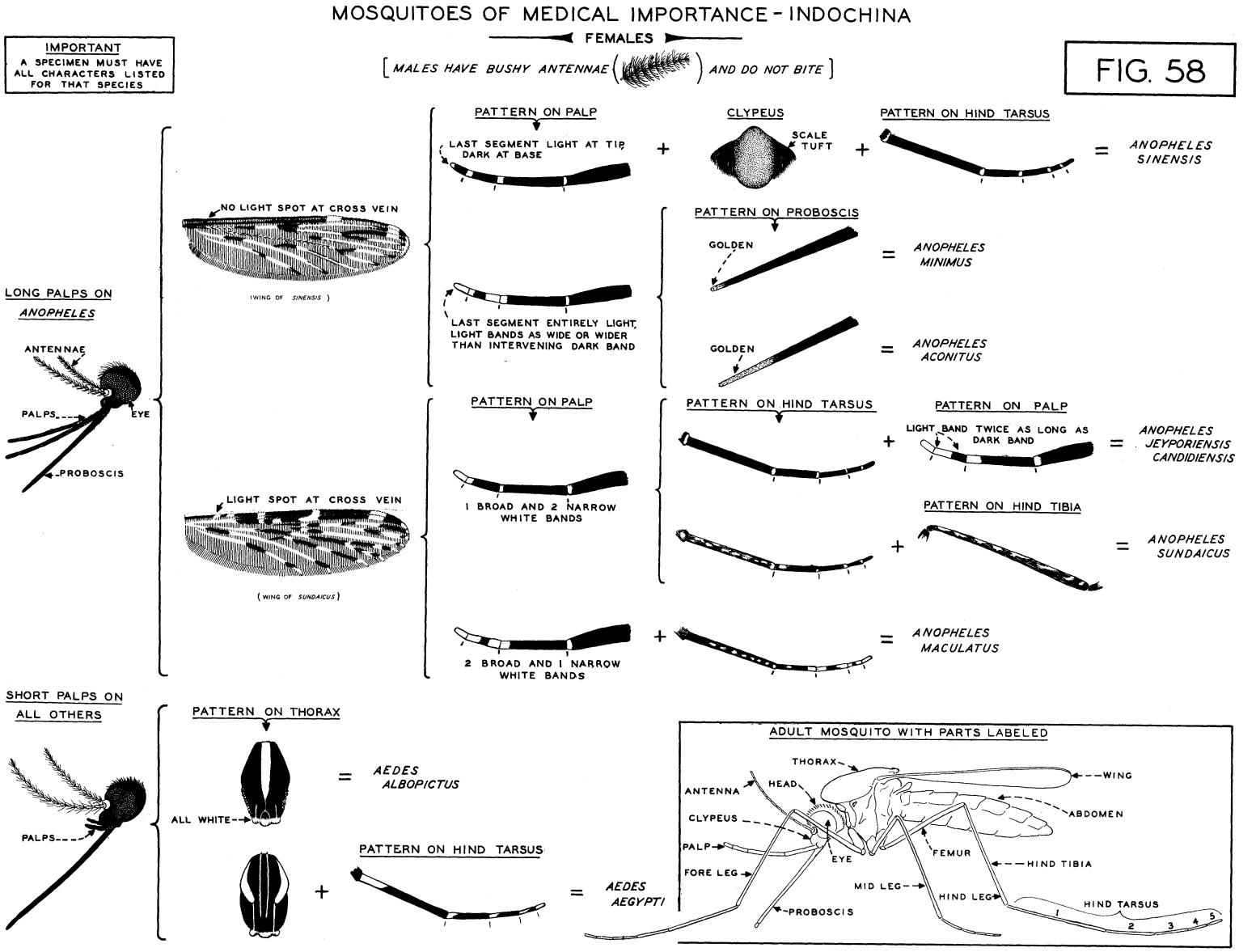
Anopheles maculatus, a third species associated with foothill habitats, breeds in a wide variety of water collections, but, like *candidiensis*, it appears to be zoophilic except when conditions are unfavorable. The females then attack man readily and have been found highly infected in nature, especially in Tonkin. This species is present in large numbers in newly cleared jungle areas.

Another less important type of malaria is of low endemicity, with occasional epidemic outbreaks. This occurs in the extensive ricegrowing areas of Tonkin in the north and Cochin China and Cambodia in the south. It is transmitted chiefly by *Anopheles sinensis*. With the clearing and cultivation of lowland jungles, this mosquito often appears in tremendous numbers. Its importance apparently depends on its large populations, since it is usually found with relatively low natural infection rates in Indochina and is chiefly zoophilic, except where animals and livestock are not present in large enough numbers to support it. Refugees from foothill areas of Tonkin have brought a great deal of malaria to the delta areas, where *sinensis* can transmit it.

Anopheles aconitus has variable breeding habits but is found most often in ricefields and fresh-water ponds in mountain and plains areas. It has been strongly suspected as a vector in southern Annam. However, in Tonkin, Cochin China, and Cambodia its importance is unpredictable and it is regarded as a secondary vector.

With few exceptions *Anopheles sundaicus* breeds only in brackish water and is restricted to the southern coast of Indochina, where it is found in lagoons, swamps, and salt-water fishponds. It is of less importance than the foregoing species because of its restricted distribution and its less definite anthropophilism, but it transmits coastal malaria, which seldom occurs except in occasional small epidemics.

References: *67, 68, 277, 310.*



DN—1315

Anopheles Species in Indochina

**aconitus*
aitkenii aitkenii
aitkenii bengalensis
alongensis
annandalei annandalei
annandalei interruptus
†annularis
†baezai
†barbirostris barbirostris
barbumbrosus
†culicifacies
†fluviatilis
gigas baileyi
jamesii
**jeyporiensis candidiensis*
jeyporiensis jeyporiensis
karwari
†kochi
†leucosphyrus
lindesayi
litoralis
**maculatus*
maculipalpis
**minimus*
†nigerrimus
pallidus
†philippinensis
**sinensis*
splendidus
†stephensi
†subpictus
**sundaicus*
†tessellatus
†umbrosus
vagus vagus
†varuna

See footnote 8, p. 63.

Yellow Fever.—This disease is not present in Indochina.

Reference: *256*.

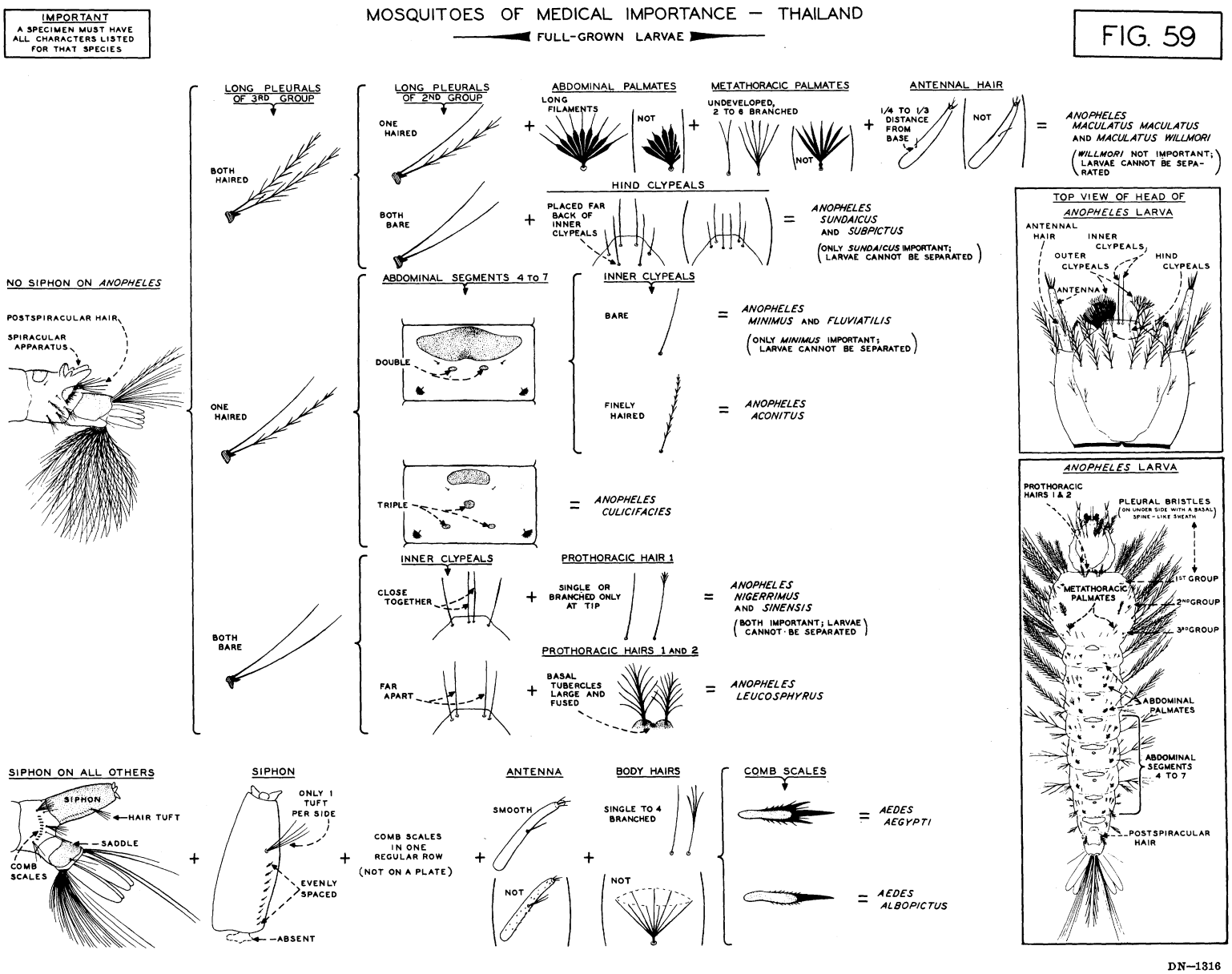
Dengue.—This disease occurs throughout Indochina, having first appeared in 1870 at Haiphong and afterward at Hanoi and Saigon, all in rather direct contact with ocean traffic. Both urban *Aedes aegypti* and the slightly wilder *A. albopictus* are extensively distributed throughout Indochina and are responsible for the transmission of this disease.

References: *256, 287, 310*.

Encephalitis.—A virus very closely resembling that of Japanese encephalitis has been recently isolated from 98 French soldiers in the vicinity of Tonkin. Its identity with the Japanese type is not yet absolutely certain, nor have studies been completed to determine its vector. Antibodies to Japanese encephalitis virus have been found in human sera at Hanoi.

References: *257, 278*.

Filariasis.—The principal medical problem due to filariasis in Indochina occurs in the Red River Delta of Tonkin. Filariasis was first found there in 1939, and both *Wuchereria bancrofti* and *W. malayi* were eventually found to be prevalent, not only in low land but in higher areas. Natural infections with infective stages of the parasites have been



found in *Anopheles minimus*, *A. jeyporiensis*, *A. vagus*, *A. maculatus*, *A. sinensis*, *Culex pipiens quinquefasciatus*, *Mansonia uniformis*, *M. indiana*, and *M. annulifera*.

In the low areas of Tonkin *sinensis* transmits both *bancrofti* and *malayi*, especially in areas where there are no cattle. In higher areas *sinensis* is diverted from man by these animals and is not so effective a vector. In many of the low areas *sinensis* is a more important vector of *bancrofti* than *quinquefasciatus*, and it is an important vector of *malayi* in areas where *Mansonia* species are absent. In delta areas *indiana* predominates, especially in the vicinity of Hanoi, where larvae are most commonly found on submerged stems of *Eichhornia crassipes* and *Salvinia rotundifolia*, rarely on *Pistia*. *M. uniformis* is rare, and *indiana* is probably not a vector of outstanding importance. Not much is known of the distribution of filariasis in the remaining parts of Indochina. In Cambodia *annulifera* is the most common and probably the most important *Mansonia* species, and in Cochin China *indiana* is absent, *annulifera* is rare, and *uniformis* is the most common important vector.

References: *135–139, 328.*

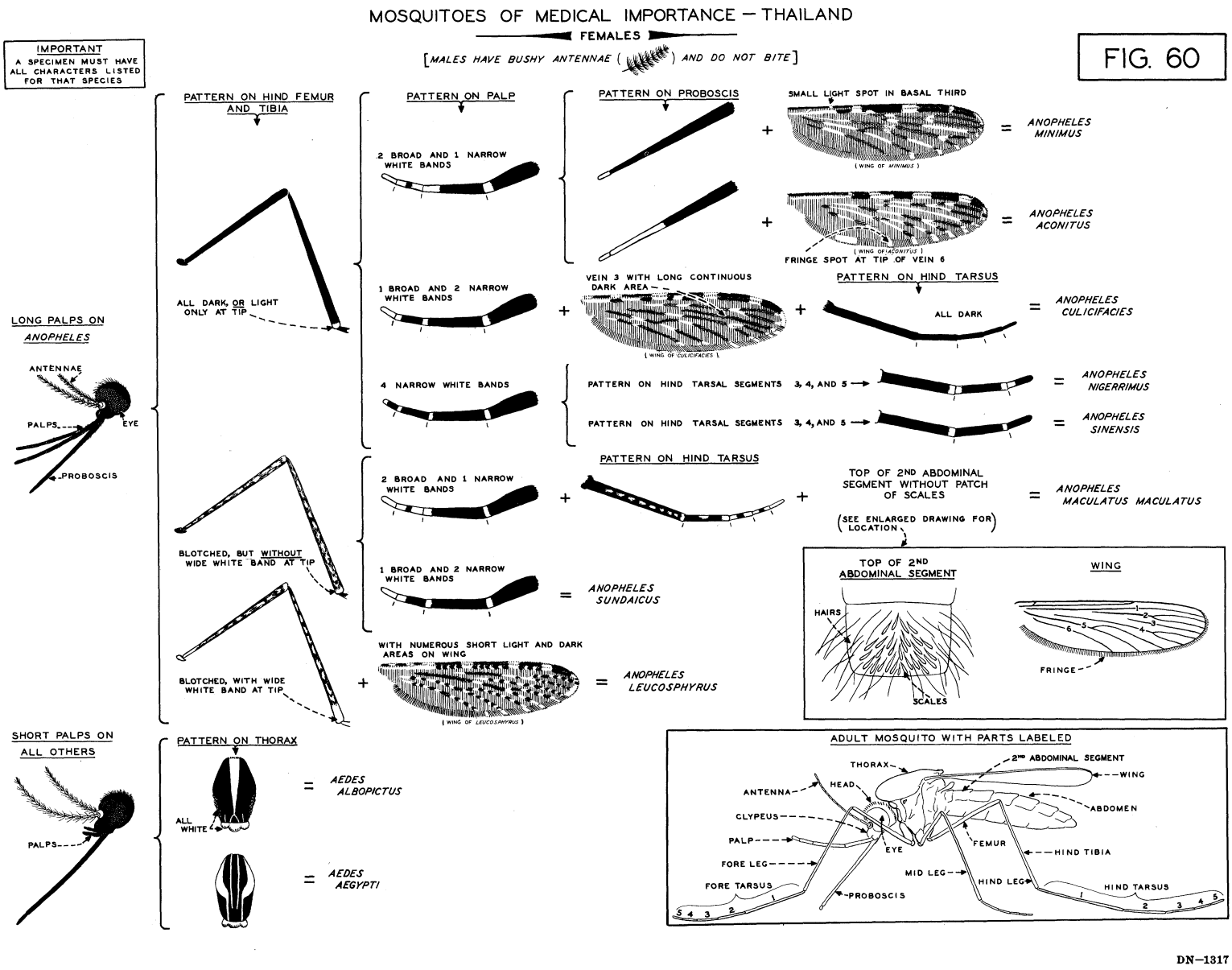
Thailand

(Figs. 59 and 60)

Physical Features.—Situated between Indochina and Burma in southeast Asia, Thailand (Siam) extends in a narrow southern peninsula to the northern border of Malaya. Geographically the country is divided into (1) the northern highlands, consisting of rather parallel, deeply forested limestone ranges with deep valleys; (2) the densely settled, west-central flood plain of the important Chao Phraya River, containing the important rice-producing areas; (3) the eastern Korat Plateau, devoted mainly to stockraising and separated from the western alluvial plain by a central mountain range; and (4) the southern peninsular area, which is largely mountainous and mineral bearing.

The central mountain range divides the northeast coast, with its October-to-February rainy season, from the west coast, which has maximum rainfall from May to October. The latter is brought by monsoons from the southwest, and a cool, dry season from October to February is caused by monsoons from the northeast. A hot, dry season generally lasts from March to May.

Reference: *301.*



Malaria.—The most important malaria problem is in the foothills throughout Thailand. Blackwater fever caused by *Plasmodium falciparum* is hyperendemic in much of this region; *P. vivax* malaria also occurs but is not so abundant or important.

Although the mountains of the south are highly malarious, they are less so than those on the Burma frontier in the northwest. A large part of this foothill malaria is maintained by *Anopheles minimus*. As in many other parts of southeast Asia this mosquito breeds at the margins of clear fresh-water streams and at the clear edges of larger water collections. The adults are highly anthropophilic and are constantly found in close association with man.

Anopheles sundaicus is responsible for a low endemic malaria along the coasts of southern Indochina, Malaya, and Burma, and probably coastal Thailand is also included.

The other species of *Anopheles* treated in the keys have never been definitely associated with malaria as a result of field studies in Thailand. They are included because (1) they are proved transmitters in countries bordering Thailand, and (2) they are present in Thailand, and under certain conditions one or more of them would have to be seriously considered in any malaria-control project.

Anopheles culicifacies, the most important vector of malaria in India and one of the most important in Burma, is present over the northwestern half of Thailand. The larvae live in many kinds of water collections, and the females bite both man and animals. The species may be a secondary vector.

Anopheles leucosphyrus is distributed throughout Burma and Assam, where it is associated with forests, and it has been implicated as a vector in northern Burma. It is not regarded as an important mosquito in Thailand.

In Malaya and parts of the Greater Sundas *Anopheles maculatus maculatus* is an important malaria transmitter. Its range extends well into South China, where it has seldom been implicated as an actual vector. Its importance in Thailand has not been adequately studied.

Anopheles aconitus is present throughout southeastern Asia, and in Indochina it is regarded as an important species. Some evidence indicates that it may contribute to the spread of malaria in Thailand. This species varies from locality to locality in its ability to transmit the disease.

Anopheles sinensis and *A. nigerrimus* have not been thoroughly investigated. *A. sinensis* is the important vector in central and northern China, but to the south its importance becomes less, whereas that of its close relative, *nigerrimus*,

becomes greater. Both species are found in large bodies of water and may be important in the ricegrowing areas of central Thailand.

References: *67, 122, 310.*

Anopheles Species in Thailand

**aconitus*
aitkenii
albotaeniatus
annandalei interruptus
†annularis
argyropus
baezai
†barbirostris
barbumbrosus
bulkleyi
**culicifacies*
†filipinae
†fluviatilis
gigas formosus
gigas sumatrana
indiensis
insulaeflorum
†jeyporiensis candidiensis
karwari
†kochi
**leucosphyrus*
ludlowi (fresh-water form)
**maculatus maculatus*
majidi
**minimus*
**nigerrimus*
pallidus
palmatus
peditaeniatus
†philippinensis
ramsayi
separatus
**sinensis*
splendidus
†stephensi
subpictus malayensis
†subpictus subpictus
**sundaicus*
tessellatus
†umbrosus
vagus
†varuna

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Thailand.

Reference: *256.*

Dengue.—In the past dengue has occurred in annual epidemics in southern and eastern Thailand, but the extent of these outbreaks is not known. A number of cases are reported annually elsewhere in this country. *Aedes aegypti* and *A. albopictus* are distributed extensively throughout the country, the former being the most urban of the Thailand culicines and the latter occurring in more rural locations.

References: *256, 310.*

Encephalitis.—Japanese encephalitis virus has been reported from the southern half of Thailand, but its vector there is not known with certainty.

Reference: *257.*

Filariasis.—This disease is endemic only on the western side of Thailand's southern peninsula between the Indian Ocean and the South China Sea. It is almost exclusively rural and is caused by *Wuchereria malayi.* The vectors are the *Mansonia* species that normally transmit *malayi* over most of the Orient and are *annulifera, longipalpis, uniformis,* and *indiana. Wuchereria bancrofti,* although not indigenous to Thailand, is constantly being introduced and may be transmitted by *Culex pipiens quinquefasciatus,* which is abundant.

Reference: *196.*

Malaya

(Figs. 61 and 62)

Physical Features.—Malaya, which is also known as British Malaya, is located at the southern tip of the Malay Peninsula and borders Thailand at about latitude 6° N. It is the southernmost part of Asia and is separated from Sumatra by a narrow strait. The mountainous backbone of the peninsula, with peaks over 7,000 feet, extends well into Malaya from the north. Much of the west coast consists of mangrove and mud flats. Large amounts of rice are grown between the coast and the mountains and in the north-central part. The east coast is largely rough and sandy. About 80 percent of the land is covered by jungle. Johore State in the south is rather flat and covered by jungle, with occasional low mountain peaks of about 3,000 feet. Singapore is an island at the southern tip of the peninsula. Its west and north coasts are covered with mangrove, and its east coast consists largely of cliffs. It is principally agricultural.

In Malaya the annual rainfall averages 100 inches in the plains and over 200 inches in the hills. Northeast and southwest monsoons slightly determine the wet and dry seasons.

Reference: *301.*

Malaria.—*Plasmodium falciparum* malaria predominates almost everywhere in Malaya. It accounts for the high death rates in this country.

Malaria occurs in Malaya throughout the year, with a gradual increase through the summer and autumn. It is particularly intense along parts of the west coast in Selangor in sunlit breeding places, where mangrove, which is usually effective in the prevention of *Anopheles sundaicus* breeding, has been cut away. Embankments and roads impede the flow of tides, and the resulting collections of brackish water support heavy *sundaicus* breeding. The distribution of this species, one of the most important vectors in Malaya, is patchy. There are large areas where conditions are favorable for breeding but where the species is not present at all.

The foothills of Malaya are highly malarious, and although *Anopheles minimus*, the foothill vector in most of southeast Asia, is present in extreme northwest Malaya, it contributes little to maintaining the disease in Malaya.

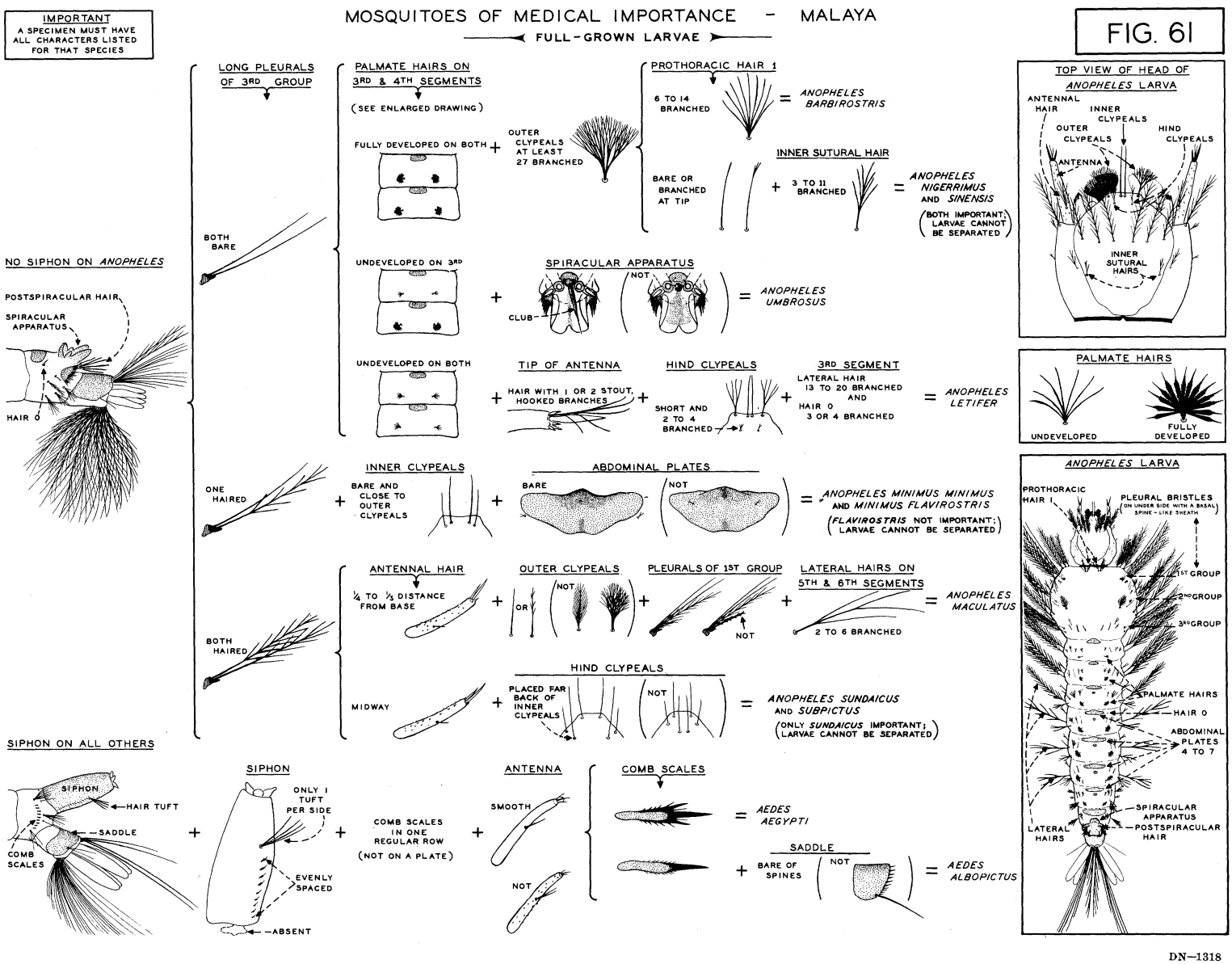
On the other hand, *Anopheles maculatus*, which occurs in almost all hilly areas from the coast to 5,000 feet, is more important. Like *minimus*, this species breeds in sunlit, clear, oxygen-rich water. It has been found with extremely high natural infection rates, although in certain areas it may be primarily zoophilic. It tends to invade the foothill areas that have been cleared of jungle.

Anopheles umbrosus transmits a large amount of malaria, especially along the densely vegetated west coast. This mosquito breeds almost entirely in the vicinity of jungle swamps. In localities where it is present with its close relative, *Anopheles letifer*, especially at the edges of jungle areas, it is extremely important. Since *letifer* lives in cultivated lowland areas close to but not within the jungle, it transmits much of Malaya's malaria in clearings where man has established plantations.

A dark-winged form of *Anopheles barbirostris* has been found with extremely high infection rates in the vicinity of the Kinta River swamps, where it is believed to contribute materially to the epidemiology of malaria, although it is not normally important unless appearing in extremely large numbers.

The records of *Anopheles sinensis* and *A. nigerrimus* in Malaya are confused. Both are vectors in various parts of Asia and both have been implicated as vectors at Kuala Lumpur. Because of its generally greater abundance in Malaya, *nigerrimus* is probably the more important of the two. Both species breed in large swamps and are presumably vectors of malaria in the ricegrowing areas.

References: *122, 272, 284, 296, 310, 357.*



DN—1318

Anopheles Species in Malaya

†*aconitus*
aitkenii aitkenii
aitkenii bengalensis
aitkenii stantoni
albotaeniatus
†*annularis*
argyropus
asiaticus
aurirostris
†*baezai*
balabacensis introlatus
**barbirostris*
barbumbrosus
brevipalpis
brevirostris
crawfordi
gigas sumatrana
hunteri
karwari
†*kochi*
lesteri
**letifer*
†*leucosphyrus hackeri*
†*leucosphyrus leucosphyrus*
leucosphyrus pujutensis
leucosphyrus riparis
lindesayi cameronensis
ludlowi
**maculatus*
**minimus*
montanus
**nigerrimus*
pallidus
peditaeniatus
†*philippinensis*
ramsayi
riparus macarthuri
roperi
separatus
similissimus
**sinensis*
†*subpictus malayensis*
†*subpictus subpictus*
**sundaicus*
†*tessellatus*
**umbrosus*
vagus
watsonii
wellingtonianus

See footnote 6, p. 10.

Yellow Fever.—This disease is not present in Malaya.

Reference: *256.*

Dengue.—This disease is endemic and epidemic in Malaya. Both *Aedes aegypti* and *A. albopictus* are vectors. The former is an almost strictly urban mosquito and the latter not only is urban but also breeds in rubber and coconut plantations, being more habitually an outdoor mosquito than *aegypti.*

References: *256, 310, 357.*

Encephalitis.—The virus of Japanese encephalitis has been isolated from four fatalities occurring among British troops and natives in Malayan jungles and in the island of Singapore. Although the vector is not known, the nonepidemic nature of these cases implicates an arthropod that normally transmits the disease from one animal or bird to another and that may infect man entirely by chance. The pres-

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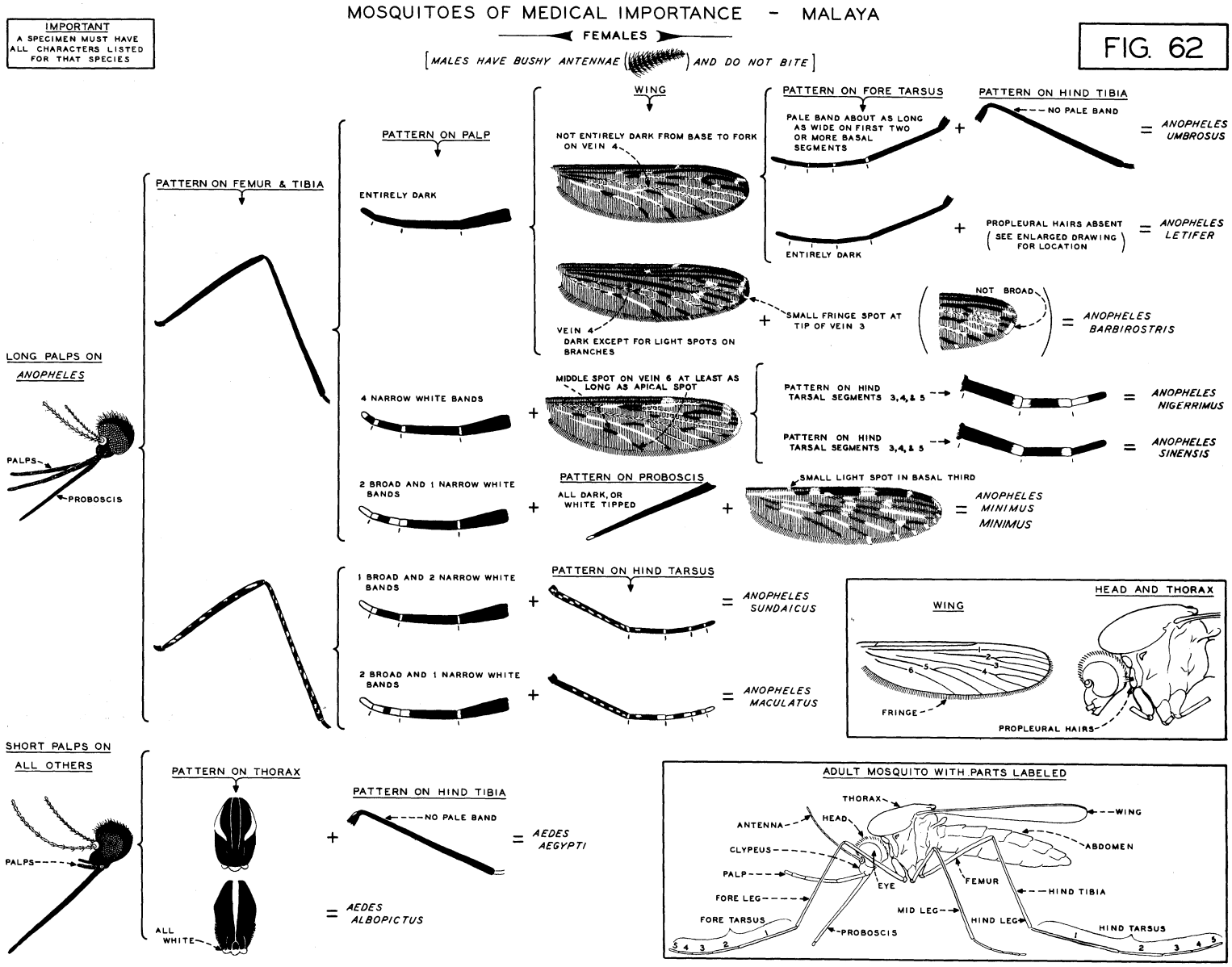


ence of dengue may complicate the exact identification of this virus in Malaya.

References: *153, 257.*

Filariasis.—*Wuchereria malayi* is the most common cause of filariasis and elephantiasis in Malaya. Filariasis is common along the northern half of the western coastal strip and in the northwest corner of Malaya but is absent from the coastal villages. Villagers who live on sandbanks intersecting various ricefield areas are especially prone to infections. In these areas *Mansonia longipalpis* is the most important vector, since it is found in far greater numbers and with much higher percentages of infection than any other *Mansonia* species. The larvae of this mosquito are often found attached to floating roots of swamp trees in this area.

References: *165, 275, 315.*

Sunda Islands

(Figs. 63 and 64)

The Sunda Islands include the Greater Sundas, consisting of Sumatra, Borneo, Celebes, and Java, and the Lesser Sundas, consisting of Bali, Lombok, Soembawa, Soemba, Flores, Timor, and the Solor and Alor Islands. The Sunda Islands comprise the eastern extension of the Malay Archipelago.

SUMATRA

Physical Features.—Sumatra, about 1,100 miles long and 280 miles wide, lies south and west of Malaya and is fringed with numerous islets. The west coast is lined with a chain of volcanic mountains, the Barisans, which divide the narrow western littoral from the swampy, flat, interior plain. Much of this plain is impenetrable forest, which has high temperatures and rainfall that ranges from about 75 inches annually in the east to over 155 inches in the west. The two rainy seasons are brought by a northwest monsoon from December to March and a southeast monsoon from May to October.

