UNITED STATES DEPARTMENT OF AGRICULTURE
Miscellaneous Publication No. 336

WASHINGTON, D. C.

ISSUED JUNE 1939
SLIGHTLY REVISED FEBRUARY 1944

THE MOSQUITOES OF THE SOUTHEASTERN STATES

By

W. V. KING, Senior Entomologist
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Division of Insects Affecting Man and Animals
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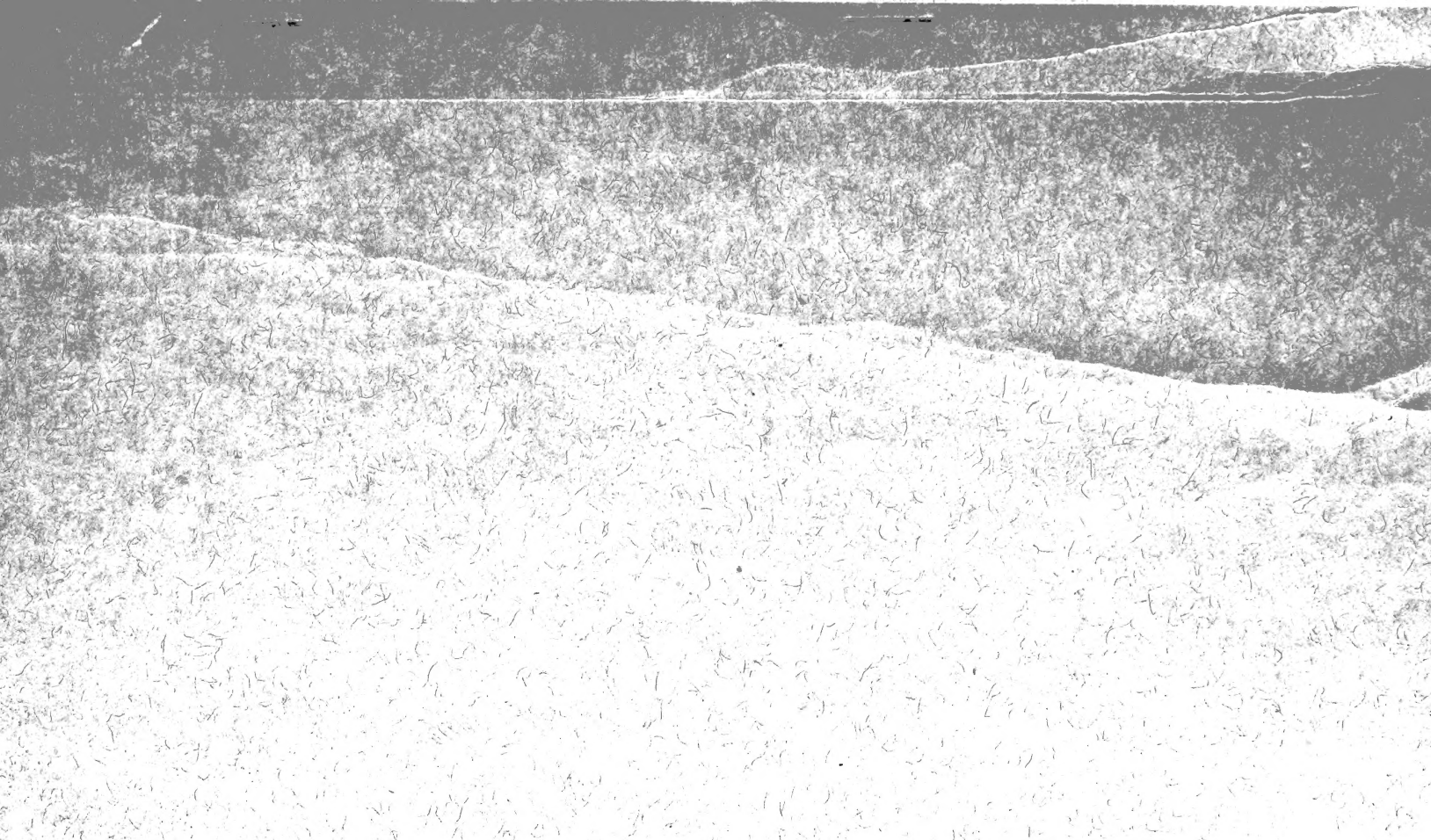

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INTRODUCTION

This publication deals with the mosquitoes recorded from the nine States east of Texas and Oklahoma and south of the latitude of the Virginia-North Carolina border, bringing together information on these species that is widely scattered through the literature, and providing a convenient means of identification. It contains notes on the habits of the species, their distribution, economic importance, and methods of control, together with descriptive keys for the identification of adults and larvae. Because fewer species are considered than in the more general reference works, an effort has been made to simplify the identification of adults by eliminating some of the more obscure generic characters in favor of others that can be made out with less difficulty. All the genera have therefore been included in a single synoptic table, and the species are separated on characters that have been found most useful. A brief generic key is added for convenient reference.

GENERA AND SPECIES FOUND IN THE SOUTHEASTERN STATES

The mosquitoes found in the Southeastern States, together with their distribution and status as to prevalence and economic impor-

tance, are listed in table 1. The information has been compiled from records in the literature, principally the comprehensive works of Howard, Dyar, and Knab (*85*)[1] and Dyar (*50*, *51*), and from collections of the present writers. The 65 species for which we have definite records include representatives of all the North American genera. The group is a fairly natural one, as most of the species are either restricted, in the United States, to the South or reach their greatest abundance there.

TABLE 1.—*Genera and species of mosquitoes occurring in nine Southeastern States, and their relative prevalence*

Genus and species	Occurrence recorded in [1]—									Prevalence and importance [2]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Aedes:										
aegypti	+	+	+	+	+	+	+	+	+	1
atlanticus	+	+	+	+[1]	+	+	P	+	+	2
atropalpus						+	+	+		4
canadensis	+	+[1]	P	+	+	+	+	+	+	2
cinereus		+[1]			?	+			+[1]	4
dorsalis					?					
dupreei	+	+[1]	+	+[1]	+	+	P	+	+	4
fulvus pallens	+	+	+[2]	+	+	+	P	+	+	4
grossbecki				+	+	+[1]				4
infirmatus	+	+	P	+	+	+	P	+	+	2
mitchellae	+	+	+	+[1]	+[1]			+	+[1]	4
sollicitans	+	+	+	+	+	+		+	+	1
sticticus	+	+	+	+[1]	+	+	+	+	+[1]	4
stimulans				+						4
taeniorhynchus	+	+	+	+	+	+		+	+	1
thibaulti		+	+	+	+	+	P	+	+[2]	4
tormentor	+	+	+	+	+	+		+[2]	+	4
triseriatus	+	+	+	+	+	+	+	+	+	2
trivittatus		+			+	+[1]	+[1]	+[1]	+[2]	4
vexans	+	+	+	+	+	+	+	+	+	2
Anopheles:										
albimanus	+									4
atropos	+	P	+	+	+			+[1]	+	4
barberi	+	+	+	+	+	+	+	+	+	4
bradleyi	+	+[1]	+	+	+			+[2]	+	4
crucians	+	+	+	+	+	+	+	+	+	3
georgianus	+[1]	+	+[1]	+[1]	+[1]			+[1]	+[1]	4
pseudopunctipennis				+	+	+[1]	+			4
punctipennis	+	+	+	+	+	+	+	+	+	3
quadrimaculatus	+	+	+	+	+	+	+	+	+	1
walkeri	+	+	P	+[1]	+	+	+	+[2]	+[2]	4
Culex:										
apicalis	+	+	+	+[1]	+	+	+	+	+	3
atratus [3]	+[1]									4
bahamensis	+									4
erraticus	+	+	+	+	+	+	+	+	+	3
nigripalpus	+	+	+	P	+				+	4
peccator	+	+	+	+	+	+	+	+	+	4
pilosus	+	+	+	+[1]	+			+	+	4
pipiens		+[1]	+[1]				+	+	+[1]	4
quinquefasciatus	+	+	+	+	+	+	+	+	+	1
restuans	+	+	+	+	+	+	+	+	+	3
salinarus	+	+	+	+[1]	+	+	+[1]	+	+	2
tarsalis	+[2]				+	+	+[1]			4
Culiseta:										
inornata	+	+[1]	+	+	+	+	+[1]	+	+	3
melanura	+	+	+	+[1]	+	+	P	+	+	4
Deinocerites:										
cancer	+									4
Mansonia:										
perturbans	+	+	+	+[1]	+	+	+	+	+	1
titillans	+									4
Megarhinus:										
rutilus	+	+								4
septentrionalis		+	+	+	+	+	+	+	+	4
Orthopodomyia:										
alba			+					+[2]		4
signifera	+	+	+	+	+	+	+	+	+	4
Psorophora:										
ciliata	+	+	+	+	+	+	+	+	+	2
confinnis	+	+	+	+	+	+	+	+	+	1

[1] Italic numbers in parentheses refer to Literature Cited, p. 87.

TABLE 1.—*Genera and species of mosquitoes occurring in nine Southeastern States, and their relative prevalence*—Continued

Genus and species	Occurrence recorded in—									Prevalence and importance [2]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Psorophora—Continued.										
cyanescens	------	+[1]	+	+	+	+	+[2]	+[2]	+[2]	4
discolor	+	+	+	+	+	+	+	+	+[1]	4
ferox	+	+	+	+	+	+	+	+	+	2
horrida	------	+[1]	+[1]	+	+[2]	+	+	+[1]	+[2]	4
howardii	+	+	+	+	+	+	+	+	+	4
pygmaea	+	------	------	------	------	------	------	------	------	4
signipennis	------	------	------	------	------	+	------	------	------	4
varipes	+	+	+	+	+	+	+	+[1]	+[2]	2
Uranotaenia:										
lowii	+	+[1]	+[1]	+[1]	+	+[2]	------	------	+	4
sapphirina	+	+	+	+	+	+	+	+[1]	+	3
Wyeomyia:										
mitchellii	+	------	------	------	------	------	------	------	------	4
smithii	------	------	+	------	------	------	------	+	+	4
vanduzeei	+	------	------	------	------	------	------	------	------	4
Total [4]	51	48	45	47	49	46	34	48	49	------

[1] +Indicates definite records, +[1] those taken from KING, W. V., ROTH, L., TOFFALETI, J., and MIDDLEKAUFF, W. W. (NEW DISTRIBUTION RECORDS FOR THE MOSQUITOES OF THE SOUTHEASTERN UNITED STATES DURING 1942. Jour. Econ. Ent. 36: 573–577. 1943); +[2], those taken from BRADLEY, G. H., FRITZ, ROY F., and PERRY, L. E. (ADDITIONAL MOSQUITO RECORDS FOR THE SOUTHEASTERN STATES. Jour. Econ. Ent. In press); P, that the species probably occurs here although it has not been recorded; and ?, that the identification given in the record is questionable.

[2] 1=important economic species; 2=locally abundant and annoying, principally out of doors; 3=common species, not very troublesome; 4=usually rare or of very restricted distribution.

[3] King *et al.* recorded *Culex atratus* Theob. from Florida, Boca Chica Key, Dec. 9, 1942.

[4] Exclusive of questionable identifications.

The following species are listed as being of economic importance:

Anopheles quadrimaculatus, the common malaria mosquito, transmits malaria and is a bad pest otherwise.

Aedes aegypti, the yellow-fever mosquito, transmits yellow fever and dengue fever and is a serious house pest.

Culex quinquefasciatus, the southern house mosquito, is a serious house pest. It transmits bird malaria and is an intermediate host for some of the filaria.

Aedes sollicitans, the salt-marsh mosquito, is the most important salt-marsh species generally in the Eastern and Southern States.

Aedes taeniorhynchus, the small, black salt-marsh mosquito, is another salt-marsh species of economic importance, especially in Florida.

Psorophora confinnis, the Florida glades mosquito, is an important fresh-water species in southern Florida, and is also troublesome in other areas.

Mansonia perturbans, the common *Mansonia*, is a severe pest in areas where suitable breeding conditions occur.

(Some of these species may also transmit equine encephalomyelitis or other diseases.)

The woods mosquitoes, taken collectively, are also important pests of man and animals. The principal ones in the Southeast are *Aedes triseriatus*, *A. infirmatus*, *A. atlanticus*, *A. vexans*, *Psorophora ferox*, and *P. ciliata*. *Culex salinarius* is important at times, and various other species, such as *P. cyanescens*, *P. varipes*, *A. canadensis*, and *Mansonia titillans*, may become annoying in restricted localities.

Of the 51 species taken in Florida, 8 are tropical species, and 7 of these 8 have not been found elsewhere in the United States. Two (*Psorophora pygmaea* and *Anopheles albimanus*) have been recorded only once each on the extreme southern keys and apparently have not become established in the State. Two (*Culex bahamensis* and *C. atratus*) are known to occur at present only on the Florida Keys. The former is probably the same species as that reported several years ago as *Culex corniger* from Knights Key (*50*). The other 4 species (*Wye-*

omyia vanduzeei, *W. mitchellii*, *Mansonia titillans*, and *Deinocerites cancer*) are fairly common in southern Florida, but have not been found north of about latitude 29°. Twelve species are recorded for Georgia, Alabama, and Mississippi which have not yet been found in Florida; some of them probably will be found there. The Arkansas records contribute 2 more species, which are incursions from the western and northern faunas, and further collecting in the border States, particularly near their western and northwestern boundaries, will probably increase the known number of such incursions. However, in the northeastern part of the region at least, the Virginia records contain only 1 species (*Aedes cantator* Coq.) not found in the list. The questionable record for *A. dorsalis* in Louisiana is discussed in the text. The reported occurrences of *Culex coronator* in New Orleans (*15*) and of *Aedes nigromaculis* in Louisiana (*51*) are believed to have been based on misidentifications, and the species are not included in the list.

LITERATURE ON MOSQUITOES

The literature on mosquitoes, especially that dealing with bionomics, methods of control, and disease transmission, has become exceedingly large, and the articles have appeared in widely scattered publications. General reference works covering the mosquitoes of the United States are, however, comparatively limited.

Of the references that include the southeastern species, the large monograph by Howard, Dyar, and Knab (*85*) contains detailed descriptions, a large number of illustrations, and much information on mosquito bionomics and distribution. The systematic part of this work was later extensively revised and condensed by Dyar (*51*). A shorter article by Dyar (*50*) is also available, but the names of many of the species given therein have since been revised.

Matheson's handbook (*115*) is the most recent general reference work on North American mosquitoes. It contains brief descriptions of the genera and species and keys for their identification, numerous anatomical illustrations, an explanation of the taxonomic terms in use, and condensed accounts of mosquito biology, the relation of mosquitoes to human welfare, the problem of mosquito reduction, and instructions for their collection and study. Several of the southern species are not included in this work, and some of the descriptive matter and keys now need revision.

Edwards (*53*) has prepared a valuable catalog of the mosquitoes of the world, which contains, in addition to the list of species and synonyms, keys to the subfamilies, tribes, genera, and subgenera, and general information on distribution of the species.

The publications of the New Jersey Agricultural Experiment Station on the mosquitoes of that State (*69*, *139*) have been utilized by southern workers, as they contain illustrations of a number of the species that occur in the South, as well as detailed information on mosquito bionomics and control. Komp (*105*) has published a guide to the identification of common mosquitoes in the Southeastern States. Tables for the identification of anopheline larvae have been prepared by Bradley (*34*) and King and Bradley (*99*).

Among other references on bionomics and control special mention should be made of Boyd's (*20*) work on malariology. Approximately half of this volume has to do with the natural history of anophelines and their relation to the transmission of malaria. Hardenburg (*68*) and Herms and Gray (*71*) deal with practical phases of mosquito eradication, and Le Prince and Orenstein (*112*) with mosquito control in Panama. Covell (*43*) has published a comprehensive review of the literature on the control of *Anopheles*, which includes 570 references. Two series of short papers on the engineering aspect of mosquito control have been issued, one by the National Malaria Committee [2] and another by the Engineering News-Record (*54*). The United States Department of Agriculture has published a bulletin (*84*) on mosquito remedies and preventives.

The serial publications that contain numerous original articles on mosquitoes include Proceedings of the National Malaria Committee, formerly published annually in the Southern Medical Journal and reprinted as symposia, Proceedings of the New Jersey Mosquito Extermination Association, the Public Health Service reports, the Public Health Service bulletins (which formerly included the transactions of conferences of malaria field workers (*143*), Proceedings of the Florida Anti-Mosquito Association (mimeographed), and Insecutor Inscitiae Menstruus (discontinued in 1926). Articles on mosquitoes appear also in the American Journal of Tropical Medicine and in various other medical and entomological journals. The Review of Applied Entomology, Series B: Medical and Veterinary, is almost indispensable to workers who wish to keep informed on the current mosquito literature of the world.

GENERAL CHARACTERISTICS AND HABITS OF MOSQUITOES

Mosquitoes are small two-winged flies belonging to the order Diptera, family Culicidae. In the subfamily Culicinae, which comprises the true mosquitoes, the wings, legs, and other parts of the body are more or less covered with scales, and the mouth parts are produced into an elongate proboscis, which is employed for piercing and bloodsucking by the females of most species. The males do not suck blood. The males can usually be distinguished from the females by their bushy antennae and by differences in the length or shape of the palpi (fig. 1). The size of different species of mosquitoes varies considerably (fig. 2).

There are four stages in the life cycle of a mosquito—the egg; the larva, often called wiggler or wiggletail; the pupa or tumbler; and the adult winged insect or imago. The eggs are matured in batches of 50 or less to 200 or more, and several such batches may be laid by one female. Among the bloodsucking species a blood meal is usually necessary for the production of eggs. When ovipositing, some species glue the eggs together into a raft or boat-shaped mass (fig. 3, *A*) which floats on the water, other species deposit the eggs singly on the water, and still others oviposit on the soil at the edge of the water or in moist depressions. The eggs of *Anopheles* (fig. 3, *C*) have lateral

[2] NATIONAL MALARIA COMMITTEE, SUBCOMMITTEE ON ENGINEERING. MALARIA CONTROL FOR ENGINEERS. U. S. Pub. Health Serv. B–1210, 81 pp., illus. 1936. [Processed.]

structures that keep them afloat. The incubation period is short in warm weather (usually 2 or 3 days), but in certain species, particularly *Aedes* and *Psorophora*, the eggs are able to withstand long periods of drying; in fact, they appear to require a certain amount of drying, and sometimes exposure to cold, before they will hatch.

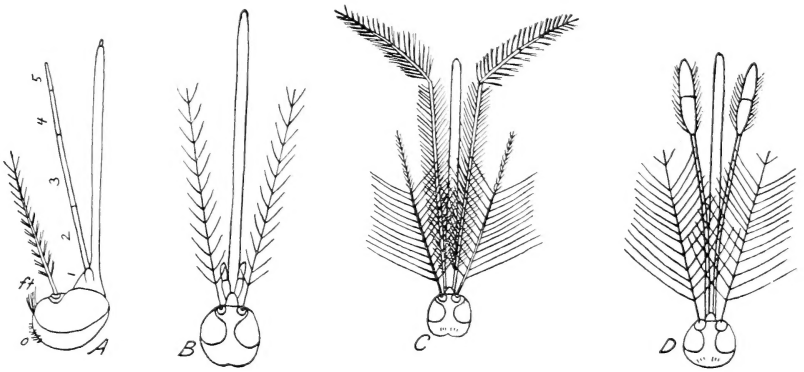

FIGURE 1.—Heads and appendages of mosquitoes: *A*, Side view of *Anopheles* female; *o*, occiput; *ft*, frontal tuft; 1–5, palpal segments. *B*, *Culex* female (from above). *C*, *Culex* male. *D*, *Anopheles* male.

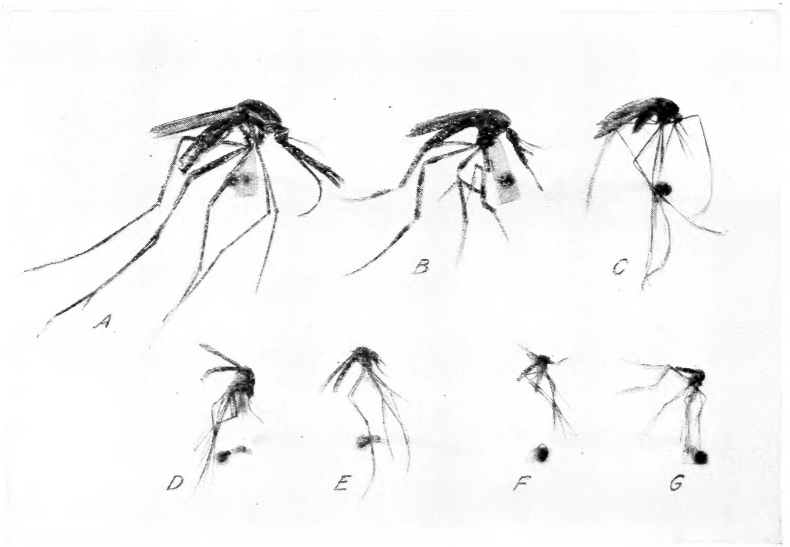

FIGURE 2.—Several species of mosquitoes, showing difference in size: *A*, *Megarhinus rutilus*; *B*, *Psorophora ciliata*; *C*, *Anopheles quadrimaculatus*; *D*, *Aedes atlanticus*; *E*, *Culex quinquefasciatus*; *F*, *C. erraticus*; *G*, *Uranotaenia lowii*.

The larvae of all mosquitoes are aquatic and most of them free swimming. Although possessing tracheal gills, the larvae of most species must come to the surface for air, and an elongated air tube or other modified apparatus is provided for obtaining air through the surface film. During the period of development, which lasts 4 to

10 or more days, the larval skin is shed four times, each successive instar showing a progressive increase in size. The first two instars are very small and are easily recognized as immature. In the third instar the hairs have fewer branches than in the fourth instar, and the sclerotization of the anal segment is less complete. Immature *Anopheles* larvae usually have a collar of dark sclerotin around the base of the head.

The food of mosquito larvae consists of minute plants and animals and fragments of organic debris, which the larvae strain from the water by the action of their mouth parts. Barber (*3*, *4*) reared the larvae on pure cultures of various organisms, and concluded that the presence of living food organisms was necessary for any consid-

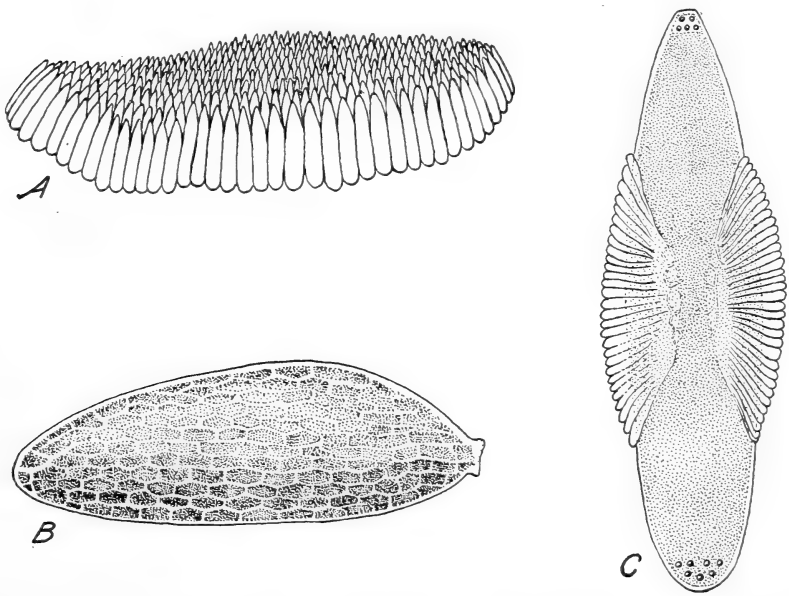

FIGURE 3.—Eggs of mosquitoes: *A*, Egg raft of *Culex restuans; B*, egg of *Aedes taeniorhynchus; C*, egg of *Anopheles quadrimaculatus*, showing floats. (Howard, Dyar, and Knab.)

erable growth. Hinman (*72*) has suggested that materials in solution and colloids in suspension in the breeding waters may play a part in larval nutrition. A discussion of the food of anopheline larvae is given in the notes on *Anopheles quadrimaculatus*.

With the fourth molt the pupa appears. The pupal stage (fig. 4) is also aquatic and is a period of marked transformation, during which the adult insect is formed. The imago usually emerges after about 2 days.

The length of life of adult mosquitoes under natural conditions is difficult to determine, but for most of the southern species it is probably only a few weeks during the summer months. Some of the northern species of *Aedes* that emerge early in the spring apparently live much longer. Daily observations on abundance following the emergence of a large brood of certain species of *Anopheles* (*151*) and

Aedes have shown a marked reduction in numbers within 2 weeks. The southern house mosquito probably lives longer than this, and the yellow-fever mosquito may live, on an average, a month or more, with a maximum of several months.

In the North the females of *Culex*, *Anopheles*, and some other mosquitoes hibernate. True hibernation of *Anopheles* apparently does not occur in the South, as the females become active during warm periods and larvae are found in the breeding places (*1*, *8*, *26*, *64*, *147*). The same is true of some of the culicines in the warmer sections (*47*, *73*). *Aedes* and *Psorophora* pass the winter in the egg stage, although some winter development of *A. sollicitans* occurs along the south Atlantic and Gulf coasts (*66*).

The piercing organs of the female mosquito consist of six elongated parts enclosed in a flexible sheath called the labium. When the mouth parts are inserted in the skin for bloodsucking, the sheath is bent backward in the middle like a bow. There are two pairs of slender cutting organs, the mandibles and the maxillae, and two additional organs called the hypopharnyx and the labrum-epipharnyx. The latter is channeled, and the last two organs, when pressed together, form a tube through which blood and other liquids are drawn. A very small separate duct is found in a ventral thickening of the hypopharnyx, through which is injected the secretion from the salivary glands. This salivary secretion is responsible for the itching sensation caused by mosquito bites. Not all species of mosquitoes have bloodsucking females. In the genus *Megarhinus* the proboscis of the female is not adapted to piercing, and some of the species in other genera are not known to take blood meals.

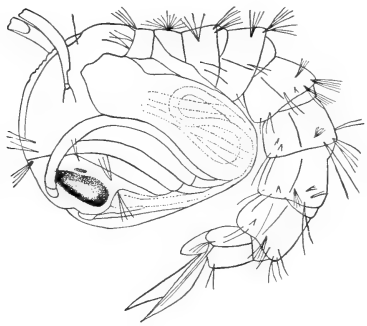

FIGURE 4.—Pupa of *Culex pipiens*. (Howard, Dyar, and Knab.)

The mouth parts of the male are not adapted for piercing, and the males probably subsist on the nectar of flowers and fruit juices. Both the males and the females can be kept alive in the laboratory for considerable periods on fruit juices or sirups.

COLLECTION AND PRESERVATION OF MATERIAL

Anopheles larvae are usually found at the surface of the water among aquatic vegetation or floating debris and are collected by skimming through such material with a dipper or pan. A white-enameled dipper, having the handle lengthened by the insertion of a cane or smooth stick, makes a convenient implement for collecting larvae. Around emergent vegetation or logs the larvae may be drawn into the dipper by submerging one edge so that the water flows in rapidly as the dipper nears the obstruction. The larvae may be removed from the dipper to the collecting jar with a large-mouthed pipette provided with a rubber nipple (fig. 5), or a spoon may be used for this purpose. Wide-mouthed bottles (2 to 6 ounces) make convenient collecting jars.

Uranotaenia larvae and certain species of *Culex*, especially *C. erraticus*, are taken frequently with anophelines. Many other mosquito larvae, however, particularly those of *Aedes* and *Psorophora*, are more active and usually drop to the bottom of the pool as soon as disturbed. A quick plunge of the dipper is required to intercept these larvae, or they may be collected by sweeping through the water with a cloth collecting net or a fine-meshed wire strainer. Other kinds of mosquitoes, such as *Mansonia*, *Wyeomyia*, the tree-hole breeders, etc., require a special technique depending upon the character of the breeding place.

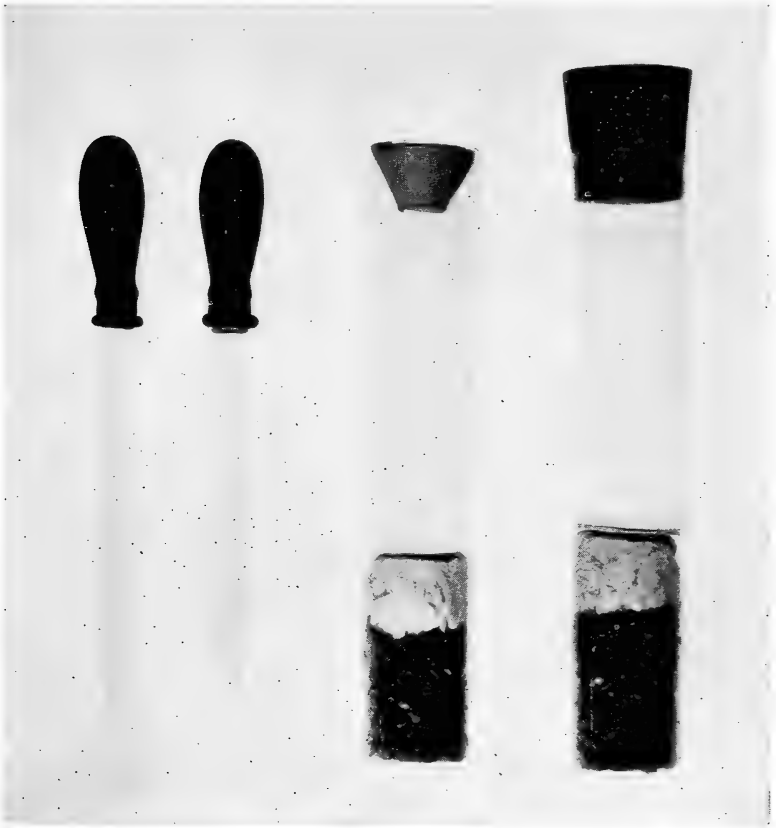

FIGURE 5.—Large-mouthed pipettes for collecting larvae and pupae, and chloroform killing tubes for collecting adults. The first of the two tubes is equipped with a paper funnel.

As soon as a collection is made, the jar should be numbered and a record kept of the locality, date, and conditions under which the larvae were found.

The larvae and pupae may be kept alive for rearing, or the large larvae (fourth instars) may be preserved for identification in 70- to 80-percent alcohol or 10-percent commercial formalin. About 1 percent of glycerin should be added if the vials are to be stored. Specimens retain their form best if killed in hot water (not over 150°F.).

Permanent slide mounts of the larvae (or of male genitalia) are conveniently made with Berlese's chloral-gum solution or one of its modifications. A formula used by the writers is as follows:

Gum arabic (clear lumps or powdered)	grams	8
Distilled water	milliliters	8
Glycerin	milliliters	5
Chloral hydrate	grams	70
Glacial acetic acid	milliliters	3

The gum arabic is dissolved in the water, and the other ingredients are added in the order given. The thick solution is strained through clean muslin and is then usually sufficiently cleared. Powdered gum arabic (or gum acacia) appears to give as good results as the lump gum and is more easily dissolved. Gater's (*58*) modification of Berlese's formula, which has been used extensively, contains 5 ml. of glucose sirup instead of glycerin, 10 ml. of distilled water, and 74 gm. of chloral hydrate. The glucose sirup is prepared with equal parts of glucose and water. In cold weather, however, white crystals may form in fresh preparations that contain glucose; therefore, honey appears to be preferable for use in this formula. Larvae may be mounted in chloral-gum medium direct from water or from a preservative after rinsing in water. Several weeks are required for the mounts to harden, but the process may be hastened by placing them in a warm incubator. The cover glasses may be sealed by ringing with cellulose cement.

Suitable balsam mounts of entire larvae require somewhat prolonged dehydration and hardening in alcohol. Good mounts can be obtained in Euparal after dehydration in Cellosolve.

For taxonomic study or for identification of species difficult to determine, it is frequently desirable to have both the larval skin and the adult of the same individual. For such rearings a nearly mature larva is isolated in a separate dish, and when pupation occurs the larval skin is removed with a pipette, spread out carefully on a slide, and a mount prepared in the chloral-gum medium. The dish or vial containing the pupa should be covered with cloth or a larger dish or plugged with cotton, and after the adult emerges sufficient time (about 24 hours) should be allowed for the sclerotin to become thoroughly hardened, before it is killed. The specimen is then placed in the collection with a number corresponding to that given the larval skin. If a balsam mount of the larval skin is desired, the specimen may be cleared on the slide with carbol-xylol or other medium.

Adult mosquitoes are usually collected while they are biting or resting in secluded corners inside or underneath buildings, in tree holes, etc. A chloroform killing tube (fig. 5) is convenient for this purpose. It may be prepared by placing a half-inch layer of cut rubber bands in the bottom of a large shell vial or test tube, saturating the rubber with chloroform, and covering with a plug of crumpled paper and a circle of stiff paper. The writers prefer a shell vial seven-eighths of an inch in diameter and about 5 inches long. When the tubes are kept tightly corked, the rubber retains the chloroform for some time. As moisture is liable to condense on the inside of the tubes, the dead mosquitoes should not be left in them long. Cyanide may also be used in the killing tubes, but it has a slower killing action and *should be handled with extreme caution since it is a deadly poison*

to man. Several types of suction collectors have been used for taking specimens alive or in large numbers.

A pill box, with a thin layer of cotton pressed down into the bottom and sides, is convenient for holding or shipping the specimens. The box should not contain so much cotton that the specimens will come in contact with the lid, and if more than a wisp is used its weight will cause it to shift about in the box during shipment. Cotton should not be placed on top of the specimens. Specimens that have been moistened, crushed, or rubbed are usually unsatisfactory for identification.

The suction type of light trap, as developed by New Jersey workers, is being used extensively for obtaining samples of the mosquito fauna of an area and records of the relative abundance of different species, particularly in connection with control operations. The specimens captured are more or less damaged, however, and usually unsuitable for the permanent collection. The upright model of this trap (fig. 6) is described by Mulhern (*131*).

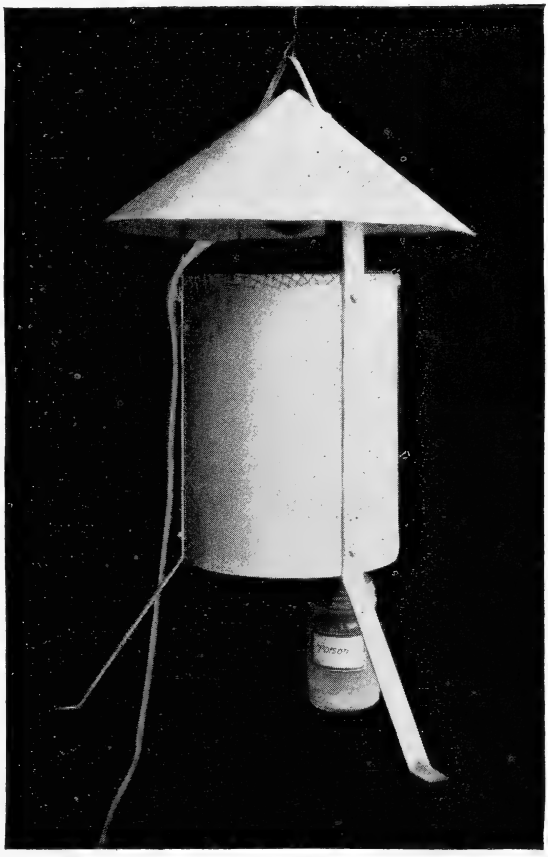

FIGURE 6.—Mosquito light trap.

