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THE MOSQUITOES OF THE NORTHWESTERN UNITED STATES
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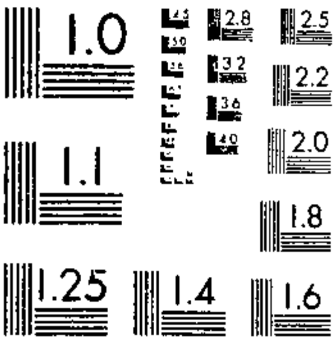

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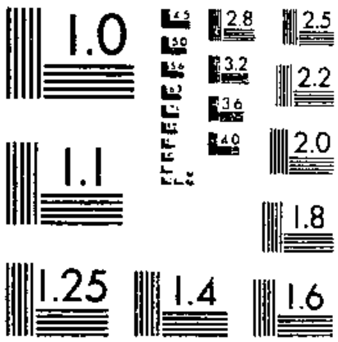

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THE MOSQUITOES OF THE NORTHWESTERN UNITED STATES

By C. M. GJULLIN and GAINES W. EDDY

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PREFACE

The purpose of this bulletin is to supply useful information to organizations facing mosquito problems in Washington, Oregon, Idaho, and adjacent States. This information should assist them in determining the magnitude of their mosquito problems and the advisability of undertaking a control program. Organizations already engaged in mosquito control in these States should also find the bulletin useful in identifying species of mosquitoes found there.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a warranty or an endorsement of the product by the U.S. Department of Agriculture to the exclusion of other products not mentioned.

CONTENTS

THE MOSQUITOES OF THE NORTHWESTERN UNITED STATES

By C. M. GJULLIN and GAINES W. EDDY, entomologists, Entomology Research Division, Agricultural Research Service[1]

This publication deals with the mosquitoes recorded from Washington, Oregon, and Idaho. A handbook on the mosquitoes found in these States (*254*)[2] was published in 1952. Since then many new data have been obtained. Widely scattered information is included here on the species, their biology, taxonomy, distribution, economic importance, and methods used for control. Several sections not included in other U.S. Department of Agriculture publications on mosquitoes have also been added.

Most of the data on species distribution were compiled from collections made by the Entomology Research Division during 1930–67. However, some records were furnished by Washington State University, Oregon State University, the University of Idaho, and the U.S. Public Health Service, and some recent records by the Washington and Oregon State Health Departments through the courtesy of Roy Myklebust and LaVerne Miller, respectively. Limited records available from literature have also been included when they provided additional information.

SPECIES FOUND IN WASHINGTON, OREGON, AND IDAHO

Six genera and 53 species of mosquitoes have been recorded from Washington, Oregon, and Idaho. Forty-one species have been collected in Washington, 45 in Oregon, and 45 in Idaho. These are listed in table 1. Distribution of the species in these States is shown on the maps in the appendix. An attempt has been made in the table to provide a rating on the basis of species abundance, distribution, and importance as pests or disease carriers to man or animals. Although for many species this cannot be done with any degree of accuracy, due simply to lack of information, the data indicate whether a species is common, rare, or absent.

Some of the more important pests and disease carriers are as follows:

Aedes communis occurs in many mountain areas and in some places is a serious handicap to recreational interests, lumbering, and road building.

Aedes dorsalis breeds in both flooded salt- and fresh-water areas. It is an abundant and troublesome pest of man and animals in some coastal and many inland areas.

Aedes hexodontus is very numerous and annoying in some mountain areas.

Aedes increpitus occurs in many semiwooded areas from sea level to 6,000 feet but is usually most numerous and annoying in mountain areas.

Aedes melanimon is present in large numbers in many inland areas and is an important pest. The larvae develop in irrigation and floodwaters.

Aedes sticticus breeds mainly in flooded willow and cottonwood flats bordering river and lake margins. It is a severe pest of man and livestock, especially along the lower Columbia River.

Aedes vexans develops in floodwater and irrigated areas. It is one of the most important pest species and is particularly numerous and annoying along the lower Columbia River.

Culex pipiens pipiens is present in large numbers in some communities in western Washington and Oregon but is seldom found in Idaho or the eastern half of Washington and Oregon. It is considered the most important house pest in most areas where

[1] The authors acknowledge the assistance of the following persons in this Division: Alan Stone, Systematic Entomology Laboratory, for many valuable suggestions and many of the larval and terminalia drawings; L. F. Lewis, A. R. Roth, Jessup Johnson, and D. M. Christenson for information on distribution abundance; Mrs. Pamela Harr and Miss Thelma Ford for many of the drawings; and W. C. McDuffie, D. E. Weidhaas, and John A. Fluno for their encouragement and assistance in preparing this bulletin.

[2] Italic numbers in parentheses refer to Literature Cited, p. 89.

Culex tarsalis is one of the most important known vectors of St. Louis and western equine encephalitis. It is also one of the most widely distributed species in the Northwest. Birds and livestock are its preferred hosts, but it will also readily attack man and other mammals. Large numbers of this species are produced in log ponds as well as in a variety of other permanent and semipermanent waters.

Other important species include *Aedes cinereus*, *A. fitchii*, *A. nigromaculis*, *Anopheles freeborni*, *Culiseta incidens*, and *C. inornata*.

TABLE 1.—*Distribution and relative importance*[1] *of mosquito species in Northwestern States*

Species	Washington	Oregon	Idaho
Anopheles:			
earlei	3	—	3
freeborni	2	2	2
occidentalis	3	3	3
pseudopunctipennis franciscanus	—	3	—
punctipennis	2	2	2
Aedes:			
aboriginis	2	2	3
aloponotum	2	3	—
campestris	3	3	3
canadensis canadensis	2	—	2
cataphylla	3	2	2
cinereus	2	2	2
communis	2	2	2
dorsalis	1	1	1
excrucians	2	2	2
fitchii	2	2	2
flavescens	2	2	2
hendersoni	—	—	3
hexodontus	2	2	2
impiger	2	2	2
implicatus	2	2	2
increpitus	2	1	1

TABLE 1.—*Distribution and relative importance*[1] *of mosquito species in Northwestern States*—Continued

Species	Washington	Oregon	Idaho
intrudens	2	3	2
melanimon	2	2	2
nigromaculis	2	2	
niphadopsis	—	3	-
pionips	3	3	3
pullatus	2	3	2
punctor	3	—	—
schizopinax	—	3	3
sierrensis	2	2	3
spencerii idahoensis	2	3	2
sticticus	1	1	2
stimulans	—	—	3
trichurus	3	--	2
trivittatus	—	—	3
ventrovittis	3	3	3
vexans	1	1	1
Culex:			
apicalis	—	3	—
boharti	—	3	—
erythrothorax	—	—	3
peus	2	2	—
pipiens pipiens	2	1	2
restuans	-	3	2
salinarius	..	3	2
tarsalis	1	1	1
territans	2	2	2
Culiseta:			
impatiens	2	2	3
incidens	2	2	2
inornata	2	2	2
minnesotae	3	3	3
particeps	—	3	—
Coquillettidia perturbans	3	2	3
Orthopodomyia signifera	—	3	—

[1] Based on numbers, distribution, and importance as pests or disease carriers: 1 = most important; 2 = less important; 3 = uncommon or rare; — = not recorded.

MOSQUITO LITERATURE

The literature on mosquitoes is extensive and increases as more mosquito-control operations are undertaken in many parts of the world. Probably no other group of insects has received so much study. Some of the more noteworthy publications are mentioned here. Others are listed at the end of the bulletin.

A four-volume monograph by Howard et al. (*147*) was the first comprehensive publication on the mosquitoes of the Western Hemisphere. It contains much information on the biology, distribution, and taxonomy of these species. The taxonomic part of this work was later extensively revised and condensed by Dyar (*84*).

Matheson's handbook (*190*), revised in 1944, gives much information on the taxonomy, biology, and control of mosquitoes of North America. Excellent taxonomic and anatomical illustrations are included. A valuable book on "The Natural History of Mosquitoes" has been published by Bates (*19*).

The taxonomy, biology, distribution, and medical importance of North American mosquitoes are covered in an authoritative, well-illustrated book by Carpenter and LaCasse (*57*), which appeared in 1955.

An illustrated monograph with diagnostic characters of the medically important mosquito species of the world has been published by Foote and Cook (*93*).

A catalog of the mosquitoes of the world, published in 1959 by Stone et al. (*261*), and its supplements (*258-260*) provide a standard reference on nomenclature and classification.

Carpenter (*56*) also reviewed the literature on the taxonomy, distribution, and bionomics of North American mosquitoes from 1955 through 1967, starting with the publication of "Mosquitoes of North America (North of Mexico)" by Carpenter and LaCasse (*57*).

A book on the physiology of mosquitoes by Clements (*75*) includes much information on this subject. The anatomy of the mosquito is described and illustrated in a publication by Snodgrass (*250*).

"A Handbook of the Mosquitoes of the Southeastern United States" by King et al. (*170*) contains information on some of the species found in the Northwest.

U.S. Department of Agriculture Handbook 46 (*254*), now out of print, was the most useful publication concerned with the species found in the Northwest. The present bulletin updates this earlier publication and adds much new information.

A book of historical interest by Herms and Gray (*141*) deals with all phases of organizing and operating mosquito-abatement districts. It includes information on laws and agencies, education of the public, and methods of mosquito abatement.

A publication by the American Mosquito Control Association (*7*) gives information on methods of organizing, type of personnel, and methods of financing mosquito-control districts. It also contains information on types of statewide enabling legislation and the type of assistance available from research agencies.

Engineering aspects of mosquito control are discussed in the "Engineering News-Record" (*89*) and in a paper by the National Malaria Committee (*200*).

Information on ground equipment and insecticides for mosquito control (*8*) and for aircraft application of insecticides (*6*) is available in two publications by the American Mosquito Control Association. U.S. Department of Agriculture Circular 977 (*272*) also contains much information on mosquito repellents, insecticides, formulations, and application equipment. The results of screening more than 19,700 organic chemicals as mosquito larvicides, adult sprays, and repellents are reported in Agriculture Handbooks 69 (*169*) and 340 (*274*).

Several State bulletins and Canadian reports will be found useful in a study of the mosquitoes of the Northwest: *California:* Freeborn (*94*) and Freeborn and Bohart (*95*); *Montana:* Mail (*187*); *Utah:* Nielson and Rees (*205*); *Ontario:* Steward and McWade (*257*); *lower Fraser Valley of British Columbia:* Hearle (*138*); *western Canada:* Rempel (*230*); and *Alaska:* Gjullin et al. (*114*). State bulletins on mosquitoes have also been issued by Arkansas (*50*), Illinois (*235*), Minnesota (*16*), Nevada (*68*), Oklahoma (*237*), Wisconsin (*82*), and Wyoming (*207*).

The following serial publications will be of interest to students of Culicidae: "Mosquito News," published quarterly by the American Mosquito Control Association at Albany, N.Y., and the "Proceedings," published each year by the New Jersey Mosquito Extermination Association, the California Mosquito Control Association, the Florida Anti-Mosquito Association, and the Utah Mosquito Abatement Association. The "Proceedings" of the Northwest Mosquito and Vector Control Association covers many subjects pertaining to pests of man and animals.

Articles on mosquitoes also appear in many other entomological, medical, and scientific journals and in the "U.S. Public Health Reports." Abstracts of the mosquito literature of the world are published in "The Review of Applied Entomology, Series B, Medical and Veterinary." A quarterly list of current mosquito literature appears in each issue of "Mosquito News."

MOSQUITO-CONTROL ORGANIZATIONS

There are a number of State or regional mosquito-control associations in the United States, but of most interest to those in the Northwest is the Northwest Mosquito and Vector Control Association organized in 1960.

There is also the American Mosquito Control Association, which is international in scope and has over 1,200 members. It is a nonprofit professional association composed of entomologists, sanitary engineers, control officials, medical personnel, and laymen, who are charged with or have an interest in mosquito control and related work. Annual meetings are usually held jointly with those of the State associations.

MOSQUITO-ABATEMENT LAWS

Local mosquito-control agencies are commonly called mosquito-abatement districts. Laws in most States have been enacted to facilitate organization of such districts. These laws vary considerably in the different States. A comprehensive discussion of laws, financing, personnel, and other matters relating to organization of mosquito-control districts has been published by the American Mosquito Control Association (7).

The Washington State law provides for the organization of mosquito-control districts in Adams, Benton, Franklin, Grant, Kittitas, Walla Walla, and Yakima Counties. Petitions containing the signatures of 10 percent of the registered voters of the area must be presented to the county commissioners of the county in which the largest area of the proposed district is located. The petition must describe the boundaries of the district, which may include sections or all of several counties.

Districts may also be formed by a resolution of the county commissioners, which must also describe the boundaries of the proposed district.

A public hearing on the district proposed by the petition or resolution must be held within 2 months. If the commissioners find that the formation of a district is in the public interest, its formation must be approved by the voters of the district at an election to be held not sooner than 30 days and not later than 60 days after the hearing. Approval for formation of the district requires a majority vote. The voters must also approve authorization of a 1-mill tax levy by a three-fifths majority at this election to provide funds for operation of the district.

A board of five trustees is appointed by the county commissioners if formation of the district is approved by the voters. The trustees manage the affairs of the district, employ personnel, and determine the amount of money required to carry on its operations. Taxes based on their estimate are collected at the same time as other county taxes. The district may also levy taxes twice a year of not more than 2 mills in excess of the 40-mill limitation if approved in special elections by three-fifths of the voters.

The law also contains a number of provisions that assist the Director of the State Health Department in establishing a statewide program for the control of mosquitoes as a health hazard. Provisions of the Washington law are given in Revised Code of Washington, chapter 17.28, 1959.

In Oregon a mosquito-abatement district may include all or any part of a county. A petition containing the signatures of not less than 25 taxpayers of the proposed district must be presented at a regular meeting of the county court. The need for such a district is determined by the county court at a hearing that must be held not sooner than 30 days and not later than 60 days after the petition is presented. Creation of the district must be approved by the voters in the district at a special election to be held not more than 5 days after the hearing.

A board of five trustees appointed by the county court manages the affairs of the district, employs personnel, and estimates the annual budget. Taxes for the operation of the district are levied after approval by the county court and the health officer on the board. These taxes may not exceed 1½ mills per dollar of assessed valuation within the district.

Counties may also contract with cities, vector-control districts, and other counties on any matter incident to control of public-health vectors. The provisions of the Oregon Vector Control law are given in Oregon Revised Statutes, chapter 452, 1959.

The Idaho Mosquito Abatement Act requires that a petition signed by 10 percent of the qualified residents of the proposed district be presented to the board of county commissioners. A district may include one or more counties or sections thereof. If, after publication of this petition, no written protests are received within 30 days, an election is then held. If protests are received, an election must be held 15 days after a public hearing. A board of five trustees is appointed by the county commissioners if the district is approved by a majority vote. The trustees manage the affairs of the district, employ personnel, and estimate the required budget for the next year. Taxes for operation of the district are levied after approval by the county commissioners and the State Department of Health. Taxes may not exceed 5 mills per dollar of assessed property valuation. Provisions of the Idaho laws are given in Idaho Code, chapter 29, 1959.

NATURAL HISTORY OF MOSQUITOES

All mosquitoes have two wings, a body partially covered with scales, and an elongated proboscis used in feeding. Another common characteristic is that they spend part of their life cycle in water. The types of water in which the larvae are found vary widely. Some genera such as *Culex*, *Culiseta*, and *Anopheles* lay their eggs on permanent or semipermanent bodies of water, whereas others such as *Aedes* usually deposit their eggs on moist soil or areas above the water level in temporary pools or marshes.

All mosquitoes pass through a complete metamorphosis consisting of four stages—the egg, the larva or wriggler, the pupa or tumbler, and the adult or imago.

EGGS

Mosquitoes lay their eggs in batches of about 50 to 200. The eggs of *Culex* (fig. 1), *Coquillettidia*, and *Culiseta* are laid in rafts on the surface of the water. The female rests on the water and cements each egg in an upright position in the raft as it is laid. The eggs of these three genera usually hatch in about 2 to 4 days depending on the temperature. The eggs of *Anopheles* are laid singly on the surface of the water and hatch in about the same period of time.

The eggs of most *Aedes* species are laid on moist soil in areas where they will be flooded by waters from irrigation, rising rivers, rain, or melting snow. Eggs of some *Aedes* species may remain viable for as long as 4 years if they are not flooded (*104*). On flooding they may hatch in minutes. Some *Aedes* species may lay eggs several times during a season if favorable locations for egg deposition are available.

Eggs of many *Aedes* species do not hatch unless the oxygen level of the water in which they are immersed is lowered (*107*, *156*). The reduction of the oxygen to the required level occurs in nature in shallow water containing organic debris and bacteria. Food for the newly hatched larvae is often more abundant in shallow water, and the lowered oxygen requirement insures that the eggs will usually hatch in this environment and not in running water or deep water where the larvae would not survive. A reduction in the oxygen level of the water is not effective in causing hatching of some *Aedes* species until a summer diapause is broken by exposure to rather low temperature (*188*). Some mosquitoes require a blood meal before they will lay eggs, but several species are able to deposit eggs without it (*66*).

LARVAE

The larvae of all mosquitoes are aquatic and nearly all are free swimming. Larvae usually obtain air through a tube, which extends through the surface of the water, or by means of a shorter type of

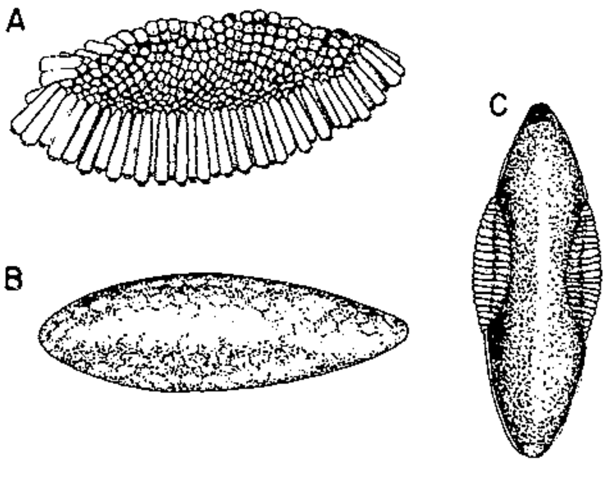

FIGURE 1.—Mosquito eggs: *A*, *Culex*; *B*, *Aedes*; *C*, *Anopheles*.

air-intake apparatus. About 4 to 14 days are required for larval development of most species. During this period the larva grows and sheds its skin four times. Larvae of *Coquillettidia perturbans*, which attach to the roots of aquatic plants, and *Aedes sierrensis*, which occur in tree holes, usually overwinter in the larval stage.

The food of mosquito larvae consists of minute plants, animals, and organic debris and is obtained by using the mouth brushes. The larvae can also utilize pure cultures of various organisms (*13*). Some species such as *Psorophora ciliata* (F.) are predaceous on other mosquito larvae. The nutritional requirements have been reported for only a few species (*245*).

PUPAE

The pupa or tumbler (fig. 2) is also aquatic and appears with the fourth molt. In most species air is obtained through a pair of trumpets at the surface of the water. *Coquillettidia* species have breathing tubes adapted to penetrate submerged plant tissue, where they attach until ready to emerge. Pupal development is usually completed in about 2 days but varies considerably with the species and water temperature. Pupae take no food.

ADULTS

A series of six stylets partially enclosed in the labium of the proboscis (fig. 3) is used by the female to penetrate the skin and draw the blood of the host. The maxillae are the main piercing organs. The tube through which the blood is drawn is formed by the labrum. The labium does not enter the wound but acts as a guide for the stylets. Salivary fluid discharged through a canal in the hypopharynx prevents the blood from coagulating. The itching sensation resulting from the bite is caused by this fluid.

Females may also feed on flower nectar and various plant juices (*40*). Newly emerged *Aedes dorsalis* adults have been observed feeding in large numbers on willow catkins and other flowers in eastern Oregon. Similar feeding habits have been noted in other species (*124, 125, 212*). Certain plants have increased the longevity of mosquitoes in the laboratory (*208*). The behavior of mosquitoes in relation to blood feeding has been reviewed by several workers (*143, 158, 198*).

The male mosquito does not have mouth parts capable of piercing the skin. Males can usually be distinguished from females by their bushy antennae and differences in the length and shape of the palpi (fig. 4). Most males apparently obtain their food from flower nectar and plant juices. Both male and female mosquitoes can be kept alive in the laboratory for considerable periods on sugar or honey-water solutions or raisins. Some mosquitoes can also utilize dry sugar (*87*).

MATING

Most mosquitoes usually mate from 1 to 3 days after emergence. Their age and conditions under which they mate vary considerably with the species. Males of many genera form compact swarms when the light reaches a certain intensity in the morning and evening. These swarms, which may be of several well-defined shapes, have been commonly referred to as "mating swarms." However, based on many observations of mosquito matings and from an analysis of the literature on the subject, Nielsen and Haeger (*202*) suggested that mating may occur when the female is in flight for a number of reasons and that male swarms are not a major occasion for mating. Mating has been observed in male swarms of many species, but this occurs only when the females fly near or into the swarms. The flight sound of a female has been shown by Roth (*236*) to be

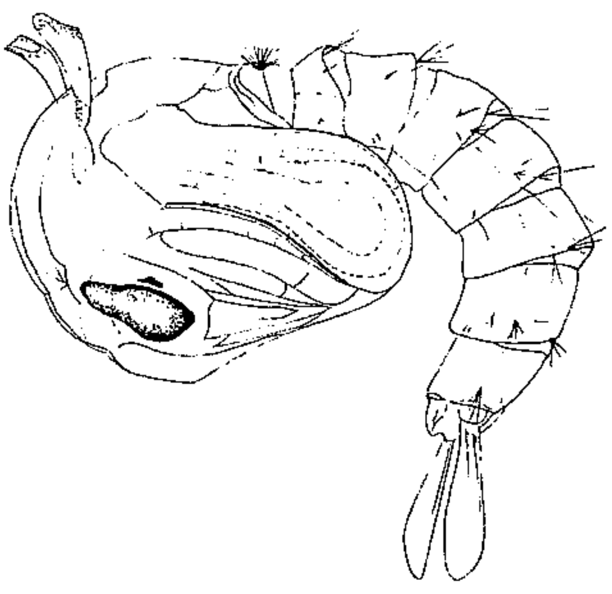

FIGURE 2.—Mosquito pupa.

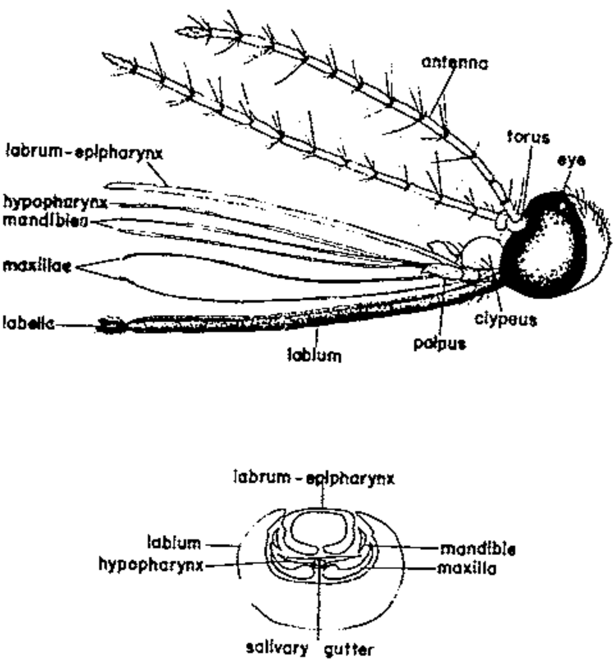

FIGURE 3.—Head and mouth parts, with cross section of proboscis, of female mosquito.

necessary before the male of *Aedes aegypti* (L.) will attempt to mate. Kliewer et al. (*171*) found that the females of *Culiseta inornata* produced a sex pheromone that attracted the males. Males were found to produce a pheromone that attracted the females in a study of three species of *Culex* by Gjullin et al. (*115*).

Male swarming occurs in several species of *Aedes, Culex, Anopheles, Coquillettidia,* and *Culiseta,* but several investigators indicate that males of *Culiseta inornata* do not swarm. Rees and Onishi (*224*) found that males hatched from the same egg rafts as the females, emerged from 6 to 12 hours earlier, and mated sometimes within 1 or 2 minutes after the female had emerged. Females of this species have been shown by Kliewer et al. (*171*) to produce a volatile substance that attracts the males.

FLIGHT HABITS

The flight behavior of mosquitoes depends on the species, population pressure, food supply, weather conditions, and other factors. Information is available for only a few species. *Aedes vexans* and *A. sticticus* females marked with a stain shortly after emergence near the Columbia River were recovered 5 miles away 24 hours later (*253*). In observations made along a canyon road these two species were numerous at 15 miles but present only in small numbers at 30 miles from the nearest breeding places. Studies on the flight range of *A. vexans* and several other species have been made by Clarke (*74*). *Aedes* species marked with fluorescent dye in a California test were recovered 20 miles or more from the area where the dye was applied (*248*). Males of *Coquillettidia perturbans* and *A. vexans* were collected in a New Jersey light trap placed on a lighthouse 8.2 miles from the nearest land (*185*).

Bailey et al. (*11*) found that *Culex tarsalis* in California had an effective flight range of 10 miles

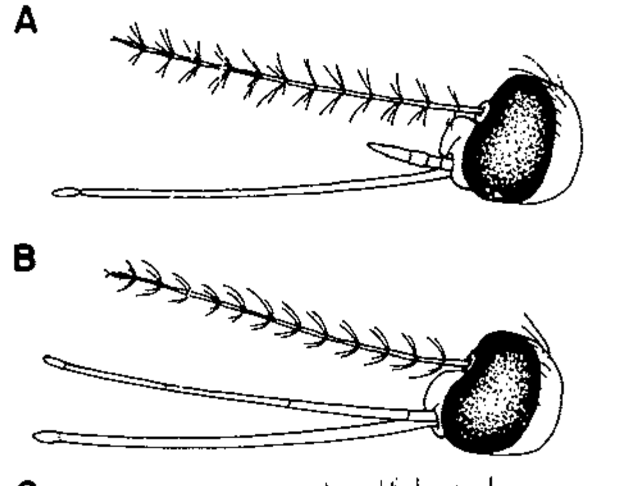

FIGURE 4.—Head and appendages: *A*, *Aedes* female; *B*, *Anopheles* female; *C*, *Aedes* male; *D*, *Anopheles* male.

in 48 hours with downwinds at 2 to 7 miles per hour and a maximum range of 15.75 miles with downwinds at 0.3 to 3.5 miles per hour. Limited upwind movement of this species against winds as high as 5 miles per hour was also observed. They estimated a likely dispersal of 20 to 25 miles in the Sacramento Valley in California. In studies of the dispersal of adults of this species into an area undergoing larvicide treatments the maximum recovery distance was 9.6 miles (*83*).

In Georgia and Florida, females of *Aedes taeniorhynchus* (Wiedemann)—a species not occurring in the Northwest—were marked with radioactive phosphorus as larvae. They migrated a maximum of 25 miles, whereas males moved a maximum of 3 miles (*88, 217*). Females of this species feed extensively on flower nectar before migrating (*125*). Many species fly between sunset and sunrise (*112*). Further information on flight habits is given under each species description.

LONGEVITY OF ADULTS

The lifespan of the mosquito under natural conditions depends largely on availability of food and shelter and prevailing weather conditions. Usually males emerge sooner and also die sooner than females. During the regular breeding season the average mosquito probably lives only a few weeks. Species that hibernate naturally live for several months.

The longevity of *Aedes vexans* and *A. sticticus* has been studied by staining newly emerged adults near their breeding areas (*253*). There appeared to be no great difference in their longevity. Numerous females of both species were taken after 30 to 60 days and a few of each were captured 104 to 113 days after being stained. The longest record for males was a single specimen of *A. sticticus* taken 94 days after staining. In the laboratory numerous species have remained alive for a month or more.

HIBERNATION

Most *Culex*, *Anopheles*, and *Culiseta* females hibernate in food-storage cellars, subfloor spaces, basements, old mines, caves, mammal burrows, rock piles, and similar places (*64, 244*). In Nevada, *Culex erythrothorax* overwinters as larvae (*61*).

Most *Aedes* species found in the Northwest overwinter as eggs in soil and debris. *Aedes sierrensis* overwinters in the egg stage in the colder parts of its range but may also overwinter as larvae or eggs in warmer areas (*67*). In the Southern States no true hibernation occurs in some species.

MOSQUITOES AND DISEASES

ENCEPHALITIS

Western equine and St. Louis encephalitis are mosquito-borne virus diseases of the central nervous system. Symptoms of severe infections may include stiff neck, high fever, headache, drowsiness, and coma. Small children may suffer severe delayed physical and mental aftereffects. The mortality rate for western equine encephalitis (WEE) ranges from 5 to 15 percent for humans and 20 to 30 percent for horses (*22*). A 2- to 11-percent mortality rate for humans has been reported for St. Louis encephalitis (SLE).

WEE and SLE were first isolated from field-collected mosquitoes in an epidemic area during the Yakima Valley outbreak in 1940 by Hammon et al. (*130*). They were isolated from *Culex tarsalis* and *C. pipiens pipiens*. WEE and SLE have since been isolated from several other species. Isolations from species occurring in the Northwest include WEE and SLE from *Aedes dorsalis* (*127, 128, 131, 268*), which probably includes the subsequently reestablished *A. melanimon* species (*36*), and WEE from *Culiseta inornata* (*129*). Many other species of several genera have been capable experimentally of transmitting WEE and SLE (*59, 92, 126*). *C. tarsalis* is considered the primary vector of these viruses and is apparently a very efficient transmitter of WEE (*266*). *C. p. pipiens* was also a vector of SLE in six States, and *Culex nigripalpus* Theobald has been an important vector in Florida (*23*). California encephalitis has also occurred in several States in the Midwest.

Man and horses usually contract all these diseases under conditions that include high prevailing temperatures, large mosquito populations, and an adequate bird population with a high rate of virus infection. Thomas and Eklund (*267*) demonstrated that garter snakes may serve as natural overwintering mechanisms for WEE virus.

MALARIA

Malaria is no longer an important disease in the United States. In 1955 there were 477 cases reported by the Public Health Service and four of these were indigenous. In 1956 there were 234 cases and the number of indigenous cases was not reported. In 1958 there were 72 confirmed and presumptive cases, of which three were indigenous. Four cases resulted from blood transfusions and the others occurred in foreign civilians and military personnel on foreign duty (*45*).

This disease was probably brought into the Northwest about 1830[3] (*242, 252*). It was fatal to a large number of the native population that contracted it and had an important bearing on the early history of the region. Apparently it is not known how it first reached the Northwest, but it was most likely brought by wagon trains coming to the Oregon territory from Independence, Mo.

Malaria was first required to be reported to the State Health Officer in Washington in 1915 and in Oregon in 1918. A total of 578 cases, exclusive of those with histories of recurrence or infection from outside the State, had been reported in Oregon by 1944 (*116*). Thirty-four cases were reported in Washington between 1935 and 1944 and 20 cases in Idaho between 1936 and 1944.

Anopheles freeborni has been considered the main vector of malaria in the area, but *A. punctipennis* may also have been a vector (*123*).

OTHER DISEASES

Mosquitoes have also been incriminated in the transmission and maintenance of several other diseases or parasites of man and animals. The viruses include yellow fever, dengue, fowl pox of poultry, rabbit myxomatosis, and Rift Valley fever (enzootic hepatitis) of sheep and other animals. Apparently fowl pox is present in the Northwest. Several species are apparently capable of transmitting fowl pox of chickens (*192*). However, present poultry management practices have reduced its importance.

Filariasis (*Wuchereria* spp.) of humans and filarial heartworm (*Dirofilaria immitis* (Leidy)) of dogs and other carnivores are also transmitted by mosquitoes. Only the dog heartworm is present in the United States, except in persons arriving from the Tropics, and it is apparently rare in the Northwest. Other diseases include tularemia of man and other animals and anaplasmosis of cattle. Anaplasmosis is a very important disease and is present over most of Washington, Oregon, and Idaho. However, little is known about the importance of mosquitoes in its transmission.

Although each disease is often transmitted by a different mosquito species, *Culex pipiens pipiens*, *Aedes vexans*, and especially *A. aegypti* are known to be important transmitters of several maladies. It would seem likely that mosquitoes are more important in the transmission and maintenance of diseases of man and animals than is presently known or suspected.

NATURAL ENEMIES OF MOSQUITOES

Mosquitoes have many natural enemies. The adults are attacked by birds, bats, dragonflies, pathogenic organisms, and various other animal and plant species. However, none of these have been highly effective. The larval and pupal stages are eaten or destroyed by plants, larval or nymphal stages of other insects, and many species of pathogenic fungi and bacteria (*142, 160, 189, 191*).

The mosquito fish or top minnow (*Gambusia affinis* (Baird & Girard)) has been used intermittently since 1910 for the control of mosquitoes. Its effectiveness as an exterminator of mosquito larvae is determined by abundance of food, kind and amount of vegetation, physical and chemical properties of the water, and other factors. Rees (*221*) examined the stomach contents of 259 field-collected *Gambusia* specimens and found more than 50 kinds of plant and animal species. His observations indicated that the selected food of the fish is not always the mosquito larva. The fish is not effective in dense vegetation and often avoids shaded areas. Under most conditions *Gambusia* cannot be relied upon as a single control agent. However, it can be of much value.

Mosquito larvae are also preyed upon by their own kind. *Psorophora ciliata* (F.) and *P. howardii*

[3] LEE, J., and LEE, D. MISSION RECORD BOOK. Methodist Episc. Church, Willamette Sta., Oreg. Ter., N.A. 1834–37. [Manuscript.]

Coquillett will readily attack other larvae. Species in the genus *Toxorhynchites* (*Megarhinus* of some authors) also attack other mosquito larvae, and one species, *T. brevipalpus* Theobald, was introduced into Hawaii by Bonnet and Hu (*37*) as an aid in the control of *Aedes albopictus* (Skuse). Members of the midge family Chaoboridae also feed on mosquito larvae. *Eucorethra underwoodi* Underwood, for example, is common in the Northwest and breeds in association with *Aedes sierrensis* and several other species. Bonnet and Mukaida (*38*) showed that the copepod (*Mesocyclops obsoletus* (Koch)) was an effective larval predator in the laboratory. Some plants such as bladderwort (*Utricularia*) capture and destroy mosquito larvae but apparently not in sufficient numbers to be of much value. Larvae and adults are also parasitized by various species of mites (*72, 91, 145*), but they do not appear to affect mosquito populations to any extent.

There are at least three dozen pathogenic and nonpathogenic organisms of mosquitoes in the United States. The pathogenic species such as are found in the fungal genus *Coelomomyces* are of interest in the control of mosquitoes. This group is highly specialized, attacking the larval and adult stages of mosquitoes and a few other insects. An excellent review by Couch and Umphlett (*78*) points out the possible use of the organisms in mosquito control. Species of *Coelomomyces* infect numerous species and several genera of mosquitoes (*71*).

Mosquitoes are also subject to protozoan infections. According to Weiser (*278*), both *Culex* and *Anopheles* have been parasitized by *Caulleryella anophelis* Hesse and *C. pipientis* Bresslau & Buschkiel. Some species are also attacked by *Lankesteria culicis* Ross. Several ciliates attack a number of species and genera of mosquitoes. Some of them are sufficiently pathogenic to have potential value in controlling mosquitoes. Information on many of the ciliated protozoa species has been reported by Corliss (*76, 77*), Kellen et al. (*166*), and Lipa (*183*).

Not much is known about viruses of mosquitoes. The encephalitis viruses do not appear to affect the adult female mosquitoes that transmit them (*266*). The same is also apparently true of yellow fever, dengue, and other viruses (*255*). However, viruses pathogenic to the larvae of certain *Aedes* spp. have been reported by Clark et al. (*73*), Chapman et al. (*69*), and Kellen et al. (*161, 162*).

Little research was conducted on diseases of mosquitoes of the west coast prior to about 1960. According to Kellen (*160*), for example, there was only one record of diseased mosquitoes in California prior to his observations in 1959. During that period he found a number of microsporidian parasites (*Thelohania* spp.) attacking several mosquito species. Several new species of *Thelohania* (Nosematidae) have been described or characterized by Kellen and Lipa (*163*) and Kellen and Wills (*165*). Research by Kellen and Myers (*164*) on *Bacillus sphaericus* Neide indicates this organism also has certain potential value in mosquito control. Although the bacterium was isolated from larvae of *Culiseta incidens*, it was later shown to be pathogenic to a number of other genera and species. Tanada (*264*) reviewed the microbial control of insect pests.

Although much remains to be learned about host-parasite relationships, many of the pathogens appear to attack only the larval stage of the mosquito and to be rather host specific. Some of the species also appear to be sufficiently pathogenic to be of interest to mosquito-control agencies, and some of them may prove valuable if methods can be found to successfully manipulate them in the field.

MOSQUITO SURVEYS

Mosquito surveys of the areas to be controlled must be made before control measures are begun. They should be conducted by an entomologist or specialist familiar with the biology and habits of mosquitoes. Larvae and adults should first be collected and identified at intervals during the season so as to obtain as much information as possible on the species present, their abundance, and importance as a pest. Information should be recorded on location of breeding places, accessibility to them, type of terrain, and other factors that might affect the control program.

Control of important breeding places in the area may be practical before extensive surveys have been completed, but large-scale operations without adequate information can be wasteful and may result in the loss of public confidence and support. Surveys of the area should be repeated in succeeding years until a thorough knowledge of the problems has been obtained.

EGG COLLECTIONS

The amount of *Aedes* breeding can be determined to some extent by sampling the top layer of soil and debris for eggs. This method can be of value in special locations but is often more time consuming and less accurate than larval sampling. Several methods have been devised for this purpose. In one method the soil samples are run through a series of three concentric screen cylinders, which operate in a water bath, and then through a salt flotation process in a machine devised for egg surveys by Horsfall (*146*). A vacuum cleaner has also been used to pick up eggs from the soil, and shaker screens remove the bulk of the soil in equipment described by Husbands (*150*). A modified grain cleaner removes the eggs from soil samples in a method employed by Gjullin (*103*). A microscope is used to recover eggs from the final product in all three methods.

Information on species and their abundance can also be obtained by flooding soil and debris samples from suspected breeding areas. Eggs of many species will hatch within minutes after they are flooded in summer. Samples taken in spring and fall will usually have to be held at warmer temperatures for a week or more before flooding. Drying and reflooding may also be necessary to obtain complete hatching of these samples. Several species that develop in snow water pools produce only one generation a year, and samples taken in the fall may require exposure to cold temperatures in order to hatch.

LARVAL COLLECTIONS

Larvae are collected to obtain information on the locations of breeding places, the species present, and their abundance. A series of dips at each location will provide information on the species, and counts of the larvae per dip will give an estimate of abundance. Locations of breeding places in rural areas can be recorded on sections of large-scale maps showing the township and the section. Colors or symbols can be used to indicate light or heavy breeding and other important data. A file of such information is a quick reference and serves as a valuable record if kept up to date.

Breeding places are generally permanent or temporary. However, the status of a given area may change over a period of time. *Anopheles*, *Culex*, *Culiseta*, and *Coquillettidia* develop typically in permanent breeding places and *Aedes* species in places that are normally flooded only for short periods. Most of these floods occur only once a year and produce one brood of *Aedes*, but additional hatches of some species may occur if they are flooded more than once as in irrigation practices.

HAND COLLECTIONS OF ADULTS

Collecting mosquitoes while they are attempting to bite is one of the simplest methods of obtaining information on abundance and biting habits of some species. Collections may be made with a chloroform tube or some other type of killing bottle. An effective method is to collect as many mosquitoes as possible as they alight to bite during a 10-minute period. Comparative information may be obtained if collections are made in a series of selected locations at the same time of the day or night. A flashlight or other light source will be helpful if night collections are to be made.

If collection on humans is for comparative purposes, the attraction potential of the individual should be determined, since different individuals do not attract the same number of mosquitoes. The same kind and color of clothing should be worn for each sampling period. The number of mosquitoes collected may also be affected by the dexterity of the collector.

Landing counts on humans are also useful for obtaining information on mosquitoes that attack during daylight. The usual procedure is to count the number of mosquitoes resting on the front of the trousers at each location. Two people working together may obtain similar information by counting the mosquitoes landing on each other.

Culex and *Anopheles* adults rest in dark corners of buildings, in subfloor spaces, under bridges, and other similar places during daylight. Collections of mosquitoes from each of such locations with a suction tube will yield information on species and abundance. One-foot-cube wooden boxes with one side left open have been used to provide uniform resting stations for this type of mosquito survey. The boxes are painted red inside and out and are usually placed on the ground in shaded locations (*121*). Mosquitoes should be collected in the morning because heat may cause them to move to cooler locations. An 18-inch square of Plexiglas to which a handle has been attached can be placed over the open end of the box (*12*). The mosquitoes may then be readily collected after chloroform has been introduced.

Information on some species of *Culex* can also be obtained by collecting the mosquitoes as they alight on the collector. Other species do not ordinarily leave their shelters before sunset, and they begin to return to them before sunrise (*112*). Collections made during the day would therefore yield less information.

TRAP COLLECTIONS OF ADULTS

The New Jersey-type light trap is very useful for sampling populations of many mosquito species. The traps are placed in strategic places throughout the area and are operated one or more nights a week. They should be hung in open spaces with the light 5 or 6 feet above the ground and in locations where the light from the trap will not compete with other lights. The current for operating the light and fan in these traps can be switched off and on manually, but it is usually more convenient to equip the trap with an electric eye or time clock switch.

If weather conditions vary considerably, the numbers taken in trap collections may be variable and may not reflect the actual populations present unless the traps are operated more than once a week. Factors affecting the collecting efficiency of this type of trap have been studied by Barr et al. (*18*). Large numbers of mosquitoes and other insects will often be collected in these traps.

To reduce the time required for handling mosquitoes in large collections, one-half or one-fourth of the catch can be identified to give reasonably accurate totals (*39*). The traps often do not give reliable data on the relative abundance of different species since some are more attracted to light than others (*149*). Also, in some areas or at certain times the mosquitoes are not active at night because of lower temperatures.

A portable light trap operated by a car battery may be used where line current is not available (*243*). Smaller traps of this type are operated by dry cell or 6-volt car batteries (*201, 262*).

Carbon dioxide is stimulating to many species of mosquitoes, and the numbers taken in light traps can be increased by placing a piece of dry ice on or near a trap. A significant increase in the numbers collected is produced by the release of 125 ml. of this gas per minute (*49*).

Mosquitoes may also be captured alive in a large trap mounted on a two-wheeled trailer (*228*). This trap is a modification of the New Jersey-type light trap, but the mosquitoes do not have to pass through the blades of a fan.

Chamberlain and Lawson (*58*) designed a rotating trap operated by a gasoline or electric motor with two or four projecting arms to which screen nets are attached. Cloth bags are fastened to the small open end of the funnel to hold the captured insects. The nets may be adjusted to operate at various levels. By mounting one cone of this trap on the fender of an automobile, continuous samples of the mosquito population can be taken. A 2- by 8-foot screen funnel trap mounted on the cab of a pickup truck has been used by Provost (*217*) to collect mosquitoes.

Several animal-baited traps have been used to collect mosquitoes (*186*). Data on *Anopheles* species that do not remain in accessible shelters during the day have been obtained in the Tropics by this method. The Malaise trap has also been used successfully for mosquito surveys (*41*) and has been more effective than animal-baited traps for some species (*85*). Four sampling methods to measure *Culex tarsalis* adult populations have been compared by Hayes et al. (*136*).

COLLECTING, PRESERVING, AND IDENTIFYING SPECIMENS

COLLECTION

Specimens to be prepared for study in the laboratory or to be preserved for a reference collection must receive special attention if they are to serve their purpose.

Larvae and Pupae

A white enamel dipper with a smooth stick about 3 feet long inserted in the handle is a convenient implement for collecting mosquito larvae and pupae. They may be removed from the dipper with an eye dropper. The tip of an ordinary eye dropper is usually too small to suck in full-grown mosquito larvae or pupae. The opening can be enlarged by breaking off the glass tip. The edges should be fire-polished.