References: *121, 301.*

Malaria.—The northeast coast of Sumatra is the only area free of malaria in this island because of the mangrove. All other coastal districts are highly malarious, partly because of *Anopheles sundaicus*. This mosquito is a brackish-water breeder that transmits malaria efficiently and causes occasional epidemics, especially on the southwest coast. A freshwater form of *sundaicus* breeds in fishponds in the long

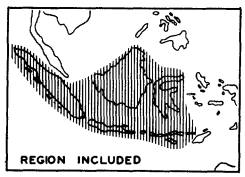
MOSQUITOES OF MEDICAL IMPORTANCE — SUNDA ISLANDS

[AREA INCLUDED: SUMATRA, BORNEO, CELEBES, JAVA, AND THE LESSER SUNDAS]

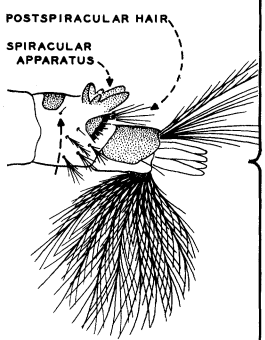
FULL-GROWN LARVAE

FIG. 63

IMPORTANT
A SPECIMEN MUST HAVE ALL CHARACTERS LISTED FOR THAT SPECIES

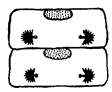


NO SIPHON ON *ANOPHELES*

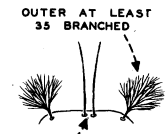


LONG PLEURALS OF 3RD GROUP

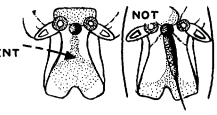
PALMATE HAIRS ON 3RD AND 4TH SEGMENTS (SEE ENLARGED DRAWING)



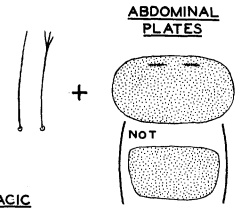
CLYPEALS



PROTHORACIC HAIR 1

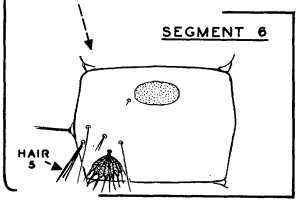


= *ANOPHELES BARBIROSTRIS*

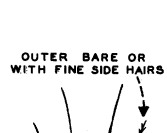


HAIR 5 ON 6TH SEGMENT SIX TO ELEVEN BRANCHED = *ANOPHELES SINENSIS*

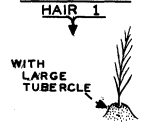
HAIR 5 ON 6TH SEGMENT TWO TO FIVE BRANCHED = *ANOPHELES NIGERRIMUS*



CLYPEALS



PROTHORACIC HAIR 1

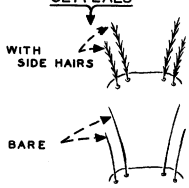


= *ANOPHELES LEUCOSPHYRUS*

= *ANOPHELES KOCHI*

ONE HAIRED

CLYPEALS

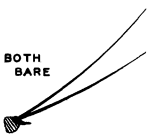


= *ANOPHELES ACONITUS*

= *ANOPHELES MINIMUS*

BOTH HAIRED

LONG PLEURALS OF 2ND GROUP



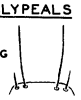
PALMATE HAIRS ON 1ST SEGMENT

POSTSPIRACULARS

= *ANOPHELES SUBPICTUS SUBPICTUS*

= *ANOPHELES SUNDAICUS*

OUTER CLYPEALS

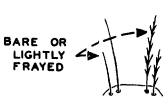


= *ANOPHELES LUDLOWI* AND *LITORALIS*

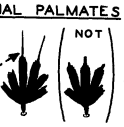
(ONLY *LUDLOWI* IMPORTANT; LARVAE CANNOT BE SEPARATED)

ONE HAIRED

CLYPEALS

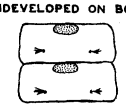


ABDOMINAL PALMATES



= *ANOPHELES MACULATUS*

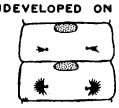
UNDEVELOPED ON BOTH



+ TIP OF ANTENNA: HAIR WITH 1 OR 2 STOUT, HOOKED BRANCHES + HIND CLYPEALS: SHORT AND 2 TO 4 BRANCHED + 3RD SEGMENT: LATERAL HAIR 13 TO 20 BRANCHED AND HAIR 0 3 OR 4 BRANCHED

= *ANOPHELES LETIFER*

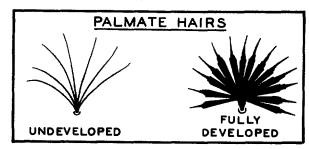
UNDEVELOPED ON 3RD

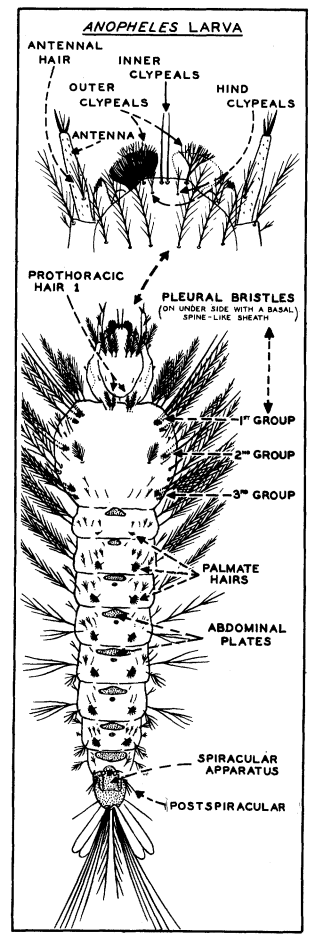


+ SPIRACULAR APPARATUS: CLUB PRESENT / NOT

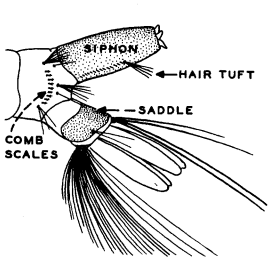
= *ANOPHELES UMBROSUS*

PALMATE HAIRS





SIPHON ON ALL OTHERS

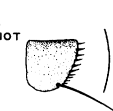


+ SIPHON: ONLY 1 TUFT PER SIDE / EVENLY SPACED / ABSENT + COMB SCALES IN ONE REGULAR ROW (NOT ON A PLATE) + ANTENNA: SMOOTH / NOT

COMB SCALES

= *AEDES AEGYPTI*

+ SADDLE: BARE OF SPINES / NOT



= *AEDES ALBOPICTUS*

MOSQUITOES OF MEDICAL IMPORTANCE — SUNDA ISLANDS

[AREA INCLUDED: SUMATRA, BORNEO, CELEBES, JAVA, AND THE LESSER SUNDAS]

FIG. 64

IMPORTANT
MUST HAVE
ERS LISTED
FOR THAT SPECIES

FEMALES

[MALES HAVE BUSHY ANTENNAE ( ) AND DO NOT BITE]

LONG PALPS ON *ANOPHELES*

ANTENNAE
PALPS
EYE
PROBOSCIS

PATTERN ON HIND FEMUR AND TIBIA

(SOMETIMES ABSENT)

PATTERN ON HIND TARSAL SEGMENTS 4 AND 5

ABDOMINAL SEGMENT 7

TUFT OF SCALES ON UNDER SIDE

NO TUFT OF SCALES ON UNDER SIDE

(WING OF *SINENSIS*)
CLOSE TOGETHER; NO SCATTERED DARK SCALES PRESENT ON VEINS 5 AND 6
+ WIDE LIGHT SPOT IN FRINGE AT TIP = *ANOPHELES SINENSIS*

(WING OF *NIGERRIMUS*)
FAR APART; NO SCATTERED DARK SCALES PRESENT ON VEINS 5 AND 6
+ HIND TARSAL SEGMENT 4 (SPOT AT BASE VERY NARROW) = *ANOPHELES NIGERRIMUS*

(WING OF *BARBIROSTRIS*)
FAR APART; SCATTERED DARK SCALES PRESENT ON VEINS 5 AND 6
+ LIGHT SPOT IN FRINGE AT TIP OF VEIN 3 VERY NARROW = *ANOPHELES BARBIROSTRIS*

PATTERN ON FORE TARSUS = *ANOPHELES SUBPICTUS SUBPICTUS*

+ PATTERN ON HIND TIBIA (NO PALE BAND) = *ANOPHELES UMBROSUS*

+ PROPLEURAL HAIRS ABSENT (SEE ENLARGED DRAWING FOR LOCATION) = *ANOPHELES LETIFER*

(WING OF *ACONITUS*)
LIGHT SPOT
= *ANOPHELES ACONITUS*

(WING OF *MINIMUS*)
NO LIGHT SPOT
= *ANOPHELES MINIMUS*

BLOTCHED

PATTERN ON HIND TARSAL SEGMENTS 4 AND 5 + PATTERN ON PALP

ONE LIGHT SPOT ON VEIN 1 = *ANOPHELES SUNDAICUS* AND *LITORALIS* (ONLY *SUNDAICUS* IMPORTANT; ADULTS CANNOT BE SEPARATED)
(WING OF *SUNDAICUS*)

TWO LIGHT SPOTS ON VEIN 1 = *ANOPHELES LUDLOWI* AND *PARANGENSIS* (ONLY *LUDLOWI* IMPORTANT; ADULTS CANNOT BE SEPARATED)
(WING OF *LUDLOWI*)

+ = *ANOPHELES LEUCOSPHYRUS*
(WING OF *LEUCOSPHYRUS*)

= *ANOPHELES KOCHI*

= *ANOPHELES MACULATUS*

WING
VEIN 1
FRINGE
HEAD AND THORAX
PROPLEURAL HAIRS

SHORT PALPS ON ALL OTHERS

PALPS

PATTERN ON THORAX + PATTERN ON HIND TIBIA (NO PALE BAND) = *AEDES AEGYPTI*

+ ALL WHITE = *AEDES ALBOPICTUS*

ADULT MOSQUITO WITH PARTS LABELED

THORAX
WING
HEAD
ANTENNA
ABDOMEN
CLYPEUS
PALP
EYE
FEMUR
HIND TIBIA
FORE LEG
MID LEG
HIND LEG
FORE TARSUS
HIND TARSUS
PROBOSCIS

DN-1321

mountain valleys of the Barisans near Lake Toba and occasionally in flooded ricefields after harvest. Its medical importance is not exactly known.

Anopheles kochi is abundant in Sumatra. Natural infections in this species range from 0 to as high as 11.5 percent but are generally low.

Although *Anopheles leucosphyrus* (subspecies not known) has been found with low natural infection rates in east and south Sumatra, this mosquito is neither common nor important except in "Soendetar" in western Sumatra, where it is present in large numbers in December and January and is definitely a vector.

Anopheles maculatus and *A. minimus* (subspecies not known) transmit malaria in the foothills, but the disease in the mountains has not been thoroughly studied. The former mosquito appears as high as 3,200 feet. It is usually found with low infection rates. *A. minimus* breeds at the edges of foothill streams and is of little importance in the island.

Anopheles barbirostris is present throughout Sumatra. Its natural infection rates are always low, and it is only occasionally important as a vector there.

Anopheles aconitus is abundant in ricefields but is a dangerous vector only at Tapanuli on the east coast and in "Djihara" in the south.

Anopheles umbrosus and *A. letifer* are vectors in Malaya and may support a certain amount of malaria in Sumatra, having been found with low infection rates.

The role of *Anopheles subpictus subpictus* as a vector is not known with certainty, since it commonly appears with other important species, especially *sundaicus*. When *subpictus* is involved in an epidemic, it is always of secondary importance, becoming infected later than the principal vector. It almost always has low infection rates.

Anopheles sinensis and *A. nigerrimus* have been recorded from the island, but records of their medical importance have been confused with each other to such an extent that their respective roles are not known with certainty. Both have been found naturally infected in ricefields of the alluvial plains, but infection rates have been rather low.

The distribution of *Anopheles ludlowi* and its subspecies is not known with certainty in Sumatra, nor has its role in malaria transmission been determined.

References: *121, 122, 284, 301.*

BORNEO

Physical Features.—Borneo, which is the largest of the Greater Sundas, lies north of Java and Bali and southwest of the Philippines. Centered in the island are densely forested mountains rising in peaks to 13,000 feet in the north, and along the south and southwest coasts are extensive swamps. A prolonged monsoon season brings rainfall exceeding 100 inches per year, but in a very few localities there is a sharp distinction between wet and dry seasons. Seasonal variation in temperature is negligible.

References: *121, 301.*

Malaria.—*Anopheles leucosphyrus balabacensis* is present wherever there is jungle shade. It is the most widely distributed of all anophelines and has been found naturally infected in every part of the island.

Both *Anopheles umbrosus* and *A. letifer* are widely distributed and naturally infected in North Borneo, Sarawak, and Brunei and are believed to contribute greatly to the maintenance of endemic malaria.

The distribution of *Anopheles sundaicus* in Borneo is not well known. It is believed to be present at least as far north as Miri in Sarawak and has been found in many malaria-free areas in Borneo. Its coastal distribution is limited by mangrove swamps, which it avoids. It is believed to be more important in occasional epidemics than in the maintenance of widespread endemic malaria.

Anopheles subpictus subpictus has been reported from two localities on the southeast coast of Borneo, but further information about its distribution or role as a vector is not available. Although *Anopheles sinensis* and *A. nigerrimus* are widely distributed, there is little evidence of these species transmitting malaria in Borneo. Natural infections have been found in both species in the island, but more thorough investigations are needed regarding their relation to disease.

Anopheles maculatus, appearing chiefly in northern Borneo, Sarawak, Brunei, and Dutch Borneo, is not regarded as a vector of malaria there. It has often been found in malaria-free areas, is rarely infected in nature, and has a marked preference for animal blood. In the other Sunda Islands this species is regarded as one of the most important anophelines.

Anopheles barbirostris is probably unimportant in Borneo, although it is very common and widely distributed.

Anopheles minimus (subspecies not known), *A. aconitus*, and *A. kochi* are present in Borneo but apparently do not transmit malaria there.

The distribution of *Anopheles ludlowi* and its importance as a vector in Borneo are not known with certainty.

Anopheles baezai, an anthropophilic species occasionally found with natural infections, is a suspected vector in the Miri-Lutong and Kuala areas. It is not included in the keys because it is probably of little importance.

References: *96, 121, 244, 301.*

CELEBES

Physical Features.—Celebes, about 90 miles east of Borneo, is composed of a central area with four large peninsulas. Mountainous land in the south-central part of the island rises to over 11,000 feet. The highlands contain fertile valleys, rich grazing land, and lakes, whereas the interior is densely forested. A northeast monsoon provides heavy rainfall, the northern part of the island receiving about 100 inches and the southern part about 150 inches a year. The climate, in general, is hot and humid, usually between 70° and 90° F.

References: *121, 301.*

Malaria.—*Anopheles sundaicus*, the most important vector in Celebes, transmits malaria in a highly endemic form along the coast of the southern peninsula and the adjacent islands, on the part of the southern coast facing Kabaena and Muna, and in "Vuton," Salayar, and Djampea. This species is coastal, breeding in brackish fishponds, pools along the coast, and silted outlets.

Anopheles subpictus subpictus is also a coastal mosquito, but it is less selective than *sundaicus*, breeding in a large variety of fresh- and brackish-water sites. Natural infection rates are low, but it is the most prevalent anopheline on the west and south coasts of the southern peninsula, and because of its abundance it can be important in causing epidemics.

Anopheles ludlowi torakala, designated as *ludlowi* in the keys, is present near the coast and inland from the base to about the center of the southern peninsula, and along the western coast of the southeast peninsula. With infection rates of 2 to 3 percent, this species appears to be responsible for much of the inland malaria in Celebes. It is regarded as second only to *sundaicus* in importance in this area.

Anopheles barbirostris has been found in almost all localities in southern Celebes where collections have been made. Because this species is found in breeding places closely associated with man and is markedly anthropophilic, it is important where it appears in large numbers. It is regarded as the third most important vector in southern Celebes.

Anopheles nigerrimus, like the preceding species, is found throughout southern Celebes and breeds in ricefields and

fishponds close to man. When this species appears in large numbers, it can cause epidemics, but even when less abundant, it maintains a certain amount of endemic malaria.

Anopheles leucosphyrus hackeri appears near the southern coast of Celebes. The importance of this mosquito is not well known.

Anopheles minimus flavirostris, or a form similar to it, is common in the interior of northern Celebes, where it causes epidemics or supports endemic malaria. In southern Celebes it is too rare to be of much importance, although it has been found with high natural infection rates. Clarification of the status of *flavirostris* in Celebes must await further field study.

Five additional *Anopheles* species—*aconitus*, *maculatus*, *kochi*, *umbrosus*, and *sinensis*—are included in the keys, because they appear in Celebes and have definitely been implicated as vectors elsewhere. They probably are not important in this island because of their scarcity and lack of natural infections.

References: *121, 161, 301.*

JAVA AND THE LESSER SUNDAS

Physical Features.—The long narrow island of Java lies east and south of Sumatra. It contains almost 40 million people, less than 4 percent of whom live in cities, yet culturally, politically, and economically it is the most important of all the Sunda Islands. It has an east-west volcanic mountain range, with peaks as high as 12,000 feet. Western Java does not have a definite rainy season, but in eastern Java a west monsoon brings a distinct wet period, especially in the lowlands, from November to March.

The entire island chain of the Lesser Sundas has distinct mountain ranges. The climate is similar to that of Java. The highest temperatures and least cloudiness occur in October and November.

References: *121, 301.*

Malaria.—*Anopheles sundaicus* is responsible for extensive endemic malaria and occasional severe epidemics along the northern and southern coasts of Java and in coastal areas of the Lesser Sundas. Brackish-water lagoons are the principal breeding places in these localities. Very severe epidemics have been reported at Tanjungpriok in western Java. *A. sundaicus* has also been found in collections of fresh water in the vicinity of Semarang, Java, in brackish-river backwaters in the eastern part of the island, and in fresh-water fishponds in Bali. This is not the same fresh-water form found in Sumatra. It more closely resembles the salt-water *sundaicus* in British India and may be important in transmission.

Anopheles aconitus is almost as important as *sundaicus* in the transmission of malaria in ricegrowing areas of west Java, although it varies considerably in importance elsewhere.

Anopheles maculatus, a common and important vector near the tea plantations of Java, invades cleared areas where jungle has been cut away from banks of small streams. It is regarded as a vector of considerable importance in the Lesser Sundas.

Anopheles leucosphyrus (subspecies not known) may be an important transmitter in Java, but its exact role has not been adequately determined.

In an outbreak of malaria at Karangbinangun, Java, *Anopheles nigerrimus* was considered to be the principal vector. Natural infection rates in this mosquito are usually low, so that the species must be present in large numbers to be dangerous. Neither *nigerrimus* nor *Anopheles sinensis* appears in Java or the Lesser Sundas.

Anopheles umbrosus and *A. letifer* are present and have been found with low infection rates. They are important in other parts of their range but have been inadequately studied in this area.

Anopheles subpictus subpictus is more common in Java and the Lesser Sundas than elsewhere. Its role in endemic and epidemic malaria in this area is not well understood, because it is found with other vectors, but it is undoubtedly a vector of some importance.

A form similar to *Anopheles minimus flavirostris* has been recorded as a vector in the area, but its actual importance is not known with certainty. Since *flavirostris* is easily confused with *aconitus*, the records of these two mosquitoes may have been confused.

Although both *Anopheles kochi* and *A. barbirostris* are present in Java and the Lesser Sundas, they are important only in restricted areas.

The presence of *Anopheles ludlowi* in Java and the Lesser Sundas is doubtful.

References: *121, 284, 301.*

Most of the malaria cases throughout the Sunda Islands are caused by either *Plasmodium vivax* or *P. falciparum*. The distribution of *Plasmodium malariae* is sporadic and is apparently limited to Sumatra and Java.

Anopheles Species in the Sunda Islands

**aconitus*
aitkenii aitkenii
aitkenii bengalensis
aitkenii borneensis
aitkenii stantoni
aitkenii treacheri
albotaeniatus
annandalei annandalei
annandalei djajasanensis
†annularis
argyropus
baezai
†bancrofti bancrofti
bancrofti barbiventris
**barbirostris*
barbumbrosus
brevipalpis
crawfordi
errabundus
gigas crockeri
gigas danaubento
gigas gigas
gigas oedjalikalahensis
gigas sumatrana
hunteri
indiensis
insulaeflorum
jamesii
karwari
**kochi*
lesteri
**letifer*
**leucosphyrus* (subspecies not known)
**leucosphyrus balabacensis*
**leucosphyrus hackeri*
litoralis
ludlowi flavescens
**ludlowi torakala*
**maculatus*
**minimus* (subspecies not known)
**minimus flavirostris*
**nigerrimus*
pallidus
palmatus
parangensis
peditaeniatus
†philippinensis
pseudobarbirostris
ramsayi
riparus macarthuri
roperi
saungi
schueffneri
similissimus
**sinensis*
stookesi
subpictus indefinitus
subpictus malayensis
**subpictus subpictus*
**sundaicus*
tessellatus kalawara
†tessellatus orientalis
tessellatus tessellatus
**umbrosus*
vagus albino
vagus limosus
vagus vagus
vanus

See footnote 8, p. 63.

Yellow Fever.—This disease is not present in the Sunda Islands.

Reference: *256.*

Dengue.—*Aedes aegypti* and *A. albopictus* are found throughout the Sunda Islands. Both species are proved vectors of dengue. The exact distribution of the disease within the Sundas is not known, although these islands comprise one of its main endemic centers. *A. albopictus* females,

which were infected with dengue by feeding on infected persons in Sumatra, have experimentally transmitted the disease to persons in Holland known to be previously uninfected. Thus a definite link has been demonstrated between the disease and this species in Sumatra.

References: *122, 256, 312.*

Encephalitis.—The virus of Japanese encephalitis has been reported from Java and the eastern coastal areas of Sumatra, but its distribution and intensity are not well known. There have been no confirmed human cases in these two islands. Human cases have been reported from British North Borneo. Little is known of the epidemiology of this disease in the Sunda Islands.

Reference: *257.*

Filariasis.—*Wuchereria malayi* probably is found throughout the Sundas. *Wuchereria bancrofti*, sporadic in the western part of the island chain, is more common on the eastern end. Both parasite species have been recorded from the northern end of Sumatra; *malayi* is common and widespread and *bancrofti* sporadic in the southern third. In Timor, southeast Borneo, and most of Celebes *malayi* predominates. *W. bancrofti* is sporadic in the last two islands. The "Serajoe" Delta of south-central Java is an endemic area for *malayi*, but elsewhere in this island filariasis is sporadic. The disease apparently does not occur in Bali, Lombok, and Soembawa, but in all the islands of the eastern Lesser Sundas it is highly endemic, with both parasite species present.

Little is actually known of the relative importance of the vectors. *Mansonia uniformis*, *M. indiana*, *M. longipalpis*, and *M. annulifera* are the important vectors of *malayi* in the Sundas. *Anopheles barbirostris* is an efficient vector of *malayi* in Java and Celebes, and *A. nigerrimus* is an important vector of that parasite at "Martapoera," Java. *Culex pipiens quinquefasciatus* is believed to be the only important vector of *bancrofti* in the Sundas.

Reference: *121.*

Philippine Islands

(Figs. 65 and 66)

Physical Features.—The Philippines consist of about 7,000 islands, which are the higher portions of partly submerged volcanic mountains. Over 4,000 of these are unnamed, and only 463 are over 1 square mile in area. The larger islands have extensive ricefields; sugarcane, tobacco, and pineapple are other important crops.

The lowlands are warm and humid, with mean daily temperatures of about 80° F. and up to 250 inches of rain annually, but the mountainous areas in the larger islands have a rather temperate climate. A northeast monsoon brings rain to the eastern coasts of the northern islands, and a southwest monsoon causes a rainy season on their west coasts. The southernmost islands have an even distribution of rain throughout the year.

Reference: *301.*

Malaria.—Little is known about the distribution of the *Plasmodium* species in this region.

This disease has never been so important in the Philippines as in Asia, presumably because of the habits of the principal vector *Anopheles minimus flavirostris*. This mosquito breeds along the banks of fresh-water streams and other collections of water in foothill areas. Endemic malaria is more or less confined to areas roughly corresponding to the distribution of *flavirostris*. This mosquito has a pronounced preference for the blood of livestock. It rarely rests inside houses for any length of time. The disease is most prevalent at the beginning and end of the rainy season, when streams are at a favorable height to support mosquito breeding. Flat coastal areas are relatively free of malaria because of the rarity of vectors, especially *Anopheles sundaicus*, and in areas other than the foothills malaria is rarely found.

Two close relatives of *flavirostris*, *Anopheles mangyanus* and *A. filipinae*, also are present in the Philippines and doubtlessly are important in malaria transmission. The former, like *flavirostris*, breeds in clear, slowly running water in foothill areas at altitudes not exceeding 2,000 feet. The larvae are found in both shaded and sunlit locations. The importance of this species in malaria transmission is not yet entirely clear, since little is known of the biting habits of the adults and since early records of infections may be confused with those of *flavirostris*.

The other species, *filipinae*, breeds in either sunny or shaded, clear or muddy water in rivers, flowing water in irrigation ditches, and in pools and lakes. This mosquito may be a vector of malaria in the Philippines, where it has been found in large numbers in northern Luzon in the presence of abundant malaria. It is the least common of the *Anopheles* species so far mentioned.

Neither *Anopheles maculatus* nor *A. leucosphyrus* is known to transmit malaria in the Philippines. The former breeds in a variety of places at altitudes up to 5,000 feet and is included in the keys because of its potential importance in these islands, since it is a dangerous vector in Malaya and certain parts of Indonesia. However, epidemiological investigations indicate that not all foothill malaria is borne by *flavirostris* and that *maculatus* is suspected in areas where *flavirostris* density is low. Evidence points to *maculatus* as a vector in certain lowland areas as well.

The larvae of *leucosphyrus* are often found in temporary collections of water, such as wheel ruts and footprints in open shade. The females bite man readily. Various forms of this species are proved vectors in parts of Assam, Burma, and North Borneo (see p. 99), but they show no evidence of transmitting malaria in the Philippines.

References: *31, 48, 49, 67, 115, 121, 122, 296, 308, 310.*

Anopheles Species in the Philippines

acaci
aitkenii aitkenii
aitkenii bengalensis
†*annularis*
baezai
balabacensis baisasi
balerensis
†*barbirostris*
cristatus
ejercitoi
**filipinae*
gigas formosus
insulaeflorum
karwari
†*kochi*
kolambuganensis
lesteri
†*leucosphyrus balabacensis*
†*leucosphyrus leucosphyrus*
leucosphyrus riparis
lindesayi benguetensis
litoralis
†*ludlowi*
**maculatus*
**mangyanus*
**minimus flavirostris*
†*minimus minimus*
†*nigerrimus*
parangensis
philippinensis
pseudobarbirostris
pseudosinensis
samarensis
†*sinensis*
subpictus indefinitus
†*subpictus subpictus*
†*sundaicus*
†*tessellatus*
vagus

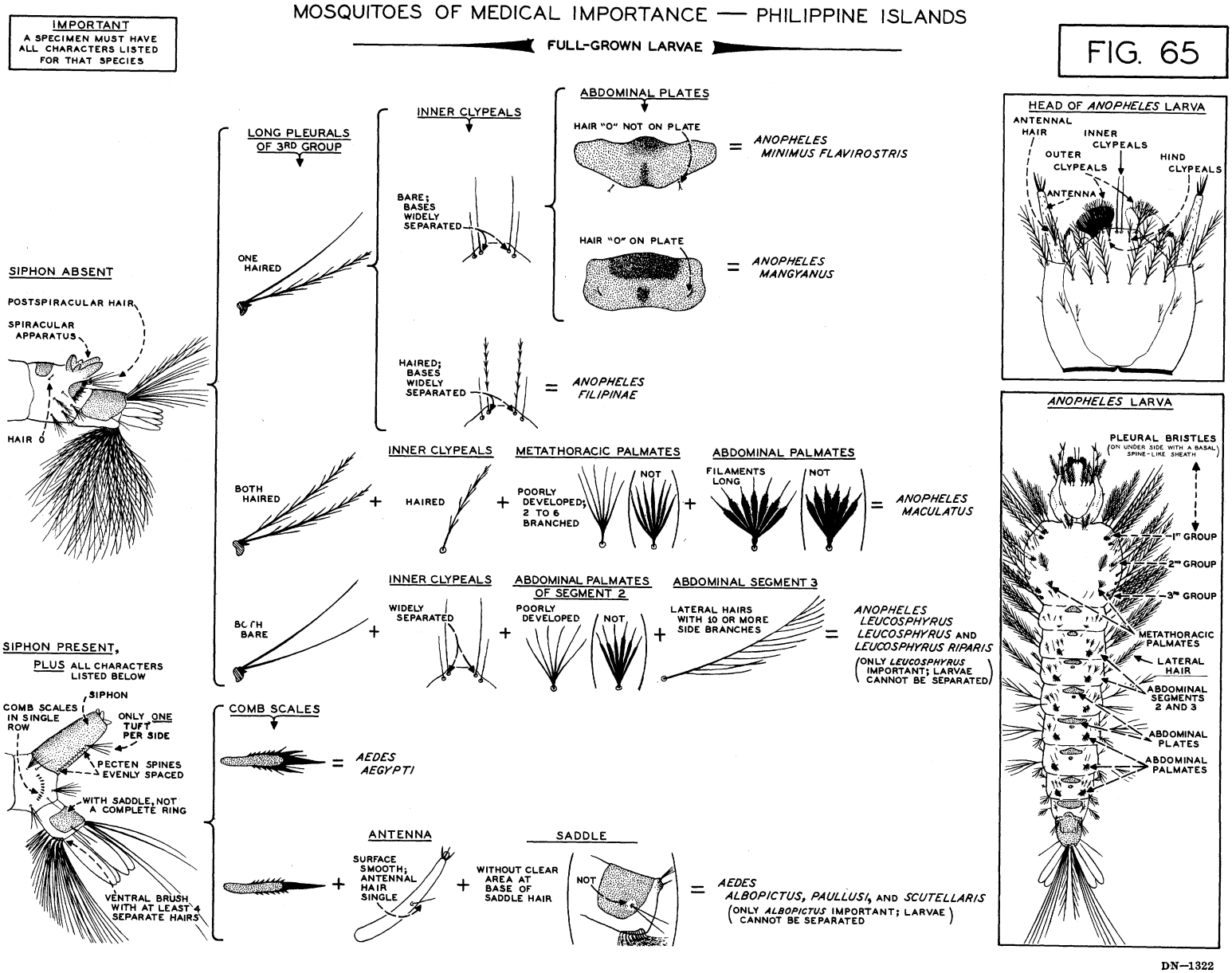
See footnote 6, p. 10.

Yellow Fever.—As in other parts of the Orient, neither urban nor jungle yellow fever is known to be endemic in the Philippines.

References: *256, 310.*

Dengue.—The classical work of Siler and others (*307*)[9] has confirmed the direct role played by *Aedes aegypti* in the

[9] Italic numbers in parentheses refer to References, p. 143.



transmission of dengue in the Philippines. This disease, which has centered principally in Luzon, has occurred near military installations. A seasonal peak of dengue cases generally occurs between April and November, its height varying from year to year. *Aedes albopictus* is an important vector of dengue in the Philippines.

References: *256, 307, 310.*

Encephalitis.—The viruses causing Japanese and St. Louis encephalitis have been reported from the Philippines. Antibodies to both viruses have been found in human sera. Nothing is known about their vectors in this region.

Reference: *257.*

Filariasis.—This disease has existed in the Philippines since 1901. It is endemic in areas where abaca is grown and in at least two other localities. Higher infection rates in males than in females indicate that the males are more exposed to the disease because of their outdoor activity in the cultivation of abaca. All known infections are caused by the periodic form of *Wuchereria bancrofti* and are probably borne by *Aedes poicilius*. No laboratory or field investigations have conclusively proved that this species is the important vector, but epidemiological observations implicate it far more than any other vector.

Reference: *293.*

AUSTRALASIA

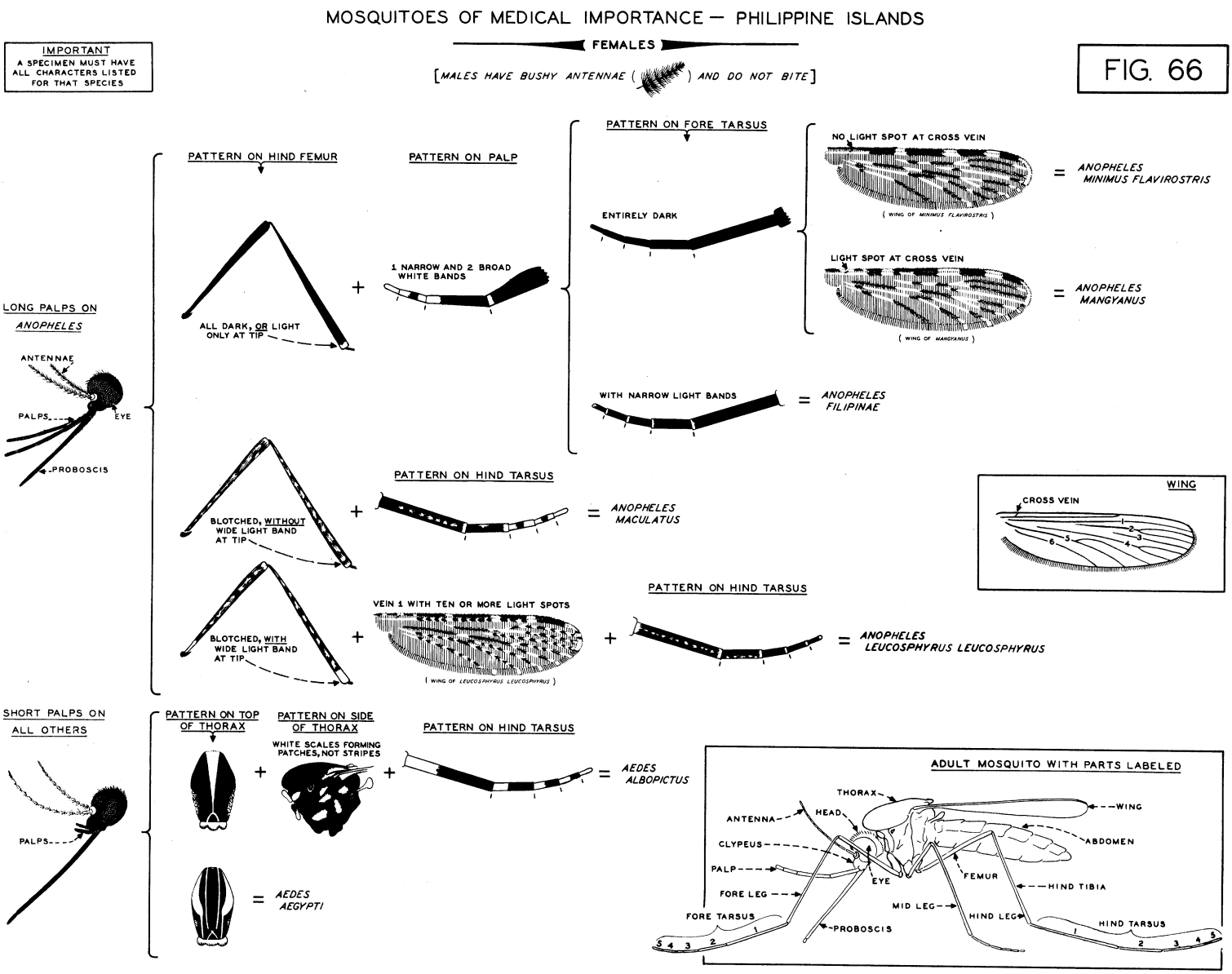
(Figs. 67 and 68)

Australasia has been divided into the following parts: (1) The Moluccas, New Guinea, and Melanesia; (2) Australia, Tasmania, and New Zealand; (3) Micronesia; and (4) Polynesia.

The Moluccas, New Guinea, and Melanesia

Physical Features.—The Moluccas are volcanic and coral islands lying between Celebes and New Guinea. There is no well-defined dry season, and the rainfall averages 75 to 100 inches per year.

New Guinea, the world's second largest island, lies between the Moluccas and Melanesia. It has a series of mountain ranges with peaks of 16,000 feet. Tropical jungle covers much of the interior. A west monsoon brings rain and high temperatures to southeast Dutch New Guinea, whereas the



east monsoon is drier and cooler. The interior mountains may have an annual rainfall of 250 to 325 inches.

Melanesia, situated east of New Guinea and south of the Equator, includes the island groups of Fiji, New Caledonia, Loyalty, New Hebrides, Solomons, Santa Cruz, and Admiralties, and the Louisiade and Bismarck Archipelagoes. The larger of these islands are volcanic and the smaller coral.

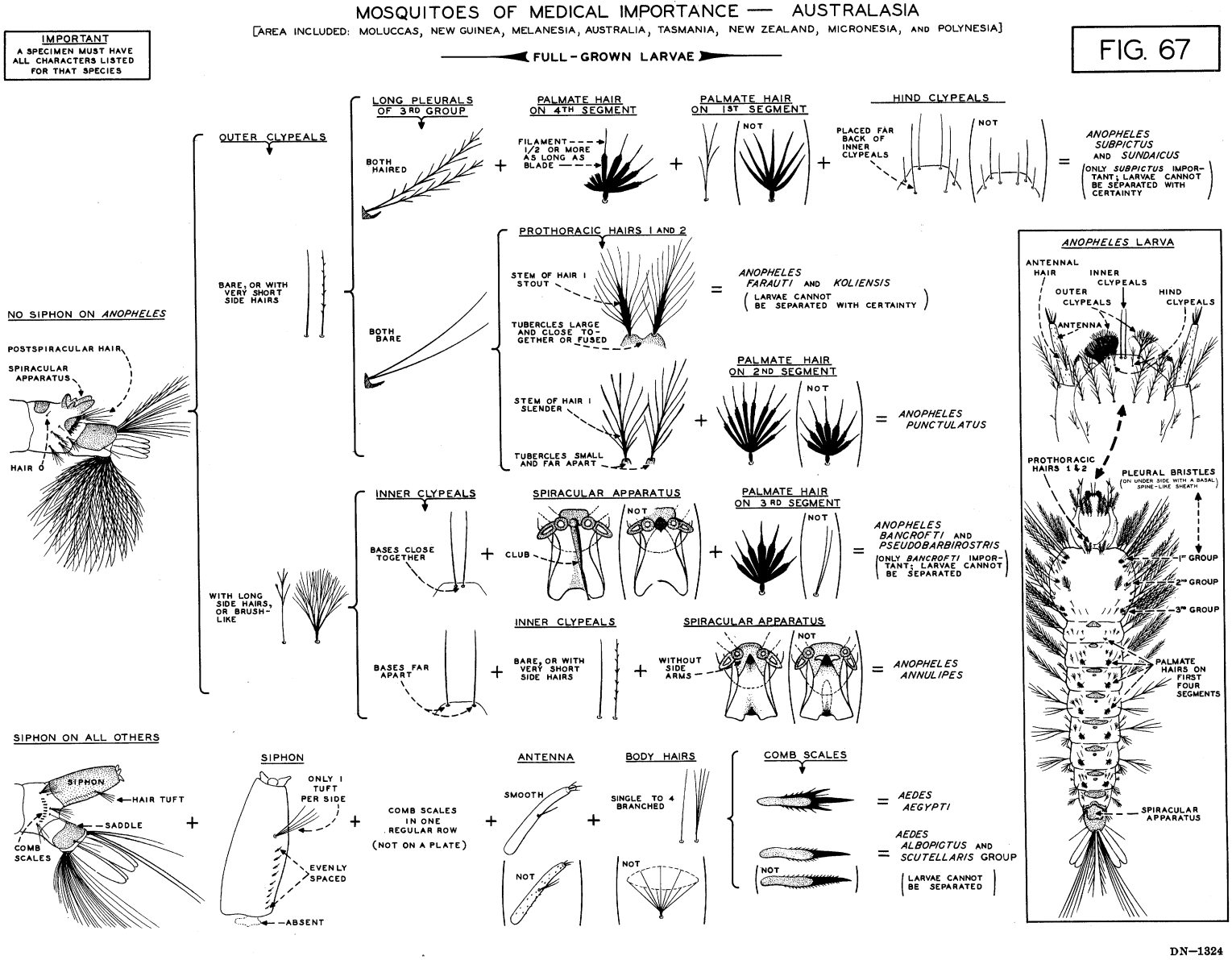
Reference: *301.*

Malaria.—Most of the Moluccan coast and the entire north coast of New Guinea have high rates of endemic malaria, whereas areas on the south coast of New Guinea are practically free of this disease. Malaria occurs at altitudes of 3,500 to 4,000 feet in the mountainous interiors. It is widespread and severe throughout the islands of Melanesia because of the low standard of living of the native populations.