Adult specimens that are to be retained in the permanent collection should be mounted and pinned into a Schmitt box or similar tight insect box having a bottom lining of sheet cork or balsa wood. Freshly killed specimens may be mounted on minuten pins, and dry specimens on paper points cut from stiff paper (fig. 7). In using the paper mount, an entomological pin is passed through the base of the narrow paper triangle and a small drop of cement is dabbed on the tip of the paper. The paper is then pressed gently onto the side of the thorax of the mosquito, with the tip directed toward the mesonotum. Care should be taken not to smear the legs or wings with the cement. For uniformity the points are usually stuck onto the left side of the specimen. A cellulose cement is preferable to

the shellac formerly employed; it may be purchased at hardware stores in small tubes, or it may be prepared by dissolving celluloid in amyl acetate (known also as pear oil or banana oil). Because of the volatility of the amyl acetate the stock of cement must be thinned frequently. In using the minuten-pin mount, the small pin is stuck into a small square or rectangular piece of cork, through which is

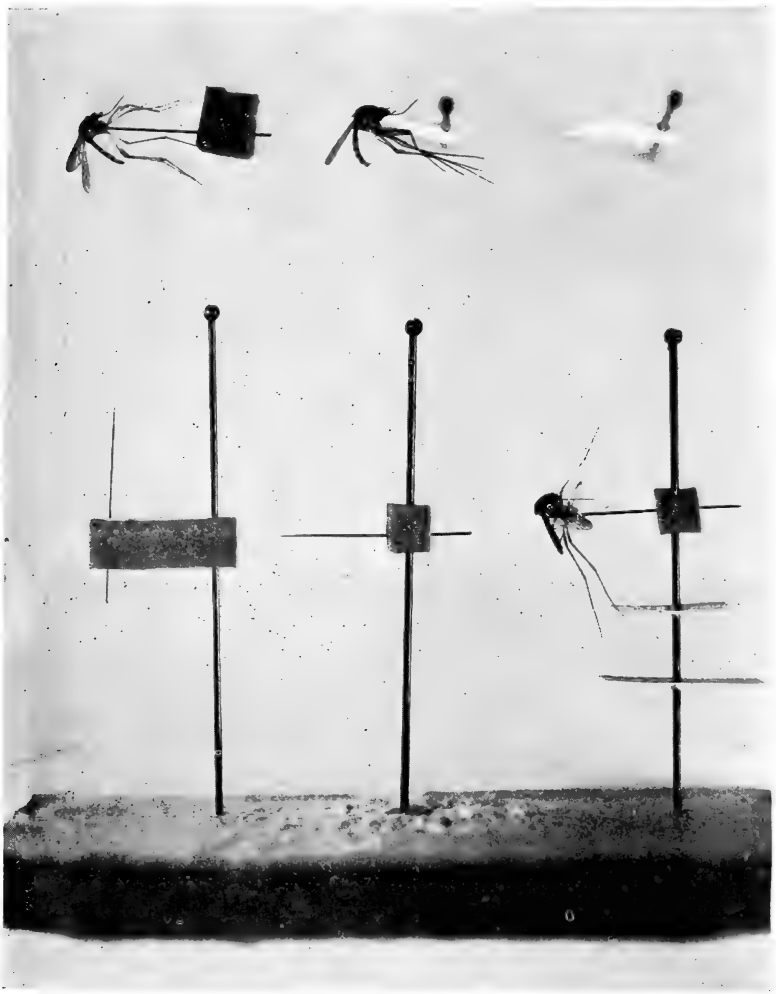

FIGURE 7.—Types of mounts used for adult mosquitoes.

also passed a larger pin (fig. 7). The tip of the small pin is then thrust through the thorax of the mosquito, usually from between the coxae toward the back. The tip of the pin should not protrude through the mesonotum. Very small, dry specimens may be stuck on the side of the minuten-pin point with a drop of cement, instead of using the paper point. The No. 3 entomological pin is probably the best general size for use with both types of mounts.

Care must be taken to protect the stored specimens from insect pests, and for this purpose flake naphthalene and paradichlorobenzene are most frequently used. The material may be sprinkled in the box or placed in a perforated container fastened in one corner of the box. Specimens that are to be kept temporarily in pill boxes may be protected by sprinkling a little flake naphthalene on the bottom of the box and covering this with a thin layer of cotton before introducing the mosquitoes. For longer storage the pill boxes may be kept in a larger box containing naphthalene or paradichlorobenzene, which must be renewed occasionally.

MOSQUITO IDENTIFICATION

The identification of the different species requires a knowledge of mosquito anatomy, as the distinguishing characters consist of variations, frequently very slight, in shape, size, coloration, or scaling of the different parts of the body. Illustrations are provided herein to show the names and locations of the principal parts that are utilized in this connection, and the diagnostic keys have been made as simple and as nearly self-explanatory as accuracy will permit.

For the examination of the external characters of adult mosquitoes, a binocular dissecting microscope is necessary for satisfactory work. It should be provided with objectives and oculars giving magnifications up to about 85×. (Higher magnifications are sometimes needed.) With high magnifications a spotlight or other source of bright illumination is required. For the examination of larvae and slide mounts of male terminalia, a compound microscope is needed and should be equipped for magnifications of about 100 and 400×. The oil-immersion objective is not ordinarily required, except for advanced work on the male terminalia. For field work and for provisional identification of adults, a good hand lens giving a magnification of 10 to 15× is very useful. In fact, after one has become thoroughly familiar with the species of a locality, he will be able to identify many of them with the hand lens, and some of them even with the naked eye.

Workers inexperienced in systematic work with mosquitoes should have on hand, for comparative study, at least a small series of correctly identified species, which can be obtained by sending material to a specialist with the request that named specimens be returned. Until one has become thoroughly familiar with the species, the material should in any case be forwarded to an authority for a check on the identifications when questions of control or information on habits are involved, since misidentifications are liable to result in serious difficulties. Identifications may be obtained through the Bureau of Entomology and Plant Quarantine and in some of the State universities and experiment stations.

MOSQUITO CONTROL

Antimosquito work may be undertaken either as a means of controlling mosquito-borne diseases or purely to eliminate annoyance. Although disease control is regarded as the more important, the fact should not be overlooked that mosquito annoyance not only is a detriment to welfare and happiness but results in a direct economic

loss by reduction of property values, injury to livestock, expense of protective measures, and in other ways. These losses frequently are much greater than the cost of mosquito control.

Nearly everyone is familiar with the efforts made to eliminate mosquito-breeding places and with the use of larvicides in antimosquito work. The practical phases of the problem, however, form a large specialized subject, and a general summary only will be given here, with reference to underlying principles and to the practices and materials that have become more or less standardized or are of recent development.

Mosquito Surveys

Mosquitoes have extremely diverse breeding habits, particularly in respect to the type of place selected for oviposition. Because of this diversity the species to be dealt with and their individual habits must be known before control measures can be applied intelligently.

If the work is undertaken for the control of one of the common diseases, such as malaria or dengue fever, the presence of the disease itself, in the Southern States at least, indicates a particular species of mosquito. A study of the distribution of human cases of the disease serves to localize the problem, and a mosquito survey is undertaken to aid in developing the plan of procedure. At the same time the possibilities of including control measures against purely obnoxious species that may be present should not be overlooked. Where relief from annoyance is the main object, a thorough species survey is necessary to determine what the problem is and the relative importance of the different kinds, since more than one species is usually involved. Even in coastal areas, where it is known that the salt-marsh species are the principal culprits, it is still highly important to know whether fresh-water breeders are sufficiently numerous to require consideration.

The surveys are begun by the collection and identification of both adult and larval specimens. During an outbreak of mosquitoes the species involved can be determined quickly by collecting adults from various parts of the affected area. In localities where mosquitoes are present more or less continuously, or where outbreaks are of frequent recurrence, collections should be repeated often enough for the relative annual abundance of the different species to be determined. At the same time information should be accumulated as to the breeding places of the common species, the topography of the area, and the extent of the control problem. A year should ordinarily be regarded as the minimum time for such preliminary studies, since mosquito abundance varies greatly with the seasons. Several years are required to obtain reliable averages as to normal abundance. Although control operations usually can be begun before such an extensive survey is completed, the practice of beginning such work with inadequate information is highly wasteful and may result in complete loss of public confidence in a worth-while project and possibly cause its abandonment. An important item in the annual budget for financing the control operations should be the provision for continuing the systematic collection and identification of specimens. Such work will furnish invaluable information as to seasonal changes in the mosquito problem and outbreaks from overlooked or distant

breeding areas, and is indispensable in measuring the results accomplished.

General methods of collecting mosquitoes have been discussed in a preceding section. Some of the special methods employed for obtaining data necessary in connection with surveys and control operations are described in the following paragraphs.

BITING RECORDS

Collecting mosquitoes while they are biting is the simplest and most direct method of determining the proportions of the different bloodsucking species. Such collections are usually made with a chloroform tube or other type of killing bottle. For data on comparative abundance in different parts of the area or at different times of the year, stations are selected and collections made for equal periods and under conditions as nearly uniform as possible. In obtaining such records the writers have adopted the procedure of sitting on a box or stool at the selected place, with the trouser legs rolled to the knees. After a minute or so has been allowed for the mosquitoes to accumulate, they are collected as they alight, for a period of 10 or 15 minutes (*101*). If the collecting is done after dark, a flashlight is necessary. Two 15-minute collecting periods or three 10-minute periods may be totaled and multiplied by 2 for the hourly rate. Collections made during the first flight period (just at dark) should not be averaged with later collections, as the numbers are usually much larger at that time.

When the mosquitoes are numerous, the numbers caught can be increased considerably by placing a short paper funnel, or guard, in the mouth of the collecting tube (fig. 5), since this permits the collector to move to the next specimen without waiting for the first one to succumb to the chloroform fumes. The guards are useful otherwise in conserving the strength of the chloroform and in preventing the loss of specimens when the mouth of the tube is turned downward.

When collecting after dark the writers have taken an average of 10 mosquitoes per minute, or 600 per hour, with a tube of this sort. If the mosquitoes are much more numerous than this, the discomfort of collecting is so great that it is considered sufficient to record abundance as 600+, or other observed rate, per hour. When the collecting is to be done at different places by two or more persons, preliminary collections should be made at one place to determine the relative attractiveness and dexterity of the different collectors, as much variation has been found in these respects.

HAND COLLECTIONS OR COUNTS OF RESTING MOSQUITOES

Some species can be obtained by daytime collecting in dark corners and other places where the adults (including the males) spend the daylight hours. This is an excellent method of obtaining comparative data on densities of adult *Anopheles*, especially those species found in the United States, since they fly into a shelter at daybreak and remain quietly there throughout the day. For these species also this method is much safer than the biting method, which is attended with danger of malaria transmission.

Favorable daytime resting places for *Anopheles* are found underneath buildings that are raised 2 or 3 feet from the ground and inside tightly boarded outbuildings or similar locations. In making the surveys a series of stations well distributed over the area under observation are selected, and weekly, biweekly, or monthly collections are made (*82*, *92*). At each location the most favorable resting place should be selected after examination of all the buildings on the premises. When the surveys are purely for comparative purposes, the collecting station does not always need to be an entire building, if it is found that one part is more favorable than another or that parts of the building are not conveniently accessible. Where the resting surface is fairly smooth and unobstructed, a well-trained and reliable collector, with the aid of a flashlight, can obtain satisfactory counts of the resting mosquitoes in much less time than would be required for collecting the specimens in killing bottles. The sex can be determined and in most cases the species identified on sight. Collections over a definite period (10 or 15 minutes) have been used as an index of density, but they may be unreliable because of variations in the rate of collection under different conditions as well as in the mechanical limitations to the numbers of mosquitoes that can be collected in a given time.

TRAP COLLECTIONS

For most species the suction type of light trap (fig. 6) is very useful for obtaining samples of the mosquito population, for records of comparative abundance, and, in control areas, for immediate information on the occurrence of outbreaks. In connection with control work the traps are placed at strategic places throughout the area and are usually operated every night. For other purposes the traps may be run on a schedule of one or more nights each week. The traps should be hung in an open space with the light itself 5 or 6 feet from the ground, and they should not be placed in the immediate vicinity of a street light.

The number of mosquitoes caught per night frequently runs into the hundreds or even thousands, and many other kinds of insects are found in the killing bottles. Under these conditions the task of separating and identifying the material is considerable, especially when the specimens are badly damaged or wet. Species not taken while biting appear in the light-trap collections, and it has been found that the different bloodsucking species are not attracted to the lights equally. Over a series of nights the writers' trap-collection records have shown more variation than the biting records, which, of course, are the more accurate index of annoyance. From a large series of trap collections made in Florida only an occasional specimen of *Aedes aegypti* has been obtained, and the numbers of *Culex quinquefasciatus* and *C. nigripalpus* appear to be very small in comparison with the amount of breeding in the neighborhood of the traps. This also seems to be true to some extent of *Anopheles quadrimaculatus*. The trap records, therefore, cannot be relied on as an index of density for these species.

Boxes of various sizes and shapes, having the inside painted black or lined with black cloth, have been employed to attract mosquitoes, particularly anophelines and the house *Culex*, as a daytime resting

place. They are placed in corners of rooms or in sheltered places outside the houses. In the morning, after the mosquitoes have entered, the open end of the box is covered and the specimens are killed, for counting, by fumigation or by placing the box in the sun.

Animal-baited traps have been used for collecting mosquitoes and, in the Tropics at least, have been employed for determining densities of anopheline species that do not remain in accessible shelters during the daytime. A number of such traps have been described.

COLLECTIONS OF LARVAE

The collecting of larvae in connection with mosquito-control surveys has for its main purpose the locating of breeding places and the determination of their importance. Some information may be obtained as to the comparative abundance of different species from the identification of a large series of collections. Rough estimates of the relative abundance of a species can be obtained by counting the larvae per dip in a series of dips. This method is utilized principally in connection with anopheline surveys. The relative importance of the area in mosquito production can be expressed numerically by multiplying the average number per dip by a factor representing the extent of the breeding area (size times percentage of breeding surface). The productivity of a breeding place per unit of surface can also be determined by the use of cloth nets or screen cages placed over the water (*29*).

Breeding places may be divided into two general classes, permanent and temporary. The two classes frequently intergrade, however, and the status of a given area may change over a period of time. *Anopheles* and *Culex* occur typically in the permanent breeding places, whereas most *Aedes* and *Psorophora* are found in the temporary collections of water produced by rainfall, floodwaters, or high tides. The status of the breeding places, particularly the permanent ones, as to productivity may change greatly during the course of a season or from year to year, owing to changes in the amount of aquatic growth or flotage, the abundance of natural enemies, and other causes.

The importance of temporary breeding places of *Aedes* and *Psorophora* is frequently difficult to determine, because considerable time may elapse between broods. One may visit suspected areas repeatedly without finding larvae, and such areas must be classified as potential breeding places until more definite evidence is obtained. The type of vegetation, especially in salt marshes, is often an indicator of the suitability of breeding conditions. Breeding occurs on the parts of the marsh that are above the normal daily tidal range, and the elevations are indicated by the type of plant growth, since many of the plant species are restricted rather sharply by the height of the water table and the frequency of tidal coverage. More definite information on suspected breeding areas can sometimes be obtained from samples of sod taken from dry depressions by scooping off a thin layer of topsoil with a small shovel. Samples from different parts of the area are placed in containers and covered with water to cause hatching of the eggs, which may begin within a few minutes. Glass containers are preferable, as the small larvae are more easily seen when these containers are held against the light. If the sods

are very moist at the time of collection, drying in the air for a week or so may be necessary to induce hatching of the eggs.

Engineering Surveys

During a mosquito survey much information will be accumulated which will be valuable in determining the feasibility of an anti-mosquito project and the best methods to be employed in handling specific problems. Where malaria or salt-marsh mosquitoes are to be controlled, an engineering survey is then undertaken to lay out the detailed plan of ditching and other operations, and to determine the approximate costs. Whether the local situation can be handled successfully within the means at hand, or at a cost commensurate with the probable benefits, is one of the first questions to be decided. Matters of the legality of the proposed work (including jurisdiction over the area involved), the probability of obtaining necessary easements on private property, etc., must also be considered.

Good maps are, of course, essential, and should be available both in small scale for use as key maps and in large scale for showing in detail the breeding places, ditching lay-outs, and natural topographic features. The different areas and the individual breeding places can then be given names or numbers for convenient reference to the mosquito-collection and engineering notes. Aerial photographic maps of rural or marsh areas are extremely valuable, as they show the bodies of water and the types of vegetation. A note-card system should be arranged and complete records kept of all inspection and survey data.

For breeding-place or other preliminary surveys when elevations or exact locations are not required, the directions given by Hulse (*86*) for preparing field maps in public-health work based on methods employed in the military service are very useful.

Control of Mosquito Larvae

Mosquito-control measures are usually directed against the larvae, since this seems to be the most vulnerable stage in their life cycle.

ELIMINATION OF BREEDING PLACES

Where at all feasible, efforts are made to eliminate the breeding places permanently by filling, drainage, or sanitation.

Filling is frequently an economical method and gives permanent relief when the fills are so graded as to leave no water-holding depressions. Large hydraulic fills, however, usually show shrinkage or surface cracks upon drying and may require one or more regradings to prevent mosquito breeding.

Drainage undoubtedly has the widest application of the various antilarval measures, especially in the control of the malaria carriers and the salt-marsh species. The drainage of swamplands in the United States has done much to reduce the malarious area and at the same time has made the land suitable for agriculture. Drainage or ditching purely for mosquito control, however, should be looked upon as distinct from agricultural drainage, since it is directed mainly toward the elimination of surface water during the time required

for larval development, or to aid in biological control. Comprehensive drainage plans, especially for malaria control, should be prepared with the aid of trained engineers.

Two phases of the drainage problem in mosquito control to which attention has been called in recent years are its possible effects upon wildlife and upon soil conservation. Through cooperative biological studies efforts are being made to determine what measures may be applied to large swamp areas, particularly those not close to centers of population, which will disturb as little as possible the natural breeding and feeding grounds of aquatic wild fowl and other desirable animal life without sacrificing the success of the mosquito-control project. Specialists in soil conservation have also called attention to the adverse effects of the drainage of natural upland storage basins, the cleaning of stream channels, and the "brushing" of stream banks, all of which increase the rapidity of run-off of flood-water with consequent erosion that may cause serious damage to agricultural lands. Such erosion is said to cause frequently a gradual widening of the flood plain and silting-up of downstream areas, which may create mosquito-producing areas as serious as those remedied.

Such factors as these must be considered in planning mosquito-control programs, and they emphasize the need of obtaining advice from competent specialists when making the preliminary surveys. The impoundage of water rather than drainage may be employed successfully in many cases, both in salt-water and fresh-water areas, since an open pond with clean margins and containing mosquito-destroying fish is not favorable for mosquito breeding (*144*). (Pl. 3.) Where the sacrifice of wildlife habitat appears necessary to accomplish effective mosquito control, a decision must be made as to the greater benefit to be derived.

Sanitation, as applied to mosquito control, includes such measures as the elimination of artificial and other breeding places of the domestic mosquitoes. It also involves the treatment of permanent bodies of water by the removal of aquatic vegetation and other protective harborage for the larvae to make them unfavorable for mosquito development.

LARVICIDES

Various kinds of larvicides are employed where permanent methods of control are not feasible. Although there are many chemicals that will poison the larvae rather easily, the number of materials that are utilized in practical work is comparatively small.

Petroleum oils have been used extensively and are effective against nearly all economic species. They act as contact poisons and kill the larvae or pupae by entering the breathing tubes. The lighter and more volatile oils, such as gasoline and kerosene, are the more toxic, whereas heavy oils are more lasting. Various mixtures of heavy and light oils have therefore been employed. Light distilled fuel oil (No. 2) is recommended for general use, since it is of fairly uniform quality, easily handled in large or small spraying equipment, and is economical in cost. Since fuel oil varies somewhat in toxicity according to the type of crude petroleum from which it is derived, preliminary tests of its effectiveness against mosquito larvae should be made before it is purchased in large quantities. The addition

of about 1 percent of castor oil or crude cresol has been recommended as a means of increasing the spreading power of the oil.

Paris green is highly toxic as a stomach poison to mosquito larvae (*5*) and is now used extensively in the control of anopheline mosquitoes. It is effective in very small quantities and, since these larvae feed at the surface of the water, the material can be applied economically as a dust in admixture with an inert diluent. Experiments by King and McNeel (*103*) have shown that this arsenical also is effective against the salt-marsh species and some of the other subsurface-feeding larvae, including *Psorophora confinnis* and *Culex quinquefasciatus*, when mixed with water and sprayed on the breeding places from a sprinking can. After several years' experience in the control of domestic mosquitoes in Miami, Fla., Stutz[3] has concluded that paris green has a valuable place in the control of these species, being especially effective in unused toilet bowls and old tires, where it can be applied in excess and prevents breeding for longer periods than do other larvicides. A heavy dusting of large piles of used tires with undiluted paris green has been highly effective. It is also sprinkled into dry containers that will become filled with water at the next rain.

Soap emulsions of pyrethrum extract in kerosene oil have been developed by workers in New Jersey (*60*) and are employed successfully as mosquito larvicides. The cost is low, and the use of pyrethrum greatly reduces the quantity of oil required, which is a desirable feature under some conditions. Two formulas for the preparation of the emulsion, adapted from those given by Ginsburg (*60*), are as follows:

Against fresh-water larvae.—Two gallons of kerosene containing pyrethrum extract equivalent to 1 pound of pyrethrum flowers per gallon, and 1 gallon of water containing 8 to 10 ounces of liquid 40-percent potash soap.

Against salt-water or fresh-water larvae.—Two gallons of kerosene containing pyrethrum extract as above plus 2 ounces of defoamer, and 1 gallon of water containing 2 ounces of sodium lauryl sulfate.

With both formulas the emulsifying agent is dissolved in the water and the oil containing pyrethrum extract slowly added with constant mixing (in a container with agitators or by pumping the mixture vigorously back into itself) until a creamy emulsion is obtained. After the foam has settled, 1 part of this stock solution is mixed with 9 parts of water, and the diluted mixture is sprayed onto the breeding places at the rate of about 50 gallons per acre. The stock emulsion can be prepared in large quantities by mixing in the tank of a power sprayer. The pyrethrum extract is usually purchased in a concentrated form, 20 pounds of the flowers per gallon, and diluted at the rate of 1 gallon of extract to 19 gallons of oil (6.4 fluid ounces per gallon of mixture).

The sodium lauryl sulfate and the defoamer can be obtained on the market, or the defoamer can be prepared by mixing equal parts of fuel oil and wool grease. The prepared stock emulsion can also be purchased. Other commercial wetting agents that may be employed as emulsifiers are available.

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[3] STUTZ, FRED H. SIXTH ANNUAL REPORT OF THE DADE COUNTY, FLORIDA, ANTI-MOSQUITO DISTRICT COVERING ACTIVITIES FOR 1940. 17 pp. [Processed.]

While the dilute pyrethrum is not toxic to fish, it is probably more injurious than an oil film or paris green to many of the aquatic insect predators. For anopheline control it is much more expensive than paris green (*70*).

NATURAL ENEMIES OF LARVAE

Various kinds of insects and other animals prey upon mosquito larvae and undoubtedly destroy large numbers. Of the many natural enemies, however, in most cases only the small larva-eating fishes have been found of practical use in control. In the Southern States the most important of these is the top-water minnow (*Gambusia affinis*), which occurs in both fresh and brackish water. These fish are most effective against subsurface-feeding larvae and in places where the larvae are not protected by aquatic vegetation. They have been used to stock ornamental pools and other isolated bodies of water. They are highly useful in permanent ponds and in the salt marshes. The International Health Board of the Rockefeller Foundation (*133*) has prepared a review of the literature on the use of fish for mosquito control, and Hinman (*75*, *76*) has given numerous references on other predators of mosquitoes.

Different aquatic plants have been claimed to be of value in eliminating mosquito breeding. One species of *Chara* (*C. fragilis*) appears to exert a deterrent effect, although certain other species of this genus have been found to be innocuous. The bladderworts (*Utricularia*) capture and destroy small aquatic animals, including mosquito larvae. Duckweed (*Lemna*) and similar floating plants (*Azolla* and *Wolffia*) may form such dense mats on the water surface that they act as a mechanical barrier to mosquito breeding, although *Anopheles* and *Culex* larvae are found associated in abundance with them when the growth is scattered. Water hyacinths (*Piaropus*) may also act in somewhat the same way. Matheson (*116*) gives a review of the literature on this subject.

CONTROL OF ADULT MOSQUITOES

Screens, bed nets, repellents, contact sprays, smudges, and fumigants are all employed for protection against mosquito annoyance.

In the screening of houses galvanized or copper screens are usually employed, and the 16-mesh screen has come to be a standard size for this purpose. Copper (or bronze) screens, although higher in first cost, are the more durable, especially in the vicinity of salt water. Monel-metal screens have also been recommended in such situations. To be effective the screening must be carefully done and special attention paid to the fitting of door and window frames, as mosquitoes will find entrance through very small openings. Bed nets made of open-mesh cloth are used extensively in some localities in the absence of, or to supplement, screening. They are frequently employed for protection of individuals, especially in malarious or salt-marsh areas. To be of value they should be in good repair and carefully adjusted.

Kerosene extract of pyrethrum (insect powder) is very effective as a contact spray and is useful in destroying mosquitoes that have gained entrance to screened houses. Most of the commercial fly sprays contain this extract. Home-made sprays may be prepared by soaking

1 pound of the ground pyrethrum flowers in a gallon of kerosene for 24 hours or longer, and then pouring off the supernatant fluid for use. Probably the most economical method of preparing a spray is to purchase a concentrated extract (usually sold to contain not less than 2.4 percent of pyrethrins by weight, or about 2 gm. per 100 ml.) and dilute it with a light oil at the rate of 1 part of extract to 19 parts of oil. Water-white kerosene is generally used for this purpose to avoid staining of the clothing or walls. The pyrethrum spray is also effective temporarily as a mosquito repellent when sprayed on the ankles or the clothing. For application on the skin, a mixture of a concentrated extract with a nonirritating oil such as petrolatum or liquid vaseline may be used. Oil of citronella and other essential oils have long been used as temporary repellents. A preparation containing diethylene glycol monobutyl ether acetate and diethylene glycol monoethyl ether as the active ingredients has been shown to be more effective than citronella (*63*) and is now available in a commercial preparation.

The dry pyrethrum powder is sometimes burned as a fumigant for destroying mosquitoes in closed rooms. It is also used as a repellent smudge, and the writers have seen it employed with good results in a large screened camp into which swarms of salt-marsh mosquitoes gained entrance with each opening of the door. In the open room the fumes were not strong enough to be objectionable to the persons present but were sufficiently toxic to incapacitate the insects. To make the smudge the powder is mounded on a plate or other flat dish and ignited at the top with the aid of a little alcohol. One or more dishes may be used, depending on the size of the room. Grass or wood smudges provide some relief to livestock in open fields and stables during severe outbreaks of mosquitoes. It seems probable that the pyrethrum smudge would be much more effective than the wood smoke for use in the stables.

Recent work in New Jersey (*61*, *62*, *145*) has shown that outdoor gatherings of people can be protected more or less from mosquito annoyance by a thorough spraying of the grounds and surrounding vegetation with a diluted emulsion of pyrethrum extract (similar to the formula given for pyrethrum larvicide). The spray is applied under sufficient pressure to produce a fine mist. Successful results were reported from tests in which areas as small as 1,000 square feet were sprayed, but Vannote (*145*) indicated that a marginal zone approximately 100 feet wide should be treated in addition to the area to be protected. In experiments conducted in Florida by the present writers (*101*), effective results were not obtainable with the species *Mansonia perturbans* on areas 106 and 150 feet in diameter (0.2 and 0.4 acre) when the ground was covered with only short vegetation, although marked reductions had occurred from the spraying in the smaller area before the grass and weeds had been cut. It was indicated that the method would not be feasible, against this species at least, for the protection of lawn parties or similar small gatherings.

The beneficial effects of various plants or trees in repelling mosquitoes have been reported, but apparently none of the reports have been substantiated when carefully investigated. (See Moznette (*130*) for one such instance.) Different plants have also been blamed for attracting mosquitoes to houses. Although no plants with such prop-

erties are definitely known, it is true that dense vegetation is attractive to many species of mosquitoes as a harboring place. This is probably due to the moisture and shade afforded by the vegetation, as well as to protection from winds. Some of the woods mosquitoes are also known to bite commonly in shady places during the daytime but will not fly into the open for a blood meal.

Adult mosquitoes have various natural enemies, such as certain birds, bats, and predacious insects, which prey upon them along with other insects. The erection of bat roosts in mosquito-infested areas has been urged as a means of control, but observations in places where bats are very numerous have shown that they have little effect in reducing the mosquito population (*81*).

Specific Problems

A few notes are given below in regard to problems of control of some of the more important species.

THE COMMON MALARIA MOSQUITO (ANOPHELES QUADRIMACULATUS)

This species develops principally in permanent bodies of fresh water containing aquatic vegetation or floating debris (pls. 1–3). Because of the breeding habits of this mosquito, malaria in the Southern States is largely a disease of rural communities and small towns. Malaria control in this region usually consists of measures against *Anopheles quadrimaculatus*, the first essential of which is the permanent elimination of the low swampy places by filling or drainage. This species does not ordinarily fly long distances, and the control of the breeding places within a mile of a populated area is thought usually to be effective (*6*, *59*, *109*, *111*). Ditches and the margins of the deeper ponds and lakes should be kept free of vegetation, and breeding in shallow ponds full of aquatic growths or in the beds of occasionally flowing streams can sometimes be controlled economically by impounding the water with dams to a depth sufficient to overcome the aquatic vegetation (pl. 3, *B*). Periodic fluctuation of the water level in such impounded areas is important in reducing the marginal growth and flotage. The impoundage of large bodies of water for hydroelectric or other purposes, however, has introduced serious problems in malaria control, and special legislation has been enacted by southern States covering the measures that must be taken to prevent breeding of anopheline mosquitoes in such projects. The Tennessee Valley Authority has found it necessary to provide for an extensive program of *Anopheles* control in the impounded areas on the Tennessee River (*16*). As this work has progressed it has proved essential to establish minimum requirements as to reservoir preparation and shore-line improvement, with special reference to vegetation control, and to provide for adequate water-fluctuation schedules (*78*, *141*).

As previously mentioned, in planning extensive drainage operations careful consideration should be given to problems of wildlife and soil conservation.

The use of chemical larvicides, such as oil and paris green, is required for treating breeding areas that cannot be eliminated, and in many places, owing to local conditions, this constitutes the main part of the control program. Paris green dusted on the water will destroy

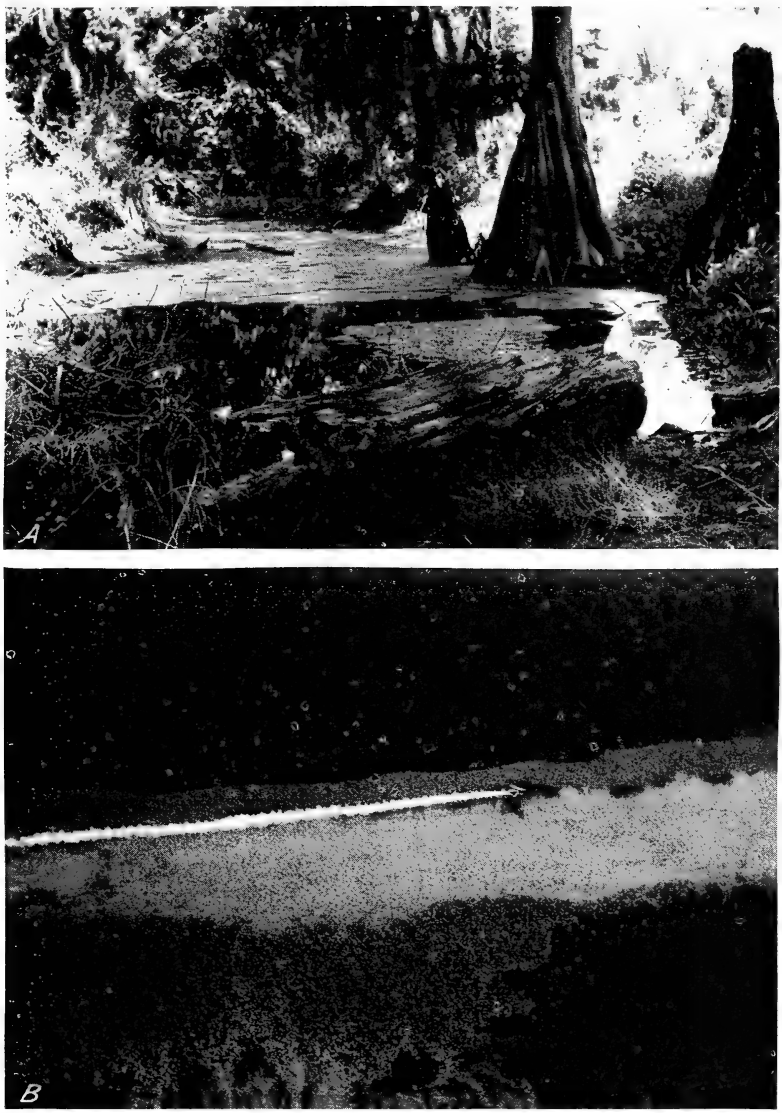
anopheline larvae because of their habit of feeding at the surface and ingesting all small particles that lie on the surface film. It is effective in such minute quantities that its use on ground waters is not dangerous to animals. One to ten percent of paris green is used with an inert diluent such as fine road dust, hydrated lime, pulverized soapstone, or other available earths. It is applied with various types of hand dusters or, for larger operations, with power dusters mounted in boats. Tests on the use of airplanes for treating large breeding areas were first carried out by the writers in 1923 and 1924 (*96*, *97*), and this method has since been employed in practical control operations (*42*, *90*, *148*, *150*). In airplane dusting the proportion of paris green is increased to 10 to 50 percent. The applications of both arsenicals and light oils must be repeated at about weekly intervals throughout the breeding season, since these materials remain effective for only a short period.

An adult anopheline density index (*92*), obtained by periodic counts of the numbers present in favorable daytime resting places (inside and underneath dwellings, in stables, outhouses, etc.), is highly useful in measuring the effectiveness of the control operations.

THE DOMESTIC MOSQUITOES (AEDES AEGYPTI AND CULEX QUINQUEFASCIATUS)

Urban antimosquito campaigns usually combine control measures against the yellow-fever and the southern house mosquitoes, and, although their practical control offers no unsurmountable difficulties, continuous efforts and expense are required to keep the numbers reduced. These species differ in breeding habits, especially as regards polluted waters and ground pools, although rain barrels and similar water containers are important breeding places for both. Where the water in these receptacles is required for domestic purposes, the barrels should be kept tightly covered and the water drawn from a spigot at the bottom; otherwise they require weekly emptying or treatment with oil, either of which is likely to be neglected. When larvae are present, spraying the surface with a small amount of kerosene or a pyrethrum fly spray is effective and imparts little odor to the water. Fire barrels may be treated by adding borax or common salt at the rate of 4 or 5 pounds per 50 gallons of water. This will prevent larval development as long as the strength of the solution is maintained. Tubs and other casual water containers left in the yard should be turned upside down when not in use, and worn-out equipment should be disposed of.

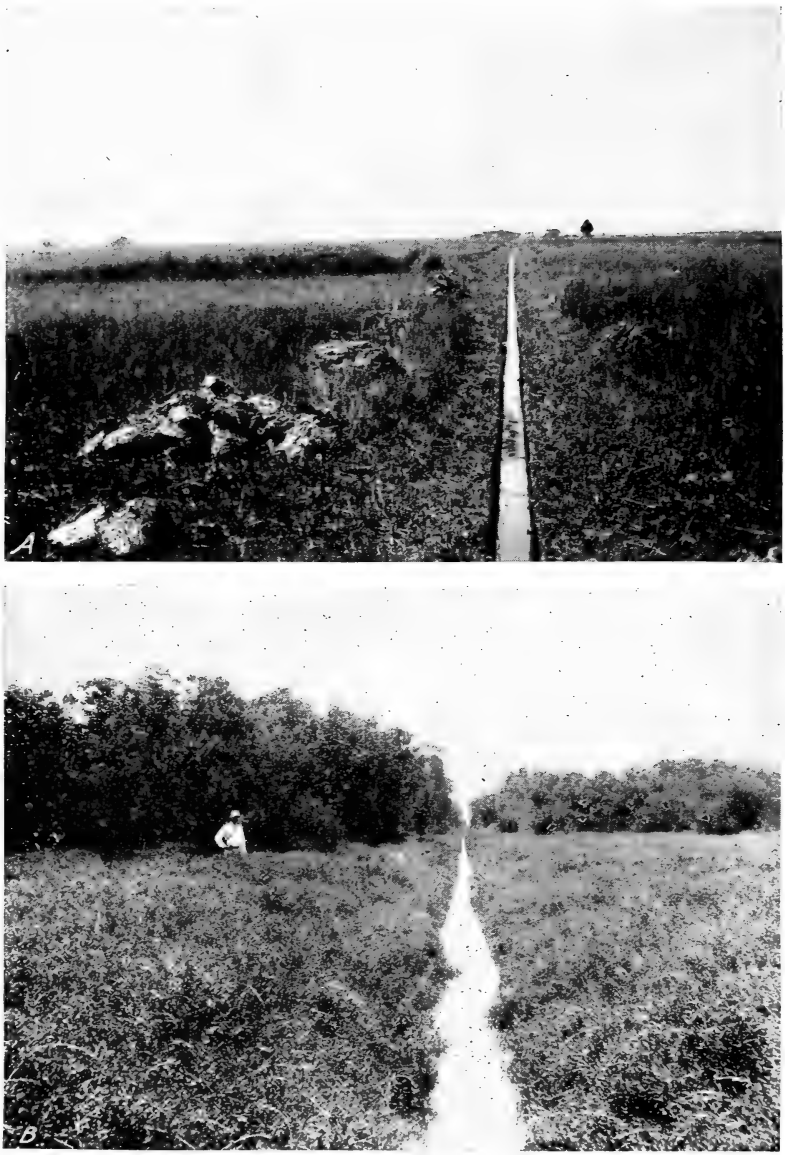
With the yellow-fever mosquito (*Aedes aegypti*) the smaller water containers, such as old cans, bottles, flower vases, and obstructed eave troughs, are important, and a campaign against this species should begin with a clean-up of yards and vacant lots. During the dengue-fever control work in Florida in 1934 a large proportion of the discarded automobile casings left in the open were found to contain water with *aegypti* larvae, and many breeding places were found in automobile-wrecking yards. Toilet bowls and flush tanks in vacant houses and apartments require systematic attention, and collections of water in the basements of buildings should not be overlooked. The adults of this species do not fly far, and when they become trouble-



A, *Anopheles* breeding pool in a cypress swamp; *B*, airplane dusting of paris green for *Anopheles* control in a swamp lake in Louisiana. The lake has a dense marginal growth of water chinquapin or American lotus (*Nelumbo lutea*), with waterlilies (*Nymphaea* sp.) and other aquatic vegetation in the middle.