The larvae and pupae can usually be reared in the laboratory. Since young larvae are often difficult to identify, they should be reared to the fourth instar. For correct identification it is often necessary to rear the larvae individually so that the larval and pupal skins can be saved and associated with the emerging adults.

Adults

The most useful specimens of adult mosquitoes are those prepared as soon as they are killed or collected. Those reared from pupae should not be killed for about 24 hours after emergence to allow them time to harden.

Chloroform is widely used as a killing agent for adults. A satisfactory killing container can be made by placing a layer of cut rubberbands or other small pieces of rubber about one-half inch deep in the bottom of a strong glass tube, 1 to 2 inches in diameter. Pour in enough chloroform to cover the rubber pieces and close with a cork or rubber stopper. When the chloroform has been absorbed by the rubber, tamp in a plug of cotton. On top of the cotton place a perforated disk of stiff paper cut to fill the tube tightly. Such a container will usually last several days before it needs recharging with chloroform. A few strips of soft tissue paper placed in the killing tube will help lessen damage to the insects.

Another hand-collection device is a suction or aspirator tube made out of a glass or clear plastic tube, one-half to three-fourths inch in diameter and 12 to 16 inches long. Over one end of the tube is placed a piece of cheesecloth and a rubber tube over that. Mosquitoes can then be sucked into the aspirator tube and blown into the chloroform tube to be killed.

After a few specimens have been killed in the chloroform tube, they should be transferred to a small container. A pill box containing pieces of soft tissue paper placed over cotton is commonly used. The mosquitoes are placed between the layers of tissue. Without the tissue paper the tarsal claws may cling to the strands of cotton and may be broken. With proper care the tissue can be used alone. Care should also be taken with the specimens, as scales and hairs needed for identification are easily rubbed off.

Adults to be retained in permanent collections are best mounted on a minuten pin stuck into a small piece of cork, through which is passed a larger pin. A No. 3 entomological pin is generally the best size for holding the cork. The tip of the minuten pin is then inserted through the thorax from the underside of the mosquito.

The mounted specimens should be carefully labeled and placed in a tightly closed insect box. The stored specimens should be protected from insect pests and dampness. Naphthalene, paradichlorobenzene, or lindane crystals or dichlorvos-impregnated strips placed in a perforated container or cloth bag securely fastened in one corner of the insect box will prevent damage from insect intruders. These fumigants must be renewed occasionally.

PRESERVATION

Ethyl alcohol, 70 to 80 percent, is probably most widely used to kill and preserve mosquito larvae and pupae. Hot, but not boiling, water is usually preferred for killing where feasible. Some workers use the KAAD formula (*210*) as a killing agent. This formula contains kerosene (1 part), 95 percent isopropyl alcohol (7–9 parts), glacial acetic acid (1 part), and dioxane (1 part). Whatever killing agent is used, it should act rapidly or else the larvae may chew off their lateral hairs or other body parts.

The KAAD formula or Cellosolve (2-ethoxyethanol) kills much more rapidly than alcohol but of course not so fast as hot water. If the specimens are to be stored for any length of time in alcohol, about 2 percent of glycerin should be added. Another solution for killing and storage of larvae has been described by Beirne (*25*). It contains 95 percent ethyl alcohol (8 parts), distilled water (5 parts), glycerin (1 part), and glacial acetic acid (1 part).

Ethyl alcohol (70–80 percent) is also probably the most widely used dehydrating material. However, Cellosolve is being used by a number of workers and in many respects is more useful than alcohol since it can be used as a killing, dehydrating, and clearing agent. Prolonged breathing of the vapors should be avoided. There are a number of materials such as xylene, beechwood creosote, phenol, or lactophenol and the oils of cedarwood, wintergreen, and clove that can and have been used as clearing agents. In any case, dehydration and clearing are improved by puncturing or otherwise opening the body cavity of the larvae. However, if this is not done with care, important identification characters may be destroyed. Also, most workers cut the abdomen just above the eighth segment during either the clearing or mounting process so as to obtain a lateral view of the siphon and end segments. Balsam is probably the most widely used mountant; however, euparal, polyvinyl alcohol, and similar materials are often used.

Although there are numerous procedures for mounting mosquito larvae, the following will serve as examples. Matheson (*191*) used hot water to kill the larvae, alcohol, 30 percent through absolute, to dehydrate, and euparal as the mountant. He also mentioned using Cellosolve as a dehydrating and clearing agent and polyvinyl alcohol as a mounting medium.

Burton (*47*) described two methods for making mounts of mosquito larvae. One technique includes 2 hours' storage of the larvae in a dehydrating-clearing mixture consisting of either 70 ml. of beechwood creosote and 25 ml. of 95 percent ethyl alcohol or 70 ml. of absolute phenol and 25 ml. of 95 percent alcohol. The larvae are then cleared in beechwood creosote for several minutes and mounted in either euparal or diaphane. The second method involves the use of lactophenol as a clearing agent and polyvinyl alcohol as a clearing agent and permanent mountant.

Carpenter and LaCasse (*57*) kill larvae in Petersen's KAAD solution, leave them in the solution overnight, and then transfer them to 70 to 80 percent ethyl alcohol. The larvae are rinsed two or three times in alcohol, dehydrated, cleared for 10 minutes in Cellosolve, then mounted in balsam. These authors stated that "water-soluble chloral gum arabic media and polyvinyl alcohol have not proved satisfactory." They also gave directions for preparation of pupae, adults, and male terminalia. Middlekauff (*195*) also described a method of making permanent mounts of mosquito larvae.

Mosquito terminalia may be permanently mounted by clearing first in cold or hot potassium or sodium hydroxide (5–20 percent), washing out the alkali by several distilled-water rinses or neutralizing in acetic or other acid, then dehydrating, and mounting with the materials or by the procedures previously mentioned. Since several species can be separated only by characters of the sexual appendages of the male adult, proper mounting of the terminalia may be very important. Staining of the terminalia renders many characters more easily seen. In fact, some workers consider that staining is required to separate some closely related species. Komp (*176*) described a method for staining, dissection, and mounting of the male terminalia of mosquitoes.

IDENTIFICATION

The principal adult characters distinguishing the different mosquito species are the shape, size, coloration, and scaling of the different body parts. A binocular dissecting microscope with a magnification up to about 85 × is necessary for satisfactory examination. For examining certain larval parts and slide mounts of male terminalia, a microscope with a magnification up to 400 × is often required. Good lighting is needed when high magnification is used.

In the field a hand lens with a magnification of 10 or 15 × is satisfactory for provisional identifications. After some experience one may be able to identify some of the species with a hand lens or even with the unaided eye. The keys in this bulletin, together with the illustrations, should help to identify most mosquito species.

HISTORY OF MOSQUITO CONTROL

The mosquito problem along the Columbia and Willamette Rivers has always severely affected the city of Portland, Oreg. In 1924 some of the civic-minded citizens requested assistance from D. C. Mote, then head of the Entomology Department of Oregon State University. His advice and guidance at meetings of leading citizens of Portland and Multnomah County helped to develop what eventually became an effective community mosquito-control operation. Mote also brought a supply of the mosquito fish (*Gambusia affinis*) from California and released them in the Portland area in March 1926.

H. H. Riddel, a resident of Skamania County, Wash., was one of the pioneers in mosquito control in the Northwestern States. His interest in the mosquito problem in this country led him to correspond with H. G. Dyar of the Smithsonian Institution. Dyar, who had collected mosquitoes in Oregon in 1916, provided him with information on the biology and breeding places of the important species in this area. In 1927 Riddel started a small mosquito-control operation in Skamania County, and in 1930 he was in charge of field operations for the Portland Chamber of Commerce Mosquito Control Committee. This committee, headed by Charles Stidd, consisted of the Oregon State entomologist and representatives of the city of Portland, Multnomah County, and Jantzen Beach. It was responsible for raising funds for the control program for more than 10 years.

G. H. Bradley of the former Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture, visited the lower Columbia River in 1929. He collected some of the more important pest species and made recommendations that stimulated organized action.

Because little was known of the biology and methods of mosquito control in these western States, the U.S. Department of Agriculture was asked to undertake a research program. In 1930 Congress appropriated funds for these investigations.

In 1930 W. V. King of the former Bureau of Entomology and Plant Quarantine opened a laboratory in Portland and made a 2 months' survey of the lower Columbia River and eastern Oregon. He examined many breeding places in several counties along the Columbia River and made hundreds of larval and adult collections of mosquitoes for identification. Aerial pictures of mosquito-breeding areas bordering the Columbia River near Portland, which were made under his direction, were also very useful in investigation and control operations.

An allotment of funds from the Civil Works Administration (*251*) in 1933-34 made it possible to carry on a large brush-clearing program, which facilitated mosquito control in many areas. This work was conducted in Multnomah, Columbia, and Tillamook Counties in Oregon and in Kitsap, Skamania, and Clark Counties in Washington.

An enabling act for the organization of mosquito-abatement districts in Oregon was passed by the State legislature in 1940. Because of opposition in many areas of the State to any increase in taxes at that time, the act stipulated that only counties having an assessed valuation of $100,000 or more could form abatement districts under this law. This law was amended in 1959 so that any county can now organize a mosquito-abatement district under its provisions. A State mosquito-control law was passed in Idaho in 1959 and a Washington State law of 1957 was amended in 1959.

Organized mosquito control has been carried on continually in Portland since 1933 and soon after that throughout Multnomah County. Major mosquito- and vector-control organizations in 1965 totaled about 15 in Oregon and seven in Washington. Idaho had only one organized but inactive district. There were, of course, numerous small communities doing continuous or intermittent control work.

The mosquito-control investigations originally undertaken by the U.S. Department of Agriculture at Portland in 1930 were transferred to Corvallis, Oreg., in 1946 and continued there until 1968, when the station was closed.

COMMON TYPES OF CONTROL PROBLEMS

Different types of mosquito-control problems occur in the Northwest. In some areas they are caused by floodwater, in others by irrigation, and in some by snow water pools. Mosquitoes that breed in permanent or semipermanent pools will usually be found in most localities.

FLOODWATER

Aedes vexans and *A. sticticus*, which develop in large numbers along the borders of the Columbia and other rivers, create one of the most important mosquito problems in this region. The larvae hatch in the spring or early summer when the streams overflow areas such as willow and cottonwood swales where the eggs have been laid. The eggs of these species are dormant when temperatures remain below 45°-50° F. (*117*). Partial dormancy of the eggs may continue until some time in June so that only some of the eggs are hatched by floods occurring in April or May.

In some seasons the larger rivers may rise, recede, and rise again to cover the same egg beds and produce an additional hatch. In other seasons two or three successive rises may occur, each of which is higher than the last. Females that emerge in the first hatch may lay eggs that will hatch in the second or third rises of the river. The Columbia may rise from its normal level of about 8 feet to 24 or even to 30 feet during a flood crest. Most of the eggs are laid between the 10- and 20-foot levels, and some of the eggs that are not flooded during a series of low flood crest years remain viable for as long as 4 years (*104*).

Large *Aedes vexans* and *A. sticticus* breeding areas have been managed efficiently by controlling water levels above the Bonneville Dam. Dikes have prevented flooding in other areas. Clearing of brush has been of value in some special locations. However, control of the major section of these types of breeding areas must often be accomplished with insecticide sprays against the larvae or with prehatch insecticide applications (*281*). These applications to dry potential breeding areas can be very hazardous to wildlife and must be avoided except where the need is fully justified by the magnitude of the mosquito problem.

IRRIGATION WATER

Breeding places for several mosquito species are provided by irrigation water. *Aedes dorsalis*, *A. melanimon*, *A. vexans*, and *A. nigromaculis* are among the most important species that may develop when water is applied and stands for a week or 10 days. Other species such as *Culex tarsalis*, *Culiseta inornata*, and *Anopheles freeborni* may be produced if water remains for longer periods. Tremendous numbers of mosquitoes breed in many areas where uncontrolled irrigation is practiced. Airplane applications of insecticide sprays to control the larvae or adults that have emerged are effective but are not a substitute for proper grading.

On small farms the careful use of water so that it does not stand for more than 4 or 5 days is effective in preventing development of mosquitoes. Application of insecticides may be necessary for breeding places that cannot be drained. For information on mosquito prevention on irrigated farms, see Agriculture Handbook 319 (*275*).

TIDAL WATERS

Aedes dorsalis is the only species that can breed in large numbers in both fresh and salt water in the Northwest. The larvae develop in some coastal areas where potholes are filled by the higher tides or where water levels fluctuate in permanent or semipermanent pools. Leveling, drainage, or similar practices are effective in preventing breeding, but such areas must be properly maintained. Insecticide control of the larvae may be necessary where these methods are inadequate or ineffective.

SNOW WATER

In many high mountain meadows and also at lower levels mosquitoes breed in pools caused by snow melt (fig. 5). Development may require several weeks at higher elevations. *Aedes communis*, *A. hexodontus*, *A. fitchii*, *A. increpitus*, and *A. cinereus* are the most common species found in these locations. Usually there is only one generation per year, but the large numbers that may be produced are a severe annoyance to those who are working or seeking recreation in these areas.

Elimination of breeding areas by drainage or maintenance of constant water levels is practical in some situations. Insecticide applications might have to be made by hand or by plane because of inaccessibility to heavy ground equipment. Prehatch applications of insecticides are used in some locations but should not be considered in areas that drain into lakes or streams.

Relief from adult mosquito populations is often obtained with airplane sprays, but if the mosquito populations are widely distributed, even large-scale insecticide applications may not provide adequate protection (*280*). Some protection may be obtained for smaller areas by applying residual sprays to the vegetation and ground around the area to be protected. However, like prehatch applications, such treatments can be a potential hazard to wildlife (*144*). Hand- or power-operated aerosol equipment can also provide protection for several hours.

PONDS AND ARTIFICIAL CONTAINERS

The mosquitoes that lay their eggs on the water are usually found where water is present continuously during the season or at least for several weeks. Such locations include natural permanent ponds, log ponds, semipermanent ponds of various types, and artificial containers. *Culex tarsalis*, *C. p. pipiens*, *C. peus*, *Anopheles freeborni*, *A. punctipennis*, *Culiseta incidens*, and *C. inornata* are commonly

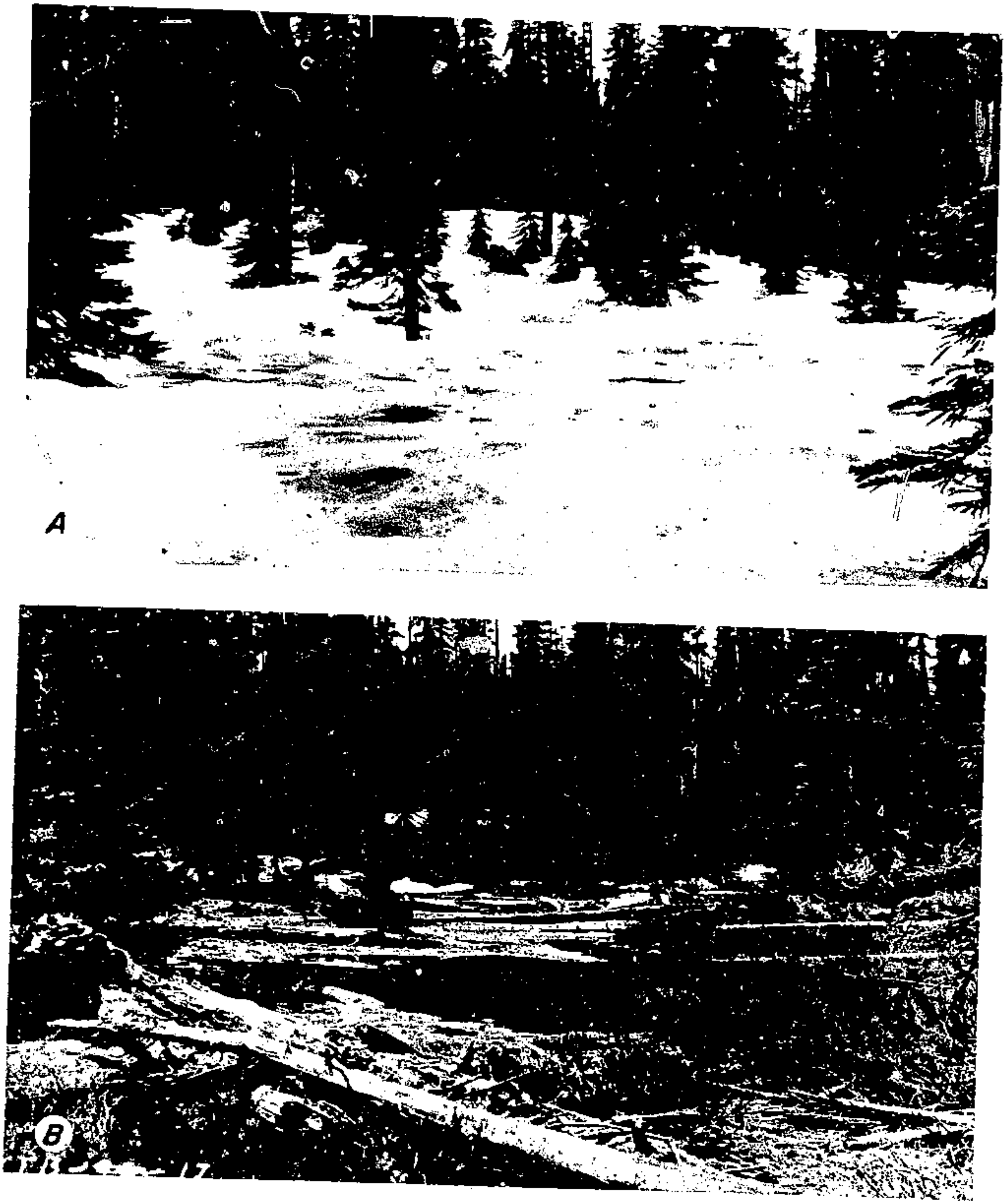

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FIGURE 5.—*A*, Snow-covered mosquito breeding site; *B*, same area after snow had melted. Mosquitoes deposit eggs in moist soil after water is gone.

found in such places. *C. tarsalis* and *C. p. pipiens* develop in large numbers in log ponds (fig. 6). *C. p. pipiens* also develops in large numbers in sewer drains, septic tanks, and water left in artificial containers. *Coquillettidia perturbans* is found in permanent water in swamps and marshes that have emergent or floating vegetation.

Insecticide sprays are often used effectively to control most of these species, except those breeding in artificial containers. Cesspools should be kept covered, and water standing in barrels, cans, old tires, and other receptacles should be emptied. Larvae of *C. perturbans* are difficult to control because they are attached to the roots of plants. Insecticide granules are sometimes applied, but eliminating host plants may be the most useful procedure to control this species.

ES-2717

FIGURE 6.—Dipping for mosquitoes in large log pond in Oregon.

TREE HOLES

Aedes sierrensis, *A. hendersoni*, and *Orthopodomyia signifera* are the only species that breed in tree holes in the Northwest. They also may be found in other places. Occasional heavy breeding of *A. sierrensis* has been noted in artificial containers, especially rubber tires, though usually not in large numbers. One application of 5 percent DDT spray in such places has prevented development of *A. sierrensis* for 3 years (*215*).

CONTROL OF MOSQUITO LARVAE

ELIMINATION OF BREEDING PLACES

Surveys made in connection with mosquito-control projects should include an engineering survey to determine the possibility of eliminating mosquito breeding places. Drainage, diking, filling, or maintenance of water levels often serve as permanent solutions to the problem. A survey should provide information on the feasibility, cost, and legality of all such improvements. Easements on properties involved may also need to be obtained. The availability of funds and the relative cost and effectiveness of other methods of control will then determine where permanent control of this type can be practical.

Drainage can be a practical method of reducing breeding areas in many places. It has been used effectively to control *Aedes dorsalis* in tidal marshes of some coastal areas. Potholes filled with water at high tides in these marshes can be drained by digging interconnecting ditches that let the water drain into main channels. Such ditches may need cleaning every year or so. Drainage has also been successfully used to remove breeding places in some mountain meadows (fig. 7). One such area has remained free of mosquitoes since 1935, when the ditches were blasted with dynamite. Little or no maintenance of ditches has been required since. The continuous functioning of this system may have been due in part to the dense root system of the vegetation in this area, which helped prevent erosion of the ditchbanks.

Breeding was also prevented along the margins of a spring-fed lake by a 3-foot dam that maintained a constant water level. Maintenance of water levels in some areas at lower elevations may permit breeding by *Culex* and *Anopheles* larvae if water margins are shallow and grassy.

Diking is a very effective method of controlling breeding places that are flooded by rising rivers. However, it may present financial problems if the reclaimed value of the land is not sufficient to defray a part of the cost.

The effects on fish and wildlife and soil conservation should also be considered before any permanent control measures are begun. In some instances the possibility of soil erosion and game reduction may be sufficiently important to justify temporary control measures with insecticides rather than elimination of the breeding area.

Breeding of some mosquito species can also be prevented by eliminating artificial breeding places such as tin cans, barrels, old tires, and unused cisterns and wells and by properly covering septic tanks.

USE OF INSECTICIDES

Where it is not feasible to eliminate mosquito breeding places, the larvae may be controlled with insecticides. The choice of insecticide depends on many factors such as cost, effectiveness, and degree of potential hazard to persons, livestock, wildlife, or beneficial insects. Status of mosquito resistance may also be a factor.

Data on the amount and kinds of materials used for mosquito control in the Pacific Northwest are available only for Oregon. A compilation of data on larvicides, adulticides, and prehatch treatments in actual pounds of toxicants used in 1966 showed the following:

Insecticide	*Pounds*
Malathion	16,758
DDT	4,781
Fenthion	3,194
Heptachlor	1,005
Parathion	860
Dichlorvos (DDVP)	221
Lethane 384	182
Lindane (includes BHC)	123
Abate	72
Naled	43
Diazinon	40
Ronnel	40
Thanite	16
Pyrethrins	12
TDE (DDD)	12
Aldrin	2
Dieldrin	2
Dursban	2
	27,365

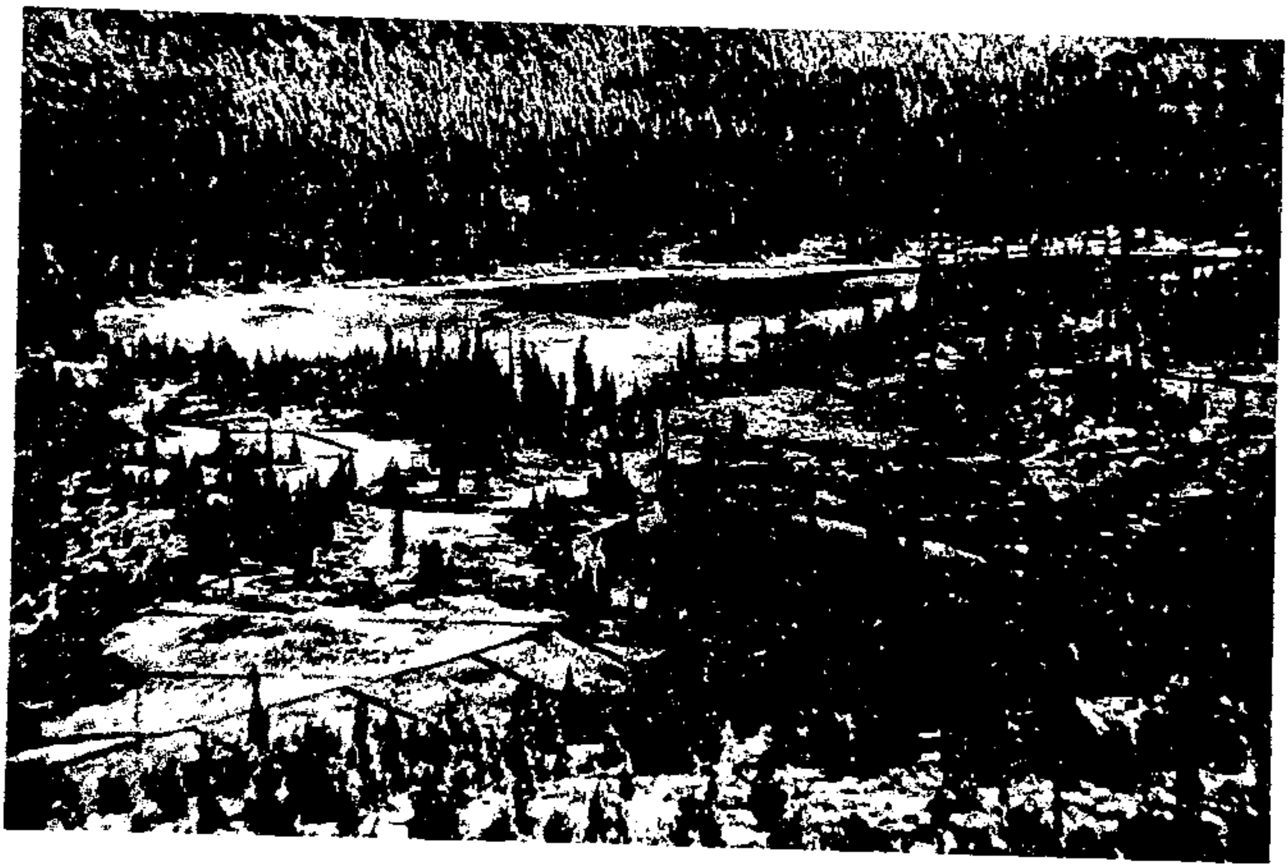

FIGURE 7.—Mountain meadows drained of surplus melting snow and seepage water into large ponds held by dams. PN-2718

In 1963, the first year in which data were compiled, 42,518 pounds were used. DDT represented about 80 percent of the total for 1963 but only about 17 percent for 1966.

Larvicides may be applied undiluted, as solutions, aqueous suspensions, dusts, or granular formulations. The choice of preparation depends on the purpose intended, presence or absence of desirable plant and animal organisms, type of vegetation, and other factors. From the standpoint of burning of vegetation and spotting of cars, houses, or other objects, aqueous suspensions are usually less hazardous than oil sprays. However, oil sprays are generally less hazardous to fish or fish-food organisms, except for some surface-feeding species. Granules are usually the most costly to use.

The choice of formulation and the amount of toxicant per acre depend to some extent on such factors as water depth, amount of aquatic vegetation, and degree of insecticide resistance, if any. Granular insecticides easily penetrate vegetation (*90*, *97*, *98*, *232*), but insecticides in deep water may be diluted too much. Therefore, an oil formulation that floats on the water would probably give better results, though oil might kill the vegetation. Some preliminary experiments may be necessary, but generally one should use the lowest amount of insecticide and the most effective formulation to do the job. Research suggests that smaller amounts of sprays may be required in the future (*172*, *197*, *256*). In fact, low-volume (1-10 fluid oz. per acre) sprays appear to be not only more effective but less costly than conventional sprays (*194*).

CONVERSION TABLES FOR LARVICIDE APPLICATIONS

Mosquito-control workers frequently have to convert larvicide applications from pounds of toxicant applied per acre to parts of toxicant per million parts of water or vice versa. Tables 2 and 3 should prove helpful. They were prepared by the late W. W. Yates, Entomology Research Division, and later modified slightly by C. N. Smith, formerly of this Division.

TABLE 2.—*Equivalent amounts of insecticides applied to flooded areas based on pounds per acre*

Pounds per acre	Grams per acre	Grams per 100 square feet	Parts per million (wt./wt.) in water: 12 inches deep	Parts per million (wt./wt.) in water: 1 inch deep
0.005	2.27	0.0052	0.0184	0.02208
.010	4.54	.0104	.00368	.04416
.015	6.80	.0156	.00552	.0662
.025	11.34	.026	.00920	.110
.050	22.68	.052	.0184	.221
.075	34.02	.078	.0276	.331
.10	45.36	.104	.0368	.442
.15	68.04	.156	.0552	.662
.20	90.72	.208	.0736	.883
.25	113.4	.26	.0920	1.10
.50	226.8	.52	.184	2.21
.75	340.2	.78	.276	3.31
1.00	453.6	1.04	.368	4.42
1.25	567.0	1.30	.460	5.52
1.5	680.4	1.56	.552	6.62
2.0	907.2	2.08	.736	8.83
2.5	1,134.0	2.60	.920	11.04
3.0	1,360.8	3.12	1.104	13.25

TABLE 3.—*Pounds per acre equivalent to parts per million (wt./wt.) of insecticides applied to flooded areas*

Parts per million	Pounds per acre in water: 1 inch deep	4 inches deep	12 inches deep
1.0	0.226	0.904	2.716
.9	.203	.814	2.444
.8	.181	.723	2.173
.7	.158	.633	1.901
.6	.136	.542	1.630
.5	.113	.452	1.358
.4	.090	.362	1.086
.3	.068	.271	.815
.2	.045	.181	.543
.1	.023	.090	.272

CONTROL OF ADULT MOSQUITOES

Effective control of adult mosquitoes in the open and in buildings can be accomplished with aerosols and space or residual sprays. Window screens, repellents, and bed nets also provide effective protection from mosquito annoyance.

Very small dosages of some of our presently available insecticides are needed for outdoor spraying and some of these can be safely sprayed over inhabited areas. Control of the adults is often more expensive than larval control, since adults disperse over wide areas and for considerable distances from their breeding places. However, when the adults are concentrated in small areas, control of adults is preferable to larviciding.

CONTROL IN BUILDINGS

Mosquitoes can be largely kept out of dwellings by screening all windows and air vents. Screen size should be about 18 by 18 mesh or smaller (*9*).

Aerosols and sprays may be used to kill mosquitoes in buildings. Droplets having a diameter of 0.1 to 50 microns have been classed as aerosols and fogs and those of 50 to 400 microns or larger have been considered as sprays. Pressurized containers sold to control flying insects usually contain pyrethrum or certain other insecticides and can be used effectively. Sprays produced by hand- or power-operated equipment may also be used, but the larger droplets will settle much more rapidly and are thus less effective.

Residual sprays applied to the interior of dwellings are very effective against adult mosquitoes. DDT applied at about 200 mg. per square foot has been successfully used in worldwide control campaigns against disease-carrying mosquitoes. Generally the spray has been applied as an emulsion at the rate of 1 gallon of 5 percent DDT for each 1,000 square feet of surface. Such applications have been effective for several months.

CONTROL OUTDOORS

Pyrethrum was one of the first materials found to be effective for controlling adult mosquitoes outdoors. Spraying the ground and vegetation with the insecticide gave protection against mosquitoes in studies made in New Jersey in 1936 (*102*). New materials and methods now make it possible to destroy mosquitoes over large areas much more effectively and at a lower cost.

As space sprays or fogs, DDT has been applied at 0.2 pound per acre and malathion at 0.1 to 0.5 pound per acre (*119*). Davis and Gahan (*80*) found that fenthion and naled were more effective than these materials against the DDT- and malathion-resistant salt-marsh mosquito *Aedes taeniorhynchus*. Mosquitoes will rapidly infiltrate sprayed areas if large and widespread populations are present. Respraying at 2- to 4-week intervals is often necessary under these conditions (*280*) but only should be done when needed.

Low-volume (1–10 oz. per acre) aerial insecticide sprays appear promising for controlling adults as well as larvae (*5, 119, 120, 172, 197, 256*). The amounts needed in future spray operations will probably be considerably less than those now used.

Mosquito annoyance around buildings in unprotected areas can be reduced by residual sprays applied to the grass and other vegetation to a height of several feet (*32*). During periods of flight activity such treatments may provide poor protection since infiltrating mosquitoes may cause considerable annoyance before they are killed. Good control has been obtained in Oregon against snow water *Aedes* with both DDT and lindane (*144*).

Aerosols and fogs are widely used to control adult mosquitoes. These may be produced by a variety of hand-carried, automotive, and aerial equipment. The more commonly used insecticides are malathion and naled. They are prepared mostly as diesel or fuel oil solutions, but other formulations are sometimes used (*81, 220*). Although operation data vary with the machine and materials used, some of the larger fogging units discharge at a rate of 40 gallons per hour.

Aerosol and fog droplets are very small and may remain airborne for long periods after they are emitted. Effective control requires movement of the insecticide clouds by air currents in the desired direction at speeds not greatly exceeding about 3 miles per hour. High winds will carry the insecticide away before it can destroy the mosquitoes. The ground temperature should be as cool as or cooler than the air temperature since the droplets will rise rapidly out of range if the temperature conditions are reversed. Favorable weather conditions occur more frequently during the late evening and early morning. The wind direction, an important limiting factor with ground equipment, is more easily avoided with airplane applications since crosswind applications can be made.

NEW MATERIALS AND METHODS IN MOSQUITO CONTROL

The possibility of controlling insects by introducing sterilized males into natural populations was suggested by Knipling (*174*) in 1937 38. The first successful eradication experiment utilizing this method was reported for the screwworm fly (*Cochliomyia hominivorax* (Coquerel)) by Baumhover et al. (*20*). A second and even more important successful eradication venture was reported for the same insect by Knipling (*175*). In the screwworm eradication experiment and program, male flies sterilized by gamma irradiation were released in sufficient numbers to outnumber wild males. The eggs of the normal females that mated with the sterilized males did not hatch, and complete eradication of the fly was accomplished (*175*).

The release of male mosquitoes sterilized by this method in field experiments with *Aedes aegypti* (*196*) and *Anopheles quadrimaculatus* Say (*277*) has so far been unsuccessful. Dame et al. (*79*) conducted extensive field studies with *A. quadrimaculatus* and concluded that the lack of success was due to behavioral deficiencies in the colonized males released. Further studies on mating behavior such as those conducted by Tantawy et al. (*265*) with *Anopheles pharoensis* Theobald may provide the information needed for the successful use of this method.

Data to support the possible use of cytoplasmic incompatibility as a means of eradication of *Culex pipiens pipiens* have been reported by Barr (*17*) and of *Culex pipiens fatigans* Wiedemann by Laven (*177*). In this technique incompatible strains are crossed. Eggs produced in such a cross result in progeny that die in the embryonic stage.

Much research has been carried on in search for chemicals that can be successfully used to sterilize insects. Information on insect chemosterilants has been reviewed by Smith et al. (*246*). Further research is needed; however, controlling mosquitoes by the sterility principle may hold promise for the future, as shown by studies by Patterson et al. (*209*).

Comparatively little research has been devoted to the role of attractants in mosquito behavior, but some intriguing evidence of the importance of attractants has been developed. There is evidence that female mosquitoes may be assisted in finding their blood host by certain chemicals emanating from the host. Other chemicals may lure opposite sexes together and thus facilitate mate-finding. Still another set of chemicals may attract female mosquitoes to their oviposition sites.

L-Lactic acid, emanating from the human skin, is attractive to females of *Aedes aegypti* that are seeking a blood meal (*3*). Lysine and alanine have also been reported attractive to this and to certain other species (*44*).

Females of *Culiseta inornata* produce a substance that is attractive to males (*171*), and males of some species of *Culex* produce a substance attractive to females (*115*). Attraction of males to females may be more usual. Thus, females of several kinds of insects, including certain flies, moths, bees, and cockroaches, are known to release chemicals that lure the males (*153, 154*). However, the presence of this lure may be difficult to demonstrate. For example, female house flies produced a substance that lured males into an olfactometer though it was not very active. More attraction occurred when the extracted material was presented in "pseudo-flies," or knots of string about the size and shape of a female fly (*234*).

Ovipositing mosquitoes prefer waters containing certain chemicals (or gases) to waters otherwise similar but lacking these substances (*106, 109, 110*). Further research might provide stronger attractants that could yield new approaches to mosquito control.

New developments pertaining to the use of low-volume aerial applications of insecticides in mosquito control have been discussed previously (pp. 21–22).

INSECTICIDE DISPERSAL EQUIPMENT

Many types of hand-operated, automotive, and aerial equipment are available for dispersing insecticides for the control of mosquitoes. Publications by the U.S. Department of Agriculture and the American Mosquito Control Association provide much information on this subject (*6, 8*). The liquefied gas aerosol bomb is very useful for killing mosquitoes in buildings. A simple dispenser for granular insecticides consisting of a shoulder-supported bag and connected tubular wand is also very useful (*218*). Two types of compressed-air guns have been developed for distributing granules from vehicles (*168, 219*). The maximum effective throw is approximately 40 feet for 16-mesh sand core granules.

Motor-driven hydraulic and compressed-air sprayers mounted on pickup trucks are widely used for applying larvicides and residual sprays to vegetation. Isaak and Hoag (*152*) obtained constant automatic pressure for compressed-air sprayers by installing a different type of compressor. In mist blowers the spray is released into the airstream of a fan, which imparts greater velocity to the droplets so that wider swath widths can be covered. This type of equipment is used for larviciding and for residual and space-spray applications. There are also a number of power-driven mist spray machines and dusting machines that can be carried by hand or on one's back. They can be used for larviciding or adulticiding and are very useful for small jobs such as around parks and campsites.

Aerosols or fogs are produced in some machines by dry heat and in others by steam. Some machines use compressed air for this purpose (*151, 279*). Most of these are designed to be transported by vehicle or by boat, but small types are carried by hand. Aerosols may be produced by introducing the insecticide solution into the hot exhaust gas of a motor vehicle (*155*). The exhaust method has also been used to disperse aerosols by plane (*241*).

The use of airplanes represents a very effective and economical method of distributing insecticides where sufficient area is being treated to justify their use. In California, which uses more mosquito-control insecticides than any other State, the materials are applied mostly by airplane. Information on aircraft use in California mosquito control such as kind of airplane, hours flown, acres treated, cost per acre, and other data can be found in the California Mosquito Control Association Year Book (*48*).

Several different planes ranging from Piper Cubs to the twin-engined C-47 have been used. A jet-propelled plane has also been found to function effectively for this purpose (*135*). Much mosquito-control work has been done with the PT-17 Stearman plane, which became available as surplus after World War II. Commercial planes built for spraying and dusting have also been used.

In nearly all these planes the spray is delivered from nozzles spaced at intervals on a spray boom, which is attached to the underside of the wings. A single rotating brush turned by a free propeller has also been used to produce the spray. The insecticide enters the brush from a pipe projecting beneath the aircraft. Insecticide granules have been applied from planes with various types of distributors, but improved distribution has been obtained with wing airfoils and conveyor belts that move the granules from the hopper to the wing (*273, 282*).

Helicopters are useful and highly effective in many locations, but so far they have proved too expensive for general use. It is very likely that the kind or type of plane and equipment used will change significantly because of changes in the amounts of insecticide applied and improvements in formulations (*5, 194*).

MOSQUITO RESISTANCE TO INSECTICIDES

The resistance of *Culex tarsalis* to DDT in Oregon was apparently the first case of mosquito resistance reported in the Northwestern States (Eddy et al. *86*). Resistance at that time was apparently confined to one area, but since then it has been found in several other areas of Oregon. Some slight resistance to DDT, dieldrin, and heptachlor has also been found in *Culex pipiens pipiens* and *C. peus* but not in other species. Several reports have been received on resistance of *C. tarsalis* to malathion, but so far there has been no real resistance to this or other organophosphates. However, in view of developments in other States, resistance to at least some of the materials could be expected.

Mosquito resistance to insecticides is apparently greater in California than in any other State. Resistance of *Culex tarsalis* to DDT was reported by Smith (*247*). Resistance in both *Culex* and *Aedes* was noted by Gjullin and Peters (*113*) and involved DDT, aldrin, heptachlor, toxaphene, and lindane. Resistance to these materials forced mosquito-control agencies to switch to organophosphate compounds. However, by 1956 *C. tarsalis* had developed considerable resistance to malathion (Gjullin and Isaak *108*). At that time there appeared to be no resistance of *Aedes* to malathion or *Aedes* or *Culex* species to parathion or EPN. However, resistance of *Aedes nigromaculis* to parathion was reported by Lewallen (*178*) and Lewallen and Brawley (*179*) and to malathion, methyl parathion, and fenthion by Brown et al. (*46*) and Gillies (*101*).

In tests with organophosphorus-resistant *Aedes nigromaculis* in California, Lewallen and Peters (*180*) stated that "Dursban offers the best prospect of reestablishing control of *A. nigromaculis* resistant to ethyl and methyl parathion and also fenthion." These authors further stated that "there appears to be some cross-resistance to Abate in this species. However, it would not seem unreasonable to assume resistance to these materials will develop if they became widely used."

Florida has also experienced a mosquito-resistance problem, especially the resistance of *Aedes taeniorhynchus* to the chlorinated hydrocarbons (*167*). According to Rogers and Rathburn (*233*), by 1955 several Florida mosquito-control districts were reporting failures with BHC and dieldrin, the most widely used substitutes for DDT. Resistance of *A. taeniorhynchus* to malathion (sixfold to fourteenfold) was reported by Glancey et al. (*118*). This apparently represents the first confirmed resistance of mosquitoes to an organophosphorus compound in Florida. Further resistance of *A. taeniorhynchus* to malathion was reported by Gahan et al. (*96*).

Resistance in one or more mosquito species of the Northern States has developed at a slower rate and is less extensive than in California or Florida (*263*).

Some progress has been made in nullifying organophosphate resistance in mosquitoes. For example, resistance to malathion in *Culex tarsalis* was found to be due to an increased ability of resistant strains to detoxify the insecticide (*33*). The effect of resistance of this species to malathion has been reduced and the usefulness of malathion restored about fiftyfold by adding materials that block or interfere with degradation of the toxicant (*213, 214*). Although further research is needed before their practical use can be ascertained, the information is encouraging.

MOSQUITO REPELLENTS

Research on mosquito repellents during and immediately after World War II by the U.S. Department of Agriculture (*272*), chemical industries, universities, and others resulted in many new materials that were far superior to citronella oil. Two of the most effective materials were 2-ethyl-1,3-hexanediol (*122*) and dimethyl phthalate (*269*). The more effective mosquito repellents tested at the Orlando, Fla., laboratory during 1942–47 were reported by Travis et al. (*270*). Those selected for use on man have been discussed further by Travis and Smith (*271*). Data on the repellency and insecticide toxicity of several thousand compounds have been compiled by the U.S. Department of Agriculture (*169, 274*).

This research resulted in the synthesis of many new compounds (*184*), of which *N,N*-diethyl-*m*-toluamide (later shortened to deet) proved outstanding. The effectiveness of this and other materials as skin and clothing treatments was reported by Gilbert (*99*) and Gilbert et al. (*100*). Diethyltoluamide is more effective against a wider range of species than either 2-ethyl-1,3-hexanediol or dimethyl phthalate. During World War II the Armed Forces used a preparation containing more than one repellent, mainly because the mixture was effective against a greater number of arthropod species than any of its ingredients alone.

Repellents in current use are irritating to the eyes or more tender areas of the body. They also may damage or affect paints and some synthetic products but not cotton or wool. Many can be used on the skin or outer clothing and may be satisfactorily applied in sprays or rubbed on by hand. Clothing properly impregnated with solutions or emulsions of repellents will usually give several days' protection against mosquitoes. Some of the commercial preparations are available in convenient dispensing containers such as those containing deet and ethyl hexanediol.

PRECAUTIONARY MEASURES IN USING INSECTICIDES

The insecticides used to control mosquitoes are similar to other chemicals in that if used improperly they may be injurious to many living organisms. Selection of an insecticide should be made only after fully evaluating its potential effects against the plant and animal species present in the area to be treated. Both immediate and long-range effects should be carefully considered. Excessive amounts should never be applied. In fact, a dosage lower than ordinarily recommended may often prove adequate.

Mosquito control can be effectively and safely achieved if sufficient precautionary measures are taken. Reading the label and following instructions are important. However, anyone planning to use insecticides in mosquito control should become thoroughly familiar with the product he plans to use. He should obtain as much information as possible about its potential effects on the equipment operator, the exposed public, pets, livestock, fish and wildlife, and beneficial insects including bees.

INFORMATION ABOUT INSECTICIDES AND POISON CONTROL CENTERS

In most States, information on the toxicity, hazards, and safe use of insecticides can be obtained from the State Board of Health, State Department of Agriculture, or State experiment station. For example, data in Oregon on insecticide identification, toxicology, precautionary measures, protective devices, and so forth are available from the occupational health or hygiene sections of the State Board of Health. Also, excellent and often complete information on specific chemicals can be obtained from the manufacturer.