In almost all this area *Plasmodium falciparum* and *P. vivax* are important, one predominating in one locality and the other in a closely adjoining one. *P. malariae* is rarely if ever found.

Malaria in the South Pacific is generally understood to be bounded by longitude 170° E. and latitude 20° S., the junction of these two lines lying just north of Aneityum, the southernmost island of the New Hebrides group. This location corresponds exactly to the distribution in the New Hebrides of *Anopheles farauti.* That species and *Anopheles punctulatus* are the most common and dangerous vectors in this area. Of these two species, *farauti* has the wider distribution. Its range includes the Moluccas and extends eastward through New Guinea, the Admiralty Islands, the Bismarck Archipelago, the Solomon Islands, and the New Hebrides. Neither malaria nor any *Anopheles* species are present in New Caledonia. In dry weather *farauti* breeds in all kinds of collections of water close to man, and during the rainy season it breeds readily in small manmade depressions exposed to sunlight. The larvae of this species are commonly found in brackish water, and for this reason the adults may be abundant in coastal areas. *A. punctulatus* has much the same range as *farauti*, but it is not found east or south of the Solomons, leaving malaria transmission in the New Hebrides solely to *farauti.* Breeding in all sorts of small collections of sunlit ground and rainwater, *punctulatus* is more characteristically a species of inland and elevated areas than *farauti.* Since these two species breed so readily in manmade habitats and are such effective hosts for malaria parasites, they maintain malaria throughout the entire island chain.

Anopheles koliensis, a close relative of both *farauti* and *punctulatus*, is believed to be an important vector on the northeast coast of Guadalcanal and in certain parts of New Guinea.



Neither the importance nor the distribution, especially in Melanesia, of *Anopheles bancrofti* is well known. It is generally agreed that this species definitely is present in the Moluccas and along the southern shore of New Guinea. In Batu Gajah in Malaya *bancrofti* has been an important vector. Undoubtedly it maintains some malaria throughout at least part of its range.

Anopheles annulipes appears sporadically in New Guinea, but it has never been proved to be a vector there. In the Port Moresby area it is at times the dominant species, and although its natural infection rates are generally low, it has been shown to transmit malaria in the laboratory as effectively as *farauti*. It may be a species of some importance in New Guinea when conditions are favorable.

Anopheles subpictus is probably the least important malaria vector in this area. It is encountered usually in small numbers in the Moluccas and New Guinea. Although it has been found naturally infected in the vicinity of Lalapipi in New Guinea, its small numbers there indicate that it is of little or no consequence in malaria transmission. Its presence in Melanesia is in doubt.

References: *63, 121, 122, 170, 224, 228, 354.*

Yellow Fever.—This disease is not present in the Moluccas, New Guinea, and Melanesia.

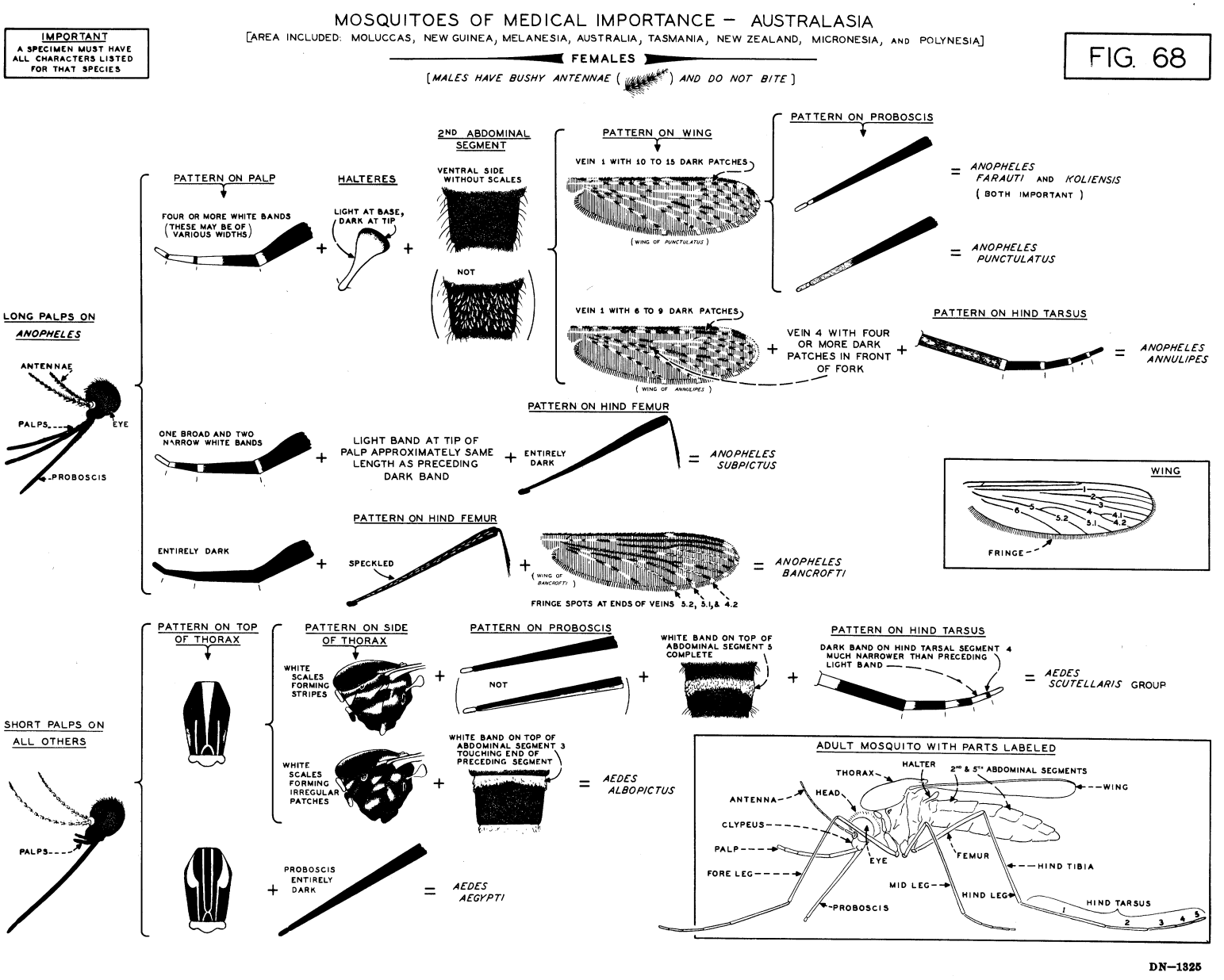
Reference: *256.*

Dengue.—This very important disease is spread throughout this area. It is transmitted by *Aedes aegypti*. *Aedes albopictus* is not believed to appear west of the Lesser Sunda Islands. A so-called jungle type of dengue occurs over vast areas in northern New Guinea. Extensive experiments in which *Aedes scutellaris* fed on persons with this disease in New Guinea and afterward transmitted the disease to susceptible volunteers in southern Australia demonstrated that this species was the vector. In the New Hebrides *scutellaris* is epidemiologically suspected as the vector of dengue in areas where *aegypti* is absent.

References: *102, 121, 245, 256.*

Encephalitis.—No information is available.

Filariasis.—This disease is endemic on the entire coast of Vogelkop in New Guinea and its associated islands, in the vicinity of Hollandia on the north-central coast, and in the eastern third of the island from "Lambringi" in the north to Daru on the southern coast. It has not been recorded in the interior. It is also endemic in small areas in New Britain, New Ireland, and the Solomons. Guadalcanal and San Cris-



tobal are the most seriously affected of the Solomons. Almost the entire northern two-thirds of the New Hebrides is heavily infected.

Throughout these areas *Wuchereria bancrofti*, with few exceptions, is the sole parasite and is transmitted principally by *Anopheles farauti* and *A. bancrofti*. *A. farauti* is found throughout the entire island chain and is responsible for the greatest number of cases. *A. bancrofti* is implicated as the important vector in the Digoel River area in southern New Guinea, where elephantiasis is abundant. *Anopheles punctulatus* is a potential secondary vector at Hollandia and in Guadalcanal, and *A. koliensis* probably contributes to filariasis in the latter island. *Culex pipiens quinquefasciatus* is a secondary vector of bancroftian filariasis at the eastern end of New Guinea. Light infections of the nonperiodic form of *W. bancrofti* occur at the northern end of New Caledonia and in Ouvéa in the Loyalty Islands, which represent the westernmost extension of nonperiodic filariasis in the Pacific. The parasite there is transmitted solely, as far as is known, by *Aedes vigilax*.

Very seldom has *Wuchereria malayi* been seen in New Guinea and Melanesia. It is believed to have been introduced into the Digoel River area in southern New Guinea, and it has been found in the New Hebrides, where *Mansonia xanthogaster* was uninfected in nature.

References: *197, 273, 287.*

Australia, Tasmania, and New Zealand

Physical Features.—Australia, which is approximately the size of the United States, has a west-central part consisting of a dry, hot desert plateau 1,000 to 2,000 feet high that rises abruptly from the west coast and extends east to Cape York Peninsula, a jungle-covered northern extension of the continent. The Great Dividing Range has 7,500-foot peaks and borders nearly all the east and south coasts to Melbourne. It encloses a basin that is bounded at the center of the continent by the eastern edge of the desert plateau. This basin is too dry to support a dense population of either people or mosquitoes. Most of the human population is concentrated along the east and south slopes of the Great Dividing Range.

Tasmania is a small island lying south of Australia. Geologically it is a part of that continent. It has a high central plateau, with alpine lakes and good farming lands.

New Zealand, about 1,200 miles southeast of Australia, is a mountainous island, which has volcanoes of about 12,300 feet and extensive farming and stockraising areas.

Reference: *301.*

Malaria.—Malarious areas are centered in the Cape York Peninsula and in the northern parts of the Northern Territory and of Western Australia. The southern limit of the disease is usually at about latitude 19° S. in Queensland and West Australia and latitude 17° S. in the Northern Territory. Epidemics occasionally occur in the vicinity of Cairns at the eastern base of Cape York Peninsula. This area receives rainfall ranging from 100 to 160 inches per year.

Plasmodium vivax and *P. falciparum* are about equally important in causing the malaria in most of this area. However, on Cape York Peninsula *falciparum* is the predominant parasite.

By far the most important *Anopheles* species in northern Australia is *farauti*, which, as in New Guinea and Melanesia, breeds in manmade depressions and is always closely associated with man.

Anopheles punctulatus is apparently absent from the Australian mainland. South of latitude 17° S. malaria occurs only rarely and is restricted to short-lived and narrowly localized outbreaks.

Anopheles annulipes may be the only vector that maintains this sporadic malaria in southern Australia and in Tasmania. Its role in transmission has never been proved in the field. Neither malaria nor any *Anopheles* species have been reported from New Zealand.

References: *67, 128, 354.*

Yellow Fever.—This disease is not present in Australia, Tasmania, and New Zealand.

Reference: *256.*

Dengue.—Endemic dengue occurs along the northern and eastern coasts of Australia, where it is transmitted principally by *Aedes aegypti. Aedes albopictus* is not found in this area.

References: *121, 256.*

Encephalitis.—Japanese encephalitis is thought to occur in Australia, but further studies are needed to confirm its presence. Murray Valley encephalitis is present. For further information, see page 4.

References: *246, 257.*

Filariasis.—The distribution of filariasis in Australia is confined to a narrow coastal strip running from the northern rivers of New South Wales to Cape York, where there is a fairly high incidence. This strip also includes an area bordering the southwest corner of the Gulf of Carpentaria. In the northern parts of Queensland filariasis is much more prevalent than farther south. The Northern Territory and the northwest part of Western Australia are weak centers of infection. The only parasite found in these areas is *Wuchereria bancrofti*, which everywhere shows well-marked periodicity and is transmitted by *Culex pipiens quinquefasciatus.* Filariasis is not present in Tasmania or New Zealand.

References: *47, 93, 163.*

Micronesia

Physical Features.—Micronesia consists of the island groups of the Marianas, Carolines, Marshalls, and Gilberts. The Marianas and a few of the Carolines are volcanic; the others are coral atolls, some of which barely rise above the sea. Temperatures remain fairly constant, and rainfall ranges from 60 to 180 inches a year. The larger islands of Micronesia have dense vegetation.

References: *64, 301.*

Malaria.—This disease is not present in Micronesia.

References: *67, 224.*

Yellow Fever.—This disease is not present in Micronesia.

Reference: *256.*

Dengue.—Reported from the Marshalls as early as 1906, dengue is perhaps the most important disease in these islands and in the Carolines, Marianas, and Gilberts as well. Several large epidemics have occurred in Saipan, Tinian, Truk, Ponape, and the Palau group. Both *Aedes aegypti* and *A. albopictus* were involved in the first two places and *aegypti* alone in the last three. In Guam a large epidemic in 1944 resulted from troops introducing the disease, which was spread by *aegypti.* This mosquito has been nearly eradicated from the island, but *albopictus* is widely distributed and is a constant health menace.

References: *188, 356.*

Encephalitis.—Japanese encephalitis occurred in an epidemic outbreak in 1947–48 in Guam. No vector has yet been implicated.

References: *246, 257.*

Filariasis.—This disease is not known in most of the Marianas. In Saipan and Tinian filariasis infection rates of 5 to 15 percent have been reported, but the disease is entirely absent from Guam. However, various degrees of filariasis endemicity characterize most of the Carolines from the Palaus in the west to Ponape and Mokil in the east. Not much is known about the disease in the northern half of the Marshalls, but several islands at the south end have human infections. Filariasis occurs in almost all the Gilberts, where infections of over 15 percent have been reported from some of the islands. As in Melanesia, the sole parasite throughout Micronesia is *Wuchereria bancrofti*, which causes the periodic form of the disease. There is no nonperiodic filariasis in this entire area.

In the Marianas, Marshalls, Gilberts, and Truk (Carolines), *Culex pipiens quinquefasciatus* appears to be the sole vector. In the Palaus (western Carolines) it is the proved vector of primary importance. In Truk *Culex annulirostris* is believed to be a potential secondary vector.

Reference: *197.*

Polynesia

Physical Features.—Polynesia comprises a large group of islands in the central Pacific, including the island groups of Hawaii, Samoa, Tonga, Tokelau, Tubuai, Tuamotu, Society, Marquesas, Cook, Ellice, and Easter. They are either summits of high volcanic mountains or low coral islands, with tropical or subtropical climates.

Reference: *301.*

Malaria.—This disease is not present in Polynesia.

Reference: *67.*

Yellow Fever.—This disease is not present in Polynesia.

Reference: *256.*

Dengue.—*Aedes aegypti* and *A. albopictus* have been responsible for severe epidemics of dengue since 1903 in the Hawaiian Islands, but this disease is maintained at a very low level between epidemics. In Tahiti, the Marquesas, and American Samoa, epidemiological evidence indicates that dengue is also transmitted by *Aedes polynesiensis.*

References: *64, 256.*

Encephalitis.—No information is available.

Filariasis.—The dividing line between periodic and nonperiodic filariasis runs between the Gilbert and Ellice Islands, south between Fiji and the New Hebrides to the southern tip of the latter, then westward between the New Hebrides and the Loyalties. All filariasis east of this line in the Pacific is caused by nonperiodic *Wuchereria bancrofti.* This form of the disease is found in most of the islands of Polynesia. The following places may be exceptions, since there is no in-

formation available for them: Phoenix Islands, northern Cook Islands, northern and southern Line Islands, and the islands lying to the south and west of the Tuamotus.

Aedes polynesiensis is the principal vector in most of this area. This mosquito, previously thought to be *Aedes pseudoscutellaris* and appearing under that name in most of the medical literature, has only recently been elevated to specific rank. It is widely distributed over Polynesia. True *pseudoscutellaris* is believed to inhabit only a small part of western Fiji, and a new evaluation of the ability of this species to transmit filariasis is needed, since all previous records refer to *polynesiensis*. Tonga is unique in that *polynesiensis* is completely replaced by *Aedes tongae*, another member of the *Aedes scutellaris* group.

Experiments in Hawaii reveal that the *bancrofti* infections in Okinawans could be transmitted easily by Hawaiian *Culex pipiens quinquefasciatus*, the commonest mosquito in Oahu. In further experiments Samoan *bancrofti* did not mature in this vector to the infective stage. Filariasis is not a problem in the Hawaiian Islands.

References: *197, 248, 263.*

Anopheles Species in Australasia

amictus amictus
amictus hilli
†*annularis*
annulatus
**annulipes*
atratipes
**bancrofti*
bancrofti barbiventris
†*barbirostris*
barbumbrosus
clowi
colledgei
**farauti*
incognitus
insulaeflorum
karwari
†*kochi*
**koliensis*
longirostris
lungae
†*maculatus*
meraukensis
†*minimus*
nataliae
†*nigerrimus*
novaguinensis
†*philippinensis*
powelli
pseudobarbirostris
pseudostigmaticus
**punctulatus*
solomonis
stigmaticus
**subpictus*
†*sundaicus*
†*tessellatus*
vagus

See footnote 8, p. 63.

NOTES ON THE MEDICALLY IMPORTANT SPECIES

In this section the following information is given about each species: (1) Bionomics, (2) relation to disease, and (3) recorded distribution. Many of the important and abundant disease vectors discussed in this section have been called by various names. Where confusion with other species and names might result, a short explanation precedes the notes on bionomics. Some of the information pertaining to bionomics and relation to disease has been taken from reviews, many of which summarize numerous short papers of restricted scope. These short papers are not listed among the references. The distribution is indicated by a list of countries from which the species has **definitely** been recorded. Bibliographic documentation of these distribution records has been omitted for brevity.

No attempt has been made to determine the exact taxonomic status of each subspecies herein discussed. Currently accepted nomenclature has been followed insofar as possible, but the primary objective has been to correctly differentiate the known disease vectors from other mosquitoes. Future investigations of distribution, biology, and taxonomic characters will eventually demonstrate the true relationships of these subspecies. This task is one for specialists with adequate time and opportunities for field studies. Our present knowledge of medically important mosquitoes seems to fully justify the treatment of many forms as subspecies, although some of these may prove to be distinct species.

AEDES SPECIES

Aedes aegypti (Linnaeus)

Many names have been applied to *Aedes aegypti*, a ubiquitous and important mosquito. One of these, *Stegomyia fasciata*, is most commonly encountered in the early literature.

Bionomics.—The adults of *aegypti* seek shaded places for resting and are rarely found over 100 yards from their larval habitats. The females are daytime biters by preference, although they sometimes attack at dusk or in complete darkness. Usually they are markedly anthropophilic, although in Uganda they seldom bite man and rarely seek blood meals during the day. The eggs are laid singly on wet surfaces near the waterline, and oviposition may continue for as long as 30 days after copulation.

The typical larval habitat of this species is in small artificial water containers, such as flower bowls, discarded cans, old tires, and gutters. Such containers throughout most of the distribution of this mosquito are close to human habitations, both outside and inside living quarters of all kinds. When the adults can easily find blood meals away from such locations, the larvae are found in small water receptacles distantly removed from human dwellings. The larvae live less commonly in rock holes and holes in recently felled trees. Sometimes they are found in plant axils. Holes in tree trunks lying on the ground are preferred to trees with vertical entrances. The water in many rock holes is exposed to rapid drying, and in such habitats the larvae must develop rapidly. The period from hatching to emergence has taken as little as 85 hours in the laboratory. This mosquito has a drought-resistant egg, since the larvae have been obtained by immersing dried tree-hole material in water. Not all hatching occurs on the first immersion, but fewer larvae are obtained at each succeeding attempt.

It appears that *aegypti* can survive for short periods at temperatures that tend to limit its distribution. The species has been found at an altitude of 8,000 feet and commonly is present in Africa at 6,000 to 7,500 feet. It is very widely distributed, probably because it is the most adaptable of all its close relatives, with the possible exception of *Aedes vittatus*.

Relation to Disease.—*A. aegypti* is regarded as the only vector of classical urban yellow fever, which most commonly occurs in epidemic form. The wide distribution of this mosquito, its adaptability to urban breeding places, and the fact that yellow fever virus matures in it combine to make it very important. The absence of yellow fever in the presence of large populations of *aegypti* throughout most of the Orient remains a mystery. It is believed that dengue may in some way actually replace that disease there. *A. aegypti* takes a small part in the transmission of jungle yellow fever when living at some distance from human habitations. Together with *Aedes albopictus* and *A. scutellaris* it is an important vector of dengue.

References: *114, 152, 253, 256, 261.* (For additional information, see the descriptions of yellow fever and dengue under each region in the preceding section.)

Recorded Distribution.—

Africa (almost all countries)
Andaman Islands
Antigua
Argentina
Assam
Australia
Bahama Islands
Barbados
Bismarck Archipelago
Borneo
Brazil
British Guiana
British Honduras
Caucasia
Celebes
Ceylon
Chile
China
Colombia
Cook Islands
Corsica
Costa Rica
Crete
Cuba
Cyprus
Dominican Republic
Ecuador
El Salvador
England
Fiji
Formosa
France
French Guiana
Gilbert Islands
Greece
Guam
Guatemala
Haiti
Hawaii
Honduras
India
Indochina
Iraq
Israel
Italy
Jamaica
Japan
Java
Lesser Antilles
Malaya
Malta
Mexico
Moluccas
New Caledonia
New Guinea
New Hebrides
Nicaragua
Nicobar Islands
Pakistan (East and West)
Panama
Paraguay
Peru
Philippine Islands
Pitcairn Island
Portugal
Puerto Rico
Samoa
Sardinia
Society Islands
Solomon Islands
Spain
Sumatra
Surinam
Syria
Thailand
Tonga
Trinidad
Turkey
United States
Venezuela
Yugoslavia

Aedes africanus (Theobald)

Bionomics.—Although the adults of *Aedes africanus* have been recorded as occasionally entering houses, they usually inhabit high rain-forest canopy. They are found only in small numbers at ground level. The females are markedly crepuscular and have a peak of biting activity shortly after sunset, although day biting has been observed in the dense evergreen shrub in Tanganyika. The females apparently prefer primate hosts. They bite man readily and will feed avidly on anesthetized monkeys. The seasonal distribution of this species closely parallels the rainfall. Large numbers of adults appear shortly before a period of maximum rain in July and again during the less intense autumn rains.

Tree holes and bamboo stumps in the forest some distance from human dwellings are the most common larval habitats. The larvae are occasionally encountered in artificial containers, such as discarded tires and cans. In Uganda they have been found in native bamboo waterpots, tree-root buttresses, and shaded holes in granite. In the "Kaimosi Forest" of Uganda they have been found in well-shaded holes in various types of boulders. When the larvae are not in tree- or rock-hole habitats, it is probably because heavy rains have washed them out of these normal breeding places.

Relation to Disease.—*A. africanus* adults are often infected with yellow fever virus in nature. This species is regarded as a potentially dangerous vector, at least in Anglo-Egyptian Sudan. In Bwamba County, Uganda, it is the dominant culicine in the forest canopy. It feeds so readily on monkeys at night that it is regarded as the principal link in the monkey-to-monkey chain of yellow fever in the forests of East-Central Africa. Its importance in West Africa has not yet been determined.

References: *114, 151, 152, 157, 169, 253, 351.* (For additional information, see the descriptions of yellow fever under Eritrea, the Somalilands, and Ethiopia; West-Central Africa; and East-Central Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Cameroons
Dahomey
Ethiopia
French Equatorial Africa
French Guinea
Gold Coast
Kenya
Liberia
Mozambique
Nigeria
Northern Rhodesia
Nyasaland
Ruanda-Urundi
Sierra Leone
Tanganyika
Uganda

Aedes albopictus (Skuse)

Bionomics.—Females of *Aedes albopictus* have often been reported persistently biting man by day in the shade; night biting is comparatively rare. In Shantung Province, China, and in other localities this species has been recorded as the most common daytime-biting mosquito. Because the species prefers woodlands to the immediate vicinity of human habitations, it is less urban than *Aedes aegypti*, although in some areas *albopictus* is commonly found near human dwellings.

Larvae usually live in tree and rock holes, cut bamboo, leaf axils, coconut shells, and many types of artificial containers, such as water buckets, cans, bottles, and drains. They are particularly abundant where rainwater is caught and stored, as in Guam. In Mauritius larvae live in most tree holes containing water.

Relation to Disease.—*A. albopictus* is an efficient vector of dengue in all areas where both the mosquito and the disease appear together.

References: *114, 169, 188, 254, 309.* (For additional information, see the descriptions of dengue under Madagascar and Adjacent Islands, North Europe and North Asia, all countries in the Orient,[10] and Australasia.)

Recorded Distribution.—

Assam
Australia
Borneo
Burma
Caucasia
Celebes
Ceram
Ceylon
China
Christmas Island (Indian Ocean)
Fiji
Formosa
French Somaliland
Hawaii
India
Indochina
Japan
Java
Lesser Sunda Islands
Lombok
Madagascar
Malaya
Mauritius
Moluccas
New Guinea
Pakistan (East and West)
Philippine Islands
Pitcairn Island
Réunion
Riouw Archipelago
Seychelles
Soemba
Sumatra
Tahiti
Thailand
Timor
Torres Strait Islands

Aedes furcifer (Edwards)

Bionomics.—Females of *Aedes furcifer* bite at night in the forest canopy in Uganda; males are scarce in the forest. Adults of this species and *Aedes taylori* fly farther than *A. aegypti* and most of its relatives.

Throughout its range, including Gold Coast, Tanganyika, and Union of South Africa, this species breeds in tree holes.

Relation to Disease.—This mosquito has been found infected with yellow fever in nature and is regarded as a potentially dangerous vector of that disease, at least in Anglo-Egyptian Sudan.

References: *114, 152, 157, 169, 232, 351.* (For additional information, see the description of yellow fever under Anglo-Egyptian Sudan.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Gold Coast
Nigeria
Portuguese Guinea
Transvaal
Uganda

[10] See footnote 2, p. 2

Aedes leucocelaenus clarki Galindo *et al.* and *Aedes leucocelaenus leucocelaenus* Dyar and Shannon

The range of *Aedes leucocelaenus* was previously thought to extend from Costa Rica to Argentina. This species has now been divided into the subspecies *A. leucocelaenus leucocelaenus* in southern Brazil and Argentina and *A. leucocelaenus clarki* in Panama and Costa Rica. *A. leucocelaenus* has distinct morphological characters, and it has not been confused to any great extent with other mosquitoes in the important medical literature.

Bionomics.—In Panama, platform studies of biting habits show that adults live at various levels in the forest canopy but predominate at ground level. The species first appears there in May at the start of the rainy season and rises to a peak of abundance during the last part of the rainy season in September and October. During the dry season it is rare or absent. In flight-range studies in Brazil, where *leucocelaenus* is very abundant, stained adults were captured about 3,200 feet or more from the point of release in the direction of the prevailing winds. Further studies show that adults will disperse as far as 3½ miles from their breeding places.

Relation to Disease.—This mosquito is infected with yellow fever virus in nature. It has been infected in the laboratory and has transmitted the virus there. Its transmission rate was 1.29 compared with that of 1.00 for *Aedes aegypti*. Because of its indiscriminate distribution at various levels in the forest, this mosquito in Panama may become infected anywhere within the forest and transmit yellow fever to man at the edge of or outside the forest. The species reaches a peak of abundance during the last part of the rainy season, when most of the yellow fever is being transmitted. It is a proved vector of yellow fever in the forests of Brazil and Colombia, but it is probably not abundant enough in Brazil to support yellow fever alone.

References: *81, 82, 131, 133, 219.* (For additional information, see the descriptions of yellow fever under Panama, Northwest South America, Brazil and the Guianas, and Lower South America.)

Recorded Distribution.—

A. l. clarki:
Costa Rica
Panama

A. l. leucocelaenus:
Argentina
Bolivia
Brazil

Aedes luteocephalus (Newstead)

Bionomics.—Females of *Aedes luteocephalus* throughout their range bite man and monkeys readily. They prefer the edges rather than the interior of open forest canopy. They are crepuscular, having a strongly marked peak of biting activity beginning shortly after sunset and lasting into the early night. This mosquito apparently survives the dry season as an adult and has been found in extremely dry areas. It appears in greatest numbers shortly before the period of greatest rainfall, from May to July, and there is a smaller peak of abundance during the lighter rains later in the year.

Larvae prefer tree holes over bamboo stumps or cut bamboo. They have occasionally been reported in sagging roof gutters, domestic containers, crab holes, and rock pools. In Anglo-Egyptian Sudan larvae live in tree holes but occasionally are flushed out into ground and rock pools and crab holes by heavy rain.

Relation to Disease.—*A. luteocephalus* has been found naturally infected with yellow fever. It is regarded as a potential vector in Anglo-Egyptian Sudan.

References: *114, 152, 157, 169, 232, 253, 351.* (For additional information, see the description of yellow fever under Anglo-Egyptian Sudan.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Bechuanaland
Belgian Congo
Eritrea
French Guinea
Gold Coast
Kenya
Liberia
Nigeria
Northern Rhodesia
Nyasaland
Sierra Leone
Southern Rhodesia
Uganda

Aedes metallicus (Edwards)

Bionomics.—In Anglo-Egyptian Sudan *Aedes metallicus* never flies far from its breeding places. It usually bites outdoors at ground level, although it enters houses to obtain blood meals. In Mombasa the females bite man freely, although they have also been reported to attack horses and cattle. Adults are crepuscular and have a well-defined peak of biting activity shortly after sunset.

Tree holes have often been recorded as the preferred larval habitat. Larvae are reported to be abundant in holes in *Ricinodendron rautanenii* in the vicinity of Livingstone, Northern Rhodesia. They have been taken from ground water under trees, and from banana axils, coconut shells, and artificial containers, such as old cans, iron and bamboo pots, and concrete basins. Larvae have been obtained by immersing dried material from tree holes in water, an indication of the presence of drought-resistant eggs.

In various parts of its range this species has been taken at altitudes up to about 6,000 feet. It is reported to be the most common tree-hole breeder in Anglo-Egyptian Sudan.

Relation to Disease.—Adults are occasionally infected with yellow fever virus in nature. The species is regarded as a potential vector of that disease, at least in Anglo-Egyptian Sudan.

References: *114, 157, 169, 232, 253, 261, 351.* (For additional information, see the description of yellow fever under Anglo-Egyptian Sudan.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Bechuanaland
Belgian Congo
Gold Coast
Kenya
Mozambique
Northern Rhodesia
Senegal
South-West Africa
Tanganyika
Transvaal
Uganda
Zanzibar

Aedes poicilius (Theobald)

Aedes poicilius was originally described in the genus *Finlaya*, which is now a subgenus of *Aedes*. It has only recently become prominent as a disease vector.

Bionomics.—Adults bite severely at dusk, and in the Philippines also during the day. They have very high and exacting humidity requirements, which make them extremely difficult to rear in the laboratory.

The larvae inhabit water-filled axils of aroid plants, banana, taro, abacá, pandanus, and pineapple.

Relation to Disease.—Even though no conclusive field or laboratory observations have proved this species to be of medical importance, it is believed to be the principal vector of filariasis in the abacá-growing areas of the Philippines. Larvae of *Wuchereria bancrofti* have developed in *poicilius* to the infective stage in the laboratory.

References: *207, 247, 293.* (For additional information, see the description of filariasis under Philippine Islands.)

Recorded Distribution.—

Borneo
Burma
Celebes
India
Java
Lombok
Malaya
New Guinea
North Bengal
Philippine Islands
Simalur
Sumatra

Aedes polynesiensis Marks

Most medical literature prior to 1951 refers to *Aedes polynesiensis* as *A. pseudoscutellaris*.

Bionomics.—Adults are common in and around native villages and are highly anthropophilic, although they attack animals as well. Females bite during the day, usually in deep shade or under cloudy conditions. The flight range is limited to about 100 yards.

Larvae are found in small water collections. Coconut shells, husks, stumps, tree holes, cacao pods, open concrete drains, tin cans, and lava holes are common breeding places.

Relation to Disease.—Since it is a day biter, *polynesiensis* transmits nonperiodic *Wuchereria bancrofti*. It is the only important intermediate host of this filaria in Polynesia, excluding Tonga. Recent laboratory investigations have shown that this mosquito, a member of the *Aedes scutellaris* group, can transmit dengue from monkey to monkey, and epidemiological evidence indicates that this species, and possibly others in the group, transmit dengue in Tahiti, Fiji, Marquesas, and American Samoa.

References: *122, 248, 289.* (For additional information, see the descriptions of dengue and filariasis under Australasia.)

Recorded Distribution.—

Austral Islands
Cook Islands
Ellice Islands
Mangareva
Marquesas Islands
Pitcairn Island
Samoa
Society Islands
Tokelau
Tuamotu Islands
Wallis Islands

Aedes scutellaris (Walker)

Aedes scutellaris consists of a complex of about 17 distinct but very closely related species known as the *scutellaris* group. The remarks below apply to only one of this group, i. e., *scutellaris* in the restricted sense. This species is treated as *Aedes scutellaris* var. *hebrideus* in some of the important literature relating to transmission of disease.

Bionomics.—*A. scutellaris* is a "bush" species. Adults are usually found close to the ground in cool, damp, well-shaded places under low vegetation. Their flight range is very limited. Females enter buildings only to feed and usually leave soon afterward, showing little or no tendency to settle or rest inside. In New Guinea their diurnal biting activity was surprisingly regular under many different conditions and in different localities. A sharp peak of activity occurred between 6 and 7 p. m. and a lower sharp peak between 7 and 8 a. m. On overcast days adults entered tents and fed during almost the entire day.

In Espiritu Santo, New Hebrides, larvae were found in all kinds of artificial containers. Ends of upturned oil drums in fuel dumps and sagging tents were their principal habitats. Other breeding places were various small, shallow collections of water in discarded tires, tin cans, corrugated sheet iron, tarpaulins, old helmets, canteen cups, coconut shells, and cacao pods. Larvae also inhabit raised coral reefs and open wells and are commonly found in tree holes. In New Guinea they live in almost any small, well-shaded collection of clear rainwater. The species does not breed in heavily polluted water.

Relation to Disease.—Because *scutellaris* appears in large numbers and attacks man readily and because other vectors are absent, it is regarded as a vector of dengue in Espiritu Santo, New Hebrides. It definitely transmitted that disease in large areas of northern New Guinea where *aegypti* was scarce or absent.

References: *102, 245, 248, 314.* (For additional information, see the description of dengue under Australasia.)

Recorded Distribution.—

Aroe Islands
Ceram
Moluccas
New Britain
New Guinea
New Hebrides
New Ireland
Philippine Islands

Aedes simpsoni (Theobald)

For a number of years *Aedes simpsoni* was thought to be represented by the variety *lilii* over most of its range, and it has not been extensively known by any other name in the literature. Recent studies indicate that *lilii* may not be a true variety. We believe that the name should not be used until further investigations disclose the true status of this mosquito.

Bionomics.—Adults of *simpsoni* occasionally enter human dwellings, usually in small numbers. In Nigeria and Gold Coast females of forest populations very rarely bite man, but in Uganda, British Cameroons, and Transvaal they frequently attack man in large numbers. In the plantations of Uganda, *simpsoni* is a much more common biter during the day than at night. The females also bite horses, cattle, goats, fowl, and monkeys.

In Uganda, leaf axils of *Xanthosoma sagittifolium*, with a capacity of approximately 4 to 8 cc., and axils of the "Gonja" variety of cultivated banana and pineapple (*Ananas comosus*) are the most important breeding places of *simpsoni* larvae. Workers in Uganda have shown that the Gonja variety of banana is much preferred by *simpsoni* over others. To be good breeding places, axils must hold clear latex-free water for a long enough time for larvae to complete development. Light rains are sufficient to keep the axils filled. Larvae sometimes exist in only a thin film of water in the axils. Wild banana, screw pine (*Pandanus*), and *Colocasia esculenta* contain no *simpsoni*, probably because these plants grow in unsuitable environments. Tree holes are uncommon habitats in Uganda, but many authors have reported finding *simpsoni* in tree holes elsewhere. Larvae are rare but present in rot holes of *Ricinodendron rautanenii* near Livingstone, Northern Rhodesia. Immature stages are also occasionally found in artificial containers, such as discarded cans, bottles, tubs, and tanks, and have been recorded from rock pools, concrete basins, bamboo pots, coconut shells, and axils of *Dracaena* and *Strelitzia*. Larvae have been obtained by immersing dried material from tree holes in water. *A. simpsoni* apparently survives the dry season because of its drought-resistant eggs.

A. simpsoni seldom enters closed forest canopy, preferring plantations and shambas at forest edges. Adults have been observed at altitudes up to 6,000 feet. In Anglo-Egyptian Sudan *simpsoni* is reported to be common in many areas with rainfall of over 15.8 inches per year.

Relation to Disease.—Adults are infected with yellow fever virus in nature. This species is regarded as a potentially dangerous vector and is probably the principal vector of yellow fever from animal reservoirs to man, at least in Anglo-Egyptian Sudan and possibly in West Africa as well.