A and *B*, Water conditions favorable for breeding of *Anopheles quadrimaculatus*.

A, A seasonal bayou overgrown with willows; *B*, a portion of the same bayou after clearing and impounding to eliminate *Anopheles* breeding.



Mosquito-control ditches in salt-marsh areas: *A*, In North Carolina; *B*, in Florida, pickleweed in foreground, mangrove trees in background.

some at any point the breeding source can usually be found on the premises or nearby. An essential part of any *aegypti* control program is the frequent and thorough inspection of premises by well-trained men.

One of the most prolific sources of production for the southern house mosquito (*Culex quinquefasciatus*) in a city or town is the storm-sewer catch basin, which is designed almost universally with a watertight debris trap below the level of the outlet. The larvae of *Aedes aegypti* also have been found in these places. In an anti-mosquito program the catch basins are usually oiled periodically with special equipment installed on trucks or motorcycles. Other important sources of mass production of *C. quinquefasciatus* are open cesspools, badly drained street gutters, and polluted ground pools, especially around city dumps or sewage outlets. Wherever possible these breeding places should be eliminated permanently by drainage, or the cesspools effectively covered; otherwise they require frequent treatments with larvicides.

Pyrethrum-extract emulsion has been recommended for treatment of polluted ground pools and sewage beds. Paris green will destroy the larvae in ditches, pools, and catch basins, although oil is usually preferred as its deters oviposition. The use of paris green for the control of both *aegypti* and *quinquefasciatus* larvae in artificial containers has been discussed under Larvicides (p. 19).

SALT-MARSH MOSQUITOES (PRINCIPALLY AEDES SOLLICITANS AND A. TAENIORHYNCHUS)

The salt-marsh mosquitoes fly extremely long distances. Migratory swarms have been observed 40 miles or more from their breeding places, although the average length of flight is, of course, much less. Because of their great flight range, local work against these species may be of little benefit, and control programs are usually undertaken on a county-wide basis. Generally, however, the actual control work should begin on the breeding marshes nearest the population centers and should progress outwardly until the desired results are obtained.

Investigations and control work against the salt-marsh species were begun in New Jersey more than 30 years ago, and New Jersey's example has been followed by most of the North Atlantic States. On the south Atlantic and Gulf coasts, except in a few counties in Florida, no large-scale operations had been attempted prior to 1933, when advantage was taken of the opportunity offered by the programs of the Federal Emergency Relief and the Civil Works Administrations (*32*, *47*, *67*, *93*). Although this work was not long continued, many valuable experimental and survey data were obtained, and these have been useful in a number of counties that have since become encouraged to provide funds for continuing the operations.

Mosquito-breeding conditions in salt marshes and the methods employed to overcome them are extremely varied. In general, the mosquitoes breed on the parts of the marsh that are not covered by daily tides, usually in pot holes and depressions of various sizes, but sometimes over extensive level areas. By the usual control practices a system of ditches (pl. 4) is installed (1) to provide for a fairly rapid run-off of surface water following the occurrence of

heavy rainfall or of high storm tides, (2) to permit free circulation of tidal water into low areas that are otherwise landlocked, and (3) to give larva-eating minnows access to the pools and ponds or other places where the larvae accumulate as the surface water is drained off.

The ditch system on any marsh should be designed to give the maximum degree of mosquito control with the least amount of ditching. The system for each marsh should be determined by the conditions presented, and stereotyped drainage systems should be avoided. Preliminary surveys are necessary to determine any natural drainage and to locate the water-holding, mosquito-breeding areas. The natural channels should then be improved and the ditches located so that they will extend from these channels to the breeding portions of the marsh, following the lowest contours. In general, the ditches should not be cut directly into ponds, but rather connected by short spurs, since it is often difficult to maintain the desired depth in the soft mud of the pond bottoms. On large marshes which are so flat that natural drainage is negligible or difficult to discern, the usual practice is to place the ditches in a parallel system at intervals of 100 to 300 feet, with main outlet ditches as needed. Even on such marshes, however, the amount of ditching may often be reduced by making preliminary surveys to locate the mosquito-breeding portions of the marsh and limiting control work to such areas. The installation of rim ditches for draining areas adjacent to the highland, where heavy breeding often occurs, is necessary on most marshes.

In New Jersey, where the marshes are usually well sodded, the standard ditch is 10 inches wide by about 20 inches deep, with the sides perpendicular. In other areas, especially in the South, the width and depth of the ditches and the slope of the sides have to be modified to meet other soil conditions and problems incident to other types of marsh vegetation. In the Florida marshes ditches 20 to 30 inches wide are most frequently dug.

Various types of heavy machinery for digging and cleaning the ditches have been developed by workers in the North, and special types of ditching spades and other tools have been designed for use by hand labor. The type of marsh in the locality in which work is to be done should govern the selection of tools. Many, or perhaps most, of the southern marshes are not adapted to the use of such machine ditchers or special spades, at least of the types so far developed, and the best tool generally for salt-marsh ditching in this region is the long-handled square-pointed shovel. For larger ditches or outlet canals a dragline or other standard machine of suitable capacity may be used to advantage.

Another important method of treating certain classes of marsh is the installation of dikes and tide gates to prevent the entrance of high tides. The tide gates, opening at low tide, also provide for the run-off of rain water. Under special conditions the tide gates may be reversed to permit the entrance of high tides and to impound the water on the marsh. This is effective in reducing *Aedes* breeding, since it is the alternate drying and flooding of the marshes that brings about the hatching of their eggs.

Experimental work by members of the Bureau of Entomology and Plant Quarantine in the vicinity of Savannah, Ga., has shown that the shutting off of the tides from marshes by means of dikes and tide

gates so that the marshes become dry eliminates much breeding of the sand fly (*Culicoides*) as well as of the mosquito. It is probable that this practice can be combined with ditching in other sections where the sand fly is a serious problem.

In the southern half of Florida, where *Aedes taeniorhynchus* is the predominant salt-marsh mosquito, the marsh vegetation is dominated by growths of several species of mangrove. This presents special problems for the mosquito-control organization (pl. 4, *B;* fig. 8), as the mangrove forms dense forests through which it is necessary to cut rights-of-way 15 to 25 feet wide before ditches can be dug. Dynamite ditching has been employed in such marshes and compares favorably in cost with hand labor.

FIGURE 8.—Red mangrove (*Rhizophora mangle*) in a Florida salt marsh, showing the dense growth and characteristically divided base.

Another difficult problem is encountered in certain areas where the marshes border more or less landlocked bodies of water in which there is ordinarily little tidal range. Strong wind tides may cause a flooding of these marshes, and continuous winds may hold the water there long enough for a brood of mosquitoes to develop even though the marsh is thoroughly ditched. To meet this problem it has been proposed to dike such areas and remove the floodwaters when necessary by means of pumps. A program along this line, combining mosquito and sand fly control, was begun in Saint Lucie County, Fla., in 1936.

The control work against salt-marsh mosquitoes in the North Atlantic States has been criticized as unnecessarily destroying the feeding and breeding grounds of wildlife. It is believed that many of the deeper ponds, as well as the plant species that serve as food, can be saved without detriment to the antimosquito work. If the ponds are of value as feeding and resting grounds for wild fowl, the ditches may be diverted or, if they are run into the ponds, a

sod dam or wooden spill gate may be inserted, somewhat lower than the marsh level, to prevent complete drainage of the pond and to permit the inflow of high tides. Deepening of the shallower ponds may be necessary to obtain surface drainage on the neighboring marsh and should greatly increase their value and permanence.

Sump drainage may be employed to decrease mosquito breeding in small, enclosed areas where drainage is difficult, or in areas that are of special value from a conservation point of view. By this method ditches are dug so that the water is concentrated in the lowest portion of the marsh, where, if no pond or pool exists, one is excavated to serve as a reservoir for maintaining predacious minnows and insect enemies of mosquito larvae. In successful operation light floodings of adjacent breeding areas are drained into the sump by the ditches, and when the whole marsh becomes flooded the ditches facilitate access of the predators to all parts of the area. Successful use of this method was reported by Stutz [3a] in Broward County, Fla., for controlling breeding in low subdivision squares where adequate drainage was impractical.

Another problem arises in connection with the lowering of the water table, which results sometimes in an undesirable change in plant species and sometimes in a subsidence of the marsh level. As such changes vary greatly with different soil and tidal conditions, a thorough study of such factors should be included in the original surveys. Where the soil texture indicates little water-holding capacity, excessive lowering of the water table may be avoided in some cases by the use of very shallow ditches.

Larvicides are employed in salt-marsh mosquito control for the treatment of areas that are not taken care of by the ditching system. Fuel oils are used extensively for this purpose and are usually applied with a knapsack sprayer. Since the heavier, less volatile oils are harmful to wild birds, fish, and other aquatic animals, it is recommended that only relatively volatile oils, such as No. 2 fuel oil, be used in treating mosquito-breeding areas where wildlife is likely to be affected. The pyrethrum-extract emulsion as described on p. 20 has been recommended where wildlife is concerned. Paris green has given promising results against salt-marsh *Aedes* larvae, and is more economical than oil in labor, material, and transportation costs, in addition to being much less disagreeable to handle. It is mixed with water and sprayed over the breeding area with a sprinkling can having a capacity of 3 or 4 gallons. Two gallons of water will cover about 1,250 square feet and should contain about 1 ounce of paris green for an application at the rate of 2 pounds per acre. For use in shallow water and with even distribution the amount of paris green can be reduced by at least one-half. The water used is dipped from the breeding place as needed. It should be strained, if necessary, to prevent clogging of the sprinkler head with trash.

NOTES ON THE GENERA AND SPECIES

The genera and species are discussed in the following pages. As few mosquitoes are known by common names, the scientific name will

[3a] STUTZ, FRED H. SIXTH ANNUAL REPORT OF THE BROWARD COUNTY, FLORIDA, ANTI-MOSQUITO DISTRICT COVERING ACTIVITIES FOR 1940. 9 pp. [Processed.]

be used to designate the kind under discussion.[4] During the early years of activity in mosquito studies, following the discovery of their disease-carrying habits, considerable confusion was caused by revisions of generic and specific names. Fortunately, these names have now become much more stabilized as a result of continued studies in various parts of the world. In the following account of the species the principal synonyms that have appeared in the United States literature are shown in parentheses under the valid name, and in a few cases the common name is also given.

Genus Anopheles Meigen

(Syn., *Nyssorhynchus* Blanch.)

The mosquitoes of this genus breed in a wide variety of aquatic environments, although their production on a large scale is chiefly in permanent bodies of water containing aquatic vegetation or surface debris. Descriptions of anopheline breeding places of various types, while not specifically referred to herein, are numerous in the literature cited in this publication. Some of the references dealing with the classification and types of breeding places in given localities are those of Bradley (*27*) for northeastern Louisiana, Barber and Komp (*7*) and Perez (*132*) for Mississippi, Boyd (*18*, *19*) for northeastern North Carolina, Watson and Spain (*149*) for northern Alabama, Meleney, Bishop, and Roberts (*125*) for western Tennessee, and Darling (*46*) for Georgia (Lee County). Boyd (*20*) has given a comprehensive review of the literature on the natural history of anophelines as well as on their relation to malaria transmission. The bionomics and ecology of the Nearctic species have recently been reviewed by Bradley and King (*35*).

All our native anophelines are fresh-water breeders, with the exception of *Anopheles atropos* and *A. bradleyi*, which breed in salt or brackish water.

The eggs (fig. 3, *C*) are laid singly—that is, not stuck together in rafts—and are provided with floats to keep them at the surface of the water. Hatching usually occurs in 2 or 3 days, and breeding is continuous during the summer months. Boyd (*18*) obtained records indicating that *A. quadrimaculatus* may have from 8 to 10 generations annually in the latitude of southwestern Georgia. In the warmer sections of the Gulf States breeding is also more or less continuous through the winter (*8*, *64*), although much reduced in volume, and the rate of development is slower. The larvae of some species are able to withstand freezing temperature (*1*). The adults are active chiefly after dusk and spend the daytime resting in dark, humid situations.

When alive, most anophelines can be recognized by their typical resting position (fig. 9, *A*, *B*), the abdomen and proboscis being held in nearly a straight line and pointed at an angle toward the resting surface. Other kinds of mosquitoes hold the body more or less paral-

[4] In scientific terminology two names, the generic and the specific, are employed for each kind of organism. A genus is sometimes divided into subgenera and, when given, the subgeneric name is inserted in parentheses between the generic and specific names. The species may also be divided into subspecies or varieties. The name, spelled out or abbreviated, of the person who first described the species is often added after the specific name. If the species is changed to another genus, the name of the author is enclosed in parentheses. The designation of a species may therefore appear as *Aedes aegypti* or *Aedes* (*Stegomyia*) *aegypti* (L.), etc.

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lel to the resting surface (fig. 9, *C*), while the head and proboscis are bent downward at an angle to the body. The larvae of *Anopheles* are easily recognized by the absence of a breathing tube and by their usual feeding position (fig. 10, *A*) parallel to the water surface. Other mosquito larvae have an elongated breathing tube and while at the surface hang downward with only the tip of the tube penetrating the surface film (fig. 10, *B*). Anophelines have tufts of modified hairs, called palmate hairs, on the upper side of the abdominal segments, by which they suspend themselves just below and parallel to the surface. While they are in this position the head is rotated for feeding until the mouth parts are uppermost, and the food is taken from or near the surface film. In the pupal stage the breathing tubes are short and widely flared as compared with those of other mosquitoes (fig. 11). The wings of all the typically Nearctic species of *Anopheles*, including *A. maculipennis* Meig., which is not known to the Southeastern States, are shown in plate 5.

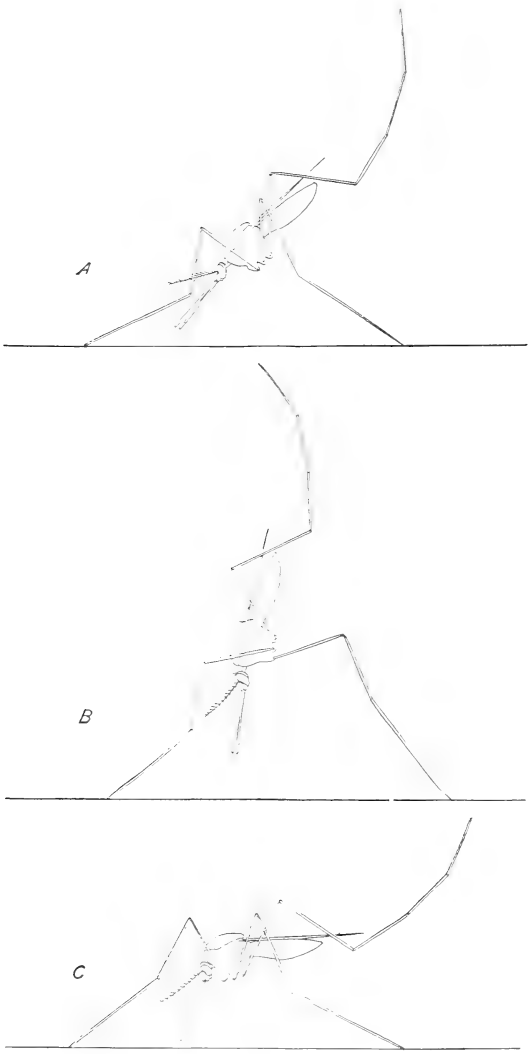


FIGURE 9.—Resting positions of mosquitoes: *A* and *B*, *Anopheles*; *C*, *Culex*.

To this genus belong the mosquitoes that transmit malaria to human beings, and all except one (*A. georgianus*) of the species listed for the Southeastern States have been proved susceptible to infection with the parasites of this disease. However, *Anopheles quadrimaculatus* is considered to be by far the most important species concerned in the transmission of the disease in this region. The others either are too rare or their blood-feeding habits appear to be such that they are seldom of importance as carriers. These conclusions are based on the

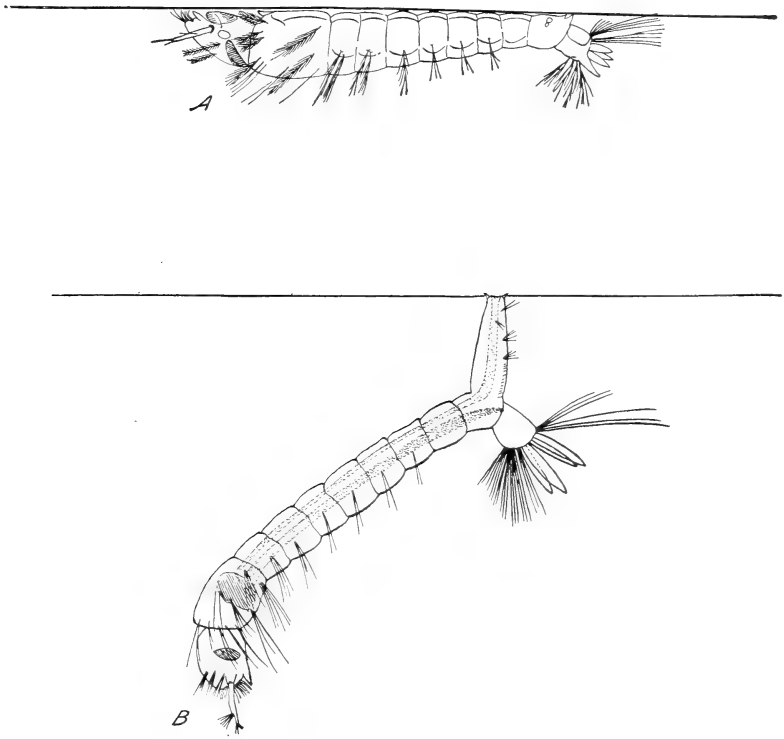


FIGURE 10.—Feeding positions of mosquito larvae: *A*, *Anopheles*; *B*, *Culex*.

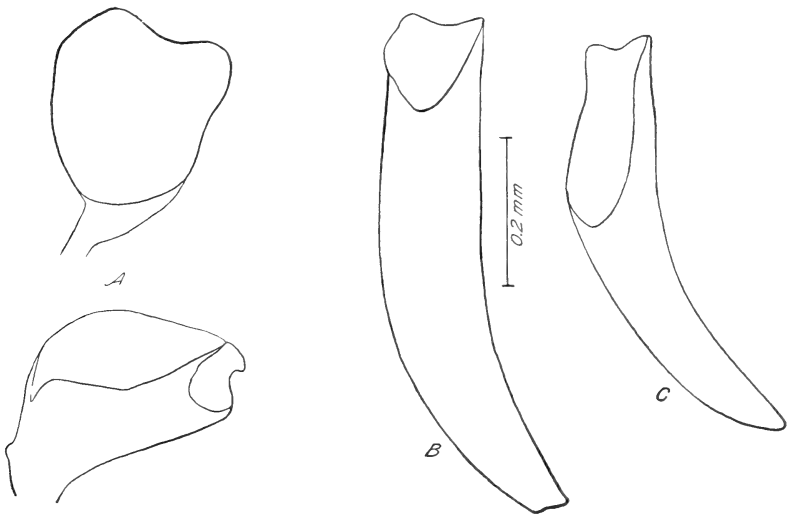


FIGURE 11.—Pupal breathing tubes: *A*, *Anopheles crucians*, from above and side; *B*, *Culex salinarius*; *C*, *C. quinquefasciatus*.

fact that malaria infection in this region has almost invariably been found associated with this species. *A. crucians* is prevalent along the coastal plains and in the lower Mississippi Valley, and since three specimens have been found infected in nature (*120*, *126*), the species cannot be entirely eliminated from consideration. Investigations several years ago in the Okefenokee swamp in southern Georgia (*121*) showed that malaria was absent in an area where *crucians* was prevalent and the only anopheline present. In Florida the malaria rate is high in the northwestern part of the State, where *A. quadrimaculatus* predominates, but low in the southern half of the State, where *crucians* is abundant and the predominating species. Such malarious foci as have been investigated in the southern part have shown locally favorable conditions for *quadrimaculatus* breeding. Frequently the two species are found associated in the breeding places, but in general the occurrence of *quadrimaculatus* and the areas of high malaria endemicity in northern Florida and southern Georgia (*25*) appear to be correlated with the presence of slightly alkaline surface waters, whereas *crucians* apparently prefers water of an acid reaction as found more generally in the southern part of Florida.

Barber and coworkers (*10*) have given a critical review of the records on infection of southern species and their role in malaria transmission.

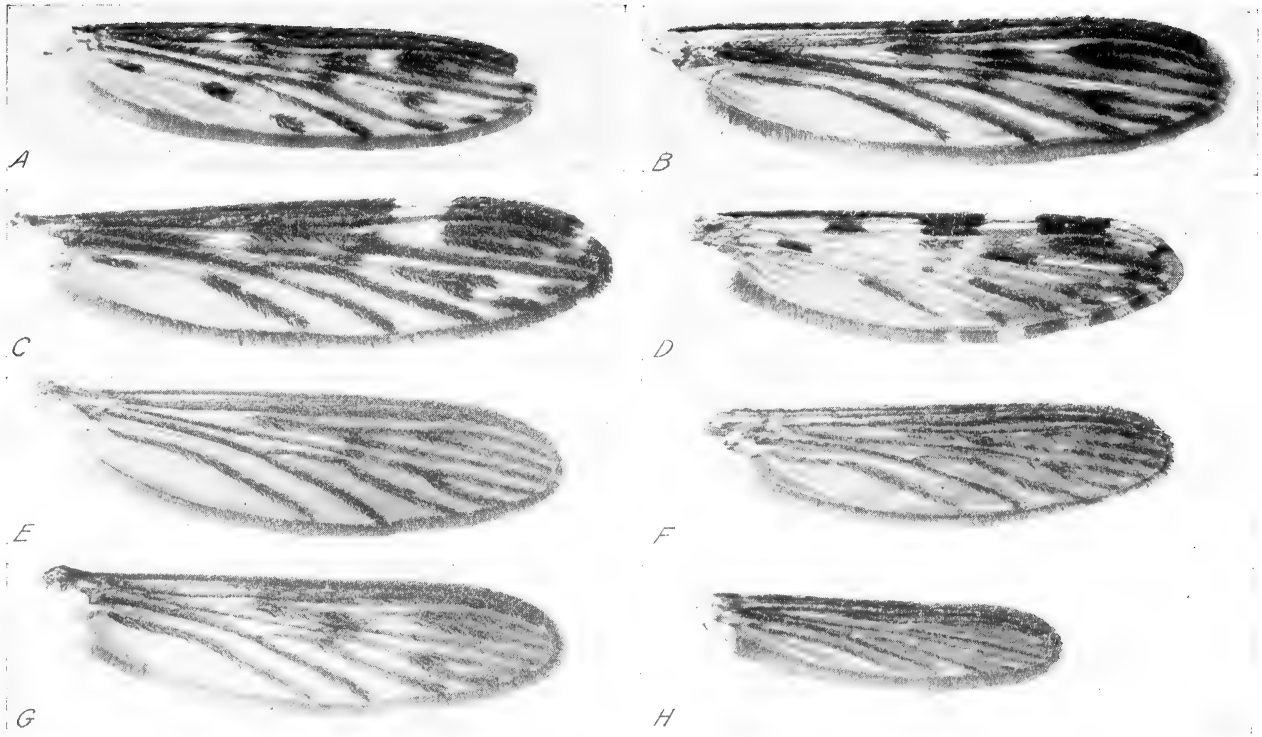
The species of *Anopheles* included here are divided into two subgenera, *albimanus* being placed in *Nyssorhynchus* and the others in the subgenus *Anopheles*. King and Bradley (*99*, *100*) have given a review of the classification and distribution of the Nearctic species.

ANOPHELES QUADRIMACULATUS Say

(Syn., A. *annulimanus* V. d. W.; the common malaria mosquito)

The common malaria mosquito breeds chiefly in permanent freshwater pools, ponds, and swamps that contain aquatic vegetation or floating debris (pls. 1–3). It is found throughout the South and is the principal species concerned with malaria transmission in this region. It is a fairly large mosquito, dark in color, with four darker spots near the center of the wing field (pl. 5, *G*). In its resting position the angle at which the body is held is not so pronounced as with some of the other species, and the position of specimens heavy with blood may not appear characteristic.

This species is active principally at night, although during the cooler months the females will seek blood meals in the daylight on warm days, in dwellings, or in the woods. The daily flight or dispersal period begins just at dusk and continues for a half hour or so. During the remainder of the night, flight is probably limited for the most part to local forays in search of a host. Another period of activity begins just at daylight and ends with a general shift to the daytime resting places. The flight range of *Anopheles quadrimaculatus* from the breeding places undoubtedly varies a good deal, probably depending largely upon the proximity of blood meals and the numbers produced. In planning control operations the maximum effective flight range is taken as about 1 mile under average conditions during the summer. Prehibernation dispersal flights in the fall may be much greater than this.



Wings of the typically Nearctic species of *Anopheles; A, crucians: B, maculipennis: C, punctipennis: D, pseudopunctipennis: E, walkeri: F, atropos: G, quadrimaculatus: H, barberi.*

Although little is known of the extent to which this species feeds upon wild animals, man and most of the domestic animals are known to be attacked by the blood-hungry females. Information on the relative attractiveness of different hosts was obtained in a series of cage experiments conducted in Baltimore, Md. (*38*, *39*). Two host species were exposed side by side to the bites of *Anopheles quadrimaculatus* females, which were afterwards collected and the blood meals identified by the precipitin test. Among cattle and horses it was found that the attractiveness varied more between individuals than between the species, and that a decided variation also occurred between individuals of the human race. The latter received on an average about one-sixth as many bites as the horse or cow. Sheep, goats, dogs, and pigs appeared to be less attractive, in the order given, while rabbits and chickens proved to be very poor hosts even in the absence of other animals.

To determine the proportion of mosquitoes that obtained blood meals from different hosts under natural conditions, a large series of records had previously been obtained at Mound, La., by testing the blood from freshly fed females collected from the tenant dwellings and outbuildings on three plantations (*102*). From a general series of collections during the mosquito season of 1922, 38 percent of the specimens taken inside the house were found to have fed on man, and about 2 percent of those from underneath the house and in the outbuildings. The weighted average was 4.3 percent for the entire *quadrimaculatus* (female) population, being 6 to 8 percent when the average number of females per location was about 200 to 500 and decreasing to 3 percent or less when the average reached 1,500 or more. The average percentages for the other hosts for which blood tests were made were as follows: Cow, 36; horse, 33; pig, 16; dog, 8; and other animals (chicken and cat), 3.

Although very high malaria infection rates (10 percent or even more) have been found among anophelines in other countries, the percentage of infected *quadrimaculatus* in malarious areas in this country appears to be comparatively low, probably much lower than is generally supposed. From an examination of 9,340 specimens collected on plantations in the vicinity of Mound, La., in 1922 (*91*), only 10 were found to contain the sporozoite form of the parasite in the salivary glands and therefore to be capable of transmitting the infection at the time of capture. This gave a sporozoite rate of 0.107 percent, or approximately 1 infective specimen per 1,000. The annual malarial rate in humans on the same plantations during that year was about 45 cases per 100. At Edenton, N. C., a gland-infection rate of 0.33 percent was obtained from dissections of 1,486 mosquitoes over a period of 3 years (*21*).

The larvae of *Anopheles* feed almost entirely at the water surface, and since they seem to make no selection of material provided it is small enough to be ingested, the food consists of the general variety of small organisms that are found at the water surface. From a large series of observations at Mound, where *quadrimaculatus* was the predominant anopheline, Bradley (*31*) reported that flagellates, diatoms, and the green algae made up a large proportion of the plankton content of the surface layer in the natural waters of that

area. The approximate average numbers of organisms per cubic centimeter in breeding places having more than one larva per dip were as follows for the breeding seasons of 1928 and 1929, respectively: Total plankton, 8,600 and 6,300; flagellates, 5,400 and 4,200; diatoms, 1,800 and 500; green algae (other than flagellate forms), 700 and 900. Present in smaller numbers were the ciliates, blue-green algae, and amoeboid protozoa, although the first two were fairly abundant at times. The four principal genera among the flagellate forms were *Euglena*, *Chlamydomonas*, *Trachelomonas*, and *Phacus*, which composed about 75 percent of the total organisms in this class in the places of high larval density. The report of studies made by Boyd and Foot (*24*) shows a similar plankton content in the surface waters at Edenton. A classification of ponds in which the abundance of desmids is used as an index to the suitability of the water for specific anopheline breeding has been suggested by Frohne (*57*).

In rearing the larvae in the laboratory various foods may be utilized, both those from the natural breeding places and artificial foods such as yeast. Barber (*3*) found that *Anopheles quadrimaculatus* could be reared to maturity on cultures of single species of organisms, including algae, bacteria, or infusoria, and that dead organic material was less suitable than living organisms. Komp (*108*) reared *Anopheles* in a food culture made from *Spirogyra* killed by heating. Boyd, Cain, and Mulrennan (*23*) report that the infusoria developing in a ripened hay infusion, when supplemented by yeast, forms an almost ideal food for the larvae, as it invariably produced large and healthy individuals. The ripening process requires at least 30 days in the summer, as the infusions must pass through a period of acid fermentation before they are satisfactory as a food supply. These authors found that the largest proportion of the larvae reached maturity at about 70° F. At this temperature development from egg to imago required about 21 days (*22*). Crowell (*44*) found that the larvae could be reared successfully on powdered dog biscuit. This is a convenient food to use and does not require a ripening process or a change of water in the rearing pans. This author also reported that, in an insectary maintained at a temperature of about 75° F., the larval period ranged from 16 to 24 days, with an average duration of each of the four instars of 4, 5, 5, and 6 days. The pupal stage required from 60 to 72 hours. At high summer temperatures, with an ample food supply, larval development under natural conditions may be completed in about 1 week, although some larvae develop more slowly than others under the same conditions. With a minimum of 3 or 4 days for the other aquatic stages (egg and pupa) and about 4 days for the preoviposition period, the minimum time for a complete generation would be 14 or 15 days. At low temperatures or with scanty food supply the developmental cycle is greatly prolonged.

ANOPHELES CRUCIANS Wied.

The *crucians* group is now known to include three closely related forms which are very similar in the adult stage but differ in larval and pupal characters. Two of the forms were described by King in 1939 (*95*) as varieties of *Anopheles crucians* (*bradleyi* and *georgianus*), but it was believed that all three represented distinct species, and they are recognized as such by the present authors.

Anopheles crucians is the common fresh-water form in the Southeastern States. In low coastal-plain areas it is frequently the predominating anopheline, but elsewhere is usually limited in abundance and distribution. Its range extends up the Atlantic coast to Massachusetts and westward into southern Illinois, central Oklahoma, and Texas, with an isolated occurrence in the Pecos Valley, N. Mex. (*100*). It also occurs on the east coast of Mexico and in some of the Caribbean regions.

Although this species is susceptible to infection with malaria parasites, it is not known to be of serious importance in the transmission of malaria; in fact, the evidence at present points to the contrary. The species frequently bites out of doors at night or even during the day in the woods. The adults also enter houses, but at Mound, La., they were always found in a much smaller percentage of the total numbers present than was the case with *Anopheles quadrimaculatus*. In the vicinity of Lake Apopka in central Florida, where *crucians* becomes extremely abundant, the number taken out of doors at night while they were attempting to bite has repeatedly been very small in comparison with the total numbers present as indicated by light-trap collections.

Observations made by the senior author in New Orleans indicate that this species may migrate for several miles when an unusual production occurs. MacCreary and Stearns (*114*) obtained specimens at two lighthouses in Delaware Bay, one 3.2 miles from the nearest shore and the other 5.5 miles. Since both these localities are near the coast, it is not certain whether the species represented was *crucians* or *bradleyi*.

The principal recognition characters for the female of this anopheline and the two related species are the three dark spots on the anal vein and the dark-scaled front margin of the wing (pl. 5, *A*). The palpi are ringed with white. The larva of *crucians* is distinguished from all other American *Anopheles* by the fact that the anterior submedian hair (hair 0) is well developed on several of the abdominal segments and the antepalmate hair on segments 4 and 5 is also multiple-branched.

ANOPHELES BRADLEYI King

(Syn., *A. crucians* var. *bradleyi* King: *A. crucians*, coastal or salt-water form)

This form was first mentioned by Root in 1924 (*134*) and was more fully described by Bradley in 1932 (*30*) as the "coastal variety" of *Anopheles crucians*. The species is now known to occur along the Atlantic and Gulf coasts from Maryland to Vera Cruz, Mexico (*100*). The localities in the Southeastern States from which it has been reported from larval identifications are Buras, La., Coden, Ala., Parris Island, S. C., various counties in Florida (*30*), Grand Bayou (*74*) and Saint Bernard Parish, La. (*47*), Craven and Onslow Counties, N. C., and Hunter Field, Ga. (table 1).

Anopheles bradleyi has been found only in brackish water near the coast, and water of a low concentration of salt (about 1.5 percent or less) appears to be preferred. The larvae have been taken with *Anopheles atropos* at the higher concentrations and with the typical *crucians* when the water was nearly fresh. The larvae were first collected in Florida in large roadside ditches near the Saint Johns River in Brevard County and have been found there repeatedly upon subsequent examinations. They were taken in aquatic grass and

especially in beds of *Chara*. Elsewhere they have been collected in salt-marsh pools containing flotage, algae, and grasses.

The larval characters most nearly resemble those of *Anopheles punctipennis*, from which they can usually be distinguished by the fact that the leaflets of the palmate hairs on segments 3 and 7 are slender, mostly with smooth margins and smaller than those on segments 4 to 6. In *punctipennis* the palmate leaflets are all about equally broad and usually notched near the tip. Many adult specimens appear to be indistinguishable from those of typical *crucians*, but about half of the females examined have the stem of vein 5 completely or mostly white-scaled, whereas it is entirely dark-scaled in *crucians*.

ANOPHELES GEORGIANUS King

(Syn., *A. crucians* var. *georgianus* King)

This species was first collected by Bellamy (*11*) in 1937 from freshwater breeding places in southern Georgia and was described by King (*95*) as a variety of *Anopheles crucians*. The spots on the wings appear to be more contrasting than in *crucians*, but no positive characters have been found for separating the adults. The larva, however, is unusual in that only three pairs of functional palmate hairs are present (on segments 4 to 6), whereas *crucians* and all the other species of *Anopheles* have at least five. The larvae are further distinguished from *bradleyi* by having a larger number of branches in the antepalmate hairs of segments 4 and 5, and from *crucians* by the lack of development of the anterior submedian hairs (hair 0) on these and other segments. In the pupal stage the corresponding hair is usually unbranched in *georgianus* but with three to five branches in *crucians*. In *bradleyi* the branching is more irregular. Slight differences in the claspette spines of the male genitalia were described by King (*95*), with *crucians* intermediate in these characters.

Anopheles georgianus has been collected by Bellamy (*11*) in Brooks, Sumter, Terrell, and Thomas Counties, Ga. A single larva was identified from a collection of *crucians* made by G. H. Bradley in ponds near Hinesville, Ga., in March 1941. It has since been reported from all the Southeastern States except Tennessee and Arkansas. Its typical habitat appears to be in seepage areas at the head of small streams, and the larvae were usually found in pure culture or with a small proportion of *crucians*. Scattered larvae were also reported from other types of ponds.