Valuable information is available from various Federal agencies. The U.S. Public Health Service has information and facilities for handling actual or suspected cases of poisoning at Wenatchee, Wash., Atlanta, Ga., and Phoenix, Ariz. Poison Control Centers have been established in several cities throughout the country. A "Directory of Poison Control Centers," U.S. Food and Drug Administration publication (FDA) 72-7001, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The publication "Clinical Handbook on Economic Poisons" by Hayes (*137*) includes many of the more commonly used insecticides. Although it was prepared primarily for the guidance of physicians, it should prove of value to mosquito-control workers and others involved in the use of chemicals.

An up-to-date list of approved protection devices for various insecticides can be obtained from the Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md. 20705. Such a list is important because some equipment will protect against some compounds but not others.

KEYS AND NOTES FOR MOSQUITO IDENTIFICATION

A total of 53 species of mosquitoes, representing six genera, have been collected in Washington, Oregon, and Idaho. Keys for their identification are based on characters provided by many earlier taxonomists who have studied these groups, by more recent contributors (*24*, *57*, *276*), and by the writers. Only the more essential characters for each species have been included, and recent synonyms are given.

The names and locations of the characters used for identifying these species are shown in figures 8 to 17.

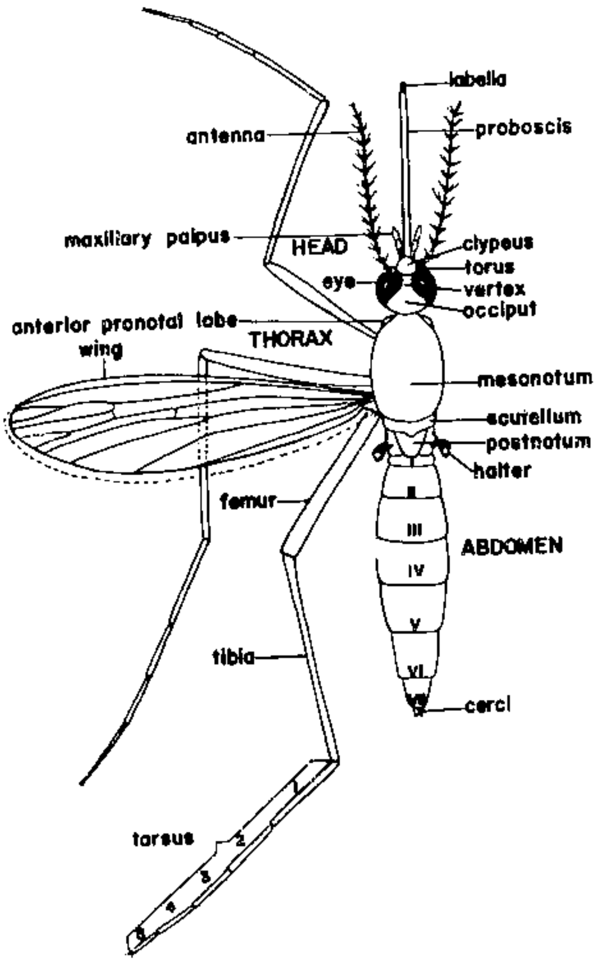

FIGURE 8.—External characters of female mosquito.

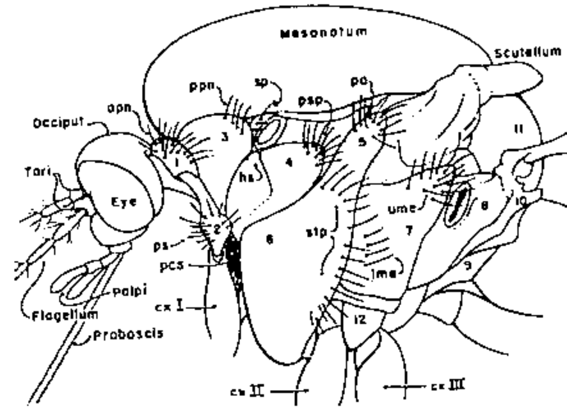

FIGURE 9.—Mosquito head and thorax, lateral view. *hs*, hypostigial spot of scales; *pcs*, postcoxal scale patch; *cx*, procoxa. Sclerites of thorax: 1, Anterior pronotum; 2, proepisternum; 3, postpronotum; 4, mesanepisternum; 5, prealar area; 6, sternopleuron; 7, mesepimeron; 8, metepisternum; 9, metasternum; 10, metepimeron; 11, postnotum; 12, meron. Setae: *apn*, anterior pronotal; *ps*, proepisternal; *ppn*, postpronotal; *sp*, spiracular; *psp*, postspiracular; *pa*, prealar; *stp*, sternopleural; *ume*, upper mesepimeral; *lme*, lower mesepimeral.

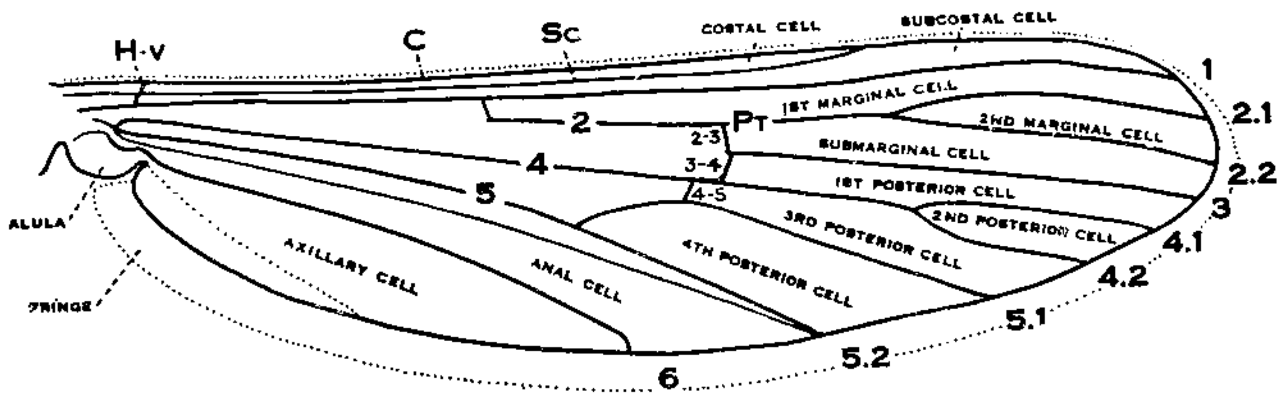

FIGURE 10.—*Aedes* wing: *H-v*, humeral cross vein; *C*, costa; *Sc*, subcosta; *Pt*, petiole of vein 2; 1, 2.1, 2.2, 3, 4.1, 4.2, 5.1, 5.2, and 6, longitudinal veins and their branches.

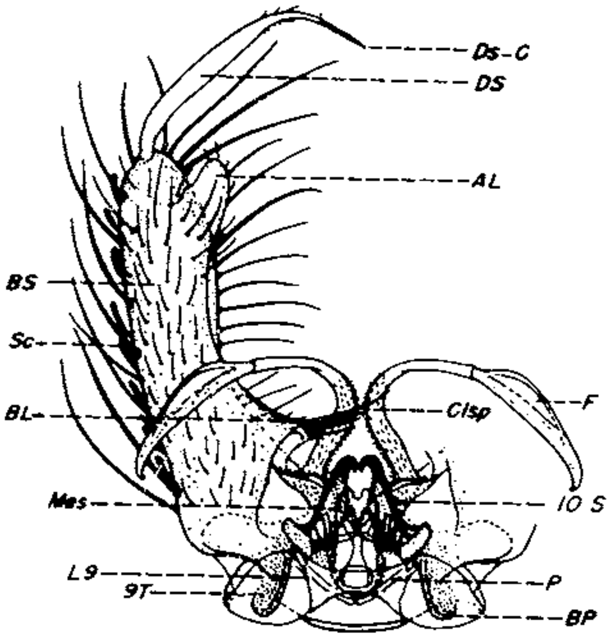

FIGURE 11.—*Aedes* male genitalia, dorsal view: *BS*, basistyle; *Sc*, scale; *BL*, basal lobe; *Mes*, mesosome; *L9*, lobe of ninth tergite; *9T*, ninth tergite; *DS-C*, dististyle claw; *DS*, dististyle; *AL*, apical lobe; *F*, filament of claspette; *Clsp*, claspette; *10S*, tenth sternite; *P*, paramere; *BP*, basal plate.

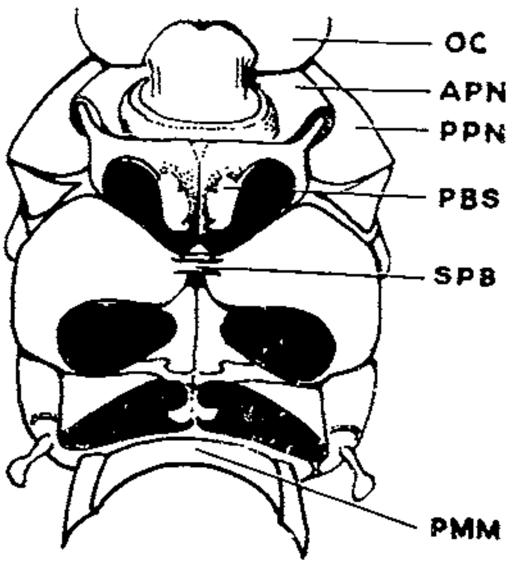

FIGURE 12.—*Aedes* thorax, ventral view: *OC*, occiput; *APN*, anterior pronotum; *PPN*, posterior pronotum; *PBS*, probasisternum; *SPB*, sternopleural bridge; *PMM*, postmetasternal membrane.

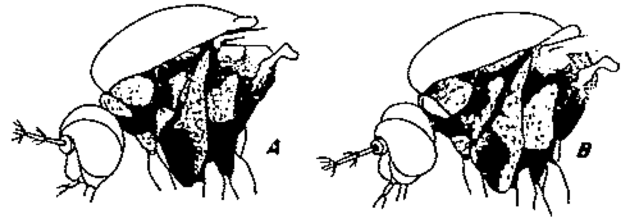

FIGURE 13.—Side of thorax showing scaling: *A*, *Aedes implicatus*; *B*, *Aedes communis*.

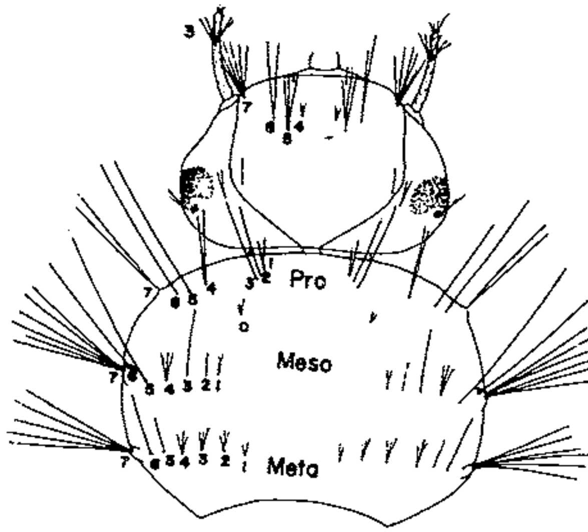

FIGURE 14.—*Aedes* larva head and thorax. Head: 3, Antennal tuft; 4, postclypeal hairs; 5, upper head hairs; 6, lower head hairs; 7, preantennal hairs. Prothorax (Pro): 1–3, Submedian hairs; 4–7, dorsal hairs. Mesothorax (Meso): 1–7, Dorsal hairs. Metathorax (Meta): 1–7, Dorsal hairs.

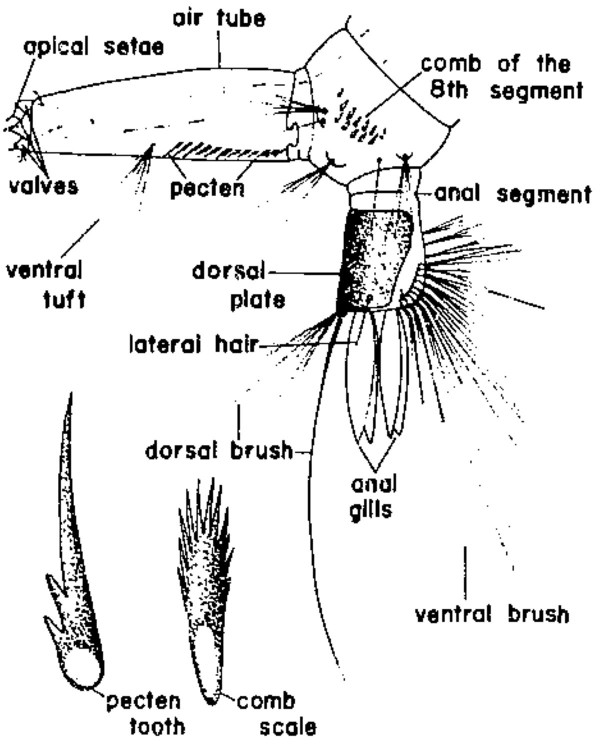

FIGURE 15.—*Aedes* larva terminal segments.

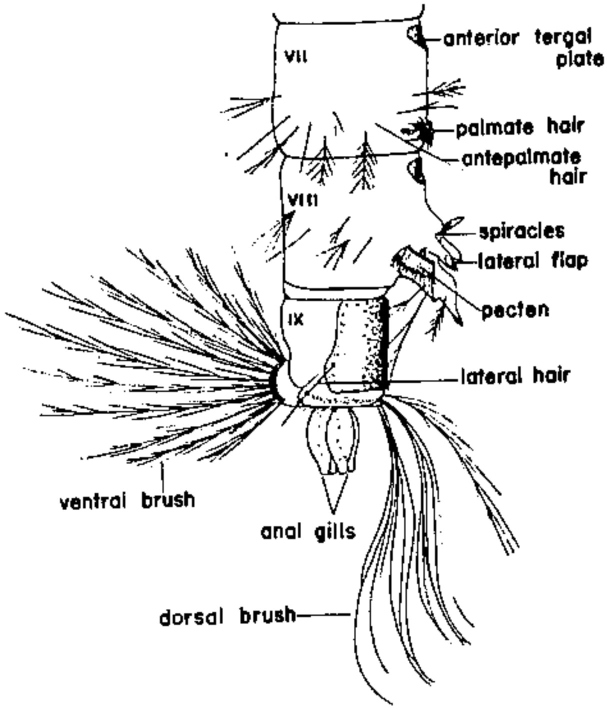

FIGURE 17.—*Anopheles* larva terminal segments VII, VIII, and IX.

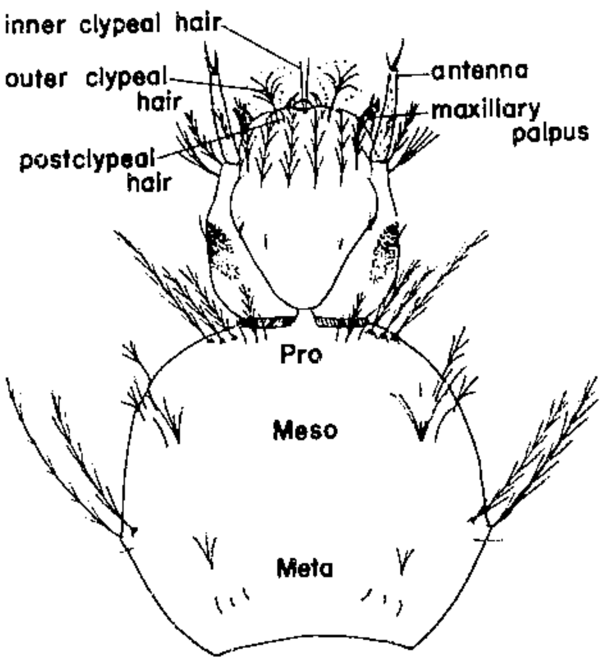

FIGURE 16.—*Anopheles* larva head and thorax.

KEYS TO GENERA

ADULTS

1. Scutellum trilobed with marginal setae on lobes only; palpi of females much shorter than proboscis 2
   Scutellum crescent shaped with marginal setae evenly distributed; palpi of females almost as long as proboscis .... *Anopheles*
2. Mesonotum with narrow paired white lines, converging half lines, and white line around lateral margin .... *Orthopodomyia*
   Mesonotum without this combination of white lines 3
3. Postspiracular bristles present .... *Aedes*
   Postspiracular bristles absent 4
4. Spiracular bristles present .... *Culiseta*
   Spiracular bristles absent 5
5. Wing scales broad, light and dark intermixed .... *Coquillettidia*
   Wing scales narrow or slightly broadened, all dark .... *Culex*

LARVAE

1. Eighth segment without dorsal siphon or respiratory tube .... *Anopheles*
   Eighth segment with elongated siphon or respiratory tube 2
2. Air tube without pecten 3
   Air tube with pecten 4
3. Distal half of air tube attenuated with saw-toothed projection at tip adapted for piercing plants .... *Coquillettidia*
   Air tube cylindrical and elongated .... *Orthopodomyia*
4. Air tube with ventral tufts at base .... *Culiseta*
   Air tube with tufts within pecten teeth or distal to them 5
5. Air tube with several pairs of ventral and occasional lateral tufts, some of which may be represented by single hairs .... *Culex*
   Air tube with single pair of ventral tufts[1] .... *Aedes*

[1] *Aedes trichurus* also has several tufts on dorsal and lateral surfaces of air tube.

Genus ANOPHELES Meigen

Keys to Species

ADULTS

1. Wings with yellowish-white spots on costal margin 2
   Wings without spots on costal margin 3
2. Palpi white banded; wings with pale spots on forks and on stem of vein 5 .... *pseudopunctipennis franciscanus*, p. 31
   Palpi unbanded; wing scales on vein 5 dark .... *punctipennis*, p. 32
3. Wings with patch of silvery or bronze scales at apex 4
   Wings dark scaled at apex .... *freeborni*, p. 30
4. Wings with scales raised on stem of vein 2 between dark spot and fork .... *earlei*, p. 30
   Wings with scales closely appressed on stem of vein 2 between dark spot and fork .... *occidentalis*, p. 31

MALE GENITALIA

1. Claspette stem with dorsal lobe bearing two or three broad leaflets; mesosome with very delicate leaflets .... *pseudopunctipennis franciscanus*, p. 31
   Claspette stem with dorsal lobe bearing two or three sharp spines; mesosome with well-developed leaflets 2
2. Ninth tergite with lobes broad, short, and slightly expanded at apex .... *earlei*, p. 30
   Ninth tergite with lobes long and slender .... *punctipennis*, p. 32, *occidentalis*, p. 31, *freeborni*, p. 30

LARVAE

1. Outer clypeal hair not branched ... *pseudopunctipennis franciscanus*, p. 31
   Outer clypeal hair branched ... 2
2. Inner clypeal hair usually branched distally ... *earlei*, p. 30
   Inner clypeal hair not branched ... 3
3. Antepalmate hair usually single on abdominal segments 4 and 5 ... *occidentalis*, p. 31
   Antepalmate hair usually two- or three-branched on abdominal segments 4 and 5 ... *punctipennis*, p. 32, *freeborni*, p. 30

Descriptions of Species

Anopheles (Anopheles) earlei Vargas

Anopheles earlei Vargas, Pan-Amer. Bur. Sanit. Bol. 22: 8. 1943.

Anopheles earlei Vargas and Matheson, Inst. Salubridad y Enferm. Trop. Rev. 9: 27. 1948.

Female.—Palpi as long as proboscis, dark brown. Mesonotum with broad frosted stripe sparsely covered with short pale-yellow hairs. Wing scales dark brown with darker spots in some areas, scales on stem of vein 2 raised between fork and dark spot; apex of wing with fringe of silver or bronze scales. Legs black; apices of femora and tibiae with pale-yellowish scales.

Male genitalia.—Claspettes bilobed with two or three spines on both ventral and dorsal lobes. Mesosome with three or four pairs of leaflets. Ninth tergite lobes short, broad, and slightly expanded at apex.

Larva.—Inner clypeal hair two- to five-branched distally or rarely unbranched, outer clypeal hair multibranched; postclypeal hair two- to five-branched or rarely unbranched. Antepalmate hair on segments 4 and 5 usually two- to six-branched.

Distribution, biology, and importance.—Early records of *Anopheles occidentalis* from the Northern States and Canada were found to be *Anopheles earlei* after the validity of this species was recognized (*57*, *238*). Early records from southern Idaho probably pertain to *A. earlei* (*4*, *133*, *254*). It also occurs in eastern Washington and northern Idaho (map 1), but it is a relatively rare species of little economic importance. Larvae have been found alone and associated with other anopheline species. They have also been taken with *Culex tarsalis* and *Culiseta inornata* larvae.

Anopheles (Anopheles) freeborni Aitken

Anopheles maculipennis freeborni Aitken, Pan-Pacific Ent. 15: 192. 1939.

Anopheles freeborni King and Bradley, Human Malaria, pp. 63–70. 1941.

Female.—Palpi as long as proboscis, dark brown. Mesonotum with frosted gray stripe bordered by dark bands; median stripe with hairlike yellowish scales and small tuft of whiter scales anteriorly. Wing scales dark brown and aggregated into spots at junction of first and second veins, forks of second and fourth, and at cross veins. Legs black; apices of femora and tibiae with pale-yellowish scales.

Male genitalia (fig. 18).—Claspettes bilobed with two or occasionally three spines on ventral lobe and usually with two spines on dorsal lobe. Mesosome with three or four pairs of nonserrated leaflets. Ninth tergite with long and slender lobes.

Larva.—Inner clypeal hair single, outer clypeal hair multibranched; postclypeal hair two- or five-branched. Antepalmate hair on abdominal segments 4 and 5 usually two- or three-branched.

Distribution, biology, and importance.—*Anopheles freeborni* is distributed throughout the

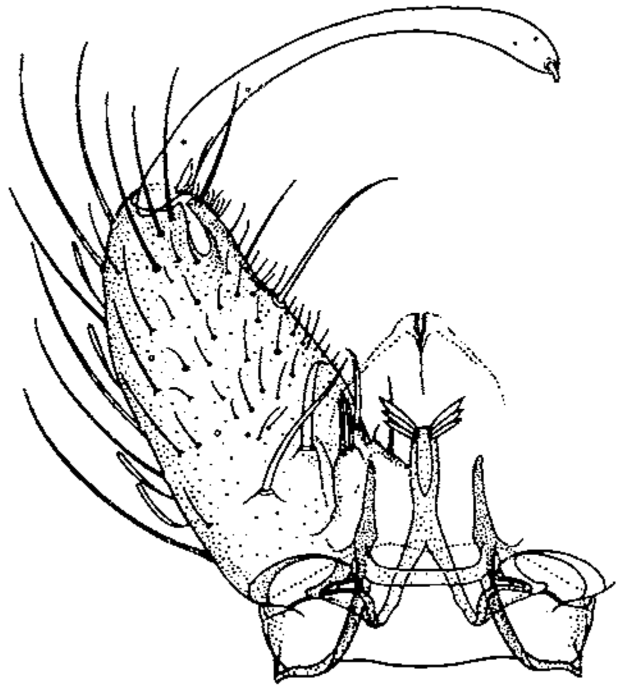

FIGURE 18.—*Anopheles freeborni* male genitalia.

Northwestern States (map 1). Comparatively large populations develop in irrigated areas in the Yakima Valley in Washington and in the vicinity of Scappoose, Prineville, and Klamath Agency, Oreg. It has been abundant in the irrigated section of west-central Idaho and is fairly prevalent in the Willamette Valley in Oregon. Morphological variations of the larvae have been examined by Abdel-Hab (*1*). This and certain other anopheline species are difficult to separate (*4, 57, 95*).

The females hibernate in cellars, barns, outbuildings, and other sheltered locations. They emerge from these places by the last part of February in the warmer parts of this region, but few eggs are laid before April or May. Larvae have been taken along the margins of rivers, creeks, and irrigation ditches and in ponds, sloughs, and roadside ditches from early May until frost.

Ecological studies in California of this and other anophelines have been made by Bailey and Baerg (*10*). Some of the specimens of *A. freeborni* they released flew as far as 17.5 miles and lived for 3 and 4 months.

It was the most important malaria carrier in the Western States before this disease was reduced to its present extremely low level in the United States. Western equine encephalitis has been isolated from it in nature.

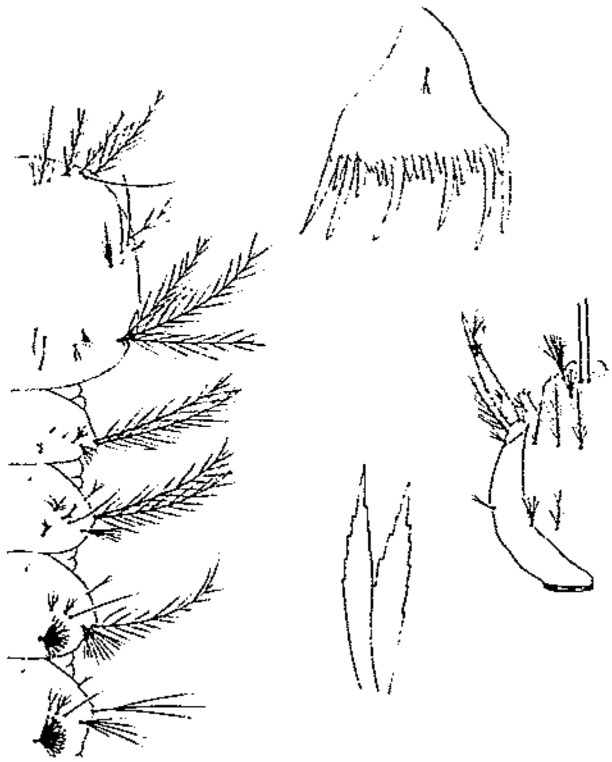

FIGURE 19.—*Anopheles occidentalis* larva.

Anopheles (Anopheles) occidentalis Dyar and Knab

Anopheles occidentalis Dyar and Knab, Wash. Biol. Soc. Proc. 19: 159. 1906.

Female.—Similar to *Anopheles earlei* but with wing scales closely appressed on stem of vein 2 between dark spot and fork.

Male genitalia.—Claspettes bilobed with two or occasionally three spines on ventral lobe and usually with two spines on dorsal lobe. Mesosome with three or four pairs of nonserrated leaflets. Ninth tergite with long and slender lobes.

Larva (fig. 19).—Inner clypeal hair single, outer clypeal hair multibranched; postclypeal hair four- to 10-branched. Antepalmate hair on abdominal segments 4 and 5 usually single.

Distribution, biology, and importance.—This species occurs along the Pacific coast from northern Mexico to Alaska. It is a rare species in Oregon and Washington and is considered to be of no economic importance (map 1). In Oregon the larvae were found near the coast in water covered with algae in a residual pond and in an open section of a small creek.

Anopheles (Anopheles) pseudopunctipennis franciscanus McCracken

Anopheles franciscanus McCracken, Ent. News 15: 12. 1904.
Anopheles pseudopunctipennis var. *franciscanus* King and Bradley, Human Malaria, pp. 63–70. 1941.
Anopheles pseudopunctipennis franciscanus Aitken, Calif. Univ. Pubs. Ent. 7: 327. 1945.

Female.—Palpi as long as proboscis, black scaled with white rings at apices of segments 2, 3, and 4. Mesonotum with median gray stripe bordered by dark bands; median stripe with hairlike gray scales and tuft of whiter ones anteriorly. Wing scales black with yellowish-white scales forming spots as follows: Costa and subcosta with two on apical half, subcosta with two additional ones on basal half; second vein with small one near cross vein and small one before apex of upper branch; third vein with small one at base and large one in middle; fourth vein with small one at cross vein and small one at apices of forks; fifth vein with small one at base and large one extending into lower fork, small ones at apices of forks and a small one near middle of upper fork; sixth vein with long spot at base. Legs black; tips of femora and tibiae with pale-yellowish scales.

Male genitalia (fig. 20).—Claspettes bilobed with two slender spines on ventral lobe and two or three broad leaflike spines on dorsal lobe. Mesosome with very small nonserrated leaflets. Ninth tergite with low conical processes.

Larva (fig. 21).—Both inner and outer clypeal hairs single and unbranched; postclypeal hair single and long. Abdominal palmate hair on segments 3 to 7 well developed and serrate. Antepalmate hair one- to three-branched on segment 4 and usually single on segment 5. Posterior spiracular plates not developed into "tails" but rounded.

Distribution, biology, and importance.—This species has been found only in extreme southwestern Oregon (map 1). The females prefer feeding on large mammals such as cows and horses and are seldom known to attack man. The larvae are usually associated with *Anopheles freeborni* along streams in sunny pools containing algae. It is of no economic importance in this area because of its small numbers and limited distribution.

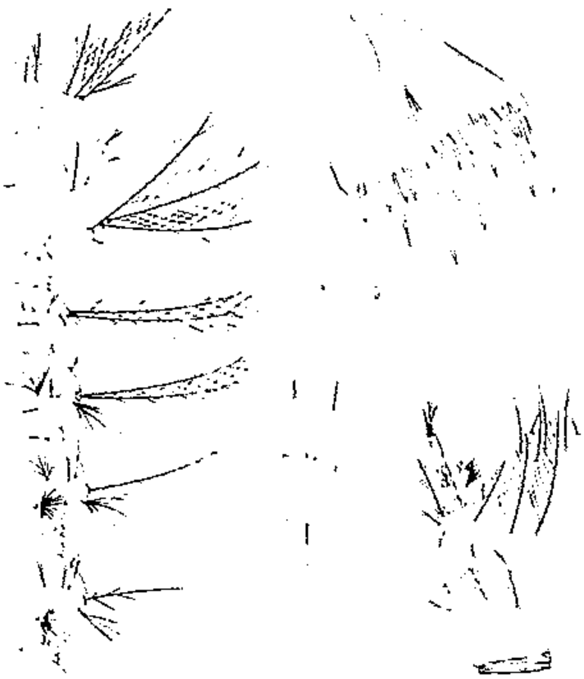

FIGURE 21.—*Anopheles pseudopunctipennis franciscanus* larva.

FIGURE 20.—*Anopheles pseudopunctipennis franciscanus* male genitalia.

Anopheles (Anopheles) punctipennis (Say)

Culex punctipennis Say, Acad. Nat. Sci. Phila. Jour. 3:9. 1823.

Female.—Palpi as long as proboscis, dark brown. Mesonotum with gray stripe bordered by dark bands; median stripe with hairlike gray scales and tuft of whiter ones anteriorly. Wing scales black with yellow ones forming spots as follows: Large one on basal third of costal margin, which involves base of second vein before fork; smaller one on apex of wing, which involves both forks of second vein; third vein with spot at apex or near middle or completely dark scaled; fourth vein with two spots on base and one spot on each fork; sixth vein with one spot in middle. Legs black; tips of femora and tibiae with pale-yellowish scales.

Male genitalia (fig. 22).—Similar to *Anopheles freeborni* except for slightly broader lobes of ninth tergite.

Larva.—Inner clypeal hair single, outer clypeal hair multibranched; postclypeal hair branched. Antepalmate hair of abdominal segments 4 and 5 two- or three-branched. Antennal tuft usually inserted below basal third.

Distribution, biology, and importance.—This is a common species throughout Washington, west of the Cascade Mountains in Oregon, and in the northern half of Idaho (map 1). Usually the species is not sufficiently numerous to be a serious pest. The larvae are often associated with *A. freeborni* in clear shaded pools. *Anopheles punctipennis* has been considered to be of little importance as a malaria carrier, but Gray (*123*) believed it may have been an important vector from 1830 to 1856 in California.

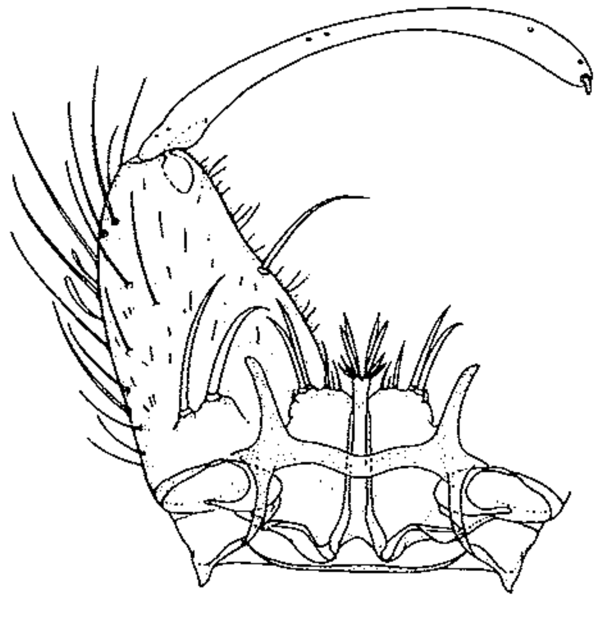

FIGURE 22.—*Anopheles punctipennis* male genitalia.

Genus AEDES Meigen

Keys to Species

ADULTS

1. Tarsal segments ringed with white
   Tarsal segments not ringed with white 2
2. Tarsi with white rings at both ends of some or all segments 14
   Tarsi with white rings at base of segments only 3
3. Wing scales black and white intermingled 7
   Wing scales uniformly dark or with some white scales on anterior vein 4
4. Wing scales uniformly mottled black and white; (tarsal claw as in fig. 26) 6
   Wing scales not uniformly mottled .... *campestris*, p. 38
5. Wings with more dark than light scales on sixth or anal vein; (tarsal claw as in fig. 55) 5
   Wings with more light than dark scales on sixth or anal vein; (tarsal claw as in fig. 36) .... *melanimon*, p. 53
6. Mesonotum golden brown; base of costa dark scaled .... *dorsalis*, p. 43
   Mesonotum with variable pattern of pale yellowish and dark spots; base of costa with white scales .... *c. canadensis*, p. 39
7. Abdomen with median stripe; proboscis ringed with white or occasionally completely dark scaled .... *sierrensis*, p. 61
   Abdomen without median stripe; proboscis not ringed with white .... *nigromaculis*, p. 55
8. Basal white rings of tarsal segments narrow (mesonotum uniformly brown; abdominal pale bands indented centrally) 8
   Basal white rings of tarsal segments broad, especially on hind legs .... *vexans*, p. 68
9. Abdomen without bands and clothed with yellow scales; (mesonotum yellowish brown with darker median area) 9
   Abdomen dark scaled with white or gray dorsal bands .... *flavescens*, p. 46
10. Lower mesepimeral bristles absent 10
    Lower mesepimeral bristles present 11
11. Mesonotum with variable pattern of brown and white scales; (tarsal claw as in fig. 38) 12
    .... *excrucians*, p. 45, *fitchii* (in part), p. 45
    Mesonotum with reddish-brown scales except white scales in prescutellar area; small white spots forward of prescutellar area present or absent; (tarsal claw as in fig. 25) .... *aloponotum*, p. 37

12. Tori without white scales on dorsal surface; palpi without hairs on basal half of apical segment at inner ventral .... *increpitus*, p. 51
surface........
Tori with white scales on dorsal surface; or with apical segment of palpi bearing large hairs on inner ventral 13
edge; or with both........
13. Lower mesepimeral bristles rarely more than two; tori with white scales on dorsal surface; (tarsal claw as in .... *fitchii* (in part), p. 45
fig. 40)........ *stimulans*, p. 64
Lower mesepimeral bristles three or more; tori with or without white scales on dorsal surface........ 15
14. Wing scales distinctly bicolored........ 16
Wing scales uniformly dark or with some white scales on anterior veins........ *niphadopsis*, p. 56
15. Lower mesepimeral bristles present; wing scales light and dark, intermixed with dark predominating........ *spencerii idahoensis*, p. 62
Lower mesepimeral bristles absent; wing scales black or white on alternating veins........ 17
16. Postcoxal scale patch present........ 24
Postcoxal scale patch absent........ 18
17. Mesonotum without lines or stripes........ 19
Mesonotum with complete or partial lines or stripes........ *cataphylla*, p. 40
18. Mesonotum gray around sides with golden-brown scales in middle that sometimes show faint dark lines........ *impiger*, p. 50
Mesonotum with dark-brown or bronzy scales, sometimes with pair of lighter spots centrally........ *schizopinax*, p. 60
19. Proboscis with yellowish-gray scales on ventral surface........ 20
Proboscis with brown scales on ventral surface........ *implicatus*, p. 51
20. Sternopleuron with scales not extending to anterior border........ 21
Sternopleuron with scales extending to anterior border........ *trichurus*, p. 65
21. Hypostigial spot of scales present........ 22
Hypostigial spot of scales absent........ *aboriginis*, p. 37, *punctor* (in part), p. 59
22. Posterior area of probasisternum without or rarely with few white scales........ 23
Probasisternum with few to many white scales........
23. Mesonotum yellowish or rarely gray scaled with paired dark-brown stripes narrowed at back and extending to .... *pionips*, p. 57
scutellum........
Mesonotum golden brown with paired dark-brown stripes that are sometimes joined .... *herodontus*, p. 49, *punctor* (in part), p. 59
.... 25
24. Lower mesepimeral bristles absent........ 29
Lower mesepimeral bristles present........
25. Mesonotum with broad median stripe of dark-brown scales broadening posteriorly; sides and anterior margins .... *hendersoni*, p. 48
with silvery-white scales........ 26
Mesonotum not marked with silvery-white scales........ 27
26. Mesonotum with lines or stripes........ 28
Mesonotum without lines or stripes........ *trivittatus*, p. 66
27. Abdomen with basal segmental white patches and with or without central white spots........ *sticticus*, p. 63
Abdomen with basal segmental white bands........
28. Coxa of front leg with central area of brown scales on anterior surface; occiput with dorsal submedian patches .... *cinereus*, p. 41
of dark scales........
Coxa of front leg with anterior surface of front leg clothed with white scales; occiput without dorsal submedian .... *ventrovittis*, p. 67
patches of dark scales........ *communis*, p. 42
29. Sternopleuron with scales extending to anterior edge........ 30
Sternopleuron with scales not extending to anterior edge........ *pullatus*, p. 58
30. Mesonotum with paired brown lines; flagellum with white scales on ventral side of first segment........
Mesonotum brownish with margin of gray scales or rarely darker centrally; flagellum without white scales on .... *intrudens*, p. 53
ventral side of first segment........

MALE GENITALIA

.... *cinereus*, p. 41
1. Dististyle inserted before apex of basistyle; unequally bifurcate at base........ 2
Dististyle not inserted before apex of basistyle; not branched at base........ *vexans*, p. 68
2. Dististyle broad and flat throughout its length with subapical claw; claspette without filament........ 3
Dististyle tapered to apex with apical claw; claspette with filament........ 4
3. Basistyle without distinct apical lobe........ 6
Basistyle with both apical and basal lobes........ *hendersoni*, p. 48
4. Basistyle with small dense patch of long hairs near middle........ 5
Basistyle without group of long hairs near middle........

5. Basal lobe a raised narrowly elongate area with many long curved spines at base and short setae extending apically ---------- *sierrensis*, p. 61
   Basal lobe a small slightly raised area with relatively short setae ---------- *nigromaculis*, p. 55
6. Filament of claspette with transverse ridges; basal lobe with two long posteriorly directed spines ---------- *trichurus*, p. 65
   Filament of claspette without transverse ridges; basal lobe with spines not posteriorly directed ---------- 7
7. Apical lobe with short broadened appressed setae ---------- 8
   Apical lobe with long hairs or nearly bare ---------- 10
8. Basal lobe partially extended toward apex of basistyle semidetached *sticticus*, p. 63, *ventrovittis*, p. 67, *spencerii idahoensis*, p. 62
   Basal lobe partially extended toward apex of basistyle not semidetached ---------- 9
9. Stem of claspette pilose to near apex ---------- *schizopinax*, p. 60
   Stem of claspette glabrous on distal one-third or more ---------- *punctor*, p. 59, *aboriginis*, p. 37, *hexodontus*, p. 49
10. Basal lobe without spines ---------- 11
    Basal lobe with spines ---------- 13
11. Filament of claspette narrow and of approximately equal width ---------- *c. canadensis*, p. 39
    Filament of claspette expanded along one margin ---------- 12
12. Basal lobe extending to apical lobe ---------- *excrucians*, p. 45, *aloponotum*, p. 37
    Basal lobe not extending beyond middle of side piece ---------- *increpitus*, p. 51
13. Basal lobe with one spine ---------- 14
    Basal lobe with two or more spines ---------- 23
14. Basal lobe extending almost to apical lobe ---------- *flavescens*, p. 46
    Basal lobe a small area at base of basistyle ---------- 15
15. Filament of claspette with sharp retrorse projection on basal third ---------- *trivittatus*, p. 66
    Filament of claspette without retrorse projection ---------- 16
16. Filament of claspette sickle shaped with small notch at base ---------- *fitchii*, p. 45
    Filament of claspette without notch at base ---------- 17
17. Stem of claspette abruptly bent at middle to form projecting angle ---------- *pullatus*, p. 58
    Stem of claspette not abruptly bent at middle ---------- 18
18. Filament of claspette slightly expanded forming circular outline ---------- *campestris*, p. 38
    Filament not expanded in circular outline ---------- 19
19. Apical lobe of basistyle with setae present in large numbers and with some setae twice length of dististyle claw ---------- *communis*,[1] p. 42, *pionips*, p. 57
    Apical lobe of basistyle with setae present in small numbers and not more than 1½ times length of dististyle claw ---------- 20
20. Apical lobe with tuft of long hairs below its base or with group of large sockets if hairs are missing ---------- *implicatus*, p. 51
    Apical lobe without tuft of long hairs at base ---------- 21
21. Filament of claspette expanded in gradual curve near base ---------- *niphadopsis*, p. 56, *cataphylla*, p. 40
    Filament expanded to sharp point near base ---------- 22
22. Basal lobe with large spine followed by row of weak setae ---------- *impiger*, p. 50
    Basal lobe with large spine not followed by row of setae ---------- *stimulans*, p. 64
23. Stem of claspette with sharp projection ending in small seta at middle; basistyle with dense tuft of setae near apex ---------- *intrudens*, p. 53
    Stem of claspette without sharp projection and basistyle without dense tuft ---------- 24
24. Stem of claspette abruptly narrowed near apex to form rounded angle; filament shorter than stem ---------- *dorsalis*, p. 43
    Stem of claspette gradually narrowed near apex; filament longer than stem ---------- *melanimon*, p. 53

LARVAE

1. Pecten with one or more of distal teeth detached ---------- 2
   Pecten without detached teeth ---------- 15
2. Air tube with hair tuft within pecten ---------- 3
   Air tube with all tufts outside pecten and distal to it ---------- 4
3. Air tube with several pairs of dorsal and lateral hair tufts ---------- *trichurus*, p. 65
   Air tube without dorsal and lateral hair tufts ---------- *cataphylla*, p. 40
4. Anal segment ringed by plate ---------- *nigromaculis*, p. 55
   Anal segment not completely ringed by plate ---------- 5

[1] Postcoxal scale patch is present on male *pionips* and absent on *communis*.