References: *114, 145, 157, 169, 232, 253, 261, 351.* (For additional information, see the descriptions of yellow fever under Anglo-Egyptian Sudan; Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Bechuanaland
Belgian Congo
Cape Province
Eritrea
Gambia
Gold Coast
Kenya
Mozambique
Natal
Nigeria
Northern Rhodesia
Nyasaland
Pemba
Ruanda-Urundi
Sierra Leone
Southern Rhodesia
Tanganyika
Transvaal
Uganda
Zanzibar
Zululand

Aedes taylori Edwards

Bionomics.—In southern Nigeria *Aedes taylori* is predominantly a tree-top biter, whose vertical distribution in the forest does not markedly change during the night. In trapping experiments at Itowolo 75 percent of *taylori* females were caught 40 to 52 feet above the ground and only about 3 percent at ground level. Mating and other activities associated with swarming are thought to occur during the early evening. *A. taylori* and *Aedes furcifer* fly farther than *A. aegypti* or any of its relatives.

The preferred breeding places are tree holes. Larvae are present but rare in rot holes of *Ricinodendron rautanenii* in the vicinity of Livingstone, Northern Rhodesia, and are found closely associated with *Aedes adersi* in tree holes in Tanganyika. Adults are most abundant before the maximum rainfall in July, indicating that tree holes may be filled to a level that enables most larvae to mature long before maximum rainfall, which may be great enough to cause these habitats to overflow. A small secondary population peak follows the rainy season in October.

Relation to Disease.—Adults have been found infected with yellow fever virus in nature. The species is regarded as a potentially dangerous vector of that disease, at least in Anglo-Egyptian Sudan.

References: *114, 157, 169, 252, 261, 351.* (For additional information, see the description of yellow fever under Anglo-Egyptian Sudan.)

Recorded Distribution.—

Nigeria
Northern Rhodesia
Tanganyika

Aedes togoi Theobald

Bionomics.—*Aedes togoi* is common in Honshu, Shikoku, Kyushu, and Hokkaido, Japan. It habitually enters houses, attracted by artificial light. In Japan it is not regarded as anthropophilic, since it has rarely been taken in collections of mosquitoes biting man, although it is the most widely distributed and highly adapted of the Japanese *Aedes* species. However, in northeast China adults enter dwellings at night and are serious pests in some localities. They are more abundant along the coast than elsewhere. There are generally two peaks of abundance, one in the spring and one in the fall.

Larvae are commonly found in water tanks, buckets, flowerpots, borrow pits, ground pools, ditches, and gutters. Because they prefer small artificial containers in the open sun, they are least numerous during the hot summer when evaporation is high. The species probably overwinters in the larval stage.

A salt-water form of *togoi* has been recorded from Japan and Hong Kong. Along the coasts of Japan and China larvae have been collected from tidewater ground and rock pools where the water has a chloride content nearly equivalent to that of sea water. Little is known of the behavior or distribution of this coastal form, although in Hong Kong adults are numerous and females bite persistently.

Relation to Disease.—*A. togoi* has been incriminated in the transmission of Japanese encephalitis, but it is believed to play a minor role. This mosquito has been experimentally infected with *Wuchereria bancrofti* and transmits filariasis in the vicinity of Hong Kong.

References: *122, 199, 223.* (For additional information, see the descriptions of filariasis under North Europe and North Asia, and South China.)

Recorded Distribution.—

China (north)
Japan
Korea
Ogasawara-gunto
Siberia

Aedes tongae Edwards

Aedes tongae was originally described as a variety of *Aedes variegatus*. At the present time it is universally accepted as a full species.

Bionomics.—Very little information is available on the habits of this species. Adults are known to attack man, and larvae inhabit coconut husks, tree holes, and wells.

Relation to Disease.—This is the only representative of the *scutellaris* group in Tonga and the only mosquito there that can transmit the nonperiodic form of *Wuchereria bancrofti*.

Reference: *122.* (For additional information, see the description of filariasis under Australasia.)

Recorded Distribution.—

Rennell Island
Sikaiana
Tonga

Aedes vittatus (Bigot)

Bionomics.—In Northern Rhodesia, parts of Uganda, Eritrea, and Spain *Aedes vittatus* bites man readily during the day. However, in Southern Africa and the "Kaimosi Forest" of Uganda, it does not seem to attack man at all. Adults have a marked ability to withstand low temperatures.

Large numbers of larvae have been found exposed to the sun in rock pools, beds or margins of streams, holes in coral, tree holes, domestic utensils, boats, cattle hoofprints, barrels, buckets, discarded tins, and wells. In one locality larvae were found in a turbid rain pool without vegetation, in broken shade, and with water having a chloride content of about 0.04 percent, an unusual habitat for this species. In arid places the larvae are found in large containers of conserved water. *A. vittatus* usually inhabits exposed rock holes when streams are dry. Since these holes dry up rapidly, the larvae must mature rapidly. The pupae have been found in rock holes only 3 days after a rain.

This species inhabits open country and has been found at altitudes up to 6,700 feet.

Relation to Disease.—*A. vittatus* is infected with yellow fever virus in nature and is regarded as a potentially dangerous vector, at least in Anglo-Egyptian Sudan.

References: *114, 152, 157, 169, 253, 351.* (For additional information, see the description of yellow fever under Anglo-Egyptian Sudan.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Arabia
Bechuanaland
Belgian Congo
British Somaliland
Cameroons
Ceylon
Corsica
Eritrea
Ethiopia
French Equatorial Africa
Gambia
Gold Coast
India
Indochina
Kenya
Liberia
Mozambique
Natal
Nigeria
Northern Rhodesia
Nyasaland
Pemba
Sierra Leone
Sokotra
Southern Rhodesia
South-West Africa
Tanganyika
Transvaal
Uganda
Zanzibar
Zululand

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ANOPHELES SPECIES

Anopheles aconitus Dönitz

In the early literature *Anopheles aconitus* has usually been confused with *A. minimus*. Philippine records refer to *Anopheles filipinae*, since *aconitus* is not present in that country.

Bionomics.—Females of *aconitus* feed avidly on man in houses and bite domestic animals in nearby shelters. In the Sunda Islands they definitely prefer human blood. Elsewhere they occasionally rest in cowsheds. Experiments in the Sundas demonstrated flight ranges as far as 1 mile, although the effective range is probably not so great. This mosquito is a nocturnal flier. Night catches along the Bengal-Burma border indicate that the fewest adults appeared in April and May, with an abundance peak in mid-November.

Larvae are found in both mountains and plains, principally in fresh water. In Burma the favored breeding places are fresh-water pools in creek and river beds containing abundant aquatic vegetation and shade, as well as lakes, drainage ditches, and fresh-water fishponds. In Malaya the larvae live in the clear, open water of swamps and in slowly flowing water. Ricefields and their drainage systems are important breeding places for the larvae, especially where the water is bordered by grass. Larvae first appear when the rice crop is about half grown, and their numbers increase rapidly after the harvest. Along the Bengal-Burma border *aconitus* is found in marshy areas at the foot of hillocks, where immature stages have been taken from pools heavily covered with vegetation.

This species is common in foothills of 1,200 to 3,000 feet, especially in the Sunda Islands. It is also present but less common in the plains.

Relation to Disease.—*A. aconitus* is regarded as a malaria vector of some importance in spite of its having been confused with *minimus*. In several experiments in the Sunda Islands it has been found in the vicinity of both man and cattle. The females taken near man had old blood, and most of the unfed females were taken near livestock. However, in other collections up to 60 percent of females contained human blood. This species is abundant but rarely infected in nature in Celebes and Borneo, but it is probably a dangerous vector in parts of Sumatra and Java. In both Malaya and Burma it has been found infected, but it is not a proved vector in either of these countries. Naturally infected *aconitus* females have been found in Indochina. This species is strongly suspected as one of the most dangerous vectors in southern Annam and is a secondary vector in Tonkin and Cochin China. It is a vector in Cambodia, but its importance there is still in doubt, and its role in Thailand is not yet clear. In China the species is not important as a vector of malaria because of its scarcity.

Development of *Wuchereria bancrofti* to the infective stage in *aconitus* has been reported from Kabaena near Celebes, but the role played by this species in the transmission of filariasis is not known with certainty.

References: *88, 120–122, 161, 242, 324.* (For additional information, see the descriptions of malaria under Indochina, Thailand, and Sunda Islands.)

Recorded Distribution.—

Andaman Islands
Assam
Bali
Borneo
Burma
Celebes
Ceylon
China (South)
Flores
Hainan
India
Indochina
Java
Malaya
Pakistan (East)
Philippine Islands
Soemba
Soembawa
Sumatra
Thailand

Anopheles adenensis Christophers

Anopheles adenensis was originally described in 1925 as a variety of *Anopheles culicifacies*, to which it is closely related.

Bionomics.—This is a common household mosquito, readily feeding on man. Larvae breed in clear water in wells, stream beds, and rain pools, and also in tanks, cisterns, irrigation ditches, sluggish streams, ricefields, and borrow pits. In Hodeida on the Red Sea coast of Yemen larvae were found in brackish water in the open cement basins of mosques.

Relation to Disease.—There is no well-defined evidence, such as dissection records, to show that this species is a malaria vector. Nevertheless, it has been reported as a vector in the vicinity of Hodeida and in and about Aden. Since *culicifacies* is an outstanding vector of malaria, *adenensis* must be suspected as an efficient vector as well. In addition to its distribution in the Orient, typical *culicifacies* is found in Oman, Trucial Oman, and Bahrein.

References: *67, 91, 119, 206, 258, 296.* (For additional information, see the descriptions of malaria under Eritrea, the Somalilands, and Ethiopia; and Arabia.)

Recorded Distribution.—

Arabia
Eritrea

Anopheles albimanus Wiedemann

Because of its extensive distribution and importance, *Anopheles albimanus* is cited a great deal in the literature. The dry-weather varieties *bisignatus* and *trisignatus* have been described from Mexico and Guatemala.

Bionomics.—Adults of *albimanus* are domestic and are the most common *Anopheles* species in houses in many localities. Most females return to outdoor resting places soon after feeding but do not usually congregate in daytime resting places. They feed as readily on livestock as on man, depending on which is available, and will choose either as a host. They become active during twilight and in Panama fly in the evening, usually between 6:30 and 7:30. Copulation has been observed only during twilight. The species is a strong flier. Females can travel as far as 12 miles from their breeding places in short flights, with intervals of feeding between them. They have been observed to fly one-half to 1 mile at right angles to a strong wind and 5 to 40 feet above the ground. They have been trapped 1½ miles from their nearest breeding places.

Larvae live in a great variety of sunlit water collections, fresh or brackish. Since the water must contain many microorganisms, be without putrefaction, and be in biological equilibrium, most temporary breeding sites are not suitable. Larvae are found principally in swamps, large ponds, lakes, seepages, irrigation ditches, and ricefields. *A. albimanus* inhabits newly established ricefields in northern Venezuela to the exclusion of any other habitat. *Utricularia* and *Naias* are particularly favored as water plants, especially when water levels are such that these plants are at the surface. During the dry season larvae become adapted to crab holes, tanks, water troughs with algae, and drums of rainwater. In the very dry northern part of the Yucatan Peninsula *albimanus* is found near villages where water is stored in artificial reservoirs, but during the rainy season the species inhabits swamps in isolated areas. During the rainy season in Mexico larvae live farther inland than during the dry season.

A. albimanus is essentially a mosquito of hot, humid climates, and its seasonal abundance is directly related to rainfall. In most localities its numbers are noticeably reduced during the dry season, although in the Canal Zone the dry

season promotes the growth of certain aquatic plants favorable for larval development. At Esquipulas, Guatemala, *albimanus* was found at an altitude of 3,200 feet, where it had become adapted to an extremely dry climate.

Relation to Disease.—This is the most important and effective malaria vector in the Caribbean region. Shortly after it was introduced into Barbados, a severe outbreak of malaria occurred where none had previously been reported. It is stated that *albimanus* is the principal vector in 17 of the 20 Caribbean countries and is regarded as the chief vector along the gulf coast of Mexico.

References: *59, 210, 226, 308.* (For additional information, see the descriptions of malaria under America North of Mexico, West Indies, Mexico, Central America, Panama, Northwest South America, and Brazil and the Guianas.)

Recorded Distribution.—

Bahama Islands
British Guiana
British Honduras
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
French Guiana
Guatemala
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Puerto Rico
Surinam
Venezuela
Virgin Islands

Anopheles albitarsis Arribalzaga

Bionomics.—In Panama *albitarsis* does not attack man or enter his habitations, even when breeding places are close by. In Brazil it enters houses in large numbers during the night and day. An unnamed form inhabits eastern Rio Grande do Norte, Paraíba, Pernambuco, Alagôas, and the Amazon Valley. It also enters houses and feeds on man in large numbers.

The preferred larval breeding places are large bodies of water, such as large ponds, ground pools, marshes, bays, and overflow areas near rivers. In Costa Rica larvae live in sunny ponds with algae and vegetation, and in Gatun Lake, Canal Zone, they have been found in mats of *Chara*, *Naias*, and *Utricularia* exposed to full sunlight. Immature stages have been observed in Trinidad ricefields and in Venezuelan lakes with *Pistia* and *Eichhornia*.

Relation to Disease.—*A. albitarsis* is believed to be a vector of malaria in parts of South America, although the evidence is conflicting. In Pará and Paraíba, Brazil, it was the only *Anopheles* species found in large numbers in houses in the presence of endemic malaria and the only species found to be infected. It is important along the coastal plain south to Espírito Santo and is strongly suspected as a vector of malaria in parts of Venezuela. In Panama, on the other hand, it is hard to find and not believed to be important there. In Argentina the species is said to be more zoophilic than anthropophilic, although it may be important in the northeastern part of that country.

References: *46, 79, 292, 308.* (For additional information, see the descriptions of malaria under Panama, Northwest South America, Brazil and the Guianas, and Lower South America.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
British Guiana
Colombia
Costa Rica
Guatemala
Panama
Paraguay
Trinidad
Uruguay
Venezuela

Anopheles annularis van der Wulp

In Malaya and elsewhere *Anopheles annularis* has been confused with *A. philippinensis* and *A. pallidus*, but it is morphologically distinct from them as shown in the pictorial keys. The name most commonly applied to this species in the past is *Anopheles fuliginosus*. A variety, *adiei*, is regarded as a seasonal form.

Bionomics.—*A. annularis* rests in large numbers in cattle sheds and usually in smaller numbers in human habitations. In Bengal it is said to be definitely anthropophilic, even though it is usually divided there in about equal proportions between houses and cattle sheds. However, throughout most of the Orient it is zoophilic. In Malaya the females are principally zoophilic but will attack man readily. In Yunnan they feed on humans in large numbers. They are active in the evening and leave their biting places at dawn. During the day resting adults are found along eroded, overhanging stream banks at some distance from human dwellings. They are attracted to artificial light, often resting near light sources. They are strong fliers, usually flying a considerable distance from their breeding places.

Larvae inhabit a variety of clear-water breeding places, including large ponds of fresh water that contain aquatic vegetation, ricefields, shallow vegetated margins of lakes and slowly moving streams, ditches, swamps, borrow pits, and large tanks. They appear in large numbers during the rainy season in Formosa, then become more scarce at the beginning of the dry season.

This mosquito is found at altitudes of 5,000 to 7,000 feet. It is believed to overwinter in both larval and adult stages in northern India.

Relation to Disease.—Early records of malaria transmission by *annularis* are confused with those of *philippinensis*. Nearly all dissection records indicate that natural infection rates are normally low in Malaya, Burma, China, and the Philippines. *A. annularis* is probably of no importance in Cochin China and Annam, Indochina, and probably of little importance in the Philippines. Elsewhere, principally in Orissa in India, Goalpara in Assam, and Formosa, it appears to be only moderately important, probably because of its zoophilism. Perhaps it is most dangerous when present in hyperendemic areas.

The complete development of *Wuchereria bancrofti* has been observed in *annularis* in Java, but the extent to which this mosquito is important in filariasis transmission there is not known.

References: *67, 84, 85, 88, 91, 122, 296.* (For additional information, see the descriptions of malaria under India and Ceylon, East Pakistan and Assam, Formosa, and Burma.)

Recorded Distribution.—

Afghanistan
Assam
Bali
Borneo
Burma
Celebes
Ceylon
China (South)
Formosa
Hainan
India
Indochina
Java
Malaya
Nepal
Pakistan (East and West)
Philippine Islands
Soemba
Sumatra
Thailand
Timor

Anopheles annulipes Walker

Bionomics.—Females of *Anopheles annulipes* feed readily on man just after sunset and the following day tend to remain in shelters. In many parts of Australia females feed readily in the open near their breeding sites. However, in the Port Moresby area of New Guinea no adults have been found near large numbers of larvae. Females fly as far as one-half mile from their breeding places.

Larvae live in direct sunlight or in shade in clear or muddy, shallow ground pools, such as hoofmarks, wheel tracks, trenches, gravel beds, and margins of open sandy

pools, and in swamps, fishponds, rock pools containing green algae or weeds, and in water collected in rubbish and large artificial containers. In the Port Moresby area larvae abound in shaded pools in beds of intermittent streams, side pools of flowing streams, and in grassy seepage or overflow areas. In the vicinity of Melbourne, Australia, they are found in semipermanent creekbeds, swampy areas, wide sluggish creeks with grassy edges, roadside ditches, and brackish-water pools.

This species is widespread throughout coastal and inland Australia at altitudes up to 4,000 feet. In the neighborhood of Townsville and Cairns and in the Northern Territory, the species is extremely abundant from February to April. During certain times of the year it is the dominant species in the Port Moresby area of New Guinea.

Relation to Disease.—*A. annulipes* can be a malaria vector experimentally. No naturally infected females were found prior to 1944. Malaria seems to be absent from a large part of the area where this species lives. However, *annulipes* can produce small epidemics of brief duration during the summer in scattered localities in the southern half of Australia.

References: *67, 120, 202, 228.* (For additional information, see the descriptions of malaria under Australasia.)

Recorded Distribution.—

Australia (New South Wales, Northern Territory, Queensland, Southern Australia, Victoria, Western Australia)
New Guinea
Tasmania

Anopheles aquasalis Curry

Anopheles aquasalis was known as *A. tarsimaculatus* by many early authors. Other names for this species include *Anopheles gorgasi* and *A. emilianus*. Recent malaria literature deals with *aquasalis* under its present designation.

Bionomics.—Although *aquasalis* females in Panama are not particularly attracted to man, in the Lesser Antilles they feed more readily on man than on domestic animals. This is often the only mosquito found in houses, even though several kinds of *Anopheles* species may be present outdoors. In British Guiana females distinctly prefer human blood, but the habit of entering houses is not particularly characteristic of this species there. Females are strong fliers, having been observed in Trinidad as far as 3 miles from their breeding places. They are believed to migrate annually for distances of 1½ to 2½ miles.

Larvae usually live in brackish water along the seacoast in swamps and ditches and in Brazil are rarely found along rivers beyond the reach of brackish tidal water. They have been found in Costa Rican fresh-water streams and Trinidad ricefields and other collections of fresh water several miles inland. They apparently have no preference for light or shade, since they have been observed in locations varying from direct sunlight to deep mangrove.

Relation to Disease.—This species is a vector of malaria in many of the Lesser Antilles, especially Trinidad, Grenada, and St. Lucia, and in the Paria Peninsula of Venezuela directly west of Trinidad. In British Guiana it apparently is not found in the presence of endemic malaria, but it is recognized as a vector in Uruguay, northern Argentina, and in several coastal localities in Brazil south of the Guianas. In Panama, where adults are rarely attracted to man, malaria is not proportional to *aquasalis* activity. The species can be important only when it is present in large numbers, since natural infection rates are almost always low. It is responsible for endemic rather than epidemic malaria.

References: *79, 226, 292, 308.* (For additional information, see the descriptions of malaria under West Indies, Panama, Northwest South America, Brazil and the Guianas, and Lower South America.)

Recorded Distribution.—

Argentina
Brazil
British Guiana
Colombia
Costa Rica
Ecuador
French Guiana
Mexico
Nicaragua
Panama
Paraguay
Peru
Surinam
Trinidad
Uruguay
Venezuela

Anopheles aztecus Hoffman

References to *Anopheles aztecus* have appeared under the names *A. freeborni*, *A. quadrimaculatus*, *A. maculipennis*, *A. occidentalis*, and *A. atropos*. *A. aztecus* was originally described as a variety of *maculipennis*. Since about 1940 it has been regarded as a full species.

Bionomics.—Females of *aztecus* readily invade human dwellings and bite man throughout the year. Their numbers are reduced in the dry spring months and increase to an average of 21 per house in late summer and fall. During the rainy period the high relative humidity encourages the presence of adults rather than the rain and consequent accumulation of water. Inside houses they commonly rest on walls and under beds. Only small numbers are found resting out of doors and then only at night. Few females are attracted to animal traps. In the laboratory adults will mate in small cages, and oviposition has occurred at the low temperature of 64° to 68° F.

The larvae live in seepage areas and along the vegetated shores of streams and irrigation canals. They appear to thrive in clear-water pools containing algae and protozoa. *Potamogeton*, *Ceratophyllum*, and *Nitella-Ceratophyllum* mats are the most favorable breeding sites. Floating vegetation, especially *Eichhornia*, *Pistia*, *Lemna*, and *Azolla*, is not favorable for larval development. Larvae are present in breeding places the year around, even when ice forms over the water. Pollution of water always follows the development of urban areas, and since *aztecus* tolerates such conditions more easily than *Anopheles pseudopunctipennis* with which it is associated, *aztecus* is gradually replacing the latter species on the outskirts of Mexico City.

Relation to Disease.—Conflicting statements on the ability of *aztecus* to transmit malaria are found in the literature. In spite of the malaria-free areas in the State of Mexico in which *aztecus* is the only anopheline present, the Xochimilco-Mixquic area of the valley of Mexico, with an elevation of about 7,500 feet, represents an endemic zone. Here *aztecus* is the only vector present in large enough numbers to support the disease. It transmits parasites in the laboratory and has been found with high infection rates in nature. Recent control of this species has markedly reduced malaria incidence.

References: *41, 67, 110, 292, 296.* (For additional information, see the description of malaria under Mexico.)

Recorded Distribution.—

Mexico

Anopheles baezai Gater

Anopheles baezai was first described as "*umbrosus* larval variation" in 1919 and was redescribed as *A. gateri* in 1936. It belongs to the *umbrosus* group. Very early records are found under the more inclusive name *umbrosus* (p. 138).

Bionomics.—Records of mosquitoes caught in animal sheds and in human-bait traps show that females of *baezai* are rather weakly anthropophilic. It is unusual to find them biting in the daytime. They have been observed resting in considerable numbers in the early part of the day on frond bases of nipa palm (*Nipa fruticans*) in Malaya.

Larvae inhabit brackish-water collections containing a variable amount of decaying vegetation, especially those that

are periodically refilled by tides. When tidal salt water is prevented from entering such pools, *baezai* tends to disappear. These breeding places are often shaded, although deep shade is not necessary for larval development. Larvae are often found with *Anopheles sundaicus* larvae but are never so numerous.

A. baezai is rather restricted in distribution and is seldom very common. It is reported to be most numerous during and after high equinoctial tides in September, when there is heavy rainfall.

Relation to Disease.—*A. baezai* is an inefficient malaria vector because of extremely high sporozoite rates, unusual forms of parasites within its body, unsuccessful attempts to infect females and to transmit malaria in the laboratory, and animal-positive precipitin tests. However, the females appear in relatively large numbers in human-bait traps as compared with those in animal shelters. Positive dissections have been made in the Miri-Lutong and Kuala areas of Borneo. *A. baezai* may be a vector in these and other localities where its populations are high.

References: *244, 357.* (For additional information, see the description of malaria under Sunda Islands.)

Recorded Distribution.—

Bali
Borneo
Celebes
Indochina
Java
Malaya
Philippine Islands
Sumatra

Anopheles bancrofti Giles

Anopheles bancrofti for a number of years was known as a variety of *A. barbirostris*. It is now recognized as a full species with several subspecies of its own.

Bionomics.—Although females may attack man outside during the day, *bancrofti* is not commonly regarded as anthropophilic. It is abundant near Cairns, Australia, but it does not attack man in large numbers. However, in Northern Territory it is frequently a troublesome biter, and in the southern part of Dutch New Guinea—Merauke and Tanahmerah—it is found in very large numbers and persistently bites man. Precipitin tests in the latter area revealed that almost 90 percent of the females taken in houses or animal shelters had human blood and 10 percent had fed on animals. Females are often found in houses resting on walls and in mosquito nets and commonly are present in cattle sheds in large numbers. The species is nocturnal.

Larvae are largely restricted to shade and are often reported in heavy woods or dense aquatic growth. In Queensland and Northern Territory shaded swampy areas are preferred breeding places. In Dutch New Guinea the species breeds in jungle and in old, cutoff courses of the Digoel River, in which the larvae are restricted to areas containing coarse reeds, algae, and *Azolla* about 1 mile from shore.

Relation to Disease.—*A. bancrofti* has not been found naturally infected with malaria in Australia, although parasites have developed in this species in laboratory experiments. It should be regarded as a dangerous vector if present in large numbers. In New Guinea this species rarely appears in the absence of *Anopheles farauti*, which is a very efficient vector. In Dutch New Guinea *bancrofti* was found with a natural infection rate of 4.3 percent in an area where *farauti* was also present in small numbers, and in Batu Gajah *bancrofti* was shown to be the principal malaria carrier. The subspecies *barbiventris* is not known to be a vector of disease.

References: *67, 121, 228, 324.* (For additional information, see the description of malaria under Australasia.)

Recorded Distribution.—

Australia (Northern Territory, Queensland, Western Australia)
New Guinea

Anopheles barbirostris barbirostris van der Wulp

Anopheles barbirostris has several easily distinguished varieties or subspecies. Only the typical one appears to be medically important.

Bionomics.—Over most of its range, including India, *barbirostris* is principally zoophilic, but it becomes more domestic farther east. In Celebes it enters houses in large numbers for blood meals, leaving soon after feeding. However, in Indochina a very low percentage of females contains human blood, and in localities in Malaya where livestock is present more mosquitoes appear to have fed on cattle than on humans. Resting adults are found along the undercut banks of streams, sides of shaded stone walls, and under uninhabited buildings. The adults fly on cloudy days or in jungle shade. In the Philippines a flight range of approximately 1,300 to 1,970 feet has been observed.

Larvae most commonly are found in the shaded, clear water of streams, rivers, large vegetated ponds, flowing irrigation ditches and canals, borrow pits, wells, and even in stagnant collections of water. Clear, fresh water is preferred. Ricefields are common breeding sites in Malaya. In India the larvae are found at vegetated margins of lakes, swamps, and sluggish rivers. In Indonesia they live in exposed or shaded, turbid and stagnant locations from the coast to high altitudes, and in the Philippines they have occasionally been taken from salt marshes.

Relation to Disease.—In most areas outside Malaya, Sumatra, and Celebes *barbirostris* is not considered to be an important vector of malaria except where it appears in large numbers or serves as an accessory vector to a more important transmitter. Experimental infection rates always have been low. In certain areas of Malaya where natural infection rates are high, *barbirostris* contributes to the maintenance of malaria. In many areas of southern Celebes an undescribed form of *barbirostris* has been found with high natural infection rates, and next to *Anopheles sundaicus* and *A. ludlowi torakala* it is the most important vector in that area. In Sumatra and northeastern India natural infection rates are usually very low, but *barbirostris* is occasionally important in Sumatra.

The development of infective stages of *Wuchereria bancrofti* in *barbirostris* after experimental feeding has been demonstrated at Batavia, Java. *A. barbirostris* is the most important vector of *Wuchereria malayi* at Kalawara-napuli, Celebes, where infection rates of up to 8.1 percent have been reported.

References: *121, 122, 161, 228.* (For additional information, see the descriptions of malaria and filariasis under Malaya and Sunda Islands.)

Recorded Distribution.—

Assam
Bali
Bangka
Borneo
Burma
Celebes
Ceram
Ceylon
China (South)
Flores
Formosa
Hainan
India
Indochina
Java
Malaya
Moluccas
New Guinea
Pakistan (East)
Philippine Islands
Soemba
Soembawa
Sumatra
Thailand
Timor

Anopheles bellator Dyar and Knab

Bionomics.—Adults of *Anopheles bellator* are found in large numbers in their normal resting places in the forest canopy 40 to 60 feet above the ground. Toward evening females leave the forest canopy, fly to nearby centers of human activity, and bite man readily. No critical studies have been made to determine the amount of zoophilism in this species,

nor is it known on what animals, if any, *bellator* feeds in the forest. Biting takes place almost entirely out of doors, especially in the evening, although some females are active throughout the day. Even though the adults rarely enter houses in Trinidad, they appear in rather large numbers inside habitations in Brazil. After obtaining blood meals, the females immediately return to the forest or cacao canopy, where they rest and their eggs develop. Many more adults are always present in the forest canopy than in biting places outside the forest.

Larvae are found in water collections in the epiphytic bromeliads that grow in immortelle trees (*Erythrina*), which are planted in cacao plantations to provide shade for the rather sensitive cacao. Water in these plants is full of organic matter and larvae develop rapidly. In Trinidad larvae are most commonly found in *Gravisia aquilega*, a bromeliad growing from 10 to 30 feet above the ground, and even though they will utilize several species of bromeliads, the removal of this particular species will destroy practically all the *bellator* breeding places. In Trinidad *bellator* is most active in areas that receive from about 90 to 110 inches of rainfall annually. When the rainfall is below or above this amount, the species tends to disappear, even though breeding places in drier or wetter areas are still abundant enough to support large populations.

Relation to Disease.—Several times in Trinidad and Brazil *bellator* has been easily infected with malaria parasites and infected females have repeatedly been captured. In these two countries most endemic malaria in the agricultural communities near cacao estates is maintained by (1) regular flights of mosquitoes between houses and forests and (2) contact of mosquitoes with people who work out of doors in areas where *bellator* has even better success in seeking them out. Bromeliad malaria exists in parts of Trinidad, principally in St. Andrew County, and in Santa Catarina, Paraná, and São Paulo in Brazil. The status of this species in malaria transmission in areas other than those discussed above is not known with certainty.

Reference: *67*. (For additional information, see the descriptions of malaria under West Indies, and Brazil and the Guianas.)

Recorded Distribution.—

Brazil
Colombia
Surinam
Trinidad
Venezuela

Anopheles brunnipes (Theobald)

Bionomics.—*Anopheles brunnipes* is generally rare, but when its numbers increase, it may become a dangerous vector. It is very abundant in some localities, especially at Pebane in Mozambique, Sierra Leone, and Leopoldville in Belgian Congo. It is a species of the cold, dry season. It has been taken in considerable numbers in human habitations in Leopoldville and "Aguas Quentes," Mozambique.

Larvae inhabit small, exposed ground pools and slowly flowing water with surface vegetation and partial shade. In Mozambique large numbers of larvae have been collected in small pools in an open road drain, where the water was very fresh, very shallow, and at some distance from human habitations. Although typical of *Anopheles gambiae* breeding places, these pools harbored none of this species.

Relation to Disease.—Malaria infection rates as low as 1.38 percent have been found in French West Africa. *A. brunnipes* is considered to be of little importance in the transmission of malaria there. In Leopoldville, Belgian Congo, on the other hand, a salivary infection rate of about 4 percent was found during the winter. These mosquitoes are seen in small numbers because of their nondomestic habits. However, they should be investigated wherever they are abundant, because other vectors may not be so active in the winter when this species is common. At present it is regarded as a secondary vector of some importance.

References: *119, 258, 260.* (For additional information, see the descriptions of malaria under West Africa, West-Central Africa, Madagascar and Adjacent Islands, and Southern Africa.)

Recorded Distribution.—

Angola
Belgian Congo
Cameroons
French Equatorial Africa
French Guinea
French West Africa
Gold Coast
Ivory Coast
Madagascar
Mozambique
Nigeria
Northern Rhodesia
Sierra Leone
Southern Rhodesia
South-West Africa

Anopheles christyi (Newstead and Carter)

Bionomics.—In Kenya *Anopheles christyi* is reported to be common in cattle sheds and rare in human habitations, and in most of Uganda it is entirely nondomestic. However, in the Kigezi highlands of Uganda it seeks man as a source of blood meals, because cattle are scarce.

In Kenya larvae are found in borrow pits, pools with muddy, stagnant water completely exposed to the sun, ditches, slow-moving streams, pools in drying stream beds, and at the edges of swamps and seepages. They often live in small bodies of water used by cattle for drinking. Fouling of this water in moderate amounts by cattle droppings does not appear to inhibit larval growth. Since *christyi* tolerates greater pollution than *Anopheles gambiae*, the latter disappears as pools become more concentrated by evaporation. In Uganda the species lives in the forest in brackish waterholes used as wallows by big game. In Tanganyika its breeding places are usually partially shaded irrigation channels and small pools that at higher altitudes have little shade. *A. christyi* easily tolerates high altitudes within its range.

Relation to Disease.—This mosquito is not generally considered to be important in the transmission of malaria. In one malaria study in Kenya none of 336 females were infected, and in another study a large number of females were shown by precipitin tests to contain blood meals taken from domestic animals. Furthermore, the seasonal prevalence of the mosquito and the annual cycle of malaria do not coincide anywhere in Kenya. On the other hand, this species is common in huts in the highland district of Kigezi, Uganda, where it was definitely thought at one time to be a vector in a malaria epidemic. However, subsequent studies showed that because both *gambiae* and *Anopheles funestus* were present, the part played by *christyi* in this outbreak is in some doubt. It is not known whether *christyi* can carry the disease elsewhere, but the possibility is slight. This species is included in the keys as a vector because of its possible role in the Kigezi highlands malaria epidemic.

References: *69, 119, 260.* (For additional information, see the descriptions of malaria under Eritrea, the Somalilands, and Ethiopia; West-Central Africa; East-Central Africa; and Madagascar and Adjacent Islands.)

Recorded Distribution.—

Belgian Congo
Ethiopia
Kenya
Madagascar
Somalia
Tanganyika
Uganda

Anopheles claviger (Meigen)

In early Italian papers *Anopheles claviger* was a name occasionally applied to *A. maculipennis*. True *claviger* has almost universally been called *Anopheles bifurcatus* in early European literature.

Bionomics.—In Sardinia *claviger* is largely sylvatic and seldom bites man. Few females have been found in domestic shelters. About one-half of those captured were

from natural hollows and about one-fourth from vegetation. However, in Israel, this species is very definitely domestic, and in Syria and Lebanon both man and animals are attacked night and day, indoors and out. In some localities man is used as a source of food only when breeding places are close by. In Europe, Caucasia, and central Asia the adults are common early in the spring and again late in the fall, particularly in Sardinia, Italy, and Albania. Over much of its range *claviger* lays eggs without a blood meal, whereas forms requiring blood for egg laying have been observed on the Black Sea coast.

In England and other localities at similar latitudes larvae live in permanent ponds and along lake margins in the shade. However, in more southern areas they are restricted to cool spring-fed pools, which in much of Asia are the characteristic breeding places. In Sardinia, springs and associated rivulets, streams, tanks, wells, waterholes, ground pools, and swamps are common habitats. Larger bodies of water are preferred during the winter and smaller, colder ones in the spring. In Caucasia and central Asia the temperature of the water in the summer is elevated to a point where larval populations are decidedly decreased. In general, breeding waters are cool, clear, and shaded. Water may be standing or running and shaded or exposed to the sun. Larvae have a habit of staying submerged for an average of about 1 minute when they are disturbed. They have been observed to stay under the surface for as long as 14 minutes. In Israel, Jordan, Syria, and Lebanon larvae are found in cisterns underneath or adjacent to man's habitations.

A. claviger is adapted to the low temperatures common to high latitudes, usually passing the winter as larvae, but in Sardinia the mosquito breeds throughout the year, even though the adults develop fat bodies. *A. claviger* has been found at altitudes of about 4,300 feet and in Morocco and Turkestan at about 9,200 feet.

Relation to Disease.—Over most of its range *claviger* is not important in malaria transmission, since it is either scarce or not attracted to man. It is important in Israel because of its habit of breeding in cisterns and other domestic water supplies. It is of local importance in villages on the central plain and coastal areas of Syria and Lebanon, where small amounts of malaria are transmitted. In the suburbs of Baku, Caucasia, where mountain springs stay cool enough through the summer to maintain large populations of the vector in close proximity to man, the species supports endemic malaria.

References: *67, 229, 239.* (For additional information, see the descriptions of malaria under North Europe and North Asia, the Near East, and Afghanistan and West Pakistan.)

Recorded Distribution.—

Albania
Algeria
Austria
Balearic Islands
Belgium
Bulgaria
Caucasia
Corsica
Crete
Cyprus
Czechoslovakia
Denmark
Egypt
Elba
European U. S. S. R.
France
Germany
Great Britain
Greece
Hungary
Iran
Iraq
Ireland
Israel
Italy
Jordan
Lebanon
Libya
Morocco
Netherlands
Poland
Portugal
Rumania
Sardinia
Sicily
Spain
Spanish Morocco
Sweden
Switzerland
Syria
Tunisia
Turkestan
Turkey
Yugoslavia

Anopheles crucians Wiedemann

Bionomics.—Although the females of *Anopheles crucians* may enter houses readily and bite man freely, they are primarily outdoor biters on porches, in outhouses, and in similar locations. Studies on the host preference of *crucians* have shown it to be more zoophilic than anthropophilic. This habit probably varies from place to place according to the availability of hosts. A flight range of 7,000 to 9,000 feet has been observed.