ANOPHELES PUNCTIPENNIS (Say)

(Syn., *Culex hyemalis* (Fitch), *Anopheles perplexens* Ludl.)

Anopheles punctipennis ranges from the Atlantic to the Pacific coast and has a variety of breeding places. In the South it appears to prefer the margins of flowing streams, probably because of the lower temperature of the water. Throughout the southern range it occurs much more commonly late in the fall and early in the spring than in the summer (*7*, *19*). At Mound, where it was never abundant, it disappeared almost entirely during the warm months. In that vicinity pure cultures of the larvae were sometimes taken in the fall in small clay borrow pits or pools free of vegetation. As a rule the species is rare in central and southern Florida. The writers have found the adults in some numbers at Rock Springs, Orange County,

near a natural spring having a good flow of clear, cool water, and have taken the larvae in a few other places in Orange and Seminole Counties. Larvae and adults have been taken in the vicinity of Gainesville, the larvae occurring there in a seepage outcrop.

Although this species readily becomes infected with malaria parasites under experimental conditions, it does not feed extensively on persons under natural conditions, and the epidemiological evidence indicates that it is not an important carrier of the disease.

The conspicuous white spot on the costa, about two-thirds the distance from the wing base (pl. 5, *C*), is the chief recognition character for this species. The palpi are unbanded. In specimens from central Florida the size of the costal spot is usually reduced considerably, and in some individuals the wing may be almost entirely dark-scaled. This variation has also been observed occasionally in other areas and is possibly the form described as *A. perplexens* (Mount Gretna, Pa.). In larval specimens from Florida the antepalmate hair of segments 4 and 5 is usually single instead of double as in other areas.

ANOPHELES PSEUDOPUNCTIPENNIS Theob.

Anopheles pseudopunctipennis and its variety *franciscanus* occur in the Southwestern States and in tropical America. The species has been recorded in small numbers from Tennessee (*51*), the Mississippi counties of Humphreys (*40*), Attala, Hinds, Holmes, Leake, Madison, and Yazoo (*110*), and by the writers from Mound and New Orleans, La. It has recently been taken in Arkansas (table 1). A Tennessee specimen in the National Museum collection is labeled from Memphis. In general appearance this species resembles *A. punctipennis*, but the palpi are ringed and the wing pattern (pl. 5, *D*) is different. No records of its breeding places in the lower Mississippi Valley are available, but in the semiarid southwestern region it is most commonly found in river valleys in open, sunlit ponds containing algae and other vegetation.

ANOPHELES ATROPOS D. and K.

Little is known of the habits of this species, which breeds in the salt water of coastal marshes. In southern Louisiana, Mississippi, and Florida adult females have been taken while biting in the open during the day, even in direct sunlight (*14*, *65*, *74*, *107*). In Florida adults were once noted on an open marsh during the day and were encountered in large numbers after dark in two other localities. A few adults have been taken in light traps in several localities on the coast in southern Florida, and larvae have been obtained at various places in the State and at Parris Island, S. C. The species has been recorded by Fisk (*55*) from Key West, Fla., and the writers have a specimen from Elliott Key, Fla. (F. H. Stutz, collector, February 1941). The species has been recorded as far north as Maryland.

Larvae were taken by Griffitts (*65*) in water ranging from 3 to 12 percent "salinity" (about 0.8 to 3.4 percent of salt), by Hinman (*74*) in water containing 0.8 to 1.85 percent of salt, and by the writers, in Florida, in water containing more than 1 percent of salt. Although the larvae of *atropos* and *bradleyi* have occasionally been taken together, the latter has usually been found in water of a lower salt content.

Anopheles atropos has been infected experimentally with malaria parasites (*122*), but it is of doubtful importance as a transmitter of the disease.

This species is dark brown, with few markings. The palpi are faintly spotted with white scales or entirely dark. The dark spots on the wings are inconspicuous or lacking (pl. 5, *F*), and the legs are without distinct white knee spots at the tips of the femora, which are usually visible in *walkeri* and *quadrimaculatus*. Examination for the knee spots is best made against a dark background, the specimen being viewed in different positions. Light reflections from the bristles or scales should not be confused with pale scaling. The characters of the male terminalia are similar to those of *walkeri*. In the larva, which was first described by Hinman (*74*), the outer clypeal hairs have only a few branches, the inner hairs are sparsely feathered near the tip, and the antepalmate hairs of segments 4 and 5 are usually single.

ANOPHELES WALKERI Theob.

This usually rare species breeds in fresh-water marshes containing aquatic vegetation. It has been taken in light traps in fairly large numbers at Zellwood, in the vicinity of Lake Apopka, Orange County, Fla. (*36*), at Reelfoot Lake, Tenn. (*89*), and at Wabasha, Minn. (*45*). The species has been recorded from Sumter County, Ga. (*12*), Crowley, La. (*9*, *107*), Bondurant, Ky. (*2*), and Scott and Little Rock, Ark. (*85*, *142*). It has also been collected by the writers at Orlando and in Volusia County, Fla. It has recently been taken in Mississippi, South Carolina, and North Carolina (table 1). The specimens listed by Dyar (*51*) from Terrebonne, La., were later identified by Hinman (*74*) as *Anopheles atropos*. The species has been reported from most of the Northern States from New Hampshire to Minnesota and Kansas, and in southeastern Canada (cf. *100*).

A study of specimens from Florida has shown some larval characters distinct from those of specimens obtained in New York State (*33*). Matheson and Hurlbut (*119*) have since reported that both forms occur in the vicinity of Ithaca, N. Y. Specimens from each State have been infected experimentally with malaria parasites (*104*, *118*), and one specimen infected with the parasites in nature has been reported from Bondurant, Ky., in the vicinity of Reelfoot Lake (*2*). The adults are readily attracted to light traps at night and the females to human hosts both in the daytime and at night (*36*, *45*, *89*). The breeding places and the resting places of adults are usually difficult to locate (*2*, *45*, *89*). The adults seem to prefer to remain on the emergent vegetation in the breeding areas. Matheson and Hurlbut (*119*) and Hurlbut (*88*) found that two distinct types of eggs were deposited by this species, "summer" and "winter" eggs, and they concluded that overwintering occurred, at least in the North, in the egg stage.

The females of this species from Florida are very dark. They usually have narrow but distinct white rings on the palpi and white knee spots at the tips of the femora. The wing spots (pl. 5, *E*) are less pronounced than in *quadrimaculatus*. In the larvae the inner clypeal hairs are set close together and are minutely feathered toward the tip, hair 1 of the prothorax is branched from the base, and hair 0 of the abdominal segments shows more development than in either

punctipennis or *quadrimaculatus*. A study of the chaetotaxy of the four instars has been published by Hurlbut (*87*).

ANOPHELES BARBERI Coq.

The larvae of this mosquito are found principally in tree holes, although the writers once took them in wooden tubs at Mound, La. The adult is very small, with unspotted wings, and is rarely encountered. It has been proved susceptible to infection with malaria parasites but is of doubtful importance in malaria transmission (*140*). Thibault (*142*) in Arkansas noted that it enters dwellings readily and is a persistent biter, although easily disturbed.

The species has been recorded from various places throughout the East and South from Ithaca, N. Y., to Houston, Tex. With recent records from Reelfoot Lake (*37*) and Norris, Tenn. (*136*) and from several counties in Georgia (notes from Justin Andrews), it has now been reported from all the Southeastern States.

ANOPHELES ALBIMANUS Wied.

(Syn., *A. albipes* Theob.)

This species is the only anopheline included here in which the tarsi are white-banded. It is a tropical species, of much importance as a vector of malaria in tropical America. It was introduced into Key West, Fla., in 1904, and apparently developed one brood there, according to the records of its discoverer, George N. MacDonell. Fortunately it did not become established and has not since been reported from that locality. At the present time the only place in the United States where it is known to occur is the lower Rio Grande Valley, Tex. The distribution of this species and the possibilities of its becoming established in southern Florida and along the Gulf coast have been discussed by King (*94*).

Genus CULEX Linnaeus

(Syn., in part, *Melanoconion* Theob., *Mochlostyrax* D. and K., *Neoculex* Dyar, *Choeroporpa* Dyar)

The mosquitoes of this genus breed in more or less permanent collections of water. The eggs are laid on the surface of the water in rafts of a hundred or more (fig. 3, *A*), and they hatch within 2 or 3 days at summer temperatures. Breeding is continuous during warm weather and even through the winter in the warmer parts of Florida and the Gulf coast. Elsewhere the winter is passed in hibernation as adult females.

In identifying some of their collections of *Culex*, particularly those taken in light traps, the writers have found it convenient to use subgeneric names, since the specimens frequently are in poor condition or difficult otherwise to identify as to species. For the small species of *Culex* Dyar's subgeneric name *Mochlostyrax* has been employed previously, but Edwards (*53*) has reclassified them on larval characters that place two of the three local species in *Melanoconion*. Since the differences are of a minor nature and it is difficult to define the two subgenera by either classification, the writers are of the opinion that only the earlier name *Melanoconion* need be retained. The 11

southeastern species of *Culex* may then be placed in three subgenera as follows: (*Culex*) *quinquefasciatus*, *pipiens*, *restuans*, *salinarius*, *nigripalpus*, *tarsalis*, and *bahamensis;* (*Neoculex*) *apicalis;* (*Melanoconion*) *erraticus*, *peccator*, and *pilosus*.

Adult specimens of *Melanoconion* are of less than medium size and are distinguished superficially from the other subgenera by the wider wing scales (more noticeably on the branches of vein 2) and by the presence of flat, dusky, or pale scales on the occiput. In *erraticus* the latter character is often obscure, and the examination should be made at fairly high magnifications and with good lighting. These scales should not be confused with the patch of broad white scales at the side of the head, which is present in the other subgenera as well.

CULEX QUINQUEFASCIATUS Say

(Syn., *C. fatigans* Wied., *C. pungens* Wied., etc.; the southern house mosquito, or house *Culex*)

The southern house mosquito breeds in water barrels and other artificial containers, in street gutters and catch basins, and also in ground pools if the water is polluted. It is one of the domestic mosquitoes and is generally the most abundant night-biting house mosquito in the cities and towns of the Southern States. In the North it is replaced by its very near relative *Culex pipiens*, and the range of the two overlaps in Virginia, northeastern Tennessee, North Carolina, and other intermediate States. The name *fatigans* has been retained for this species by the European workers and is in use in most of the Old World countries. Methods employed in the abatement of the domestic mosquitoes are discussed under Mosquito Control (p. 13).

Females are distinguished from those of other southern *Culex*, in which the proboscis and tarsi are unmarked, by the conspicuous white abdominal bands, rounded on the posterior borders and interrupted or much narrowed at the lateral margins. The mesonotum is grayish, with narrow lanceolate scales.

CULEX PIPIENS L.

(The northern house mosquito)

This is the common house mosquito throughout the Northern States. In recent years the species has been recorded from Careyville and Concord, Tenn. (*136*), Smithfield, N. C. (D. F. Ashton, 1937), Lake Lure, N. C. (record from Alan Stone), and Georgia, Alabama, and South Carolina (table 1). A reported occurrence of *pipiens* in New Orleans (*15*) is not given consideration, as the identification was undoubtedly incorrect.

The habits and general appearance of *Culex pipiens* are similar to those of *C. quinquefasciatus*, and in areas where the two species overlap identifications should be made by examination of the male terminalia. Even then the determination is often difficult for individual specimens. Females may be identified provisionally by the characters given in the key to species.

CULEX SALINARIUS Coq.

(Syn., *C. nigritulus* Smith (not Zett.))

The larvae are found principally in grassy pools of either fresh or brackish water, and sometimes also in the bilge water of boats, and in barrels. The species occurs throughout the Southeast. It is not abundant in peninsular Florida, although it becomes more numerous at Orlando during the winter. It is common elsewhere along the Gulf and Atlantic coasts and is found less abundantly inland. The adult females bite freely out of doors at night and will enter houses to feed if necessary.

Culex salinarius females are recognized by the presence of narrow bands or a few scattered scales of a yellowish or dingy-white color at the base of the abdominal segments. The seventh segment may be largely pale-scaled, and the posterior margins of the segments may appear whitish at times. The mesonotum is covered with fine, hairlike, brownish scales, and has a smooth appearance in contrast to those of *quinquefasciatus* and *pipiens*.

CULEX NIGRIPALPUS Theob.

(Syn., *C. similis* Theob.)

The larvae are common in ditches and grassy pools in central and southern Florida, where the species appears to have largely replaced its near relative *Culex salinarius*. At Orlando the larvae are occasionally found during the summer in street catch basins and in tubs. Judging by the small number of biting records in comparison with the abundance of the larvae, the species is much less inclined to attack people than is *salinarius*. Where the adults are numerous they have occasionally been taken inside houses. The species is principally of tropical occurrence and apparently does not extend far north in the United States. It has been recorded from Lee County, Ga. (*134*), and Charleston, S. C. (*56*). The writers have the species from New Orleans, La., and Brewton, Ala., and specimens have also been examined recently from Savannah, Ga. (M. A. Barber, collector, October 1940).

The adults differ from those of *salinarius* in having lateral white spots but no pale bands on the dorsum of the abdomen. The pleurae generally have few or no white scales.

CULEX RESTUANS Theob.

(Syn., *C. territans* in some recent literature; the white-dotted *Culex*)

The larvae occur in pools and rain barrels, preferring somewhat foul water, especially that containing decaying grass or leaves. The species has usually been regarded as a troublesome biter and the authors have found it so in Louisiana. Thibault (*142*), from observations made at Scott, Ark., stated that it "does not bite human beings very much, though it enters houses. Seems to prefer poultry and livestock, also juices of plants." Carpenter (*41*) noted that it is seldom troublesome in Arkansas except when present in large num-

bers. The species becomes locally abundant in the South, much more so during the winter and spring than in the summer. It is of general distribution in the Northern, Eastern, and Southern States, but becomes rare in southern Florida. The adults usually have a pair, sometimes two pairs, of small white dots on the mesonotum (fig. 12, *K*). The abdomen has conspicuous white bands which are not narrowed at the lateral margins.

Unfortunately, the name *territans* was changed to designate this species after it had been applied for years to the one now known as *apicalis*. Edwards (*53*) has shown that the synonymy is very doubtful, and the writers agree with him in the desirability of restoring the name *restuans*, so that there will be no confusion as to the species meant.

CULEX APICALIS Adams

(Syn., *C. territans Dyar* (not Walk.) in part, *C. testaceus* Dyar (not V. d. W.), *C. saxatilis* Gros., etc.)

Culex apicalis has a wide distribution and is found breeding in grassy pools and swampy places containing aquatic vegetation. The larvae are fairly common, but the adults apparently do not bite man. As they have been observed feeding on frogs, they probably live on cold-blooded animals.

The adults are recognized by the presence of narrow white bands, which widen laterally, on the posterior margins of the abdominal segments. The name *apicalis* refers to this character.

CULEX TARSALIS Coq.

The writers have one collection of this banded-legged *Culex* from Louisiana (Mound, October 13, 1913, D. L. Van Dine). The larvae were taken in a clay borrow pit with *Anopheles punctipennis*, but were not obtained again, although many collections were made in the same locality during the following 10 or 15 years. It has also been reported from Arkansas (*41*, *85*), from Orleans Parish (*47*) and Lake Charles, La. (*15*), and from Florida and Tennessee (table 1). This species is very common in the Western States.

CULEX BAHAMENSIS D. and K.

(Syn., *C. corniger* Dyar (not Theob.))

This is a tropical species that has recently been collected by Fisk (*55*) in several breeding places at Key West, Fla., including an underground cistern containing brackish water. The writers have also identified a male of this species collected on Elliott Key in the spring of 1940 by F. H. Stutz. It now seems probable that the specimens previously recorded by Dyar (*50*) as *Culex corniger* Theob., from Knights Key, Fla., were the same species, since the identification was based on a collection of females only and the two species are not easily distinguished in this stage.

The larva of *Culex bahamensis* has only two anal gills, instead of the normal four, and they are thick and bulbous. The adult female has narrow white rings on the tarsi, which occur on both sides of the joints on the hind tarsal segments.

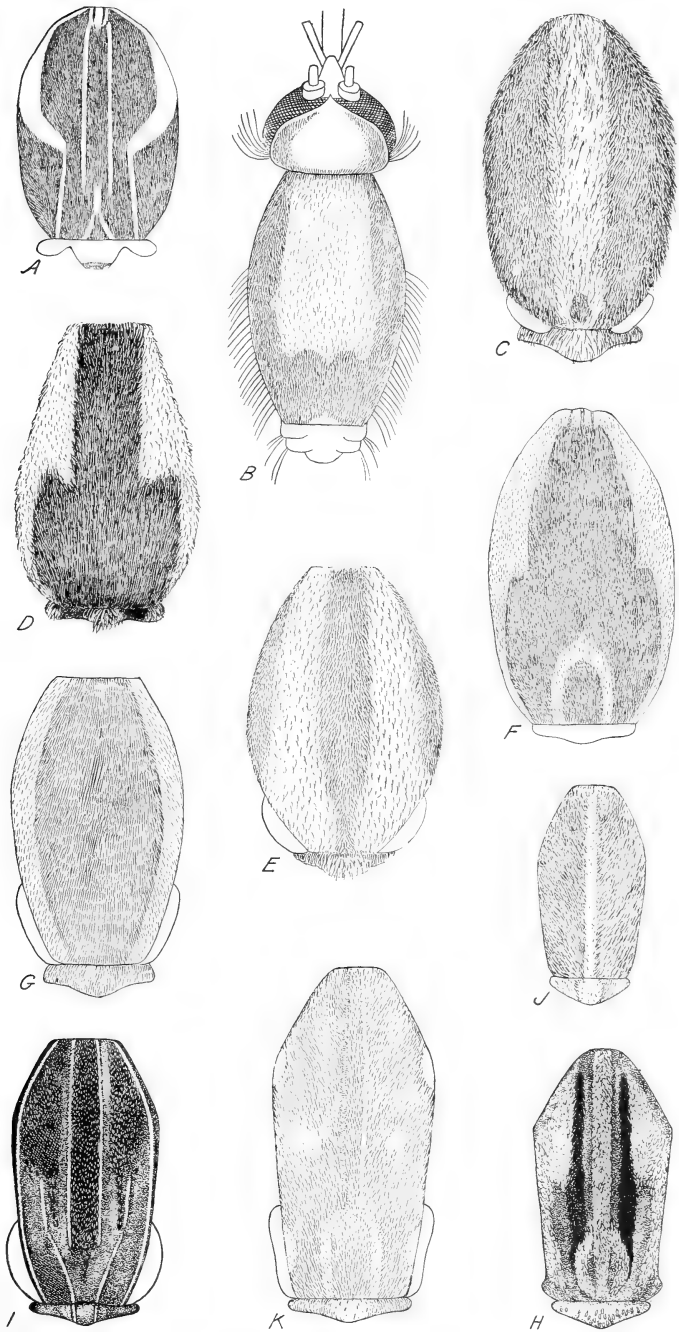


FIGURE 12.—Thoracic markings of several kinds of mosquitoes (diagrammatic): *A, Aedes aegypti; B, A. infirmatus; C, A. atlanticus; D, A. thibaulti; E, A. trivittatus; F, A. triseriatus; G, Psorophora varipes; H, P. ciliata* (at a scale one-half the size of the others); *I, Orthopodomyia signifera; J, Uranotaenia sapphirina; K, Culex restuans.*

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CULEX ERRATICUS D. and K.

(Syn., *C. egberti* D. and K., *C. peribleptus* D. and K., *C. pose* D. and K., *C. degustator* Dyar, *C. leprincei* D. and K., *C. homoeopas* D. and L., etc.; also *C. abominator* D. and K., in part, and in the United States references to *C. inhibitator* Dyar (not D. and K.) and *Melanoconion atratus* Dyar (not Theob.))

The name *erraticus* is adopted by the writers as the correct name for the common *Melanoconion* of the Southern States. This species has in recent years been known as *inhibitator* because of the synonymy published by Dyar (*51*), but a review of the original descriptions has shown that the larval and male characters of the United States form are distinct from those of the Santo Dominican species (*98*). The description and illustration of the male genitalia given by Dyar (*51*) for *erraticus* belong to *abominator* D. and K., a species that is known only from Texas.

The larvae of *Culex erraticus* are found in grassy permanent pools and swampy places, especially those having a growth of duckweed (*Lemna*). The egg raft is sometimes laid on the upper surface of the *Lemna* frond, although it is not known whether this is the usual habit. The larvae are taken frequently in association with *Anopheles* larvae. The species occurs throughout the South.

The United States species of the subgenus *Melanoconion* cannot at present be distinguished with certainty in the adult stage except by characters of the male terminalia. Since *erraticus* is the commonest one of the group, biting records for *Melanoconion* females are usually assumed to apply to this species. Female specimens having a limited area of flat scales and a large triangular patch of narrow scales on the occiput can be identified with some assurance as *erraticus*.

Melanoconion adults have been obtained in large numbers in light-trap collections in Florida, and examinations of male specimens have shown both *erraticus* and *pilosus*, principally the latter, to be present. Females, probably all *erraticus*, have been taken in Florida and Louisiana while biting out of doors at night, but usually in small numbers when compared with the abundance of the larvae. The writers' observations at Mound indicated that the species had a preference for the blood of fowls, attacking them on the roosts at night. According to Thibault (*142*), *Culex abominator* (probably *erraticus* as now known) was the most abundant and annoying species in the woods in the vicinity of Scott, Ark., especially at dusk and early in the morning, but continuing to bite throughout the day. Horsfall (*79*, *80*) did not find them of importance in southeastern Arkansas in 1935 or 1936, although he reported them as occurring in enormous numbers in rice fields in association with *Psorophora* species in 1936.

CULEX PECCATOR D. and K.

(Syn., *C. incriminator* D. and K.)

Larvae and males of this species are distinguished readily from those of *Culex erraticus* and *C. pilosus*, although the male genitalia are very similar to those of *abominator* (Texas) and *anips* Dyar (California). Nothing is known of the blood-feeding habits of the female. The larvae, when found, are almost always associated with *C. apicalis*.

The writers have taken occasional specimens at New Orleans, Mandeville, and Mound, La., and in Orange and Osceola Counties, Fla. The species has been reported previously from all the Southeastern States except Florida, but records based on female specimens alone are questionable. The larval description for the species by Dyar and Barret (*52*) was based on specimens of *Culex erraticus*. The description was corrected by King and Bradley (*98*).

CULEX PILOSUS (D. and K.)

(Syn., *Mochlostyrax floridanus* D. and K., *Culex deceptor* D. and K., *C. agitator* D. and K., etc.)

This small mosquito breeds in shallow, grassy pools, roadside ditches, hoofprints, and flooded areas. The eggs are able to withstand drying, a very unusual trait in the genus, and as a rule the breeding places are temporary. The collected larvae are easily recognized by their peculiar wriggling motions and by their habit of lying on their backs on the bottom of the container. The tip of the air tube has a pair of recurved dorsal spines, which may be used for retaining their submerged position. Nothing is known of the feeding habits of the adult. The species is common in Florida. In addition to the States listed by Dyar (*50*), it has been recorded in Lee County, Ga. (*134*), Brewton, Ala. (*106*), New Orleans, La. (E. S. Hathaway, personal communication), Charleston, S. C. (*56*), and Mississippi (table 1).

Genus AEDES Meigen

(Syn., *Stegomyia* Theob., *Heteronycha* Dyar (not L.-Arr.), *Ochlerotatus* L.-Arr., *Taeniorhynchus* L.-Arr., *Finlaya* Theob., *Aedimorphus* Theob., *Culicelsa* Felt)

With the exception of a few species, including the yellow-fever mosquito (*Aedes aegypti*) and the tree-hole breeder *A. triseriatus*, this genus typically breeds in temporary rain pools, floodwaters, and tidal marshes. The eggs are laid singly on damp soil at the edge of a pool or in moist depressions, and they are able to survive long periods of drying. When such places are flooded with water and the temperature is favorable, some of the eggs hatch almost at once and often produce enormous broods of mosquitoes; others may not hatch until subsequent floodings. With some species, at least, the eggs may also be deposited on the water surface, but most of them remain unhatched until the pool evaporates and has again been flooded. Some species of *Aedes* have but one brood each year and are found only in the spring, whereas others recur commonly during a rainy season. The winter is passed in the egg stage.

All except five of the species of *Aedes* included here are placed by Edwards (*53*) in the subgenus *Ochlerotatus*. The others are divided as follows: (*Aedes*) *cinereus;* (*Stegomyia*) *aegypti;* (*Aedimorphus*) *vexans;* (*Finlaya*) *triseriatus*, *atropalpus*. Dyar's (*51*) classification is similar except that the subgenus *Taeniorhynchus* (=*Culicelsa*) is recognized by him to include the species *taeniorhynchus*, *sollicitans*, *mitchellae*, and *atropalpus*.

AEDES AEGYPTI (L.)

(Syn., *Stegomyia fasciatus* F., *Culex calopus* Meig., *C. argenteus* Poir., etc.; the yellow-fever or dengue-fever mosquito)

The adults are rather small and dark, with conspicuous rings of white scales on the tarsi, and patches of white on the sides of the thorax and abdomen. The lyre-shaped pattern on the mesonotum (fig. 12, *A*), formed of lines of white scales, is characteristic of the species.

This species is the most thoroughly domesticated of any of the mosquitoes and apparently greatly prefers the blood of man to that of other animals. It breeds almost exclusively in artificial water containers in the vicinity of dwellings or in the dwellings themselves. The larvae are found occasionally in tree holes and similar natural collections of water, but so far as known the eggs are never deposited in ground pools. The eggs are usually laid on the sides of the receptacle just above the water line, or on the surface of the water. It appears that places which are of solid material at the water line are selected for oviposition. In Orlando, Fla., the writers have found the larvae abundant at times in the underground street catch basins, which, although partly filled with sand and dirt, were lined with brick or concrete. Fairly clean water is preferred, and sewage-polluted water in wooden or concrete cesspools is not a favorable breeding medium. The eggs are able to withstand drying for several months, and hatch very quickly when the receptacle is filled with water.

The adults are abundant during the summer in cities and towns throughout the South and are troublesome house pests. Biting is confined largely to the daylight hours, especially early in the morning and late in the afternoon, and the females seem able to gain entrance even into well-screened houses. They are wary biters and are especially annoying about the ankles. *Aedes aegypti* is thought to have been the only species involved in the epidemics of yellow and dengue fevers in the United States, although other species in other countries have been proved capable of transmitting both these diseases.

The adults have been kept alive in the laboratory for several months, and in the summer they probably live longer than any other of the southern species. They are very susceptible to cold, however, and are said to die out at temperatures below about 40° F. The eggs are more resistant, but the species probably does not overwinter in the United States except in the extreme southern part. Each summer it becomes widely dispersed into territory farther north, probably by carriage in trains, boats, etc. Although the adults are strong fliers, the usual flight range is considered to be not more than a few hundred feet.

The control of this species is discussed in the section on Mosquito Control (p. 13). A more extended account of its life history may be found in a bulletin by Howard (*83*).

AEDES SOLLICITANS (Walk.)

(The eastern salt-marsh mosquito, sometimes called the New Jersey mosquito)

This bronze, or golden-brown, species breeds in salt marshes along the Atlantic and Gulf coasts and, except in southern Florida, is by far the most important of the salt-marsh species. It is a strong flier

and commonly migrates in large swarms many miles from its breeding place. In Florida specimens sometimes are taken in the interior of the peninsula when broods emerge on the coast. The adults settle in the grass during the daytime and are extremely annoying to persons who come in their vicinity, attacking in full sunlight. The flight of migratory swarms begins just before dark, and the numbers that may be encountered in salt-marsh areas at this time are almost unbelievable. In the southern half of Florida the species may be found through the winter and is more prevalent in the spring and fall than in the summer. Adults have also been found in the winter along the Mississippi coast (*66*). Although breeding of this species is limited mostly to salt marshes or other coastal locations, there are records of its development inland associated with salt water pumped from oil wells. Carpenter (*41*) found them to be rather common near oil fields in Union and Ouachita Counties in Arkansas, and adults and larvae from this area were sent the writers for confirmation of the identification. Of interest also is a record for the species from Eddy County, N. Mex., where they were found by M. A. Barber in 1938 in a brackish swamp near Artesia. Methods for the control of the salt-marsh species are discussed in the section on Mosquito Control (p. 13).

Adults of *sollicitans* are recognized by a median, dorsal longitudinal stripe of pale scales on the abdomen, the mixed black and white scaling of the wings, and the golden color of the mesonotum. The proboscis and the legs have wide white rings, and the first segment of the hind tarsus has a white ring in the middle.

AEDES TAENIORHYNCHUS (Wied.)

(Syn., *A. taeniorhynchus niger* Giles (not Theob.) ; the black salt-marsh mosquito)

This small black and white mosquito is the most abundant and troublesome salt-marsh species along at least the southern two-thirds of the Florida coasts, which is also approximately the area where mangrove and pickleweed (saltwort) form the predominant marsh vegetation (pls. 4, *B*, and 6, *A*). In smaller numbers *taeniorhynchus* occurs along the Atlantic coast as far north as the New England States and along the Gulf coast to Mexico. Unlike *sollicitans* it is found on the Pacific coast in southern California. It also occurs commonly in the West Indies and in Central and South America to the Guianas and Peru. While it is usually not the predominant species along the Atlantic coast north of Florida, collections from four light traps operated nightly at Charleston, S. C., from July 19 to November 1, 1939 (*56*), gave a total of nearly 10,000 *taeniorhynchus* specimens compared with about 200 *sollicitans*. In a series of light-trap collections made by McCreary (*113*) at Fenwick Island lighthouse in southern Delaware in 1940, the total counts over a 60-day period, excluding the collection for one night, showed nearly equal numbers of the two species (about 6,500 of each from two traps). On the night of September 10 the enormous total of 271,772 mosquitoes were obtained from a single trap (operated at ground level), of which 192,221 were *taeniorhynchus* and 69,465 were *sollicitans*. From many collections obtained by the writers in similar traps in Florida the maximum record for *taeniorhynchus* for a single

night has been about 3,000. The species seems much less inclined than *sollicitans* to attack in bright sunlight, but it commonly is very annoying in the shade in the mangrove and other woods.

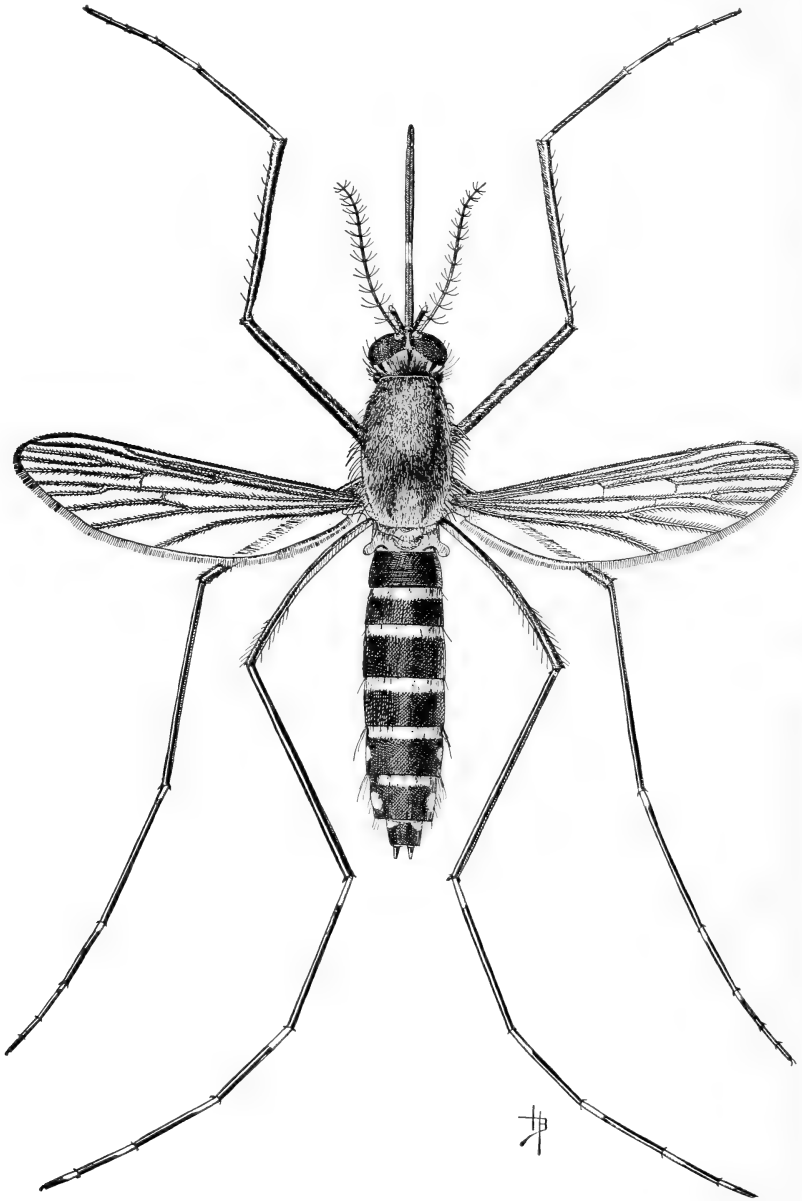

FIGURE 13.—*Aedes taeniorhynchus*, one of the salt-marsh mosquitoes.

Aedes taeniorhynchus breeds prolifically in the salt marshes when they are flooded by rains or tides and also in fresh-water pools nearby. In the laboratory the eggs have hatched and the larvae have

A, A prolific breeding place of *Aedes taeniorhynchus* in a pickleweed marsh; *B*, a breeding place of *Mansonia perturbans*, large shallow pond filled with pickerelweed.

been reared in water varying in salinity from completely fresh to that of sea water. The females become troublesome at times in the interior of the Florida peninsula and have been taken in considerable numbers in the vicinity of Orlando, which is about 30 miles from salt water. Many larvae were once found in fresh water standing on a vacant lot within the city limits of Orlando, the only record of the species that the writers have among many collections of *Aedes* larvae from the same locality. In these larvae as well as in those of *A. sollicitans* from New Mexico (mentioned previously) the anal gills were as long as the anal segment, instead of in the normal budlike form, a condition that may be associated with their development in fresh water. The species was found by Carpenter (*41*) to be breeding inland, along with *A. sollicitans*, in salt water from oil wells in Union and Ouachita Counties, Ark., and by E. B. Johnson (June 1939) at Oil City, Caddo Parish, La. These locations are several hundred miles from the coast.

The adults are less than medium sized and are dark in color, with white rings on the proboscis and tarsi (fig. 13). The mesonotum is dark-scaled sprinkled with white, and the wings are dark-scaled. The abdomen is without a longitudinal stripe, and the first hind-tarsal segment lacks the median white ring of *sollicitans*. Southern and tropical specimens having the tip of the last hind-tarsal segment dark are sometimes classified as variety *niger*. Specimens from the North Atlantic States usually have this segment entirely white.

AEDES MITCHELLAE (Dyar)

This comparatively rare species resembles *Aedes sollicitans* except that the wings are entirely dark-scaled and the first segment of the hind tarsi is not ringed with white. It breeds in rain-water pools and is a rather severe biter. While it has not been found breeding in salt marshes, its range seems to be limited to the Coastal Plain. It has been recorded from Mobile, Ala., Victoria, Tex., southern Georgia, several places in Florida (*50*, *85*), and Lee County (*134*) and Waycross, Ga. (D. G. Hall, 1931). The writers also have records from different places in Florida and have collected the species in light traps at Orlando and several points near the coast. It was taken at Holly Ridge, N. C. (G. H. Bradley, April 2, 1941). Recently Mississippi, Louisiana, and South Carolina have been added to the range of this species (table 1).

AEDES TRISERIATUS (Say)

(The tree-hole *Aedes*)

This common woods species has patches of silvery-white scales on the sides of the thorax (fig. 12, *F*), which give it a rather conspicuous appearance. The proboscis and legs are unmarked. It breeds principally in tree holes but to some extent also in water barrels and other artificial water containers. It is widely distributed throughout the United States and has been reported in all the Southeastern States. It is frequently a troublesome biter in the woods. When the larvae are found in water barrels associated with those of *Aedes aegypti*, they can usually be distinguished with the naked eye by their darker appearance.

AEDES VEXANS (Meig.)

(Syn., *Culex sylvestris* Theob., *C. stimulans* Coq. (not Walk.))

Aedes vexans is of wide occurrence throughout the United States and other countries and is a serious pest in many areas. It breeds in rain pools and floodwaters, and there may be several broods during the season. It is seldom abundant in the extreme South, and the writers have taken only occasional specimens in Florida. The adults have narrow rings of white scales on the hind tarsi, and the white abdominal bands usually show a V-shaped notch in the middle of the posterior border. The proboscis and thorax are unmarked.