6
5. Upper and lower head hairs usually single 8
Upper and lower head hairs multiple .... *niphadopsis*, p. 56
6. Air tube about 4 by 1; gills small and budlike 7
Air tube about $2\frac{1}{2}$ by 1; gills pointed and as long as or longer than segment .... *ventrovittis*, p. 67
7. Comb with six to 13 scales .... *spencerii idahoensis*, p. 62
Comb with 13 to 29 scales .... *cinereus*, p. 41
8. Upper and lower head hairs five or more; tufts in nearly a straight line with preantennal tuft 9
Upper and lower head hairs less than five; tufts not inserted in line with preantennal tufts 10
9. Air tube 3 by 1 or shorter 12
Air tube 4 by 1 or longer .... *intrudens*, p. 53
10. Plate of anal segment incised; lateral abdominal hairs single on segments 3 to 6 11
Plate of anal segment not incised; lateral abdominal hairs double or triple on segments 1 to 5 .... *vexans*, p. 68
11. Anal gills longer than plate; comb scales with long apical spine .... *campestris* (in part), p. 38
Anal gills short and budlike; comb scales without long apical spine .... *flavescens* (in part), p. 46
12. Air tube $3\frac{1}{2}$ to 4 by 1 13
Air tube $4\frac{1}{2}$ to $5\frac{1}{2}$ by 1 .... *fitchii* (in part), p. 45
13. Mesothoracic hair 1 fifteen times as long as mesothoracic hair 2 14
Mesothoracic hair 1 two to three times as long as mesothoracic hair 2 .... *aloponotum*, p. 37
14. Lateral abdominal hairs usually double on segments 1 to 6 .... *excrucians*, p. 45
Lateral abdominal hairs double on segments 1 and 2 and single on 3 to 6 16
15. Anal segment ringed by plate 18
Anal segment not ringed by plate .... *hexodontus*, p. 49
16. Comb with five to nine scales 17
Comb with 10 to 26 scales .... *punctor*, p. 59
17. Comb with 10 to 19 scales, each scale thorn shaped with long central spine; lateral spinules minute
Comb with 17 to 26 scales, each scale not thorn shaped; most lateral spinules one-half to three-fourths as long .... *trivittatus*, p. 66
as central spine 19
18. Antennae smooth with antennal tuft consisting of single hair 20
Antennae spiculated with antennal tuft multiple .... *hendersoni*, p. 48
19. Comb with eight to 12 scales; air tube with acus detached .... *sierrensis*, p. 61
Comb with 12 to 23 scales; air tube with acus attached
20. Air tube slender, 4 by 1 or more; apical setae of air tube hook shaped and as long as lateral valve .... *fitchii* (in part), p. 45
section 21
Air tube stout, $3\frac{1}{2}$ by 1 or less; apical setae of air tube not hook shaped and shorter than lateral valve section 22
21. Lateral hair equal to or longer than anal plate 24
Lateral hair shorter than anal plate .... *flavescens* (in part), p. 46
22. Prothoracic hair 1 single; air tube $3\frac{1}{2}$ by 1 or more 23
Prothoracic hair 1 double or multiple; air tube 3 by 1 or less .... *schizopinax*, p. 60
23. Plate of anal segment with longer spicules on apical area .... *aboriginis*, p. 37
Plate of anal segment without longer spicules on apical area 25
24. Upper head hairs four to eight, lower three to five 27
Upper head hairs one to four, lower one to two .... *pionips*, p. 57
25. Comb with more than 56 scales 26
Comb with less than 56 scales .... *pullatus*, p. 58
26. Prothoracic hair 5 usually triple .... *c. canadensis*, p. 39
Prothoracic hair 5 single or double .... *impiger*, p. 50
27. Comb with eight to 16 scales 28
Comb with 17 or more scales .... *communis*, p. 42
28. Comb with 28 to 70 scales; spicules on anal plate minute and not longer at apex 29
Specimens without this combination of characters 30
29. Spicules on anal plate definitely longer at apex of plate 32
Spicules not longer at apex of plate .... *implicatus*, p. 51
30. Upper and lower head hairs usually single (occasionally one may be double but rarely both) 31
Upper head hairs usually double or triple, lower head hairs single or double .... *increpitus*, p. 51
31. Comb with median spine less than $1\frac{1}{2}$ times as long as subapical spinules .... *stimulans*, p. 64
Comb with median spinules about $1\frac{1}{2}$ times as long as subapical spinules .... *sticticus*, p. 63
32. Median spine of comb scale two or more times length of adjacent spinules 33
Median spine of comb scale less than twice length of adjacent spinules ....

33. Upper head hairs two or three, lower head hairs one or two . . . . *campestris* (in part), p. 38
Upper head hairs one or two, lower head hairs usually single 34
34. Dorsal hair 1 of mesothorax several times as long as 2 . . . . *dorsalis*, p. 43
Dorsal hair 1 of mesothorax approximately same length as 2 . . . . *melanimon*, p. 53

Descriptions of Species

Aedes (*Ochlerotatus*) *aboriginis* Dyar

Aedes aboriginis Dyar, Insecutor Inscitiae Menstruus 5: 99. 1917.

Female.—Mesonotum yellowish to light golden brown with paired dark-brown stripes and posterior half lines. Postcoxal scale patch present. Scales on sternopleuron extending to anterior edge. Posterior area of probasisternum bare or rarely with a few scales. Hypostigial spot of scales absent. Lower mesepimeral bristles one or two. Abdomen black with basal white bands widening at sides. Wings dark scaled in about 95 percent of specimens. Legs dark.

Male genitalia (fig. 23).—Basistyle three times as long as broad; apical lobe long and rounded with short curved setae; basal lobe flatly conical with numerous setae and long curving spine near base. Claspette stem glabrous on distal one-third to one-half, slightly curved and expanded near middle; filament shorter than stem, slightly expanded at middle, and terminating in blunt curved point.

FIGURE 23.—*Aedes aboriginis* male genitalia.

Larva (fig. 24).—Upper head hairs three to five, lower two to four. Prothoracic hair 1 double or triple. Lateral abdominal hairs single or double. Comb with about 23 to 35 scales in a patch; each scale with long central spine and adjacent shorter spines. Air tube about $2\frac{1}{2}$ by 1; pecten fine and even and not reaching middle; tuft consists of four to six large hairs. Anal segment with plate extending to near ventral line; lateral hair longer than plate; gills pointed and from one to two times as long as plate.

Distribution, biology, and importance.—This species is present in considerable numbers in some places in the timbered coastal areas of Washington and Oregon (map 2) but is uncommon in Idaho. It is also common at moderate elevations in the Cascade Range and in other mountain areas in Washington and northern Idaho. The larvae are found in snow and rain pools in wooded and semiwooded areas. It is of economic importance only in a few areas.

Aedes (*Ochlerotatus*) *aloponotum* Dyar

Aedes aloponotum Dyar, Insecutor Inscitiae Menstruus 5: 98. 1917.

Female.—Tori with inner surfaces predominantly white scaled. Mesonotum reddish brown scaled with white scales in prescutellar area and usually with some white scales around lateral margins, also occasionally with paired small white scale spots forward of prescutellar area. Mesepimeral bristles absent or rarely there may be one. Abdomen black with basal segmental white bands and frequently with scattered white scales. Wings predominantly dark scaled with pale scales intermixed. Legs dark with broad basal white bands on all segments of hind tarsi, narrower basal bands on segments 1 to 4 of middle tarsi, and narrow basal bands on segments 1 to 3 of front tarsi; tarsal claw with tooth broad, short, and not parallel (fig. 25).

Male genitalia.—The characters of the male genitalia of this species are similar to those of *Aedes excrucians* (fig. 38).

Larva.—Upper head hairs triple or in fours, lower double or occasionally triple. Antennae spiculated, tufts multiple. Mesothoracic hair 1 two to three times as long as mesothoracic hair 2. Lateral abdominal hairs usually double on segments 1 to 6 but occasionally may be single on 6. Comb with about 17 to 33 scales; each scale from central area of comb with long median spine and lateral spinules usually extending more than half length of median spine. Air tube slender, about 5 by 1; pecten not reaching middle with two to three large detached teeth; tuft with four to six large hairs. Anal segment extending about three-fourths distance down sides; lateral hair shorter than plate; gills as long or longer than plate.

Dyar, who named this species, recognized its close relationship to *Aedes excrucians* when he stated that it could also have been classified as a race of

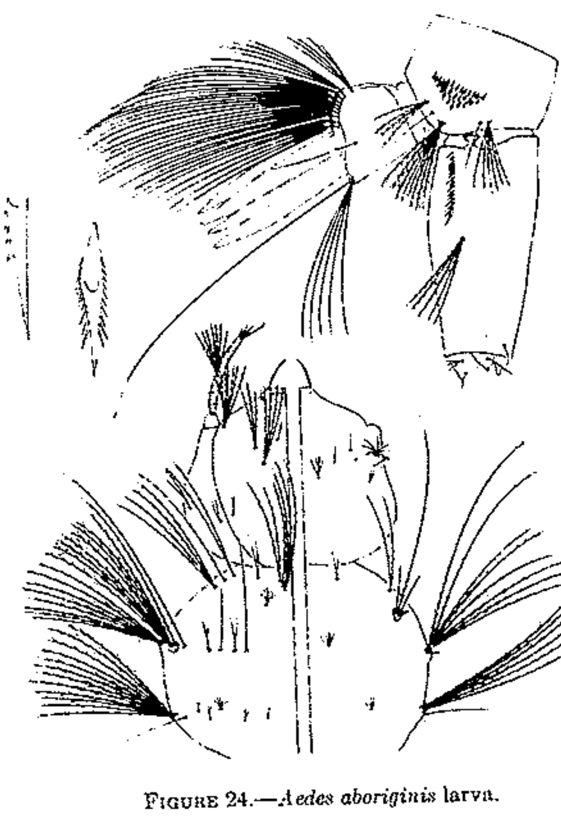

FIGURE 24.—*Aedes aboriginis* larva.

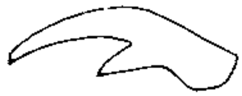

FIGURE 25.—*Aedes aloponotum*, claw of female.

excrucians on the Pacific coast. It was considered a synonym of *excrucians* by Matheson (*190*), Stage et al. (*254*), and Carpenter and LaCasse (*57*). However, Boddy (*35*) described additional characters. More recently other characters of the larvae and female have been found that establish this as a distinct species (*111*).

Distribution, biology, and importance.—This species occurs in small numbers in wooded or semiwooded areas in Washington and Oregon (map 3). It has been collected as far east as Spokane, Wash., and as far south as Odell Lake in Oregon. Little is known about its economic importance.

Aedes (*Ochlerotatus*) *campestris* Dyar and Knab

Aedes campestris Dyar and Knab, N.Y. Ent. Soc. Jour. 15: 213. 1907.

Female.—Mesonotum yellowish white with median brown stripe; sides with narrow brownish margin. Abdomen black with median white line; apical and basal white bands forming small paired segmental dark areas; last two segments frequently all white scaled. Wing scales pale and dark intermixed; white scales usually predominating. Legs with dark and pale scales; tarsi dark with basal and apical white bands, except on last two segments of middle tarsi and last three segments of front tarsi.

Male genitalia (fig. 26).—Basistyle about three times as long as wide; apical lobe low convex with rather long setae; basal lobe rounded, slightly raised, and covered with many setae; large spine and several long spinelike setae at basal margin. Claspette stem with two or three small setae just before apex; filament narrowly and roundly expanded in sickle shape.

Larva (fig. 27).—Upper head hairs two or three, lower one or two. Lateral abdominal hairs usually double on segments 1 to 5 and single on 6. Comb with 20 to 32 scales in triangular patch. Air tube about 3 by 1, tapering, with pecten reaching two-thirds distance to apex; small tuft near tip; last two or three teeth stouter and slightly detached. Anal

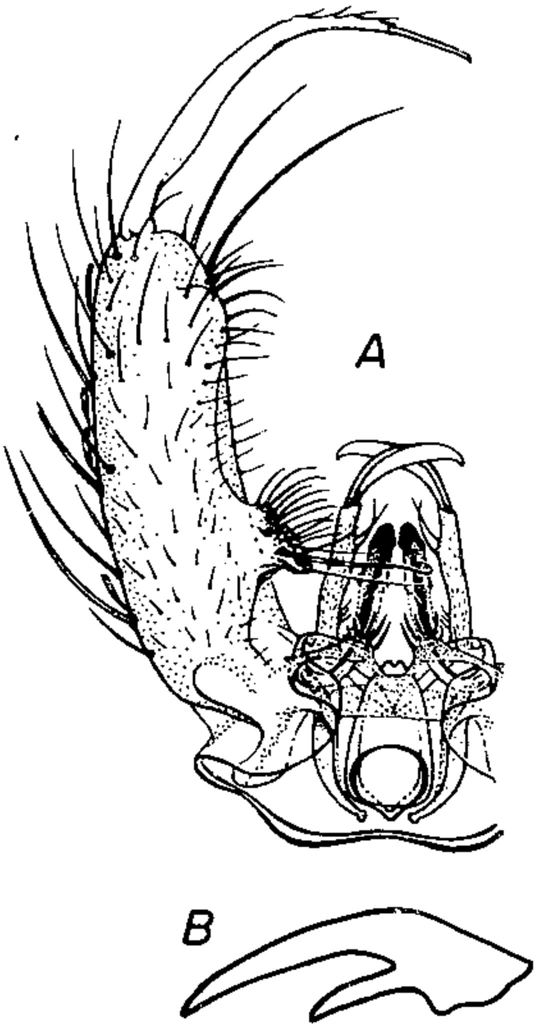

FIGURE 26.—*Aedes campestris: A*, Male genitalia; *B*, claw of female.

segment as long as wide; plate lightly spiculated extending nearly to ventral line; lateral hair shorter than plate; gills budlike and shorter than plate.

Distribution, biology, and importance.—This species has been found in semiarid areas in southern Idaho and in eastern Oregon and Washington (map 4). The larvae develop in pools where the water is slightly alkaline. Adults are usually not numerous but may develop in sufficient numbers to cause annoyance in localized areas. A flight range of 10 miles has been reported by Rees (*222*).

Aedes (*Ochlerotatus*) *canadensis canadensis* (Theobald)

Culex canadensis Theobald, Monog. Culicidae 2: 3. 1901.

Female.—Mesonotum reddish brown with pale-yellow scales around margins. Abdomen black without basal white bands or with narrow indistinct ones; sides with triangular white spots. Wing scales all dark. Legs dark; hind and middle tarsi apically and basally white banded, last segment of hind tarsi entirely white scaled; front tarsi apically and basally banded on segments 1 and 2.

Male genitalia (fig. 28).—Basistyle slightly more than twice as long as wide; apical lobe large, low, and broadly rounded with short bladelike setae; basal lobe large with many short setae. Claspette stem cylindrical and setose, larger seta before apex; filament narrow, linear, pointed, and slightly shorter than stem.

Larva (fig. 29).—Upper head hairs four to nine, lower three to six. Prothoracic hair 5 usually single or double. Lateral abdominal hairs usually double on segments 1 to 5 and single on 6. Comb with 25 to 40 scales in irregular patch; each scale with rounded fringe of spines apically. Air tube 3 by 1; pecten even, reaching beyond one-third of tube, followed closely by tuft of four to six medium hairs.

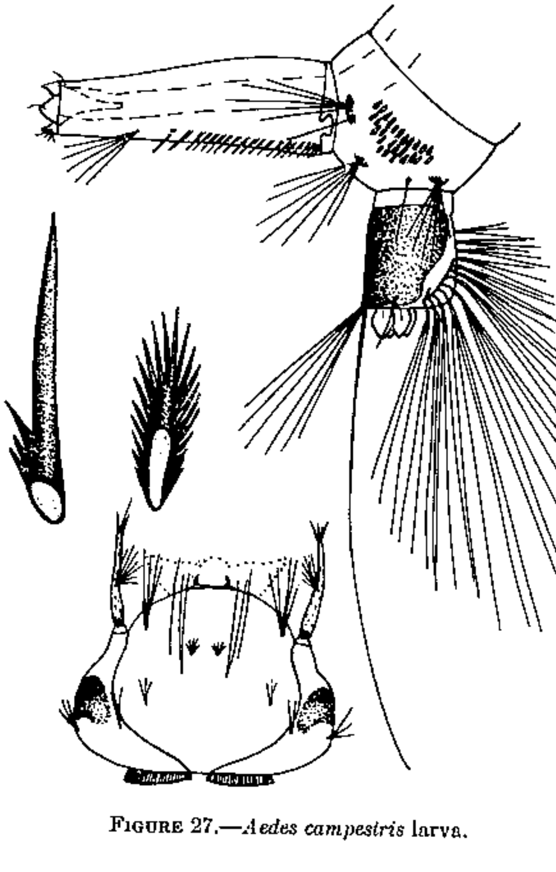

FIGURE 27.—*Aedes campestris* larva.

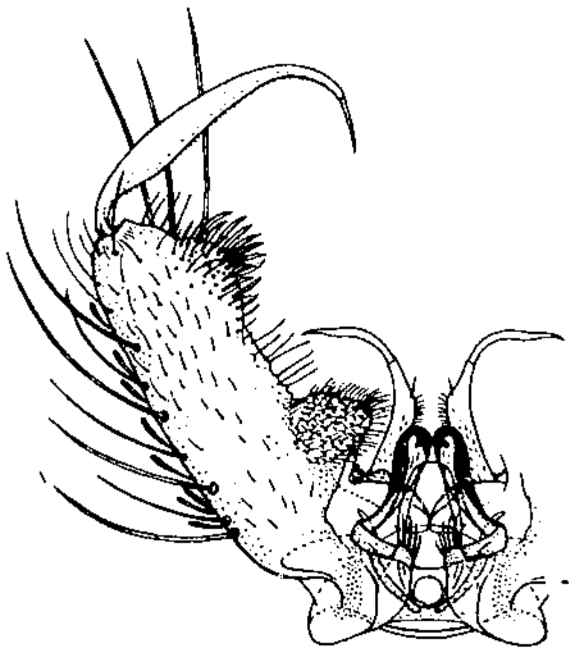

FIGURE 28.—*Aedes canadensis canadensis* male genitalia.

Anal segment with plate extending about two-thirds down sides; lateral hair shorter than plate; gills about one to 1½ times length of plate.

Distribution, biology, and importance.—This species has not been taken in Oregon but has been collected in large numbers in northern Idaho and has also been taken in a number of counties in northeastern Washington (map 5). The larvae breed in temporary forest pools left from melted snow. They were also found developing in pools in open meadows. The adults bite avidly and are present in sufficient numbers to be annoying in localized areas.

Aedes (Ochlerotatus) cataphylla Dyar

Aedes cataphylla Dyar, Insecutor Inscitiae Menstruus 4: 86. 1916.
Aedes prayi Dyar and Shannon, Wash. Acad. Sci. Jour. 15: 78. 1925.

Female.—Mesonotum gray around sides with golden-brown scales in middle, which sometimes show faint dark lines. Scutellum with pale-yellowish scales. Lower mesepimeral bristles two to seven. Postcoxal scale patch present. Sternopleuron with scales not extending to frontal border. Hypostigial spot of scales present or absent. Abdomen black with basal segmental white bands. Wing scales dark with pale scales at base of costa and first vein. Legs dark with mixture of pale scales; tarsi mostly black.

Male genitalia (fig. 30).—Basistyle about three times as long as wide; apical lobe small, elongated, and narrowly attached with few short setae; basal lobe small, elevated into transverse ridge at base with row of long setae and slender spine at margin. Claspette stem lightly hirsute except at apex; filament expanded in gradual curve at basal third.

Larva (fig. 31).—Upper and lower head hairs single. Lateral abdominal hairs usually double on segment 1 to 5 and single on 6. Comb with about 10 to 25 scales in two irregular rows; each scale with long median spine and shorter lateral spinules. Air tube about 3 by 1, tapering, with evenly spaced pecten teeth to hair tuft; three to five widely spaced teeth beyond tuft. Anal segment with plate reaching about two-thirds distance down sides; lateral hair shorter than plate; gills as long or longer than plate.

Distribution, biology, and importance.—This species has been found in a few places in mountain areas and occasionally at lower levels in all

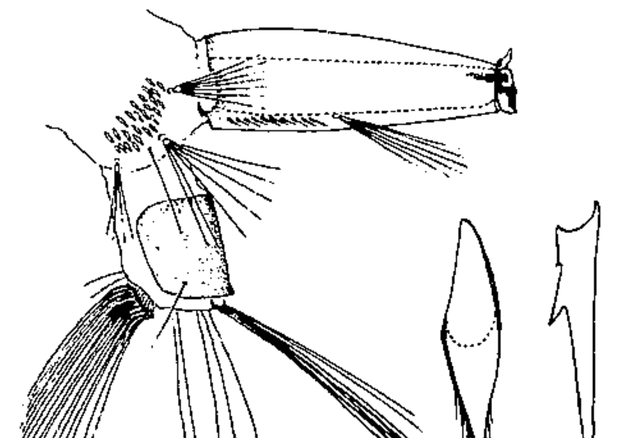

FIGURE 29.—*Aedes canadensis canadensis* larva.

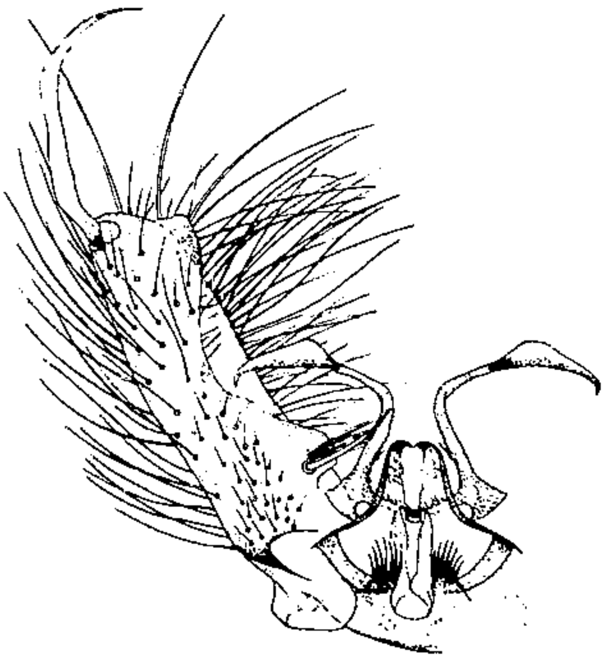

FIGURE 30.—*Aedes cataphylla* male genitalia.

Larva (fig. 33).—Upper and lower head hairs in tufts of five or more, tufts in nearly straight line with preantennal tuft. Lateral abdominal hairs double on first and second segments, single and long on third to sixth. Comb with nine to 15 scales in double row. Air tube slender, about 4 by 1; pecten extending past middle of tube with about three detached teeth; tuft small. Anal segment with plate extending about three-fourths down sides; lateral hair usually double and shorter than plate; gills two or more times length of plate.

Distribution, biology, and importance.—This mosquito is found throughout the partially wooded areas of all three States (map 4). It breeds in woodland and open meadow pools. Larvae have been collected from early April at lower levels to late June at higher elevations. In some mountain areas it is the predominating species and is a serious pest; it is found in smaller numbers at lower elevations. In Nevada it is apparently found only in three States (map 6). The larvae have been collected in pools and roadside ditches in open and partially wooded areas. Carpenter (*51*) found that from 5 to 7 weeks were required for development of the immature stages at an elevation of 6,100 feet in California. Freeborn (*94*) observed that the adults bite fiercely and will attack man and horses in the daytime.

Aedes (*Aedes*) *cinereus* Meigen

Aedes cinereus Meigen, System. Beschreibung der Bekannten Europäischen Zweiflügeligen Insekten 1: 13. 1818.

Female.—Mesonotum clothed with reddish-brown scales. Lower mesepimeral bristles absent. Postcoxal scale patch absent. Abdomen black without white bands or with narrow partial or complete ones; lateral spots usually joined to form line. Wing scales dark. Legs dark brown; coxa of front leg with white scales and a central patch of brown scales on anterior surface.

Male genitalia (fig. 32).—Basistyle about twice as long as wide; apex cone shaped with long setae. Dististyle subapically inserted with forked arms of unequal length; short branch with setae apically, long branch forked at end. Claspette two-branched; filament absent.

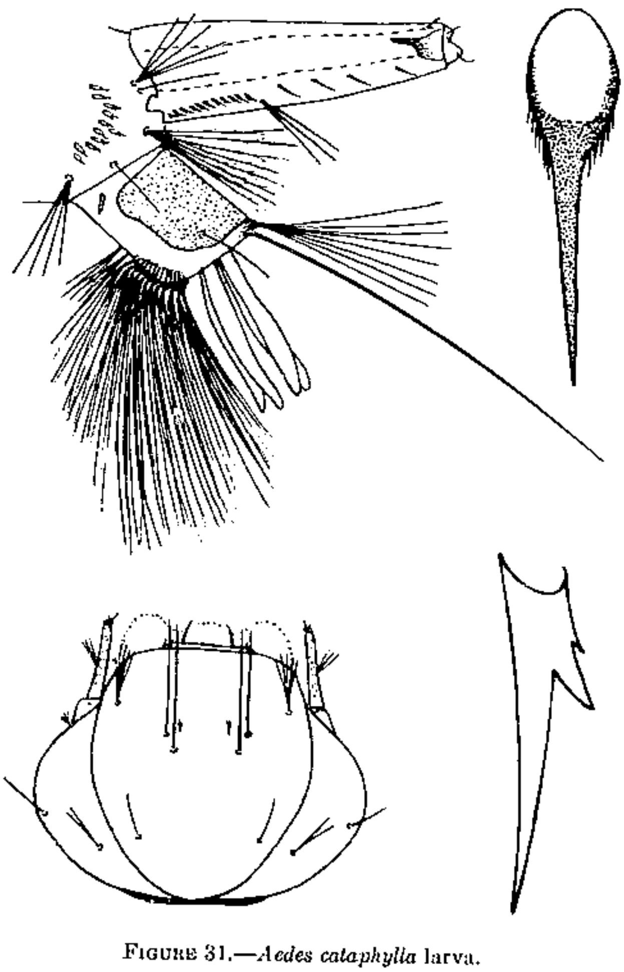

FIGURE 31.—*Aedes cataphylla* larva.

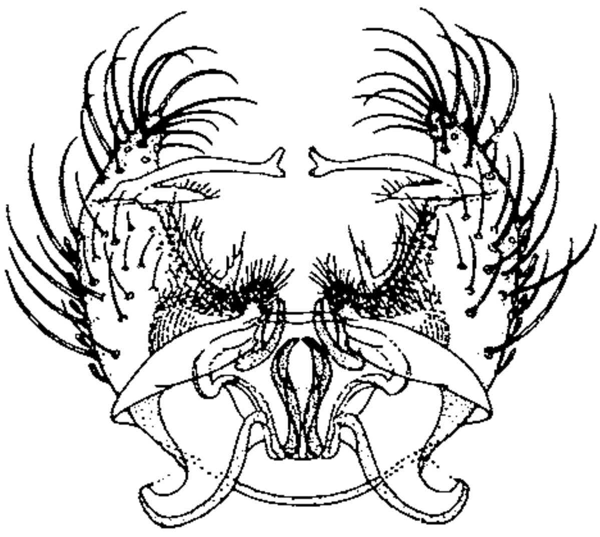

FIGURE 32.—*Aedes cinereus* male genitalia.

foothill and valley areas (*63*). The females attack both during the day and at dusk. They are known to rest near the ground in the grass or underbrush or other places near their breeding sites.

Aedes (Ochlerotatus) communis (DeGeer)

Culex communis DeGeer, Mém. Pour Servir Hist. des Insects 6, pl. 17, figs. 2 and 5. 1776.

Female.—Mesonotum dull yellow or gray scaled with narrow pale median line separating paired dark-brown lines and with posterior brown half lines. Coloration is variable and may be brown scaled centrally with mixture of pale scales and border of grayish-yellow scales. Lower mesepimeral bristles two to five. Postcoxal scale patch absent. Sternopleuron with scales extending to anterior edge. Hypostigial spot of scales absent. Abdomen dark brown with basal white bands. Wings dark scaled; patch of two or three to many pale scales at base of costa in about 85 percent of specimens. Legs dark; femora partially pale.

Male genitalia (fig. 34).—Basistyle about three times as long as wide; apical lobe large rounded with many long setae; basal lobe small, quadrilateral in outline, partially detached at base, surface with some small setae, several larger curved ones, and stout spine on margin. Claspette stem lightly hirsute on basal half; apical half more slender; filament angularly expanded to its maximum width near base, top with groove created by flange along its sides.

Larva (fig. 35).—Upper and lower head hairs single. Lateral abdominal hairs double on first to fifth segment and single on sixth. Comb with about 28 to 70 scales in triangular patch; each scale with central spine and adjacent spines or spinules of variable length. Air tube stout and about 2½ by 1; pecten teeth evenly spaced to near middle of tube; tuft of four to eight hairs. Anal segment with plate extending only about two-thirds distance down sides; spicules minute; lateral hair shorter than plate; gills about twice length of plate.

Examination of comb scales of larvae from locations in Washington, Oregon, and Idaho has shown

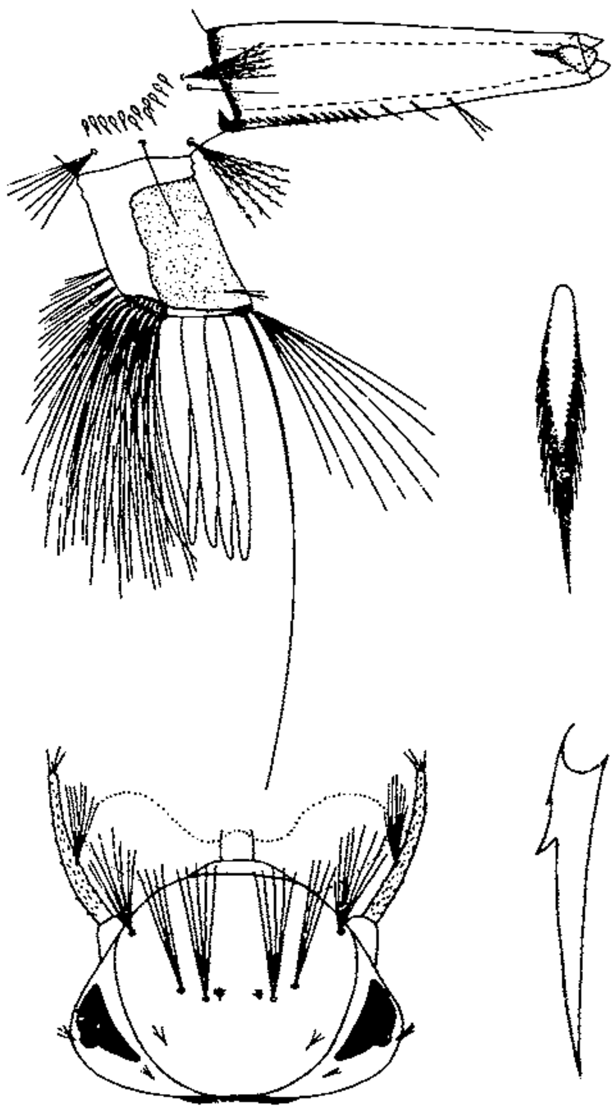

FIGURE 33.—*Aedes cinereus* larva.

FIGURE 34.—*Aedes communis* male genitalia.

that in several of these locations larvae with the three types of comb scales were present in the same pools (*111*). The two most divergent types of scales are shown in figure 35. No other differences were seen in these larvae (*111*).

Distribution, biology, and importance.—This is one of the most widely distributed species in high mountain areas of the Northwest (map 4). In many localities it is present in large numbers and is a serious pest. It breeds in flooded mountain meadows and woodland pools left by melting snow and around the margins of mountain lakes. The larvae may be found alone or in association with other species such as *Aedes pullatus*, *A. cataphylla*, *A. intrudens*, *A. fitchii*, or *A. hexodontus*. In Oregon it is numerous throughout the Cascade Range and Blue Mountains. It is abundant in the Cascade and other mountain ranges in Washington and northern Idaho and is present in smaller numbers in central and southern Idaho. The adults are sometimes seen late in May and may occur until mid-August. The females are persistent biters, and although they will attack during the day, they are generally more active at dusk.

Aedes (*Ochlerotatus*) *dorsalis* (Meigen)

Culex dorsalis Meigen, System. Beschreibung der Bekannten Europäischen Zweiflügeligen Insekten 6: 242. 1830.

Female.—Palpi tips usually dark scaled. Mesonotum yellowish white with median brown stripe or with only few brown scales medianly; posterior brown half lines and side lines may or may not be present. Abdomen predominantly white scaled with median white stripe and transverse segmental white bands; last one or two segments may be entirely white scaled. Wing scales dark and light, light predominating; sixth or anal vein with more light than dark scales. Legs with dark and pale

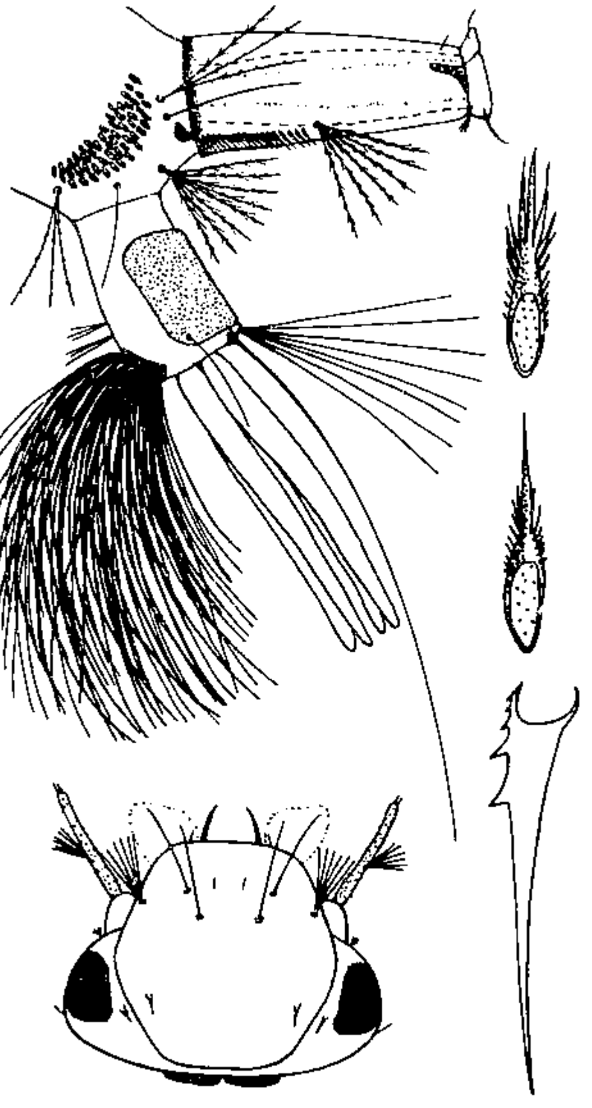

FIGURE 35.—*Aedes communis* larva.

scales; tarsi dark with apical and basal white bands on all but last two segments of middle tarsi and last three segments of front tarsi.

Male genitalia (fig. 36).—Basistyle about three times as long as wide; apical lobe rounded and somewhat shortened apically, surface clothed with straight setae of medium length; basal lobe prominent, slightly constricted at base, and covered with short setae, a stout spine on margin, and a smaller adjacent spine followed by several setae. Claspette stem straight and constricted just before apex with few setae at constriction; filament broadly expanded in rounded rectangular shape near middle.

Larva (fig. 37).—Upper and lower head hairs single or occasionally uppers may be double. Dorsal hair 1 of mesothorax three or four times as long as hair 2. Lateral abdominal hairs triple on segments 1 and 2 and double on rest. Comb with about 20 to 31 scales in patch. Air tube tapering, about 3 by 1; pecten evenly spaced to near middle of tube; multiple tuft set close to end of pecten. Anal segment with plate extending about halfway down sides; lateral hair shorter than anal plate; gills from ½ to 1½ length of plate.

A dark winged form of *Aedes dorsalis* has been reported by Chapman and Grodhaus (*70*) from Humboldt County, Calif. This population has more dark than light scales on the sixth wing vein. Two such specimens from Kernville and two from North Bend on the Oregon coast have been found on reexamination of our pinned collection of about 800 specimens of *A. dorsalis* and *A. melanimon* from the

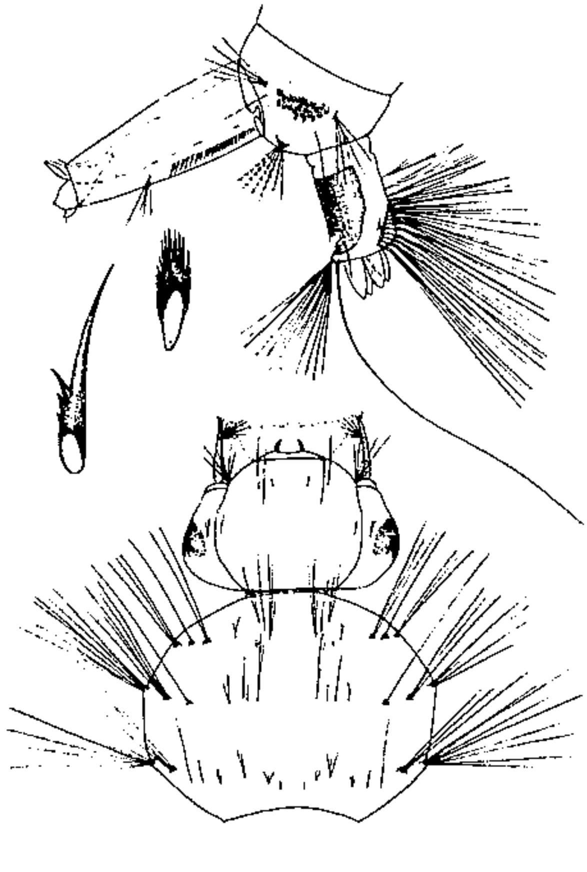

FIGURE 37.—*Aedes dorsalis* larva.

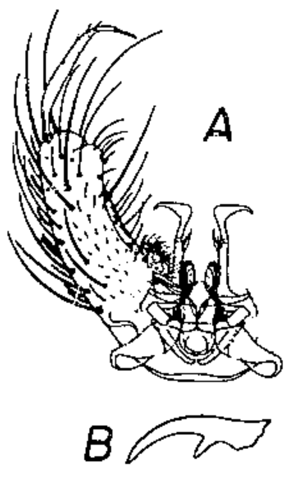

FIGURE 36.—*Aedes dorsalis*: *A*, Male genitalia; *B*, claw of female.

Northwestern States. The claw characters appear to be adequate for separating the dark winged form of *A. dorsalis* from *A. melanimon*. Characters for separation of this species from *A. melanimon* are given by Bohart (*36*), Chapman and Grodhaus (*70*), and Richards (*231*).

Distribution, biology, and importance.—This is one of the most important and widely distributed species in the Northwest (map 5). It is the only species in this region that breeds naturally in brackish or salt-water marshes and is also one of the most abundant and troublesome species in irrigated areas and in flooded grasslands. The larvae are frequently associated with those of *A. melanimon*. The females will bite at any time of the day or night but are most active in the evening. Natural infections of western equine encephalitis and St. Louis encephalitis have been isolated from this species. Migratory flights of 22 miles in Utah and 30 miles in California have been recorded for this species (*223*).

Aedes (Ochlerotatus) excrucians (Walker)

Culex excrucians Walker, Insecta Saundersiana, Diptera 1: 429. 1856.

Female.—Tori with inner surfaces predominantly white scaled. Mesonotum yellowish white with median brown stripe, varied pattern of brown and white scales. Mesepimeral bristles absent or rarely one. Abdomen black with basal segmental white bands and frequently with scattered white scales. Wings predominantly dark scaled with pale scales intermixed. Legs dark with broad basal white bands on all segments of hind tarsi, narrower basal bands on segments 1 to 4 of middle tarsi, and narrow basal bands on segments 1 to 3 of front tarsi.

Male genitalia (fig. 38).—Basistyle about three times as long as wide; apical lobe prominent with small setae; basal lobe slightly raised, rugose, and extending to base of apical lobe, surface covered with short setae. Claspette stem hirsute except at apex; filament angularly expanded to sharp point near base.

Larva (fig. 39).—Upper and lower head hairs usually double but occasionally uppers may be triple and lowers single. Mesothoracic hair 1 two or three times as long as mesothoracic hair 2. Lateral abdominal hairs double on segments 1 and 2 and single or double on rest. Comb with about 13 to 33 scales; each scale from central area of comb with long median spine and lateral spinules not extending more than half length of median spine. Air tube slender, about 5 by 1; pecten not reaching middle with two or three large detached teeth; tuft with four to six large hairs. Anal segment with plate extending about three-fourths distance down side; gills as long or longer than plate.

Distribution, biology, and importance.—This species is widely distributed but usually does not occur in large numbers (map 7). It has been taken in coastal areas of Washington and also at higher inland elevations. The larvae develop in roadside ditches, meadows, and other temporary pools. The species may be a pest in localized areas in the evening and will also bite at any time of day in shaded areas.

Aedes (Ochlerotatus) fitchii (Felt and Young)

Culex fitchii Felt and Young, Science (n.s.) 20: 312. 1904.

Female.—Tori with white scales on dorsal half. Mesonotum yellowish white to light brown with broad median brown stripe or variable pattern of brown and light scales. Lower mesepimeral bristles none to two, rarely three or four. Abdomen black with basal white bands and sometimes with apical white scales that may extend into median white line. Wings dark scaled, usually with mixture of white scales along costa and occasionally with pale scales scattered over rest of wing. Legs dark; tarsi with basal white bands on all except last two segments of front tarsi and first segment of middle tarsi, white bands broader on hind legs; tarsal claw with short tooth not parallel with claw.

Male genitalia (fig. 40).—Basistyle about three times as long as wide; apical lobe prominent and slightly elongated, surface clothed with long setae

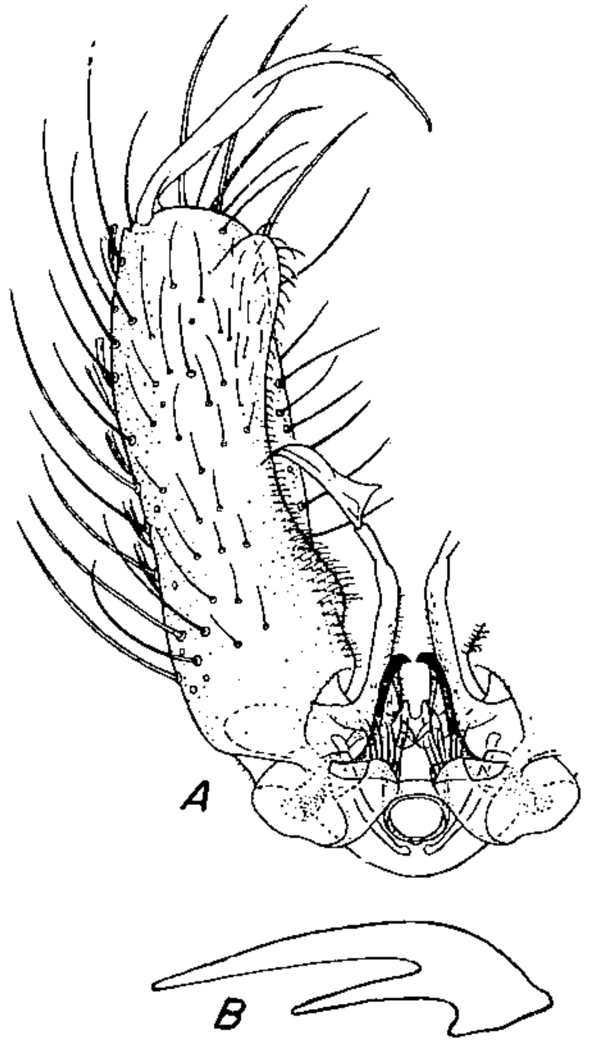

FIGURE 38. *Aedes excrucians*:—*A*, Male genitalia; *B*, claw of female.

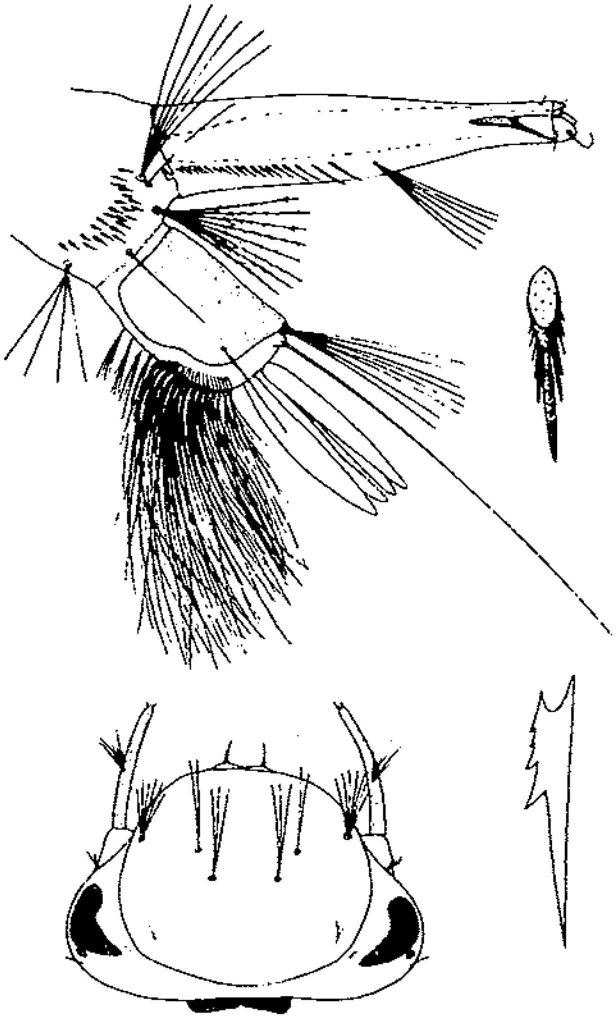

FIGURE 39.—*Aedes excrucians* larva.

bordered by several shorter ones; basal lobe triangular with many setae, those at margin of base longer and preceded by spine. Claspette stem lightly hirsute except at apex; filament short and sickle shaped with notch at base.