Larvae frequently are found with those of *Anopheles quadrimaculatus* but, unlike that species (see p. 133), *crucians* is predominantly an acid-water breeder. In the Southern United States larvae are found in the complete absence of *quadrimaculatus* in dense cypress swamps and coastal-plain ponds. Their favorite habitats are impoundments, blocked streams, seepages, and occasionally wheel ruts, temporary pools in pine forests, and other accumulations of water without vegetation. In Jamaica larvae have been collected from streams, seepages, and ponds with sunlit or lightly shaded water, but not in brackish water. In the United States *crucians* larvae are found in breeding places all winter long and have even been taken from mud at the bottom of ice-covered water.

Relation to Disease.—Because of its high densities along the coastal plain of the Southern United States, its house-entering habits, and its occasional anthropophilic tendencies, *crucians* has been considered a potential vector of malaria in the Southeastern United States, even though it is often present in large numbers in the absence of appreciable malaria. It is probably important in Cuba, but farther east its role as a vector is not known.

References: *67, 292, 308, 349.* (For additional information, see the descriptions of malaria under America North of Mexico, West Indies, and Mexico.)

Recorded Distribution.—

British Honduras
Cuba
Dominican Republic
Guatemala
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Puerto Rico
United States

Anopheles cruzi Dyar and Knab

Bionomics.—*Anopheles cruzi* inhabits the rain-forest canopy, living in greatest numbers at some height above the ground. In Santa Catarina, Brazil, large numbers of females fly to houses in the outskirts of the towns of Brusque, Joinvile, São Francisco, and Florianópolis, which adjoin rain forests, where they have been observed biting man in extremely large numbers. *A. cruzi* larvae have habits and breeding places similar to those of *bellator* (see p. 115).

Relation to Disease.—As long ago as 1903 *cruzi* was incriminated as a vector of malaria in the mountain forests of São Paulo, Brazil, where railroad laborers were contracting a considerable amount of malaria. Not long afterward *cruzi* was found naturally infected with malaria parasites in Paranaguá, Brazil. In 1942, 1943, and 1944 it was again found naturally infected, and it was easily infected experimentally with malaria parasites. It is now regarded as an important vector.

References: *67, 237.* (For additional information, see the description of malaria under Brazil and the Guianas.)

Recorded Distribution.—

Brazil
British Guiana
Costa Rica
Ecuador
French Guiana
Panama
Peru
Surinam
Venezuela

Anopheles culicifacies Giles

The name commonly employed in the early literature for *Anopheles culicifacies* was *A. listonii*, but *culicifacies* has been used in recent important literature relating to disease transmission.

Bionomics.—Adults of *culicifacies* rest in large numbers in small dark spaces in houses and cowsheds during the day. In some localities females are zoophilic, feeding actively on cattle and birds at dusk, but in most areas they prefer man as a host. Flight ranges from 1½ to 1¾ miles have been observed.

Fresh, clean water attracts most ovipositing females, although immature stages occasionally are found in brackish water. The usual breeding sites are fresh water with grassy edges, such as irrigation ditches, seepages, pools, slow-moving streams, canals, riverbeds, freshly formed collections of rainwater in borrow pits, fallow ricefields, shallow tanks, pits, and wells. The species prefers sunlight or light shade, avoiding dense shade, for oviposition.

A. culicifacies is ordinarily a plains species, but it is found at moderate altitudes in the Himalayas, having been recorded up to 6,500 feet. In India it overwinters as a larva and is most prevalent from May to November in the northern parts of that country.

Relation to Disease.—This species is one of the most important malaria vectors wherever it appears. It is probably an important mosquito east and south of the Iranian deserts, in the Punjab of West Pakistan, and in parts of Afghanistan, East Pakistan, Assam, South China, and Thailand. It is of primary importance in India, Ceylon, and Burma. In many localities in South China it is too rare to transmit the disease.

References: *84, 88, 91, 122.* (For additional information, see the descriptions of malaria under Iran, Afghanistan and West Pakistan, India and Ceylon, East Pakistan and Assam, South China, Burma, and Thailand.)

Recorded Distribution.—

Afghanistan
Arabia
Assam
Bahrein
Burma
Ceylon
China (South)
India
Indochina
Iran
Pakistan (East and West)
Thailand

Anopheles darlingi Root

Bionomics.—*Anopheles darlingi* Root is one of the most domestic mosquitoes in the New World. It feeds readily on man and enters human habitations in large numbers. In studies in the rural areas of Stann Creek Valley and the Toledo District of British Honduras, about 72 percent of all mosquitoes caught in houses were *darlingi*; only 27 percent captured at sunset on horses were this species. In another locality three-fourths of the *Anopheles* species inside houses near beds and in dark places were *darlingi*, whereas not one was caught on a horse used as bait just outside. High humidity and rainfall are primary requisites for adult survival.

Larvae are commonly found in mats of surface vegetation in bodies of water that lack appreciable current or waves. They live in shaded water with low salt content and neutral or slightly acid reaction. Some larvae are specially adapted to floodwaters. In the Amazon Valley the dry season is extensive enough to eliminate the species from large areas, during which time it breeds in swamps or other large bodies of deep, still water that are not affected by dry weather. In Brazil larvae live at the shaded edges of impoundments, where wave action is damped by branches of trees extending into the water, and they do not live in ditches, small pools, or swamps. In British Honduras larvae are common along deeply shaded stream edges.

Relation to Disease.—This species is the most efficient indigenous malaria vector in north and northeast Brazil. In the Amazon Valley it causes small regular epidemics of malaria, a disease that is never found without *darlingi* in this area. Because this species is closely associated with malaria in Venezuela and British Guiana, it is extremely important in those localities and in most others where it and malaria appear together.

References: *79, 292, 308.* (For additional information, see the descriptions of malaria under Mexico, Central America, Panama, Northwest South America, Brazil and the Guianas, and Lower South America.)

Recorded Distribution.—

Argentina
Bolivia
British Guiana
British Honduras
Colombia
Ecuador
French Guiana
Guatemala
Honduras
Mexico
Peru
Surinam
Venezuela

Anopheles domicolus Edwards

Bionomics.—*Anopheles domicolus* is a localized species. In studies in northern Nigeria it represented 0.25 percent of all *Anopheles* species caught in human habitations. Breeding places of the larvae are not known.

Relation to Disease.—This mosquito is regarded as a subsidiary vector of malaria in French West Africa and Haute-Volta, where 3 of 283 and 1 of 44 females, respectively, were found to harbor sporozoites.

References: *119, 258, 260.* (For additional information, see the description of malaria under West Africa, East-Central Africa, and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
French West Africa
Gold Coast
Ivory Coast
Nigeria
Northern Rhodesia
Sierra Leone
Southern Rhodesia
Uganda

Anopheles d'thali Patton

Originally described from the Aden hinterland, *Anopheles d'thali* has been discussed in some literature under the name *A. rhodesiensis*. However, the *rhodesiensis* species of Africa is entirely different (p. 133).

Bionomics.—Females of *d'thali* feed readily on man. They are often found in tents, barracks, and houses, and they also rest in cowsheds. Adults have been found 1¼ miles from their nearest breeding places in Arabia.

Larvae inhabit springs, wells, and riverbed pools, usually with moderate shade and some floating vegetation. In India deep riverbed pools full of water plants and algae are preferred breeding places. In Yemen larvae are found in the quiet marginal water of drying streams, with emergent short vegetation and filamentous green algae. In many parts of Arabia they are commonly found in holes in volcanic rocks fed by underground water and in underground aqueducts and tanks. In Sinai the species shows little preference for any one type of breeding place. Larvae have been found in all kinds of water collections, including stagnant weedy pools, small swiftly flowing streams, fresh water moving slowly over grass, and in weedy pools near fresh-water streams. In British Somaliland seepages, footprints, and waterholes are inhabited by these larvae, although they are usually rare when *Spirogyra* is present.

In India *d'thali* is prevalent from July to September and at Khajraho it has been found at an altitude of approximately 2,000 feet. It is a highland and plateau species in Jordan.

Relation to Disease.—In Arabia and Sinai *d'thali* is suspected of being a vector of malaria. It was the most preva-

lent species when 100 percent of the personnel of a military post became ill with malaria. It is believed to be a vector in northern Ethiopia and British Somaliland.

References: *67, 91, 120, 206, 239.* (For additional information, see the descriptions of malaria under Northwest Africa; Egypt; Eritrea, the Somalilands, and Ethiopia; and Arabia.)

Recorded Distribution.—

Algeria
Anglo-Egyptian Sudan
Arabia
British Somaliland
Egypt
Eritrea
Ethiopia
India
Iran
Iraq
Israel
Jordan
Libya
Morocco
Pakistan (West)
Somalia
Tunisia

Anopheles farauti Laveran

Throughout most of the literature *Anopheles farauti* has been represented as *A. punctulatus* var. *moluccensis*. In 1946 *farauti* was definitely determined to be a full species.

Bionomics.—Females are most active at night but have been observed to feed during the day if the sky is overcast. In some areas they are seldom found in native huts during the day, whereas in others they enter houses in considerable numbers in the daytime. In most localities females will feed on man to the complete exclusion of livestock. In the New Hebrides they feed readily on horses and cattle even when man is present. Adults rest in heavy stands of *kunai* grass and are found close to the ground on the stems. They are rarely observed close to their breeding places.

In the Solomons and New Hebrides the dry-season breeding places are rivers, streams, ponds, lagoons, taro gardens under water, roadside ditches, and occasionally wells and animal wallows. During the wet season larvae live in almost all types of manmade depressions filled with fresh rainwater. In Guadalcanal, eggs, larvae, and pupae are commonly flushed by heavy rains from permanent breeding places, such as ruts, foxholes, bomb craters, trenches, and borrow pits, to the flat alluvial plains of the northeast coast. In northern Queensland the species breeds in lagoons and potholes along riverbanks. Larvae are found in pure, brackish, or rather stagnant rainwater, where vegetation may or may not be present. They have been taken from heavily shaded mangrove areas, but open sunlight is apparently preferred. They are rarely found in coconut shells. The aquatic cycle usually lasts from 13 to 15 days.

Relation to Disease.—Because of its high susceptibility to infection and its domesticity, *farauti* is the most important vector of malaria in Australasia. In the Moluccas, New Guinea, Admiralty Islands, Bismarck Archipelago, northern Australia, and the Solomon Islands this species is especially important. It is said to be the only vector in the New Hebrides, and natural infection rates in New Guinea are very high. Malaria and the distribution of *farauti* are bounded by longitude 170° E. and latitude 20° S. The reasons for these limits are as yet unexplained.

In the Solomons-New Hebrides area *farauti* is an important vector of filariasis. Almost 14 percent of this species was found infected with *Wuchereria bancrofti* in the New Hebrides and over 50 percent in Guadalcanal.

References: *67, 103, 122, 146, 294, 324.* (For additional information, see the descriptions of malaria and filariasis under Australasia.)

Recorded Distribution.—

Admiralty Islands
Australia (Northern Territory, Queensland)
Bismarck Archipelago
Ceram
Moluccas
New Britain
New Guinea
New Hebrides
New Ireland
Solomon Islands

Anopheles filipinae Manalang

Anopheles filipinae belongs to the so-called *funestus-minimus* subgroup of *Anopheles* (p. 120) and was originally known as a variety of *A. minimus*.

Bionomics.—Almost nothing is known about the habits of *filipinae* adults. Flight-range experiments show that stained adults may travel as far as 3,300 feet from the point of release.

Larvae inhabit small, slowly flowing, spring-fed streams, grassy margins of canals, clear or muddy water of streams, flowing irrigation ditches, pools, lakes, and other impoundments. They are occasionally associated with aquatic vegetation, such as *Pistia*, *Ipomoea*, and water hyacinths.

Relation to Disease.—Large numbers of *filipinae* are found in northern Luzon, where malaria has been known to occur. In central and southern Luzon the species is not at all common. The natural infection rate has, in general, been very low, and as far as is known no experimental infections have been performed.

References: *67, 120, 204, 308.* (For additional information, see the description of malaria under Philippine Islands.)

Recorded Distribution.—

Philippine Islands

Anopheles fluviatilis James

In many early references *Anopheles fluviatilis* was called *A. listonii* and *A. christophersi*.

Bionomics.—Females of *fluviatilis* appear to prefer houses as nighttime resting places but have also been found in considerable numbers in cowsheds. Two subspecies of *fluviatilis* may exist in India. One form in the south is strongly anthropophilic and feeds readily on man; the other in the north bites cattle almost exclusively. The southern form feeds from 1½ hours after dusk to midnight. Most of the females rest out of doors during the day. In a study in India few adults were found in villages beyond 2,600 feet from their breeding places. Once they were reported at a greater distance.

Larvae inhabit pools in stream beds, slow-flowing water with vegetation, leaks from springs and irrigation ditches, swamp edges, lake margins, drains, ponds, and tanks. Most of the streams in which this species is found have grassy edges. In Yemen *fluviatilis* was observed at an elevation of about 7,300 feet in natural pools along a ditch with stonewort rushes and filamentous green algae. Although sometimes found in ricefields, the species does not breed prolifically there. Larvae have never been observed in large numbers. Dispersed breeding over immense areas is responsible for the importance of this species.

Widely distributed throughout India, especially in foothill areas and hilly or rocky areas, this species is more common in the west than in the east. At Peshawar, West Pakistan, this species has been observed from May to November, with population peaks in May and June and again in November. It has been found at an elevation of 6,000 feet at Kashmir and as high as 7,500 feet at Murree. In southern India it is not normally found below 1,000 feet.

Relation to Disease.—Undoubtedly this is a very important vector of malaria. Although few experimental infections have been reported in the literature, *fluviatilis* has been found naturally infected in many areas of India. It is considered to be of greatest importance in peninsular India, is a suspected vector in Arabia, and transmits malaria in the foothills of West Pakistan.

References: *67, 91, 120, 206.* (For additional information, see the descriptions of malaria under Arabia, Afghanistan and West Pakistan, and India and Ceylon.)

Recorded Distribution.—

Afghanistan
Arabia
Assam
Burma
Ceylon
China (South)
India
Indochina
Iran
Iraq
Pakistan (East and West)
Thailand
Turkestan

Anopheles freeborni Aitken

Bionomics.—*Anopheles freeborni* readily enters homes and animal shelters, biting actively through the night. At the end of the dry season fertile females migrate as far as 12 miles and settle in outbuildings, homes, and cellars. They apparently do not stay in one place but move from one spot to another throughout the winter. Since a single female may bite several persons without taking a full blood meal at any one time, it can transmit malaria during the winter, when it lives almost entirely inside houses and sheds, biting near the floor. These females have well-developed fat bodies, and even when they take blood meals, usually no eggs develop during the winter months. When the females leave these winter haunts for summer breeding, they bite viciously in full daylight and then lay eggs. In midseason, adults rarely fly farther than 1 mile from their breeding places.

Adults oviposit in all kinds of water collections. Many of these dry out as the summer progresses. Larvae live in permanent or semipermanent water collections, as well as in seepage areas, vegetated borrow pits, hoofprints, carelessly irrigated fields, and edges of streams and canals where vegetation protects them from water movement. Larvae prefer water that is clean, clear, and slightly alkaline, and they swim to lightly shaded sunlit places with flotage, algae, or emergent vegetation. Although *freeborni* will breed in brackish water, it tends to avoid sewage pollution and organic material. Favorite habitats are ricefields in which the water remains fairly fresh.

A. freeborni is a mosquito of semiarid regions having seasonal rainfall. Peaks of adult abundance occur during the early summer and at the end of the dry season in the fall.

Relation to Disease.—This mosquito has been regarded for years as the important malaria carrier in the Western United States, and it may play a small part in the transmission of that disease in Lower California and on the north-central plateau of Mexico.

Reference: *67.* (For additional information, see the descriptions of malaria under America North of Mexico and Mexico.)

Recorded Distribution.—

Mexico
United States

Anopheles funestus Giles

Anopheles funestus has been known by various names, because it is present in most of tropical Africa, appears in such large numbers, and is so important. It is very similar to *Anopheles minimus* and its relatives in the Orient. *A. funestus imerinensis* is the only medically important form of *funestus* in Madagascar.

Bionomics.—Precipitin tests almost always show that more *funestus* females have fed on man than on cattle. Females most commonly bite indoors, and experiments show that they are attracted to man by his odor. In one part of Africa females were found to enter native huts from 8 p. m. to about 2 a. m. and in another part between 2 and 6 a. m. A large number of females remain in houses, where they feed until after dawn. Under normal conditions adults are not likely to be found in large numbers beyond one-half mile from their nearest breeding places, but under unusual conditions they may fly as far as 4 miles.

Two kinds of breeding places may be frequented by the larvae. The most characteristic of these is large and rather permanent, and it includes swamps, lakeshores, and ponds. The other larval habitat comprises smaller bodies of water, such as hill streams, furrows, ditches, and seepages, and occasionally wells and artificial containers. Females sometimes seek these smaller water collections when no large bodies of water are available to support the large populations that are sometimes found. Floating vegetation such as *Pistia*, *Eichhornia*, *Marsilea*, low grass, and rice provide optimum breeding conditions for the larvae, which are killed more easily by high temperatures than are those of *Anopheles gambiae*.

Where breeding takes place in large permanent bodies of water, the populations of *funestus* are more constant throughout the year than those of *gambiae*. In hilly regions where the former species breeds in streams, the populations tend to fluctuate with flushing rains.

Relation to Disease.—This is one of the two most important vectors of malaria in Africa. In contrast to *gambiae*, whose seasonal variation in abundance adapts it to the transmission of much of the epidemic malaria in Africa, *funestus* fluctuates relatively little in numbers because of its habit of breeding in large bodies of water, and it is responsible for severe endemic malaria. Large populations of *funestus* have been reported several times in the absence of malaria, possibly because of the presence of biological races that cannot transmit the malaria parasite.

Since developing stages of *Wuchereria bancrofti* have often been found in *funestus*, this species is probably an important vector of filariasis in areas where it is locally abundant.

References: *143, 258.* (For additional information, see the descriptions of malaria and filariasis under Anglo-Egyptian Sudan; Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; Madagascar and Adjacent Islands; and Southern Africa.)

Recorded Distribution.—

Africa (except Cape Province and Orange Free State in the Union of South Africa, and French Somaliland)
Madagascar
Mascarene Islands
Mauritius

Anopheles gambiae Giles

The name most commonly used in the past for *Anopheles gambiae* was *A. costalis*. Fortunately *gambiae* is a distinctive mosquito, and it may often be identified in old records by its excellent ability to transmit malaria.

Bionomics.—*A. gambiae* is highly anthropophilic. Most precipitin tests demonstrate that more than 50 percent of females contain human blood, and they are nearly always attracted to man in preference to animals. Their manner of entering and leaving houses varies from area to area. In some localities this species may be entirely domestic, in some it may enter houses only at night and leave before morning, and in others it may not enter houses at all. It prefers the darkest houses, and when inside it tends to find the darkest corners. Adults usually enter houses from 11 p. m. to 5 a. m. Females are commonly found in outdoor resting places and sometimes bite in the open, where they are most active after midnight. They have a peak of biting activity between 2 and 4 a. m. Sometimes they will bite outside during the day where no great changes in temperature or humidity occur during a 24-hour period. Females are able to travel long distances, having been caught as far as 4¼ miles downwind from their breeding places. Normally they fly an average of about 1 mile without assistance from the wind.

The most important larval breeding places are manmade and are therefore close to man's habitations and places of work. Where *gambiae* is abundant, the larvae are usually

found in borrow pits, drains, excavations, hoofprints, and even artificial containers in areas with denuded and eroded soil resulting from overstocking, roadmaking, deforestation, swamp reclamation, and veld burning. Important larval habitats also include overflow of rivers, backwaters, pools left by receding rivers, and rainwater in natural depressions. Larvae are found the year around in permanent breeding grounds in frost-free areas. In the warm parts of the year *gambiae* overflows into areas where it cannot exist during the winter. Larvae can withstand considerable extremes of water temperature. Their breeding places are generally exposed to the weather and lack vegetation. The time of development from larva to adult, usually about 6 days, varies considerably with temperature and humidity.

Larval and adult populations are correlated with rainfall. An increase at the beginning of the rainy season is followed by a later reduction, sometimes before the dry season begins. Normal breeding places are often flooded by heavy rains to the point where they become unsuitable for larval habitats, and as a result the adult populations are reduced.

Relation to Disease.—This species is regarded as the most important vector of malaria throughout Africa, because it greatly prefers human blood and does not discriminate in its choice of breeding places and because parasites can mature exceptionally well in *gambiae*. In malarious areas salivary gland infection rates are always high. It is associated with endemic as well as epidemic malaria, and it has often been found in the complete absence of other possible vectors. Even when other vectors are present, *gambiae* is nearly always the most important one. It is the only vector in Africa that exists in the presence of endemic malaria at altitudes over 6,000 feet.

In Liberia *gambiae* has been found with high rates of natural infection with *Wuchereria bancrofti*. In at least one coastal locality *gambiae* is believed to be the principal vector of filariasis.

References: *143, 258.* (For additional information, see the descriptions of malaria and filariasis under Brazil and the Guianas; Egypt; Anglo-Egyptian Sudan; Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; Madagascar and Adjacent Islands; Southern Africa; and Arabia.)

Recorded Distribution.—

Africa (all tropical countries)
Arabia
Madagascar
Mascarene Islands
Mauritius

Anopheles hancocki Edwards

Bionomics.—*Anopheles hancocki* readily bites man. Throughout much of its range, especially in Uganda, it commonly feeds inside houses, although occasionally human dwellings have been reported to be free of adults. However, in Sierra Leone no adults have ever been caught indoors.

In Uganda the larvae have been observed most commonly in clear, slowly running water in ditches and wells containing *Pistia*. In Sierra Leone immature stages have often been found at stream margins and in seepage water.

Relation to Disease.—Since malaria transmission by *hancocki* has always been studied in locations with large populations of *Anopheles gambiae*, the true value of the former species as a vector is difficult to determine. For example, in Uganda up to 9 percent of *hancocki* females were found infected, but the species was present with large numbers of *gambiae*, whose infection rates were even higher. Therefore, it is regarded as a secondary vector in Uganda. *A. hancocki* is considered to be a subsidiary vector in Ivory Coast and Haute-Volta, and it must be regarded as a vector of some importance wherever it exists.

This species, appearing for short periods of time in large numbers, has been found infected with larval stages of *Wuchereria bancrofti*, and in at least one locality in Liberia it is believed to be a rather important vector of filariasis.

References: *69, 119, 143, 260.* (For additional information, see the descriptions of malaria under West Africa, West-Central Africa, East-Central Africa, Madagascar and Adjacent Islands, and Southern Africa.)

Recorded Distribution.—

Angola
Belgian Congo
Cameroons
Dahomey
French Equatorial Africa
French West Africa
Gold Coast
Ivory Coast
Kenya
Liberia
Madagascar
Nigeria
Sierra Leone
Uganda

Anopheles hargreavesi Evans

Bionomics.—*Anopheles hargreavesi* is both endophilic and exophilic, but there are no records of its using animals as a source of blood meals. In Nigeria it is common in native huts and bites man freely out of doors as well, with a peak of activity at midnight or later. As many females of *hargreavesi* as of *Anopheles gambiae* were attracted to human bait during all-night catches in the vicinity of Lagos, Nigeria. At Itowolo, southern Nigeria, biting-activity studies showed that the number of flying *hargreavesi* females increased rather rapidly at twilight, continued to increase until midnight, and fell rather sharply near dawn.

Larvae were found to be associated with *Pistia* in two locations in Nigeria. One was a collection of foul, sewage-contaminated water and the other a clear-water pool in an open jungle area. Larvae also are found among blades of grass in open swamps.

In Abeokuta, Nigeria, breeding is practically nonexistent during the dry season but increases soon after the onset of the rains.

Relation to Disease.—This species is of considerable importance as a vector of malaria. It has been successfully infected in the laboratory, and in southern Nigeria it has been found with high sporozoite rates in nature. Because it appears in larger numbers and has a more uniform seasonal distribution than *gambiae*, it may be a more important vector of malaria than that species in Itowolo, Nigeria, and it may be of considerable importance in other parts of West Africa where it is common.

References: *119, 251, 258, 260.* (For additional information, see the descriptions of malaria under West Africa, West-Central Africa, East-Central Africa, and Southern Africa.)

Recorded Distribution.—

Angola
Belgian Congo
Cameroons
Dahomey
French Equatorial Africa
Gold Coast
Ivory Coast
Liberia
Nigeria
Sierra Leone
Uganda

Anopheles hispaniola (Theobald)

Many early records of *Anopheles hispaniola* are found under the name *A. turkhudi*, a very close relative whose distribution is believed to be principally within the Orient. It is not known whether the range of *turkhudi* extends westward to meet or overlap that of *hispaniola*.

Bionomics.—*A. hispaniola* is said to be domestic in some parts of its range, but it is wild and found only rarely in houses in others. During studies in Sardinia about one-half of the *hispaniola* adult collections were from domestic shelters, the remainder from mine shafts, grottoes, and vegetation. Adults were rarely found near breeding places containing large numbers of larvae.

Larvae are most commonly found in shallow, clear, sunlit water, usually in small pools but occasionally in moving

water. *Spirogyra* commonly grows in these breeding places, sometimes to the complete exclusion of other plants or algae. Larvae live in ricefields in the vicinity of Calasparra, Spain, although that type of breeding place may not be common elsewhere. In Algeria the species breeds in stream beds, and in at least one area where the flow of water was low and rather regular, larvae were recovered from an irrigation channel with considerable vegetation growing along its edge. In Jordan larvae were found in streams, springs, ditches, and seepages, in sunlight or partial shade. Experiments in Sardinia showed that larvae can remain submerged for as long as 35 minutes.

In several localities in Spain this species was encountered at elevations of about 3,300 feet to 4,300 feet and in Morocco up to 8,200 feet. At least in Sardinia *hispaniola* is a late-summer and fall species, and it has been found in even the driest part of Algeria.

Relation to Disease.—In much of Spain this species is found with *Anopheles labranchiae atroparvus*, so that its true role as a malaria vector is not clear. However, in Tenerife and in other parts of the Canaries, *hispaniola* is the only *Anopheles* species that bites man in the presence of active malaria, and it may be presumed to transmit malaria elsewhere as well. It is regarded as having some importance in Morocco and in northern Algeria, where it is reported as a secondary vector. It is not regarded as a serious vector of malaria in Sardinia, where the species is relatively scarce and rarely bites man.

References: *29, 67, 237, 239, 329, 336, 339.* (For additional information, see the descriptions of malaria under Northwest Africa, and Spain and Portugal.)

Recorded Distribution.—

Algeria
Arabia
Canary Islands
Egypt
Greece
Iraq
Italy
Jordan
Libya
Morocco
Sardinia
Spain
Spanish Morocco
Tunisia

Anopheles homunculus Komp

Bionomics.—The town of Blumenau in Santa Catarina, Brazil, is situated in the immediate vicinity of tall rain forests. Adults of *Anopheles homunculus* ordinarily inhabiting the lower parts of the forest canopy where it is very humid have been observed flying in large numbers day and night into the town, where they bite man readily. In Trinidad the adults live only in the extremely humid and deep Aripo Valley, which has an annual rainfall of over 125 inches. Here the females occupy the lower 30 feet of cacao-plantation and forest canopy and fly and bite outside the forest on very humid nights. Adults are rarely found in areas with less than 80-percent average relative humidity, and then they are restricted almost entirely to the forest. For information on larval bionomics, see page 29.

Relation to Disease.—This species may be a vector of malaria in Brazil, because it lives near human habitations in large numbers and bites man readily. So far as is known it has never been found infected in nature.

Reference: *67.* (For additional information, see the descriptions of malaria under West Indies, and Brazil and the Guianas.)

Recorded Distribution.—

Brazil
Colombia
Trinidad
Venezuela

Anopheles jeyporiensis candidiensis Koidzumi

Originally described from Formosa, *Anopheles jeyporiensis candidiensis* has been given its present name throughout most of the important literature. It has also been referred to as *Anopheles aconitus* var. *tonkinensis*. No attempt has been made to distinguish it from the type form in many of the early records.

Bionomics.—Females of *candidiensis* bite man readily inside houses and tents, starting about 2 hours after nightfall. After feeding they rest outside and are seldom found in human habitations during the day.

Typical breeding sites, especially in Indochina, are those with moving, grass-margined water. In India and China larvae are found in the grassy, shallow water in seepage areas on hillsides and in abandoned ricefields and at the grassy margins of lakes and swamps. Along the Bengal-Burma border larvae live in collections of water so thickly overgrown with vegetation that they cannot be readily seen.

In Assam and Burma this mosquito appears in greatest numbers during the early months of the year.

Relation to Disease.—In hillock parts of the Arakan area along the East Pakistan-Burma border most of the pre-monsoon malaria is transmitted by *candidiensis*. In southwestern Yunnan and Indochina this mosquito is considered to be next or equal to *Anopheles minimus* in importance as a vector of foothill malaria. Although in China almost all dissections of the females for malaria have been positive, *candidiensis* is considered to be of only secondary importance in the hilly areas. It has been found with high natural infection rates in Hong Kong.

With natural infections of *Wuchereria bancrofti* of up to 4.6 percent, *candidiensis* is an important vector of filariasis at Hong Kong. Natural infections with that parasite have also been reported from Indochina.

References: *88, 91, 122, 242.* (For additional information, see the descriptions of malaria and filariasis under East Pakistan and Assam, South China, Burma, and Indochina.)

Recorded Distribution.—

Assam
Burma
China (South)
Formosa
Hainan
India
Indochina
Pakistan (East)

Anopheles kochi Dönitz

Bionomics.—Females of *Anopheles kochi* feed readily on man but appear to prefer the blood of cattle. In some areas they bite man with some reluctance. In Assam adults rest during the day in the jungle, but in other areas they are found more commonly in open places, such as on shaded stone walls, under the overhanging banks of streams, and in houses and stables. In Java they habitually enter human habitations at twilight. Males were observed to swarm 4 to 6 feet above the head of a man in Malaya.

Larvae live in various places containing either turbid or fresh water but are never found in salt or brackish water. They prefer open sites, such as small muddy pools, flowing irrigation ditches, stagnant drains, jungle pools with decaying vegetation, buffalo wallow holes, fallow ricefields, hoofmarks, ruts, and other depressions in the ground. In the Philippines larval breeding is common in cut bamboo and artificial containers, although presumably suitable habitats situated nearby remain free of larvae.

A. kochi, because of the nature of its breeding places, reaches a peak of abundance during the rainy season.

Relation to Disease.—Experimental infections show this species to be a potentially efficient vector of malaria. It appears to be of greatest importance at times when its populations are high or when livestock is absent. High natural infections in the Greater Sundas, especially Sumatra, indicate it is of some importance there. In Java it is only locally important and in Celebes does not usually play a part in malaria transmission. Natural infection rates are almost always so low in the Philippines, Malaya, Indochina,

and most of India that the species is believed to be of little or no importance in these countries.

References: *91, 121, 122, 161, 341.* (For additional information, see the descriptions of malaria under Sunda Islands.)

Recorded Distribution.—

Assam
Bali
Bangka
Borneo
Burma
Celebes
Ceram
China (South)
Flores
Formosa
Hainan
Indochina
Java
Malaya
Moluccas
Pakistan (East)
Philippine Islands
Soemba
Soembawa
Sumatra
Thailand

Anopheles koliensis Owen

Anopheles koliensis is morphologically intermediate between *Anopheles farauti* and *A. punctulatus*. Its medical importance was discovered during World War II, but the form has been known long enough so that confusion with other vectors has been avoided.

Bionomics.—Females of *koliensis* are strongly anthropophilic and tend to remain in human habitations after feeding, leaving some time during the following day or night. They rest during the day in such locations as tentpoles and dark bedding in native huts and appear in greater numbers than either *farauti* or *punctulatus*. Ninety percent of the females taken in the tents of a native-labor camp over a period of several weeks in one locality in Guadalcanal were *koliensis* and 10 percent *farauti* and *punctulatus*. During this time larvae of *koliensis* constituted about 10 percent of the total *Anopheles* species present. Females become active about 9 p. m. and continue to fly until daylight, with the greatest activity after midnight.

Temporary pools in grassland at the edges of jungles are most commonly frequented by larvae. They are found more often in water exposed to the sun than in dense jungle shade. During the dry season the species is relatively scarce. It is almost always associated with *farauti*, at least in Guadalcanal.

Relation to Disease.—*A. koliensis* is probably of major importance in malaria transmission on the northeast coast of Guadalcanal.

References: *56, 57, 271, 294, 353.* (For additional information, see the description of malaria under Australasia.)

Recorded Distribution.—

New Britain
New Guinea
Solomon Islands

Anopheles labranchiae atroparvus Van Thiel

Anopheles labranchiae atroparvus, an important member of the *A. maculipennis* group in northern Europe, was originally distinguished from *A. messeae*, a close relative, on the basis of its shorter wings and darker color. Later studies revealed its relationship to *Anopheles labranchiae*. The names *Anopheles fallax* and *A. cambournaci* apply only to local variations of this mosquito. For additional details, see page 125.

Bionomics.—Although definitely anthropophilic, *atroparvus* over extensive areas is effectively attracted away from man by the presence of stabled animals. It enters houses in largest numbers in midsummer and fall. Most of the females must take occasional blood meals during winter hibernation, but egg laying is suspended during this time and complete hibernation has sometimes been observed. In Portugal males swarm just after sunset inside or outside buildings, only a few females entering the swarm. Males and females will mate in small cages.

In the U. S. S. R. and other northern areas *atroparvus* breeds in brackish water of slight to moderate salinity and tends to be a coastal form. In Caucasia it is found infrequently in fresh water, but in Spain and Italy, where it lives well inland, it is found solely in fresh-water habitats. In Portugal larvae usually live in ricefields.

This subspecies cannot live in localities where extreme cold prevents winter feeding; extremely hot, dry summers also present unsuitable conditions.

Relation to Disease.—*A. l. atroparvus* is responsible for the so-called winter house malaria of the Netherlands and East Friesland on the adjacent north coast of Germany. It is often a carrier of malaria in Spain, Portugal, and Rumania, but there is little or no malaria transmission indoors by this subspecies in the U. S. S. R., because most houses are heated. It transmits some malaria on the Black Sea coast between the Bug and Danube River Deltas. This mosquito is not everywhere associated with malaria, although it is found throughout large areas of Europe. Its effectiveness as a vector is believed to be intermediate between *labranchiae* and *messeae*.

References: *53, 67, 77, 147, 346.* (For additional information, see the descriptions of malaria under North Europe and North Asia; Spain and Portugal; and Italy, the Balkans, and Adjacent Islands.)

Recorded Distribution.—

Balearic Islands
Belgium
Caucasia
Czechoslovakia
Denmark
France
Germany
Great Britain
Hungary
Israel
Italy
Netherlands
Poland
Portugal
Rumania
Sardinia
Spain
Sweden

Anopheles labranchiae labranchiae Falleroni

Bionomics.—Man is the normal host for *labranchiae* in most areas. Females of this subspecies are usually attracted to stabled animals to a small extent, differing in this habit from most other members of the *maculipennis* group. In most localities they persistently enter houses, even when large numbers of domestic animals are nearby, but occasionally they fly back and forth between stables and houses, biting both man and animals. However, in Sardinia the preferred shelters are pigsties and stables. In Elba a study showed that 96 percent of the observed adults rested in animal shelters rather than in houses, especially during the winter. Considerable numbers of females have been found in grottoes and under bridges, living away from man, especially in areas where they are forced to feed on wild mammal and bird hosts. Overwintering females prefer inhabited and uninhabited rural houses rather than village centers.

In Sicily the subspecies overwinters in the adult stage but does not hibernate in the strict sense, up to half the population taking blood meals throughout the cold months. Temperatures probably regulate the numbers of adults that feed during the winter. A small number of females develop fat bodies during this time. A radius of about 1.9 miles is the effective flight range of this subspecies.

In Italy the subspecies breeds principally in brackish water, with at least 10 parts per thousand of sodium chloride. In Corsica, Sardinia, and Sicily, and along the Barbary coast of North Africa from Tripoli to Morocco, it breeds in both marshy and fresh water. In Sicily larvae live in many kinds of water accumulations, ranging from coastal marshes to gravelly beds of upland streams, where *labranchiae* has no fresh-water competitors. In Sardinia intermittent, slow-moving, or stagnant water courses are the principal breeding places. About 99 percent of larval collections in that island

have been made from clear, sunny, fresh water containing horizontal plants, more commonly in quiet than in moving water. In Elba larvae have been found in irrigation water, wells, and brackish stagnant water near the coast. The first two generations in the spring inhabit larger pools formed by spring rains. These pools are shallow, warmed by the sun, and contain vegetation consisting of short meadow grass and water buttercups (*Ranunculus aquatilis*). This subspecies also frequents tiny rivulets exposed to the sun, tanks, wells, permanent swamps, marshes, lakes, and certain ricefields and their ditches.

A. l. labranchiae is principally a maritime mosquito. In Sardinia seasonal activity begins in February, rises to a peak of adult density in June or July, then shows a rapid decline, with a small peak again in the fall.