AEDES INFIRMATUS D. and K.

(Syn., *Culicelsa confirmatus* Dyar (not L.-Arr.), in part)

This vicious biting mosquito breeds in temporary rain pools and at times becomes very abundant. The thorax has a wide, conspicuous central stripe of silvery scales (fig. 12, *B*), but the proboscis and tarsi are unmarked. In common with most of the other woods mosquitoes, the females attack readily during the daytime in or near woods, and at night they may be encountered in the vicinity of dwellings. They seldom enter houses except when they become excessively abundant. The species has been recorded from Arkansas, Louisiana, Florida, North Carolina (*50*), Georgia (*134*), and South Carolina (*56*). The writers also have collection records from Louisiana, Florida, and Mississippi. It probably will be found in all the Southeastern States.

AEDES DUPREEI (Coq.)

This rare species breeds in temporary rain puddles. The larvae are seldom collected, owing to their habit of hiding among the leaves and trash at the bottom of pools. They are recognized by the extremely long anal gills. The adult females closely resemble those of *Aedes atlanticus* and *A. tormentor*, although they are somewhat smaller. The writers have taken them in Florida at Perry, Boyd, and Carbur and in Orange County, and in Louisiana at New Orleans and Mound. The species has been recorded from Baton Rouge, La., Scott, Ark., (*85*), Pickwick Reservoir, Ala. (*136*), Charleston, S. C. (*56*), and North Carolina (D. F. Ashton, 1938), as well as from some of the Northeastern States and the Tropics. It has recently been reported from Georgia and Mississippi (table 1).

AEDES ATLANTICUS D. and K.

(Syn., *Ochlerotatus serratus* Coq. (not Theob.), in part)

Aedes atlanticus breeds in shady temporary rain pools. It is a vicious biter and is usually associated with *A. infirmatus* and other woods species. It resembles *infirmatus* except that the white stripe on the thorax is much narrower (fig. 12, *C*). The species is common in the Gulf States and is probably distributed throughout the southeastern region. In addition to the localities given by Dyar, it has been reported from Alabama (*67*), Arkansas (*80*), South Carolina (*56*), and Mississippi (table 1).

AEDES TORMENTOR D. and K.

(Syn., *Ochlerotatus serratus* Coq. (not Theob.), in part)

Aedes tormentor is almost identical in appearance with *A. atlanticus*, and its identification depends upon larval or male genitalic characters, which are given in the keys. The larvae are darker than those of *infirmatus*, with which it was usually taken in Louisiana. At New Orleans larvae of this species were more often taken than those of *atlanticus*, while the reverse was true in Florida. One larva of *tormentor* was collected on Parris Island, S. C., in 1935, and in this specimen the thorax and eighth abdominal segment were white, in striking contrast to the rest of the body. Florida specimens are sometimes rather conspicuously marked in a similar manner. The species was taken by Root (*134*) in Georgia, and it has now been recorded from all the Southeastern States except Tennessee.

AEDES THIBAULTI D. and K.

This is a rare species that breeds in stump holes. It probably has but one brood each year, in the spring. The species is listed by Horsfall (*79*, *80*) as of local importance in southeastern Arkansas. It was taken by the writers at Mound, La. (*28*), and has been reported from Mississippi (*51*), Mississippi County, Mo. (*50*), Wilson Dam, Huntsville (*136*), Leighton, and Madison County, Ala. (*137*), Edgecombe County, N. C. (D. F. Ashton, May 1938), and from Orangeburg County, S. C. (table 1).

AEDES CANADENSIS (Theob.)

This mosquito is rare in Florida and elsewhere in the extreme South, but farther north it is a troublesome biter. It is said to have but one brood annually, which appears in the spring. It is not known to enter houses. In addition to the localities listed by Dyar (*50*), the writers have specimens from New Orleans and Mound, La., Lumberton, Miss., and Orlando, New Smyrna Beach, and Gainesville, Fla. It was taken by Dupree at Baton Rouge, La. Recently it has been taken in Georgia (table 1). It was reported by Horsfall (*79*, *80*) to be the most annoying of the woods mosquitoes in Arkansas during March and April.

AEDES FULVUS PALLENS Ross

(Syn., *A. bimaculatus* (Coq.), in part; *A. fulvus* Dyar (not Wied.), in part)

This is a bright-yellowish species of striking appearance, limited to the Southern States, and seldom collected. It was encountered in considerable numbers on one occasion (1914) in the vicinity of New Orleans, and the females were fierce biters. The writers have taken it in Orange, Volusia, and Seminole Counties, Fla. Root (*134*) obtained the species in Georgia, and a record for South Carolina has been received from S. L. Crosthwaite (Charleston County, September 4, 1941). It has now been recorded from all the Southeastern States except Tennessee. Edwards (*53*) considered this species distinct from the tropical *fulvus* to which Dyar (*51*) assigned it, and in a communication to the writers (September 12, 1938) confirmed

this opinion after comparing Florida specimens with *fulvus* and related species from South America. It has recently been described as a distinct subspecies by Ross.[5]

AEDES STIMULANS (Walk.)

(Syn., variety *mississippi* Dyar, *Culicada subcantans* Felt)

This is a northern forest species which has been recorded once from Mississippi (Electric Mills). These specimens were named *A. stimulans mississippi* by Dyar (*49*), but the variety was later placed as a synonym of the type form. *Ochlerotatus subcantans*, reported from Baton Rouge, La., by Mitchell (*127*), was probably *Aedes vexans*.

AEDES GROSSBECKI D. and K.

(Syn., *Culex squamiger* Smith (not Coq.), *C. sylvicola* Gros.)

This is a rare northeastern species that has been recorded from two localities in Mississippi (Natchez and Scott). Dupree's (*48*) *Culex squamiger* and Mitchell's *Lepidoplatys sylvicola*, reported from Baton Rouge, La. (*127*), may have been this species. A specimen of *Aedes grossbecki* was collected by E. B. Johnson at Monroe, La., in 1939, and the identification was confirmed by the present writers. A collection from Arkansas has recently been reported (table 1). The adults are of rather striking appearance, with patches of white on the sides of the mesonotum, a mixture of black and white scales on the legs and wings, and wide tarsal bands. The writers are not familiar with the larva.

AEDES STICTICUS (Meig.)

(Syn., *Culex pretans* Gros., *Aedes hirsuteron* (Theob.))

This species, previously known in the United States as *Aedes hirsuteron*, has been recorded in the Southeast from Lee County, Ga. (*134*), Rives and Memphis, Tenn., and Scott, Ark. (*50*), Wilson Dam, Florence, and Huntsville, Ala. (*136*), and Bladen County, N. C. (D. F. Ashton, March 1939). The writers have examined a specimen, probably of this species, from Monroe, La. (E. B. Johnson, collector, March 1939), and have a specimen from Tallahassee, Fla. *Ochlerotatus pretans*, reported from Baton Rouge, La., by Mitchell (*127*), may have been *sticticus*, or perhaps *thibaulti*. With the recording of the species from Mississippi and South Carolina it has now been found in all of the Southeastern States (table 1). Edwards (*53*) places *hirsuteron* as a synonym of *sticticus*.

AEDES TRIVITTATUS (Coq.)

This is a northern species that has been recorded from Georgia (*134*), Louisiana (*51*), and recently from Arkansas, Tennessee, South Carolina, and North Carolina (table 1).

AEDES ATROPALPUS (Coq.)

This species has been recorded in the Southeast from North Carolina (*51*), Kinzel Springs and Knoxville, Tenn. (*136*), and Petit Jean Mountains, Ark. (*41*). Breeding occurs normally in rock holes, but Shields (*136*) found the larvae on one occasion in an abandoned septic tank at Knoxville, Tenn.

[5] ROSS, E. S. THE IDENTITY OF AEDES BIMACULATUS (COQUILLETT) AND A NEW SUBSPECIES OF AEDES FULVUS (WIEDEMANN) FROM THE UNITED STATES (DIPTERA, CULICIDAE). Wash. Ent. Soc. Proc. 45 : 143–151, illus. 1943.

AEDES CINEREUS Meig.

(Syn., *A. fuscus* O. S., etc.)

This is a comparatively rare northern species that has been recorded from Arkansas, where it was said to be abundant but a nonbiter (*142*), and recently from South Carolina and Georgia (table 1). Dupree's identification of *Aedes fuscus* from Baton Rouge, La., may have been correct, although the species was not taken by the present writers at Mound or New Orleans. Specimens identified as *fuscus* by Beyer (*13*) and others in New Orleans were undoubtedly *Uranotaenia lowii*. A peculiar character of this species is that both the male and the female have short palpi.

AEDES NIGROMACULIS (Lud.)

Aedes nigromaculis belongs to the arid western regions. It was reported from Louisiana by Dyar (*51*), but the identification was believed by Alan Stone, after examination of the original specimen, to be incorrect.

AEDES DORSALIS (Meig.)

Aedes dorsalis was reported from Delta, La., by Howard, Dyar, and Knab (*85*), but the record is questionable, as the collection date was 1904 and the species has not been reported since from that locality. The specimen has now been lost. Beyer's identification (*15*) of the species from Lake Charles, La., needs confirmation. This species is abundant and widely distributed in the Western and Northwestern States, and is said to breed in either salt or fresh water.

Genus PSOROPHORA Robineau-Desvoidy

(Syn., *Janthinosoma* L.-Arr., *Grabhamia* Theob.)

To this genus belong some of our larger and showier mosquitoes. Most of them are severe biters, but at the present time none are known to carry disease, although one species (*Psorophora confinnis*) appears in such swarms in southern Florida as to cause the death of livestock by its mass attacks. The breeding habits of the group are similar to those of the typical *Aedes*, to which they are closely related. The eggs are adapted to withstand drying and may lie dormant on the ground for long periods. They hatch upon being flooded, and the larvae may complete their development in transient pools, as they develop very rapidly. The larvae of two of the species (subgenus *Psorophora*) are predacious upon other mosquito larvae and are therefore of some benefit to mankind. The females of these two species, the familiar gallinippers, offset the benefit to some extent, however, as they are themselves avid bloodsuckers.

The species of this genus are divided into three subgenera as follows: (*Psorophora*) *ciliata* and *howardii;* (*Grabhamia*) *confinnis*, *discolor*, *pygmaea*, and *signipennis;* (*Janthinosoma*) *ferox*, *varipes*, *cyanescens*, and *horrida*.

PSOROPHORA CONFINNIS (L.-Arr.)

(Syn., *P. columbiae* (D. and K.), *Janthinosoma floridense* D. and K., and *Culex jamaicensis* Dyar (not Theob.), in part; the Florida glades mosquito)

The Florida glades mosquito, long known as *Psorophora columbiae*, breeds in temporary pools of rain water and occurs commonly throughout the Southeast. It is most abundant in the Florida Everglades, where it occasionally appears in enormous swarms and has caused large losses of livestock by its attacks (*17*). During these outbreaks it is almost impossible for humans to remain out of doors at night or in sheltered places during the day without some protection. Workers in sugarcane fields sometimes protect themselves by means of smudge pots, and large smudges are employed for the relief of stock. The problem in the Florida Everglades has not been thoroughly investigated, and the possibilities of control have not been determined, although breeding would appear to be too widespread to offer much encouragement to any efforts in this direction. The species also develops abundantly from grassy swales and depressions in other parts of Florida. During 1936, when conditions were not generally favorable for the production of *Aedes taeniorhynchus*, *Psorophora confinnis* was the predominant species along both the east and west coasts in the southern half of the State.

The writers have observed the species in fairly large numbers in Louisiana, but it was seldom annoying there. Thibault (*142*) reported it as being annoying near its breeding place and troublesome to livestock in Arkansas. Horsfall (*79*, *80*) found it developing in large numbers in rice fields in the same State.

Psorophora confinnis adults are fairly large and dark, with the proboscis and tarsi conspicuously banded. The thorax and legs are speckled with white, and the femora have a narrow white ring near the apex. The abdomen has diffuse pale scaling, which tends to concentrate on the middle and posterior parts of the segments.

PSOROPHORA CILIATA (F.)

(Syn., *P. ctites* Dyar; the shaggy-legged gallinipper)

This is a very large, yellowish-black mosquito with heavily scaled legs and a median longitudinal stripe of yellow scales on the mesonotum (figs. 2, *B*, and 12, *H*). It breeds in temporary rain pools, and its larvae feed on those of other mosquitoes, especially *Psorophora confinnis*. It is a severe biter, is widely distributed in the South and East, and at times becomes fairly abundant. Notes on the breeding habits of this and the following species were published by Morgan and Dupree in 1903 (*129*).

PSOROPHORA HOWARDII (Coq.)

(Howard's gallinipper)

This large, bluish-black mosquito is commonly associated with *Psorophora ciliata* in the Southeastern States, but is usually less abundant. Its habits are similar to those of *ciliata*, and the larvae feed on those of other species or on each other. They have also been

observed devouring small polliwogs. Dyar (*50*) recorded *P. howardii* from five of the Southeastern States, and it has since been reported from Georgia (*134*), Louisiana (*15*), and Alabama and Tennessee (*136*). The writers have collected specimens in Louisiana and Florida.

PSOROPHORA FEROX (Humb.)

(Syn., *Janthinosoma sayi* D. and K., *Culex posticatus* Wied., *C. musicus* Say, etc.; the white-footed woods mosquito)

The white-footed woods mosquito is encountered frequently in forests and shady spots throughout the South and East and is a severe biter. The last two segments of the hind tarsi are white; the other tarsal segments and the proboscis are uniformly dark. The waving white tips of the hind feet make it easily recognized in the field even while on the wing. The larvae breed in temporary rain pools. They, too, are easily recognized (except from *Psorophora varipes*) by the unusual length of the antennae. The first notes on the life history of this species were published by Morgan in 1902 (*128*).

PSOROPHORA VARIPES (Coq.)

(Syn., *P. discrucians* H., D., and K. (not Walk.), in part)

This mosquito breeds in temporary rain pools and is a severe biter. It is rare in most of the Southeast, but the writers found it to be exceedingly annoying in the woods of northeastern Louisiana. It does not fly out into the sunlight to bite, and its presence may be unsuspected unless woods are entered. The species has not been observed to travel far from its breeding places. Horsfall (*79*) and Carpenter (*41*) have reported it as occurring in large swarms in Arkansas following the spring floods. The recorded localities in the United States for the species are Clarksdale, Miss., Scott, Ark., Charleston, Mo., Wister, Indian Territory (*51*, *85*), Lee County (*41*) and southeastern Arkansas (*79*), Guntersville (*136*) and Sheffield, Ala. (E. H. Hinman, collector, 1940); and the writers have records for Memphis, Tenn., Mound, La., Brunswick, Ga., and McDavid, Ocklockonee, Matecumbe, and Villa Tasso, Fla.; and it has recently been reported from North Carolina and South Carolina (table 1). It is also found in tropical America, where its range overlaps that of the related species *Psorophora discrucians*.

The species is similar to *Psorophora ferox* except that the white marking on the hind tarsi is limited to the fourth segment and the thoracic scaling (fig. 12, *G*) is somewhat different.

PSOROPHORA CYANESCENS (Coq.)

Psorophora cyanescens is recorded from all the Southeastern States except Florida and also from Texas, Kansas, and tropical America. It is rare in most of the South, but is reported as very abundant and annoying at times in Arkansas (*142*) and Alabama (*136*). The adults are similar to those of *ferox* except that the tarsi are entirely dark.

PSOROPHORA HORRIDA (D. and K.)

This comparatively rare species has a rather wide distribution, having been reported from Maryland to Missouri and Texas. In the

Southeast it has been recorded from all the States except Florida. A reported occurrence in New Orleans, La. (*146*), is considered questionable. It is one of the four species of the subgenus *Janthinosoma* occurring in the United States. Matheson (*117*) has described unusual male genitalic characters for the species, and Rozeboom (*135*) has given the first description of the larva, which he found to have long antennae, similar to those of *Psorophora ferox*. The two species were taken together and were found only in shaded pools. The adults of both species have the last two segments of the hind tarsi white, but in *ferox* the broad whitish scales of the mesonotum are scattered (as in *P. cyanescens*) whereas in *horrida* they are segregated in patches at the sides (as in *P. varipes*).

PSOROPHORA DISCOLOR (Coq.)

Psorophora discolor occurs sparingly throughout the South. The larvae have unusually large, S-shaped antennae and long anal gills. The adults have well-defined wing spots and are distinguished from *P. signipennis* by the characteristic distribution of these spots, as given in the key. The writers' specimens of this species are from Mound, La. (G. H. Bradley), Loyston, Tenn. (S. E. Shields), Paducah, Ky. (G. E. Quinby), McComb, Miss. (T. T. Bracken), Decatur, Ala. (W. V. King), Leon County, Fla. (B. V. Travis), and Monroe, La. (E. B. Johnson). Previously published records are for Brewton, Ala. (*105*), Lee County, Ga. (*134*), Scott, Ark. (*142*), southeastern Arkansas (*79*), Huntsville, Ala. (*136*), Charlotte, N. C., Clarksdale, Miss., and Baton Rouge, La. (*50*). It has recently been reported from South Carolina (table 1).

PSOROPHORA PYGMAEA (Theob.)

This tropical species has been recorded once from the Florida keys (Key West) (*85*). The collection was made in 1901 and the species has not since been reported from the United States.

PSOROPHORA SIGNIPENNIS (Coq.)

Psorophora signipennis occurs in the arid western regions. It was reported from Arkansas by Dyar (*51*), and Carpenter (*41*) has since reported it from Dyess, Ark. The writers have a single larva, apparently of this species, from Mercedes, Tex. (sent in by P. T. Riherd), in which the hairs at the tip of the air tube are rather long, about two-thirds as long as in larvae of *P. cyanescens* from the same locality, and do not therefore agree with the characters usually given in keys for the separation of these species. The larva, however, is readily distinguished on other characters, as shown in the present key.

Genus MANSONIA Blanchard

(Syn., *Taeniorhynchus* L.-Arr., *Coquillettidia* Dyar)

The mosquitoes of this genus lay their eggs in rafts on marshes or lakes having certain kinds of aquatic vegetation. Upon hatching, the young larvae descend below the surface of the water and attach themselves by inserting the tip of the air tube into the stems and roots of aquatic plants, through which they obtain air. The pupae

also have breathing tubes specially modified for penetrating the soft tissues of the plants, to which they remain attached until ready to transform to the adult stage, when they rise to the surface.

Because of their habits, which are unique among mosquitoes, the larvae cannot be reached by ordinary surface larvicides such as oil. In experiments carried out by the writers in Florida, partial control has been obtained with common salt and with soap emulsions of pyrethrum extract in oil, but the results have been variable and the methods were not sufficiently economical to be feasible. In limited areas practical control can be obtained by destroying the host plants or by draining the ponds for a short period during the winter or early in the spring before the adults emerge.

As *Mansonia* larvae are often difficult to locate, the following notes are given on the methods found by the writers to be successful in collecting them (*123*). Since the larvae of *M. perturbans* have the habit of detaching themselves when their host plants are disturbed, they are likely to be missed if only the roots of such plants are examined. It is therefore necessary to search for the larvae in the bottom muck and trash of a pond area from which the host plants have been uprooted. This material may be scooped up with a large strainer and then examined in small quantities in shallow pans of clear water. As the larvae usually stay on the bottom of the pans, a careful search must be made. The white color of the larvae and their continuous movements aid in locating them among the trash. The collection of the larvae of *M. titillans*, which attach themselves to the roots of a floating plant (waterlettuce), is much simpler. These larvae are readily taken by lifting the host plants quickly into a pan of water for examination, or the plants may be lifted from the water by bringing the dish up under them. Some larvae usually remain attached to the roots, while others are found moving about in the dish. Specimens of *M. perturbans* are also found at times on the same plant.

Mansonia adults have very broad wing scales, mixed brown and white, and the proboscis and tarsi are banded. The abdomen is blunt at the tip and lacks the longitudinal stripe of white scales found in *Aedes sollicitans*. The two species found in this region are placed in separate subgenera, *titillans* in subgenus *Mansonia* and *perturbans* in *Coquillettidia*.

MANSONIA PERTURBANS (Walk.)

This speckled brown and white mosquito is widely distributed in the Eastern and Southern States. The adults are strong fliers and severe biters, and in many localities become a serious pest. The eggs are laid on the surface of the water in rafts similar to those of *Culex*. Breeding takes place in marshes and lakes having a thick growth of aquatic vegetation, to the roots of which the larvae and pupae attach themselves. Larval development is extremely slow, and the winter is spent in this stage. The pupal period is also long for mosquitoes, lasting 5 or 6 days.

Throughout most of its range this species is believed to have a single generation each year, a large proportion of the adults emerging over a comparatively short period late in the spring or early in

the summer. In the vicinity of Lake Apopka in central Florida, adults are present from March to December, a peak of abundance occurring in May or the last of April and a secondary peak the first part of August. Rearing experiments in artificial containers at Orlando have shown that, from eggs obtained in the spring, practically all the larvae will have reached the fourth stage and some adults may emerge in about 3 months, but the remainder of the larvae go through until the next year. It appears, therefore, that a partial second brood occurs in this area.

In northern localities larvae have been found associated with such plants as cattail (*Typha*), aquatic sedges (*Carex*), pickerelweed (*Pontederia*), and swamp-loosestrife (*Decodon verticillatus*). In Florida the principal host plant is the common pickerelweed (*Pontederia cordata*) (pl. 6, *B*). Larvae have also been collected, in varying numbers, from the following plants, which are named in the approximate order of importance: Cattail (*Typha latifolia* and the rarer *T. angustifolia*), frog's-bit (*Limnobium spongia*), waterlettuce (*Pistia stratiotes*), arrowhead (*Sagittaria lancifolia* and *S. montevidensis*), spatterdock (*Nymphaea macrophylla*), and water-hyacinth (*Piaropus crassipes*) (*124*). Fortunately the water-hyacinth is not a favorable host plant. Otherwise the pest would undoubtedly be much more widely distributed and abundant in the extreme South, where the hyacinth covers large areas of lakes, bayous, and canals.

A method for collecting the larvae is mentioned in the preceding discussion of the genus *Mansonia*.

The females will bite readily during the daytime in shady, moist places, but the main flight takes place during the half hour just before and after dark. Following this dispersion they are more active in the early part of the night than later.

MANSONIA TITILLANS (Walk.)

This is a tropical species and is found in the United States only in southern Florida. It closely resembles *Mansonia perturbans*, and the two are found in the same breeding places. The eggs are laid on the under surface of the leaves of waterlettuce, and the larvae and pupae have been found attached to the roots of this plant only. The adults may become fairly abundant and annoying locally. In 1933 larvae were taken in some numbers near the Saint Johns River at the latitude of Melbourne, but none could be found there the following year. Adults have been taken in light traps as far north as New Smyrna Beach on the coast, and several specimens have been collected in Orange County (latitude about 29°).[6] This appears to be about the northern limit of its range, although its host plant occurs farther north.

Genus CULISETA Felt

(Syn., *Theobaldia* Neveu-Lemaire, *Culicella* Felt, *Climacura* H., D., and K.)

Most of the species of this genus have a northerly range, and only two occur in the South, these two being very diverse in appearance, and neither of them important as a pest or as a disease carrier. The

[6] In January 1942 they were taken at Leesburg, Fla., by T. E. McNeel.

eggs are laid in rafts, and both the larvae and the adults resemble *Culex*. *Culiseta inornata* is placed in subgenus *Culiseta* and *C. melanura* in subgenus *Climacura*.

CULISETA INORNATA (Will.)

(Syn, *Culex consobrinus* How. (not R.-D.))

This is a rather large species, which breeds in open grassy pools and occasionally in artificial water receptacles. It is widely distributed throughout the United States, and has been reported for all the Southeastern States. In the South the larvae and adults are encountered usually only during the cooler months. In New Orleans the larvae were sometimes found in abundance during the winter, but they disappeared completely from March to November, and the manner of passing the summer is unknown. The larvae were usually found associated with those of *Culex restuans*. In Florida the writers have taken the species at Zellwood, New Smyrna Beach, and Palm Beach.

CULISETA MELANURA (Coq.)

Culiseta melanura breeds in small permanent collections of water. It is rare and of sylvan habits but occurs over a wide range in the Southern and Eastern States. The writers have taken the species at Mound and New Orleans, La., Wilson Dam, Ala., and in several places in Orange and Volusia Counties, Fla. It has now been recorded from all the Southern States except Tennessee.

Genus Uranotaenia Lynch-Arribalzaga

The members of this genus are very small, and some are brilliantly colored. They are recognized as a group by the very short forks of wing vein 2. The palpi of both males and females are short, but the male antennae are plumose. The eggs are laid in irregularly shaped rafts on the surface of permanent bodies of water in which there is considerable plant growth. The larvae are commonly associated with anopheline larvae and, when viewed in the water from above, somewhat resemble the latter in the shape and dark color of the head and the position of the body. Three species are found in the United States, and two of them occur in the Southeast, neither of which is of economic importance. Hinman (*77*) has published some biological notes on these two species in southern Louisiana.

URANOTAENIA SAPPHIRINA (O.-S.)

(Syn., *U. socialis* Theob.)

This mosquito breeds in grassy pools, swamps, and vegetation at the margins of lakes. The adults are rarely seen on the wing but may be found resting in hollow trees and in the grass or around the bases of trees and stumps in swampy places. They are said to bite humans on occasion, but their biting has never been observed by any of the writers. The specific name comes from the median longitudinal line of brilliant blue scales on the mesonotum. The species is a common one and undoubtedly occurs throughout the South. It has been reported from all the Southern States.

URANOTAENIA LOWII Theob.

(Syn., *U. continentalis* D. and K.)

The larvae of this species occur in ground pools, chiefly the grassy margins of lakes. The adults are rarely seen and are not known to bite humans. The species has been recorded from Florida and Louisiana (*50, 85*), and there are recent records from Charleston, S. C. (*56*), Arkansas, Georgia, Alabama, and Mississippi (table 1). In southern Florida it appears to be the predominant one of the two species. The last two segments of the hind tarsi are white, and the sides of the thorax have a few pale purplish scales.

Genus MEGARHINUS Robineau-Desvoidy

The mosquitoes of this genus are very large and brilliantly colored. The long, tapered proboscis is bent downward (fig. 2, *A*) at nearly a right angle and is not fitted for puncturing, the adults probably subsisting entirely on nectar, as they have been observed feeding in flowers. The eggs are laid singly on the surface of the water. The larvae breed in water in tree holes and occasionally in artificial receptacles. They are predacious on other mosquito larvae, principally *Orthopodomyia signifera* and *Aedes triseriatus*, as well as being cannibalistic, but owing to their rarity and their restricted habitat they cannot be of much benefit in controlling economic species.

Two closely related species are found in the United States distinguishable only by tarsal markings in the male.

MEGARHINUS SEPTENTRIONALIS D. and K.

(Syn., *M. portoricensis* How. (not Von Röder), *M. herrickii* Theob.)

The larvae of this large mosquito are found principally in water in tree holes, and occasionally in rock holes and artificial water receptacles, where they feed on other mosquito larvae. Several male specimens in the writers' collections from Mound, La., and Bay Saint Louis, Miss., all have the dark fore tarsi of this form. The species has been recorded from all the Southeastern States except Florida.

MEGARHINUS RUTILUS Coq.

This species also breeds in tree holes, but it is very rare and almost nothing is known of its habits. It is distinguished from *septentrionalis* by minor characters of the males. It has been recorded from Florida and Georgia (*85*). Two males at hand from Savannah, Ga., (D. G. Hall, collector) and several males from Orlando, Fla., show the pale tarsal markings of this form. Single records from Alabama and Mississippi are very questionable, since the identifications were made from female specimens and Dyar afterwards (*51*) listed the species only from Florida.

Genus ORTHOPODOMYIA Theobald

(Syn., *Bancroftia* Lutz)

The mosquitoes of this genus breed in water in tree holes and occasionally in artificial water containers. The eggs are laid singly at the water's edge and hatch in 2 to 3 days. Two species are found in the Southern States.

ORTHOPODOMYIA SIGNIFERA (Coq.)

Orthopodomyia signifera is a medium-sized mottled black and white mosquito, which superficially resembles the yellow-fever mosquito. The mesonotum (fig. 12, *I*) has six or eight delicate longitudinal lines of white scales, all of which are nearly straight. The larvae breed in water in tree holes and rain barrels and are preyed upon by *Megarhinus* larvae. Thibault (*142*), in Arkansas, reported it as being abundant near the breeding places and as entering dwellings to bite, an observation that the writers have not been able to confirm. The species has been collected in all the Southern States. Dyar (*50*, *51*) gives the range of the species as the Southern States and the Eastern States from Texas to Massachusetts.

ORTHOPODOMYIA ALBA Baker

Orthopodomyia alba was described in 1936 from specimens collected in tree holes near Ithaca, N. Y., where they were found associated with the larvae of *O. signifera*. Adults of the two species were said to be similar in appearance, but the larvae differed considerably, particularly in the absence of sclerotic plates on the abdomen in *O. alba* and in other characters as shown in the key. The species was first recorded for the South by Shields and Miles (*138*), who obtained it from a tree hole in Colbert County, Ala., and the writers have examined a few larvae and reared adults from this series. With a few minor exceptions, the larval characters agree with those given in Baker's description. Lately it has been collected in North Carolina (table 1).

Genus Deinocerites Theobald

The mosquitoes of this genus breed exclusively in holes made by certain species of crabs, and the adults rest in the upper part of the crab holes. It is said that they will bite humans on occasion, but they are rarely encountered and are of little or no economic importance. Only one species occurs in Florida. The antennae are extremely long, and the sides of the thorax have a shingled appearance. The palpi are short, and the antennae are similar in both sexes.

DEINOCERITES CANCER Theob.

(Crab-hole mosquito)

The crab-hole mosquito breeds in holes made by land crabs in the marl soil of the coastal marshes of southern Florida. The larvae of *Aedes taeniorhynchus* and occasionally *Psorophora confinnis* have been found associated with those of *Deinocerites cancer* when the surface water left on the marshes by rain or high tides had drained away. The adults are seldom seen, but have been taken in light traps at Miami and in several other localities as far north as New Smyrna (latitude about 29°). They have been taken occasionally, while biting at night in Dade County, Fla., by the writers and by F. H. Stutz.

Genus Wyeomyia Theobald

The species of this genus breed in water that collects in such plants as the bromeliads (air plants). The eggs are laid singly on the leaf

surfaces and hatch when flooded by rain water that collects at the leaf bases. The adults are small and are rarely seen except in forests and shady places, where their host plants occur. The females of some of these species bite readily, but their attacks are usually rare and they are troublesome only where the host plants are abundant. Three species occur in the United States, two of which are limited to southern Florida. All these species have some white markings on the tarsi, although they are usually faint in dead specimens and are easily overlooked. The most obvious recognition character is the marking of the abdomen, in which the dark scales of the dorsum and the white scales of the venter meet at the side to form a straight line. The mesonotum lacks the dorsocentral bristles and is covered with broad, appressed scales instead of the narrow, semierect scales of *Culex*. They differ from all the other genera in having a tuft of bristles on the postnotum. The palpi are short in both sexes.

WYEOMYIA MITCHELLII (Theob.)

The larvae of this mosquito occur in water that collects at the base of the leaves of epiphytic Bromeliaceae. They occur throughout the year, provided their breeding places do not become dry. The females bite readily and are encountered occasionally in some abundance. They do not migrate far from their breeding places. The white markings on the feet are more noticeable when the insects are flying. When at rest the hind legs are turned up over the back with the feet pointing forward. The species is found in the United States only in southern Florida. Specimens have been taken as far north as Orange and Volusia Counties (latitude 28.5–29°).

WYEOMYIA VANDUZEEI D. and K.

The habits and distribution of this species are almost identical with those of *Wyeomyia mitchellii*. The adults of the two species are distinguished with difficulty, except by male terminalia.

WYEOMYIA SMITHII (Coq.)

(Pitcherplant mosquito)

This is a northeastern species that has been reported as far south as Theodore, Ala. It breeds exclusively in the pitcherplant (*Sarracenia purpurea*). The female is not known to bite.

SYNOPTIC TABLES FOR IDENTIFICATION OF THE MOSQUITOES OF THE SOUTHEAST

The accompanying tables have been prepared in the usual form of opposed couplets, but the principal keys are more detailed than usual, to provide in one place a fairly complete comparative description of each species. The most obvious characters are given in the first sentence of each couplet and are followed, in brackets, by others that help to define the species or group. The latter are used frequently in confirming a provisional identification, and should be of especial value to one just beginning a study of mosquito taxonomy. Many of them are of further use when the first characters mentioned

cannot be employed owing to the loss of scales or appendages. When there is doubt as to which part of a couplet the specimen fits, it is the practice to follow out both divisions to find a later fit if possible. When a character is mentioned (usually within the brackets) in one part of a couplet but not in the other, it may or may not be present in one or more of the species to which the other part of the couplet leads and is referred to later with each of these species or groups. While these are not specific characters, they are of assistance at times in determining which division of the key to follow.

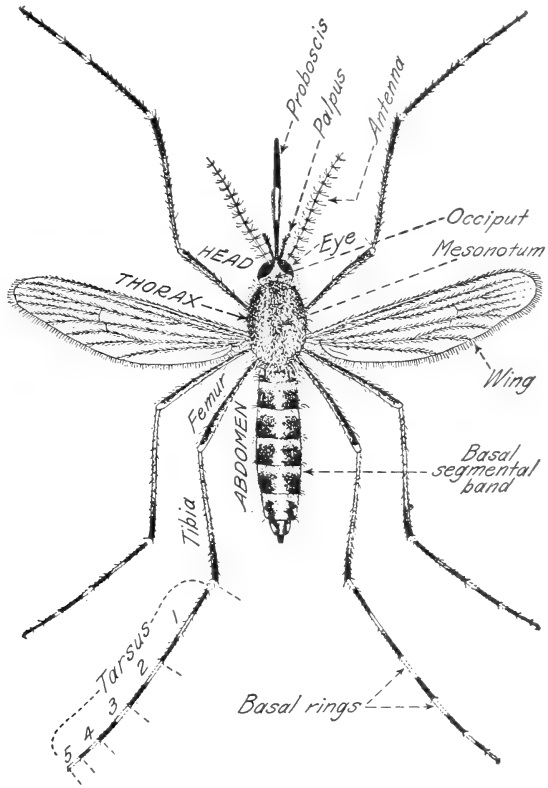

FIGURE 14.—Female mosquito (*Aedes sollicitans*), with names of the parts.

As previously mentioned, a preliminary identification of the genus is not required in using the key to adults. In practical experience it is found that specific characters in the adult frequently are more easily recognized than generic characters, and in routine work most identifications are made without reference, for example, to the thoracic bristles, the genus being known by the recognition of the species. However, some of the genera, such as *Anopheles* and *Megarhinus*, are recognizable on sight, and in the larval stage practically all the species fall naturally into the generic groupings, as may be noted in the larval key.

The external characters and the terminology of the parts employed in the descriptions of adult mosquitoes are shown in figures 14, 15, and 16.