Larva (fig. 41).—Upper head hairs three to four, lower two to three. Mesothoracic hair 1 about 15 times as long as mesothoracic hair 2. Lateral abdominal hairs usually double. Comb with about 12 to 30 scales; each scale with median spine about twice as long as subapical spines. Air tube slender, tapering, about 4½ by 1; closely set pecten teeth to middle of tube, occasionally with one or more teeth slightly detached; apical setae hook shaped and as long as lateral valve. Anal segment with plate extending nearly to ventral line; lateral hair longer than plate; gills about 1½ times as long as plate.

Distribution, biology, and importance.—*Aedes fitchii* is most prevalent in mountainous regions but is also found near sea level (map 4). First-instar larvae have been taken in early February in the Willamette Valley of Oregon. The larvae develop in flooded meadows or potholes in semiwooded areas. It is an important pest and is present over most of Washington, Oregon, and Idaho wherever suitable breeding areas are found.

Aedes (*Ochlerotatus*) *flavescens* (Müller)

Culex flavescens Müller, Fauna Insectorum Fridrichsdalina . . ., p. 87. 1764.

Female.—Mesonotum with yellowish-brown scales and broad median stripe of slightly darker brown scales, which may blend so that stripe is indistinct. Lower mesepimeral bristles usually absent. Abdomen covered with dull-yellow scales or with dark median line and sides partially black scaled anteriorly. Wing with mixture of yellowish and dark scales. Legs brown with mixture of yellow scales; tarsi with basal white band on all except

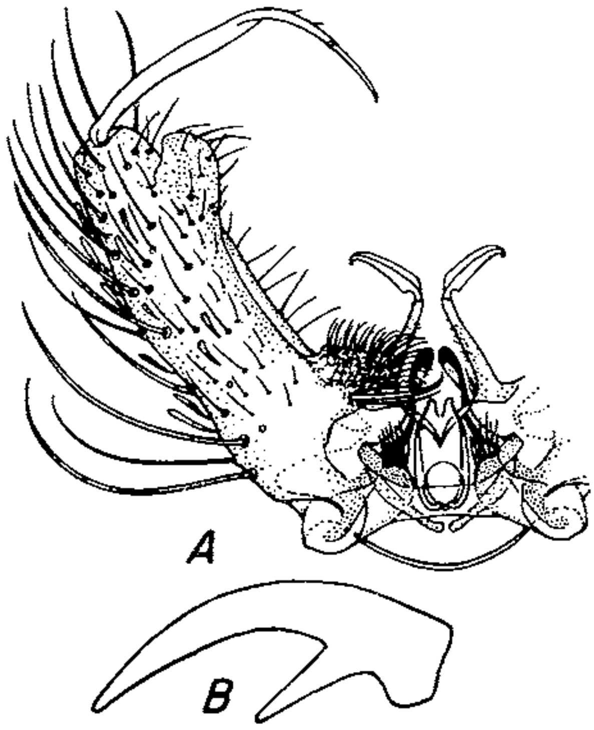

FIGURE 40.—*Aedes fitchii*: *A*, Male genitalia; *B*, claw of female.

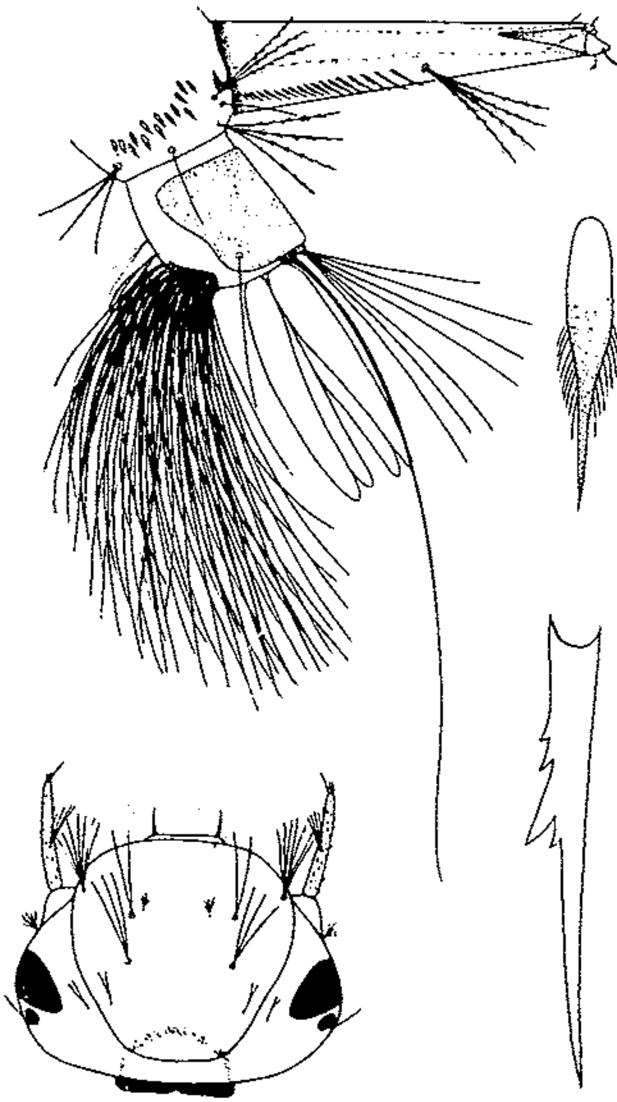

FIGURE 41.—*Aedes fitchii* larva.

last segment of front and middle tarsi, white bands broader on hind legs; tarsal claw with short blunt tooth.

Male genitalia (fig. 42).—Basistyle more than twice as long as wide; apical lobe prominent rounded with many setae; basal lobe a rugose, slightly elevated area with many setae, a stout spine, and several long setae near base; lobe extending nearly to base of apical lobe. Claspette stem with three stout setae on inner margin of base; filament angularly expanded to rounded point near base.

Larva (fig. 43).—Upper head hairs usually three to four, lower usually double. Prothoracic hair 1 single. Lateral abdominal hairs double on segments 1 to 6. Comb with about 20 to 35 scales in patch; median spine of individual scale about twice as long as lateral spinules. Air tube tapering, about 3½ to 4 by 1; pecten reaching middle with or without one or two detached teeth, followed by tuft of four to six hairs. Anal segment with plate extending down about two-thirds; lateral hair about as long as plate; gills from one to two times length of plate.

Distribution, biology, and importance.—This is one of the larger species found in the Northwest. It is a typical plains species and has been taken in limited numbers in widely separated places east of the Cascade Range (map 2). However, it rarely occurs in sufficient numbers to be a serious pest. Larvae have been found in meadow pools and

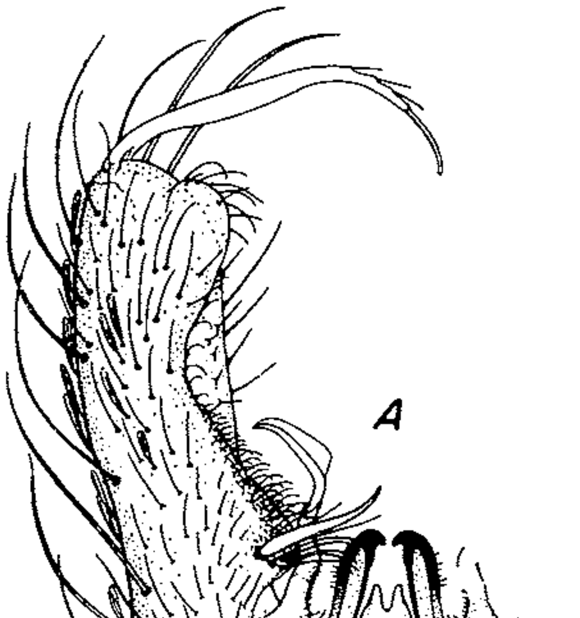

FIGURE 42.—*Aedes flavescens*: *A*, Male genitalia; *B*, claw of female.

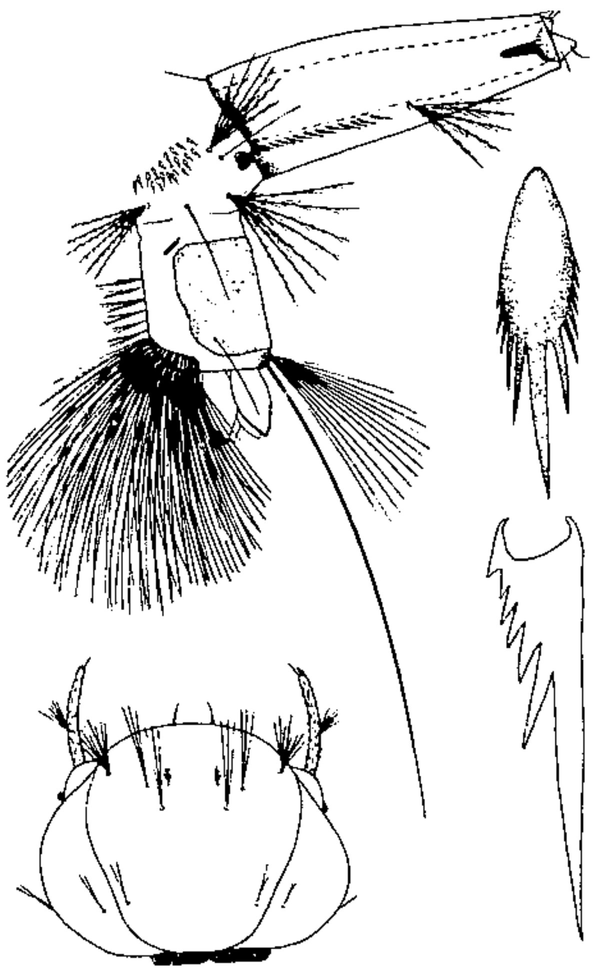

FIGURE 43.—*Aedes flavescens* larva.

marshes in the vicinity of alkaline flats. It has been observed to attack in bright sunlight and during a breeze of about 7 miles per hour. Hearle (*139*) reported on its life history.

Aedes (Finlaya) hendersoni Cockerell[4]

Aedes triseriatus var. *hendersoni* Cockerell, Jour. Econ. Ent. 11: 199. 1918.
Aedes triseriatus hendersoni Cockerell, Ent. Soc. Amer. Ann. 53: 600-606. 1960.

Female.—Mesonotum with stripes of dark-brown scales that become broader posteriorly; stripes separated by narrow partial or complete white stripe; sides and prescutellar space with white scales. Postcoxal scale patch absent. Lower mesepimeral bristles absent. Abdomen dark scaled; segments with lateral basal white spots. Wings dark scaled. Legs dark scaled; tips of femora white scaled.

Male genitalia (fig. 44).—Basistyle about three times as long as wide; apical lobe absent; basal lobe represented by group of setae near base of basistyle; small dense patch of long hairs near middle. Claspette stem long, hirsute to near apex with small setae on inner surface; filament long, narrower than claspette, and gradually tapered to slightly recurved point.

Larva (fig. 45).—Antennae smooth with single hair near middle. Upper head hair single or rarely double, lower two to five. Lateral abdominal hairs double or triple on segments 1 and 2 and double on segments 3 to 6. Comb with eight to 12 scales; each scale evenly fringed with short spinules. Air tube slightly less than 3 by 1; one or more pecten teeth frequently extending below sclerotized area of tube;

FIGURE 44.—*Aedes hendersoni* male genitalia.

[4] The mesonotum of *Aedes triseriatus* adults has no central white stripe and a smaller white scaled prescutellar area. The acus of the air tube is attached to the sclerotized area and the upper and lower gills are of unequal length and shorter than the plate.

FIGURE 45.—*Aedes hendersoni* larva.

Female.—Mesonotum yellowish to light golden brown with paired dark-brown lines and posterior half lines. Postcoxal scale patch present. Scales on sternopleuron extending to anterior margin. Posterior area of probasisternum with white scales. Lower mesepimeral bristles two or three. Abdomen black with basal segmental white bands. Wings dark scaled with patch of two or three to many pale scales at base of costa in about 95 percent of specimens. Legs dark; femora partially pale scaled.

Male genitalia (fig. 46).—Basistyle three times as long as broad; apical lobe long and rounded with short curved setae; basal lobe flatly conical with numerous setae and long curving spine near base. Claspette stem pilose on basal half, slightly curved and expanded near middle; filament shorter than stem, slightly expanded at middle, and terminating in blunt curved point.

Larva (fig. 47).—Upper and lower head hairs usually double, but occasionally one or more tufts acus detached from base of tube. Anal segment with small plate extending less than halfway down sides; lateral hair one to three branched and attached on edge or on adjacent nonsclerotized area; anal gills bluntly rounded, about equal in length, and about three times as long as plate.

Distribution, biology, and importance.—*Aedes hendersoni* breeds in tree holes but little is known of its ecology. Larvae are found in association with *A. triseriatus* in some areas, but Breland (*43*) believes that *A. hendersoni* is a western species and that *A. triseriatus* is predominantly an eastern and southeastern species. Nielsen et al. (*204*) found that specimens from Ada County, Idaho (map 7), which were originally reported as *triseriatus*, are typical *hendersoni*. Their observations support Breland's separation of the two species. The three collections made in Idaho are the only records reported for this species.

Aedes (*Ochlerotatus*) *hexodontus* Dyar

Aedes hexodontus Dyar, Insecutor Inscitiae Menstruus 4: 83. 1916.

Aedes cyclocerculus Dyar, ibid. 8: 23. 1920. "(in part)."

Aedes leuconotips Dyar, ibid. 8: 24. 1920. "(in part)."

FIGURE 46.—*Aedes hexodontus* male genitalia. (Courtesy of Carpenter and LaCasse *57*.)

may be single or triple. Comb with five to nine scales in row; scales thorn shaped with minute lateral basal spinules. Air tube 2½ by 1; pecten not quite reaching middle of tube. Anal segment ringed by plate; lateral hair longer than plate; gills pointed and about 1½ to three times length of plate.

Distribution, biology, and importance.—*Aedes hexodontus* is a mountain species usually associated with *A. communis* and *A. fitchii*. It is not so widely distributed (map 2) as these species, but in some areas it is very abundant and an important pest. Large numbers of the larvae develop in meadows in the Cascade Range in the vicinity of Mount Adams and Mount Rainier National Park in Washington and in the Mount Hood and Diamond Lake areas in Oregon. This species has also been taken in various places in Idaho. It is a persistent biter during the day.

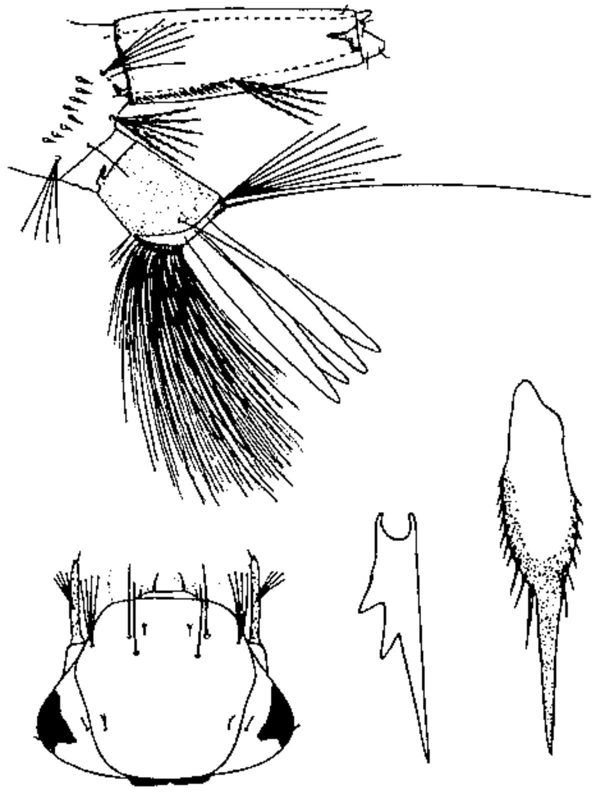

FIGURE 47.—*Aedes hexodontus* larva.

Aedes (Ochlerotatus) impiger (Walker)

Culex impiger Walker, List of Dipterous Insects in Brit. Mus., v. 1, p. 6. 1848.

Aedes nearcticus Dyar, Canad. Arctic Exped. Rpt. 3 (C), p. 32. 1919.

Aedes "impiger:" Vockeroth, Canad. Ent. 86: 109. 1954. Not *impiger* of authors.

Female.—Mesonotum with brownish scales with or without mixture of yellowish-white scales around sides and two lighter colored patches of scales centrally, entire surface with many black bristles. Scutellum with pale-yellowish scales. Postcoxal scale patch present. Sternopleuron with scales usually not extending to anterior edge. Lower mesepimeral bristles three to eight. Abdomen black with basal segmental white bands. Wing scales usually dark with patch of pale scales on base of costa. Legs dark; femora and tibiae partially pale scaled.

Male genitalia (fig. 48).—Basistyle about 3½ times as long as wide; apical lobe rounded, surface with a few small setae; basal lobe conically sloped to basal edge with row of long setae and spine at margin, rest of surface bare or with few small setae. Claspette stem hirsute on basal half; filament angularly expanded to its maximum width near base.

FIGURE 48.—*Aedes impiger* male genitalia.

Larva (fig. 49).—Upper and lower head hairs single. Lateral abdominal hairs multiple on first segment and usually double on second to fifth. Comb with eight to 16 scales; each scale with long median spine and series of smaller basal lateral spines. Air tube about 2½ by 1; pecten on basal third, followed by multiple tuft. Anal segment with plate extending about halfway down sides; lateral hair shorter than plate; gills several times length of segment.

Distribution, biology, and importance.—This species occurs in a few places in the high mountainous areas of Washington, Oregon, and Idaho (map 3). The largest numbers have been found in Mount Rainier National Park in Washington and near Diamond Lake in Oregon. The larvae hatch with the first melting snow. The species is apparently too rare to be of much importance as a pest.

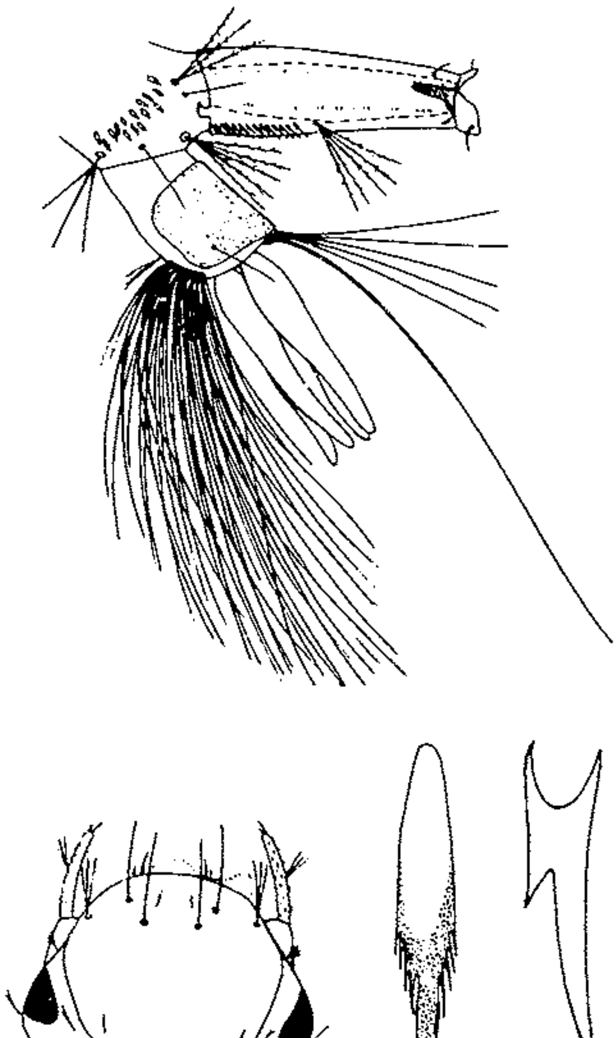

FIGURE 49.—*Aedes impiger* larva.

Aedes (Ochlerotatus) implicatus Vockeroth

Aedes impiger Dyar, Insecutor Inscitiae Menstruus 8: 8. 1920.

Aedes (Ochlerotatus) implicatus Vockeroth, Canad. Ent. 86: 110. 1954.

Female.—Mesonotum with median oblong area of brown scales, usually in form of broad stripe or paired stripes; margins grayish white. Lower mesepimeral bristles one to three or rarely none. Postcoxal scale patch present. Sternopleuron with scales not extending to frontal border. Wing scales dark with patch of two or three to many pale scales at base of costa. Legs dark; femora pale scaled beneath.

Male genitalia.—Basistyle about four times as long as wide; apical lobe small, elongated, and narrowly attached with few short setae, tuft of long hairs just below base; basal lobe small, elevated into transverse ridge with row of long setae and slender spine at margin. Claspette stem lightly hirsute except at apex; filament angularly expanded to sharp point near base.

Larva (fig. 50).—Upper and lower hairs single or occasionally with uppers double. Lateral abdominal hairs double on first to fourth segments and single on fifth and sixth. Comb with 17 to 25 scales; each scale with fringe of spines, median spine slightly longer. Air tube about 2½ by 1; closely set pecten teeth not reaching middle, followed by tuft of three or four hairs. Anal segment with plate spiculated apically and extending about halfway down sides; lateral hair shorter than anal plate; anal gills pointed and only about as long as plate.

Distribution, biology, and importance.—This species occurs in small numbers in the Northwestern States (map 6). The larvae are usually associated with other *Aedes* larvae in pools in semiwooded areas at the higher elevations. It is considered unimportant as a pest.

Aedes (Ochlerotatus) increpitus Dyar

Aedes increpitus Dyar, Insecutor Inscitiae Menstruus 4: 87. 1916.

Female.—Tori without white scales on dorsal half. Mesonotum yellowish white to light brown with broad median brown stripe or variable pattern of brown and light scales. Mesepimeral bristles one to five. Wings dark with white scales along costal area. Legs dark; tarsi with basal white bands on all except last two segments of front tarsi and first segpointed and from ½ to about 1½ times length of plate.

Distribution, biology, and importance.—This is a common species that is generally distributed over the plains areas of Washington, Oregon, and Idaho (map 2). The larvae have been taken also in open meadows and small pools in semiwooded country from sea level to an elevation of about 6,000 feet. Chapman (*68*) has collected larvae at 8,200 feet in Nevada. Distribution and ecology of the species in California have been studied by Carpenter (*58*). Our associates, L. F. Lewis and D. M. Christenson, have shown (unpublished data) that in the Willamette Valley of Oregon development of larvae and pupae and even some adult emergence occur in winter. This information would indicate that all stages of this species may be involved in carrying it through the winter in some areas. This species is one of several found at higher elevations that contribute to the serious discomfort of man and animals.

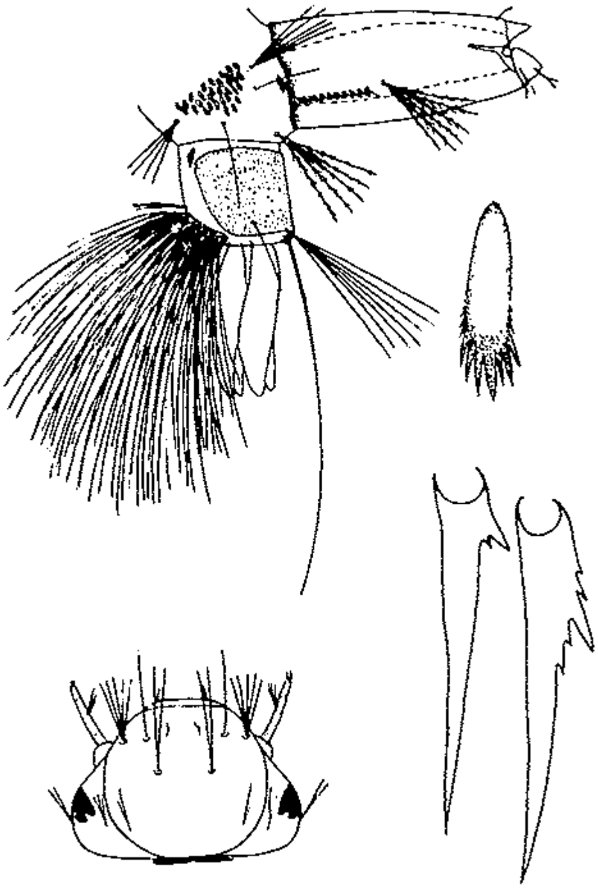

FIGURE 50.—*Aedes implicatus* larva.

ment of middle tarsi, white bands broader on hind legs.

Male genitalia (fig. 51).—Basistyle more than three times as long as wide; apical lobe prominent and bluntly pointed with few small inwardly directed setae; basal lobe a small rugose elevated area with short setae that extend halfway to apical lobe. Claspette stem lightly hirsute except at apex; filament angularly expanded to sharp point near middle.

Larva (fig. 52).—Upper head hairs usually two or occasionally three, lower one or two. Lateral abdominal hairs one or two long hairs on each segment. Comb with about 20 to 40 scales in patch; each scale fringed with spines, central spine slightly longer. Air tube about 3 to 3½ by 1; pecten not reaching middle of tube; tuft of four to six hairs. Anal plate extending only about two-thirds down sides, apex with well-developed spicules on apical area; lateral hair shorter than anal plate; anal gills

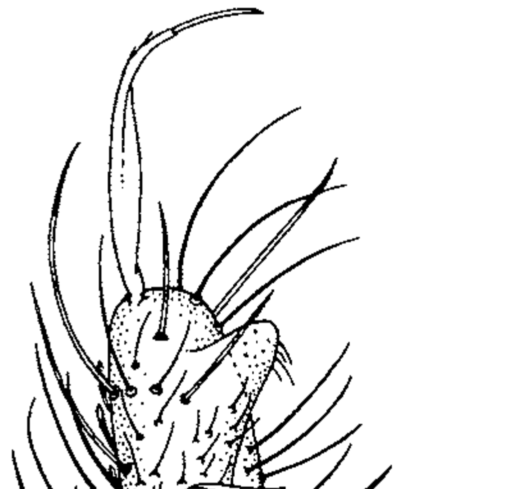

FIGURE 51.—*Aedes increpitus* male genitalia.

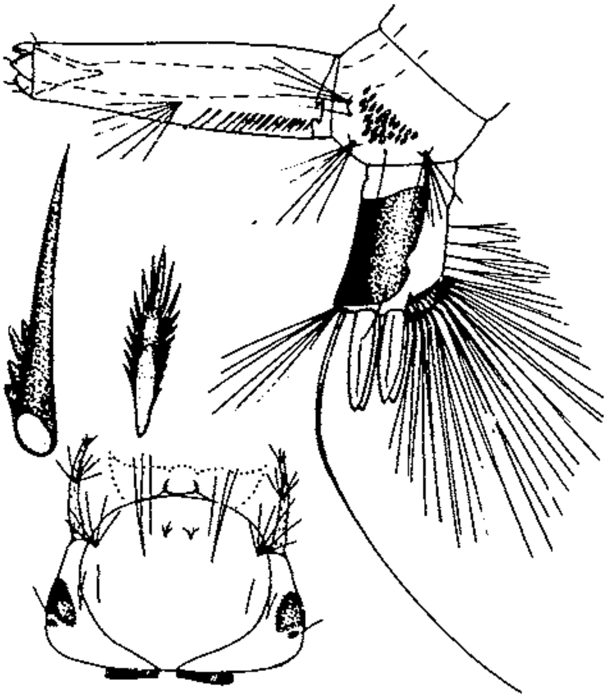

FIGURE 52.—*Aedes increpitus* larva.

Aedes (Ochlerotatus) intrudens Dyar

Aedes intrudens Dyar, Insecutor Inscitiae Menstruus 7: 23. 1919.

Female.—Mesonotum uniformly bronze brown or occasionally with indications of median brown stripes. Postcoxal scale patch absent. Sternopleuron with scales not extending to anterior edge. Lower mesepimeral bristles one to five. Abdomen black with broad basal white bands; venter completely white scaled. Wing scales dark with or without small patch of pale scales at base of costa. Legs with mixture of pale scales; tarsi mostly black.

Male genitalia (fig. 53).—Basistyle about three times as long as wide, dense tuft of setae near apex; apical lobe prominent rounded with numerous rather long setae; basal lobe elongate with large spine at base and two spines on raised apex. Claspette stem with basal half hirsute and forming sharp projection ending in stout seta at middle; apical half slender; filament angularly expanded to sharp point at middle.

Larva (fig. 54).—Upper head hairs usually four, lower two or three. Lateral abdominal hairs usually double on first segment and single on second to sixth. Comb with 10 to 17 scales in irregular double row. Air tube about 2½ by 1; pecten reaching middle with two or three detached teeth, followed by large multiple tuft. Anal segment with plate extending to near ventral line and ventral margin deeply incised; anal gills longer than segment.

Distribution, biology, and importance.—*Aedes intrudens* larvae have been found in small numbers in pools in open as well as forested areas in the Northwestern States (map 6). The adults differ from those of other forest species in that they frequently enter houses (*84*). This species does not occur in sufficient numbers to be of economic importance.

Aedes (Ochlerotatus) melanimon Dyar

Aedes melanimon Dyar, Insecutor Inscitiae Menstruus 12: 126. 1924.

Female.—Palpi tips with pale scales. Mesonotum yellowish white with median brown band and posterior brown half stripes; anterior lateral margins also narrowly brown scaled. Abdomen predominantly dark scaled with median white stripe and transverse segmental narrow white bands. Wing scales dark and light with dark predominating on most veins; sixth or anal vein with more dark than light scales. Legs with dark and pale scales; tarsi dark with apical and basal white bands on all but last two

FIGURE 53.—*Aedes intrudens* male genitalia.

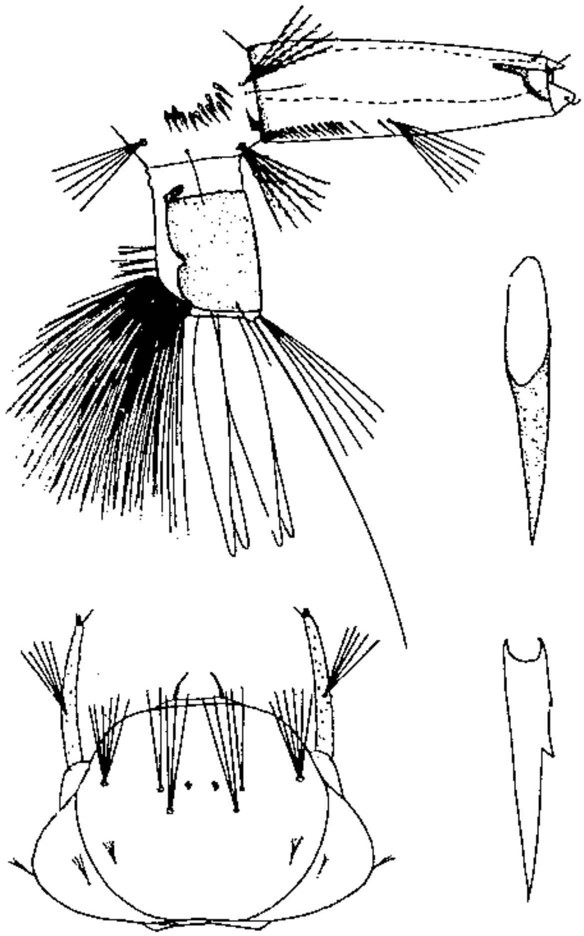

FIGURE 54.—*Aedes intrudens* larva.

segments of middle tarsi and last three segments of front tarsi.

Male genitalia (fig. 55).—Basistyle about three times as long as wide; apical lobe rounded and somewhat shortened apically, surface clothed with few straight setae of medium length; basal lobe rises in slope from sidepiece, surface covered with short setae; stout spine on margin and smaller adjacent spine. Claspette stem curved and evenly narrowed with few setae near apex; filament with long shank and more broadly expanded area near middle.

Larva (fig. 56).—Upper and lower head hairs single or occasionally double. Dorsal hair 1 of mesothorax approximately same length as 2 but shorter than 3 or 4. Abdomen with lateral tufts usually double or triple on segments 1 and 2 and double on rest. Comb of 20 to 31 scales in triangular patch; each scale fringed with spines, apical spines longer. Air tube tapering, about 3 by 1; pecten teeth evenly spaced to near middle of tube with multiple tuft set close to end of pecten. Anal segment with plate extending about two-thirds down sides; lateral hair shorter than anal plate; gills ½ to 1½ length of plate.

This species, which had been considered a synonym of *Aedes dorsalis*, was resurrected in 1955 by Barr (*14*). Characters for the separation of these two species have been described by Bohart (*36*), Chapman and Grodhaus (*70*), and Richards (*231*).

Distribution, biology, and importance.—This species occurs in eastern Washington and Oregon and is also found in smaller numbers in southern Idaho (map 5). The larvae develop in irrigated meadows and flooded grasslands. In many

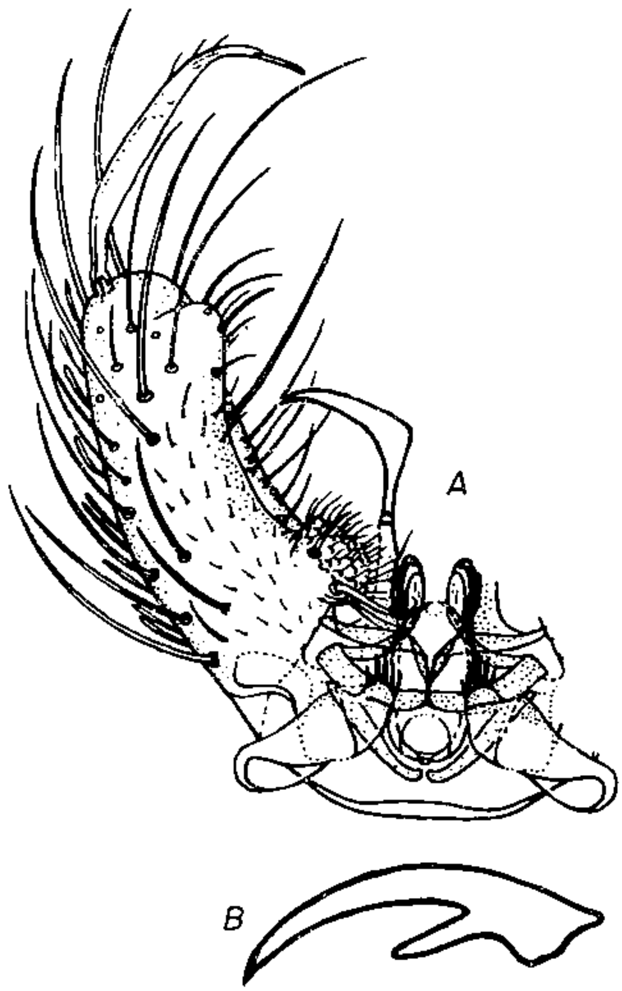

FIGURE 55.—*Aedes melanimon*: *A*, Male genitalia; *B*, claw of female. (Drawn from specimen of *Aedes dorsalis* and modified to represent *Aedes melanimon*.)

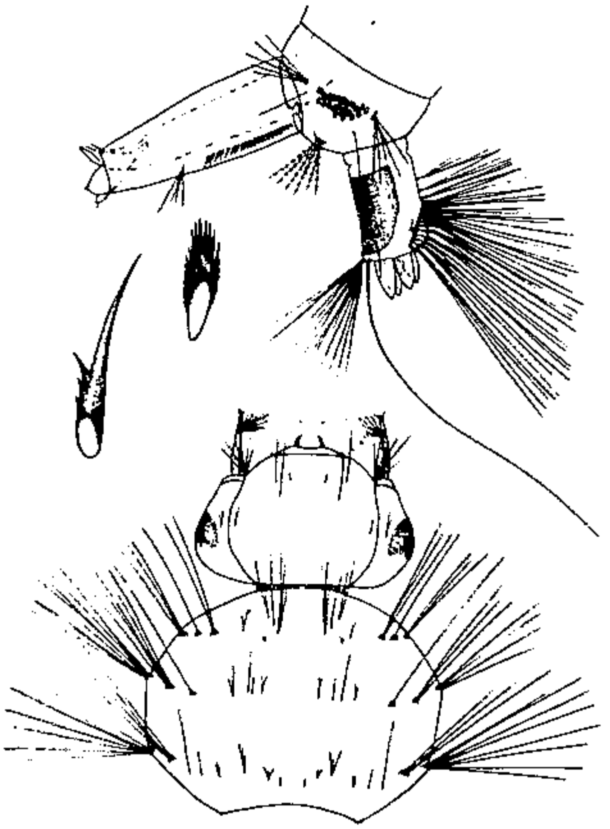

FIGURE 56.—*Aedes melanimon* larva. (Drawn from specimen of *Aedes dorsalis* and modified to represent *Aedes melanimon*.)

of these areas the larvae are associated with those of *A. dorsalis*. The females are an important pest of man and animals. Chapman (*62*) found that in Nevada this species was much more timid and less inclined to bite than *A. dorsalis* in the daytime. Richards (*231*) stated that western equine encephalitis, which was reported from *A. dorsalis* in Weld County, Utah, prior to the resurrection of *Aedes melanimon* in 1955, was undoubtedly isolated from *A. melanimon*.

Aedes (*Ochlerotatus*) *nigromaculis* (Ludlow)

Grabhamia nigromaculis Ludlow, George Wash. Univ. Bul. 5: 85. 1907.

Female.—Proboscis of female ringed with white, or ring may occasionally be indistinct or absent. Mesonotum with varying shades of yellowish scales, broad median bronze-brown stripe, and brown sides. Abdomen black with basal segmental bands and median stripe of yellowish scales; lateral spots usually concolorous with median stripe. Wing scales pale and dark, dark predominating. Femora and tibiae partially pale scaled; tarsi black with basal white bands except on segments 4 and 5 of front and middle tarsi; last segment of hind tarsi occasionally all white, white band on first segment broadly extended by scattered white scales.

Male genitalia (fig. 57).—Basistyle twice as long as wide; apical lobe absent; basal lobe a small elevated area with many rather short setae. Claspette stem with cylindrical stem and short seta near outer end; filament narrow and as long as stem.

Larva (fig. 58).—Upper and lower head hairs usually single but may be double. Comb with about nine thornlike scales. Air tube about 2 by 1; pecten extending well past middle with three stout detached teeth; small tuft near tip. Anal segment ringed by plate; lateral hair single and shorter than plate; gills pointed and from one to two times as long as plate.

Distribution, biology, and importance.—This species is often found associated with *Aedes dorsalis* and certain other species in open irrigated or flooded meadows in prairie or open country. However, it is apparently rather restrictive in its breeding habits. It has been found in south-central Washington and in the semiarid plains of Oregon and Idaho (map 3). It is numerous in the lower

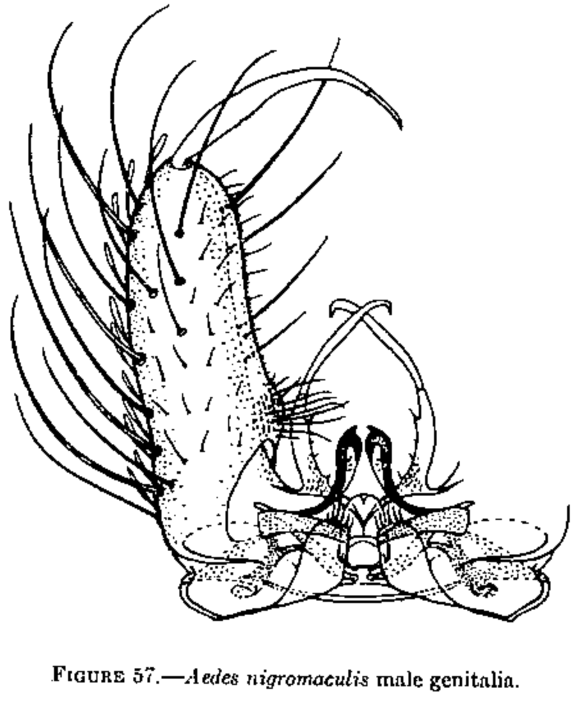

FIGURE 57.—*Aedes nigromaculis* male genitalia.

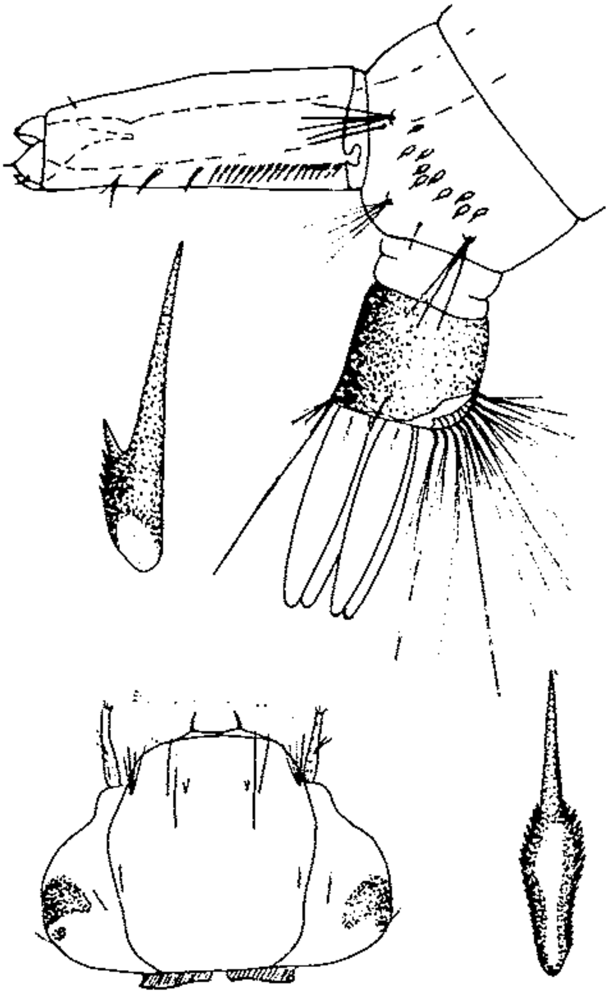

FIGURE 58.—*Aedes nigromaculis* larva.

Payette River district of western Idaho. It has recently been found near Eugene, Oreg., and may well establish itself in the Willamette Valley. It is an important pest in some other irrigated sections where new broods may be produced with each flooding. This species is a strong flier. Experimentally it has transmitted western equine, St. Louis, and Japanese B encephalitis viruses.

Aedes (Ochlerotatus) niphadopsis Dyar and Knab

Aedes niphadopsis Dyar and Knab, Insecutor Inscitiae Menstruus 5: 166. 1918.

Female.—Mesonotum with median brown stripe and usually with posterior half lines; margins, sides, and antescutellar space with white scales. Lower mesepimeral bristles two or three, or rarely none. Abdomen black with basal white bands with or without median line of white scales. Wings with mixture of pale and dark scales, dark predominating. Legs with mixture of pale and dark scales.

Male genitalia (fig. 59).—Basistyle about three times as long as wide; apical lobe small, elongate, narrowly attached, bare or with few small setae; basal lobe small, elevated into transverse ridge with row of three or four stout setae preceded by short spine at margin. Claspette stem lightly hirsute on basal half; filament expanded in gradual curve near basal third.

Larva (fig. 60).—Upper and lower head hairs usually single, occasionally double. Comb with 10 to 12 scales in irregular double row. Air tube nearly 4 by 1; pecten teeth not extending to middle with last two or three teeth detached, followed by large tuft. Anal segment longer than wide; plate extending about halfway down sides; lateral hair shorter than plate; gills budlike and shorter than plate.