Relation to Disease.—*A. l. labranchiae* is almost always associated with intense malaria. Because of its history of natural infections and its close association with man, this subspecies is the principal if not the sole vector of malaria in Sardinia and an important vector in Spain, northern Italy, and north Africa.

References: *53, 67, 72, 147, 237.* (For additional information, see the descriptions of malaria under Northwest Africa; North Europe and North Asia; Spain and Portugal; and Italy, the Balkans, and Adjacent Islands.)

Recorded Distribution.—

Albania
Algeria
Balearic Islands
Corsica
Elba
Israel
Italy
Libya
Morocco
Sardinia
Sicily
Spain
Spanish Morocco
Tunisia
Yugoslavia

Anopheles letifer Gater

Anopheles letifer appears in early records under the name of *A. umbrosus* (see p. 138).

Bionomics.—*A. letifer* enters houses and bites man freely from dusk to dawn. Adults probably rest out of doors during the day. They have been found in small numbers on tree trunks and vegetation in cultivated areas. It is unusual for females to bite during the day, although they have been observed to do so in shady sites. This species is decidedly anthropophilic, as shown by a study of it and several of its close relatives, in which more than 90 percent of the captured specimens contained human blood.

Larvae of *letifer* prefer the dark-brown water of peaty soil, such as that found in settlements and in plantations of coconut, pineapple, rubber, and coffee. They also inhabit coastal collections of water that contain variable amounts of vegetation, but they are intolerant of sea water and are never found in it when fresh-water pools are a few yards away. In Borneo larvae live under secondary shrub and tend to breed in the shade, preferring water with a pH of 5.8 or lower.

A. letifer is characteristically a mosquito of the flat coastal plain and is found only in small numbers in hilly country near the coast. Neither adults nor larvae are found within virgin swampy jungle, the edge of which forms a distinct dividing line between the area occupied by this species and that inhabited by *umbrosus*. In the State of Selangor in Malaya *letifer* reaches a peak of abundance during the last 4 months of the year because of the increased rains at that time.

Relation to Disease.—In certain parts of Malaya *letifer* is economically the most important vector of malaria, since its breeding habits bring it into close association with man's agricultural activities. Moderate to severe endemic malaria exists in one area in Malaya, where *letifer* is the only species present in large enough numbers to transmit it and where infection rates are very high. In some parts of Borneo *letifer*, with *umbrosus* and *Anopheles baezai*, is the chief vector. Its exact vector status in many areas is in doubt, because it is confused with *umbrosus* in the early records.

References: *243, 284.* (For additional information, see the descriptions of malaria under Malaya and Sunda Islands.)

Recorded Distribution.—

Borneo
Malaya
Sumatra

Anopheles leucosphyrus balabacensis Baisas, *Anopheles leucosphyrus hackeri* Edwards, and *Anopheles leucosphyrus leucosphyrus* Dönitz

Anopheles leucosphyrus is composed of 6 or 7 closely related forms, none of which are well known. In most early literature these are not named, but the three subspecies discussed below can often be distinguished, because they are the only ones able to transmit malaria.

Bionomics.—In northern Borneo the females of *Anopheles leucosphyrus leucosphyrus* and *A. l. balabacensis* feed on man during the night and have been captured inside bed nets in the morning. A peak of biting activity has been reported between 12 and 1 a. m. In Labuan, British North Borneo, *balabacensis* starts to feed in the early evening and has a peak of biting activity between 1 and 4 a. m. In Celebes *Anopheles leucosphyrus hackeri* is typically a house mosquito; only small numbers of adults have been taken in outdoor resting places.

Larvae of *leucosphyrus* and *balabacensis* are found in shaded temporary locations, such as rainwater in tracks and wheel ruts, often in open jungle. *A. l. hackeri* breeding is largely confined to water collections in fallen, split bamboo and rotten logs. On the coast of Malaya larvae live in water collections in the bases of the nipa palm (*Nipa fruticans*). In Celebes *hackeri* breeds in sunlit marshy fields, stopped-up gutters, ditches, pools, and small wells.

Relation to Disease.—In the "Bukitkuda, Lajau-batu, and Manikar" areas of Labuan, where endemic malaria is severe, *balabacensis* is the only vector and has very high rates of gland infection. Elsewhere in northern Borneo this subspecies is probably an important vector. Transmission tends to fluctuate throughout the year, with definite periodic increases. Records of transmission in Burma and Assam almost certainly refer to *balabacensis*, since no other form, with the possible exception of *leucosphyrus*, is known to exist there. In much of Malaya the *leucosphyrus* complex appears to be relatively unimportant, and *balabacensis* is scarce or absent. *A. l. hackeri* has been found naturally infected in Celebes and is important there.

References: *97, 98, 139, 243, 282.* (For additional information, see the descriptions of malaria under East Pakistan and Assam, South China, Burma, Thailand, Sunda Islands, and Philippine Islands.)

Recorded Distribution.—

A. l. balabacensis:
Assam
Borneo (North)
Burma
Labuan
Philippine Islands

A. l. hackeri:
Borneo
Malaya
Soemba
Sumatra

A. l. leucosphyrus:
Andaman Islands
Borneo
Celebes
Java
Malaya
Philippine Islands
Sumatra

A. leucosphyrus (var. not known):
Formosa
Indochina

Anopheles listeri de Meillon

Bionomics.—In Zululand and Natal adults of *Anopheles listeri* have never been recorded in large numbers indoors,

probably because studies have been made only in areas where there is no extensive breeding. However, females are found in very large numbers in habitations in South-West Africa, where they bite man.

Larvae of *listeri* are similar to those of *Anopheles gambiae* in that they prefer exposed or grass-shaded pools in riverbeds in close proximity to man. They are often found with *gambiae* and *Anopheles pretoriensis*.

Relation to Disease.—Because *listeri* rests in houses and bites man in large numbers, it is a potentially important vector of malaria in South-West Africa. Conclusive research to determine its actual role has not been carried out, nor have many dissections been made to demonstrate whether it is naturally infected.

References: *119, 258, 259.* (For additional information, see the description of malaria under Southern Africa.)

Recorded Distribution.—

Cape Province
Mozambique
Natal
Southern Rhodesia
South-West Africa
Transvaal

Anopheles ludlowi torakala van Hell

For a long time the presence of an unidentified vector of malaria in the interior of south Celebes had been suspected. Recent studies have shown that it is actually a subspecies of *Anopheles ludlowi*. The adult is very similar to that of *Anopheles ludlowi ludlowi*, the presence of which in Celebes has not yet been determined with certainty.

Bionomics.—Adults of *Anopheles ludlowi torakala* are found in the interior of Celebes more frequently in houses than out of doors, although females feed readily on man out of doors, definitely preferring human blood. Very little additional information about adult biology is available.

Larvae live almost exclusively in beds of large rivers, occupying small shallow pools in sand and gravel banks when the water level in the main stream is low. Consequently, they are swept away during the rainy season. Larvae are almost always found in fresh water exposed to open sunlight and have often been observed up to about 300 feet above sea level.

Relation to Disease.—This mosquito has been found naturally infected several times in the midst of malaria outbreaks in south Celebes. It is the most prevalent mosquito and the only one infected. Dissections in six localities at different times showed that 2 to 3 percent had gut infections. *A. l. torakala* is thought to be a more important vector in south Celebes than any other species, including *Anopheles sundaicus*.

Reference: *161.* (For additional information, see the descriptions of malaria under Sunda Islands.)

Recorded Distribution.—

Celebes
Formosa (?)
Malaya (?)

Anopheles maculatus Theobald

Bionomics.—Females of *Anopheles maculatus* feed readily on man but are also attracted to cattle. In some areas they may ignore man almost entirely. In Malaya the species appears to prefer livestock, but under certain conditions it will bite man even when cattle are in the immediate vicinity. Females are active at night and in some areas will readily enter houses. They have been trapped in bed nets during the night, especially in the Philippines, and usually bite between 9 p. m. and 2 a. m. Adults do not rest in houses after feeding but seek shelter out of doors. In Java they rest during the day in the vegetation along the banks of streams. In other areas adults are seldom found in buildings. In Formosa they have never been taken in houses, although larvae have been found nearby. Swarms of *maculatus* males have been observed in Malaya 15 to 20 feet above the ground in open clearings. Flight ranges have been reported to be well over one-half mile. Females migrate great distances from summer to winter habitats.

Larvae have been collected in China, Formosa, and the Sunda Islands from riverbed pools with sandy or stony bottoms and sometimes in rapidly flowing mountain streams with whirlpools. In Malaya the favorite breeding places are drains, pools, seepages, springs, ricefields, marshes, borrow pits, lake margins, and reservoirs. The species will also breed in hoofmarks and artificial receptacles. Fresh water is generally preferred. However, the larvae are sometimes found in stagnant or polluted water but never in salt or brackish water. Although aquatic vegetation is not necessarily associated with breeding, larvae often live in algae at the edges of shaded forest streams. They prefer sunlit or lightly shaded breeding sites and only rarely are found in dense jungles. In the Philippines, Malaya, and the Lesser Sundas recently cleared jungle may be an important breeding place.

A. maculatus is usually associated with hilly or mountainous country. It has been found at altitudes up to 5,000 feet.

Relation to Disease.—This species is an important vector of malaria in some areas. In Malaya, Sumatra, Java, the Riouw Archipelago, and Bangka it has been reported with extremely high infection rates and is one of the most important vectors of malaria. In the Philippines it is suspected strongly as a vector of that disease. In Indochina, South China, and India some authorities consider it to be a minor vector, whereas others think it to be very important. The Formosa studies failed to reveal infected specimens in the field, even though the species was encountered in large numbers during the dry season in the southern and central parts. In Celebes it is relatively rare and has never been found infected.

References: *44, 88, 120–122, 308, 340, 341, 357.* (For additional information, see the descriptions of malaria under South China, Formosa, Indochina, Thailand, Malaya, Sunda Islands, and Philippine Islands.)

Recorded Distribution.—

Afghanistan
Assam
Bangka
Borneo
Burma
Celebes
Ceylon
China
Flores
Formosa
Hainan
India
Indochina
Java
Malaya
Pakistan (East and West)
Philippine Islands
Riouw Archipelago
Sumatra
Thailand
Timor

Anopheles maculipennis Meigen

In early works of European authors *Anopheles maculipennis* was used in a very broad sense to include the forms we recognize today as *Anopheles messeae*, *A. melanoon melanoon*, *A. melanoon subalpinus*, *A. labranchiae labranchiae*, *A. labranchiae atroparvus*, and *A. sacharovi*, as well as so-called *A. maculipennis typicus*, the mosquito actually described by Meigen from Germany. Subsequent studies of the group, beginning about 1920, have brought to light more and more differences in the various populations of the *maculipennis* group. Refinements in methods of investigative biology eventually demonstrated the presence over Europe and Asia of rather distinct biological, and to some extent morphological, segregates. As these were defined, they were named. As relationships among the various forms were finally clarified by crossbreeding techniques, the names were eventually combined to reflect a more exact relation-

ship as we understand it today. Details of the status of each of the medically important species and subspecies of the *maculipennis* group are given separately in this handbook. As a result of the segregation described above, there remains today a form, discussed below, which is variously called *maculipennis*, *maculipennis typicus*, *maculipennis maculipennis*, or *maculipennis* s. s. (strict sense), as opposed to the more general term *maculipennis* group.

Bionomics.—Females of *maculipennis* are primarily zoophilic. The presence of cattle tends to divert them from man as a source of food. In Portugal, for instance, where this species is not a vector, it is abundant in animal shelters but rare in houses, and in Albanian studies, where *subalpinus* and *maculipennis* were found in almost equal numbers, it was represented in every collection of adults taken from stables. In the Mediterranean region *maculipennis* is said to spend the winter in complete hibernation, usually initiating fat-body formation in September. However, in the northern part of the U. S. S. R. and in Transcaucasia females hibernate in cold shelters or out of doors, where they take blood meals throughout the winter.

Larvae are found in a wide variety of breeding places consisting of small pools, ditches, slow-moving streams, and ricefields. They most often prefer small accumulations of water but also occupy larger marshes in Albania and other parts of the Balkans. In Albania this species breeds in immense numbers along the shores of "Lake Maliq," a large, shallow, marshy body of water, and in lesser numbers in a wide variety of habitats, including pools and ditches. Larvae were once found in water with 20 parts per thousand of sodium chloride. In the U. S. S. R. the chief breeding places are pebbly riverbeds, in which a sparse algal growth may be present. The species is found characteristically in upland waters that are cold, fresh, and pure, usually with some vegetation and with sunlight during at least part of the day.

In Tirana, Albania, *maculipennis* builds to two population peaks, one about July 1 and the other in August. The abundance of both larvae and adults decreases between these two peaks, probably because of high summer temperatures.

Relation to Disease.—*A. maculipennis* has been found in large numbers with *messeae*, transmitting endemic malaria in the villages at "Lake Maliq" on the Albania-Yugoslav frontier. In Caucasia, Transcaucasia, and northern Iraq it is believed to be the chief or sole vector with high natural infection rates. However, in most of the Mediterranean region this mosquito is in contact with man so rarely that, even though it may transmit malaria occasionally, it is seldom able to support even a mildly endemic form of the disease. Exceptions are Macedonia and a center of severe malaria on the Turkish coast. The species may also support mildly endemic malaria in northern Iran.

References: *53, 54, 67, 76, 147, 349.* (For additional information, see the descriptions of malaria under North Europe and North Asia; Italy, the Balkans, and Adjacent Islands; the Near East; Iran; and Afghanistan and West Pakistan.)

Recorded Distribution.—

Albania
Algeria
Austria
Balearic Islands
Bulgaria
Caucasia
Corsica
Crete
Czechoslovakia
France
Germany
Greece
Hungary
Iran
Iraq
Italy
Morocco
Netherlands
Norway
Poland
Portugal
Rumania
Sicily
Spain
Sweden
Switzerland
Syria
Tunisia
Turkey
U. S. S. R.
Yugoslavia

Anopheles mangyanus Banks

Anopheles mangyanus, another member of the *A. funestus-minimus* subgroup, is variously referred to in early records as *A. minimus*, *A. funestus*, and *A. aconitus* var. *filipinae*.

Bionomics.—Little information is available about the habits of *mangyanus* adults. They have been collected from clearings in heavy woods. Inconclusive results have been obtained in flight-range studies. In one experiment extremely small numbers of adults were captured as far as one-half mile from their point of liberation.

Larvae are found in clear water along the edges of shallow, flowing streams, with sandy or rocky beds in forested areas. They prefer the protection of grasses and exposed roots, especially those of bamboo. Vegetated irrigation ditches harbor larvae in large numbers.

This species has not been found in mountains above 2,000 feet.

Relation to Disease.—*A. mangyanus* lives in malarious areas in the Philippines and can be made highly infective in the laboratory. This species is generally believed to be a vector in the Philippines, since it invades newly cleared areas where it is associated with intense malaria.

References: *120, 204, 308.* (For additional information, see the description of malaria under Philippine Islands.)

Recorded Distribution.—

Philippine Islands

Anopheles melanoon subalpinus Hackett and Lewis

Anopheles melanoon melanoon is the geographical representative of *A. melanoon* in the southern half of Italy. It is not important in the transmission of malaria. *A. m. subalpinus* was originally based on a distinctive egg type found in Spain, northern Italy, and the Balkans, and it was described as a variety of *maculipennis*. Biological studies have shown it to be a subspecies of *melanoon*. For additional details, see page 125.

Bionomics.—Females of *subalpinus* rarely bite man. They are frequently found in stables near fresh-water marshes.

Larvae are usually associated with large bodies of water, such as marshes and lake margins. In Albania this subspecies has the most strictly limited habitat of all members of the *maculipennis* complex. In that country no larvae live in water that is heavily shaded, without vegetation, with small surface area, strong surface movements, or with high nitrate or saline content.

Relation to Disease.—This subspecies is not known to be a malaria vector in most of its range. In Lenkoran' in the U. S. S. R. and the delta of the Safīd Rūd River, it is the principal vector of severe malaria, but in Europe it is never involved in malaria transmission because it is very zoophilic.

References: *53, 54, 67, 147, 346.* (For additional information, see the descriptions of malaria under North Europe and North Asia; and Italy, the Balkans, and Adjacent Islands.)

Recorded Distribution.—

Albania
Balearic Islands
Bulgaria
Caucasia
Crete
France
Greece
Hungary
Iran
Israel
Italy
Spain
Switzerland (?)
Turkey
Yugoslavia

Anopheles melas Theobald

Anopheles melas has commonly appeared in the early literature as a variety of *A. gambiae* because of its very close morphological similarity to that species.

Bionomics.—Like *gambiae*, *melas* frequents houses and is distinctly anthropophilic. Once inside a house, it rarely leaves to rest outside.

Breeding takes place almost exclusively in brackish or sea water, often with very high salt concentration. The species is littoral, occupying lagoons or tidal swamps, principally those of the mangrove *Avicennia*. Swamps containing *Rhizophora* mangrove rarely harbor larvae. The flat peaty soil, which is usually poorly drained and in which *Avicennia* grows, provides ideal breeding conditions, and populations of larvae always increase after rain or flooding by tides. Larvae do not seem to be affected by sudden changes in the salinity of the water. Since *melas* tolerates higher concentrations of sea water than *gambiae*, a test to distinguish the two species has been devised. This consists of the introduction of unknown larvae into a concentration of sea water greater than 37½ percent. *A. gambiae* will not survive, whereas *melas* will complete its development.

Relation to Disease.—Like *gambiae*, *melas* females are extremely important vectors of malaria, and parasites develop as efficiently in *melas* as in *gambiae*. *A. melas* is the only vector in many littoral localities on the African West Coast.

Recent studies in Marshall Territory, Liberia, indicate that *melas* is the important vector of filariasis during the dry season and at the beginning of the wet season.

References: *143, 258, 285, 286.* (For additional information, see the descriptions of malaria and filariasis under West Africa, West-Central Africa, and Southern Africa.)

Recorded Distribution.—

Belgian Congo
Dahomey
French Equatorial Africa
French Guinea
Gambia
Gold Coast
Ivory Coast
Liberia
Nigeria
Portuguese Guinea
Senegal
Sierra Leone

Anopheles messeae Falleroni

Long ago some females of the *Anopheles maculipennis* group were noticed laying two types of eggs, gray ones (*Anopheles labranchiae*) and dark ones with various patterns (*Anopheles messeae* and others). The characteristics of the *messeae* egg pattern are shown in the pictorial key for Italy, the Balkans, and Adjacent Islands (p. 67). For additional details, see page 125.

Bionomics.—Females of *messeae* rarely bite man, although they are definitely attracted to him in certain localities. They spend the winter either out of doors or in cold shelters, such as outhouses, cellars, and lofts. During this time they are immobile and take no blood. Hibernation, therefore, is complete, at least in northern Europe. The species does not live where winters are mild enough to prevent this hibernation. A large number of females develop fat bodies in preparation for the winter.

Larvae are usually associated with luxuriant, submerged vegetation. They are found with *maculipennis* and *Anopheles melanoon subalpinus* in the highland areas of the Yugoslav frontier, where they breed along the shores of large, shallow, marshy lakes. Elsewhere they tend to live in big river valleys and large marshes. Restrictions on larval habitats of *messeae* are similar to those described for *subalpinus* in Albania (p. 126). In the British Isles the species lives in inland fresh-water ponds and streams, where its optimum breeding temperature is about 77° F.

Relation to Disease.—*A. messeae* is the chief malaria vector throughout most of northern U. S. S. R. and the only one in the vast region containing the Zavolzh'ye and western Siberia. However, it is believed that *messeae* is not closely enough associated with man to maintain malaria in most areas of Europe, the Balkans, and Caucasia. It is associated with malaria transmission in only a few places in Europe—parts of Hungary, eastern Rumania, and "Lake Maliq" in Albania—where dense human populations are close to large marshy areas. There are large areas in much of the Balkans and Caucasia without malaria where *messeae* breeds prolifically.

References: *53, 54, 67, 249.* (For additional information, see the descriptions of malaria under North Europe and North Asia; and Italy, the Balkans, and Adjacent Islands.)

Recorded Distribution.—

Albania
Austria
Belgium
Bulgaria
Corsica
Crete
Czechoslovakia
Denmark
France
Germany
Great Britain
Hungary
Israel
Italy
Netherlands
Norway
Poland
Rumania
Sweden
Switzerland
Turkey
U. S. S. R.
Yugoslavia

Anopheles minimus flavirostris Ludlow

Anopheles minimus flavirostris was originally described as *Myzomyia flavirostris* from specimens collected on Luzon. This is the subspecies of *Anopheles minimus* throughout the Philippines. In that area it is an easily identified mosquito, but early records of its importance as a vector may be mixed with those of *Anopheles mangyanus* and *A. filipinae*. Its status in other parts of the Orient is uncertain, and some workers consider the forms that resemble *flavirostris* in India, Malaya, and the Sunda Islands to be a different mosquito.

Bionomics.—Females of *flavirostris* appear in large numbers inside houses at night. They feed and leave again before morning and rest under overhanging streambanks during the day. They use both man and domestic animals as food sources, although they are not attracted to the latter in large numbers. The normal flight range is said to be over 500 yards, and it is over a mile when they are blown by the wind. In the Philippines experiments have revealed flight ranges of about three-fourths mile during the dry season. No flights have been observed against the wind.

Larvae are found at the edges of clear, slow-running, partly shaded streams and in the clear water of swamp edges, irrigation channels, drains, and borrow pits. In the Philippines they are nearly always prevalent near bamboo, which may be in the form of scraps or mats of fallen plants floating in the water. They also are found along margins of foothill streams shaded by tall bamboo trees but rarely in ricefields or brackish water.

A. m. flavirostris is found throughout foothills and rolling land, seldom above an altitude of 2,000 feet. In the Philippines an annual rise in abundance begins in November or December when the rainy season is almost over, and the peak of activity and populations last from January to March, after which there is a decline during the dry season.

Relation to Disease.—This subspecies is considered to be one of the most important vectors of malaria in the Philippine Islands. It is reportedly present in Java with high natural infection rates, and in northern Celebes it is reported to sustain endemic malaria. In southern Celebes it has rarely been found infected.

References: *91, 116, 122, 161, 308.* (For additional information, see the descriptions of malaria under Sunda Islands and Philippine Islands.)

Recorded Distribution.—

Bali
Borneo
Celebes
Java
Philippine Islands
Sumatra (?)

471779 O—59——9

Anopheles minimus minimus Theobald

The literature pertaining to *Anopheles minimus minimus* prior to 1916 contains many references to *A. listonii* and *A. christophersi*, which are names that have since been shown to refer to *minimus*.

Bionomics.—Females of *minimus* are found in large numbers in houses and cattle sheds, preferring these to outside locations. They are not commonly found in jungle areas, although they may be encountered resting under secondary growth in jungle clearings. They feed readily on man and in South China and Indochina are reported to be the most anthropophilic of all anophelines. From 93 to 97 percent of blooded females have been reported to contain human blood in Indochina. In some areas adults will feed on livestock if that source of food is more easily visited. In South China intermittent feeding on domestic animals has been reported from 8 p. m. to 4 a. m., the peak of biting activity occurring from 10 p. m. to 2 a. m. and the adults staying inside the same shelters during the next day. Eggs are laid in largest numbers between nightfall and midnight.

Larvae are found in clear, slowly running, partly shaded streams and in the clear water at the edges of swamps, irrigation channels, drains, ricefields, and borrow pits. In India this subspecies breeds in clean grassy streams and seepages, especially in some shade, during the monsoon season. In localities such as South China where it overwinters in the larval stage, immature stages collect in large masses in certain parts of more permanent rivers and streams during the cold months.

A. m. minimus is abundant at low altitudes, is common at 2,000 to 3,000 feet, and has been reported at altitudes as high as 5,000 feet. In China there are two peaks of adult density. The first is from May to mid-June at the start of the rainy season, after which larvae are flushed out of their breeding places, and the second in October and November, caused by renewed breeding during the light autumn rains.

Relation to Disease.—This subspecies is considered to be a very important vector of malaria throughout its range. It is the outstanding transmitter in the hilly areas of China south of latitude 30° N. Extremely high natural infection rates have been observed in Fukien, Yunnan, and Szechwan Provinces and in Hong Kong. This subspecies is an efficient and important vector throughout India, East Pakistan, Assam, Indochina, Thailand, Burma, Formosa, Malaya, and Sumatra.

In Tonkin and Hong Kong infective stages of *Wuchereria bancrofti* have been observed in *minimus*. In Tonkin *minimus* is a probable vector of filariasis.

References: *87, 91, 122.* (For additional information, see the descriptions of malaria and filariasis under India and Ceylon, East Pakistan and Assam, South China, Formosa, Burma, Indochina, Thailand, Malaya, and Sunda Islands.)

Recorded Distribution.—

Assam
Bali
Burma
Celebes
Ceylon (?)
China (South)
Flores
Formosa
Hainan
India
Indochina
Java
Malaya
Pakistan (East)
Soemba
Soembawa
Sumatra
Thailand
Timor

Anopheles moucheti moucheti Evans

Bionomics.—*Anopheles moucheti moucheti* is very strongly endophilic and anthropophilic and far outnumbers other house-frequenting mosquitoes in the Belgian Congo.

Larvae are commonly found in quietly flowing, moderately shaded water, and in the Congo, where this subspecies is typically a stream breeder, they are observed singly in vegetation along banks of streams and pools. Larvae also are found among short vegetation in running water in the western arid parts of South-West Africa.

A statistical analysis of conditions along the Congo River has shown that the rise and fall of the water is directly correlated with the numbers of adults caught in habitations. A change in water level results in a change of adult populations about 1 month later.

Relation to Disease.—In the presence of *Anopheles gambiae* and *A. funestus*, this subspecies is a secondary vector of malaria and is less efficient than *gambiae*. It may be of primary importance in the absence of those two species. In Yangambi and Stanleyville, Belgian Congo, and Jinja, Uganda, low natural infection rates have been reported. In those areas *moucheti* is thought to be of some importance in spite of the presence of large numbers of infected *gambiae*, which transmit most of the malaria.

References: *119, 258–260.* (For additional information, see the descriptions of malaria under West Africa, West-Central Africa, and East-Central Africa.)

Recorded Distribution.—

Belgian Congo
Cameroons
French Equatorial Africa
Nigeria
Spanish Guinea
Uganda

Anopheles moucheti nigeriensis Evans

Bionomics.—In a series of investigations at Lagos, southern Nigeria, *Anopheles moucheti nigeriensis* represented 0.5 percent of the total anophelines caught indoors.

Larvae in Nigeria are found in partly wooded swamps and along the banks of the Ogun River. *A. m. nigeriensis* is associated with clear-water swamps and *Pistia* throughout most of its range.

Relation to Disease.—In the villages near Lagos, Nigeria, high natural infection rates indicate that this subspecies may be an effective vector of malaria. Little is known about its ability to transmit the disease.

References: *119, 168, 258, 260.* (For additional information, see the description of malaria under West Africa.)

Recorded Distribution.—

French Guinea
Nigeria

Anopheles multicolor Cambouliu

Bionomics.—*Anopheles multicolor* has been observed in some areas to enter habitations and bite and in others to be definitely exophilic, even when large populations are present. Adults are strong fliers, having been found in the eastern desert of Egypt about 8 miles from their nearest breeding places.

The choice of breeding sites is wide. Larvae are commonly found in water of high salinity and pH; a concentration of salt of almost 6 percent has been recorded. Once they were found in water that was almost two times as concentrated as sea water, with the surface heavily encrusted with salt. Their breeding places include pans, small pools with and without water weeds, stagnant or flowing drains, unused shallow wells, and fresh-water collections and cesspools, usually in desert oases. The larvae have never been observed in large numbers in ricefields in Egypt.

Relation to Disease.—The importance of this oasis species as a vector has not been firmly established. Although it is rather easily infected with malaria parasites in the laboratory, it has not been found naturally infected. Because of this and the fact that females are highly exophilic, some workers have doubted its importance. On the other hand, this species is said to carry, along with *Anopheles pharoensis*, most of the malaria in Egypt, and it may occasionally be

more important than *A. sergenti* in north Africa. Its role as a vector in Arabia is not known.

References: *119, 258.* (For additional information, see the descriptions of malaria under Northwest Africa, Egypt, and Arabia.)

Recorded Distribution.—

Algeria
Anglo-Egyptian Sudan
Arabia
Cyprus
Egypt
India
Iran
Iraq
Israel
Jordan
Lebanon
Libya
Morocco
Pakistan (West)
Spain
Spanish Morocco
Syria
Tunisia
Turkey

Anopheles nigerrimus Giles

A medically important mosquito in Celebes, originally called *Anopheles hyrcanus* var. X, is now known to be *Anopheles nigerrimus*. Other names applied in the past to this species are *Anopheles nero*, *A. pursati*, *A. williamsoni*, *A. bentleyi*, *A. venhuisi*, and "pupal type D of Crawford." For additional details, see page 135.

Bionomics.—The behavior characteristics of *nigerrimus* and *sinensis* adults are essentially alike. Information on the bionomics of the latter applies to *nigerrimus* as well.

Larvae of *nigerrimus* prefer deep ponds, swamps, and other large bodies of water covered by plants. Fishponds containing *Pistia stratiotes* harbor these larvae in large numbers in Malaya. In Java this species prefers deep swamps and swampy ricefields, with a great deal of vegetation, like *Azolla*, *Pistia*, *Jussiaea*, *Hydrilla*, *Eichhornia*, and *Spirodela*. In Celebes the larvae are found in undrained, swampy ricefields and fishponds covered with vegetation, as well as in neglected pools and ditches in settlements. Larvae prefer shade, since their temperature requirements are lower than those of *sinensis*.

Relation to Disease.—Considerable evidence shows that *nigerrimus* has been a vector in several malaria outbreaks. As "*hyrcanus* variety X," it was regarded as the principal vector in outbreaks in Benteng and farther south in Celebes and in the Karangbinangun district of Java. The natural infection rates in those localities, as well as in Sumatra, were rather low. *A. nigerrimus* may support a mild endemic malaria if mosquito populations are small. In the vicinity of Kuala Lumpur, Malaya, *nigerrimus* and *sinensis* were the principal vectors in an outbreak of malaria. This has probably occurred many times where the range of the two species overlaps. *A. nigerrimus* may be an important vector in the southern ricegrowing areas of Thailand. It is apparently unimportant as a vector in India, where it has not been found naturally infected.

Development of *Wuchereria bancrofti* to the infective stage in *nigerrimus* has been observed, but little is known of the part *nigerrimus* plays in the actual transmission of filariasis.

References: *122, 161, 283.* (For additional information, see the descriptions of malaria and filariasis under Thailand, Malaya, and Sunda Islands.)

Recorded Distribution.—

Assam
Borneo
Burma
Celebes
Ceylon
China (South)
Hainan
India
Indochina
Java
Malaya
Moluccas
Pakistan (East and West)
Philippine Islands
Sumatra
Thailand

Anopheles nili (Theobald)

Bionomics.—In certain restricted localities near rivers *Anopheles nili* is found in large numbers, and it enters houses and bites man. However, throughout Africa, with the exception of parts of Belgian Congo, Liberia, Sierra Leone, and French West Africa, it is rare, and when it is occasionally found in houses, it is usually not infected. In south Africa adults have never been found indoors. House-entry studies in localities where larvae are abundant show endophilism to be accidental. In Anglo-Egyptian Sudan *nili* and *Anopheles wellcomei* are the most abundant species in rural areas.

Larvae inhabit vegetated banks of flowing rivers and streams. Vegetation such as *Pistia* or shade from other sources is important to this species. Vegetated islands are the principal breeding grounds along the Congo River. Since the larvae in South-West Africa live along the margins of swiftly flowing streams and rivers, they are likely to be found along the two main river courses. In Kenya larvae have been reported underneath steep, undercut streambanks in the deep shade of high jungle vegetation.

Although the species is often rare and usually found in small numbers, it is widespread over Africa. It is essentially absent from arid regions because of the lack of shaded breeding places. Adult populations of *nili*, like those of *Anopheles moucheti moucheti*, are directly correlated with the rise and fall of the Congo River.

Relation to Disease.—In parts of Anglo-Egyptian Sudan, Belgian Congo, Liberia, Sierra Leone, and French West Africa, high natural malaria infection rates have been encountered. In these localities females may not be abundant. Nevertheless, the species should be considered as a secondary vector of malaria and less important than *Anopheles gambiae* or *A. funestus*.

References: *119, 258–260.* (For additional information, see the descriptions of malaria under Anglo-Egyptian Sudan; Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Bechuanaland
Belgian Congo
Cameroons
Dahomey
Ethiopia
French Equatorial Africa
French Guinea
French West Africa
Gold Coast
Ivory Coast
Kenya
Liberia
Mozambique
Natal
Nigeria
Northern Rhodesia
Nyasaland
Sierra Leone
Southern Rhodesia
South-West Africa
Spanish Guinea
Transvaal
Uganda

Anopheles oswaldoi (Peryassú)

Bionomics.—Females of *oswaldoi* are apparently not attracted to human habitations but will attack man when their jungle habitats are invaded. Even though a few specimens have been collected in houses in jungles in the Fort Sherman reservation in Panama, *oswaldoi* is not regarded as a species that frequents houses there or in Trinidad. In Surinam it prefers animal shelters and seldom invades houses.

Larvae breed in the well-shaded fresh water of jungle pools, swamps, and stagnant streams.

A. oswaldoi is a jungle mosquito that normally is not closely associated with man. It is most prevalent, at least in Surinam, at the end of the rainy season.

Relation to Disease.—Although common in some parts of Brazil, *oswaldoi* is not regarded as an important malaria vector in that country because of its wild habitat. In Panama it transmits malaria to man when its jungle haunts are invaded, and it is believed to do so in Colombia under similar circumstances.

References: *67, 79, 222, 226, 292, 308.* (For additional information, see the descriptions of malaria under Panama, Northwest South America, and Brazil and the Guianas.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
British Guiana
Colombia
Costa Rica
Ecuador
French Guiana
Guatemala
Panama
Paraguay
Surinam
Trinidad
Venezuela

Anopheles paludis Theobald

Bionomics.—*Anopheles paludis* inhabits the low tropical rain forest and is most active from August or September to April or May. It is not normally a domestic anopheline and is generally assumed not to enter human dwellings, although at Coquilhatville, Belgian Congo, it has been regularly captured in native huts. In Nigeria the species attacks man freely out of doors. In Africa a few *paludis* females have been caught in monkey-baited traps between 6 and 10 p. m., one specimen as high as 58 feet in a tree. Observations indicate that *paludis* is most active in darkness under conditions of low temperature and relatively high humidity. *A. paludis* lives in both rain forests and plantations, most commonly in the former. During the daytime it is extremely scarce in the forest canopy; at night it bites in both forest and plantation areas. *A. paludis* shows an ill-defined peak of activity just before and after 1 a. m.

In Liberia larvae live in dense shade in swamps that contain aquatic vegetation. In southern Nigeria and Sierra Leone the species is found in the clear water of swamps, ponds, backwaters of streams, springs, ditches, and ricefields. Aquatic and semiaquatic vegetation is almost always present in those habitats. Larvae are rarely found in completely exposed rain pools. In the high grasslands of the Transvaal they appear to be resistant to frost.

Relation to Disease.—*A. paludis* is regarded as a malaria vector of some importance in several areas of the Belgian Congo. Females captured in native huts have been found with stomach infection rates of 5.5 percent and salivary gland infection rates of 0.39 percent.

References: *69, 119, 148, 149, 152, 252, 258, 260.* (For additional information, see the description of malaria under West-Central Africa.)

Recorded Distribution.—

Angola
Belgian Congo
Ethiopia
French West Africa
Gold Coast
Liberia
Nigeria
Senegal
Sierra Leone
Tanganyika
Uganda

Anopheles pattoni Christophers

Bionomics.—Little is known about the habits of *Anopheles pattoni* adults, but females are known to be zoophilic as well as anthropophilic.

The species hibernates as second- or third-instar larvae, presumably throughout the entire winter, sometimes under thick ice. During the breeding season immature stages live in slowly running hill streams, rock pools, and pools in streams with sandy bottoms and an abundance of algae.

Relation to Disease.—For many years this species has been regarded as the principal malaria vector in northern China, but until 1937 infected specimens had never been found in nature. Females were shown to be good experimental vectors of malaria in 1929. *A. pattoni* is a vector in Shantung, Hopei, Szechwan, Shansi, Shensi, and eastern Kansu Provinces of China. It definitely lives as far north as Ch'in-huang-tao, and its presence farther north in Manchuria is possible.

References: *37, 67, 88, 90, 174.* (For additional information, see the description of malaria under North Europe and North Asia.)

Recorded Distribution.—

China (north)
Manchuria

Anopheles pharoensis Theobald

Bionomics.—In Egypt the females of *Anopheles pharoensis* commonly enter houses and bite man viciously in the open at sunset. Precipitin tests show also that *pharoensis* is definitely anthropophilic in Egypt. This is true in other areas as well, although it may be only weakly anthropophilic in certain parts of Kenya, Nigeria, and Uganda, since here it does not enter houses as freely as *Anopheles gambiae* and *A. funestus.* In the central Sudan immense numbers of females have been known to bite both man and animals. Studies show that adults are blown for comparatively long distances from their breeding places in Egypt. This mosquito is often associated with extensive wet-season flooding along the banks of rivers and in grassy areas.