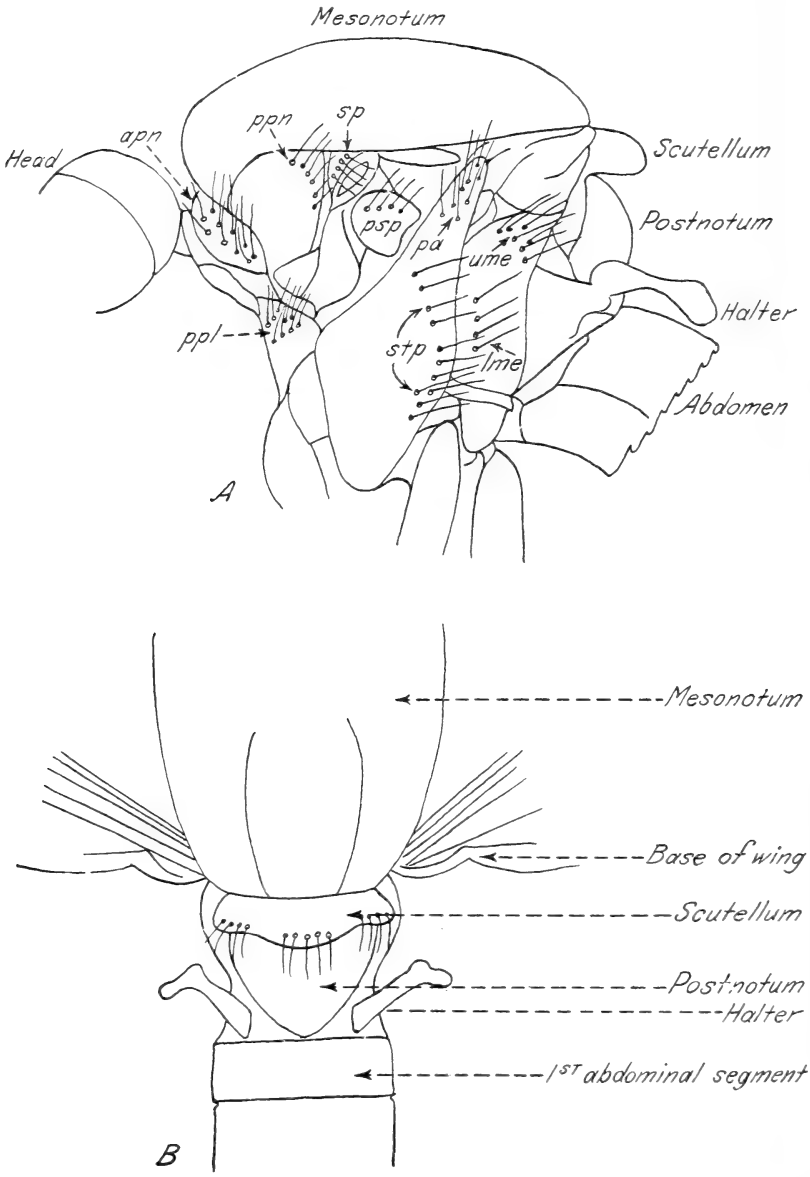

FIGURE 15.—*A*, Composite diagram of thorax of adult mosquito, showing the groups of pleural bristles: *apn*, Anterior pronotal (prothoracic); *ppn*, posterior pronotal (proepimeral); *ppl*, propleural (prosternal); *sp*, spiracular; *psp*, postspiracular; *pa*, prealar; *stp*, sternopleural; *ume*, upper mesepimeral; *lme*, lower mesepimeral. *B*, Posterior portion of thorax from above.

In preparing to identify a mosquito specimen, one should make a preliminary examination at a comparatively low magnification, to note the more obvious markings of the tarsi, proboscis, thorax, etc. With experience the approximate position of the insect, frequently both genus and species, is recognized from this examination. In the Southern States, after the *Anopheles* are separated, nearly all the

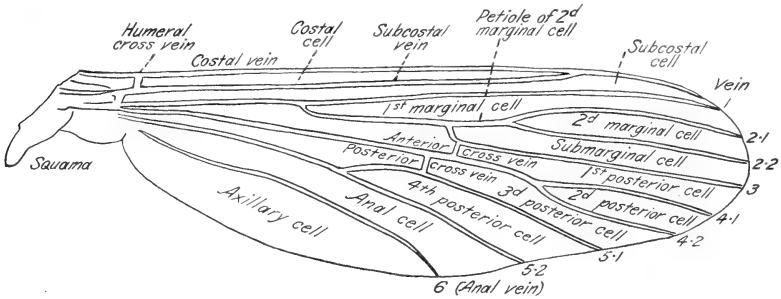

FIGURE 16.—Wing of mosquito (Howard, Dyar, and Knab). The corresponding symbols for the veins in the Comstock-Needham system are: 1, *R;* 2.1 and 2.2, R_2 and R_3; 3, R_{4+5}; 4.1, M_{1+2}; 4.2, M_3; 5.1 and 5.2, Cu_1 and Cu_2; anterior cross vein, *r–m;* posterior (basal) cross vein, *m–cu.*

species having the legs unbanded and the mesonotum unmarked are *Culex*, *Culiseta*, or *Deinocerites*. The species of banded-legged *Culex* are extremely rare in this area. In the species of all the other genera, except *Psorophora cyanescens* and *Aedes cinereus*, some of the tarsal segments are ringed with white, or the mesonotum has bicolorous scaling in definite patterns.

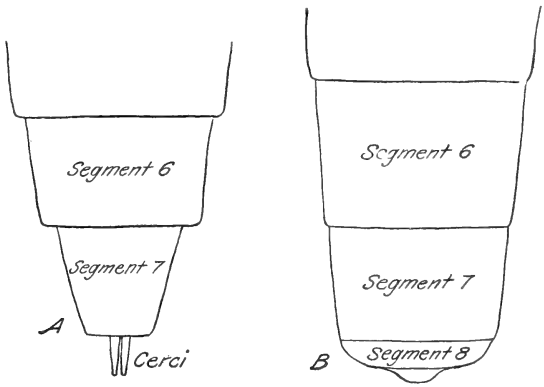

FIGURE 17.—Characteristic shapes of tip of female abdomen: *A*, *Aedes* (also similar in *Psorophora*); *B*, *Culex.*

Aedes and *Psorophora* females can nearly always be distinguished from those of other genera by the tapered end of the abdomen, as shown in figure 17. This is a very useful character to remember in working with the keys, but it has not been employed as the principal means of separating these genera because it is not always definite. (Particular care must be taken in examining specimens filled with

blood or ova.) As shown in the generic key, *Aedes* and *Psorophora* are distinguished also from the other mosquitoes, except *Mansonia titillans*, by the presence of postspiracular bristles. The *Psorophora* are distinguished from *Aedes* by having spiracular bristles as well, although it is frequently very difficult to see them. In *Psorophora*, however, the dorsal or lateral pale scaling of the abdominal segments is apical or diffuse, whereas in *Aedes* it is generally basal or extends from the base. In *Psorophora*, subgenus *Grabhamia*, the femora and tibiae are speckled, and at least the hind femur has a narrow white ring near the apex. In subgenera *Psorophora* and *Janthinosoma* the mesonotum is partially or completed covered with broad, flat scales, and some of the leg scales frequently are erect. The subgeneric divisions of *Aedes* are not easily defined on markings, and these groupings have not been included. The subgenera of *Culex* have been referred to in the discussion of that genus.

Difficulties may arise from the separation of the species of *Wyeomyia* on the pale tarsal markings, as these are easily overlooked. The species are of extremely limited distribution, however, and are rarely collected. The positive means of identification of the genus is by the presence of postnotal bristles.

Keys to Adults

All the known southeastern species are included in the first key. Following this is a short key to the male terminalic characters of the dark-legged *Culex* and then a separate key giving a synopsis of generic characters.

SPECIES KEY

In the species key the characters apply primarily to the female, unless the male is mentioned. Although the markings of the male are generally similar to those of the female and the males of most species can be identified by the characters given, some differences occur in the distribution of the pale scales. The white bands on the abdominal segments, for example, cannot be used satisfactorily in identifying the males of the subgenus *Culex*. This key is preceded by a synopsis of the principal divisions.

Mosquitoes having long palpi in both sexes ..... Couplet 2
Genus *Anopheles* 2
Mosquitoes having a rigid proboscis, down-curved on outer half; very large, iridescent species 10
Genus *Megarhinus* 10
Mosquitoes having the second marginal cell very short; very small species having iridescent thoracic markings 12
Genus *Uranotaenia* 12
Mosquitoes without tarsal or mesonotal markings 14
Genus *Deinocerites* 14
Genus *Psorophora* (*P. cyanescens*); *Aedes* (*A. cinereus*) 16
Genus *Culex* (except *C. bahamensis* and *C. tarsalis*); *Theobaldia* 17
Mosquitoes with tarsal or mesonotal markings, or both 26
Large species, with long, erect scales on femora and tibiae; the gallinippers 27
Genus *Psorophora* (*Psorophora*) 27
Bright yellow species 28
Genus *Aedes* (*A. fulvus pallens*) 28

Mosquitoes with tarsal or mesonotal markings, or both—Continued.

1. Female palpi as long as proboscis or nearly so (fig. 1, *A*). [Abdomen not covered with flat scales; scutellum evenly rounded; wings usually spotted; male palpi long, clubbed at tip (fig. 1, *D*).] Tribe Anophelini, genus *Anopheles* 2

   Female palpi much shorter than proboscis. [Abdomen covered with flat scales; wings usually unspotted; male palpi not clubbed at tip.] 9

2. Wings with areas of white scales 3

   Wings entirely dark-scaled 6

3. Tarsi dark 4

   Tarsi with conspicuous white rings. [Hind tarsi with segments 3 and 4 and the apical half of segments 2 and 5 white; a narrow white ring at apex of segment 1; some of segments on other tarsi narrowly ringed; wings well spotted with white.] A tropical species, reported once from Key West ..... *Anopheles albimanus*

4. Costa with a white spot at the outer third (opposite tip of subcostal vein); anal vein with one or two areas of dark scales 5

   Costa dark except at extreme tip of wing; anal vein with three dark spots separated by white (two spots in male). [Apical segment of palpi pale and segments 3 and 4 with narrow pale bands or a few pale scales at the joints; stem of vein 5 frequently white-scaled in *bradleyi* but always dark in *crucians* and *georgianus*.]

   Anopheles crucians
   Anopheles bradleyi
   Anopheles georgianus

5. Veins 3 and 5 entirely dark-scaled. [Subcosta and vein 1 dark opposite base of vein 2; apical half and basal one-fourth of anal vein dark-scaled; palpi dark; mesonotum with a wide median frosted stripe, the sides dark.] Common in certain parts of the South

   Anopheles punctipennis

   Veins 3 and 5 with long pale areas centrally. [A white spot on subcosta and vein 1 opposite base of vein 2; apical half of anal vein dark, basal half white; apical palpal segment pale and a narrow ring at base of fourth segment.] Has been taken occasionally in the States along the Mississippi River ..... *Anopheles pseudopunctipennis*

6. Wings with spots of dark scales, more or less distinct, or palpi with rings of white scales; mesonotal bristles mostly short 7

   Mesonotal bristles very long, average length about one-half width of mesonotum: wings unspotted: palpi and legs dark-scaled. A small species breeding in tree holes ..... *Anopheles barberi*

7. Wings with four distinct black spots; palpi dark; femora with very small spots of white at tips (knee spots). [Processes of ninth tergite of male stout, expanded at tip.] Prevalent throughout the South

   Anopheles quadrimaculatus

   Palpi ringed with white scales or knee spots lacking; dark spots on wings usually indistinct; general appearance very dark. [Processes of ninth tergite of male long and pointed.] 8

8. Palpi narrowly but usually distinctly ringed at apex of each segment; knee spots present. [Phallosome (mesosome) of male with second pair of leaflets from apex more than half the length of first pair.] Breeds in fresh water ..... *Anopheles walkeri*

   Knee spots usually absent; palpi with faint white rings on apical segments or entirely dark; wing spots indistinct or lacking. [Phallosome of male with the second pair of leaflets no more than half the length of first pair.] Breeds in salt water ..... *Anopheles atropos*

9. Proboscis normal, straight or only slightly curved, not tapered. [Scutellum trilobed and with separated tufts of setae.]——Tribe Culicini 11
Very large iridescent species of striking appearance; proboscis rigid, the outer half tapered and sharply curved downward (fig. 2, *A*). [Female palpi one-half or two-thirds as long as proboscis; second marginal cell less than half as long as its petiole; scutellum evenly rounded and scaled.] Rare tree-hole breeders
Tribe Megarhinini, genus *Megarhinus* 10

10. Front tarsi of male entirely dark. [Mesonotum dark, with a median line and a border of white or yellowish scales; abdomen dark blue above, yellowish below; palpi and legs with iridescent blue reflections; female tarsi of front and middle legs with second, third, and part of fourth segments white; hind tarsi with fourth and most of fifth segments white; male with fourth segment of hind tarsi pale and second segment of middle tarsi pale on one side, or dark; front tarsi dark.] Occurs sparingly in most of the South
Megarhinus septentrionalis
Female very similar to above; male also similar except that second and part of third segments of front and middle tarsi are pale dorsally. Very rare, Florida and Georgia——*Megarhinus rutilus*

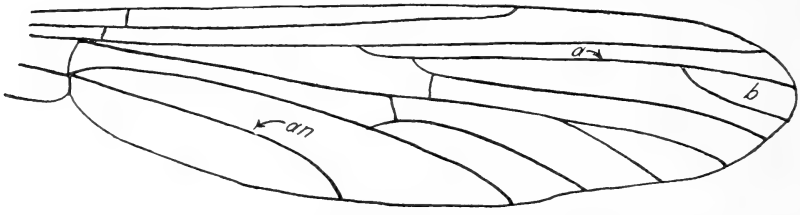

FIGURE 18.—Wing of *Uranotaenia*, showing relation of length of the second marginal cell (*b*) to its petiole (*a*); also the short anal vein (*an*).

11. Second marginal cell normal, as long as or longer than its petiole; mostly medium-sized or large species, or, if small, without lines of bluish scales on thorax—— 13
Second marginal cell less than half as long as its petiole (fig. 18); very small species with lines of bluish or purplish scales on thorax and on base of vein 5. [Anal vein short, ending before level of fork of vein 5; squamae bare; palpi short in both sexes.]——Genus *Uranotaenia* 12

12. Mesonotum with a narrow median longitudinal line of bright bluish scales (fig. 12, *J*); tarsi all dark. A common species
Uranotaenia sapphirina
Mesonotum dark above, with a short line of purple scales on lateral margin; patches of pale purplish scales on sides of thorax and on anterior pronotal lobes; apex of third and entire fourth and fifth hind-tarsal segments white. Common in Florida and southern Louisiana——*Uranotaenia lowii*

13. Tarsi not ringed with white and mesonotum without distinct markings (except small white dots in *C. restuans*)—— 14
Tarsi with pale markings or mesonotum marked with bicolorous scaling in definite patterns (lines or patches)—— 26

14. Antennae normal, not longer than proboscis, first flagellar segment of about same length as succeeding ones—— 15
Antennae much longer than proboscis, with a very long first flagellar segment, equal in length to several of succeeding ones. [Tip of abdomen somewhat appressed laterally, making height equal to width; sternopleural sclerite almost completely covered (shingled) with dark appressed scales; mesonotum with hairlike scales; palpi and antennae similar in both sexes.] The crab-hole mosquito, found in coastal areas of southern Florida—— *Deinocerites cancer*

15. Tip of abdomen blunt (fig. 17, *B*), eighth segment visible, the cerci retracted or inconspicuous; mesonotum covered with narrow lanceolate scales or with hairlike scales (if very small species, covered with

broad, dark, appressed scales, see last half of couplet 43). [Postspiracular bristles absent.]---------- *Culex, Culiseta* 17

Tip of abdomen tapered (fig. 17, *A*), eighth segment usually retracted, the cerci exserted. [Postspiracular bristles present.]---------- 16

16. Mesonotum with scattered broad, pale scales; abdominal segments with apical pale scaling. A bluish *Psorophora* (*Janthinosoma*), which lacks the white bands on the hind tarsi (see couplet 40)

Psorophora cyanescens

Mesonotal scales narrow, dark; abdomen usually with basal segmental bands that widen laterally. [Palpi short in both sexes.] Rare in South---------- *Aedes cinereus*

17. Medium-sized or small species; wings and legs not speckled with white scales. [The two cross veins arising from vein 4 well separated.]---- 18

A large species with unusually broad, lightly scaled wings; costa and first vein, femur, and tibia sprinkled with white. [The two cross veins in center of wing (arising from vein 4) separated by less than the length of either one; dorsal surface of abdominal segments with diffused pale scaling basally and laterally; spiracular bristles present; base of subcostal vein on under side of wing with a row of long setae.] Rare in Florida but occasionally common elsewhere

Culiseta inornata

18. Dorsal abdominal white bands or lateral spots basal when present-- 19

Abdomen with narrow dorsal bands and (or) lateral spots of white scales on apical (posterior) margin of segments---- *Culex apicalis*

19. Abdomen dorsally with conspicuous segmental bands of white scales. [Seventh segment without pale scales posteriorly; occiput with narrow, curved scales; outstanding wing scales narrow.]---------- 20

Abdomen unbanded dorsally or with narrow segmental bands (fairly broad bands of yellowish scales sometimes present in *C. salinarius*)-- 22

20. Abdominal bands with a rounded posterior border (usually most typical on segments 3 to 5) and the bands interrupted or much narrowed at lateral margins. [Mesonotum without dots; mesonotal vestiture of narrow, curved, or lanceolate scales pale brown or grayish and having a coarse appearance; second marginal cell usually two and a half to three times the length of its petiole.] The southern house mosquito

Culex quinquefasciatus

Abdominal bands continuous to lateral margins, their posterior borders somewhat irregular but not evenly rounded. [Second marginal cell long, usually four or five times as long as its petiole.]---------- 21

21. Mesonotum usually with a pair, sometimes two pairs, of small white dots near the middle (fig. 12, *K*) and with grayish scales around the margins; mesonotal vestiture otherwise brownish and with a smooth appearance, mostly of fine hairlike scales. The white-dotted *Culex*

Culex restuans

Mesonotum without white dots; mesonotal scales coarser and grayish in color (similar to *C. quinquefasciatus*). The northern house mosquito, recorded from several Southern States---------- *Culex pipiens*

22. Wings with all outstanding scales long and slender (fig. 19, *A*); occiput (top part of head back of eyes) without flat scales; mesonotum with very fine dark-brown hairlike scales. Medium-sized species---------- 23

Outstanding scales of wing, at least on branches of vein 2, slightly or distinctly broadened (fig. 19, *B*); occiput with some broad, flat scales (except in *Culiseta melanura*)---------- 24

23. Abdomen usually with a few yellowish or dingy white scales at base of some segments, or with narrow transverse bands; tips of segments sometimes slightly pale-scaled and seventh segment frequently entirely pale-scaled; three or four groups of white scales on side of thorax. Abundant in some sections of South and East

Culex salinarius

Abdomen dark-scaled above except for lateral white spots on some segments; scaling on pleurae somewhat variable but frequently entirely lacking or, if present, limited as a rule to less than a half dozen scales in any of the groups. Abundant in Florida, rare elsewhere

Culex nigripalpus

24. Occiput with broad dusky or pale appressed scales in front, sometimes limited to a narrow border along the eyes, but extending to or nearly to vertex; abdominal segments with or without narrow white bands. Small *Culex*, subgenus *Melanoconion*_____ 25

Occiput without flat scales. [Proboscis unusually long (longer than abdomen); wing scales dense and distinctly broadened; spiracular bristles and ventral setae at base of subcosta present as in *Culiseta inornata* (lacking in all *Culex*).] A comparatively rare species, greatly resembling typical *Culex*_____ *Culiseta melanura*

25. Occiput mostly covered with broad appressed scales, the narrow scales limited to a median line or a small triangular patch. [Tip of male abdomen much enlarged in *Culex peccator*.]_____ *Culex pilosus*
Culex peccator

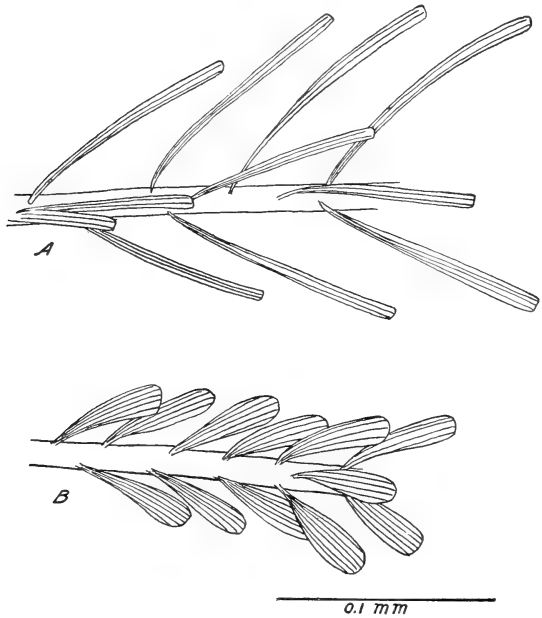

FIGURE 19.—Representative shapes of the outstanding wing scales on the central portion of the forks of vein 2: *A*, *Culex* (*Culex*); *B*, *Culex* (*Melanoconion*).

Occiput with a large median triangular area of narrow scales extending nearly to the vertex, the broad appressed scales often reduced to a narrow line bordering the eyes. [Mesonotal scaling often bronzy or golden.]_____ *Culex erraticus*

(Adults of the *Melanoconion* species cannot be identified with certainty except by characters of the male terminalia, which are given in a separate table).

26. (13) Not exceptionally large species; legs not markedly shaggy_____ 28

Very large species of striking appearance, the gallinippers (fig. 2, *B*); legs shaggy or with tufts of long, erect scales toward tips of femur and tibia. [Side of mesonotum with an area of broad white appressed scales, bordered by smooth nude areas; posterior pronotal lobe nude, or with very few scales or bristles.]
Psorophora (*Psorophora*) 27

27. Legs, especially the hind pair, with long, erect scales; mesonotum with a median stripe of golden scales (fig. 12, *H*); tarsi with basal pale rings; proboscis ringed; general color yellowish__ *Psorophora ciliata*

Legs much less shaggy, only tips of femora and hind tibiae with long, erect scales; mesonotum without a median stripe of golden scales; first two segments of hind tarsi usually with very narrow pale basal rings; proboscis not ringed; general color bluish
Psorophora howardii

28. Mesonotum bright yellow (both scales and integument), with two prominent, shiny, black spots on posterior corners; costa and vein 1 yellow-scaled from base to tip of subcostal vein. [Proboscis, femora, and tibiae yellow, tipped with dark; first two tarsal segments largely yellow, apical segments darker.] A conspicuously yellow species; usually rare ..... *Aedes fulvus pallens*
Not so marked 29

29. Proboscis and tarsi ringed with white 30
Proboscis not ringed with white 40

30. Wing scales very broad, mixed brown and white. [Abdomen blunt; femora, tibiae, and proboscis with mixed brown and white scaling.] Genus *Mansonia* 31
Outstanding wing scales narrow (cf. veins 2 and 4) 32

31. Hind tibiae with a wide pale ring on apical half, and first segment of hind tarsi with a wide pale ring at middle; proboscis broadly ringed; postspiracular hairs absent. Locally prevalent in Southern and Eastern States ..... *Mansonia perturbans*
Tibia and first segment of hind tarsi unbanded or bands indistinct; pale ring on proboscis narrow; postspiracular hairs present. Southern Florida and Tropics ..... *Mansonia titillans*

32. Femora without white rings; abdominal tergites with basal pale bands or lateral spots, or a longitudinal pale stripe 33
Hind femur with a very narrow ring of white scales toward apex; abdominal segments pale-scaled apically, the pale scaling diffuse or extending forward at sides or centrally. [Legs and wings with mixed dark and pale scales, wings of some species also with spots of pale scales; spiracular and postspiracular bristles present; claws of females not toothed.] ..... *Psorophora* (*Grabhamia*) 37

33. Tarsal segments with basal and apical pale rings, at least on hind tarsi. [Female abdomen blunt; postspiracular hairs absent.] Banded-legged *Culex* 34
Tarsal segments without apical banding. [Abdomen tapered; postspiracular hairs present.] ..... *Aedes* (*taeniorhynchus* group) 35

34. Tarsal rings broad; femora and tibiae with a longitudinal line of white scales on outside; wings usually with a patch of white scales at base of costa. Taken very rarely in Louisiana, Arkansas, Florida, and Tennessee, common in Western States ..... *Culex tarsalis*
Tarsal rings very narrow, apical banding limited to hind tarsi; femora and tibiae not lined with white; wing scales entirely dark. A tropical species that has been recorded from the Florida keys
Culex bahamensis

35. Abdomen with a dorsal longitudinal stripe of yellowish scales (fig. 14); femora and tibiae speckled with white. [Mesonotum golden; proboscis and hind-tarsal segments broadly ringed; last hind-tarsal segment entirely white.] 36
Abdomen with transverse dorsal bands but without a longitudinal stripe; dark portions of femora not speckled; mesonotum with dark or brownish scales, sprinkled with silver posteriorly. [Proboscis and tarsi usually with rather narrow bands of white scales; first hind-tarsal segment not ringed in middle; tip of last hind-tarsal segment usually dark in southern specimens; wing scales narrow, entirely dark.] An important salt-marsh species, of somewhat less than the average size ..... *Aedes taeniorhynchus*

36. Wing scales brown and white mixed; first hind-tarsal segment with a pale ring in middle. Important salt-marsh species ..... *Aedes sollicitans*
Wing scales entirely dark, first hind-tarsal segment without a central pale ring. A fresh-water breeder, usually rare ..... *Aedes mitchellae*

37. First hind-tarsal segment ringed in middle or largely pale 38
First hind-tarsal segment without a central ring. A West Indian species, recorded once from Florida (Key West) ..... *Psorophora pygmaea*

38. Legs and wings black-scaled, speckled with white, but wings without well-defined areas of pale scales; first hind-tarsal segment dark, ringed with white in middle and at base; mesonotal scales dark, well sprinkled or frosted with white. A fairly large, blackish species, common in the Southern States ..... *Psorophora confinnis*

Costa and veins with well-defined areas of pale scales; tibia and first hind-tarsal segment largely pale-scaled, intermixed with dark and ringed with dark scales apically 39

39. Wing costa with a spot or area of pale scales at base and one at tip of subcostal vein, remainder of costa dark intermixed with white; anal vein with apical third dark-scaled, basal portion pale; wing fringe without pale spots. [Vein 3 with apical half and base dark-scaled, separated by a spot of pale scales; anterior fork of vein 4 and both forks of vein 5 pale centrally.] Rare southern species *Psorophora discolor*

Apical half of costa with two prominent dark spots separated by a longer pale area; anal vein with pale scaling apically and basally, separated by a spot of dark scales at about apical third; pale fringe spots present opposite tips of all longitudinal veins. Recorded only from Arkansas in the Southeastern States ..... *Psorophora signipennis*

40. (29) Tarsal pale scaling restricted to one or more of last three segments of hind tarsi. [Abdomen blue-black, the tergites with apical or lateral pale scaling; mesonotum with broad appressed pale scales, mixed with the dark scales or segregated at sides.] *Psorophora* (*Janthinosoma*, except *P. cyanescens*) 41

Tarsal pale scaling not restricted to apical segments of hind tarsi or tarsi entirely dark. [Dorsal segmental pale scaling of abdomen basal when present.] 43

41. Last two segments of hind tarsi white 42

Fourth segment of hind tarsi white, at least dorsally, the fifth segment dark. [Mesonotum dark in center, sides covered with broad white scales (fig. 12, *G*).] Usually rare. (Formerly known as *Psorophora discrucians*) ..... *Psorophora varipes*

42. Mesonotum covered with a mixture of brown and broad white scales. [Hind tibia and tarsus with erect scales; tarsal markings usually extending onto tip of segment 3.] Common woods species, the white-footed mosquito. (Formerly known as *Psorophora sayi*) *Psorophora ferox*

Mesonotum dark centrally, the sides covered with broad yellowish-white scales. Rare ..... *Psorophora horrida*

43. Medium-sized species; mesonotum with a vestiture of narrow-curved or hairlike scales. [Metanotum without setae; abdominal tergites with pale bands or lateral spots on the segments.] 44

Very small species, mesonotum covered with broad, appressed, dark scales; some of midtarsal segments white for entire length on one side, but tarsal markings sometimes very indistinct; abdominal scales entirely dark dorsally and pale ventrally, the two colors meeting at side in a straight line. [Metanotum with a tuft of setae; dorsocentral bristles of mesonotum absent; anterior pronotal lobes large, covered with flat scales; tip of abdomen blunt and more or less expanded; palpi short in both sexes.] ..... Genus *Wyeomyia* 60

44. Tarsi ringed with white 45

Tarsi not ringed with white 53

45. Mesonotum with delicate longitudinal lines of white or silvery scales .. 46

Mesonotum without such lines 48

46. Thorax with four silvery lines, the outer pair curved to form a lyre-shaped marking (fig. 12, *A*); outstanding wing scales narrow and dark. [Hind tarsi with wide contrasting basal white bands, last two segments largely white; front and middle tarsi with narrow basal bands or spots on first two segments, the others dark.] The yellow-fever mosquito ..... *Aedes aegypti*

Mesonotum with four long silvery lines, and four short lines posteriorly, not in shape of lyre (fig. 12, *I*); wing scales broad, mixed with white. [Hind tarsi with broad basal and apical bands; femora sprinkled with white; tibiae and proboscis with longitudinal lines of white scales; fourth segment of fore tarsi very short; wing with a

white spot extending across the veins from the stem of vein 2 to 5.1, and base of anal vein white; spiracular and postspiracular bristles absent; posterior pronotum with two to five bristles.] Rare, tree-hole breeders ..... Genus *Orthopodomyia* 47

47. Tergite of second abdominal segment with continuous black scaling apically; integument of segment 1 brownish ..... *Orthopodomyia signifera*
Tergite of segment 2 almost entirely pale-scaled, extending to the apex in middle of segment; integument of segment 1 yellowish
Orthopodomyia alba

48. Tarsal segments ringed only basally 49
Hind-tarsal segments ringed basally and apically; last hind-tarsal segment entirely white 51

49. Tarsi with very narrow basal bands, those on hind tarsi usually no wider than diameter of segment; basal abdominal pale bands with a V-shaped notch in middle of posterior margin on some segments; wing scales narrow, entirely dark. Rare in Florida, frequently abundant elsewhere. (Formerly known as *A. sylvestris*) ..... *Aedes vexans*
Tarsal segments with broad basal bands; wing scales intermixed with white; mesonotum whitish on sides, with a median dark stripe 50

50. Wing scales narrow. Recorded from Mississippi ..... *Aedes stimulans*
Wing scales broad; femora and tibiae speckled. Recorded from Mississippi, Louisiana, and Arkansas ..... *Aedes grossbecki*

51. Wing scales dark; abdomen dark-scaled dorsally, with basal bands or lateral pale spots 52
Wing scales bicolored; abdominal segments almost entirely pale-scaled except for dark quadrate spots laterally; mesonotum pale, with a median dark stripe of variable width. Reported from Louisiana
Aedes dorsalis

52. Mesonotum golden brown, without a median longitudinal dark stripe. Occurring sparingly throughout the South ..... *Aedes canadensis*
Mesonotum pale, with a well-defined median dark stripe. Breeds in rock holes ..... *Aedes atropalpus*

53. (44) Mesonotum dark brown, with a median longitudinal silvery stripe. [Abdominal segments with lateral pale spots.] 54
Mesonotum without a median silvery stripe 57

54. Median stripe extending full length of mesonotum, the pale area usually narrower (variable in *A. dupreei*) than the dark area on each side (fig. 12, *C*) 55
Median stripe ending just back of middle of mesonotum, the silvery area wider than the dark area on each side (fig. 12, *B*). [Claspette of male terminalia with a flattened filament having one long and several shorter median, retrorse spines.] Fairly common ..... *Aedes infirmatus*

55. Medium-sized species (wing about 3.5 mm.); occiput with a large median area of pale lanceolate scales bordered by broad, appressed, mostly dark scales 56
Small species (wing about 2.5 mm.); occiput with a narrow median line of pale lanceolate scales, bordered by broad pale and dark scales. [Mesonotum of male with a very broad median stripe or entirely silvery-scaled; claspette of male terminalia with a slender stem and filament, the latter slightly longer than the stem and tapered to a sharp point; stem of claspette with a bristle inserted in a raised tubercle near base.] ..... *Aedes dupreei*

56. Two species that are difficult to separate except by male characters. Male terminalia:
Stem of claspette long, greatly enlarged in middle, and densely hirsute; filament stout, much shorter than stem ..... *Aedes atlanticus*
Stem of claspette long and slender, slightly pilose; filament much shorter, with a short, pointed, slightly hooked tip
Aedes tormentor

57. Mesonotum with a prominent patch or stripe of pale scales on each side, dark centrally 58
Mesonotum with two broad submedian stripes of yellowish-white scales, dark centrally and along lateral edges (fig. 12, *E*). [Dark portions of femora not speckled with white; tibiae and first tarsal segments slightly pale on one side.] Usually rare in South ..... *Aedes trivittatus*

58. Tibiae and tarsi almost entirely dark-scaled; dark portions of femora not speckled with white; abdominal tergites with lateral pale spots ---- 59
Tibiae and first segments of tarsi pale on one side for nearly their entire length; dark portions of femora speckled with white; abdominal segments sometimes with basal pale bands that widen laterally. [Mesonotum broadly pale-scaled for its full length on each side, the disk also with pale scales; posterior pronotum with lanceolate scales.] Rare in Southern States ---- *Aedes sticticus*

59. Posterior pronotum densely covered with broad, appressed, white scales; mesonotum with silvery-white scales along sides, the median area broadly dark-scaled (fig. 12, *F*). A common woods species, breeding in tree holes ---- *Aedes triseriatus*
Posterior pronotum with lanceolate scales, not closely appressed; mesonotum with broad patches of yellowish-white scales anteriorly, reduced to narrow lateral stripes posteriorly by an abrupt widening of the median dark-scaled area (fig. 12, *D*). A fairly large species, usually rare ---- *Aedes thibaulti*

60. (43) Hind legs without markings; segments 3 to 5 of midtarsi white on one side. The pitcherplant mosquito, rare ---- *Wyeomyia smithii*
Hind-tarsal segments with basal spots or streaks of white scales underneath; midtarsi as in *W. smithii*. Two species found in the United States only in southern Florida, breeding in the water in air plants (Bromeliaceae) ---- 61

61. Anterior pronotal lobes silvery-scaled ---- *Wyeomyia vanduzeei*
These scales darker, with purplish reflections (difficult to distinguish from the preceding) ---- *Wyeomyia mitchellii*

KEY TO DARK-LEGGED SPECIES OF CULEX BY MALE TERMINALIA [7]

1. Tenth sternite with an apical tuft of short bristles or spines; subapical lobe of sidepiece not divided ---- Subgenus *Culex* 2
Tenth sternite comb-shaped apically, with a row of short, stout teeth ---- 6

2. Subapical lobe of sidepiece with eight appendages; base of tenth sternite produced laterally into a blunt point or a short, nearly straight arm ---- 3
Subapical lobe with five or six appendages; base of tenth sternite produced into a long, stout, strongly curved arm ---- 4

3. Ventral arm of mesosomal plate long, ribbonlike, curved sharply outward toward sidepiece at about the outer third and tapered to a point; dorsal arm slender, pointed, lying more or less parallel with the inner margin of the ventral arm and extending little if any beyond the curved shoulder of this arm ---- *Culex quinquefasciatus*
Ventral arm of mesosomal plate of same general shape as above but somewhat shorter; dorsal arm broader, semicylindrical in appearance, with a truncate, slightly upturned tip; this arm placed obliquely, usually extending to or toward tip of ventral arm ---- *Culex pipiens*

4. Mesosomal plate with two arms and with a median row or group of four to seven short, stout teeth ---- 5
Mesosomal plate without a median row of teeth, the processes consisting of a short lateral arm and a longer posterior arm, which has a small tooth near the base. (Subapical lobe of sidepiece with three rods, a leaf, and two setae) ---- *Culex restuans*

5. Dorsal arm of mesosomal plate short, bent in middle at a right angle (thumblike), with a pointed tip; subapical lobe of sidepiece with three rods, a leaf, and two setae; spines of tenth sternite all sharp-pointed ---- *Culex salinarius*
Mesosomal plate with a stout, straight, dorsal arm from near base; lobe of sidepiece with only one seta after the leaf (apically); spines on one side of tuft of tenth sternite short and bluntly rounded *Culex nigripalpus*

6. Subapical lobe of sidepiece with distinct divisions; comb-shaped portion of tenth sternite bent inward nearly at right angles; mesosomal plate with a long, curved basal arm, directed ventrally (basal hook) Subgenus *Melanoconion* 7

[7] Illustrations of these structures have been omitted, on the assumption of some familiarity with this specialized subject on the part of those using this key.