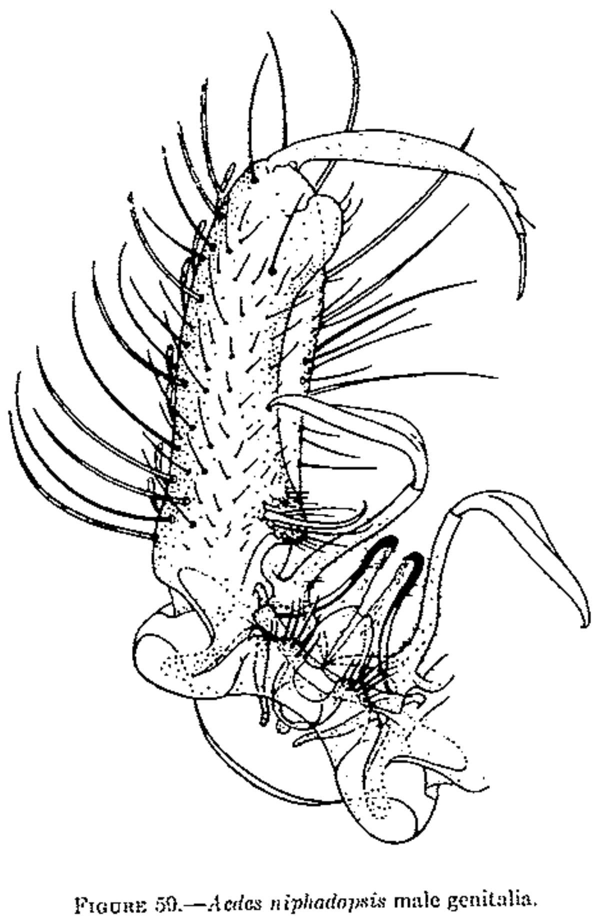

FIGURE 59.—*Aedes niphadopsis* male genitalia.

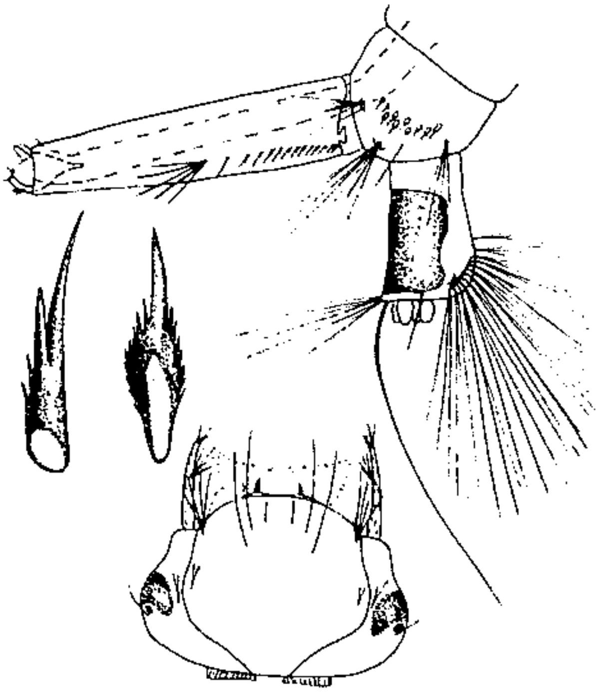

FIGURE 60.—*Aedes niphadopsis* larva.

Distribution, biology, and importance.—This species has been found in Klamath and Deschutes Counties in Oregon and in several counties in southern Idaho (map 6). Adults have been collected in large numbers in some locations in Custer County, Idaho. Larvae were collected at the edge of a drainage ditch in the open country below Klamath Falls in March. It has been found in several locations in the southwestern part of Idaho by Harmston and Rees (*133*). Nielsen and Rees (*205*) stated that it is an annoying pest in western and northern Utah.

Aedes (Ochlerotatus) pionips Dyar

Aedes pionips Dyar, Insecutor Inscitiae Menstruus 7: 19. 1919.

Female.—Mesonotum with dull-yellow or white scales, two broad, well-defined, dark-brown stripes, and posterior half lines; median stripes separated by line of pale scales. Postcoxal scale patch present. Sternopleuron with white scales extending to anterior border. Posterior area of probasisternum with white scales. Lower mesepimeral bristles one to four or rarely none. Hypostigial spot of scales absent. Abdomen with or without narrow basal white bands. Wing scales dark with small patch of pale scales at base of costa in about 85 percent of specimens. Legs dark; femora partially pale scaled.

Male genitalia (fig. 61).—Basistyle about three times as long as wide; apical lobe large and rounded with many long setae; basal lobe partially detached at base, surface with some small setae, several larger curved ones, and stout spine on margin. Claspette stem lightly hirsute on basal half, apical half more slender; filament flat and expanded angularly to its maximum width at base.

Larva (fig. 62).—Upper head hairs usually five, lower four. Prothoracic hair 1 single. Lateral abdominal hairs usually double on segments 1 and 2 and single on 3 to 6. Comb with 60 or more scales; each scale with rounded fringe of spines apically. Air tube about 3 by 1; pecten not reaching middle, followed by large multiple tuft. Anal segment with plate extending about two-thirds down sides; lateral hair shorter than plate; anal gills about twice length of segment.

Distribution, biology, and importance.—This species has been found in Baker County, Oreg., and in Blaine and Bear Lake Counties in Idaho (map 6). The larvae have been taken in open flooded meadows in semiwooded areas. In Alaska the larvae were found in bogs, roadside ditches, vehicle tracks, and small bodies of water in recently disturbed

FIGURE 61.—*Aedes pionips* male genitalia.

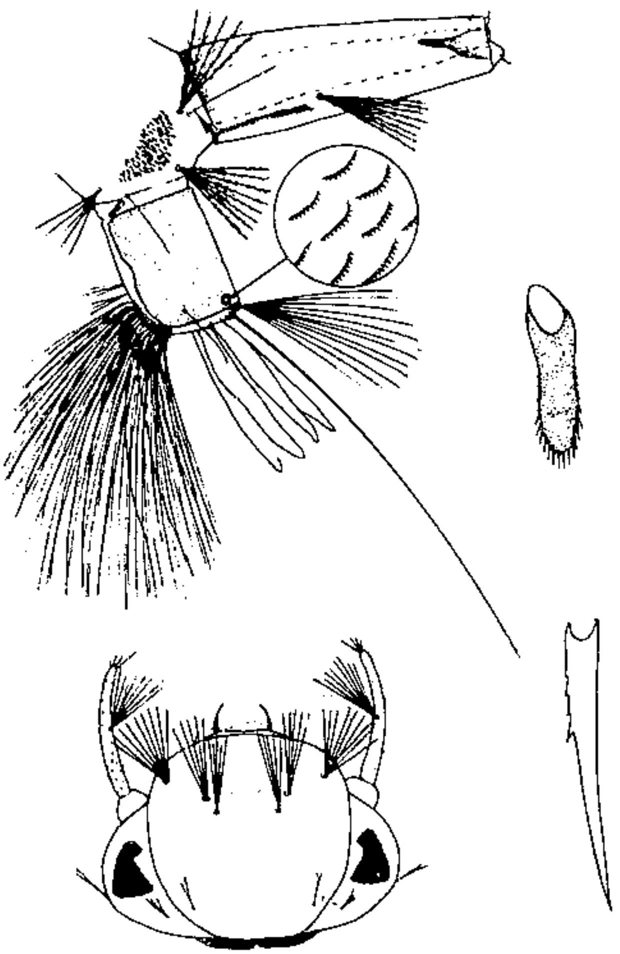

FIGURE 62.—*Aedes pionips* larva.

soil (*114*). Little is known of its habits, and because of its rarity it is considered of little economic importance.

Aedes (Ochlerotatus) pullatus (Coquillett)

Culex pullatus Coquillett, Wash. Ent. Soc. Proc. 6: 168. 1904.

Female.—Mesonotum with yellowish-brown scales; narrow bare median line with parallel stripes of brown scales, each stripe bordered by broader stripe with few dark scales; with or without narrow bare curved posterior half lines. Postcoxal scale patch absent. Sternopleuron with scales not extending to anterior border. Lower mesepimeral bristles one to five. Hypostigial spot of many white scales. Abdomen black with basal white bands. Wings dark scaled with patch of pale scales at base of costa in about 95 percent of specimens. Legs dark; femora and tibiae partially pale scaled.

Male genitalia (fig. 63).—Basistyle about 3½ times as long as wide; apical lobe prominent and somewhat elongated, ventral surface covered with numerous long setae; basal lobe represented by large spine at margin and some small setae. Claspette stem with basal half large, pilose, and forming rounded projection at middle, apical half slender; filament angularly expanded to rounded point near middle.

Larva (fig. 64).—Upper head hairs five to seven, lower usually four; hairs short and tufts set close together. Prothoracic hair 5 usually triple. Lateral abdominal hairs double or triple on first to fifth segment and single on sixth. Comb 29 to 55 scales in triangular patch, each scale fringed with spines, apical spines longer. Air tube 3 by 1; pecten teeth closely set, not reaching middle, closely followed by large six- to seven-haired tuft. Anal segment with plate extending about two-thirds down sides; lateral hair shorter than plate; gills 1½ to two times length of plate.

Distribution, biology, and importance.—Although this species is not too common, it has been taken in a number of places in the high forested

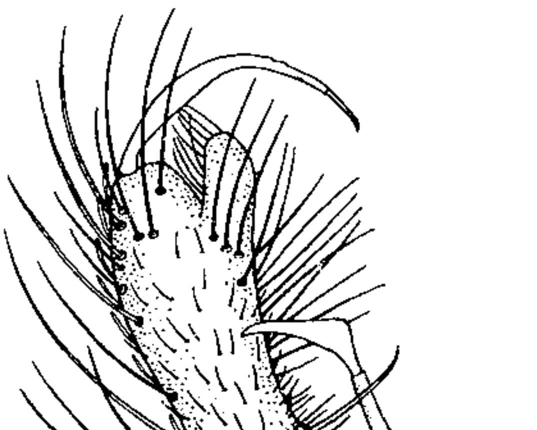

FIGURE 63.—*Aedes pullatus* male genitalia.

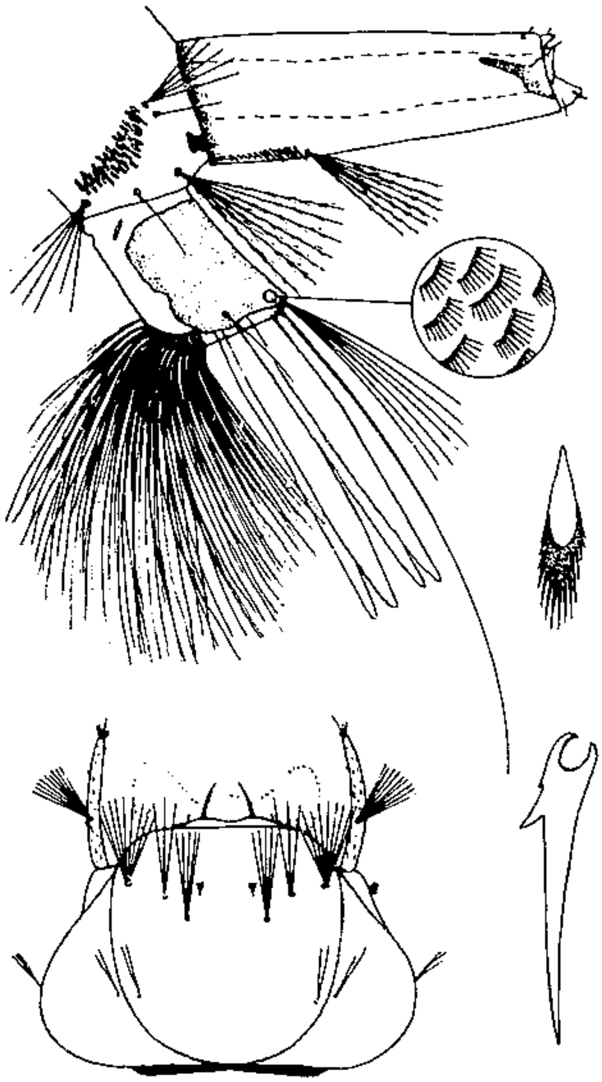

FIGURE 64.—*Aedes pullatus* larva.

mountainous areas (map 4). The larvae are usually found in melting snow pools associated with a number of other species. The adults emerge rather late and are severely annoying for only a short time. They have been observed to bite in shaded areas during daylight.

Aedes (Ochlerotatus) punctor (Kirby)

Culex punctor Kirby, Fauna Boreali-Amer., pt. 4, p. 309. 1837.

Aedes cyclocerculus Dyar, Insecutor Inscitiae Menstruus 8: 23. 1920. "(in part)."

Aedes leuconotips Dyar, ibid. 8: 24. 1920. "(in part)."

Female.—Mesonotum pale yellow to yellowish brown with paired dark-brown stripes and usually with posterior submedian half stripes. Postcoxal scales present. Sternopleuron with scales extending to anterior border. Probasisternum usually without or with few white scales on posterior area. Hypostigial spot of scales absent. Abdomen black with basal segmental white bands. Wings completely dark scaled or with few pale scales at base of costa. Legs dark; femora and tibiae with or without scattered pale scales.

A "tundra" variety of *punctor* was found in the tundra areas of Alaska by Knight (*173*). This form in which the mesonotum is brown and unlined is not known to occur in the Northwest.

Male genitalia (fig. 65).—The characters of the male genitalia of this species are the same as those of *Aedes hexodontus*.

Larva (fig. 66).—Upper and lower head hairs single or double. Lateral abdominal hairs usually single or double on segments 1 to 6. Comb with 10 to 19 stout scales in irregular row; each scale with long median spine and very short lateral spinules. Air tube 2½ by 1; pecten fine and not reaching middle of tube; tuft centrally placed. Anal segment ringed by plate or narrowly open ventrally; lateral

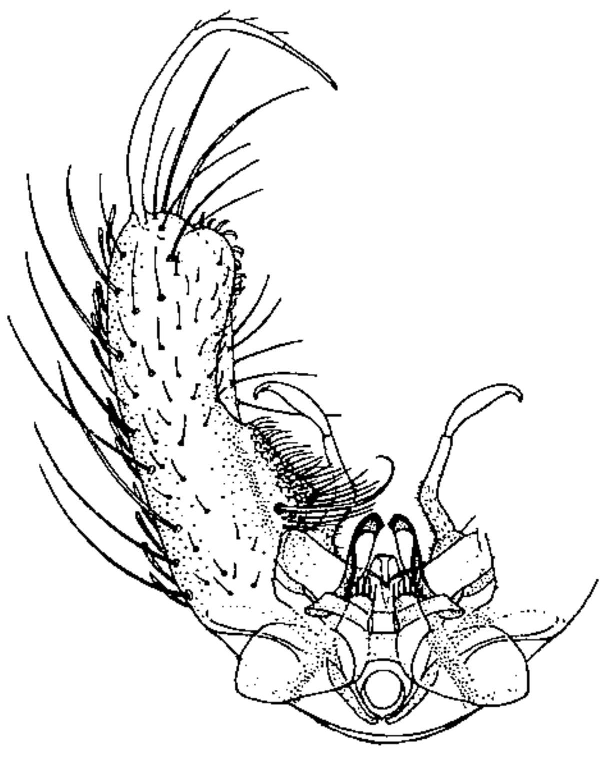

FIGURE 65.—*Aedes punctor* male genitalia.

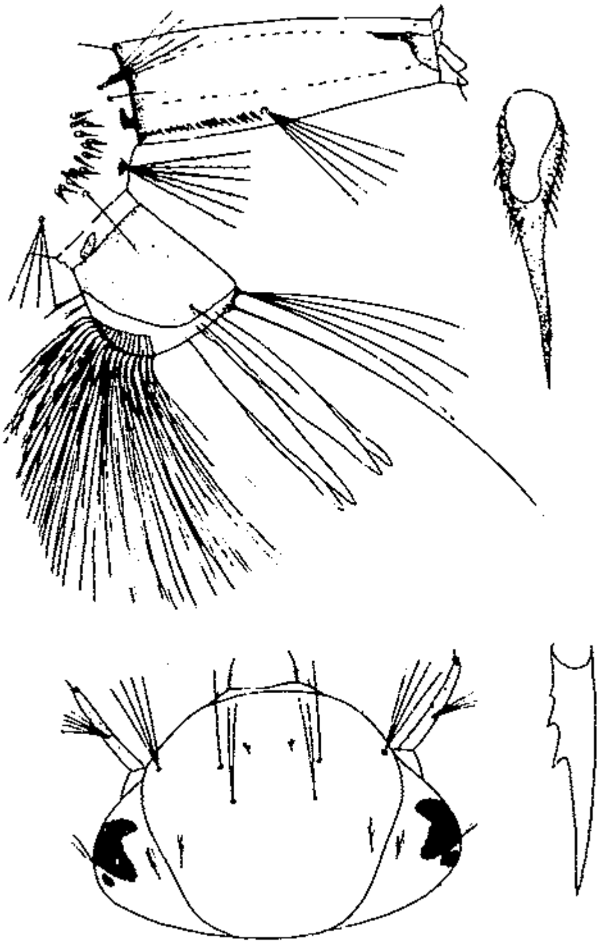

FIGURE 66.—*Aedes punctor* larva.

hair longer than plate; gills 1½ to three times as long as plate.

Distribution, biology, and importance.—This species has been collected in several places in northern Washington and northern Idaho (map 7). Myklebust (*199*) collected biting adults in Chelan County, Wash., June 1961, and we collected small numbers of third- and fourth-instar larvae in April 1963 in semiwooded swampy areas in Pend Oreille County, Wash. Ogden[5] collected adults near Lake Wenatchee, Wash. Matheson (*190*) stated that the larvae may also occur in grassy bogs and in forest pools containing decaying leaves. This species, which can be an important pest (*222*), is probably of little importance in the Northwest because of its limited numbers.

Aedes (Ochlerotatus) schizopinax Dyar

Aedes schizopinax Dyar, U.S. Natl. Mus. Proc. 75 (23): 1. 1929.

Female.—Proboscis with yellowish-gray scales on ventral surface. Mesonotum with bronze-brown stripes separated by golden-brown stripe with bare median line. Postcoxal scale patch present. Sternopleuron with scale patch extending to anterior edge. Lower mesepimeral bristles present. Abdomen dark with basal white bands. Wings dark scaled with patch of two or three to many scales at base of costa. Legs dark; undersurface of femora pale scaled.

Male genitalia (fig. 67).—Basistyle length about three times its midwidth; apical lobe long and rounded with short curved setae; basal lobe flatly conical with numerous setae, curved spine followed

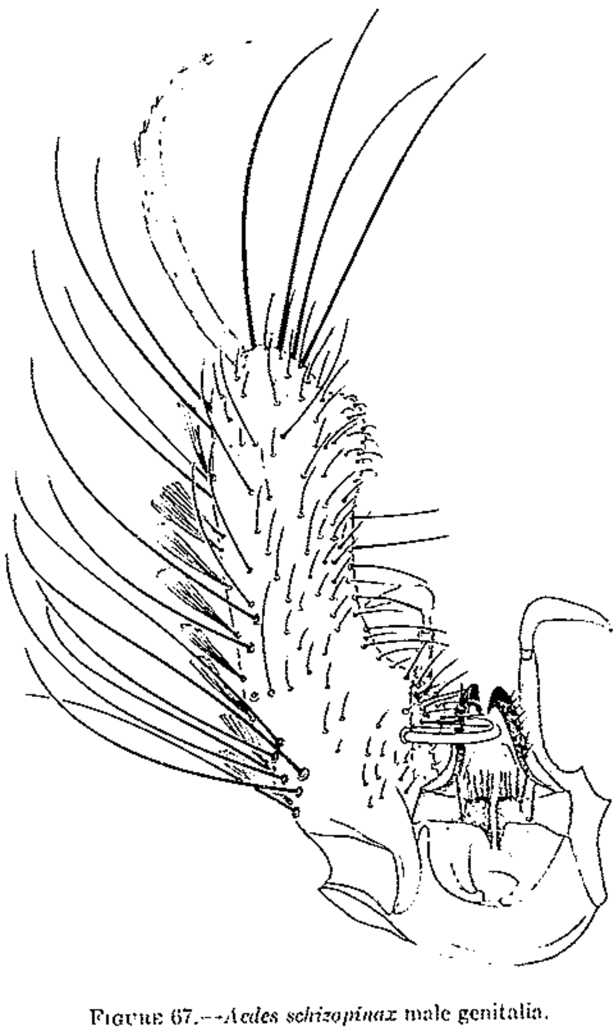

FIGURE 67.—*Aedes schizopinax* male genitalia.

[5] Ogden, W. B. Personal communication. 1963.

by row of long slender setae. Claspette stem slightly curved, expanded near middle, and pilose to near apex; filament nearly as long as stem, expanded near middle, and terminating in blunt curved point.

Larva (fig. 68).—Upper head hairs three to five, lower two or three. Prothoracic hair number 1 long and three- to five-branched. Lateral abdominal hairs double. Comb with about 40 scales; each scale with long median spine and short lateral spinules. Air tube about 3 by 1; pecten teeth not reaching middle; tuft of three to five hairs. Anal segment with plate spiculate on apical area and extending to near ventral line; lateral hair equal to or longer than plate; gills about as long as plate.

Distribution, biology, and importance.—This is a rare species of little economic importance in this region. It has been found in only two counties in southern Idaho and in only two counties in eastern Oregon (map 7). Larvae have been collected in water in cattle tracks and in pools in mountain valleys below 7,000 feet (*203*). The females did not attack man in areas where the larvae developed, but they could be collected in light traps. Carpenter (*54*) collected larvae in similar types of breeding areas in California mountains at elevations of 5,100 to 7,800 feet. Adults of this species were seen resting on the vegetation in one area, but he was not able to attract or capture them in the daytime.

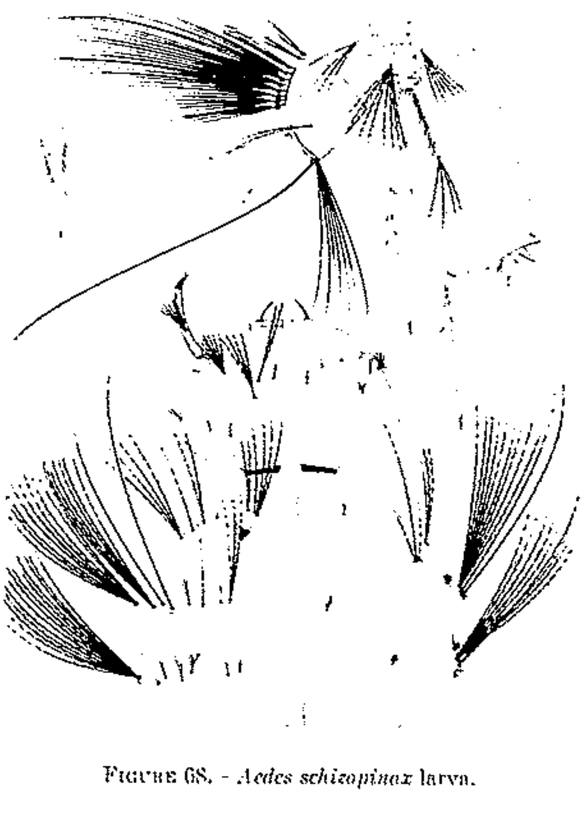

FIGURE 68. - *Aedes schizopinax* larva.

Aedes (*Finlaya*) *sierrensis* (Ludlow)

Taeniorhynchus sierrensis Ludlow, Canad. Ent. 37: 321. 1905.

Culex varipalpus "Coquillett" Ludlow, ibid. 38: 132. 1906.

Aedes sierrensis "(Ludlow)" Belkin and McDonald, Calif. Vector Views 3 (10): 54. 1956.

Female.—Palpi black scaled with tip broadly white scaled and few white scales at apex of second segment. Mesonotum brown with median anterior patch and narrow posterior curved lines of yellow scales; margins with mixture of pale scales and scutellum with broad white scales. Abdomen black with median triangular patches of white scales that may extend narrowly to lateral white patches to form band. Wing scales dark with patch of white scales at base of costa. Legs dark with white bands involving both ends of all but last two segments of front and middle tarsi, which are black, and last segment of hind tarsi, which is white.

Male genitalia (fig. 69).—Basistyle three times as long as wide; apical lobe absent; basal lobe narrow with long spines basally and short setae extending to apical fourth of basistyle. Claspette with cylindrical stem; filament narrow, ligulate, and as long as stem.

Larva (fig. 70).—Antennae slender without spines and with single hair beyond middle. Upper head hairs usually single or sometimes double, lower head hairs usually double or sometimes single or triple. Lateral abdominal hairs usually double or triple on first three segments, double on fourth and fifth, and single on sixth. Comb with about 12 to 23 scales; each scale fringed with short spinules. Air tube about 3 by 1; pecten teeth evenly spaced on basal fourth or third of tube; tuft slightly beyond pecten; acus attached. Anal segment with plate extending down about halfway; lateral hair longer than segment; anal gills enlarged, bluntly rounded at apex, about equal in length, and about four times as long as segment.

Distribution, biology, and importance.—The species occurs in all the Northwestern States (map 5) but is usually not too abundant, especially in Idaho (*52*). The largest numbers are found in the foothills of the Coast Ranges and the Olympic Mountains in Washington. It is a rather small mosquito and breeds in tree holes and in many kinds of artificial containers. Reeves (*225*) reported finding it also in rock pools and wooden receptacles under trees. In Oregon numerous larval collections have been made in old automobile tires and tree stumps. The larvae may be found in midwinter if temperatures below freezing do not prevail for long periods.

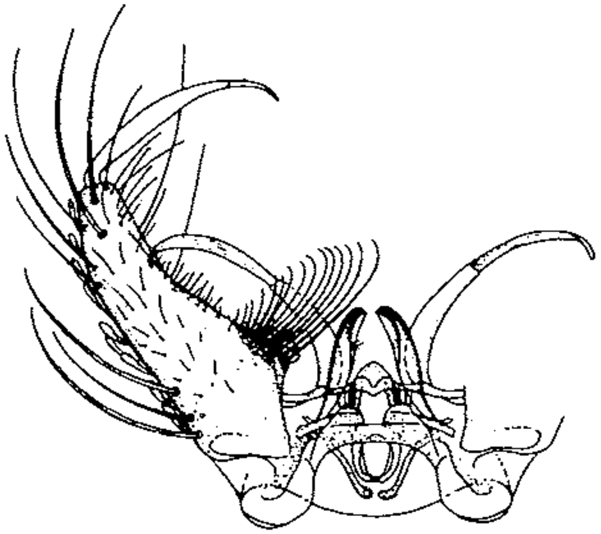

FIGURE 69.—*Aedes sierrensis* male genitalia.

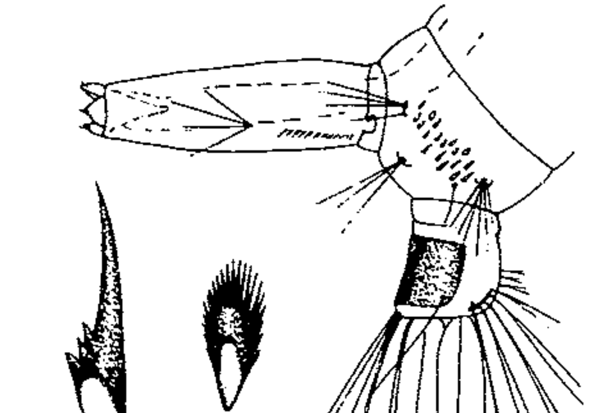

FIGURE 70.—*Aedes sierrensis* larva.

Peyton (*211*) stated that the life cycle may be completed in as little as 15 days under optimum conditions. In unpublished observations on development at approximately 75° F. we found that about 12 days were required for eggs (conditioning), 10–14 days for larvae, and 4–6 days for pupae. This compares favorably with the data reported by Judson et al. (*157*). These authors found that the dissolved oxygen required for egg hatching was very low (0.025 p.p.m. or less).

It is a persistent biter but apparently has a restricted flight range. It has been found to be an experimental vector of western equine encephalitis.

This species was resurrected in 1956 by Belkin and McDonald (*26*). These same authors (*27*) described a new but closely related species from Arizona, *Aedes monticola* Belkin & McDonald, and gave separating characters and a general discussion of the "*varipalpus*" complex.

Aedes (*Ochlerotatus*) *spencerii idahoensis* (Theobald)

Grabhamia spencerii var. *idahoensis* Theobald, Monog. Culicidae 3: 250. 1903.

Female.—Mesonotum with broad reddish-brown stripe usually separated by fine line of grayish scales, faint posterior half lines present or absent, sides and antescutellar space with grayish-white scales. Lower mesepimeral bristles absent. Abdomen black with broad basal white bands. Wings with costa, first, third, and fifth veins dark scaled, other veins with pale scales. Legs mostly pale scaled; femora, tibiae, and some of apical tarsi partially dark scaled outwardly.

Male genitalia.—The characters of the male genitalia of this species are considered the same as those of *Aedes sticticus*.

Larva (fig. 71).—Upper and lower head hairs single, or occasionally with one or two hairs double. Lateral abdominal hairs usually triple on segments 1 to 3 and single on 4 to 6. Comb with 13 to 29 scales in irregular patch; each scale with broad terminal spine of medium length and short lateral spinules. Air tube stout, about 2½ by 1; pecten of closely set teeth to middle or slightly beyond, last two teeth detached, followed by small tuft. Anal segment with plate nearly reaching to ventral line;

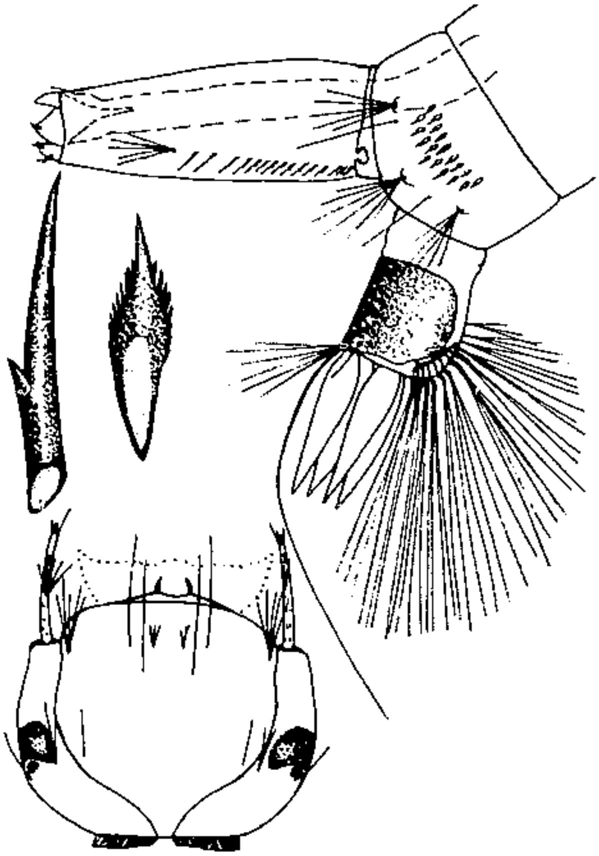

Figure 71.—*Aedes spencerii idahoensis* larva.

lateral hair shorter than plate; gills pointed and about twice length of plate.

Distribution, biology, and importance.—This species is more common in Idaho than Washington or Oregon (map 5). It commonly occurs in the treeless plains or in low mountain areas. It has been found in largest numbers in southern Idaho, where it is an important daytime pest in localized areas. The larvae have been collected in open meadows, flooded areas partially grown up with willows, timbered river bottoms, and roadside ditches.

Aedes (*Ochlerotatus*) *sticticus* (Meigen)

Culex sticticus Meigen, System. Beschreibung der Bekannten Europäischen Zweiflügeligen Insekten 7: 1. 1838.
Culex hirsuteron Theobald, Monog. Culicidae 2: 98. 1901.
Aedes aldrichi Dyar and Knab, U.S. Natl. Mus. Proc. 25: 57. 1908.
Aedes gonimus Dyar and Knab, Insecutor Inscitiae Menstruus 5: 165. 1918.
Aedes lateralis (Meigen) Edwards, *in* Wytsman, Genera Insectorum 194: 144. 1932.

Female.—Mesonotum yellowish white with two golden-brown stripes and posterior half lines; anterior stripes separated by narrow median line of pale scales, which is sometimes indistinct or absent. Postcoxal scale patch absent. Lower mesepimeral bristles absent. Abdomen black with basal white bands. Wing scales dark with or without patch of pale scales on base of costa. Legs dark; femora and tibiae partially pale scaled.

Male genitalia (fig. 72).—Basistyle nearly three times as long as wide; apical lobe large and rounded with short curved setae; basal lobe expanded, semidetached apically, outer surface with short setae, large spine at base, and adjoining tuft of long setae. Claspette stem cylindrical and slightly tapered at apex with one or two setae above midpoint of inner side; filament short, broad, expanded at middle, and terminating in blunt, curved point.

Larva (fig. 73).—Upper head hairs two or three, lower one or two. Lateral abdominal hairs variable, usually multiple on first segment and double on second to sixth. Comb with about 18 to 28 scales in triangular patch; each scale with long median spine and short lateral spinules. Air tube stout, 2½ by 1; closely set even pecten teeth to near middle of tube;

Figure 72.—*Aedes sticticus* male genitalia.

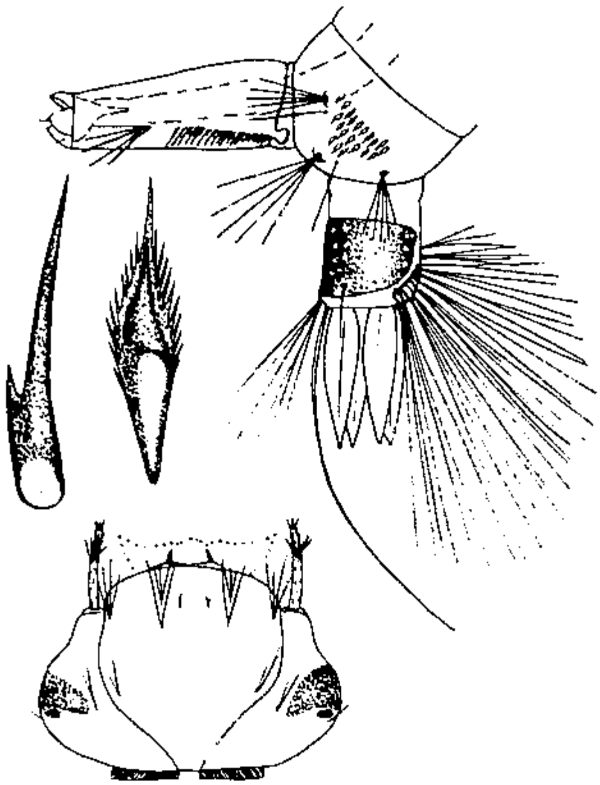

FIGURE 73.—*Aedes sticticus* larva.

Aedes (Ochlerotatus) stimulans (Walker)

Culex stimulans Walker, List of Dipterous Insects in Brit. Mus., pt. 1, p. 4. 1848.

Female.—Tori with or without white scales on dorsal half. Mesonotum yellowish white to light brown with broad median brown stripe or variable pattern of brown and light scales. Lower mesepimeral bristles three or four, rarely one or two. Abdomen black with basal segmental white bands. Wings completely dark scaled or with admixture of white ones on costa. Legs dark; tarsi with basal white bands on all except last two segments of front and last segment of middle tarsi, white bands broader on hind tarsi; tarsal claw with short tooth not parallel to claw.

Male genitalia (fig. 74).—Basistyle about three times as long as wide; apical lobe with few short setae; basal lobe low, flatly rounded, with many short setae and stout marginal spine. Claspette stem hirsute except at apex; filament thin and angularly expanded near middle.

Larva (fig. 75).—Upper head hairs one to three, lower one to two. Lateral abdominal hairs triple on segment 1, double on 2 to 5, and single on 6. Comb with about 25 to 35 scales; each scale with median spine about 1½ times as long as lateral ones. Air multiple tuft set close to end of pecten. Anal segment with plate extending nearly to ventral line; spicules minute or absent; lateral hair shorter than plate; anal gills pointed and about twice length of plate.

Distribution, biology, and importance.—This is one of the most important mosquito pests in the Northwestern States. It breeds in large numbers in the brushy bottom lands along the Columbia River and in similar places. It also occurs along some other rivers in northwestern Washington and various locations in Idaho (map 3). The larvae, which are usually associated with *Aedes vexans*, are found in large numbers for about 100 miles below the Bonneville Dam when the annual spring flood of the Columbia inundates the bottom lands. The adults disperse for 15 to 20 miles or more and remain a serious pest to man and livestock throughout the summer. The eggs may remain viable for at least 3 or 4 years if not reached by normal floods (*105*). This species has been capable of transmitting western equine and St. Louis encephalitis viruses.

FIGURE 74.—*Aedes stimulans* male genitalia.

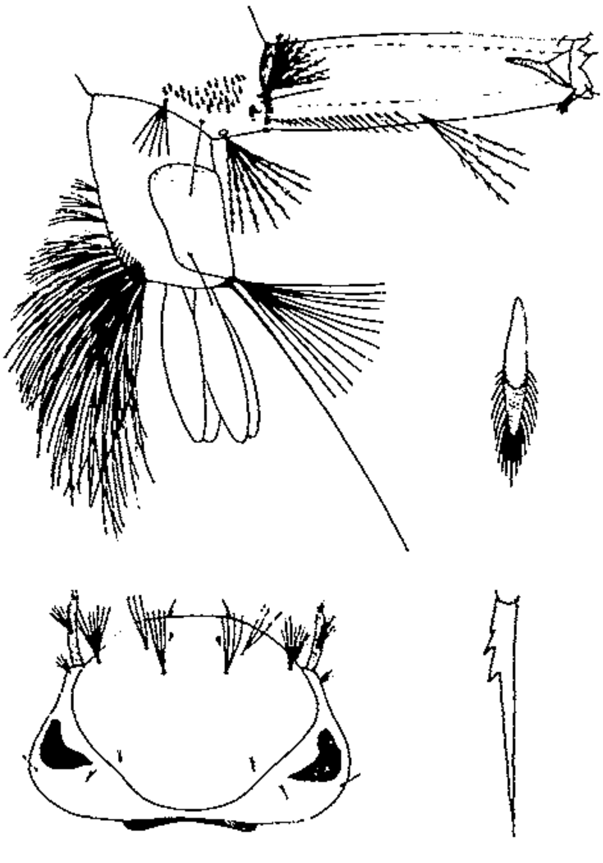

FIGURE 75.—*Aedes stimulans* larva.

tube 3 to 3½ by 1; pecten teeth extending nearly to middle, followed by small tuft; apical setae shorter than lateral valve. Anal segment with plate spiculated apically and extending about two-thirds down sides; lateral hair shorter than plate; gills about as long as plate.

Distribution, biology, and importance.—The larvae of this species breed in snow pools and other overflow pools in woodland areas. They are said to be persistent biters in areas where they are numerous. Harmston and Rees (*133*) collected this species in three counties in southern Idaho (map 7).

Aedes (Ochlerotatus) trichurus (Dyar)

Culex trichurus Dyar, N.Y. Ent. Soc. Jour. 12: 170, 244 1904

Female.—Mesonotum with median brown or mixed brown and gray scaled stripe expanded in width behind middle, sides and margins with grayish-white scales. Postcoxal scale patch present. Sternopleuron with scales extending to anterior edge. Probasisternum with white scales on posterior area. Lower mesepimeral bristles three to six. Hypostigial spot of few to many white scales. Abdomen black with basal segmental white bands. Wing scales dark, usually with patch of two or three to many pale scales at base of costa. Legs black; femora pale scaled beneath.

Male genitalia (fig. 76).—Basistyle three times as long as wide; apical lobe prominent and angularly rounded with few setae; basal lobe small, covered with setae, and bearing two long slender posteriorly directed spines. Claspette stem with long cylindrical curved stem slightly expanded before apex; filament short and conical with series of transverse ridges.

Larva (fig. 77).—Upper head hairs usually double, lower single. Lateral abdominal hairs triple on segment 1, double on 2 and 3, and single on 4 to 6. Comb with about 12 to 16 thorn-shaped scales in double row. Air tube about 3 by 1; pecten reaching basal fourth of tube with four to five widely separated detached teeth; multiple hair tuft within pecten and additional small tufts on dorsal and

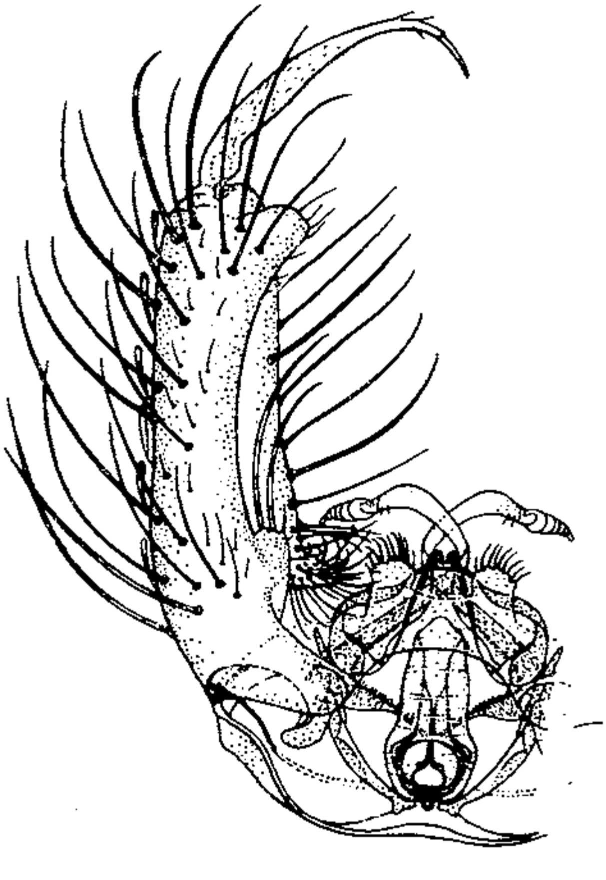

FIGURE 76.—*Aedes trichurus* male genitalia.

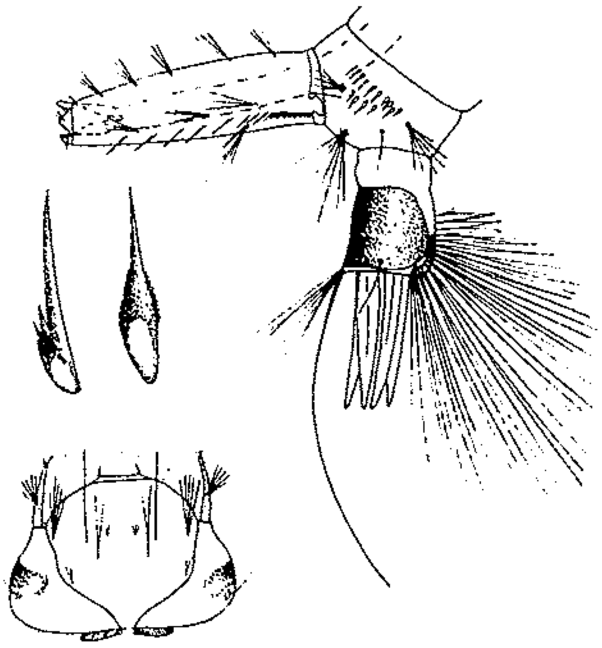

FIGURE 77.—*Aedes trichurus* larva.

lateral surfaces of siphon. Anal segment with plate nearly reaching ventral line; gills slightly longer than segment.

Distribution, biology, and importance.—This rather uncommon mosquito occurs in semiwooded areas in Idaho and northeastern Washington (map 6). The larvae have been found in pools in the margin of woods, in large open-flooded areas with sparse small brush, and in cattail ponds. The females have been reported to feed readily on man but are less aggressive than *Aedes communis*. This species occasionally may be fairly numerous in small localized areas.

Aedes (*Ochlerotatus*) *trivittatus* (Coquillett)

Culex trivittatus Coquillett, N.Y. Ent. Soc. Jour. 10: 193. 1902.

Female.—Mesonotum with pair of yellowish-white stripes separated by median stripe of brown scales, anterior margins yellowish white, lateral margins brown. Lower mesepimeral bristles absent. Postcoxal scale patch absent. Abdomen black scaled with basal white triangular patches and with or without central white spots. Wings dark scaled. Legs dark scaled; first tarsal segments pale.

Male genitalia (fig. 78).—Basistyle about three times as long as wide; apical lobe rounded with few short setae; basal lobe prominent, bluntly conical with many short setae apically, large spine, and group of long fine setae near base. Claspette stem cylindrical and hirsute; filament expanded into sharp retrorse projection at basal third and terminating in curved point apically, retrorse expansion occasionally with small spines.