Larvae are generally associated with large bodies of fresh water and are almost invariably found in the presence of aquatic vegetation of some sort despite the large variety of breeding places. In Kenya, Uganda, and Mozambique larvae are associated with tall grass, reeds, and papyrus; with *Pistia*, *Potamogeton*, and floating vegetation at stream edges, in lakeshore swamps, and in borrow pits; and with roots of decaying aquatic plants in open lakes. In Egypt, in addition to the above sites, larvae have been found in ricefields, sakieh pits, abandoned wells, and old water tanks. They have been reported from wells in Ethiopia. Larvae have been observed in ricefields several times in Egypt and Kenya, although in Mozambique and Madagascar this habitat has not been noted to any great extent. In Lakes Kivu and Albert in Belgian Congo large numbers of larvae are found in *Ceratophyllum demersum.* There is no extensive breeding in rivers in this area during the dry season. The species is a swamp breeder in South-West Africa and is probably restricted to the extreme northern part of that country. Young larvae tend to remain at the bottom of collecting containers in contrast to those of *gambiae*, which ordinarily stay at the surface.

This species may appear in very large numbers for a night or two, and then disappear for long periods.

Relation to Disease.—Although there is some doubt about the role *pharoensis* plays as a vector of malaria, much evidence points to its considerable importance. *A. pharoensis* is said to be the most important vector, along with *Anopheles multicolor*, of malaria in Egypt. In almost all experiments it has been successfully infected and is often found infected in nature in Egypt, French West Africa, southern Nigeria, Kenya, and Uganda. In central Sudan, where it is found in large numbers, it is not looked upon as an important species, but in other parts of French West Africa it has been noted as a secondary vector. It is regarded as a minor vector in Madagascar. Although dissections in these and certain other areas have proved entirely negative for malaria parasites and positive dissection rates have always been low, *pharoensis* has been associated with outbreaks of malaria where it was the only known vector present. In such locations, of course, it is of great importance, but where it is present in large numbers with *gambiae* and *funestus*, its importance may be considerably less. It is said to be of little importance in South-West Africa.

References: *119, 258–260.* (For additional information, see the descriptions of malaria under Egypt; Eritrea, the Somalilands, and Ethiopia; West Africa; East-Central Africa; Madagascar and Adjacent Islands; Southern Africa; and Arabia.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Arabia
Bechuanaland
Belgian Congo
Cameroons
Dahomey
Egypt
Ethiopia
French Equatorial Africa
French Guinea
French West Africa
Gambia
Gold Coast
Israel
Ivory Coast
Kenya
Madagascar
Mozambique
Natal
Nigeria
Nyasaland
Senegal
Sierra Leone
Somalia
Southern Rhodesia
South-West Africa
Syria
Tanganyika
Transvaal
Uganda

Anopheles philippinensis Ludlow

Many early records of *Anopheles annularis* may apply to *A. philippinensis*, since the morphological resemblance between the two species is striking.

Bionomics.—Little is known about the habits of *philippinensis* adults. In Burma females have been collected in houses as well as in cattle sheds and stables, but in Yunnan they have never been found in human dwellings. Females are reported to be definitely anthropophilic in Bengal but predominantly zoophilic in Indochina. In Malaya swarms of males, usually 4 to 8 feet above the ground and not related to any ground object, have been observed from shortly after sunset to complete darkness. In the Philippines adults are attracted by the hundreds to white light.

Larvae live in large bodies of water, such as tanks, sloughs, quiescent lake margins, impounded water, large ponds, and open rush swamps, usually in rather dense vegetation.

Relation to Disease.—Considerable variation in natural infection rates for malaria is given in the literature. In the western part of the Ganges Delta area of East Pakistan, where the species is an important vector, infection rates are very high. Elsewhere infection rates are rather low or negative, and the species is believed to have no importance in malaria transmission.

Complete development of *Wuchereria bancrofti* has been observed in *philippinensis*. However, only a few specimens have been found naturally infected. The role of this mosquito as a vector of filariasis in nature is not exactly known.

References: *84, 91, 122, 308, 341.* (For additional information, see the descriptions of malaria and filariasis under East Pakistan and Assam.)

Recorded Distribution.—

Andaman Islands
Assam
Borneo
Burma
China (South)
Hainan
India
Java
Malaya
New Guinea
Pakistan (East)
Philippine Islands
Sumatra
Thailand

Anopheles plumbeus Stephens

Although originally described from Ireland, *Anopheles plumbeus* has been recorded from a large number of localities in Europe and western Asia. It was known in Europe for some time as *Anopheles nigripes*. *Anopheles barianensis* is found in India and is very closely related to *plumbeus*, but it is apparently of no importance in the transmission of malaria.

Bionomics.—*A. plumbeus* is a persistent biter, but it is universally known as a wild mosquito, preferring natural resting places to indoor haunts in most of its range. In Albania females have been commonly collected from stables.

Larvae live in water-filled tree holes and in similar habitats, such as hollows in the tops of stumps and pieces of wood with depressions filled with rainwater. In dry seasons they are sometimes found in water butts, tanks, cisterns, rain barrels, and even in peat beds. In Turkey they have been reported from small caves containing water and in small heavily shaded ground pools. The species of tree may have special significance, but the results of various investigations have differed widely in this respect. In Czechoslovakia larvae commonly live in water of pH 8.8 to 9.1 in hollows of "*Acer pseudoplatanoides*" and *Fagus sylvatica*. The numbers of fourth-instar larvae always appear to be small, possibly because development in the trees is limited to a certain number of larvae on account of the space available. In Albania *plumbeus* is the easiest of all *Anopheles* species to rear in the laboratory. Larvae were kept in rainwater at about 80° F., to which a small amount of blood serum was added; adults resulting from these rearings appeared to be normal in all respects.

A. plumbeus is closely associated with deciduous forests. It is believed to overwinter in the larval stage. Over most of its range it is not an abundant mosquito. In Albania and Turkey two population peaks occur, one in April and one in August and September. In England adults are most numerous from April to October and larvae have been collected during every month of the year.

Relation to Disease.—Experimentally *plumbeus* appears to be a very efficient vector and plays a small part in endemic malaria on the shores of the Black Sea. Because of the nature of its breeding places and adult habits, this species is not regarded as a vector elsewhere.

References: *52, 54, 216, 217, 249, 346.* (For additional information, see the description of malaria under North Europe and North Asia.)

Recorded Distribution.—

Albania
Algeria
Arabia
Austria
Caucasia
Corsica
Czechoslovakia
Denmark
France
Germany
Great Britain
Greece
Hungary
Iran
Iraq
Ireland
Italy
Mongolia
Netherlands
Portugal
Rumania
Sardinia
Sicily
Spain
Sweden
Switzerland
Turkey
Yugoslavia

Anopheles pretoriensis Theobald

Bionomics.—*Anopheles pretoriensis* seldom frequents houses in south Africa, Nyasaland, Kenya, Ethiopia, or Tanganyika. Large numbers of adults rest in outdoor haunts, such as grassy banks of streams, natural cavities in the earth, and moist clefts or rocks near breeding places. In Southern Rhodesia, where the greatest numbers of females have been observed indoors, only about 20 percent of the total catches of mosquitoes were from indoor locations. Precipitin tests in Kenya indicate that this mosquito has a slight preference for human blood.

Rarely seeking deep shade for oviposition, *pretoriensis* tends to prefer sites that are lightly shaded or exposed to the sun. In south Africa larvae have been found in completely exposed water, such as rain puddles, pools left by drying streams, seepages, and ponds. In South-West Africa they are very commonly associated with *Anopheles gambiae* in exposed pools and seepages. In Southern Rhodesia larvae live in a wide variety of locations, except heavy shade, deep wells, or artificial containers. In Kenya they inhabit streams, rivers, swamps, and irrigation canals, permanent or otherwise. About one-half of the total larvae have been collected from clear water. In Yemen they were taken at altitudes of 1,000 to 3,000 feet in the quiet marginal water of drying streams containing filamentous green algae and short vegetation.

Evidence indicates that this mosquito is anthropophilic to some extent and exophilic over the greater part of its range. In Nyasaland it is a dry-season anopheline.

Relation to Disease.—The importance of this species as a malaria vector is probably slight in the presence of *gambiae* and *Anopheles funestus*, since it rarely enters houses. In Ethiopia the species may be a vector of malaria, but its exact relation to this disease is not known with certainty. The low natural infection rates for females found out of doors in Transvaal and Southern Rhodesia indicate that this species may be of some importance in those countries.

References: *119, 206, 258–260.* (For additional information, see the descriptions of malaria under Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; Madagascar and Adjacent Islands; and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Angola
Arabia
Bechuanaland
Belgian Congo
British Somaliland
Cameroons
Eritrea
Ethiopia
French West Africa
Gold Coast
Ivory Coast
Kenya
Liberia
Madagascar
Mozambique
Natal
Nigeria
Nyasaland
Somalia
Southern Rhodesia
South-West Africa
Tanganyika
Transvaal
Uganda

Anopheles pseudopunctipennis pseudopunctipennis Theobald

Anopheles pseudopunctipennis pseudopunctipennis may be composed of several biological forms, since at least two egg types have been found. The other subspecies, *Anopheles pseudopunctipennis franciscanus*, is present in California but is not a vector of malaria.

Bionomics.—In the highlands of Lower California, Mexico, Guatemala, and Argentina females of *pseudopunctipennis* fly considerable distances, enter houses, and feed avidly on man. In Argentina they feed in large numbers inside houses. On the other hand, several localities in Central America and the West Indies have reported *pseudopunctipennis* to be exophilic. Females are apparently not attracted to houses in parts of Costa Rica, the Canal Zone in Panama, or Grenada.

Almost all larval habitats are exposed to sunlight and contain mats of green algae. The habitats are usually pools and eddies in shallow or drying streams, seepages, ground pools, and tanks. In Panama larvae are found in clear water rich in *Spirogyra*, but as far south as Argentina larvae can be found throughout the year in the presence or absence of algae. They live in algal mats and cling to flotage in shallow, quiet or running water. In some areas with a long dry season this species maintains itself in springs and other fresh-water collections in the mountains and returns to its breeding places at lower altitudes when rain pools form in riverbeds.

A. p. pseudopunctipennis is essentially a mountain and dry-season species. Rainfall is the chief climatic factor controlling its abundance. In Mexico heavy rains flood larvae from the mountains into extensive areas at lower altitudes. The species is most common in Grenada through July and August. In Peru its peak of abundance is between January and June.

Relation to Disease.—*A. p. pseudopunctipennis* is regarded as an important malaria vector. It has been found with high natural infection rates in several localities in the northwestern Provinces of Argentina, where this mosquito has been known for years as a dangerous transmitter. In Mexico infection rates up to 67.2 percent have been reported. The species is responsible for large amounts of endemic malaria in the central valley at 6,000 to 7,000 feet. It is almost solely responsible for the malaria in Tacna in southern Peru and Arica in northern Chile. It is the only *Anopheles* species and vector on the entire western slope of the Andes in Peru and the chief vector on the eastern slope. It is responsible for the malaria present at high altitudes in Ecuador and southwest Colombia. At Lake Atitlán in Guatemala it causes malaria outbreaks in villages along the shore. In the United States and Panama it is not an important vector.

References: *67, 226, 292, 308, 334.* (For additional information, see the descriptions of malaria under America North of Mexico, Mexico, Central America, Panama, Northwest South America, and Lower South America.)

Recorded Distribution.—

Argentina
Bolivia
British Honduras
Chile
Colombia
Costa Rica
Ecuador
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Peru
United States
Venezuela

Anopheles pulcherrimus Theobald

Bionomics.—Females of *Anopheles pulcherrimus* rest, often in exceedingly large numbers, in houses, tents, barracks, and cattle sheds. They prefer human settlements, but occasionally they are found far from man and his domestic animals. Females feed on man and animals and may attack in the evening, at night, or in the daytime, outdoors or indoors. The adults are strong fliers. Since they are able to withstand dryness, they may be carried long distances by the wind.

Larvae are found in the open, sunlit, weedy waters of swamps, seepages, marshes, ponds, and ricefields. They commonly inhabit polluted and often stagnant water but never in any of the breeding places listed above unless the water temperature is very high.

A. pulcherrimus is the typical mosquito in the oases of mid-Asian deserts. It breeds in larger bodies of water and hibernates as a third- or fourth-instar larva. The mosquito rarely is present above an elevation of 1,000 feet and is most numerous along the low, broad river valleys. In the hottest parts of its range the populations begin to increase in May. Farther north there is little increase in numbers until later in the year.

Relation to Disease.—The species has been easily infected experimentally with malaria parasites, and it has been found naturally infected in central Asia and Sind in West Pakistan, although in the latter country it is probably not an effective malaria vector. It is regarded as an important transmitter in the Murgab Valley of central Asia, where it maintains severe endemic malaria in the absence of other *Anopheles* species.

References: *67, 91, 120, 346.* (For additional information, see the descriptions of malaria under North Europe and North Asia, and Afghanistan and West Pakistan.)

Recorded Distribution.—

Afghanistan
Arabia
Caucasia
India
Iran
Iraq
Israel
Lebanon
Pakistan (West)
Syria
Turkestan

Anopheles punctimacula Dyar and Knab

Bionomics.—Females of *Anopheles punctimacula* are anthropophilic, but they will feed on livestock. They often visit human habitations in large numbers. In Panama the species is abundant in jungle areas, where it makes long flights, enters houses, and feeds on humans. Along the Chagres River of Panama many more females have been captured in houses than around domestic animals.

Larvae most commonly live in small streams, ponds, swamps, and other habitats containing clear, cool, densely shaded water.

Relation to Disease.—*A. punctimacula* in Panama is easily infected experimentally with malaria parasites, is found naturally infected, and enters houses readily. For these reasons it is believed to be an important vector in that country and also in the Cauca Valley of Colombia, where it is associated with intense malaria. Its role as a vector has not been determined elsewhere with certainty. In certain areas of Brazil it is not regarded as a vector because of its scarcity.

References: *67, 79, 226, 292, 308.* (For additional information, see the descriptions of malaria under Central America, Panama, and Northwest South America.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
British Guiana
British Honduras
Colombia
Costa Rica
Ecuador
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Peru
Venezuela

Anopheles punctulatus Dönitz

The *Anopheles punctulatus* group consists of four closely related species in Australasia. They are known as *Anopheles farauti*, previously treated in older literature as *A. punctulatus* var. *moluccensis*, *A. koliensis*, *A. clowi*, and *A. punctulatus*. The species commonly referred to as *punctulatus* in areas west of the Moluccas is *Anopheles tessellatus*.

Bionomics.—In some areas females of *punctulatus* enter houses freely and feed readily on man, but in others they do not attack man often, either indoors or in the open. They do not usually remain indoors after obtaining a blood meal. Although the species is occasionally said to be exclusively anthropophilic, little is actually known about its blood preferences. All precipitin tests highly positive for human blood have been performed on mosquitoes collected near human habitations. Females are nocturnal; very few are active before 9 p. m. They are dangerous because of their noiseless flight, painless bite, and their presence in locations when few other *Anopheles* species are present. Outdoor resting places are probably in jungle areas near breeding places and near native villages.

Larvae are found in all types of water exposed to sunlight or partial shade. These include pools, ditches, hoofprints, water barrels, bilge water of boats, wheel ruts, trenches, bomb craters, and muddy pools, which occasionally contain algae. Although observed coastally as well as inland, immature stages are rarely found in brackish water and rarely, if ever, in flowing water. Larvae are often found in accumulations of water in stands of the sago palm. In Guadalcanal larvae are restricted to valleys of large streams and rivers and usually live some distance from the coast in temporary pools exposed to sunlight. They are rarely found at stream margins or in drying stream beds, and then only during the dry season. Eggs may be laid in mud, and even after complete drying will hatch upon subsequent wetting. The range of the species is frequently extended to the coast along the river courses during the rainy season, when larvae frequent temporary pools in large numbers. These pools may be very muddy, with or without marginal vegetation. Larvae are extremely active, especially when crowded in locations without vegetation, and spend much time submerged.

In New Guinea this species is seasonal, reaching a peak of abundance about June. During dry weather it almost disappears. In Guadalcanal the life cycle is completed in from 6 to 8 days. Development is very synchronous; i. e., all the individuals of any given generation attain adulthood at about the same time.

Relation to Disease.—The importance of this species is nearly equal to that of *farauti* in the transmission of malaria in Australasia. It has been found with high natural infection rates in New Guinea, Ceram, and Guadalcanal, although in certain localities it is present in large numbers where there is not a proportional amount of malaria.

The complete development of *Wuchereria bancrofti* in *punctulatus* has been experimentally demonstrated in New Britain. Up to 15 percent of this mosquito species has been found naturally infected in Guadalcanal. It is not known what role the species plays in the transmission of filariasis in nature.

References: *57, 121, 122, 228, 294.* (For additional information, see the descriptions of malaria and filariasis under Australasia.)

Recorded Distribution.—

Australia (Northern Territory, Queensland)
Ceram
Moluccas
New Britain
New Guinea
New Hebrides
New Ireland
Solomon Islands

Anopheles quadrimaculatus Say

Anopheles quadrimaculatus is distantly related to the European members of the *A. maculipennis* complex. It is referred to in the very early American literature as *Anopheles maculipennis*.

Bionomics.—*A. quadrimaculatus* is the most abundant North American anopheline found in houses and other man-made shelters and, with *Anopheles freeborni*, is the most definitely anthropophilic, even though livestock is preferred over humans as a source of blood. This species passes the winter in the adult stage, even in the southern part of its range, where larvae are found the year round. Fertilized females gather in immense numbers in basements, root cellars, and hollow trees. The effective flight range is about 1 mile. This distance is exceeded from time to time because of random flight patterns.

This species usually breeds in ponds, swamps, bayous, and borrow pits where sunshine and floating or emergent vegetation are abundant. The saying, "Quads are where you find them," has a basis in fact. Larvae may also be found in heavily polluted water, tin cans, barrels, borrow pits without vegetation, cornfield furrows, and other unusual habitats. They prefer to stay in the parts of these breeding waters that are made slightly alkaline by the action of sunlight and vegetation. In the Mississippi Valley this species prefers densely wooded swamps, which contain more highly alkaline water than those on the Atlantic coastal plain, where the water is much more acid. Larvae apparently cannot tolerate deep shade and acid water together.

Relation to Disease.—This species is the most important vector of malaria in eastern North America. Although malaria has almost entirely disappeared from the United States, *quadrimaculatus* is ever present and a constant source of danger. Its importance in Mexico has not been thoroughly studied.

Reference: *67.* (For additional information, see the descriptions of malaria under America North of Mexico and Mexico.)

Recorded Distribution.—

Bahama Islands
Mexico
United States

Anopheles rhodesiensis Theobald

Anopheles rupicolus has been confused with *A. rhodesiensis* in the past because of its extremely close morphological relationship. The former species is not a medically important species so far as is known. Kirkpatrick's (*205*)

Egyptian records of *rhodesiensis* actually refer to *Anopheles d'thali.*

Bionomics.—*A. rhodesiensis* is not regarded as domestic in Sierra Leone, south Africa, Southern Rhodesia, Mozambique, or Kenya. It has occasionally been found inside houses in Tanganyika and Sierra Leone, although in many parts of Sierra Leone it does not appear in or near human dwellings at all. Females do not feed readily on humans under laboratory conditions. In Southern Rhodesia only three females, one of which contained parasites, were ever captured in habitations during a 4-year study. Little is known about the outdoor haunts of this species, even in south Africa, where it is common and does not frequent houses.

Larvae live in a large variety of exposed or shaded breeding places, such as rock pools, stream beds, seepages with little shade, margins of streams with running water, springs, pools, ditches, hoofprints, and large artificial containers. In Tanganyika the species breeds in nearly all available water collections, but in arid places, such as in South-West Africa, it is restricted to streambanks and fountains, where larvae are common in short vegetation.

Relation to Disease.—This species is a potential vector of malaria, although its lack of endophilism and natural infections tend to make it of little importance. In Koinadugu, Sierra Leone, only once was it found with a high rate of natural infection. The species is believed to be a vector of secondary importance in Ethiopia. Investigators have completely failed to infect *rhodesiensis* in the laboratory with *Plasmodium malariae* and only rarely have they infected it with *P. falciparum.*

References: *205, 206, 258, 259.* (For additional information, see the descriptions of malaria under Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; and Southern Africa.)

Recorded Distribution.—

Bechuanaland
Belgian Congo
British Somaliland
Cameroons
Cape Province
Egypt
Eritrea
Ethiopia
French West Africa
Gold Coast
Iran
Ivory Coast
Kenya
Mozambique
Northern Rhodesia
Nyasaland
Sierra Leone
Somalia
Southern Rhodesia
South-West Africa
Tanganyika
Transvaal
Uganda

Anopheles rufipes ingrami Edwards

Anopheles rufipes ingrami was described in 1929 as a variety of *A. rufipes* on the basis of a difference in markings on the third hind tarsal segment of the female (see p. 58).

Bionomics.—Near Freetown, Sierra Leone, *ingrami* is extremely rare in human habitations, even though the mosquito may be breeding extensively in the immediate vicinity. On the other hand, it has been found in considerable numbers in human habitations in northern Nigeria.

Large numbers of larvae have been observed in big, shallow pools of fresh water at Kissy near Freetown during April and May.

Relation to Disease.—The importance of *ingrami* to the distribution of malaria has not been determined accurately. This subspecies is included as a possible vector, because in northern Nigeria (1) it has been found in houses in considerable numbers, (2) experimental infections have been obtained, and (3) extensive breeding has been recorded.

References: *119, 258.* (For additional information, see the descriptions of malaria under West Africa and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
French West Africa
Gold Coast
Mozambique
Nigeria
Northern Rhodesia
Sierra Leone

Anopheles rufipes rufipes Gough

Bionomics.—Large numbers of females of *Anopheles rufipes rufipes* have been captured in human habitations in Southern Rhodesia and central Sudan, and sometimes they outnumber *A. gambiae* in houses in northern Haute-Volta. In contrast, adults are seldom found indoors in south Africa and Kenya. They are commonly observed in streambank crevices and similar locations close to breeding places. Flights of up to one-half mile have been reported from French West Africa.

The breeding waters of this species are usually unshaded, but larvae are apparently tolerant of certain amounts of shade. They have been found in stagnant or semistagnant pools, rock pools, residual pools in riverbeds, marshes, hoofmarks, cement tanks with clear rainwater, swamps, and seepage areas. The water in many of these places may be moving.

This mosquito is comparatively rare in South-West Africa because of the extensive dry areas in that country.

Relation to Disease.—Up to 1947 this mosquito was regarded as an unimportant vector of malaria, but more recent investigations in French West Africa have shown that it plays a much more vital part in malaria transmission than had ever been suspected. Because high sporozoite rates have been found in that country, *rufipes* is considered to be as important as *gambiae* and *Anopheles funestus* there. It is important in Anglo-Egyptian Sudan, where it occasionally appears in large numbers. In Southern Rhodesia, south Africa, and Kenya it has not been found naturally infected.

References: *119, 167, 168, 258, 259, 260.* (For additional information, see the descriptions of malaria under Anglo-Egyptian Sudan; Eritrea, the Somalilands, and Ethiopia; West Africa; West-Central Africa; East-Central Africa; Madagascar and Adjacent Islands; and Southern Africa.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Bechuanaland
Belgian Congo
Cameroons
Dahomey
Egypt
Eritrea
Ethiopia
French Equatorial Africa
French Guinea
French West Africa
Gambia
Gold Coast
Ivory Coast
Kenya
Madagascar
Mozambique
Natal
Nigeria
Portuguese Guinea
Senegal
Southern Rhodesia
South-West Africa
Transvaal
Uganda
Zanzibar

Anopheles sacharovi Favr

Anopheles sacharovi, which was originally described from Caucasia, has been shown to be a member of the *A. maculipennis group.* Some workers prefer the older name, *Anopheles elutus*, since they feel that the application of Favr's name is uncertain. For additional details, see page 125.

Bionomics.—Females of *sacharovi* are anthropophilic and the presence of domestic animals does not divert them from feeding on man to any important extent. Adults are common in houses and stables, sometimes in large numbers, even in Iraq and northern Iran, where there is some evidence that most of the females rest outdoors in the summer and indoors in the winter. In Syria and Lebanon no adults were found outdoors, nor was any outside feeding demonstrated. Fat-body development has been observed as early as September in some areas. In Israel, Iraq, and northern Iran prehibernation flights have been observed. At high elevations fe-

males hibernate in cool shelters and do not take winter blood meals, but in the lowlands they hibernate in cattle sheds, stables, and houses, where they feed throughout the winter.

In the Mediterranean area the species breeds typically in large brackish marshes and less commonly in a variety of other habitats. These include inland and coastal swamps, boggy ground in fresh-water areas, neglected water-storage tanks, and channels and their leakages. Larvae in Syria and Lebanon are found in both large and small collections of water covered with floating aquatic vegetation, such as *Potamogeton* and *Ranunculus* but rarely in upright emergent vegetation. Quiet water is preferred but never with much salinity. In Jordan and Israel larvae commonly live in exposed or partially shaded water collections with the subaquatic vegetation of marshes, lakes, ponds, ditches, and seepages. In the northern part of the Jordan Valley larvae are found in rather large bodies of water, and the stream habitat is rather unusual. In Iraq and northern Iran larvae inhabit ricefields and large mountain rivers overgrown with vegetation.

A. sacharovi is a lowland species that likes and withstands heat. It has occasionally been taken at altitudes up to approximately 3,500 feet in Tadzhikistan. In Syria and Lebanon larvae are found throughout the winter and begin to appear in large numbers as early as March. Population peaks of both larvae and adults occur in July and August. In the northern parts of its range the species is a late-summer form, but in southern localities there is a rapid increase in numbers in the spring, a reduction through the summer, and a later increase in the fall.

Relation to Disease.—*A. sacharovi* transmits malaria wherever it is abundant. It is a very important and dangerous vector. It is especially important in northern Italy and the southern Balkans. In the northern parts of Jordan, Israel, and Syria the species is associated with very highly endemic malaria. In Iraq and along the Caspian coast of Iran *sacharovi* is almost always associated with high spleen rates. It is an important vector as far east as West Pakistan. There are isolated places, i. e., in the Amu Darya Valley of the U. S. S. R., where *sacharovi* is abundant in the complete absence of malaria.

References: *53, 67, 118, 147, 229, 239, 241.* (For additional information, see the descriptions of malaria under Northwest Africa; North Europe and North Asia; Italy, the Balkans, and Adjacent Islands; the Near East; Arabia; Iran; and Afghanistan and West Pakistan.)

Recorded Distribution.—

Albania
Algeria
Bulgaria
Caucasia
China (north)
Corsica
Crete
Cyprus
Czechoslovakia
Egypt
Greece
Iran
Iraq
Israel
Italy
Jordan
Lebanon
Libya
Morocco
Rumania
Sardinia
Spanish Morocco (?)
Syria
Turkestan
Turkey
U. S. S. R.
Yugoslavia

Anopheles sergenti (Theobald)

Most of the records of *Anopheles culicifacies* in north Africa west of the Somalilands refer to *A. sergenti.*

Bionomics.—Adults of *sergenti* are common in houses and tents. Precipitin tests show that many females captured in houses contain human blood. Females bite fiercely after dark. In Egypt large numbers of adults rest in underground aqueducts during the spring and summer and feed on man in ricefields toward the end of the breeding season. Adults are strong fliers, having been found in rather large numbers up to 1½ miles from their nearest breeding places. In Israel prehibernation flights of up to 3¾ miles have been reported.

Larvae are most often found among stones in small pools and springs at the edges of lakes. They also live in seepages, slow-moving streams, and irrigation channels, where they avoid direct sunlight. In Egypt larvae are common in ricefields or stagnant water and are sometimes found in borrow pits associated with vegetation. In Yemen a single larva was taken at about 3,700 feet in quiet marginal water of a drying stream in the presence of a fine, green, floating water grass, and several larvae were observed at a lower altitude in the presence of short vegetation and filamentous green algae. Irrigation ditches, swamps, and rock pools are larval habitats in Syria and Lebanon. *A. sergenti* is found in breeding places with *Anopheles superpictus* throughout Jordan.

A. sergenti is most abundant in September and October in Israel and Egypt and through November in Jordan. It passes the winter in the larval stage. Adult populations do not build up until late summer of the following year.

Relation to Disease.—The seasonal prevalence of this species over most of its range closely parallels that of malaria. Because larvae and adults are so universally abundant and since *sergenti* is commonly found with natural infections, it is an important vector in the oases of north Africa east of Algeria and in Egypt, Israel, western Jordan, and parts of Arabia. In northern Iran and Iraq this mosquito is too rare to be an important vector.

References: *91, 120, 154, 229, 241.* (For additional information, see the descriptions of malaria under Northwest Africa, Egypt, the Near East, and Arabia.)

Recorded Distribution.—

Albania
Algeria
Arabia
Canary Islands
Egypt
Iran
Iraq
Israel
Jordan
Lebanon
Libya
Morocco
Pakistan (West)
Spain
Spanish Morocco
Syria
Tunisia
Turkey

Anopheles sinensis Wiedemann

Much of the early medical literature on *Anopheles sinensis* in the Orient refers to at least two closely related species belonging to the *A. hyrcanus* group. One of these is *sinensis* itself, the other is *Anopheles nigerrimus* (p. 129). Both are unique in being the only members of the group that are medically important. Recent investigations have enabled taxonomists to separate and identify the various closely related species in this group and to assign some early records to the species as they are now recognized.

Bionomics.—The records of *sinensis* indicate that this anthropophilic mosquito has definite zoophilic tendencies. In China it is principally zoophilic but will bite man readily on occasion. Tendencies toward zoophilism have been also noted in Indochina. In Malaya and elsewhere females attack man early in the evening, biting freely outside but rarely inside habitations. A noticeable reduction in numbers occurs as early as 9 p. m. Even in areas where females are commonly found in cattle sheds, they find their way to man-baited net traps placed out of doors.

Larvae are found most often in ricefields and pools containing quiet water. They also live in swamps, borrow pits, cisterns, irrigation ditches, and margins of lakes and streams. In China larvae have been found in stagnant water and old manure pits containing rainwater. In Okinawa the species breeds in small clear pools and is seldom found in brackish water. In Malaya it prefers open, grassy ponds for development and is sometimes found on the coast with *Anopheles sundaicus.* Breeding is usually abundant in jungle areas that have been cleared for cultivation. Larvae are adapted to

rather open habitats and prefer relatively high water temperatures. Laboratory experiments show them to have higher thermal death points than the species that normally live in shade.

Relation to Disease.—In Japan and Formosa this species is a malaria vector of primary importance. In Formosa it lives in the plains, being replaced by *Anopheles minimus* in the foothills. Together with *Anopheles pattoni* and *A. maculipennis*, it is probably the only vector of malaria in Manchuria and central China. It is the most important vector in the ricegrowing areas of South China and Formosa, and in Indochina it is the chief transmitter of malaria in the ricefields of Tonkin, Cambodia, and Cochin China. In Thailand and Malaya it is regarded as a vector of secondary importance. In Thailand dissections of wild-caught specimens are sometimes entirely negative for malaria parasites. Although many records from Sumatra and possibly Borneo may refer to *nigerrimus*, *sinensis* is regarded as a secondary vector there. In all areas studied the average natural infection rate is rather low.

Development of both *Wuchereria bancrofti* and *W. malayi* to the infective stage in *sinensis* has been demonstrated experimentally. This mosquito has been found naturally infected with *bancrofti* in the Shanghai area of China, where *sinensis* is believed to play an important role in filaria transmission.

References: *67, 91, 122, 283.* (For additional information, see the descriptions of malaria and filariasis under North Europe and North Asia, South China, Formosa, Indochina, Thailand, Malaya, and Sunda Islands.)

Recorded Distribution.—

Assam
Burma
Celebes
China
Formosa
Hainan
Indochina
Japan
Malaya
Manchuria
Pakistan (East)
Sumatra
Thailand
U. S. S. R.

Anopheles stephensi mysorensis Sweet and Rao

Bionomics.—Females of *Anopheles stephensi mysorensis* are less hardy and can be induced to feed on an arm extended into a cage with much more difficulty than the type form. This mosquito prefers rabbit blood to that of man in the laboratory. Colonies of this subspecies are established with considerable difficulty.

In some areas the larvae are found only in wells. Elsewhere they live in irrigation channels and at stream margins.

Relation to Disease.—In Vizagapatnam, India, this mosquito is suspected of being the principal vector of malaria. It is generally considered to be less important than the type form.

References: *67, 322.* (For additional information, see the description of malaria under India and Ceylon.)

Recorded Distribution.—

India

Anopheles stephensi stephensi Liston

Bionomics.—Adults of *Anopheles stephensi stephensi* are commonly found in houses, cowsheds, barracks, and other types of manmade shelters. They feed readily on man in the laboratory and in nature. They are usually difficult to find, because they hide in small, out-of-the-way places, such as the many small, dark creases and crevices in folded or crumpled cloth. Their flight range does not usually exceed one-half mile. Adults have been found up to 1½ miles from their nearest breeding places in Bahrein near the Iraq coast.

Larvae are found in both urban and rural locations. The outstanding type of breeding place consists of wells and other artificial containers, such as cisterns, water collections near buildings, flooded cellars, and bases of running fountains. In rural areas larvae are found in all sorts of breeding places containing fresh, brackish, or sewage-contaminated water either in direct sun or in the shade. Pools, stream beds, slowly moving creeks, irrigation channels, drains, and miscellaneous breeding places with fresh water often contain larvae. In Iraq the breeding places consist of small, shallow, grassy pools that tend to disappear later in the summer, especially where palms are being cultivated. Larvae habitually sink deep into the water and stay submerged for long periods.

In Iraq *stephensi* breeds throughout the year. It has two marked seasons of intensity, one in May and June and the other in October and November.

Relation to Disease.—Except for *Anopheles culicifacies*, *stephensi* is probably the most important vector of malaria in western and northwestern India. It is commonly encountered in Bombay, Bangalore, and Lucknow, and it is responsible for the transmission of malaria in urban and rural areas of Afghanistan and West Pakistan. It is the only vector usually associated with epidemics on the alluvial plains of Iraq, which are subjected to intense flooding, and is by far the outstanding vector along the Persian Gulf coast, including Al-Qaṭīf and Hofuf oases, and at Al-Kharijah in the Najd. The species is frequently found with natural infections.

References: *67, 91, 120, 241, 347.* (For additional information, see the descriptions of malaria under the Near East, Arabia, Iran, Afghanistan and West Pakistan, India and Ceylon, and Burma.)

Recorded Distribution.—

Afghanistan
Arabia
Assam
Burma
China (South)
India
Indochina
Iran
Iraq
Pakistan (East and West)

Anopheles subpictus subpictus Grassi

Anopheles rossii, a name commonly used in the past for *A. subpictus subpictus* in India, has also been applied to other species in regions east of that country. Two forms of *subpictus*, *Anopheles subpictus indefinitus* and *A. s. malayensis*, are found in countries east of India and have no known medical importance.

Bionomics.—Although normally domestic, *subpictus* is both zoophilic and anthropophilic in Indochina, where studies have revealed as few as 2 percent of wild-caught females with human blood. Adults are repeatedly encountered in large numbers in all kinds of buildings.

Larvae live in many different types of locations containing fresh, brackish, or polluted water. The breeding places may be borrow pits, buffalo wallows, brick pits, drains, pools from leaks in irrigation ditches, furrows in gardens or fields, roof gutters, ricefields, irrigation channels, and artificial containers. In the Sunda Islands, especially Celebes, larvae also breed in the brackish water of lagoons and fishponds, with salt concentrations of up to 8.5 grams per liter. Larvae have been taken many times from brackish water in Indochina. In Malaya females most commonly oviposit in fresh and brackish water in pools, ponds, and open swamps. Larvae are rarely found in ricefields.

The habitat of *subpictus* is primarily in coastal and lowland areas. In the Punjab of India the species is found only during and following the monsoon season, where it first appears in June and is prevalent from July to December. In southern India and Burma it breeds throughout the year.

Relation to Disease.—This species is of little importance in malaria transmission, although parasites are able to mature efficiently in it. Few or no natural infections have been reported outside southeast India, the Sunda Islands, or

Australasia. Java, Sumatra, and Celebes have had epidemics with which both *subpictus* and *Anopheles sundaicus* have been associated. In those areas *sundaicus* is believed to be the chief vector and *subpictus* may become infected late in the epidemic. On the west and south coasts of Celebes and in northern Madoera *subpictus* is as important as *sundaicus*, and it may transmit some malaria in New Guinea. *A. s. subpictus* can be important, in spite of its low infection rates, because of its extremely large populations. There are no reliable records of natural infections in either the Philippines or Malaya, where *malayensis* and *indefinitus* are found.

On the basis of experiments with artificial infections, *subpictus* is believed to be a good vector of *Wuchereria bancrofti* in Batavia, Java. It is a possible vector in India, but elsewhere its importance is not known.

References: *91, 122, 161.* (For additional information, see the descriptions of malaria under Sunda Islands and Australasia.)

Recorded Distribution.—

Afghanistan
Assam
Bali
Bangka
Borneo
Burma
Celebes
Ceram
Ceylon
China (South)
Flores
Formosa
India
Indochina
Iran
Java
Malaya
Moluccas
Nepal
New Guinea
Pakistan (East and West)
Philippine Islands
Soemba
Soembawa
Sumatra
Thailand
Timor

Anopheles sundaicus (Rodenwaldt)

Anopheles sundaicus has commonly been referred to as *Myzomyia ludlowi* and *A. ludlowi* in early malaria literature.