Subapical lobe not distinctly divided; apex of tenth sternite less strongly curved; mesosomal plate without basal hook; outer end of mesosomal plate studded with small tubercles. Subgenus *Neoculex*, *Culex apicalis*

7. Basal division of subapical lobe of sidepiece divided into two subequal arms, each with a long, stout, capitate filament at tip; stem of clasper comparatively slender 8

Basal division of subapical lobe with one arm bearing a stout filament at tip and a second filament arising from a tubercle near the base; apical division of lobe with a very large, fan-shaped leaf; clasper greatly enlarged apically, the stem stout and constricted near middle; sidepiece subspherical, with a dense patch of fine hairs on inner surface ..... *Culex peccator*

8. Ninth tergite with a widened plate, the lobes projecting from its posterior corners as a pair of short arms; apical swelling of clasper cap-shaped, tapering abruptly; lobe of sidepiece without an expanded leaflet ..... *Culex pilosus*

Lobes of ninth tergite ovate, prominent, with numerous hairs; apical swelling of clasper moderate, gradually tapered; lobe of sidepiece with an expanded leaflet on the apical division ..... *Culex erraticus*

KEY TO GENERA

1. Abdomen with a vestiture of fine hairs; female palpi as long as proboscis; male palpi long, clubbed at tip; scutellum rounded
Tribe Anophelini, genus *Anopheles*

Abdomen covered with flat scales; female palpi much shorter than proboscis; male palpi long or short, not clubbed at tip 2

2. Proboscis rigid, outer half tapered and strongly curved downward; scutellum evenly rounded and scaled
Tribe Megarhinini, genus *Megarhinus*

Proboscis flexible, not bent downward; scutellum trilobed, with separated tufts of setae ..... Tribe Culicini 3

3. Wings with second marginal cell less than half as long as its petiole *Uranotaenia*

Wings with second marginal cell at least as long as its petiole 4

4. Postnotum with a tuft of setae; squamae without a fringe of hairs *Wyeomyia*

Postnotum bare; squamae with a fringe of hairs 5

5. Postspiracular bristles present; segment 1 of abdomen narrowed, segment 8 much narrowed and retractile 6

Postspiracular bristles absent (except in *Mansonia titillans*, in which wing scales are very broad); segment 7 of abdomen not narrowed; segment 8 short but not retractile 7

6. Spiracular bristles present; dorsal segmental pale scaling of abdomen usually apical; mesonotum with at least some broad appressed scales or (in subgenus *Grabhamia*) with simple claws in female .. *Psorophora*

Spiracular bristles absent; dorsal abdominal pale scaling usually basal; scales of thorax narrow or only slightly broadened ..... *Aedes*

7. Spiracular bristles present; base of subcostal vein with a tuft of hairs on under side of wing ..... *Culiseta*

Spiracular bristles absent; hairs absent on under side of subcostal vein .. 8

8. Wing scales broad, mixed brown and white; setae absent at base of vein 1 9

Outstanding wing scales narrow or only slightly broadened, dark; a few setae near base of vein 1 on upper side of wing 10

9. Fourth segment of fore tarsi very short; lower mesepimeral bristles absent; mesonotum with longitudinal lines of white scales ..... *Orthopodomyia*

Fourth segment of fore tarsi normal; lower mesepimeral bristles present; mesonotum without lines of white scales ..... *Mansonia*

10. Antennae not longer than proboscis, the first flagellar segment of normal length; male with bushy antennae and long palpi (in United States species) ..... *Culex*

Antennae much longer than proboscis, the first flagellar segment as long as several of succeeding segments; male antennae and palpi similar to those of female ..... *Deinocerites*

KEY TO LARVAE (FOURTH-STAGE)

The genera are separated in couplets 1 to 9, and the species in the couplets that follow. Air-tube lengths, when mentioned in connection with the species, are given in multiples of the diameter of the base of the tube. Mounted larval skins become flattened by pressure of the cover glass, and allowance must be made for this in estimating the proportions of the tube. Variations may occur in the number of branches as given for certain hairs; that is, a normally double hair may occasionally be single or triple, or a single hair double. In ex-

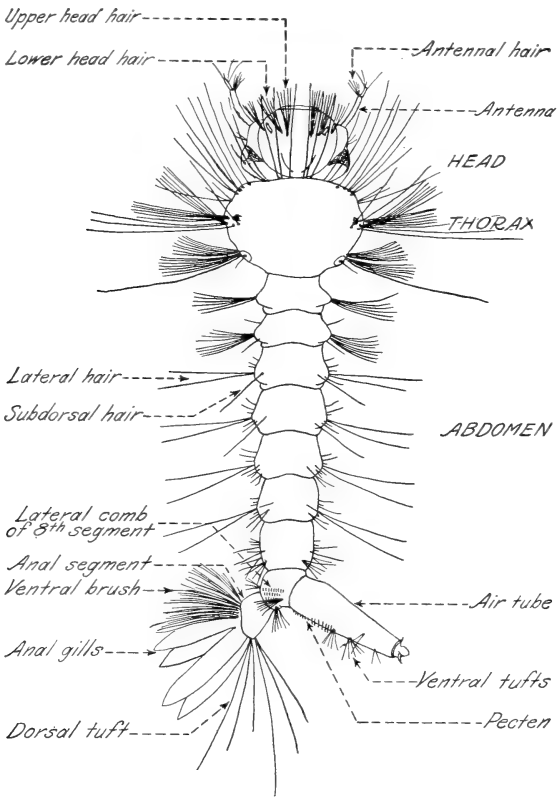

FIGURE 20.—Larva of *Culex quinquefasciatus* with the parts named (Howard, Dyar, and Knab).

amining flattened specimens care must be taken to distinguish between the upper and lower surfaces of the body. The terminology of the larval parts is shown in figures 20, 21, and 22.

Some difficulty is often experienced in distinguishing between third and fourth instars, and no certain rules can be given except for differences in size and in the width of the head capsule. In *Anopheles* larvae a comparatively wide collar of dark sclerotin (chitin) at the base of the head is usually distinguishable in the third instar. In larvae of *Psorophora* and *Culex*, and in those species of *Aedes* in which the anal segment is completely ringed by a plate of sclerotin in the

fourth instar, the ring is incomplete, so far as observed, in the third instar. With other species of *Aedes* the plate is reduced to a small dorsal saddle in the third and earlier instars.

1. Eighth abdominal segment with an elongate air tube (figs. 10, *B*, and 20); abdomen without palmate hairs 2
   Air tube lacking (spiracles sessile); some abdominal segments with dorsal palmate hairs (figs. 10, *A*, and 22, *B*) ..... *Anopheles* 10
2. Air tube of normal shape, cylindrical or fusiform 3
   Distal half of air tube attenuated (fig. 23, *B*), with saw-toothed projections at tip adapted for piercing the roots of aquatic plants ..... *Mansonia* 21
3. Air tube with a pecten (fig. 24, *A*) 4
   Air tube without a pecten (*Megarhinus*, *Orthopodomyia*, *Wyeomyia*) 8

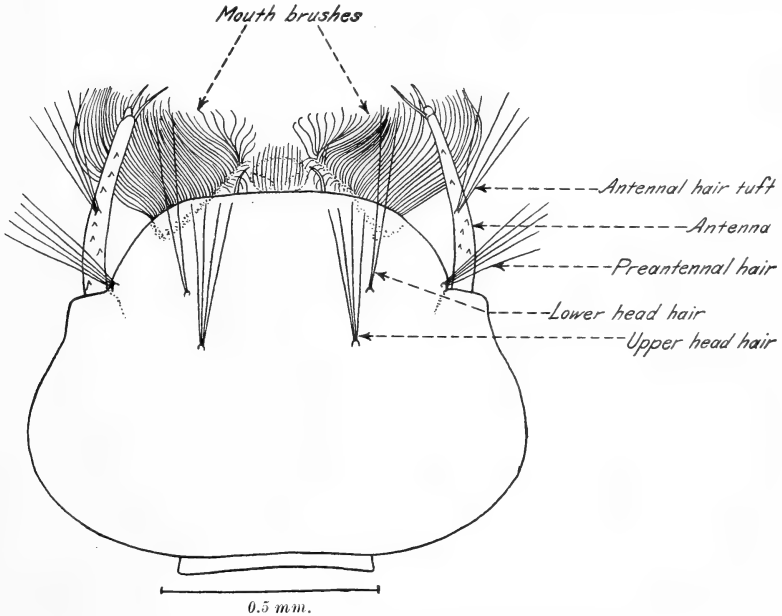

FIGURE 21.—Head of larva of *Aedes vexans*.

4. Head hairs normal, slender, frequently multiple; head wider than long, rounded 5
   Head elongate, elliptical; upper and lower head hairs single, stout, spinelike (fig. 25, *A*). [Eighth abdominal segment with a lateral plate having a row of teeth on its posterior margin; air tube with one pair of ventral brushes; anal segment ringed by plate.] ..... *Uranotaenia* 20
5. Air tube with several paired ventral hair tufts or single hairs, a row of hairs beyond pecten, or a pair of tufts at base (*Culex*, *Culiseta*) 23
   Air tube with a single pair of ventral hair tufts, more or less centrally placed (sometimes very small or obsolete in *Psorophora*; a second very small pair near apex in *Deinocerites*). [Antennae in most of the species of uniform shape, the hair tuft placed near middle.] (*Psorophora*, *Aedes*, *Deinocerites*) 6
6. Anal segment not completely ringed by plate, or, if ringed, tufts forming ventral brush posterior to plate (fig. 24, *A* and *B*); air tube not inflated 7
   Anal segment completely ringed by sclerotic plate and plate pierced on midventral line by tufts of ventral brush (fig. 23, *A*); mouth brushes formed of stout prehensile hairs (subgenus *Psorophora*), or air tube large and swollen centrally (except in *P. discolor*), with few pecten spines. [Comb of few scales in a single row.] ..... *Psorophora* 34

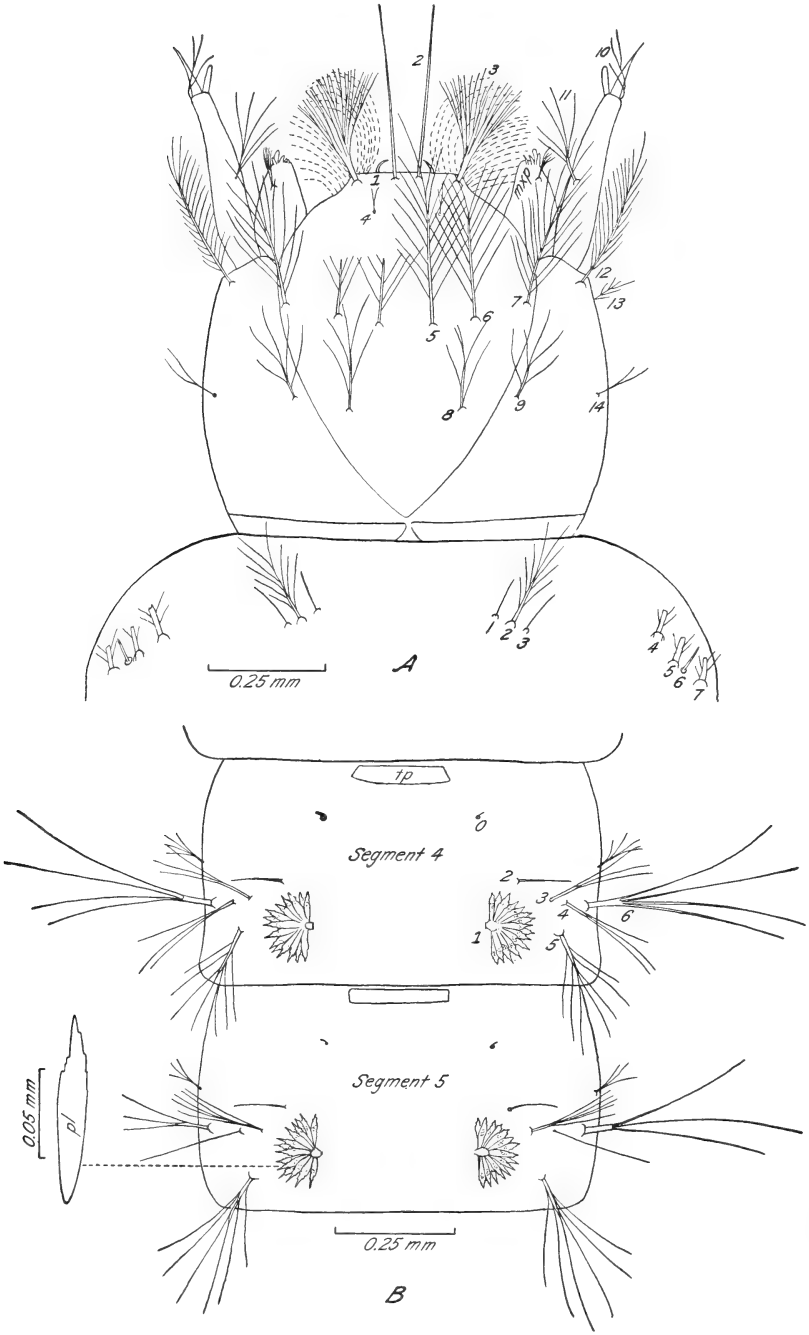

FIGURE 22.—Dorsal hairs of larva of *Anopheles quadrimaculatus: A*, Head and part of prothorax; *B*, abdominal segments 4 and 5. Head hairs: 1, Preclypeal; 2, inner clypeal; 3, outer clypeal; 4, postclypeal; 5–7, frontal; 8–9, inner and outer sutural (occipital); 10, terminal antennal; 11, antennal; 12, preantennal (basal); 13, subbasal; 14, orbital; *mxp*, maxillary palp. Prothorax: 1, Inner submedian; 2, middle submedian; 3, outer submedian; 4–7, lateral. Abdominal segment 4: 0, Anterior submedian; 1, palmate; 2, antepalmate; 3–5, sublateral; 6, lateral; *tp*, tergal plate. Segment 5: *pl*, Enlarged palmate leaflet.

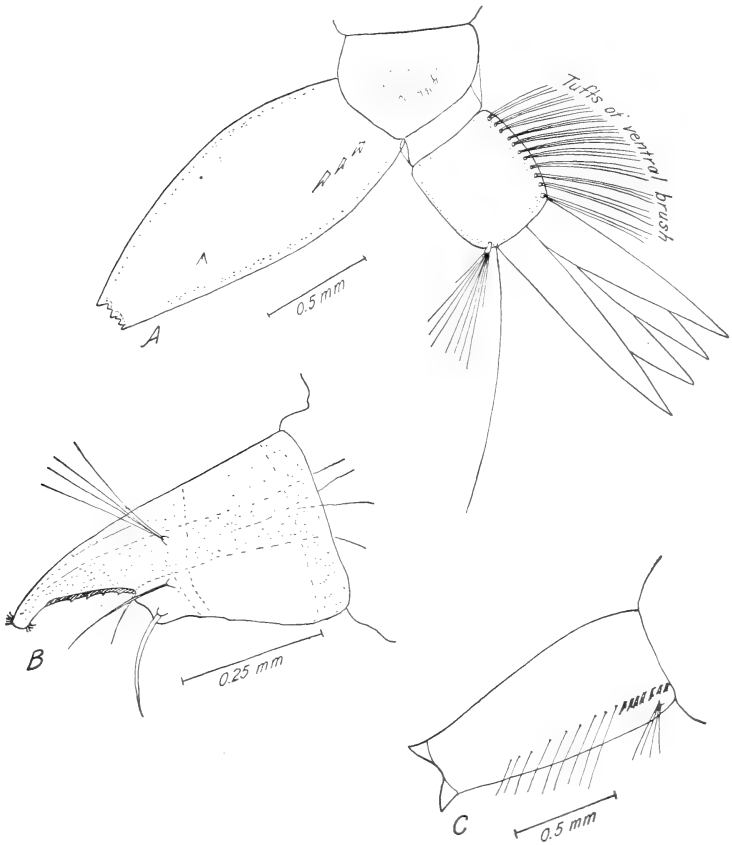

FIGURE 23.—Types of air tubes: *A*, *Psorophora ferox* (also showing terminal segments of abdomen); *B*, *Mansonia perturbans*; *C*. *Culiseta inornata*.

7. Head normal, without lateral pouches; anal gills four; air tubes short and stout in most species ..... *Aedes* 43

DEINOCERITES

Head with a prominent triangular pouch on each side (fig. 25, *B*); only two, very short, anal gills; air tube about 4:1. [Lower head hairs single or double, much longer than upper head hairs; comb of eighth segment of many scales in a patch; tuft of air tube usually double or triple; anal segment with divided dorsal and ventral sclerotic plates.] Breeds in crab holes along coast of southern Florida. One species ..... *D. cancer*

8. Eighth abdominal segment with comb scales; mouth brushes ciliform 9

MEGARHINUS

Eighth abdominal segment without comb scales but with a lateral plate bearing two stout spinulose hairs on posterior margin; mouth brushes consisting of about 10 stout, closely appressed, prehensile, curved rods (fig. 25, *C*). [Air tube short, a single pair of ventral tufts near base; anal segment ringed by plate; anal gills very short.] Very large predacious larvae, occurring in tree holes. The two United States species are separated on male characters ..... *M. septentrionalis*
M. rutilus

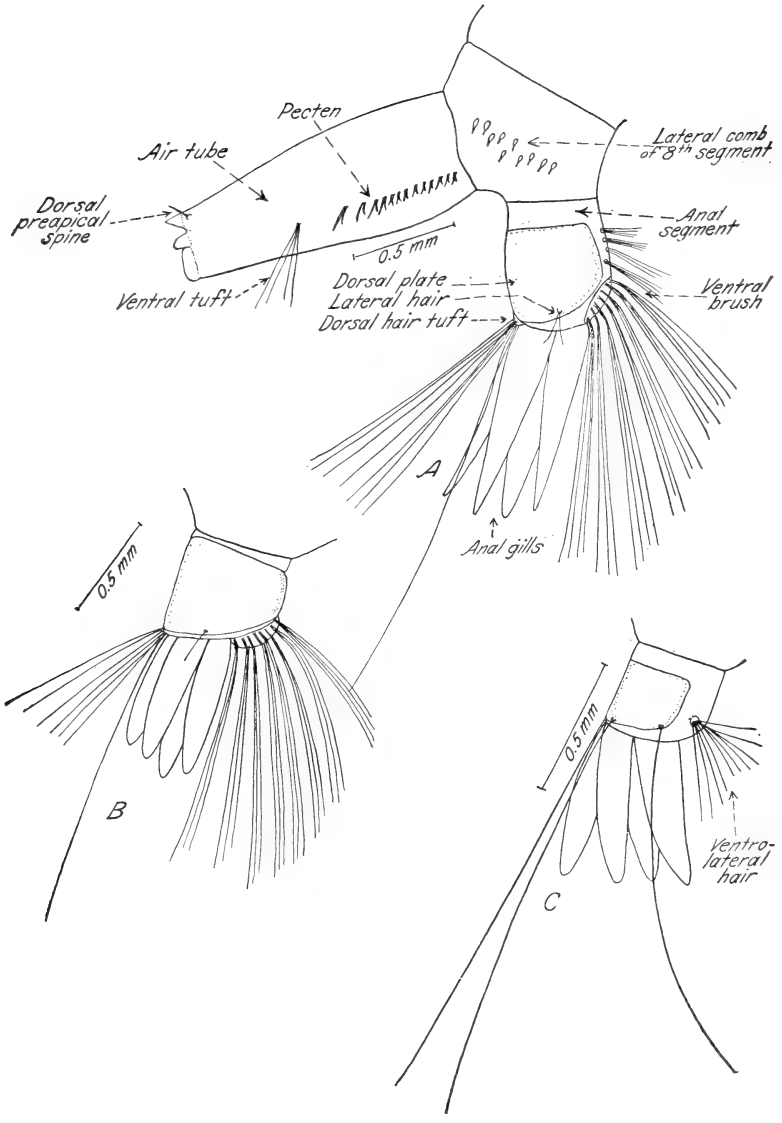

FIGURE 24.—*A*, Posterior portion of abdomen of larva of *Aedes vexans; B*, anal segment of larva of *Aedes mitchellae; C*, same of *Wyeomyia mitchellii*.

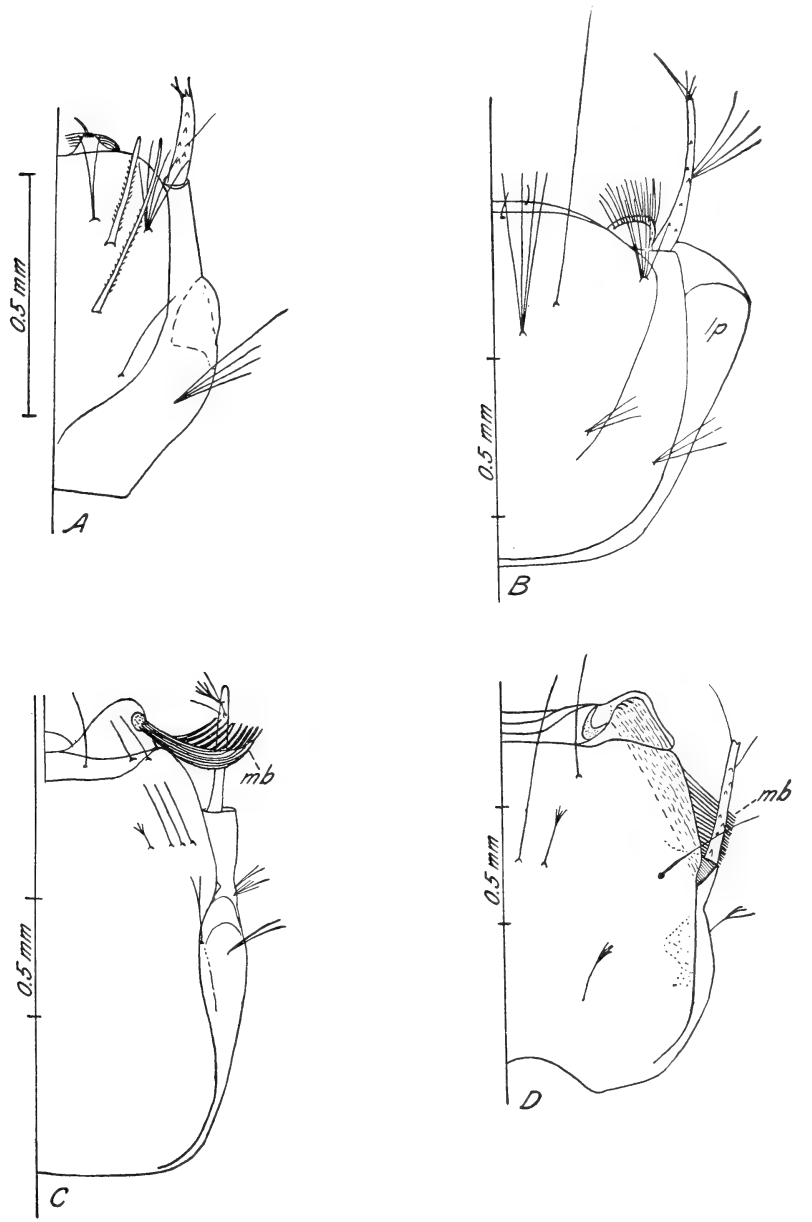

FIGURE 25.—Portions of heads of various mosquito larvae: *A*, *Uranotaenia sapphirina*; *B*, *Deinocerites cancer*; *C*, *Megarhinus septentrionalis*; *D*, *Psorophora ciliata*. *lp*, lateral pouch; *mb*, mouth brush.

9. Anal segment with usual median ventral brush, consisting of a close-set row of tufts; air tube with one pair of hair tufts, attached before middle, each with several long hairs. [Comb with one row of short scales and a second row of very long, pointed scales; antenna with a tuft of about four long hairs, attached before middle; head hairs all multiple; lateral hairs on abdominal segments 3 to 6 long and single; air tube 3 or 4:1.] Tree-hole breeders ..... *Orthopodomyia* 22

Anal segment without a median ventral brush, but with a pair of ventrolateral tufts (fig. 24, *C*); air tube with scattered hairs or small tufts. [Comb scales in a single row; antenna with a single or double hair beyond middle.] Breed in water-holding plants ..... *Wyeomyia* 62

ANOPHELES

10. Abdomen with plumose lateral hairs on first three segments only; head with large plumose frontal hairs (fig. 22) 11

Abdomen with plumose lateral hairs on first six segments (the branches sparse); frontal head hairs minute, single. [Palmate hairs well developed on segments 2 to 7.] A tree-hole breeder ..... *A. barberi*

11. Outer clypeal hair branched 12

All clypeal hairs simple, the inner pair well separated. [Palmate hairs developed on segments 3 to 7, the leaflets ending in long, slender filaments; postspiracular plate sometimes with a slender tail on each side.] ..... *A. pseudopunctipennis*

12. Outer clypeal hairs sparsely feathered or branched (5 to 10 short branches) on apical half. [Inner clypeal hairs forked or sparsely feathered at tip.] 13

Outer clypeal hairs thickly branched, the branching dichotomous 14

13. Inner clypeal hairs closely approximated; lateral hairs on abdominal segments 4 and 5 branched, usually in threes; palmate hairs well developed on segments 4 to 7 and partially developed on segment 3, the leaflets with notched or serrated edges toward tip ..... *A. atropos*

Inner clypeal hairs widely separated (by about one-third the distance between the outer clypeal hairs); lateral hairs on segments 4 and 5 simple; palmate hairs developed on segments 1 to 7, sometimes a pair on the metathorax also; leaflets long and slender, with smooth margins ..... *A. albimanus*

14. Abdominal segments with but one conspicuous hair anterior to palmate hair, this hair (the antepalmate hair, or hair 2) usually single or double, but sometimes with three to six branches, on segments 4 and 5; hair 0 undeveloped or very much smaller than hair 2 15

Abdominal segments with two conspicuous tufted hairs (hairs 2 and 0) anterior to palmate hair; these hairs usually approximately equal in size and with four to nine branches on segments 4 and 5. [Lateral hairs of segments 4 and 5 usually branched at about basal third; palmate hairs developed on segments 3 to 7.] ..... *A. crucians*

15. Basal tubercles of inner anterior clypeal hairs separated by more than the diameter of one tubercle 16

Basal tubercles of inner anterior clypeal hairs separated by less than their diameter; occipital hairs usually with not more than five branches 17

16. Occipital hairs usually with 8 to 10 branches; palmate hairs on segment 3 developed about equally as those on segment 4, and palmate hairs on segment 2 frequently partially developed and functional. [Antepalmate hairs of segments 4 and 5 mostly single; antennal hair tuft usually attached near middle, the hairs reaching base of apical spine.] ..... *A. quadrimaculatus*

Occipital hairs with 2 to 5 branches; palmate hairs less developed on segment 3 than on segment 4 and rudimentary on segment 2; see also couplet 19 ..... *A. bradleyi*

17. Inner anterior clypeal hairs simple (rarely forked toward tip); hair 1 of prothorax short, single or weakly branched at tip; palmate hairs rudimentary on segments 1 and 2 18

Inner clypeal hairs with sparse, minute feathering toward tip; hair 1 of prothorax with three to five strong branches from near base. [Hair 0 on abdominal segments comparatively large, with three to seven

branches; palmate hairs on segments 1 and 2 partially developed; antepalmate hairs on segments 4 and 5 usually single, sometimes double or triple.] ---- *A. walkeri*

18. Five pairs of functional palmate hairs (segments 3 to 7); antepalmate hairs on segments 4 and 5 single or double ---- 19

Only three pairs of functional palmate hairs (segments 4 to 6); antepalmate hairs on segments 4 and 5 with three to six branches (occasionally two) ---- *A. georgianus*

19. Leaflets of palmate hairs on segments 3 and 7 slender, usually somewhat smaller than those on segments 4 to 6 and mostly with smooth margins. [Antepalmate hairs on segments 4 and 5 single or double; distance between clypeal hairs variable.] ---- *A. bradleyi*

Palmate hairs on segment 3 with broad leaflets, usually notched or serrated on outer half and about equal in size to those on segments 4 to 6. [Antepalmate hairs on segments 4 and 5 usually double, except in specimens from central Florida, in which they are usually single.] *A. punctipennis*

URANOTAENIA

20. Upper lateral hair of abdominal segments 1 and 2 double ---- *U. lowii*

Upper lateral hair of abdominal segments 1 and 2 triple (lower hair single in both species) ---- *U. sapphirina*

MANSONIA

21. Anal segment with ventral tufts piercing the sclerotic ring; antenna with two long hairs from a notch beyond the tuft, extending to end of antenna; lateral spine of maxilla serrate ---- *M. titillans*

Anal segment without ventral hair tufts piercing the sclerotic ring; antenna with two short hairs from a notch beyond tuft, extending less than halfway to tip; lateral spine of maxilla smooth *M. perturbans*

ORTHOPODOMYIA

22. Segments 7 and 8 of abdomen each with a large sclerotic plate (a much smaller one usually present also on segment 6). [Lateral hairs of abdominal segments 1 and 2 comparatively short, multiple; tuft of air tube with many branches; anal segment ringed by the plate, the lateral hair single.] ---- *O. signifera*

Abdominal segments without sclerotic plates. [Lateral hairs of segments 1 and 2 double or triple, long; tuft of air tube with three or four hairs; anal segment not completely ringed by the plate, the lateral hair double or triple.] ---- *O. alba*

CULEX; CULISETA

23. Both upper and lower head hairs multiple, long. [Comb of many scales in a patch.] ---- 24

Upper and lower head hairs not both multiple ---- 30

24. Air tube with hair tufts or a few single hairs beyond pecten, none at base ---- *Culex* (*Culex*) 25

Air tube with a pair of multiple hair tufts at base; pecten with a short row of strong teeth, followed by a row of long setae (fig. 23, *C*); air tube stout, about 3:1 ---- *Culiseta inornata*

25. Antenna with the hair tuft placed in a constriction at outer third, the part beyond the tuft more slender; hair tufts of tube multiple, mostly in parallel lines ---- 26

Antenna rather short, of uniform shape, the hair tuft placed near middle; air tube about 4:1, with four to six long single hairs irregularly placed and one pair of small subapical tufts, usually triple. *Culex restuans*

26. Anal gills four, normal, tapered; pecten spines evenly spaced ---- 27

Only two anal gills, thick and bulbous; apical pecten spines progressively more widely spaced. [Air tube spinose, 5 or 6:1, with six or seven pairs of multiple ventral tufts, two or three of the basal pairs attached before end of pecten; lateral abdominal hairs on segments 3 to 6 double or triple.] Florida keys ---- *C. bahamensis*

27. Air tube with four or five pairs of hair tufts beyond pecten, the subapical pair laterally out of line (fig. 20); hairs usually little, if any, longer than diameter of tube 28
Air tube with five pairs of long tufts, the proximal pair attached near or before end of pecten, none out of line. [Air tube about 4:1.] *C. tarsalis*

28. Air tube long and slender, 7 or 8:1, sides nearly parallel; frontal head hairs usually with three or four branches 29
Air tube stouter, about 4:1, head hairs usually with five or more branches ..... *C. quinquefasciatus*
C. pipiens

29. Thorax with fine spicules (best observed toward sides); lateral hair of anal segment usually single; basal (or proximal) tufts of air tube usually double or long and single, occasionally triple ..... *C. nigripalpus*
Thorax glabrous; lateral hair of anal segment usually double, occasionally single; basal tufts of air tube usually with three or four branches, occasionally with two ..... *C. salinarius*

30. Pecten spines fringed on one side nearly to tip; ventral tufts of air tube long (those nearest base about twice diameter of tube or more), multiple and finely feathered ..... *Culex* (*Melanoconion*) 32
Pecten spines with one to four coarse side teeth; air tube with comparatively short tufts (little, if any, longer than diameter of tube). [Air tube long, 6 or 7:1.] 31

31. Head hairs long, usually single, the lower pair or both hairs occasionally double; air tube slightly expanded toward tip, with four or five paired ventral tufts beyond pecten (none at base); comb a patch of scales, the single scale rounded and fringed apically; body finely pilose ..... *C. apicalis*
Lower head hairs single, the upper ones shorter and multiple; air tube with a tuft of hairs at base and with a row of about 12 short, subequal tufts on midventral line; comb a single row of long barlike scales ..... *Culiseta melanura*

32. Air tube long and slender, 5 or 6:1, with four to six pairs of ventral hair tufts beyond pecten 33
Air tube short (about 3:1), with about eight pairs of very long hair tufts, basal two within pecten. [Comb of eighth segment of 8 to 12 scales in a curved or irregular row, the single scales long and pointed, unfringed; a stalked ovoid gill at base of antenna; head hairs small, usually single, upper ones sometimes double; thorax slightly spicular.] *Culex pilosus*

33. Lower head hairs single, upper ones shorter, double or triple; body sparsely spicular; comb with the scales in a patch, each scale rounded and fringed apically; air tube slightly flared at tip ..... *C. peccator*
Lower head hairs long, single, upper ones short, multiple (four or more); body usually densely spicular-pilose; comb with one irregular or partially double row of scales, the individual scales long and pointed and fringed on basal half ..... *C. erraticus*

PSOROPHORA

34. Mouth brushes formed of stout prehensile hairs (each hooked at tip and with a row of comblike teeth along the side) (fig. 25, *D*). [Air-tube pecten with numerous teeth, which are prolonged into hairs; tuft of air tube a single long hair.] Very large predacious larvae 35
Mouth brushes normal, ciliform. [Pecten with a few strong, widely spaced teeth; tuft of air tube sometimes very small.] 36

35. Lateral hair of anal segment with three or four branches near base *P. ciliata*
Lateral hair of anal segment single or forked some distance from base: teeth of pecten somewhat stouter than in *P. ciliata* ..... *P. howardii*

36. Antenna very large, inflated apically, two long bristles at outer third in addition to central hair tuft; air tube small with a paired tuft of very long hairs; head hairs single ..... *P. discolor*
Antenna not inflated; air tube large, inflated, ventral tuft small or obsolete 37

37. Head hairs double or single 38
Both upper and lower head hairs multiple ..... *P. confinnis*

38. Upper head hairs double, lower double or triple; antennae unusually long and prominent 39
Upper and lower head hairs single; antennae normal, no longer than head 41
39. Lateral abdominal hairs single or double on segments 4 to 6; lateral hair of anal segment branched from near base 40
Lateral hairs usually multiple, with three to five branches, on segments 3 to 6; lateral hair on anal segment branched at tip or single. [Pecten with three or four short spines; tuft of air tube small and laterally placed; comb with seven scales.] (Rozeboom, *135*) ..... *P. horrida*
40. Pecten of four to six spines, each with a small basal tooth on each side, subequal in size; lateral abdominal hairs double on segments 3, single on segments 4 to 6; comb of five scales ..... *P. varipes*
Pecten of three or four long spines, each except the basal pair with a comparatively long basal tooth on one side, and usually with one or two much smaller ones on the same side, sometimes a very small tooth on opposite side; lateral abdominal hairs branched three or four times on segment 3, double on segment 4, and single on 5 and 6; comb with seven or eight scales ..... *P. ferox*
41. Air tube with a pair of long hairs at tip; pecten with three or four spines 42
Hairs at tip of air tube inconspicuous; pecten with six spines *P. pygmaea*
42. Antennal and preantennal tufts multiple, conspicuously feathered; tip of antenna with three short apical spines and two longer subapical spines; six comb scales ..... *P. signipennis*
Antennal and preantennal tufts with two or three branches, some of which may be secondarily divided, sparsely feathered; antenna with three long apical spines only; four comb scales ..... *P. cyanescens*

AEDES

43. Upper head hairs multiple, lower ones double or multiple (fig. 21). [Anal segment not completely ringed by the sclerotic plate; tuft of air tube beyond pecten.] 44
Either the upper or the lower head hairs single (both pairs single except as shown under individual species) 49
44. Pecten with one to three distal teeth more widely spaced (fig. 24, *A*); comb of few scales in a single irregular or partially double row 45
Pecten with evenly spaced teeth; comb scales in a triangular patch 46
45. Upper head hairs with three to five branches, lower ones usually with two or three; lateral abdominal hairs double or triple on segments 3 to 5 ..... *A. vexans*
Upper and lower head hairs with more than four branches; lateral abdominal hairs single on segments 3 to 5 ..... *A. cinereus*
46. Lower head hairs double 47
Lower head hairs with three or more branches 48
47. Single comb scale with a long apical spine ..... *A. sticticus*
Single comb scale with lateral spines nearly as long as apical spine *A. grossbecki*
48. Upper lateral hairs on abdominal segments 1 and 2 double, lower hairs single or double; antennae much shorter than head and little longer than preantennal hair; comb scales rounded and fringed with subequal spinules ..... *A. canadensis*
Upper lateral hairs or both pairs on segments 1 and 2 multiple; antennae nearly as long as head and much longer than preantennal hair; comb scales with apical spine somewhat longer and stouter than other spines ..... *A. thibaulti*
49. Pecten with the distal teeth more widely spaced. [Comb of many scales in a patch, single scales with apical fringe of subequal spinules.] 50
Pecten with evenly spaced teeth 51
50. Both head hairs single; lateral hairs multiple on segments 3 and 4; sclerotic plate on anal segment small, covering about half the segment; body glabrous ..... *A. atropalpus*
Lower head hairs double; lateral hairs usually single on segments 3 to 5; anal segment completely ringed by plate; body spicular-pilose ..... *A. fulvus pallens*

51. Anal segment not completely ringed by the sclerotic plate. [Lateral hairs normally double or triple on segments 3 to 5.]---------- 52
Anal segment completely ringed by the plate---------- 55
52. Antennal hair single (rarely forked); comb of few (8 to 15) scales in a single or partly double row---------- 53
Antennal hair multiple; comb of many scales in a patch---------- 54
53. Single comb scale with a stout apical spine and shorter side spines (fig. 26, *C*); head hairs and preantennal hair single; tuft of air tube with three or more branches; lateral hair of anal segment single or double---------- *A. aegypti*
Single comb scale elongate, evenly fringed with short spinules (fig. 26, *D*); lower head hair with two to four branches; preantennal and lateral hair of anal segment multiple; tuft of air tube usually single or double---------- *A. triseriatus*
54. Upper head hair double; anal gills as long as the segment; single comb scale pointed, with an apical spine somewhat longer than others; body glabrous---------- *A. stimulans*
Head hairs usually single; anal gills very short, budlike; comb scale rounded, fringed apically with subequal spinules---------- *A. dorsalis*

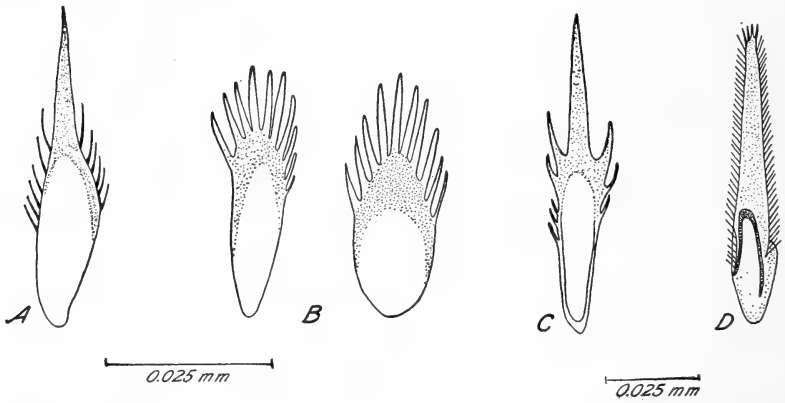

FIGURE 26.—Enlarged comb scales of *Aedes* larvae: *A*, *sollicitans*; *B*, *taeniorhynchus*; *C*, *aegypti*; *D*, *triseriatus*.