Larva (fig. 79).—Upper and lower head hairs single. Lateral abdominal hairs usually double on segments 1 and 2 and single on 3 to 5. Comb with about 17 to 26 scales; each scale with median spine slightly longer and somewhat broader than subapical spines. Air tube about 2 by [illegible] pecten extending beyond middle, followed by multiple hair tuft. Anal segment ringed by plate; lateral hair slightly shorter than plate; gills 2½ to three times as long as plate.

Distribution, biology, and importance.—The larvae of this species breed in floodwater pools in meadows and woodlands. Observations on the biology have been made by Abdel-Malek (*2*). It is an important pest in some areas in the East, but

FIGURE 78.—*Aedes trivittatus* male genitalia.

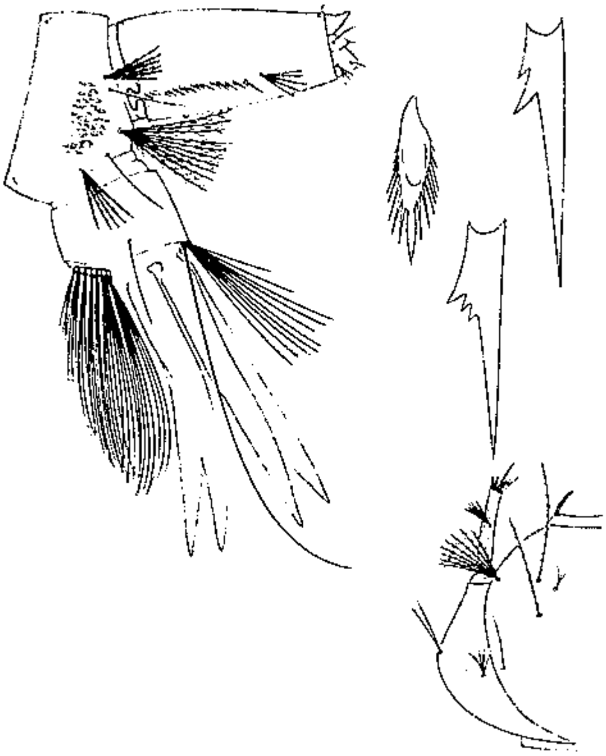

FIGURE 79.—*Aedes trivittatus* larva.

in the Northwest it has been found only in small numbers by Harmston and Rees (*133*) in Canyon and Owyhee Counties of Idaho (map 7).

Aedes (*Ochlerotatus*) *ventrovittis* Dyar

Aedes ventrovittis Dyar, Insecutor Inscitiae Menstruus 4: 48. 1916.

Female.—Mesonotum brown, darker centrally, fringe of yellowish scales around margin. Postcoxal scale patch absent. Lower mesepimeral bristles absent. Abdomen black with basal white bands, which may be narrow or absent medianly. Wing scales dark with or without mixture of white scales extending outwardly from base of veins. Legs dark with mixture of pale scales; tarsi mostly dark.

Male genitalia (fig. 80).—The characters of the male genitalia of this species are considered the same as those of *Aedes sticticus*.

Larva (fig. 81).—Upper and lower head hairs single or rarely with one of hairs double. Lateral abdominal hairs usually multiple on segments 1 to 3, double or single on 4 and 5, and single on 6. Comb with six to 12 thornlike scales; each scale with long median spine and minute lateral spinules. Air tube tapering, about 2½ by 1; pecten reaching nearly to middle of tube with one to four detached teeth; tuft of five to six hairs near middle of tube. Anal segment with plate nearly reaching ventral line; lateral hair shorter than plate; gills about 2½ times length of plate.

Distribution, biology, and importance.—This species has been taken only in a few places at higher elevations (map 6). The larvae have been collected in pools in open meadows and in roadside borrow pits grown up with willows. Adults are seldom present in sufficient numbers to be annoying. Carpenter (*55*) found the larvae in largest numbers in very small depressions on the sloping ground of mountain meadows in California, where melting snows kept these depressions filled and occasionally carried the larvae along into larger pools.

FIGURE 80.—*Aedes ventrovittis* male genitalia.

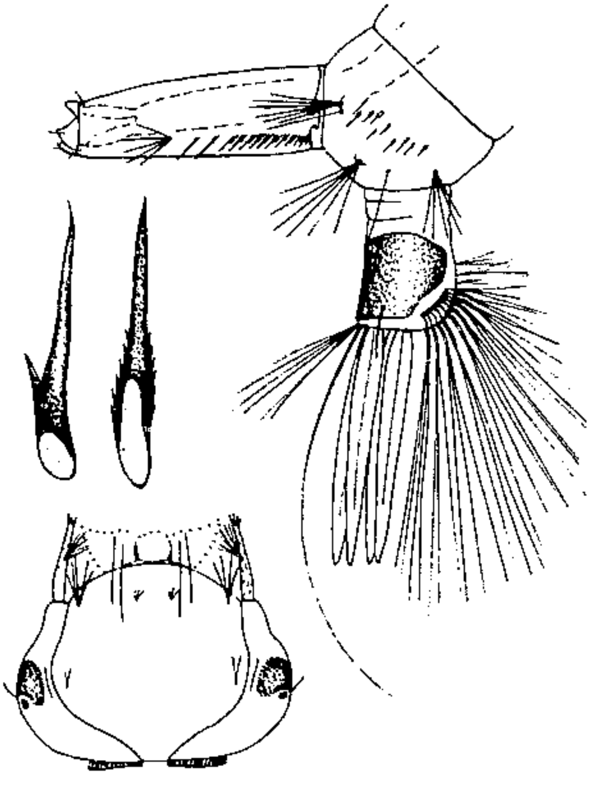

FIGURE 81.—*Aedes ventrovittis* larva.

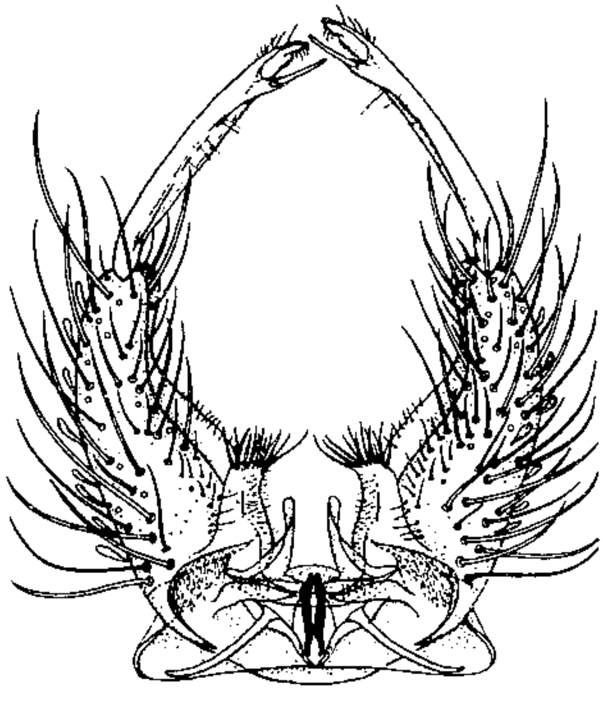

FIGURE 82.—*Aedes vexans* male genitalia.

Aedes (*Aedimorphus*) *vexans* (Meigen)

Culex vexans Meigen, System. Beschreibung der Bekannten Europäischen Zweiflügeligen Insekten 6: 241. 1830.

Female.—Mesonotum clothed with bronze-brown scales, paler at base of wings and around antescutellar space. Lower mesepimeral bristles absent. Abdomen black with centrally indented basal white bands. Wing scales brown. Legs with narrow basal white bands on all segments of hind tarsi, first four segments of middle tarsi, and first three segments of front tarsi.

Male genitalia (fig. 82).—Basistyle twice as long as wide; dististyle long, broad, and divided near apex; short arm with stout claw. Claspette stem short and capitate with dense crown of spines; filament absent.

Larva (fig. 83).—Upper head hair two to four, lower two or three. Lateral abdominal hairs two to three on first to third segment, two on fourth and fifth, and single on sixth. Comb with nine to 14 scales in irregular double row; each scale with long central spine and short lateral spinules. Air tube 3 by 1; pecten reaching past middle with one to three

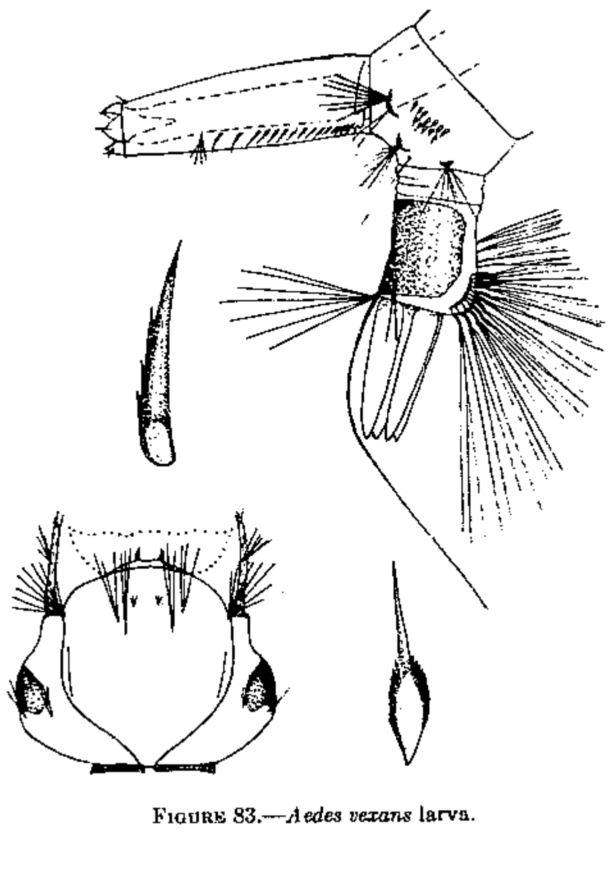

FIGURE 83.—*Aedes vexans* larva.

detached teeth and small multiple-haired tuft near end of pecten. Anal segment with plate extending almost to midventral line; lateral hair shorter than plate; gills about 1½ to two times length of plate.

Distribution, biology, and importance.—This species is found over the greater part of the Northwestern States (map 3). It is one of the most important pest species in both irrigated and floodwater areas. It is present in overflow areas along many rivers, but it is most abundant on the bottom lands along the Columbia River and its tributaries for about 100 miles below the Bonneville Dam. In this area the larvae are associated with those of *Aedes sticticus* in the partially open, brushy, or wooded areas. The adults sometimes disperse for 15 to 20 miles or more from their breeding places and are a serious pest to man and livestock for 3 to 4 months during the summer. Along the Columbia River several hatchings may occur depending on the number of floods, since all eggs may not hatch with the first flooding. More than one generation may also occur in the irrigated sections. This species has been found naturally infected with western equine encephalitis and has been experimentally infected with St. Louis encephalitis virus.

Genus CULEX Linnaeus

Keys to Species

ADULTS

1. Tarsi and proboscis ringed with white ----
   Tarsi and proboscis not ringed with white ---- 2
2. Femora and tibia with line of white scales on outer surfaces; inner surfaces of tori white scaled; ventral segments of abdomen with median dark-scaled V ---- 3
   Femora and tibia without white line of scales on outer surfaces; inner surfaces of tori without white scales; ventral segments of abdomen with median dark-scaled oval spot ---- *tarsalis*, p. 77
3. Abdominal segments with apical white lateral patches and white bands ---- *peus*, p. 73
   Abdominal segments with pale basal lateral patches and partial or complete white or yellowish bands ---- 4
4. Hind femur with pale posterior stripe ending shortly before apex; palpi about three times as long as flagellar segment 4 ---- 6
   Hind femur with pale posterior stripe complete; palpi about twice as long as flagellar segment 4 ---- *apicalis*, p. 70
5. Occiput with dorsal pale scales ashy white; abdominal segment 5 of unengorged dried specimens about 1.3 times as broad as long ---- 5
   Occiput with dorsal pale scales yellowish; abdominal segment 5 of unengorged dried specimens about 1.5 to 1.7 times as broad as long ---- *territans*, p. 78
6. Mesonotum reddish brown with narrow hairlike golden-brown scales; coxae reddish brown ---- *boharti*, p. 71
   Mesonotum brown or dark brown with narrow curved scales; coxae brown or dark brown ---- *erythrothorax*, p. 72
7. Abdominal segments with narrow to normal basal bands ---- 7
   Abdominal segments with few dingy-yellow basal scales or with narrow basal bands; seventh segment partially or completely covered with yellowish scales ---- 8
8. Mesonotum usually with pair of small white spots near middle; abdominal bands broadly joined to lateral patches ---- *salinarius*, p. 76
   Mesonotum without white spots; abdominal bands narrowed laterally or entirely disconnected from lateral patches ---- *restuans*, p. 75
   ---- *p. pipiens*, p. 74

MALE GENITALIA

1. Tenth sternite crowned with single row of blunt teeth ----
   Tenth sternite crowned with tuft of short bristles ---- 2
2. Mesosome plates joined at base but not connected subapically by sclerotized bridge ---- 4
   Mesosome plates joined at base and connected subapically by sclerotized bridge ---- *apicalis*, p. 70
3. Mesosome plates broad at midpoint and strongly narrowed to blunt sclerotized point apically ---- 3
   Mesosome plates of even width; apex broadly rounded and not heavily sclerotized ---- *boharti*, p. 71
4. Subapical lobes of basistyle with eight appendages ---- *territans*, p. 78
   Subapical lobe of basistyle with six or less appendages ---- *p. pipiens*, p. 74
   ---- 5

5. Subapical lobe of basistyle with one of filaments clublike; 10th sternite with outer spines on apex blunt ---- *tarsalis*, p. 77
   Subapical lobe of basistyle with one of filaments broad and leaflike; 10th sternite with all spines on apex pointed ---- 6
6. Mesosome with one stout blunt tooth ---- *restuans*, p. 75
   Mesosome with several teeth ---- 7
7. Mesosome with about four stout teeth ---- *peus*, p. 73
   Mesosome with six or more teeth ---- 8
8. Mesosome with right angle bend at middle of dorsal arm; most apical tooth nearly straight and much smaller than adjacent teeth ---- *salinarius*, p. 76
   Mesosome with nearly straight dorsal arm; most apical tooth bent and about same size or larger than adjacent teeth ---- *erythrothorax*, p. 72

LARVAE

1. Upper head hairs one to three, lower single or double ---- 2
   Upper head hairs four or more, lower three or more ---- 4
2. Air tube more than seven times its greatest diameter; basal diameter about twice apical diameter; ventral tufts less than one-half length of air tube ---- *apicalis*, p. 70
   Air tube less than seven times its greatest diameter; basal diameter less than twice its apical diameter; ventral tufts about one-half as long as air tube ---- 3
3. Fourth abdominal segment distinctly paler than third or fifth; spicules relatively slender near dorsal apex of saddle ---- *boharti*, p. 71
   Abdominal segments evenly colored or occasionally with fourth segment pale; spicules becoming course near dorsal apex of saddle ---- *territans*, p. 78
4. Air tube with four to six long single irregularly placed hairs and subapical tuft of two or three small hairs ---- *restuans*, p. 75
   Air tube with multiple tufts ---- 5
5. Air tube with five pairs of tufts in nearly straight line ---- *tarsalis*, p. 77
   Air tube with four, five, or six pairs of tufts with one or more pairs laterally out of line ---- 6
6. Air tube 4 to 5 by 1; lower head hairs three or four ---- 7
   Air tube 6 to 7 by 1; lower head hairs six or seven ---- 8
7. Microsetae on dorsal apex of anal plate much larger than those on dorsal middle; lateral abdominal hairs usually triple on third and fourth segments ---- *peus*, p. 73
   Microsetae on dorsal surface of anal plate inconspicuous and of about equal size; lateral abdominal hairs usually double on third and fourth segments ---- *p. pipiens*, p. 74
8. Air tube with four or five pairs of tufts, subapical pair out of line; comb usually with more than 65 scales ---- *salinarius*, p. 76
   Air tube with five pairs of tufts, third and fourth pairs usually laterally out of line; comb usually with 35 to 60 scales ---- *erythrothorax*, p. 72

Descriptions of Species

Culex (Neoculex) apicalis Adams

Culex apicalis Adams, Kans. Univ. Sci. Bul. 2: 26. 1903.
Culex apicalis Bohart, Ent. Soc. Amer. Ann. 41: 336. 1948.

Female.—Mesonotum with grayish to light-brown scales and with pale scales around margins; central area scales often forming median line and curved lateral line. Abdomen dark scaled with apical segmental white bands. Wings dark scaled. Legs dark scaled; hind femora with pale posterior stripe ending shortly before apex.

Male genitalia (fig. 84).—Subapical lobe of basistyle with two rods and about six spines. Tenth sternite crowned with short blunt spines. Mesosome plates relatively narrow and not connected subapically.

Larva (fig. 85).—Upper head hairs two or three, lower one or two. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Comb of many scales in patch. Air tube about 8 by 1; pecten teeth on basal third, followed by five or six pairs of tufts beyond pecten.

Distribution, biology, and importance.—Larvae of *Culex apicalis* have been collected only near Cave Junction in Josephine County, Oreg., in 1962 by Hoffman[6] (map 8). In Nevada the aquatic stages have been found in the vicinity of

[6] Hoffman, B. L. Personal communication. June 30, 1967.

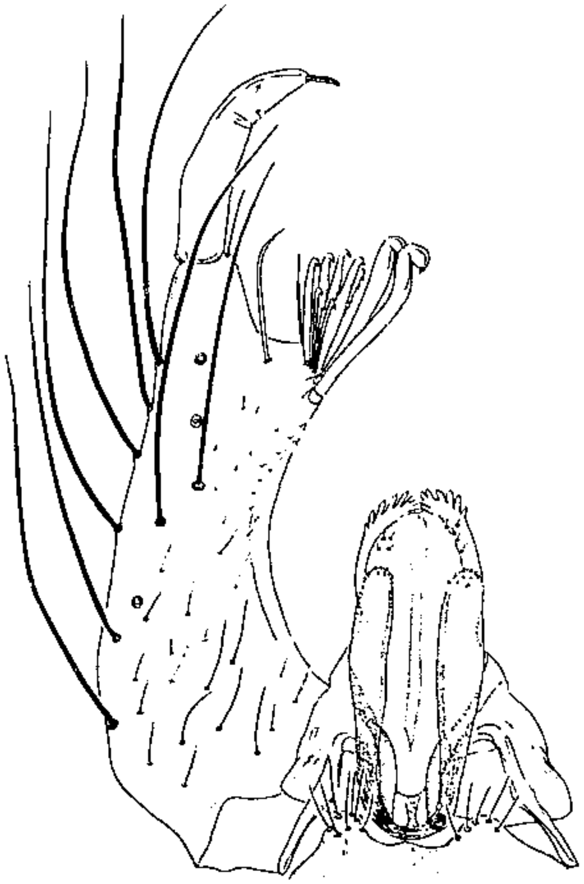

FIGURE 84.—*Culex apicalis* male genitalia.

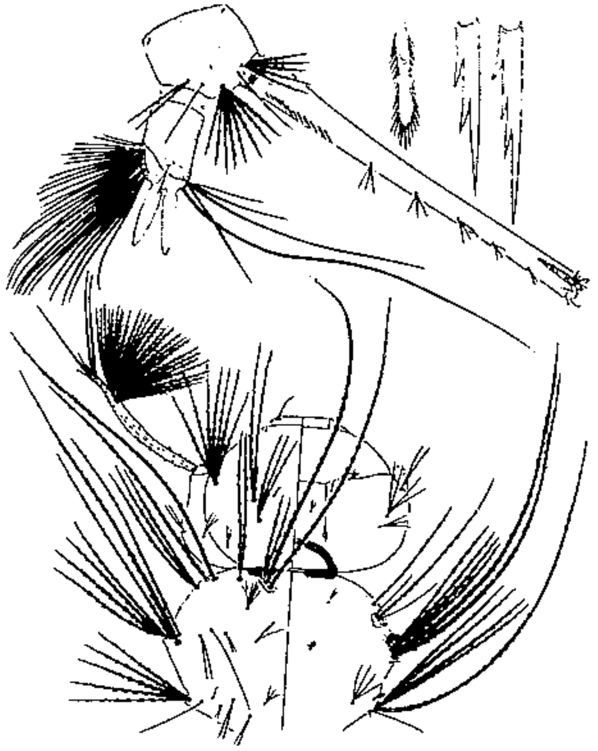

FIGURE 85.—*Culex apicalis* larva.

fresh water springs by Chapman (*68*). The females are not known to bite man. Linam and Nielsen (*182*) found that the females overwintered in an abandoned sandstone shaft in one area in Utah.

Culex (Neoculex) boharti Brookman and Reeves

Culex boharti Brookman and Reeves, Pan-Pacific Ent. 26: 159. 1950.

Female.—Occiput with narrow curved yellowish-brown scales and brown forked scales dorsally. Mesonotum brown scaled with pale scales around margins and pair of pale spots near middle. Abdomen dark scaled with apical segmental white bands. Wings dark scaled. Legs dark scaled; hind femora with pale posterior stripe extending to apex.

Male genitalia (fig. 86).—Subapical lobe of basistyle with two rods and about six spines. Tenth sternite crowned with short blunt spines. Mesosome

FIGURE 86.—*Culex boharti* male genitalia.

plates broad, narrowing at top, and heavily sclerotized apically; plates joined by a sclerotized band near apex.

Larva (fig. 87).—Upper head hairs usually double and lowers single. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Abdomen evenly pigmented except for fourth segment, which is much paler. Comb with many scales in patch. Air tube about 6½ by 1; pecten teeth on basal third, usually followed by five pairs of tufts, first tuft occasionally within pecten.

Distribution, biology, and importance.—This species has been collected as larvae in several counties in Oregon (map 8). It is likely more widely distributed than these records indicate. The larvae were found associated with *Culex territans* along the margin of a lake formed by a beaver dam and with *C. territans*, *Anopheles freeborni*, and *Culiseta incidens* in the grassy margin of a spring-fed stream. The females are not known to bite man and little is known of its economic importance.

Culex (Culex) erythrothorax Dyar

Culex erythrothorax Dyar, U.S. Natl. Mus. Proc. 32: 124. 1907.

Female.—Mesonotum with narrow hairlike golden-brown scales, prescutellar area partially pale scaled. Abdomen with dark-brown scales and with narrow indistinct yellowish-white basal bands on segments 2 to 7. Wing scales all dark. Legs dark; undersurface of femora and tibiae partially pale scaled.

Male genitalia (fig. 88).—Subapical lobe of basistyle with three rods, a spine, a broad leaf, and a seta. Tenth sternite crowned with many spines; basal arm long and curved. Mesosome plates broad; each plate with short slender ventral arm, long stout dorsal arm, and number of pointed teeth.

Larva (fig. 89).—Upper and lower head hairs multiple. Lateral abdominal hairs usually multiple on first and second segments and double on third to sixth. Comb with many scales in patch; each scale fringed with short spinules laterally and longer ones apically. Air tube about 6½ by 1; pecten teeth on basal fourth, followed by five pairs of tufts, next to the last one or two pairs more dorsal and out of line.

Distribution, biology, and importance.—This species has been taken only in Canyon County,

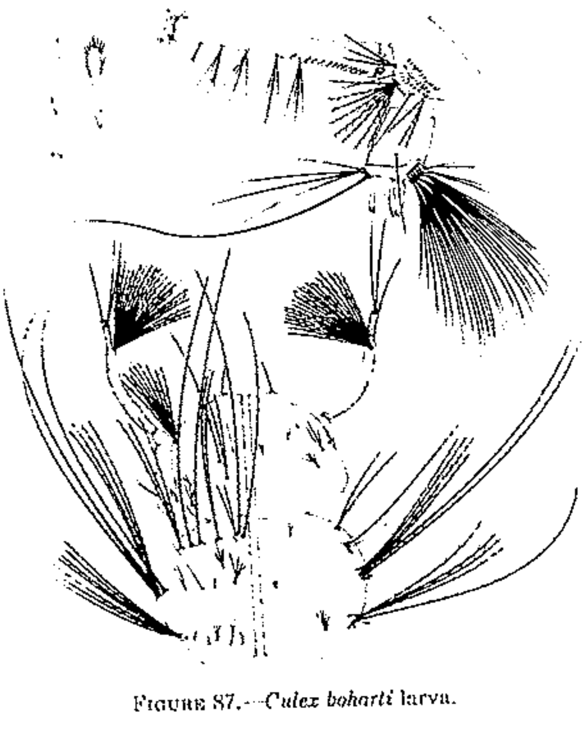

FIGURE 87.—*Culex boharti* larva.

FIGURE 88.—*Culex erythrothorax* male genitalia.

FIGURE 89.—*Culex erythrothorax* larva.

Idaho (*153*) (map 8). Nielsen and Rees (*205*) stated that it is abundant in the northern valleys of Utah, where its preferred breeding places are permanent swamps containing considerable vegetation. Chapman (*61*) found that in Nevada the principal brood develops from eggs laid from September to November and that the larvae overwinter in the second to fourth instars. He also showed that autogenous populations occur in Nevada, and he (*65*) studied the bioecology of the species. The females were found to feed on chickens, mice, rats, squirrels, and lizards (Henderson and Senior *140*). They will also readily attack man and may be a pest in some areas.

Culex (*Culex*) *peus* Speiser

Culex affinis Adams, Kans. Univ. Sci. Bul. 2: 21-47. 1903.
Culex peus Speiser, Insekten-Börse 21: 148. 1904.
Culex stigmatosoma Dyar, U.S. Natl. Mus. Proc. 32: 123. 1907.

Female.—Proboscis ringed with white. Tori without scales and basal segment of flagellum brown scaled. Mesonotum with bronze-brown scales intermingled with paler ones and forming no definite pattern. Abdomen black with basal segmental white bands; venter pale scaled, each segment marked with median oval dark-scaled spot. Wing scales all dark. Legs dark; tarsi with ring of white scales on both ends of all segments except first one or two of front and middle legs.

Male genitalia (fig. 90).—Subapical lobe of basistyle with three rods, a seta, a broad leaf, and a seta. Tenth sternite densely crowned with slender spines; basal arm long, stout, and curved. Mesosome plates each with broadly rounded ventral arm, long pointed dorsal arm, and about four stout teeth.

Larva (fig. 91).—Both pairs of head hairs multiple. Lateral abdominal hairs triple on first to sixth segments. Comb with many scales in patch. Air tube about 4 to 5 by 1; pecten on basal third, followed by four to six, usually five, pairs of hair tufts, subapical pair(s) out of line. Position and number of tufts on air tube vary considerably (*42*).

Distribution, biology, and importance.—This species occurs principally in the southwestern half of Washington and western part of Oregon (map 9). No collections have been made in Idaho. The larvae develop in large numbers in log ponds. They also occur in street catch basins and in water

FIGURE 90.—*Culex peus* male genitalia.

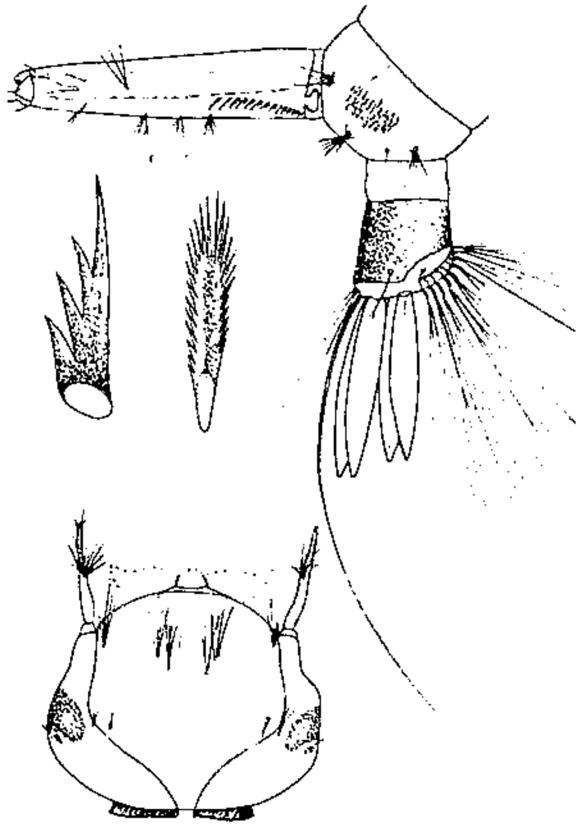

FIGURE 91.—*Culex peus* larva.

polluted by sewage. The females rarely bite man. Although the species is known to feed on chickens, mice, guinea pigs, and man in the laboratory, most specimens that we and our associates collected in Oregon were very reluctant to feed on white mice, chickens, or frogs. However, this is not considered unusual for strains initially brought into the laboratory. Western equine encephalitis has been isolated from wild caught specimens in California (*131*).

Culex (*Culex*) *pipiens pipiens* (Linnaeus)

Culex pipiens L., Systema Naturae per Regna Tria Naturae, ed. 10: 602. 1758.

Female.—Mesonotum brown scaled. Abdomen black with basal segmental white bands, which are widest at middle and narrowed at sides where they join lateral patches. Wing scales all brown. Legs brown; undersurface of femora and tibiae pale scaled.

Male genitalia (fig. 92).—Subapical lobe of basistyle with three rods, three setae, a broad leaf, and a seta. Tenth sternite densely crowned with short spines; basal arm short and blunt. Mesosome plate large; ventral arm curved, laterally directed, and tapered to point; dorsal arm straight, truncate, and extending across point of ventral arm; third pointed process projecting below ventral arm.

Larva (fig. 93).—Both pairs of head hairs multiple. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Comb with numerous scales in triangular patch. Air tube gradually tapering, about 5 by 1; pecten with about 12 teeth on basal fourth, followed by four pairs of hair tufts, subapical pair laterally out of line.

Distribution, biology, and importance.—This species develops in largest numbers where human populations provide it with a favorable environment. It is apparently more widely distributed in Washington and Oregon than in Idaho (map 9). The distribution of *Culex pipiens pipiens* and *C. p. quinquefasciatus* Say in North America has been studied by Barr (*15*).

The larvae develop in temporary and permanent pools, catch basins, improperly covered cesspools, and artificial containers. In Oregon large numbers breed in log ponds. The females commonly enter houses and usually bite after dark. Reeves and Hammon (*229*) found that of 52 wild caught

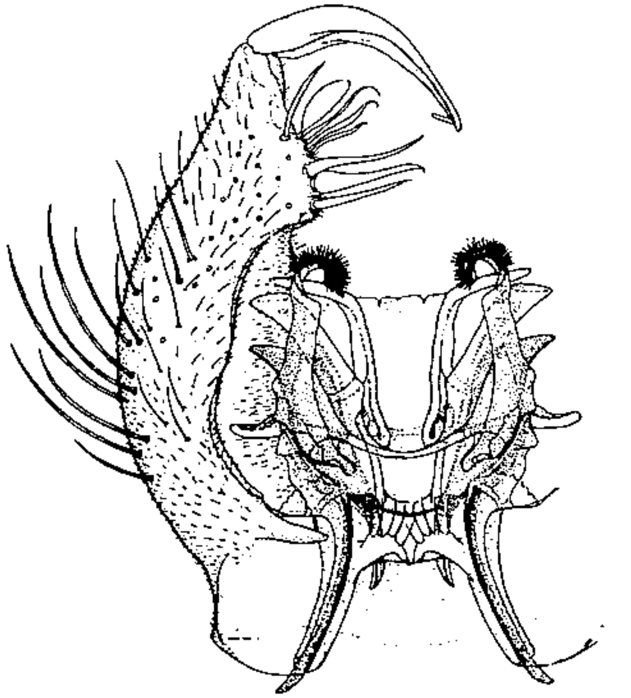

FIGURE 92.—*Culex pipiens pipiens* male genitalia.

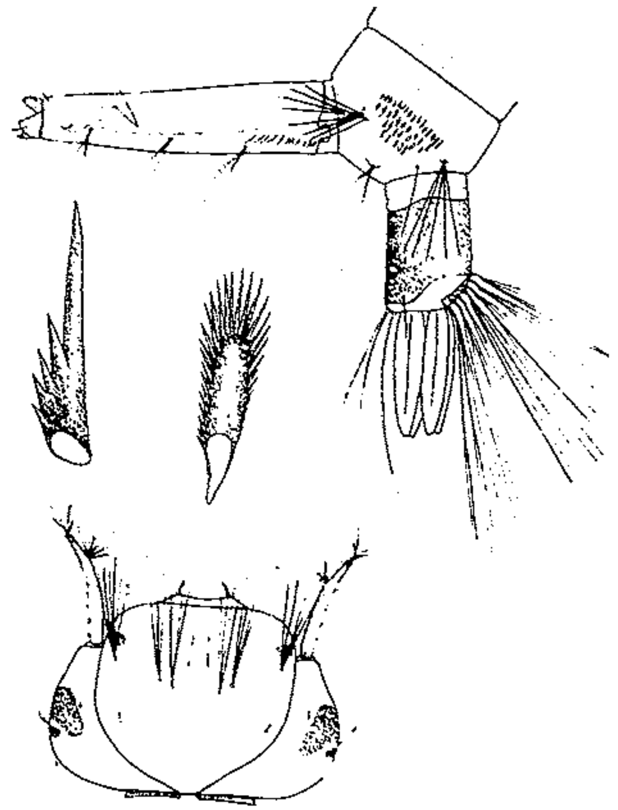

FIGURE 93.—*Culex pipiens pipiens* larva.

freshly engorged females collected at Yakima, Wash., 76 percent had fed on birds and the rest on horses, cows, or dogs. Nielsen and Rees (*205*) stated that in Utah the females readily enter dwellings but rarely attempt to bite. In the Willamette Valley of Oregon we noted that the species readily enters homes, where it is probably the most important nocturnal pest of man. Of the numerous freshly engorged mosquitoes collected by the junior author in his home at night, all were *C. p. pipiens*. This species was reported to be a serious pest in New Jersey by Smith (*249*).

St. Louis and western equine encephalitis were recovered from this species in the Yakima Valley, Wash. (*129*). It was considered to be the principal vector of encephalitis in the 1933 outbreak in St. Louis, Mo.

C. p. pipiens, *C. p. quinquefasciatus*, and *C. p. molestus* Forskal are very closely related species. Some information indicates that *C. p. pipiens* feeds mainly on birds and that *C. p. quinquefasciatus* and *C. p. molestus* will feed on man, animals, and birds. Autogenous strains of these species have been reported by several investigators. The *C. p. pipiens* complex has been reviewed by several workers such as King et al. (*170*) and Mattingly et al. (*193*). Much further work will be necessary in the United States to clarify the status of this complex group.

Culex (*Culex*) *restuans* Theobald

Culex restuans Theobald, Monog. Culicidae 2: 142. 1901.

Female.—Mesonotum with hairlike golden-brown scales, grayish scales around margins, and usually with pair of pale scaled spots near middle. Abdomen brown scaled with yellowish-white bands of moderate width that are continuous with lateral white spots. Wing scales all dark. Legs dark scaled; undersurface of femora and tibiae pale scaled.

Male genitalia (fig. 94).—Subapical lobe of basistyle with three rods, a broad leaf, and two stout setae. Tenth sternite crowned with slender pointed spines; basal arms stout and moderately curved. Mesosome plates broad; each plate with long slender ventral arm, short stout blunt tooth, and short curved dorsal arm.

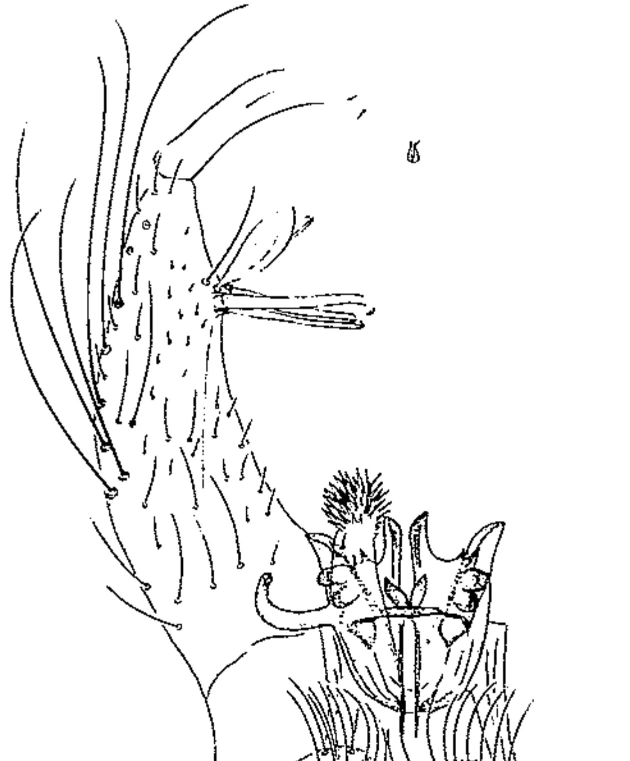

FIGURE 94.—*Culex restuans* male genitalia.

Larva (fig. 95).—Upper and lower head hairs multiple. Lateral abdominal hairs double on first and second segments and single on third to sixth. Comb with many scales in patch. Air tube about $4\frac{1}{2}$ by 1; pecten teeth on basal third, followed by three pairs of irregularly placed long single hairs and distal pair of two or three small hairs.

Distribution, biology, and importance.—This species is reported from five counties in southern Idaho by Harmston and Rees (*133*) and from Douglas County, Oreg., by Harmston et al. (*132*) (map 8). The larvae develop in permanent and semipermanent pools, ditches, and artificial containers. The preferred hosts have been indicated to be birds and livestock, but some authors have reported that it may get into houses and be annoying to man. Western equine encephalitis virus has been isolated from this species by Norris (*206*).

Culex (*Culex*) *salinarius* Coquillett

Culex salinarius Coquillett, Ent. News 15: 73. 1904.

Female.—Mesonotum with golden-brown scales, prescutellar area partially pale scaled. Abdomen dark scaled with narrow or indistinct basal bands of yellowish scales joined to lateral patches of pale scales. Wing scales all dark. Legs dark scaled; undersurface of femora and tibiae partially pale scaled.

Male genitalia (fig. 96).—Subapical lobe of basistyle with three rods, a broad leaf, and two setae. Tenth sternite crowned with slender pointed spines; basal arm long and curved. Mesosome plates connected near base; each plate with bluntly pointed ventral arm, group of strong pointed teeth, and stout pointed dorsal arm that is bent at right angles at middle.

Larva (fig. 97).—Upper and lower head hairs multiple. Lateral abdominal hairs triple on first and second segments and double on third to sixth. Comb usually with 65 or more scales in patch. Air tube 6 to 7 by 1; pecten teeth on basal fourth, followed by four or five pairs of tufts, subapical pair out of line.

FIGURE 95.—*Culex restuans* larva.

FIGURE 96.—*Culex salinarius* male genitalia.

FIGURE 97.—*Culex salinarius* larva.

Distribution, biology, and importance.—This species has been collected in three counties in southern Idaho (*153*) (map 8). The larvae are reported to develop in a wide variety of different environments, including grassy pools, ditches, and marshes, and have also occasionally been found in barrels. Nielsen and Rees (*205*) stated that the females bite readily and may enter dwellings but are not an important pest in Utah.

Culex (*Culex*) *tarsalis* Coquillett

Culex tarsalis Coquillett, Canad. Ent. 28: 43. 1896.

Female.—Proboscis ringed with white. Tori with inner surfaces and basal segment of flagellum with ventral surface bearing many white scales. Mesonotum dark brown with white scales around margins and two narrow white lines extending posteriorly from median white spots. Abdomen black with basal segmental white bands; venter with pale scales, each segment marked with dark-scaled V, apex anteriorly directed. Wing scales dark with some white scales on costal veins. Legs black; femora and tibiae with line of white scales on sides; tarsi with ring of white scales at both ends of all segments except first one or two on front and middle legs.

Male genitalia (fig. 98).—Subapical lobe of basistyle with two rods, a seta, a narrow leaf, and a seta. Tenth sternite crowned with short pointed spines medianly and short broad blunt ones outwardly; basal arm long, stout, and curved. Mesosome plates each with long ventral arm, several stout teeth, and long dorsal arm.

Larva (fig. 99).—Both pairs of head hairs multiple. Lateral abdominal hairs triple on first to sixth segments. Comb with numerous scales in triangular patch. Air tube slender and about 5 by 1; pecten on basal third, followed by five pairs of tufts usually inserted in straight line; distal tufts out of line in some specimens (*181*).

Distribution, biology, and importance.—This is one of the most important and widespread species in the Northwest (map 9). The larvae develop in many types of permanent and semipermanent water such as log ponds, ditches, and marshes. Other important breeding places are pools formed by floodwaters and irrigation. This species has been found in all counties in Oregon and in nearly all counties in Washington and Idaho. In Utah it has been found at elevations up to 9,000

FIGURE 98.—*Culex tarsalis* male genitalia.

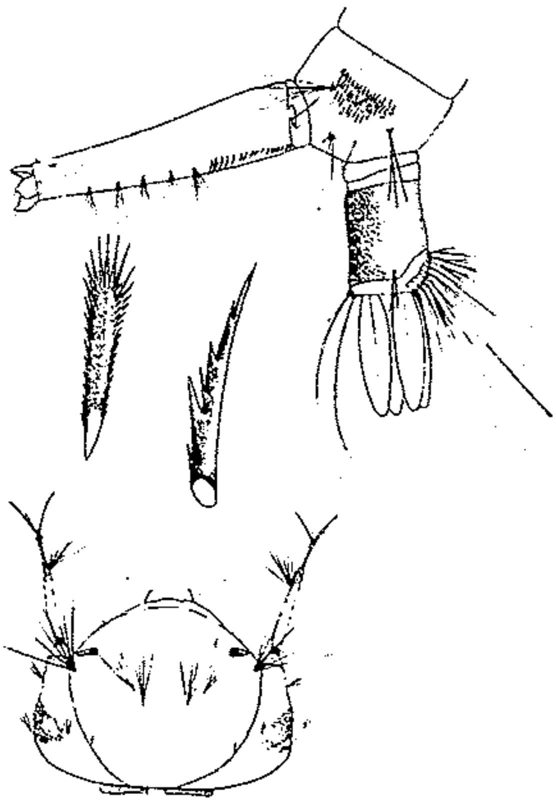

FIGURE 99.—*Culex tarsalis* larva.

feet (*205*). The adults seek shelter during the daytime. In the Central Valley in California the adults remain in resting shelters from 8 a.m. until sunset (*112*).

The preferred hosts are domestic and wild birds, but this species will bite man, livestock, and other animal species (*21*). It will feed on rodents, snakes, and frogs when these are restrained (*140*). This species seldom bites man during daylight but will readily attack soon after sundown (*21, 112*). Autogenous strains of *Culex tarsalis* were first reported by Bellamy and Kardos (*28*) and by Chao (*60*). An autogenous colony in our laboratory has been reared for many generations on a sugar-water diet. Hibernating females have been found in late winter in storage cellars (*159*), in rock piles (*239*), under rocks on rock-covered hillsides (*184*), and in abandoned mines (*84*) or caves (*216*).

This species is the most important known vector of western equine encephalitis (WEE) and St. Louis encephalitis (SLE). California encephalitis virus has also been isolated from it. Blackmore and Dow (*34*) suggested that it is unlikely it is a winter reservoir of encephalitis virus since less than 0.3 percent of the hibernating females recovered by them had taken a blood meal. However, Bellamy et al. (*30*) showed experimental overwintering of SLE virus in this species. Rush et al. (*240*) found no WEE virus in large populations of winter caught adults. They also reported that it is unlikely the virus overwinters in this species. Studies by Bellamy and Reeves (*29*) in Bakersfield, Calif., showed that a diapause, which they believed to be caused by a decreasing period of daylight, results in an almost complete cessation of blood feeding from October to January.

Considerable information on the flight and dispersal habits of this species has been obtained by Reeves (*227*) and Bailey et al. (*11*). Although the maximum flight distance recorded by these workers was 15.75 miles, they stated "effective numbers of *C. tarsalis* disperse 2 and 3 miles downwind in one evening and significant numbers can travel 7 miles or more in two evenings, with the aid of the wind." They estimated a likely dispersal of 20–25 miles in the Sacramento Valley of California. In studies on the dispersal of adults into an area undergoing larvicide treatments the maximum recovery distance was 9.6 miles (*83*).