Bionomics.—Adults of *sundaicus* are anthropophilic and zoophilic and are commonly found in both cattle sheds and houses. Engorged females have often been captured in rooms and nets in which people have been sleeping. Nevertheless, some feeding on animals is indicated by nearly all precipitin tests. Females do not bite until several hours after nightfall and remain for some time near biting places after obtaining blood meals. They are strong fliers and have commonly been seen 2 miles, once as far as about 4 miles, from their nearest breeding places.

Except in Sumatra, Java, and restricted parts of Celebes, *sundaicus* is known to breed only in brackish water. Larvae inhabit sunlit lagoons, salt-water fishponds, swamps, and polluted water on the coast. They are occasionally found in clear-water pools as well. In Java larvae are commonly associated with abundant green fishpond algae, such as *Enteromorpha*, which forms a feltlike cover over the water surface. Although larvae tolerate water with a maximum of about 30 grams of salt per liter, they are more commonly found in concentrations of 4 to 18 grams per liter. Deeply shaded, virgin mangrove areas are unfavorable for larval development, except where they have been cleared to admit sunlight. Larvae in fresh-water inland locations in Sumatra, Java, and Celebes do not differ morphologically from those in coastal brackish-water sites. When fresh-water fishponds were abolished at Mandahiling, Sumatra, as a last resort to control *sundaicus*, it disappeared, since it would not breed in any other water nearby. Larvae have been found in fresh water in Celebes, but they are rare.

Relation to Disease.—*A. sundaicus* is regarded as a vector of utmost importance throughout its range and is one of the most effective carriers of malaria known. It is very easily infected in the laboratory. This species has been repeatedly associated with severe periodic outbreaks in coastal areas throughout the Orient, especially in Java, Sumatra, and the Lesser Sundas, where natural infection rates as high as 54 percent have been reported. Extremely high natural infection rates have been reported from nearly every other area where this species is found. The percentage rates for some of these areas are Java 1 to 36, Sumatra 2 to 15 and once as high as 46, and the East Pakistan-India border 23.4. Along the coast of Malaya it is responsible for extensive endemic malaria.

Natural infections of *sundaicus* with *Wuchereria bancrofti* have been reported from various areas. Experimentally *bancrofti* is able to complete its development in this mosquito to the infective stage.

References: *91, 120, 122, 161, 228, 242, 324.* (For additional information, see the descriptions of malaria under India and Ceylon, East Pakistan and Assam, Formosa, Burma, Indochina, Thailand, Malaya, Sunda Islands, and Philippine Islands.)

Recorded Distribution.—

Andaman Islands
Assam
Bali
Bangka
Borneo
Burma
Celebes
Ceram
China (South)
Flores
Formosa
Hainan
India
Indochina
Java
Nicobar Islands
Pakistan (East)
Philippine Islands
Soembawa
Sumatra
Thailand
Timor

Anopheles superpictus Grassi

Bionomics.—Adults of *Anopheles superpictus* habitually fly great distances to congregate in localities where fairly large groups of host animals are present, but no long-range dispersals have been noted except those preliminary to winter hibernation. Females are commonly found inside habitations of all kinds and readily feed on man, even when livestock is in the immediate vicinity. Before and immediately after taking blood meals they fly to animal shelters to rest on spider webs and in dark corners, and they have been found in outdoor resting places as well. They are very resistant to dry air. In Israel their normal range is about 1 to 1½ miles from their breeding places. Once in Italy a flight range of 4.3 miles was noted. Partly or completely hibernating females have been found in the winter in stables and houses. They exhibited a full fat-body development as does *Anopheles maculipennis*. *A. superpictus* overwinters as an adult in most of its range.

Larvae are found in the open sunlit pools left in beds of small mountain or hill streams during the dry season. They also are found in gently flowing water, especially in bays or where the edges are weedy. Larvae have been found in streams with a central velocity of 2.1 miles per hour. In Italy the species is common in ricefields and comprises up to 10 percent of all anophelines found there. Larvae never live in foul water but often inhabit comparatively quiet bodies of water, with a saline concentration of up to 0.5 percent. They may lie submerged for up to 8 minutes in a collecting container. During the winter they have been found under or enclosed in ice.

A. superpictus normally lives at altitudes up to 5,000 feet and has been found as high as 7,000 feet. It requires a warm, dry summer and is everywhere most prevalent during the hottest, driest parts of the year. It does not survive a prolonged winter. Its northern limit of distribution is determined by the amount of precipitation, since excessive rains tend to destroy its breeding places. In northern parts of Asia *superpictus* is a late-summer species, but it appears in large numbers earlier in the season in the south. In Turkey it reaches a peak of abundance in July and August.

Relation to Disease.—This species is almost always a dangerous malaria vector wherever it is sufficiently abundant. It has been easily infected in the laboratory, and it has been found with natural infections in many parts of its range. It can maintain highly endemic malaria in the complete absence of other vectors and is one of the most widely known malaria vectors.

References: *67, 91, 120, 217, 346.* (For additional information, see the descriptions of malaria under Northwest Africa; Egypt; North Europe and North Asia; Italy, the Balkans, and Adjacent Islands; the Near East; Iran; and Afghanistan and West Pakistan.)

Recorded Distribution.—

Afghanistan
Albania
Algeria
Arabia
Balearic Islands
Bulgaria
Canary Islands
Caucasia
Crete
Cyprus
Egypt
Greece
India
Iran
Iraq
Israel
Italy
Jordan
Lebanon
Libya
Pakistan (West)
Spain
Syria
Tunisia
Turkestan (?)
Turkey
Yugoslavia

Anopheles tessellatus Theobald

Very early records of *Anopheles tessellatus* in the eastern part of the Orient are found under the name *A. punctulatus.*

Bionomics.—Although females readily feed on man, *tessellatus* is a semidomestic and zoophilic mosquito. Females have been caught in human-bait traps in Malaya, but three investigations in Indochina showed very low percentages of females with human blood. In India the species rests in both houses and cowsheds and is often reported feeding on buffalo. In the Philippines resting adults have been captured at eroded banks of streams and in damp, shaded cracks of stone walls. The flight range of adults in the Sunda Islands is about 1,100 yards. In Philippine experiments an adult was recorded over a mile from the point of liberation.

In some areas clear water is the larval habitat, but in others dirty stagnant water and sometimes mud puddles of limited size are preferred. In Malaya more larvae are found in drains and swamps than in ground pools. Almost no collections have been made from ricefields and streams. In the Philippines, on the other hand, the species is most abundant in ricefields, and smaller numbers of larvae live along vegetated margins of streams, springs, and irrigation ditches containing clear water. Over most of its range it breeds in either shaded or open locations.

Relation to Disease.—This mosquito is an important vector of malaria in Formosa, where experimental infections have been demonstrated and where infected females are often found in nature. The rate of natural infections is too low to implicate this species in the transmission of malaria elsewhere.

Experiments indicate that *tessellatus* may be a good vector of *Wuchereria bancrofti* in Java. There have been no confirmatory field investigations.

References: *91, 120, 122.* (For additional information, see the description of malaria under Formosa.)

Recorded Distribution.—

Andaman Islands
Assam
Bali
Borneo
Burma
Celebes
Ceram
Ceylon
China (South)
Formosa
Hainan
India
Indochina
Java
Malaya
Moluccas
New Guinea (?)
Pakistan (East)
Philippine Islands
Soembawa
Sumatra
Thailand

Anopheles umbrosus Theobald

Most early records of *Anopheles umbrosus* refer to a large number of closely related species sometimes known as the "*Anopheles umbrosus* group," which contains three medically important species: *A. umbrosus* (see below), *A. letifer* (p. 124), and *A. baezai* (p. 114). As a result of recent studies by Reid and Hodgkin (*284*), *umbrosus* has recently been redefined, and in this restricted sense the following remarks are made.

Bionomics.—*A. umbrosus* is the only species belonging to the *umbrosus* group that bites during the day. It bites outdoors in the jungle, accompanied by *Mansonia* (*Mansonoides*) *longipalpis*, but it enters houses, often one-half mile or so from the edge of the jungle, and bites indoors during the night. When in houses it will attack boldly, even under electric lights. In Malaya this mosquito is markedly anthropophilic. The adults rest on jungle vegetation near their breeding places.

Larvae are found almost entirely within the jungle in brown, peaty water. Elsewhere they invariably are observed in heavy shade. They prefer small pools along the borders of slow-moving streams.

A. umbrosus is a coastal-plain mosquito, found principally in dense, swampy jungle and occasionally in adjoining foothills.

Relation to Disease.—*A. umbrosus* has long been recognized as an important vector of malaria. Where *letifer* and *umbrosus* females occur together while biting humans outside jungle areas, *letifer* may be the more important vector. However, there is little doubt that *umbrosus* is a vector of considerable importance, especially in the western coastal areas of Malaya, where dissections of numerous wild-caught females since 1936 show a salivary gland infection rate of about 0.5 percent. In several areas of Borneo *umbrosus* has been found with salivary gland infections and has definitely been incriminated as a vector of malaria. Several positive dissections recorded from the Sunda Islands probably include species other than *umbrosus.* In south Celebes this mosquito is not regarded as a vector.

References: *66, 161, 243, 284.* (For additional information, see the descriptions of malaria under Malaya and Sunda Islands.)

Recorded Distribution.—

Andaman Islands
Assam
Bangka
Borneo
Celebes
Indochina
Java
Malaya
Sumatra

Anopheles varuna Iyengar

Anopheles varuna is closely related to *A. minimus* and has often been treated as a variety of that species. Many records of *minimus* in southern India possibly refer to *varuna.* Some records of *Anopheles listonii*, especially those pertaining to breeding in wells, probably refer to *varuna.*

Bionomics.—Adults of *varuna* have been captured in houses and cattle sheds. In some localities females definitely prefer the blood of man; in others cattle blood is preferred.

Except in India, where this species most commonly breeds in wells, larvae inhabit stagnant fresh-water ponds and ditches during and shortly after the monsoon season. They are commonly collected at roadsides from small pools of storm water in borrow ditches and from slow-running streams.

Relation to Disease.—*A. varuna* is a proved vector of malaria in restricted areas of east-central India. It is of little importance elsewhere, either because of its preference

for feeding on cattle or its scarcity. It has been found infected in nature.

References: *67, 91, 121, 161, 303.* (For additional information, see the description of malaria under India and Ceylon.)

Recorded Distribution.—

Assam
Burma
Celebes
Ceylon
India
Indochina
Pakistan (East)
Sumatra

Anopheles vestitipennis Dyar and Knab

Bionomics.—Females of *Anopheles vestitipennis* are endophilic and anthropophilic. Experiments in Cuba show that *vestitipennis* prefers human to calf blood but might prefer the blood of other animals to either of them. In the rural areas of Stann Creek Valley, British Honduras, this species was much more common in houses than in livestock traps nearby.

Larvae are found in cool fresh-water streams, seepages, ponds, and rain pools with abundant shade. In Puerto Rican sugarcane fields they are associated with *Anopheles grabhamii* in stagnant ditches filled with all kinds of vegetation. In Cuba larvae are found in partial shade in fresh-water swamps some distance from the coast, primarily in the western half of the island, where dense vegetation, detritus, and short grass cover areas of open water. Small clumps of coarse grass harbor large numbers of larvae in flooded forest rain pools of British Honduras.

A comparatively rare species over most of its range, *vestitipennis* is most abundant near isolated swampy and marshy areas.

Relation to Disease.—This species can be infected experimentally with malaria parasites, although parasite development, at least in Cuba, appears to be slow. In that island *vestitipennis* is suspected of being a malaria vector, but its role in the presence of *Anopheles albimanus* is not known. It has been found with natural infections in British Honduras where active cases of malaria are present.

References: *78, 221, 226, 292, 308.* (For additional information, see the description of malaria under Central America.)

Recorded Distribution.—

British Honduras
Colombia
Costa Rica
Cuba
Dominican Republic
Guatemala
Haiti
Honduras
Jamaica
Mexico
Panama
Puerto Rico
Trinidad
Windward Islands

CULEX SPECIES

Culex pipiens pallens Coquillett

Bionomics.—*Culex pipiens pallens* is one of the most abundant mosquitoes in the Shanghai area, where females avidly attack man.

Larvae are found in polluted water from March to December in that area.

Relation to Disease.—Experimental infections with *Wuchereria bancrofti* have revealed that *pallens* is probably one of the most efficient vectors of filariasis in the Shanghai area. It is not susceptible to *Wuchereria malayi* infection in the laboratory.

References: *177, 183, 187, 189.* (For additional information, see the description of filariasis under North Europe and North Asia.)

Recorded Distribution.—

China
Japan
United States (introduced into California)

Culex pipiens quinquefasciatus Say

Culex fatigans, the name used for *C. pipiens quinquefasciatus* by most European workers, is commonly found in the literature pertaining to the vector characteristics of the latter.

Bionomics.—*C. p. quinquefasciatus* is one of the most common mosquitoes found in human habitations in the Tropics and Subtropics of the world. In most of its range females are intensely anthropophilic and feed actively only at night. Even in the laboratory females bite only at night except when they have undergone a period of starvation. In parts of Africa they are attracted to natives rather than to Europeans. Females of *quinquefasciatus* rest in or under all kinds of buildings near humans, especially where the air is humid. They lay from 2 to 4 rafts of eggs, usually at night but rarely in broad daylight. Adults have been observed to fly as far as 3 or 4 miles from their nearest breeding places.

Larvae are never found far from human habitations. They live in flooded, open cement drains, cesspools, latrines, shallow wells, ditches, and ground pools. They are common in household storage water and other collections of water close to houses, especially water that is poorly covered and is polluted. In the lower Congo River Valley larvae are commonly found in poorly drained land surrounding villages. In India they commonly inhabit ricefields near villages and are especially common where rice is fertilized with green manure. Immature stages can adapt to a high degree of salinity and can easily survive in water with a pH of 5 to 10.

Relation to Disease.—In laboratories in many parts of the world *Wuchereria bancrofti* has been found to mature in *quinquefasciatus* to the infective stage. This mosquito is the only vector of Bancroftian filariasis in the New World and an important vector in many parts of the Old World, including tropical Africa. It is not a good vector of *Wuchereria malayi*, and in areas where that parasite predominates, *quinquefasciatus* may not be an important vector of filariasis.

References: *61, 95, 122, 166, 194, 250, 255, 268, 338.* (For additional information, see the descriptions of filariasis under Central America, Brazil and the Guianas, Northwest Africa, Egypt, West-Central Africa, East-Central Africa, India and Ceylon, East Pakistan and Assam, Formosa, Indochina, Thailand, Sunda Islands, and Australasia.)

Recorded Distribution.—The distribution of this species is worldwide in the Tropics and Subtropics. In the New World it is found between latitude 40° N. and latitude 35° S. Its range encompasses almost all the countries of continental Africa south of the Sahara Desert and Egypt, and it extends east across the southern half of the Arabian peninsula and the Orient, including India, to the China coast. This species inhabits Kyushu in the Japanese islands, Formosa, and all the Sunda Islands. It is found almost everywhere in Australasia.

Culex tarsalis Coquillett

Bionomics.—Principally zoophilic in its feeding habits, *Culex tarsalis* prefers the blood of wild and domestic fowl and attacks horses, cows, pigs, chickens, and sheep. It only occasionally seeks the blood of man. It feeds principally at dusk or at night, and the bite is painful. Females are attracted to light and enter vehicles and dwellings readily. In California this mosquito will fly as far as 2½ miles and has an effective flight range of about 1 mile. Females overwinter in buildings, caves, and cellars. In hot, dry localities on the Pacific Coast and in the Southwestern States adults appear between April and October and reach a peak of abundance in July and early August. East of the Mississippi River and south of Michigan and Illinois this peak appears in August and September, and the mosquitoes are present until December in some localities.

Larvae are found in many types of breeding places. These may be in water that is clear, fresh, alkaline, or stagnant with

organic matter, and they may be open sunlit or shady pools of various sizes. The type of breeding place varies with the locality. In Lower California larvae have been reported from a brackish tidal marsh, in the hot Southwest they are common in stagnant water near cultivated areas, on the Canadian prairie they are most common in reedy roadside ditches, in the Pacific Northwest they are found in poorly drained irrigated areas, and in the West it is the most common mosquito breeding in thermal waters with temperatures from 82.4° to 102.2° F.

C. tarsalis has been reported as the most abundant mosquito in the Pacific coastal region and the most ubiquitous mosquito in California, but it becomes more scarce in the Central and Eastern States. Because of its wide variety of breeding places, *tarsalis* builds up large populations in years of moderately heavy rainfall.

Relation to Disease.—*Aedes dorsalis*, *A. vexans*, *A. nigromaculis*, and *Culiseta melanura* have been incriminated in the transmission of western equine encephalitis, but *C. tarsalis* is unquestionably the most important vector of this virus. The biting activity of *tarsalis* and this virus disease are distinctly correlated. Over 100 strains of the virus have been isolated from wild-caught *tarsalis* adults in various parts of the United States. The distribution of *tarsalis* and the appearance of this virus in horses are strikingly related. Although this species harbors St. Louis encephalitis virus in nature, its exact role in transmitting it is not well known.

Reference: *200.* (For additional information, see the descriptions of encephalitis under America North of Mexico and Mexico.)

Recorded Distribution.—

Canada
Mexico
United States

Culex tritaeniorhynchus Giles

Bionomics.—In Japan *Culex tritaeniorhynchus* is the most important night biter during July and August. Its most intense biting begins just after sunset and lasts as late as 9 p. m., although females bite throughout the night. A comparison of animal-trap catches in Japan showed that when humans were used as bait, about 75 percent of all catches were *tritaeniorhynchus* mosquitoes; when horses were used, 89 percent; and cows, 93 percent. This mosquito, therefore, is not definitely anthropophilic in its biting habits, and, as with *Culex tarsalis*, man is nearly always an accidental host. The adults in Okinawa are reported to rest on damp rocks in woods and in vegetation near the ground. They commonly attack horses.

Early in the breeding season larvae are found in freshwater collections, such as natural- and artificial-water impoundments, ground pools, field drainage, and irrigation ditches. The species spreads to diverse habitats as the season progresses and inhabits polluted breeding places later in the year.

In Japan ricefields are said to be preferred breeding places. However, the drainage of ricefields is not necessarily correlated with the reduction in mosquito abundance. In Japan most larvae disappear by October. Population intensity appears to be more closely related to rainfall than to temperature. In Okinawa the habits are more diversified than those of any other mosquito, and larvae are found in all kinds of water collections. In Yemen larvae were observed in a drying stream where the quiet marginal water had short emergent vegetation and filamentous green algae. In Leyte larvae were found in a variety of locations with or without vegetation, and all were exposed to sunlight. In central China larvae have been reported from bomb craters and ricefields containing decayed vegetation, usually in complete shade.

This species is abundant in Korea, Japan, and eastward through central China. In Korea the population peak does not appear until mid-August, in Okinawa maximum abundance is reported to occur in early September, and in central China large numbers of adults are found in October. Population densities in these areas appear to be higher in rural than urban localities, apparently because ricefields are the habitat.

Relation to Disease.—Evidence indicates that this species is the most important, if not the only, vector of Japanese encephalitis virus in Japan. The virus has been found in wild-caught mosquitoes during the peak of biting activity in areas where the virus exists, and mosquitoes have successfully transmitted it in laboratory experiments under a variety of conditions. Because Japan is the only locality in which extensive experiments have been carried out and because there is no direct evidence that this species actually transmits the virus elsewhere, its importance as a vector in countries outside Japan can only be surmised. As far as is known, it is presumed to be the vector in any area where it and Japanese encephalitis appear together. Thus in Korea it is said to be probably the most important vector and the only one definitely associated with the disease there. Epidemiological evidence indicates that *tritaeniorhynchus* is a vector in Okinawa, although *Culex pipiens quinquefasciatus* has been suspected in the past. In Guam the vector is not known, and *tritaeniorhynchus* is not present there. The disease is not definitely known to exist in Manchuria, but this species is present in northern China.

References: *39, 51, 62, 154, 176, 206, 223, 272, 332, 348.* (For additional information, see the descriptions of encephalitis under Europe and North Asia, and Australasia.)

Recorded Distribution.—

Arabia
Borneo
British Somaliland
Celebes
Ceylon
China (northern and South)
Dahomey
Egypt
Flores Island
Gold Coast
India
Iran
Iraq
Israel
Japan
Java
Lebanon
Madagascar
Manchuria
Mascarene Islands
Mozambique
Nigeria
Okinawa
Philippine Islands
Sumatra
Syria
Tanganyika
Turkey
Zanzibar

Culex univittatus Theobald

No previous names have appeared in the medical literature for *Culex univittatus*, but a subspecies, *C. u. neavei*, is distributed along the White Nile River.

Bionomics.—Adults of *univittatus* are most common during the summer and early fall in Egypt and Anglo-Egyptian Sudan. Females appear to prefer birds as sources of blood meals, since bird-baited traps attracted this species almost exclusively. Observations also indicate that the species feeds on domestic animals. Furthermore, precipitin tests showed that only 11 percent of blooded *univittatus* females caught in light traps contained human blood. There is no evidence to indicate that females hibernate during the winter.

Larvae are found in swampy places during the entire year.

Relation to Disease.—Recent investigations indicate that *univittatus* is the principal vector of West Nile virus along the Nile River and Delta in Egypt and in southern Anglo-Egyptian Sudan. The species has been incriminated on the basis of epidemiological evidence and because it has been found more heavily infected with the virus in nature than

any other mosquito tested. In the laboratory this species has transmitted the recently discovered Sindbis virus (see p. 4).

References: *325, 326.* (For additional information, see the descriptions of encephalitis under Egypt and Anglo-Egyptian Sudan.)

Recorded Distribution.—

Anglo-Egyptian Sudan
Egypt

HAEMAGOGUS SPECIES

Haemagogus albomaculatus Theobald

Bionomics.—Although adults of *Haemagogus albomaculatus* are most active from 9 to 11 a. m. in bright sunlight, they may also fly during the evening and at night. As long ago as 1917 females were reported to enter houses and bite man, but this habit has not been confirmed recently.

Practically nothing is known about the larval habitats of this species.

Relation to Disease.—*H. albomaculatus* is probably a vector of jungle yellow fever. Investigations in British and French Guiana and Surinam have shown it to be the only species of *Haemagogus* found in certain localities where almost half the native population was immune to the virus.

References: *173, 211.* (For additional information, see the description of yellow fever under Brazil and the Guianas.)

Recorded Distribution.—

British Guiana
French Guiana
Surinam

Haemagogus capricornii Lutz

Haemagogus capricornii for many years was confused in the taxonomic and medical literature with *H. spegazzinii spegazzinii* and *H. equinus.*

Bionomics.—Almost nothing is known about the bionomics of *capricornii.* It probably does not exist in areas with an annual rainfall of less than about 40 inches.

Relation to Disease.—*H. capricornii* is unquestionably implicated in the transmission of jungle yellow fever. It transmits the disease in the laboratory and is suspected of being naturally infected. In Brazil specimens of *spegazzinii* were found infected in nature. Actually *capricornii* might have been the species, since males of the latter were later found among the *spegazzinii* specimens from which the virus was originally isolated.

References: *218, 337.* (For additional information, see the description of yellow fever under Northwest South America.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
French Guiana

Haemagogus equinus (Theobald)

Bionomics.—A distinctly arboreal mosquito, *Haemagogus equinus* has been shown by studies in Panama to predominate at various levels above the ground but slightly less so than *H. spegazzinii falco.* During the rainy season *equinus* has a high, well-marked peak of abundance, whereas during dry weather it may disappear altogether.

Larvae are principally tree-hole inhabitants but may be found occasionally in artificial containers near human habitations.

This is the most widespread of all *Haemagogus* species in Panama, Central America, and Mexico, because it can live in many different kinds of habitats. These include tropical rain forest, tropical deciduous forest, thorny scrub in the more northern parts of its range, and mangrove.

Relation to Disease.—*H. equinus* has never been found with confirmed infections of yellow fever virus in nature. However, experiments show that it can easily transmit the virus in the laboratory, and transmission rates of up to 0.45 have been found, compared with a transmission rate of 1.00 for *Aedes aegypti.* The maximum number of females attacking man in certain areas of Panama is about the same as that in areas of endemic yellow fever in Brazil.

References: *133, 172, 220, 330.* (For additional information, see the descriptions of yellow fever under America North of Mexico, Mexico, Central America, Panama, Northwest South America, and Brazil and the Guianas.)

Recorded Distribution.—

Argentina
British Guiana
Colombia
Costa Rica
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Surinam
United States
Venezuela

Haemagogus mesodentatus gorgasi Galindo and Trapido and *Haemagogus mesodentatus mesodentatus* Komp and Kumm

Haemagogus mesodentatus is a complex of closely related species and subspecies. The following remarks refer to the original form found in Costa Rica by Komp and Kumm.

Bionomics.—Adults of both *Haemagogus mesodentatus gorgasi* and *H. m. mesodentatus* are principally arboreal. The typical subspecies *m. mesodentatus* inhabits the tropical rain forest of the Caribbean slope, and *gorgasi* lives principally in the deciduous forest on the Pacific side.

Almost nothing about larval habitats appears in the literature.

Relation to Disease.—Both these subspecies have been good laboratory vectors of yellow fever, but none were found with natural infections.

Reference: *330.* (For additional information, see the descriptions of yellow fever under Mexico, Central America, and Panama.)

Recorded Distribution.—

H. m. gorgasi:
El Salvador
Guatemala
Mexico

H. m. mesodentatus:
Costa Rica
Honduras
Mexico
Nicaragua
Panama

Haemagogus spegazzinii falco Kumm *et al.*

Haemagogus spegazzinii falco has been listed in recent literature under the names *H. janthinomys* and *H. capricornii.*

Bionomics.—*H. s. falco* is an arboreal, diurnal forest mosquito that feeds avidly on man and has a peak of activity about midday in subdued light. Females are most abundant in open, sunny clearings or at forest margins; males are rarely seen in nature. Rain-forest studies in Panama show that half of the *falco* females live at high elevations and only about 20 percent close to the ground. In deciduous forest or where large trees have been thinned out, females will attack at ground level. This species was not seen at all during the dry season in February, March, and April in Panama. It is not so abundant as other vectors, such as *Haemagogus equinus* or *Aedes leucocelaenus*, although it reaches a high population peak during the rainy months of the year.

Larvae are most often found in tree holes with elongated and very narrow apertures. Since so few records of larval

habitats appear in the literature, the important sources of breeding obviously have been overlooked in most forest studies. In Colombia large numbers of larvae have been found in tree holes, rotted tree stumps, and in water held in fallen-tree buttresses, which are all rather unusual breeding places for *falco*.

H. s. falco most commonly lives on mountain slopes from 300 to 1,500 feet, but once it was found at 4,200 feet.

Relation to Disease.—This mosquito has been found infected with yellow fever virus in nature several times and is easily infected in the laboratory, where a transmission rate of 0.73 was found for *falco* and *capricornii* together as compared with that of 1.00 for *Aedes aegypti*. *H. s. falco* has been incriminated as a vector of jungle yellow fever in several parts of South America. It frequents many endemic yellow fever areas of Colombia and is presumed to be important in all parts of its range where it is abundant.

References: *55, 130, 133, 172, 210, 220, 330.* (For additional information, see the descriptions of yellow fever under Central America, Panama, Northwest South America, and Brazil and the Guianas.)

Recorded Distribution.—

Brazil
Colombia
Costa Rica
Honduras
Nicaragua
Panama

Haemagogus spegazzinii spegazzinii Brèthes

Considerable confusion has existed regarding the nomenclature of *Haemagogus spegazzinii*, since its two subspecies, *H. s. spegazzinii* and *H. s. falco*, are very closely related to each other and to *H. capricornii*.

Bionomics.—Adults of *spegazzinii* are predominantly arboreal. In flight studies they have been recaptured more than 3,000 feet from the point of liberation in the direction of the prevailing wind. Additional studies show that this mosquito may fly as far as 7 miles from its breeding place.

Studies on the biology of this mosquito in Brazil have revealed very few larval habitats. Cut sections of bamboo have been suspended at various levels in forest areas, but these have failed to attract ovipositing females. Those few tree holes in which larvae have been found were small and had extremely small apertures. The scarcity of this subspecies during the dry season may be explained by the fact that these small holes dry out very rapidly and thoroughly.

Relation to Disease.—*H. s. spegazzinii* has been incriminated as a vector of jungle yellow fever in several parts of South America, especially in Ilhéus, "Anado," and Goiás in Brazil, where it is the only vector in areas where yellow fever is endemic. It is regarded as the most important vector of jungle yellow fever in Brazil today.

References: *81–83, 130, 218.* (For additional information, see the descriptions of yellow fever under Northwest South America, and Brazil and the Guianas.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
French Guiana
Panama
Trinidad
Venezuela

MANSONIA SPECIES

Mansonia annulifera (Theobald)

Bionomics.—Almost nothing is known about the bionomics of *Mansonia annulifera* adults. They are known to be strongly anthropophilic.

The siphon of this and other *Mansonia* larvae is specially adapted for puncturing underwater stems of aquatic plants. Larvae obtain oxygen for respiration from the air passages of these submerged plant tissues. Larvae are found mostly in ponds, pools, backwaters, and marshes that favor the growth of *Pistia* spp. and *Eichhornia* spp.

Relation to Disease.—*M. annulifera* is probably the most important vector of *Wuchereria malayi* in the Orient, Greater Sunda Islands, Philippines, and Merauke in New Guinea. Although this species has been found with natural infections of *Wuchereria bancrofti* at Travancore, India, these parasites are probably unable to mature in *annulifera* elsewhere in its range.

Reference: *122.* (For additional information, see the descriptions of filariasis under India and Ceylon, East Pakistan and Assam, Indochina, Thailand, and Sunda Islands.)

Recorded Distribution.—

Borneo
Burma
Celebes
India
Indochina
Java
New Guinea
Philippine Islands
Sumatra
Thailand

Mansonia indiana Edwards

Bionomics.—Little is known of the bionomics of *Mansonia indiana* adults. However, females are known to be strongly anthropophilic.

Larvae have been found only in association with *Pistia* spp. (see also p. 143).

Relation to Disease.—*M. indiana* is described in the literature as an efficient and important vector of *Wuchereria malayi* in Java. Under experimental conditions in Indochina, *Wuchereria bancrofti* has matured in *indiana* to the infective stage, but the extent to which this mosquito transmits *bancrofti* in nature has not been thoroughly investigated.

Reference: *122.* (For additional information, see the descriptions of filariasis under East Pakistan and Assam, Indochina, Thailand, and Sunda Islands.)

Recorded Distribution.—

Borneo
India
Indochina
Java
Sumatra
Thailand

Mansonia longipalpis (van der Wulp)

Mansonia longipalpis was originally described as a *Culex* species. The name *Mansonia annulipes*, which should not be confused with *M. annulifera*, has also been used for this species.

Bionomics.—Adults of *longipalpis* have been found at considerable distances from their known breeding places. Females are anthropophilic.

Larvae are associated with *Pistia* spp. (see also p. 143).

Relation to Disease.—*M. longipalpis* is an important vector of *Wuchereria malayi* in parts of the Orient, Sunda Islands (especially Sumatra and the west coast of Celebes), Philippines, and Borneo. *W. malayi* has developed rapidly in *longipalpis* to the infective stage in the laboratory, and this mosquito has been found infected with parasites many times in nature. However, *Wuchereria bancrofti* is apparently unable to mature to the infective stage in *longipalpis*.

Reference: *122.* (For additional information, see the descriptions of filariasis under Thailand, Malaya, and Sunda Islands.)

Recorded Distribution.—

Borneo
Burma
Celebes
India
Java
Malaya
New Guinea
Philippine Islands
Sumatra
Thailand

Mansonia uniformis (Theobald)

Bionomics.—Adults of *Mansonia uniformis* are active night and day. Females are persistent biters of man, attacking indoors and outdoors in large numbers. They have been observed to fly during heavy rainstorms.

Although *Pistia* spp. are the important host plants for *uniformis* in the Philippines, larvae have been found associated with the following species of aquatic plants in Java:

"Adontella leptostachya"
Azolla pinnata
Eclipta alba
Eichhornia crassipes
Hygrophila quadrivalvis
Hymenacline amplexicaulis
H. interrupta
Isachne miliacea
Jussiaea repens
Leersia hexandra
Lemna paucicostata
Nymphaea stellata
Oryza sativa
Pistia stratiotes
Salvinia rotundifolia
Spirodela polyrhiza

Larvae have also been collected from mangrove swamps in Papua.

Relation to Disease.—*M. uniformis* is an important vector of *Wuchereria malayi* in south Borneo and elsewhere in the Sunda Islands. In China it is able to transmit *malayi* but is a less effective vector than *Anopheles sinensis* there. Experiments have shown that *uniformis* may become infected with *Wuchereria bancrofti*, but this mosquito is not an important vector of that filaria in nature.

Reference: *122.* (For additional information, see the descriptions of filariasis under India and Ceylon, East Pakistan and Assam, South China, Indochina, Thailand, and Sunda Islands.)

Recorded Distribution.—

Australia
Borneo
Burma
Celebes
Ceram
China (eastern and South)
India
Indochina
Java
Malaya
New Guinea
Philippine Islands
Sumatra
Thailand

SABETHES SPECIES

Sabethes chloropterus (Humboldt)

Bionomics.—*Sabethes chloropterus* breeds in tree holes in both tropical rain and deciduous forests. Adults are definitely arboreal. The species is able to survive seasons that are unfavorably dry for other vectors of yellow fever. It is rare at altitudes over 3,000 feet.

Relation to Disease.—Because it occurs in large numbers in endemic yellow fever areas, and because it transmits yellow fever virus in the laboratory, *chloropterus* is considered to be an important vector of the disease in lower Mexico, Central America, and Panama. Its importance elsewhere has not been investigated.

References: *226, 331.* (For additional information, see the descriptions of yellow fever under Mexico, Central America, and Panama.)

Recorded Distribution.—

Argentina
Bolivia
Brazil
Colombia
Costa Rica
El Salvador
Guatemala
Guianas
Mexico
Nicaragua
Panama
Trinidad
Venezuela

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GLOSSARY [2]

Alluvial.—Related to deposits of soil made by flowing water.

Anthropophilism, anthropophilic.—A feeding habit in which the blood of man is preferred over that of other animals (see zoophilism).

Arboreal.—Tree inhabiting.

Breeding place.—A location, usually on or near water, where female mosquitoes lay eggs and in which immature stages (larvae and pupae) develop.

Crepuscular.—Active during twilight hours.

Diurnal.—Active by day.

Endemism, endemic.—Pertaining to or prevalent in a particular area. A situation in which a disease has a low incidence but is constantly present in a given area. Active transmission of the disease need not take place during the entire year (see hyperendemism).

Endophilism, endophilic.—A condition in which mosquitoes prefer to rest and feed indoors.

Epidemic.—A situation in which a disease attacks many people in a given area at the same time or within a very short period of time. Usually the susceptibles contract the disease in a much shorter period than that required for a state of hyperendemicity (see endemism and hyperendemism).

Epidemiology, epidemiological.—A study of all factors bearing on the cause and transmission of disease. Consideration is given in these studies to (1) the causative agent and its biology; (2) the identification, habits, and relative importance of the vector; (3) the susceptibility and proximity to vectors of the affected human population; and (4) presence and possible importance of intermediate hosts.

Exophilism, exophilic.—A condition in which mosquitoes prefer to rest and feed out of doors.

Gland infection.—See salivary gland infection.

Gut infection.—The presence of malaria parasites on the gut wall of a female mosquito.

Hyperendemism, hyperendemic.—A situation in which all susceptible individuals in an area eventually contract a disease. Transmission usually takes place the year around without seasonal interruption (see endemism).

Infection rate.—The number of salivary gland- and/or gut-infected mosquitoes expressed as a percentage of the total number examined for parasites (see salivary gland infection and gut infection). This rate is not expressed in units of time.

Isotherm.—A line connecting points on the earth's surface having the same temperature at a given time or the same mean temperature over a given period.

Morbidity.—Disease rate, expressed as the percentage of cases of sickness in a given population in a specific period of time irrespective of deaths.

Mortality.—Death rate, expressed as the percentage of deaths in a given population in a specific period of time.

Parasite rate.—The percentage of a human population whose blood shows, on microscopic examination, the presence of parasites.

Precipitin test.—A method for determining the source of a mosquito blood meal by comparing reactions with specific antisera.

Salivary gland infection.—The presence of malaria parasites in the salivary glands of a female mosquito.

Spleen rate.—The percentage of a human population having spleens enlarged enough for external detection (i. e., palpation). This rate is not expressed in units of time.

Stomach infection.—See gut infection.

Sylvatic.—Living in forested areas.

Variety.—A mosquito that possesses a slightly different character or variety of characters than is wholly characteristic of the population of which it is a member. "Variants" appear at random and do not seem to be associated with geographical or ecological variations in habitat. Mosquitoes possessing these characters do not represent distinct subgroupings within the population.

Vector.—The agent that transmits a disease organism from an infected individual to an uninfected one.

Zoophilism, zoophilic.—A feeding habit in which the blood of other animals is preferred over that of man (see anthropophilism).

[2] Definitions of certain terms used in the text are phrased here only in the sense in which they are used in this handbook.

INDEX

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