55. Comb of few scales (less than 12) in a single row. [Single comb scale pointed, thornlike; lateral hairs usually single on segments 3 to 5; dorsal preapical spines on air tube small.]---------- 56
Comb of many scales in a patch---------- 58
56. Tuft of air tube beyond the pecten---------- 57
Tuft of air tube before end of pecten; anal gills about twice the length of segment---------- *A. tormentor*
57. Anal gills very long with prominent tracheae; lower head hairs double or triple; antennal hair usually double---------- *A. dupreei*
Anal gills no more than twice length of segment, one pair longer than the other; head hairs single; antennal hair multiple---------- *A. atlanticus*
58. Comb scale thorn-shaped, with a long apical spine and smaller lateral spinules (fig. 26, *A*); lateral abdominal hairs single or double---------- 59
Comb scales rounded apically, with a fringe of subequal spinules (fig. 26, *B*); lateral hairs on segments 3 to 5 with three or more branches. [Body distinctly pilose; air tube short, 2:1 or less, dorsal preapical spines nearly as long as pecten teeth; antennal hair small, usually double or triple.]---------- *A. taeniorhynchus*
59. Dorsal preapical spines of air tube (fig. 24, *A*) as long as apical pecten tooth; lateral abdominal hairs usually double on segments 3 to 5, body glabrous or nearly so---------- 60

These spines small, not more than half as long as apical pecten tooth; lateral hairs single on segments 3 to 5; anal gills longer than anal segment 61

60. Air tube about 3:1; anal gills longer than segment, tapered to a blunt point; upper head hairs sometimes double ..... *A. mitchellae*
Air tube about 2:1; anal gills shorter than segment, budlike ..... *A. sollicitans*

61. Apical spine of comb scale longer than lateral spinules by about half its length; body sparsely spiculate; anal gills longer than the segment; pecten ends about at middle of air tube ..... *A. infirmatus*
Lateral spinules of comb scale nearly as long as apical spine; body glabrous; pecten extending beyond middle of air tube. (From published descriptions, *85, 139*) ..... *A. trivittatus*

WYEOMYIA

62. Upper and lower head hairs single 63
Upper head hairs multiple, lower ones double; ventrolateral tufts of anal segment of about 12 subequal hairs; air tube with numerous long, single, irregularly placed hairs, a few shorter double tufts apically ..... *W. mitchellii*

63. Ventrolateral tufts of anal segment with three long hairs; air tube with all hairs single ..... *W. smithii*
Ventrolateral tufts of anal segment with one or two long and three or four shorter hairs; air tube with a row of six small single or double tufts dorsally, a large double or triple tuft below, and two or three small single or double ones apically ..... *W. vanduzeei*

LITERATURE CITED

(1) Balfour, Marshall C.
1928. studies on the bionomics of north american anophelines. winter activities of anophelines in coastal north carolina (36° n. lat.). Amer. Jour. Hyg. 8: 68–76, illus.

(2) Bang, F. B., Quinby, G. E., and Simpson, T. W.
1940. anopheles walkeri (theobald): a wild-caught specimen harboring malaria plasmodia. U. S. Pub. Health Serv. Rpts. 55: 119–120, illus.

(3) Barber, M. A.
1927. the food of anopheline larvae—food organisms in pure culture. U. S. Pub. Health Serv. Rpts. 42: 1494–1510, illus.

(4) ———
1928. the food of culicine larvae. U. S. Pub. Health Serv. Rpts. 43: 11–17.

(5) ——— and Hayne, T. B.
1921. arsenic as a larvicide for anopheline larvae. U. S. Pub. Health Serv. Rpts. 36: 3027–3034.

(6) ——— and Hayne, T. B.
1924. some observations on the dispersal of adult anopheles. U. S. Pub. Health Serv. Rpts. 39: 195–203.

(7) ——— and Komp, W. H. W.
1929. breeding places of anopheles in the yazoo-mississippi delta. U. S. Pub. Health Serv. Rpts. 44: 2457–2462.

(8) ———Komp, W. H. W., and Hayne, T. B.
1924. some observations on the winter activities of anopheles in southern united states. U. S. Pub. Health Serv. Rpts. 39: 231–246.

(9) ——— Komp, W. H. W., and Hayne, T. B.
1926. malaria in the prairie rice regions of louisiana and arkansas. U. S. Pub. Health Serv. Rpts. 41: 2527–2549.

(10) ——— Komp, W. H. W., and Hayne, T. B.
1927. the susceptibility to malaria parasites and the relation to the transmission of malaria of the species of anopheles common in southern united states. U. S. Pub. Health Serv. Rpts. 42: 2487–2502.

(11) BELLAMY, R. EDWARD.
1939. AN ANOPHELINE FROM INLAND GEORGIA RESEMBLING THE BRACKISH-WATER RACE OF ANOPHELES CRUCIANS. Jour. Parasitol. 25: 186.
(12) ——— and ANDREWS, JUSTIN.
1938. SYMPOSIUM ON MALARIA—PART 1. THE OCCURRENCE OF ANOPHELES WALKERI THEOBALD IN GEORGIA. South. Med. Jour. 31: 797.
(13) BEYER, GEO. E.
1901. THE MOSQUITOES AND THEIR RELATION TO DISEASE. New Orleans Med. and Surg. Jour. 54: 131–155, illus.
(14) ———
1923. A NEW SPECIES OF ANOPHELES IN LOUISIANA, ANOPHELES ATROPOS D. & K. Amer. Jour. Trop. Med. 3: 351–363, illus.
(15) ———
1923. MOSQUITOES OF LOUISIANA. La. State Bd. Health Quart. Bul. 14: 54–84, illus.
(16) BISHOP, E. L.
1936. MALARIA-CONTROL ACTIVITIES OF THE TENNESSEE VALLEY AUTHORITY. U. S. Pub. Health Serv. Rpts. 51: 970–975.
(17) BISHOPP, F. C.
1933. MOSQUITOES KILL LIVE STOCK. Science 77: 115–116.
(18) BOYD, MARK F.
1927. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. I. THE NUMBER OF ANNUAL GENERATIONS OF A. QUADRIMACULATUS. Amer. Jour. Hyg. 7: 264–275, illus.
(19) ———
1929. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES: PHYSICAL AND CHEMICAL FACTORS IN THEIR RELATION TO THE DISTRIBUTION OF LARVAE IN NORTHEASTERN NORTH CAROLINA. Amer. Jour. Hyg. 9: 346–370, illus.
(20) ———
1930. AN INTRODUCTION TO MALARIOLOGY. 437 pp., illus. Cambridge, Mass.
(21) ———
1930. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. VI. SOME OBSERVATIONS ON IMAGINES. Amer. Jour. Hyg. 12: 449–466, illus.
(22) ——— and CAIN, THOMAS L., JR.
1932. ON LARGE SCALE REARING OF ANOPHELES QUADRIMACULATUS IN CAPTIVITY. Amer. Jour. Hyg. 16: 832–835.
(23) ——— CAIN, T. L., JR., and MULRENNAN, J. A.
1935. THE INSECTARY REARING OF ANOPHELES QUADRIMACULATUS. Amer. Jour. Trop. Med. 15: 385–402, illus.
(24) ——— and FOOT, HELEN.
1928. STUDIES ON THE BIONOMICS OF AMERICAN ANOPHELINES. THE ALIMENTATION OF ANOPHELINE LARVAE AND ITS RELATION TO THEIR DISTRIBUTION IN NATURE. Jour. Prev. Med. 2: 219–242, illus.
(25) ——— and PONTON, GERALD.
1933. THE RECENT DISTRIBUTION OF MALARIA IN THE SOUTHEASTERN UNITED STATES. Amer. Jour. Trop. Med. 13: 143–166, illus.
(26) ——— and WEATHERSBEE, ALBERT A.
1929. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. V. WINTER ACTIVITIES OF ANOPHELINE IMAGINES IN COASTAL NORTH CAROLINA (36° N. LAT.). Amer. Jour. Hyg. 9: 682–694, illus.
(27) BRADLEY, G. H.
1924. THE NATURAL BREEDING PLACES OF ANOPHELES MOSQUITOES IN THE VICINITY OF MOUND, LOUISIANA. Amer. Jour. Trop. Med. 4: 199–223, illus.
(28) ———
1925. THE LARVA OF AEDES THIBAULTI DYAR AND KNAB (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 13: 89–91.
(29) ———
1926. OBSERVATIONS ON THE EMERGENCE OF ANOPHELES MOSQUITOES Amer. Jour. Trop. Med. 6: 283–297, illus.
(30) ———
1932. ON THE IDENTIFICATION OF ANOPHELES MOSQUITO LARVAE IN FLORIDA. Ent. Soc. Wash. Proc. 34: 41–43.

(31) Bradley, G. H.
1932. some factors associated with the breeding of anopheles mosquitoes. Jour. Agr. Res. 44: 381–399, illus.
(32) ———
1934. mosquito control work under the cwa in alabama and mississippi. N. J. Mosquito Extermin. Assoc. Proc. 21: 100–102. illus.
(33) ———
1936. on the occurrence of anopheles walkeri theobald in florida (diptera, culicidae). South. Med. Jour. 29: 857–859, illus.
(34) ———
1936. on the identification of mosquito larvae of the genus anopheles occurring in the united states (diptera, culicidae). South. Med. Jour. 29: 859–861, illus.
(35) Bradley, G. H., and King, W. V
1941. bionomics and ecology of nearctic anopheles. *In* Human Malaria (Amer. Assoc. Adv. Sci. Pub. 15), pp. 79–87.
(36) ——— and McNeel, T. E.
1935. mosquito collections in florida with the new jersey light trap. Jour. Econ. Ent. 28: 780–786.
(37) Brown, Frank R., and Pearson, Jed W.
1938. some culicidae of the reelfoot lake region. Tenn. Acad. Sci. Jour. 13: 126–132.
(38) Bull, Carroll G., and Reynolds, Bruce D.
1924. preferential feeding experiments with anopheline mosquitoes. ii. Amer. Jour. Hyg. 4: 109–118, illus.
(39) ——— and Root, Francis M.
1923. preferential feeding experiments with anopheline mosquitoes. i. Amer. Jour. Hyg. 3: 514–520, illus.
(40) Carley, Paul S., and Balfour, Marshall C.
1929. prevalence of malaria in humphreys and sunflower counties, mississippi in 1927–1928. South. Med. Jour. 22: 377–382, illus.
(41) Carpenter, Stanley J.
1941. the mosquitoes of arkansas. Rev. ed. Ark. State Bd. Health, 87 pp., illus.
(42) Cook, S. S., and Williams, L. L., Jr.
1928. airplanes and paris green in control of anopheles production. South Med. Jour. 21: 754–759, illus. [Discussion, pp. 759–760.]
(43) Covell, Gordon.
[1931.] malaria control by anti-mosquito measures. 148 pp., illus. Calcutta, Simla, and London.
(44) Crowell, Robert L.
1940. insectary rearing of anopheles quadrimaculatus (a preliminary report). Amer. Jour. Hyg. 32: 12–20, illus.
(45) Daggy, Richard H., Muegge, Oswald J., and Riley, William A.
1941. a preliminary survey of the anopheline mosquito fauna of southeastern minnesota and adjacent wisconsin areas. U. S. Pub. Health Serv. Rpts. 56: 883–895, illus.
(46) Darling, S. T.
1925. discussion on relative importance in transmitting malaria of anopheles quadrimaculatus, punctipennis, and crucians and advisibility of differentiating between these species in applying control measures. South. Med. Jour. 18: 452–457. [Discussion, pp. 457–458.]
(47) Dozier, Herbert L.
1936. observations on breeding places and winter activities of mosquitoes in the vicinity of new orleans, louisiana. Ent. Soc. Wash. Proc. 38: 148–155, illus.
(48) Dupree, J. W.
1905. the mosquitoes of louisiana and their pathogenic possibilities, with remarks upon their extermination. New Orleans Med. and Surg. Jour. 58: 1–16.
(49) Dyar, Harrison G.
1920. the american aedes of the stimulans group (diptera, culicidae). Insecutor Inscitiae Menstruus 8: 106–120.

(50) DYAR, HARRISON G.
1922. THE MOSQUITOES OF THE UNITED STATES. U. S. Natl. Mus. Proc. 62, art. 1, 119 pp.
(51) ———
1928. THE MOSQUITOES OF THE AMERICAS. Carnegie Inst. Wash. Pub. 387, 616 pp., illus.
(52) ——— and BARRET, HARVEY P.
1918. DESCRIPTIONS OF HITHERTO UNKNOWN LARVAE OF CULEX (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 6: 119–120.
(53) EDWARDS, F. W.
1932. DIPTERA. FAM. CULICIDAE. 258 pp., illus. Bruxelles. *In* Wytsman, P., Genera Insectorum, fasc. 194.
(54) ENGINEERING NEWS-RECORD EDITORS.
1936. MOSQUITO CONTROL ENGINEERING. 57 pp., illus. New York.
(55) FISK, FRANK W.
1939. NEW MOSQUITO RECORDS FROM KEY WEST, FLA. (Sci. Note) Jour. Econ. Ent. 32: 469.
(56) ——— and LEVAN, JAMES H.
1940. MOSQUITO COLLECTIONS AT CHARLESTON, SOUTH CAROLINA, USING THE NEW JERSEY LIGHT TRAP. (Sci. Note) Jour. Econ. Ent. 33: 578–579.
(57) FROHNE, W. C.
1939. ANOPHELINE BREEDING: SUGGESTED CLASSIFICATION OF PONDS BASED ON CHARACTERISTIC DESMIDS. U. S. Pub. Health Serv. Rpts. 54: 1363–1387.
(58) GATER, B. A. R.
1934. AIDS TO THE IDENTIFICATION OF ANOPHELINE LARVAE IN MALAYA. 160 pp., illus. Singapore.
(59) GEIGER, J. C., PURDY, W. C., and TARBETT, R. E.
1919. EFFECTIVE MALARIA CONTROL IN A RICEFIELD DISTRICT WITH OBSERVATIONS ON EXPERIMENTAL MOSQUITO FLIGHTS. Jour. Amer. Med. Assoc. 72: 844–847, illus.
(60) GINSBURG, JOSEPH M.
1935. LARVICIDES, AND A METHOD FOR TEMPORARY PROTECTION FROM ADULT MOSQUITOES IN LIMITED AREAS. N. J. Mosquito Extermin. Assoc. Proc. 22: 147–151.
(61) ———
1936. PROTECTION OF OUTDOOR GATHERINGS FROM THE MOSQUITO PEST. N. J. Mosquito Extermin. Assoc. Proc. 23: 166–173.
(62) ———
1937. PRINCIPLES UNDERLYING THE PROTECTION OF OUTDOOR MEETINGS FROM THE MOSQUITO PEST AND METHOD OF APPLICATION. N. J. Mosquito Extermin. Assoc. Proc. 24: 5–11.
(63) GRANETT, PHILIP.
1940. STUDIES OF MOSQUITO REPELLENTS. I. TEST PROCEDURE AND METHOD OF EVALUATING TEST DATA. II. RELATIVE PERFORMANCE OF CERTAIN CHEMICALS AND COMMERCIALLY AVAILABLE MIXTURES AS MOSQUITO REPELLENTS. Jour. Econ. Ent. 33: 563–572, illus.
(64) GRIFFITTS, T. H. D.
1918. WINTER HIBERNATION OF ANOPHELES LARVAE. U. S. Pub. Health Serv. Rpts. 33: 1996–1998.
(65) ———
1927. ANOPHELES ATROPOS DYAR AND KNAB. A NOTE ON ITS BREEDING AND OTHER HABITS. U. S. Pub. Health Serv. Rpts. 42: 1903–1905.
(66) ———
1928. SOME PHASES OF THE SALT-MARSH MOSQUITO PROBLEM IN THE SOUTH ATLANTIC AND GULF STATES. N. J. Mosquito Extermin. Assoc. Proc. 15: 87–91.
(67) GUYTON, F. E.
1935. PEST MOSQUITO CONTROL IN ALABAMA UNDER C. W. A. Jour. Econ. Ent. 28: 786–790, illus.
(68) HARDENBURG, W. E.
1922. MOSQUITO ERADICATION. 248 pp., illus. New York.
(69) HEADLEE, THOMAS J.
1921. THE MOSQUITOES OF NEW JERSEY AND THEIR CONTROL. N. J. Agr. Expt. Sta. Bul. 348, 229 pp., illus.

(70) HENDERSON, JOHN M., and HOWARD, R. S., JR.
1940. A COMPARATIVE EVALUATION OF PARIS GREEN AND PYRETHRUM EMULSION AS ANOPHELINE LARVICIDES IN GEORGIA; A PROGRESS REPORT. Amer. Jour. Trop. Med. 20: 585–592.
(71) HERMS, WILLIAM BRODBECK, and GRAY, HAROLD FARNSWORTH.
1940. MOSQUITO CONTROL—PRACTICAL METHODS FOR ABATEMENT OF DISEASE VECTORS AND PESTS. 317 pp., illus. New York and London.
(72) HINMAN, E. HAROLD.
1930. A STUDY OF THE FOOD OF MOSQUITO LARVAE (CULICIDAE). Amer. Jour. Hyg. 12: 238–270.
(73) ———
1931. THE WINTER BREEDING AND ACTIVITY OF CULICINE MOSQUITOES AT NEW ORLEANS (30° N. LAT.). Amer. Jour. Trop. Med. 11: 459–467, illus.
(74) ———
1932. A DESCRIPTION OF THE LARVA OF ANOPHELES ATROPOS D. & K., WITH BIOLOGICAL NOTES ON THE SPECIES. Ent. Soc. Wash. Proc. 34: 138–142.
(75) ———
1934. PREDATORS OF THE CULICIDAE (MOSQUITOES). I.—THE PREDATORS OF LARVAE AND PUPAE, EXCLUSIVE OF FISH. Jour. Trop. Med. and Hyg. [London] 37: 129–134.
(76) ———
1934. PREDATORS OF THE CULCIDAE (MOSQUITOES). II.—PREDATORS OF ADULT MOSQUITOES. Jour. Trop. Med. and Hyg. [London] 37: [145]–150.
(77) ———
1935. BIOLOGICAL NOTES ON URANOTAENIA SPP. IN LOUISIANA (CULICIDAE, DIPTERA). Ent. Soc. Amer. Ann. 28: 404–407.
(78) ———
1938. BIOLOGICAL EFFECTS OF FLUCTUATION OF WATER LEVEL ON ANOPHELINE BREEDING. Amer. Jour. Trop. Med. 18: 483–495, illus.
(79) HORSFALL, W. R.
1936. OCCURRENCE AND SEQUENCE OF MOSQUITOES IN SOUTHEASTERN ARKANSAS IN 1935. Jour. Econ. Ent. 29: 676–679.
(80) ———
1937. MOSQUITOES OF SOUTHEASTERN ARKANSAS. Jour. Econ. Ent. 30: 743–748.
(81) HOWARD, L. O.
1916. MOSQUITOES AND BATS. N. J. Mosquito Extermin. Assoc. Proc. 3: 69–78.
(82) ———
1921. [MOSQUITO WORK AT MOUND, LA.] N. J. Mosquito Extermin. Assoc. Proc. 8: 75–83, illus.
(83) ———
1923. THE YELLOW-FEVER MOSQUITO. U. S. Dept. Agr. Farmers' Bul. 1354, 14 pp., illus.
(84) ——— and BISHOPP, F. C.
1932. MOSQUITO REMEDIES AND PREVENTIVES. U. S. Dept. Agr. Farmers' Bul. 1570, 13 pp.
(85) HOWARD, LELAND O., DYAR, HARRISON G., and KNAB, FREDERICK.
1912–17. THE MOSQUITOES OF NORTH AND CENTRAL AMERICA AND THE WEST INDIES. Carnegie Inst. Wash. Pub. 159. 4 v. in 3, illus. Washington, D. C.
(86) HULSE, F. E.
1922. SKETCH MAPPING FOR PUBLIC HEALTH PROBLEMS. Amer. Jour. Pub. Health 12: 1034–1038, illus.
(87) HURLBUT, HERBERT S.
1938. A STUDY OF THE LARVAL CHAETOTAXY OF ANOPHELES WALKERI THEOBALD. Amer. Jour. Hyg. 28: 149–173, illus.
(88) ———
1938. FURTHER NOTES ON THE OVERWINTERING OF THE EGGS OF ANOPHELES WALKERI THEOBALD WITH A DESCRIPTION OF THE EGGS. Jour. Parasitol. 24: 521–526, illus.

(89) JOHNSON, H. A.
1936. NOTES ON THE OCCURRENCE OF A. WALKERI. South. Med. Jour. 29: 856–857.
(90) KIKER, CALVIN C., FAIRER, CHARLES D., and FLANERY, PAUL N.
1938. FURTHER OBSERVATIONS ON AIRPLANE DUSTING FOR ANOPHELES LARVAL CONTROL. South. Med. Jour. 31: 808–813, illus.
(91) KING, W. V.
1924. ANOPHELINE INFECTION UNDER NATURAL CONDITIONS. South. Med. Jour. 17: 596–597.
(92) ———
1928. THE ANOPHELES DENSITY INDEX IN MALARIA RESEARCH AND CONTROL WORK. South. Med. Jour. 21: 763–767, illus.
(93) ———
1934. FEDERAL CIVIL WORKS ADMINISTRATION CONTROL PROJECTS AND SALT-MARSH CONDITIONS IN FLORIDA. N. J. Mosquito Extermin. Assoc. Proc. 21: 96–100, illus.
(94) ———
1937. ON THE DISTRIBUTION OF ANOPHELES ALBIMANUS AND ITS OCCURRENCE IN THE UNITED STATES. South. Med. Jour. 30: 943–946.
(95) ———
1939. VARIETIES OF ANOPHELES CRUCIANS WIED. Amer. Jour. Trop. Med. 19: 461–471, illus.
(96) ——— and BRADLEY, G. H.
1926. AIRPLANE DUSTING IN THE CONTROL OF MALARIA MOSQUITOES. U. S. Dept. Agr. Dept. Cir. 367, 16 pp., illus.
(97) ——— and BRADLEY, G. H.
1926. AIRPLANE DUSTING IN THE CONTROL OF MALARIA MOSQUITOES. Jour. Trop. Med. and Hyg. [London] 29: 311–313, illus.
(98) ——— and BRADLEY, G. H.
1937. NOTES ON CULEX ERRATICUS AND RELATED SPECIES IN THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 30: 345–357, illus.
(99) ——— and BRADLEY, G. H.
1941. GENERAL MORPHOLOGY OF ANOPHELES AND CLASSIFICATION OF THE NEARCTIC SPECIES. *In* Human Malaria (Amer. Assoc. Adv. Sci. Pub. 15), pp. 63–70, illus.
(100) ——— and BRADLEY, G. H.
1941. DISTRIBUTION OF THE NEARCTIC SPECIES OF ANOPHELES. *In* Human Malaria (Amer. Assoc. Adv. Sci. Pub. 15), pp. 71–78, illus.
(101) ——— BRADLEY, G. H., and MCNEEL, T. E.
1937. EXPERIMENTS IN FLORIDA IN REPELLING MOSQUITOES BY OUTDOOR SPRAYING. N. J. Mosquito Extermin. Assoc. Proc. 24: 163–172.
(102) ——— and BULL, CARROLL G.
1923. THE BLOOD FEEDING HABITS OF MALARIA-CARRYING MOSQUITOES. Amer. Jour. Hyg. 3: 497–513, illus.
(103) ——— and MCNEEL, T. E.
1938. EXPERIMENTS WITH PARIS GREEN AND CALCIUM ARSENITE AS LARVICIDES FOR CULICINE MOSQUITOES. Jour. Econ. Ent. 31: 85–86.
(104) KITCHEN, S. F., and BRADLEY, G. H.
1936. ANOPHELES WALKERI THEOBALD AS A VECTOR OF PLASMODIUM FALCIPARUM (WELCH). Amer. Jour. Trop. Med. 16: 579–581.
(105) KOMP, W. H. W.
1923. GUIDE TO MOSQUITO IDENTIFICATION FOR FIELD WORKERS ENGAGED IN MALARIA CONTROL IN THE UNITED STATES. U. S. Pub. Health Serv. Rpts. 38: 1061–1080, illus. (Revised, 1936.)
(106) ———
1923. NOTES ON CULEX FLORIDANUS D. & K. (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 11: 133–135, illus.
(107) ———
1926. OBSERVATIONS ON ANOPHELES WALKERI AND ANOPHELES ATROPOS (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 14: 168–176.
(108) ———
1928. A SUCCESSFUL METHOD OF REARING ANOPHELES LARVAE. South. Med. Jour. 21: 760–761.

(109) KUMM, HENRY W.
1929. STUDIES IN THE DISPERSION OF ANOPHELES MOSQUITOES. Amer. Jour. Trop. Med. 9: 67–77, illus.

(110) ———
1929. THE GEOGRAPHICAL DISTRIBUTION OF THE MALARIA CARRYING MOSQUITOES. Amer. Jour. Hyg. Monog. 10, 178 pp., illus.

(111) LE PRINCE, J. A. A., and GRIFFITTS, T. H. D.
1917. FLIGHT OF MOSQUITOES. STUDIES ON THE DISTANCE OF FLIGHT OF ANOPHELES QUADRIMACULATUS. U. S. Pub. Health Serv. Rpts. 32: 656–659, illus.

(112) ——— and ORENSTEIN, A. J.
1916. MOSQUITO CONTROL IN PANAMA; THE ERADICATION OF MALARIA AND YELLOW FEVER IN CUBA AND PANAMA. 335 pp., illus. New York and London.

(113) MACCREARY, DONALD.
1941. COMPARATIVE DENSITY OF MOSQUITOES AT GROUND LEVEL AND AT AN ELEVATION OF APPROXIMATELY ONE HUNDRED FEET. Jour. Econ. Ent. 34: 174–179, illus.

(114) ——— and STEARNS, L. A.
1937. MOSQUITO MIGRATION ACROSS DELAWARE BAY. N. J. Mosquito Extermin. Assoc. Proc. 24: 188–197, illus.

(115) MATHESON, ROBERT.
1929. A HANDBOOK OF THE MOSQUITOES OF NORTH AMERICA. . . . 268 pp., illus. Springfield, Ill., and Baltimore, Md.

(116) ———
1930. THE UTILIZATION OF AQUATIC PLANTS AS AIDS IN MOSQUITO CONTROL. Amer. Nat. 64: 56–86, illus.

(117) ———
1934. NOTES ON PSOROPHORA (JANTHINOSOMA) HORRIDUS DYAR AND KNAB. Ent. Soc. Wash. Proc. 36: 41–43, illus.

(118) ——— BOYD, MARK F., and STRATMAN-THOMAS, WARREN K.
1933. ANOPHELES WALKERI, THEOBALD, AS A VECTOR OF PLASMODIUM VIVAX, GRASSI AND FELETTI. Amer. Jour. Hyg. 17: 515–516.

(119) ——— and HURLBUT, H. S.
1937. NOTES ON ANOPHELES WALKERI, THEOBALD. Amer. Jour. Trop. Med. 17: 237–243, illus.

(120) MAYNE, BRUCE.
1919. THE OCCURRENCE OF MALARIA PARASITES IN ANOPHELES CRUCIANS IN NATURE: PERCENTAGE OF INFECTION OF ANOPHELES QUADRIMACULATUS AND LATEST DATE FOUND INFECTED IN NORTHERN LOUISIANA. U. S. Pub. Health Serv. Rpts. 34: 1355–1357.

(121) ———
1926. REPORT OF A SURVEY TO DETERMINE THE MALARIA PREVALENCE IN THE OKEFENOKEE SWAMP. U. S. Pub. Health Serv. Rpts. 41: 1652–1660, illus.

(122) ——— and GRIFFITTS, T. H. D.
1931. ANOPHELES ATROPOS D. AND K.—A NEW POTENTIAL CARRIER OF MALARIA ORGANISMS. U. S. Pub. Health Serv. Rpts. 46: 3107–3115, illus.

(123) MCNEEL, T. E.
1931. A METHOD FOR LOCATING THE LARVAE OF THE MOSQUITO MANSONIA. Science 74: 155.

(124) ———
1932. OBSERVATIONS ON THE BIOLOGY OF MANSONIA PERTURBANS (WALK.) DIPTERA, CULICIDAE. N. J. Mosquito Exterm. Assoc. Proc. 19: 91–96, illus.

(125) MELENEY, HENRY E., BISHOP, EUGENE L., and ROBERTS, FRANK L.
1929. OBSERVATIONS ON THE MALARIA PROBLEM OF WEST TENNESSEE. South. Med. Jour. 22: 382–394, illus.

(126) METZ, C. W.
1919. ANOPHELES CRUCIANS WIED. AS AN AGENT IN MALARIA TRANSMISSION. U. S. Pub. Health Serv. Rpts. 34: 1357–1360.

(127) MITCHELL, EVELYN GROESBEECK.
1907. MOSQUITO LIFE . . . 281 pp., illus. New York and London.

(128) MORGAN, H. A.
1902. OBSERVATIONS UPON THE MOSQUITO, CONCHYLIASTES MUSICUS. U. S. Div. Ent. Bul. 37 (n. s.): 113–115, illus.
(129) ——— and DUPREE, J. W.
1903. DEVELOPMENT AND HIBERNATION OF MOSQUITOES. U. S. Div. Ent. Bul. 40: 88–92.
(130) MOZNETTE, G. F.
1924. MOSQUITO SURVEY OF BAMBOO KEY, FLORIDA. Fla. Ent. 8: 25–28.
(131) MULHERN, THOMAS D.
1934. A NEW DEVELOPMENT IN MOSQUITO TRAPS. N. J. Mosquito Extermin. Assoc. Proc. 21: 137–140, illus.
(132) PEREZ, MANUEL.
1930. AN ANOPHELINE SURVEY OF THE STATE OF MISSISSIPPI. Amer. Jour. Hyg. 11: 696–710, illus.
(133) ROCKEFELLER FOUNDATION, INTERNATIONAL HEALTH BOARD.
1924. THE USE OF FISH FOR MOSQUITO CONTROL. 120 pp., illus. New York.
(134) ROOT, FRANCIS METCALF.
1924. NOTES ON THE MOSQUITOES OF LEE COUNTY, GEORGIA. Amer. Jour. Hyg. 4: 449–455.
(135) ROZEBOOM, L. E.
1939. THE LARVA OF PSOROPHORA (JANTHINOSOMA) HORRIDA DYAR & KNAB (DIPTERA; CULICIDAE). Jour. Parasitol. 25: 145–147, illus.
(136) SHIELDS, S. E.
1938. TENNESSEE VALLEY MOSQUITO COLLECTIONS. Jour. Econ. Ent. 31: 426–430.
(137) ——— and LACKEY, JAMES B.
1938. CONDITIONS AFFECTING MOSQUITO BREEDING, WITH SPECIAL REFERENCE TO AEDES THIBAULTI DYAR AND KNAB (DIPTERA, CULICIDAE). Jour. Econ. Ent. 31: 95–102, illus.
(138) ——— and MILES, VIRGIL I.
1937. THE OCCURRENCE OF ORTHOPODOMYIA ALBA IN ALABAMA (DIPTERA: CULICIDAE). Ent. Soc. Wash. Proc. 39: 237.
(139) SMITH, JOHN B.
1904. REPORT OF THE NEW JERSEY STATE AGRICULTURAL EXPERIMENT STATION UPON THE MOSQUITOES OCCURRING WITHIN THE STATE, THEIR HABITS, LIFE HISTORY, ETC. 482 pp., illus. Trenton.
(140) STRATMAN-THOMAS, W. K., and BAKER, F. C.
1936. ANOPHELES BARBERI COQUILLET, AS A VECTOR OF PLASMODIUM VIVAX GRASSI AND FELETTI. Amer. Jour. Hyg. 24: 182–183.
(141) STROMQUIST, W. G.
1935. MALARIA CONTROL IN THE TENNESSEE VALLEY. Civ. Engin. 5: 771–774, illus.
(142) THIBAULT, JAMES K., JR.
1910. NOTES ON THE MOSQUITOES OF ARKANSAS. [DIPTERA, CULICIDAE]. Ent. Soc. Wash. Proc. 12: 13–26.
(143) UNITED STATES PUBLIC HEALTH SERVICE.
1919–25. [TRANSACTIONS OF ANTIMALARIA CONFERENCES 1 TO 5.] U. S. Pub. Health Serv., Pub. Health Buls. 104, 115, 125, 137, 156, illus.
(144) VAN DINE, D. L.
1922. IMPOUNDING WATER IN A BAYOU TO CONTROL BREEDING OF MALARIA MOSQUITOES. U. S. Dept. Agr. Bul. 1098, 22 pp., illus.
(145) VANNOTE, ROBERT L.
1937. METHOD OF APPLYING THE LARVICIDE AS A REPELLENT. N. J. Mosquito Extermin. Assoc. Proc. 24: 11–15.
(146) VIOSCA, PERCY, JR.
[1924.] REPORT OF THE ENTOMOLOGIST. Parish of Orleans and City of New Orleans Bd. Health Ann. Rpt. 1923: 31–47, illus.
(147) ———
1925. A BIONOMICAL STUDY OF THE MOSQUITOES OF NEW ORLEANS AND SOUTHEASTERN LOUISIANA. N. J. Mosquito Extermin. Assoc. Proc. 12: 34–50, illus.

(148) WATSON, R. B., KIKER, C. C., and JOHNSON, H. A.
1938. THE ROLE OF AIRPLANE DUSTING IN THE CONTROL OF ANOPHELES BREEDING ASSOCIATED WITH IMPOUNDED WATERS. U. S. Pub. Health Serv. Rpts. 53: 251–263, illus.

(149) ——— and SPAIN, E. L., JR.
1937. STUDIES ON MALARIA IN THE TENNESSEE VALLEY. THE INFLUENCE OF PHYSIOGRAPHY ON THE OCCURRENCE OF BREEDING PLACES OF ANOPHELES QUADRIMACULATUS IN NORTHERN ALABAMA. Amer. Jour. Trop. Med. 17: 289–305, illus.

(150) WILLIAMS, L. L., JR., and COOK, S. S.
1927. PARIS GREEN APPLIED BY AIRPLANE IN THE CONTROL OF ANOPHELES PRODUCTION. U. S. Pub. Health Serv. Rpts. 42: 459–480, illus.

(151) ——— and LEGARE, A. E.
1928. LENGTH OF LIFE OF ANOPHELES QUADRIMACULATUS AFTER BEGINNING OF CONTROL OF PRODUCTION. South. Med. Jour. 21: 735–737, illus.

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(Valid names are in roman type, synonyms in italics. Figures in bold-faced type indicate page on which the genus or species is described.)

U. S. GOVERNMENT PRINTING OFFICE: 1944