Culex (*Neoculex*) *territans* Walker

Culex territans Walker, Insecta Saundersiana, Diptera 1: 428. 1856.
Culex apicalis of authors, not Adams.

Female.—Occiput with narrow curved white to golden scales and brown forked scales dorsally. Mesonotum brown scaled with pale scales around margins and pair of pale spots near middle. Abdomen dark scaled apically with segmental white bands. Wings dark scaled. Legs dark scaled; hind femora with pale posterior stripe extending to apex.

Male genitalia (fig. 100).—Subapical lobe of basistyle with two rods and about five spines. Tenth sternite crowned with row of short blunt spines.

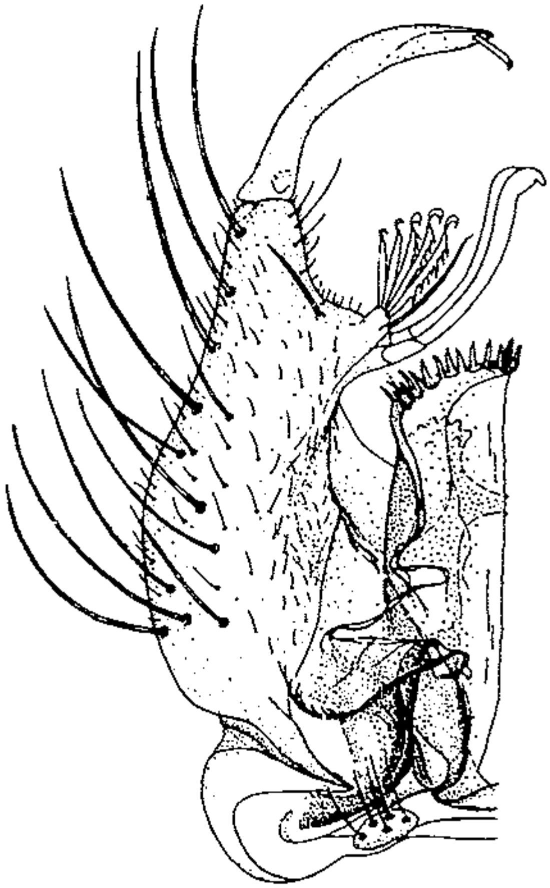

FIGURE 100.—*Culex territans* male genitalia.

Mesosome halves forming relatively even oblong outline, terminating apically in rounded serrated margin; halves joined by sclerotized band near apex.

Larva (fig. 101).—Head hairs single or double. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Abdominal segments usually evenly pigmented or segment 4 may be pale in some specimens. Comb with numerous scales in triangular patch. Air tube about $6\frac{1}{2}$ by 1; pecten teeth on basal third usually followed by five pairs of tufts, first tuft occasionally within pecten.

Distribution, biology, and importance.—This species is well distributed in the Northwestern States but occurs only in small numbers (map 8). In California Freeborn and Bohart (*95*) recorded this species from the northern counties. The larvae are found in swampy areas or in other permanent or semipermanent pools containing considerable aquatic or nonaquatic vegetation. They also occur along the grassy margins of streams. These populations may include both *Culex territans* and *C. boharti*. The females have been observed to feed on frogs and snakes but are not known to bite man. Little is known about the economic importance of the species.

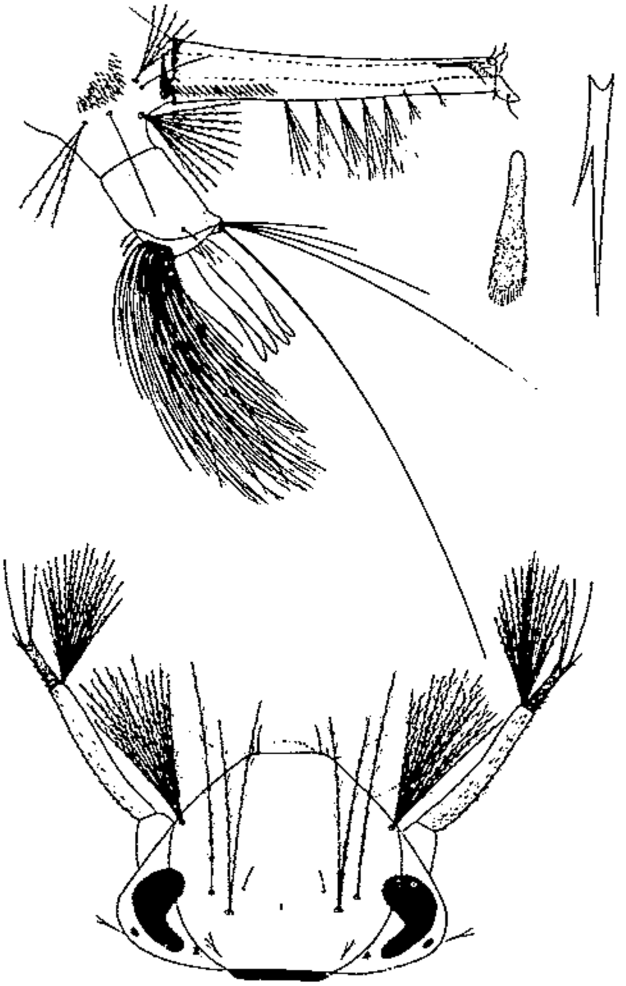

FIGURE 101.—*Culex territans* larva.

Genus CULISETA Felt

Keys to Species

ADULTS

1. Femora with distinct preapical white rings ... *particeps*, p. 84
   Femora without white rings ... 2
2. Sternopleuron with scales extending to anterior border; tori with white scales ... 3
   Sternopleuron with scales not extending to anterior border; tori without white scales ... 4
3. Wing scales black with dense patches of dark scales ... *incidens*, p. 81
   Wing scales brown with admixture of white scales on anterior veins ... *inornata*, p. 83
4. Tarsi with pale white rings at both ends of tarsal joints; wings without spots ... *minnesotae*, p. 84
   Tarsi without white rings; wings with faint spots ... *impatiens*, p. 80

MALE GENITALIA

1. Apical lobe absent ... 2
   Apical lobe present ... 3
2. Lobes of ninth tergite with short broad spines ... *inornata*, p. 83
   Lobes of ninth tergite with rather long setae ... *minnesotae*, p. 84
3. Eighth tergite with row of 20 to 40 short spines on basal margin; basal lobe large with single spinelike seta and several smaller ones ... *impatiens*, p. 80
   Eighth tergite with less than 12 spines on basal margin; basal lobe with two or three spines ... 4
4. Eighth tergite with none to three spines at center of basal margin ... *particeps*, p. 84
   Eighth tergite with five to 10 spines at center of basal margin ... *incidens*, p. 81

LARVAE

1. Air tube with normal pecten teeth on basal fourth not followed by long hairs ... *minnesotae*, p. 84
   Air tube with normal pecten teeth near base followed by series of long hairs extending beyond middle ... 2
2. Upper and lower head hairs about equal in length and number ... *impatiens*, p. 80
   Upper head hairs shorter and more numerous than lower ... 3
3. Lateral hairs of anal segment stout and as long or longer than segment ... *inornata*, p. 83
   Lateral hairs of anal segment fine and shorter than segment ... 4
4. Postclypeal hairs about as long as head hairs; posterior margin of anal plate with short spicules at apex ... *particeps*, p. 84
   Postclypeal head hairs shorter and more delicate than head hairs; anal plate without spicules ... *incidens*, p. 81

Descriptions of Species

Culiseta (Culiseta) impatiens (Walker)

Culex impatiens Walker, List of Dipterous Insects in Brit. Mus., v. 1, p. 5. 1848.

Female.—Tori without white scales. Mesonotum with brown and yellowish scales, two fine pale lines extending posteriorly from median pale patches, and variable pattern of other pale scales. Sternopleuron without white scales at anterior edge. Abdomen black with basal segmental white bands. Wing scales brown and aggregated to form faint spots at forks of second and fourth veins and bases of second and third veins. Legs dark brown; femora white tipped.

Male genitalia (fig. 102).—Basistyle stout, conical, about twice as long as wide; apical lobe a small slightly elevated chitinized area with long setae; basal lobe large and conical in outline, apex rounded with one large spinelike seta and several smaller ones. Lobes on ninth tergite only slightly separated and each bearing about 10 long setae. Eighth tergite with row of 20 to 40 short stout spines on basal margin.

Larva (fig. 103).— Both pairs of head hairs multiple and long. Lateral abdominal hairs multiple on first to fifth segment and double on sixth. Comb with numerous scales in triangular patch. Air tube stout, 2 by 1; pecten of eight to nine teeth on basal fourth, followed by long hairs that nearly reach apex of tube; paired tufts large and arising close

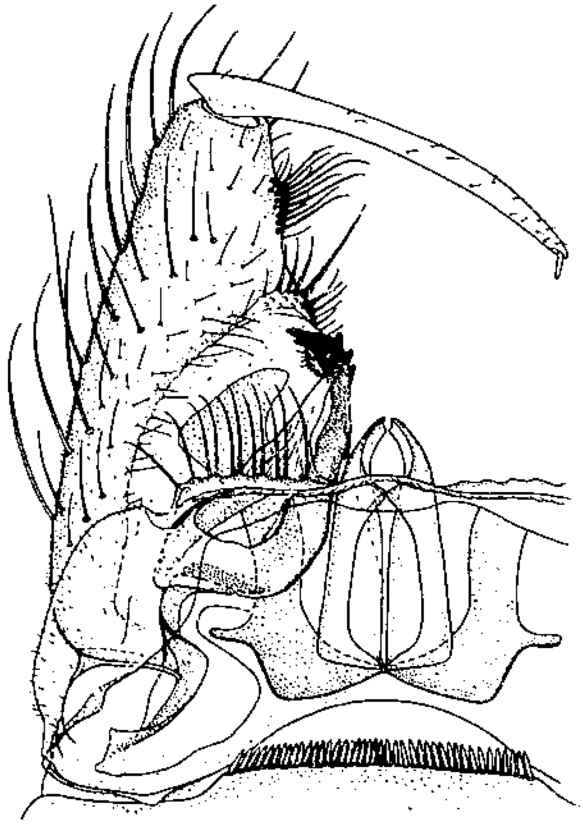

FIGURE 102.—*Culiseta impatiens* male genitalia.

to base between rows of pecten. Anal segment ringed by plate; gills bluntly pointed and longer than segment.

Distribution, biology, and importance.—This species has been found in small numbers in the timbered sections of Oregon and Washington and in two counties in Idaho (map 10). The larvae have been taken in roadside ditches, holes left from fallen or uprooted trees, margins of beaver-dam lakes, wheel ruts in logging roads, and other small pools with bordering brush or trees. The females will bite man but are seldom present in sufficient numbers to be of importance.

Culiseta (*Culiseta*) *incidens* Thomson

Culiseta incidens Thomson, Kongliga Svenska Eugenies Resa 6, Diptera: 433. 1868.

Female.—Tori white scaled. Flagellum with first segment white scaled ventrally. Mesonotum with dark-brown scales and mixture of yellowish scales some of which form partial longitudinal lines or spots. Sternopleuron with scales extending to anterior edge. Abdomen black with basal segmental white bands. Wing scales dark, aggregated into patches on fork and base of second vein, fork of fourth vein, upper fork of fifth, and middle of sixth veins. Legs dark brown with narrow faint white rings on bases of some tarsal segments; femora and tibia with narrow white rings at their apices.

Male genitalia (fig. 104).—Basistyle more than twice as long as wide; apical lobe a small elevated

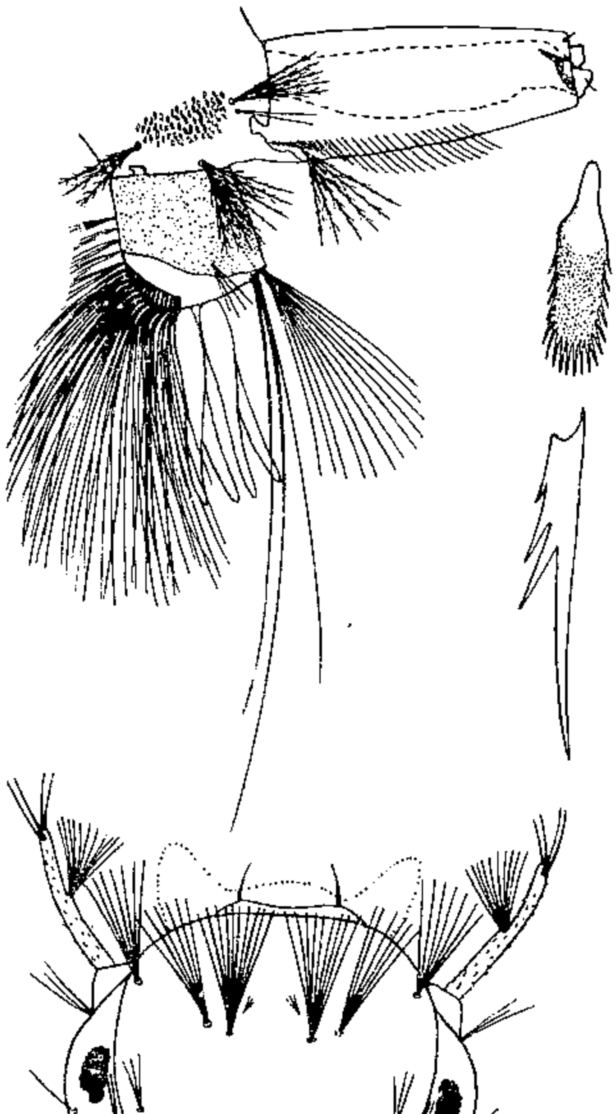

FIGURE 103.—*Culiseta impatiens* larva.

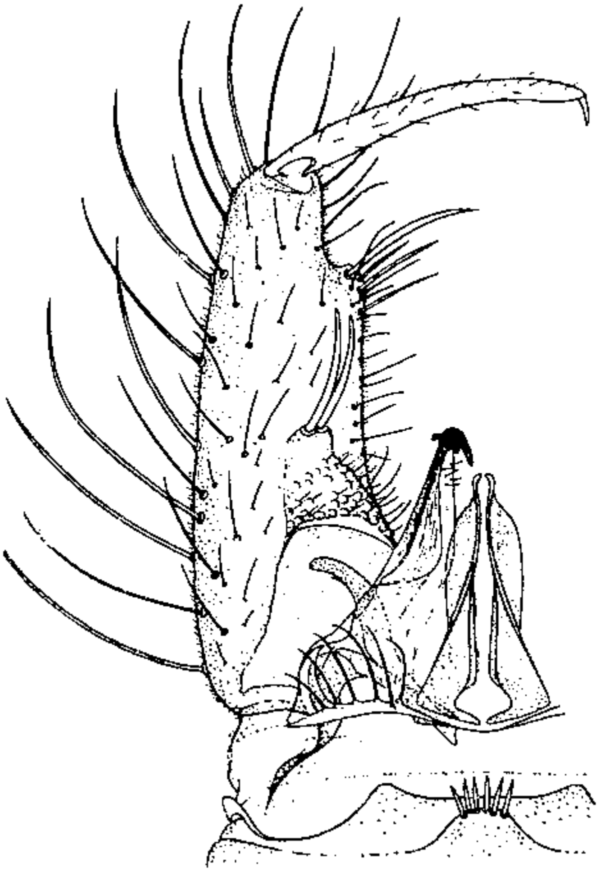

FIGURE 104.—*Culiseta incidens* male genitalia.

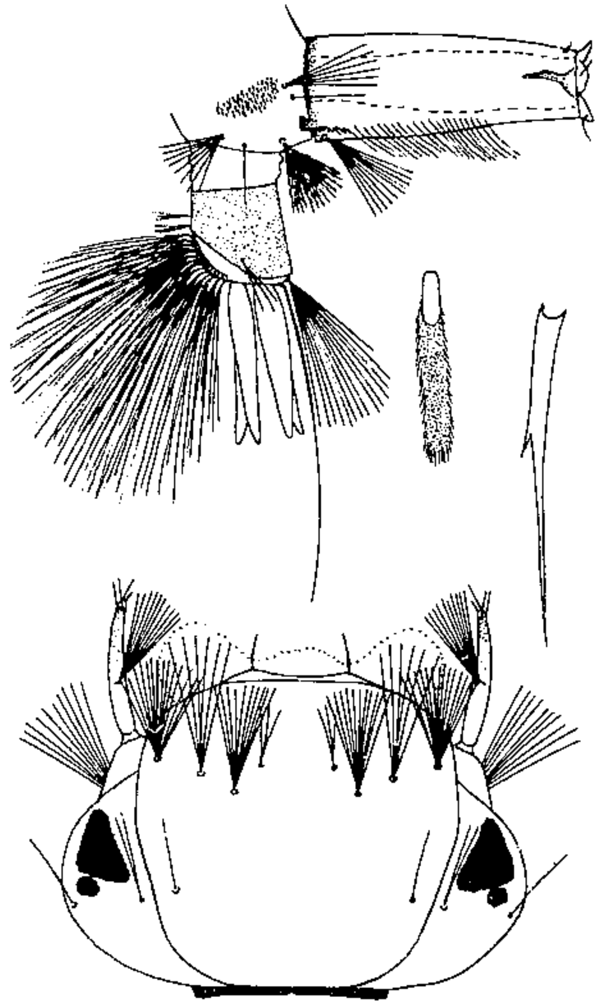

FIGURE 105.—*Culiseta incidens* larva.

area with a number of small setae and a long spine; basal lobe small and conical with small setae, apex with two stout spines. Lobes of ninth tergite slightly separated, each bearing five to eight rather long setae. Eighth tergite with five to 10 spines on basal margin.

Larva (fig. 105).—Both pairs of head hairs multiple; lower tufts longer than upper. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Air tube stout, about 2 by 1; pecten with few basal teeth that have one or two minute denticles; teeth followed by long hairs to apical third of tube; paired multiple tuft inserted near base between rows of pecten. Anal segment ringed by plate; lateral hair shorter than segment; gills slightly longer than segment.

Distribution, biology, and importance.—This species is widely distributed at lower elevations in the Northwestern States (map 10). The largest numbers occur in Washington and Oregon west of the Cascade Mountains, but it is common also in Idaho. The larvae breed in both permanent and semipermanent pools and in artificial containers. They are often associated with *Culiseta inornata* and *Culex tarsalis*. Only the females hibernate. They will readily attack man but are not considered important as a pest because of their small numbers and breeding habits. The species has been reported as favoring mammals for blood meals, although it is seldom abundant enough to be a pest of livestock. It has been infected experimentally with western equine, St. Louis, and Japanese B encephalitis viruses.

Culiseta (Culiseta) inornata (Williston)

Culex inornatus Williston, U.S. Dept. Agr., Div. Ornith. and Mammals, N. Amer. Fauna 7: 253. 1893.

Female.—Tori with white scales. Mesonotum with mixture of brown and yellowish scales, usually with two fine pale median posterior half lines and pale obscure longitudinal stripes. Sternopleuron with scales extending to anterior edge. Abdomen black with broad basal segmental bands widening at sides, last segment entirely pale scaled. Wing scales dark brown with mixture of pale scales on anterior veins. Legs with mixture of brown and pale scales.

Male genitalia (fig. 106).—Basistyle stout conical, less than twice as long as wide; apical lobe absent or faintly indicated; basal lobe conical and prominent with two or three spines on apex and small setae on sides. Lobes of ninth tergite broad rounded projections with 10 to 14 short thick spines. Eighth tergite without row of spines on basal margin.

Larva (fig. 107).—Both pairs of head hairs multiple; uppers usually slightly shorter with about seven to nine evenly sized hairs; lowers with three to five hairs, inner ones larger. Lateral abdominal hairs multiple on first and second segments and double on third to sixth. Comb with many scales in patch; each scale rounded and evenly fringed apically. Air tube 3 by 1; pecten of 10 to 18 stout teeth, followed by long hairs that extend nearly to apex of tube; paired tuft large and arising from base of tube between rows of pecten. Anal segment ringed by plate; gills longer than segment with tips rounded.

Distribution, biology, and importance.—This species is rather widely distributed (map 10). It occurs in largest numbers in poorly drained irrigated areas. However, it has been collected in almost every type of semipermanent and permanent water. The larvae are often found with those of *Anopheles freeborni* and *Culex tarsalis*. It is also

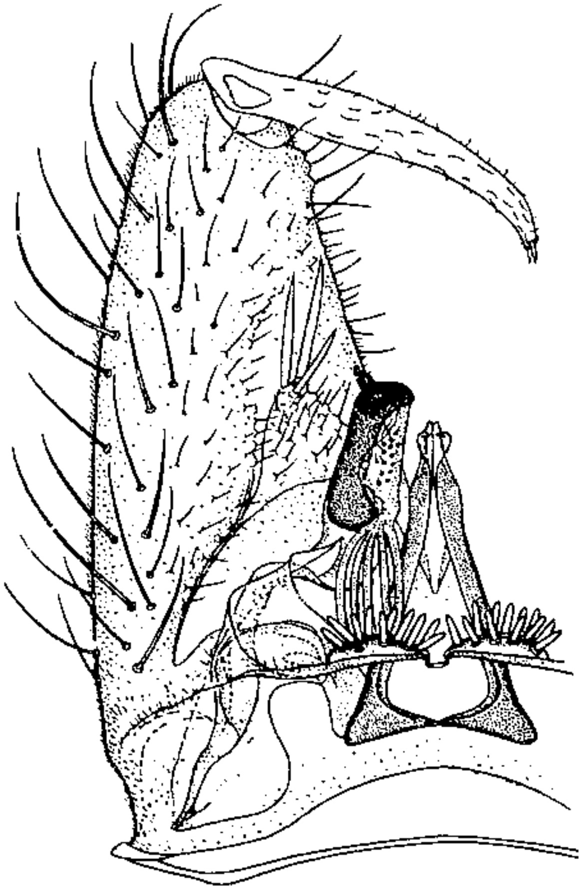

FIGURE 106.—*Culiseta inornata* male genitalia.

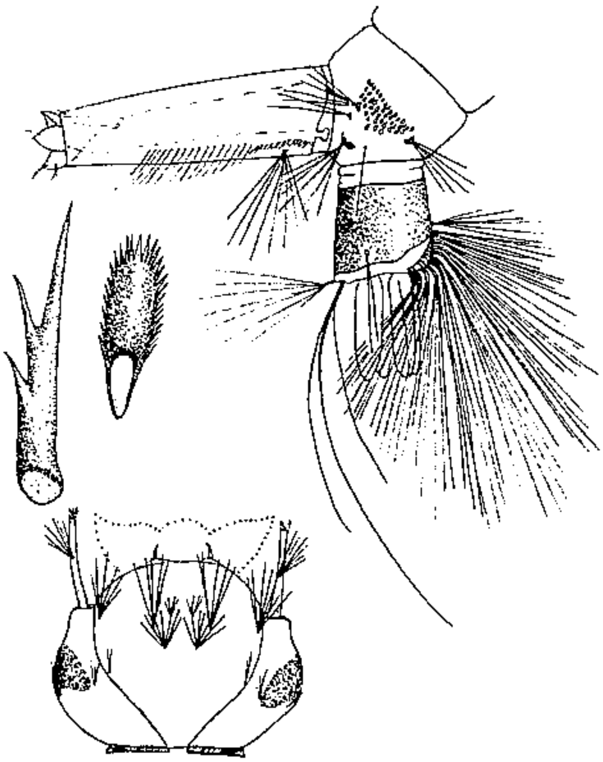

FIGURE 107.—*Culiseta inornata* larva.

found in shaded pools in forests at elevations up to 6,000 feet. It is not a serious pest of man but can become a pest of livestock because of its long breeding season and wide distribution in irrigated areas. The females hibernate, and Rees (*222*) believed that some larvae may overwinter, since they are very resistant to low temperatures. Western equine encephalitis has been isolated from this species in nature. Experimentally the species has been shown to transmit St. Louis and Japanese B encephalitis viruses.

Culiseta (Culicella) minnesotae Barr

Culiseta minnesotae Barr, Wash. Ent. Soc. Proc. 59: 163. 1957.

Female.—Mesonotum integument brown with pair of reddish-brown nearly bare stripes, two stripes separated by narrow stripe of darker brown; scales fine, narrow, reddish brown except for pair of silvery-white spots back of middle and pair of posterior silvery-white half lines that enclose additional scattered white scales. Abdomen brown scaled with scattered yellowish-white scales most heavily concentrated along apices and bases of segment. Wing scales dark with pale scales on base of costa. Legs dark; faint white rings at both ends of first, second, and third tarsal segments and occasionally with rings on other segments.

Male genitalia (fig. 108).—Basistyle conical, more than twice as long as wide; apical lobe absent; basal lobe prominent and conical with three to five spines on apex and small setae on sides. Lobes of ninth tergite with broad projections, each with six to 12 slender setae. Mesosome sides rising in nearly straight line to rather square dark shoulders, which terminate into slightly higher point centrally. (In *Culiseta morsitans* (Theobald) the mesosome is funnel shaped and not dark terminally.) Eighth tergite with group of small spines centrally on basal margin.

Larva (fig. 109).—Upper head hairs multiple, usually five- to eight-branched (range 5–11); lower double or triple. Postantennal tuft usually nine- to 12-branched (range 8–14). Lateral abdominal hairs multiple on first and second segments and single on third to sixth. Comb with numerous scales. Air tube about 7 by 1; pecten of about six to 13 teeth on basal fourth; small paired tuft at base between rows of pecten; tufts in ventral brush usually 17 to 18 (range 16–19). Anal segment ringed by plate; gills about same length as plate.

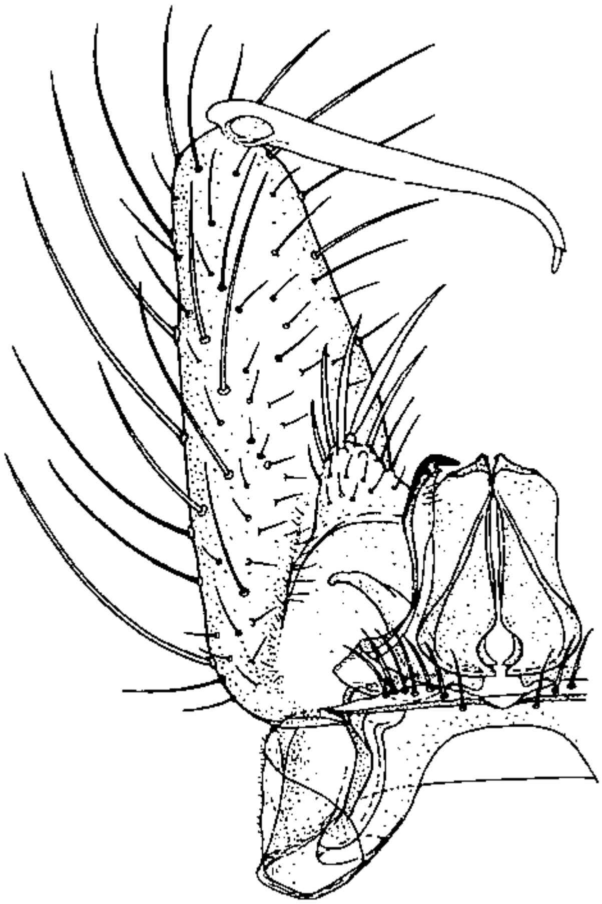

FIGURE 108.—*Culiseta minnesotae* male genitalia.

Distribution, biology, and importance.—This rare species has been found in small numbers in Washington and Oregon and two counties in Idaho (map 10). The larvae have been collected from unshaded pools with scattered grass fed by fresh water. Although little is known of the feeding habits of the adults, they apparently do not readily attack man.

Culiseta (Culiseta) particeps (Adams)

Culiseta particeps Adams, Kans. Univ. Sci. Bul. 2, p. 26. 1903.

Culiseta maccrackenae Dyar and Knab, Wash. Biol. Soc. Proc. 19: 134. 1906.

Culiseta particeps (Adams), Stone, Kans. Ent. Soc. Jour. 31: 236. 1958.

Female.—Mesonotum dark brown with light-brown median stripe and narrow white posterior half lines; sides, anterior margin, and margins of antescutellar space with mixture of white scales. Abdomen black with basal segmental white bands and few scattered white scales. Wing scales dark with few pale scales on costal veins, dark scales forming spots at base of second, forks of second and fourth, upper fork of fifth, and on cross veins. Legs dark scaled; femora pale scaled on underside with preapical pale ring; tarsi with broad white rings, narrower on distal segments and usually absent on fifth segment of front and middle tarsi.

Male genitalia (fig. 110).—Basistyle about three times as long as wide; apical lobe a small elevated area with number of long setae; basal lobe small and conical with many small setae, apex with two or three stout spines. Lobes of ninth tergite slightly raised areas with many long setae. Eighth tergite with none to three spines at center of basal margin.

Larva (fig. 111).—Both pairs of head hairs multiple; lower with about three long hairs, upper more numerous. Postclypeal hair three- to five-branched and about as long as head hairs. Comb with many

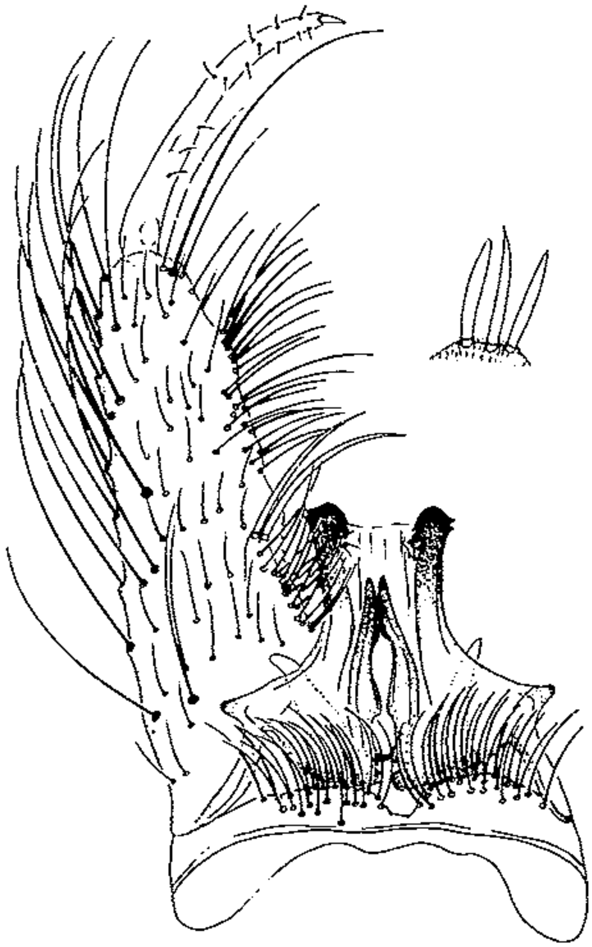

FIGURE 110.—*Culiseta particeps* male genitalia.

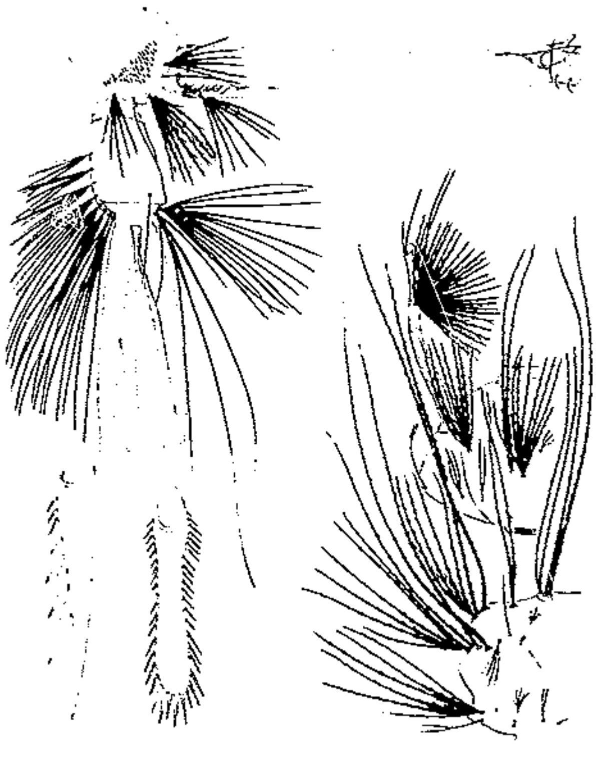

FIGURE 109.—*Culiseta minnesotae* larva.

scales in patch. Air tube stout, about 2 by 1; pecten with few basal teeth, followed by long hairs that extend nearly to apex of tube; paired tufts near base of tube between rows of pecten. Anal segment ringed by plate with small patch of short spicules near apex; lateral hair shorter than segment; gills slightly longer than segment.

Distribution, biology, and importance.—This species is rare in the Northwest (map 10). The single collection from Washington was represented by larvae taken at Port Townsend, Jefferson County, by Myklebust (*199*) in July 1961. In southwestern Oregon collections the larvae were associated with larvae of *Culiseta incidens* and *Culex territans* in pools overgrown with vegetation. Little is known of the feeding habits or economic importance of the adults.

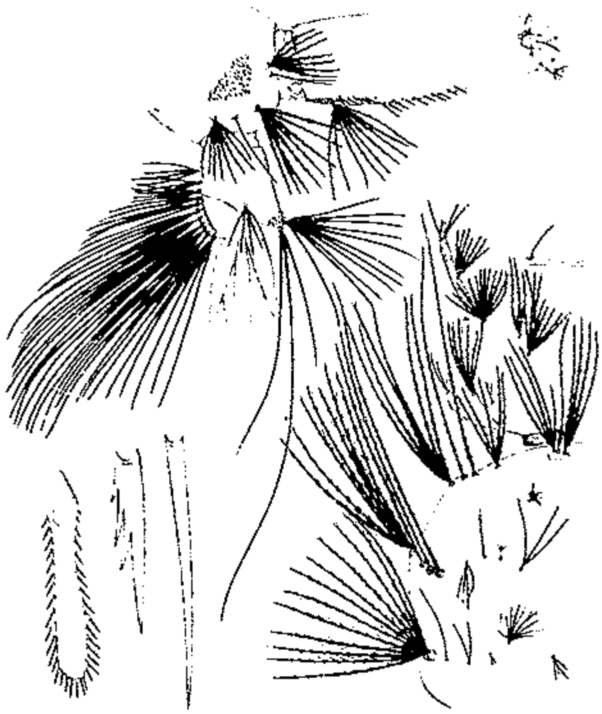

FIGURE 111.—*Culiseta particeps* larva.

Genus COQUILLETTIDIA Dyar

Description of Species

Coquillettidia perturbans (Walker)

Culex perturbans Walker, Insecta Saundersiana, Diptera 1: 428. 1856.
Mansonia perturbans (Walker), Mosquitoes N. Amer., p. 109. 1955.

Female.—Mesonotum with narrow curved pale-yellow scales with or without two faint silvery longitudinal lines. Abdomen black with narrow basal segmental white band, sometimes lacking medianly or consisting of scattered black and white scales on last few segments. Wing scales broad, black and white intermixed. Legs dark with mixture of white scales; hind tibiae with preapical pale ring; first segments of all tarsi with narrow basal white rings and broad median white ring; all other tarsal segments with basal half white scaled.

Male genitalia (fig. 112).—Basistyle about 1½ times as long as wide; apical lobe absent; basal lobe a triangular raised median section terminating in stout cylindrical blunt rod. Dististyle flattened and broadly expanded beyond middle, apex with short stout claw.

Larva (fig. 113).—Antennae long and slender with large tuft beyond middle and short pair of hairs not far beyond tuft. Dorsal head hairs in multiple

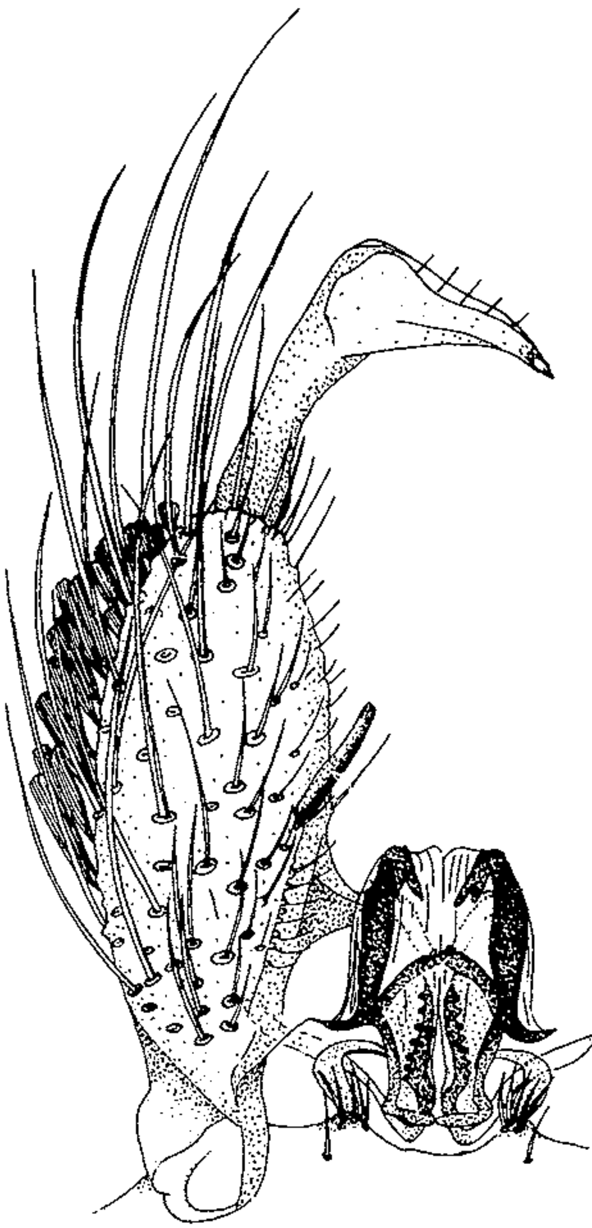

FIGURE 112.—*Coquillettidia perturbans* male genitalia.

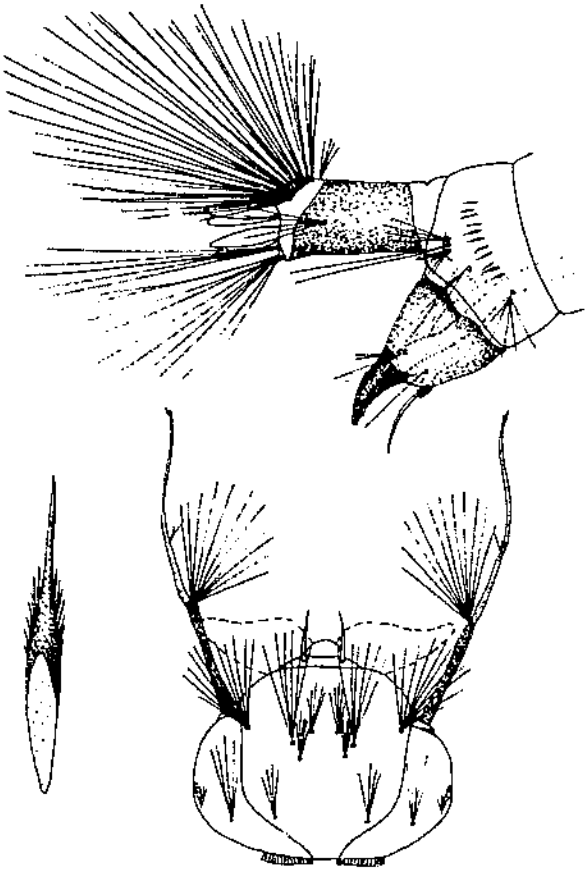

FIGURE 113.—*Coquillettidia perturbans* larva.

groups. Comb with 10 to 25 scales in single row, some scales out of line. Air tube short, broad at base, attenuated apically, and fitted for piercing; stout spine, single stout hair, and multiple tuft near middle. Anal segment much longer than wide, ringed by plate; multiple lateral tuft before apical margin; anal gills slender and shorter than segment.

Distribution, biology, and importance.—Although this species has been collected in all three States, it does not occur in large numbers (map 6). The eggs are laid in rafts in swamps, marshes, or log ponds containing cattails, sedges, or other suitable host plants. The eggs hatch in 4 or 5 days, and the small larvae attach themselves to the roots or stems of the plants by means of the modified tip of their air tube, which is inserted into the root to provide air. The pupa also attaches itself to plants by means of modified air tubes. It comes to the surface when the adult is ready to emerge. The species usually overwinters in the larval stage and there is apparently only one generation each year even as far south as Florida (*31*). Adults have been collected from early June to September in Douglas County, Oreg., by Harmston et al. (*132*) but were most numerous in June and July. The adults readily bite man and animals, but in most areas they do not occur in large enough numbers to be a serious pest. Howitt et al. (*148*) showed that this species may transmit eastern equine encephalitis in nature.

Genus ORTHOPODOMYIA Theobald

Description of Species

Orthopodomyia signifera (Coquillett)

Culex signifera Coquillett, Canad. Ent. 28: 43. 1896.
Orthopodomyia californica Bohart, Ent. Soc. Amer. Ann. 43: 399. 1950.

Female.—Mesonotum brown scaled with narrow paired central white lines, half lines converging over scutellum, and narrow white line around lateral margin. Sides of thorax with lines and patches of white scales. Lower sternopleural bristles usually four to 10. Abdomen dark scaled with narrow partial or complete basal white bands. Wing with intermingled white and dark scales. Legs mostly dark scaled; white scales on femora and tibia; front tarsi mostly dark scaled, middle tarsi with narrow apical and basal white rings on first and second segments, and hind tarsi with broad apical and basal white rings on all segments.

Male genitalia (fig. 114).—Basistyle about three times as long as wide; claw of dististyle with many small teeth; apical lobe absent; basal lobe conical with few large spines apically and smaller setae subapically. Tenth sternite heavily sclerotized with several apical teeth. Ninth tergite with few setae and no lobes.

Larva (fig. 115).—Upper and lower head hairs multiple. Lateral abdominal hairs multiple on first and second segments. Comb of eighth segment in double row of about 15 to 25 scales. Air tube about 2.5 to 3.5 by 1; pecten absent; ventral tuft barbed, five- to 12-branched, inserted near middle of air tube, individual hairs ranging from 1.7 to 2.3 times as long as section of air tube extending beyond

FIGURE 114.—*Orthopodomyia signifera* male genitalia.

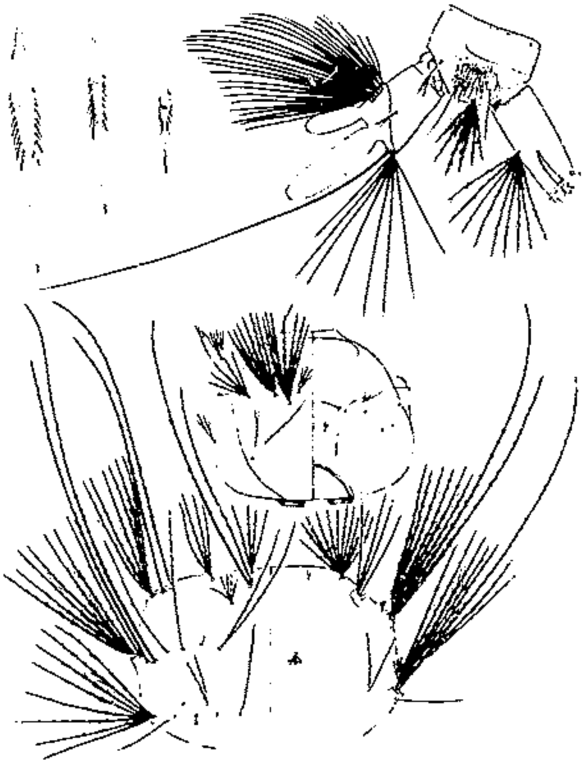

FIGURE 115.—*Orthopodomyia signifera* larva.

point of insertion of tuft. Anal segment ringed by plate; small plate at base of segment; lateral hair single or double and shorter than plate.

Distribution, biology, and importance.—In the Northwestern States this species has been collected only from water in a hollow oak tree in Benton County, Oreg., where it was associated with *Aedes sierrensis* (map 8). It occurs in tree holes in several kinds of trees and also occasionally in wooden containers (*67, 220*). The females will take blood meals from several species of birds but will not bite man (*283*). The larvae survive the winter in the Southern States but may be destroyed by freezing in northern climates.

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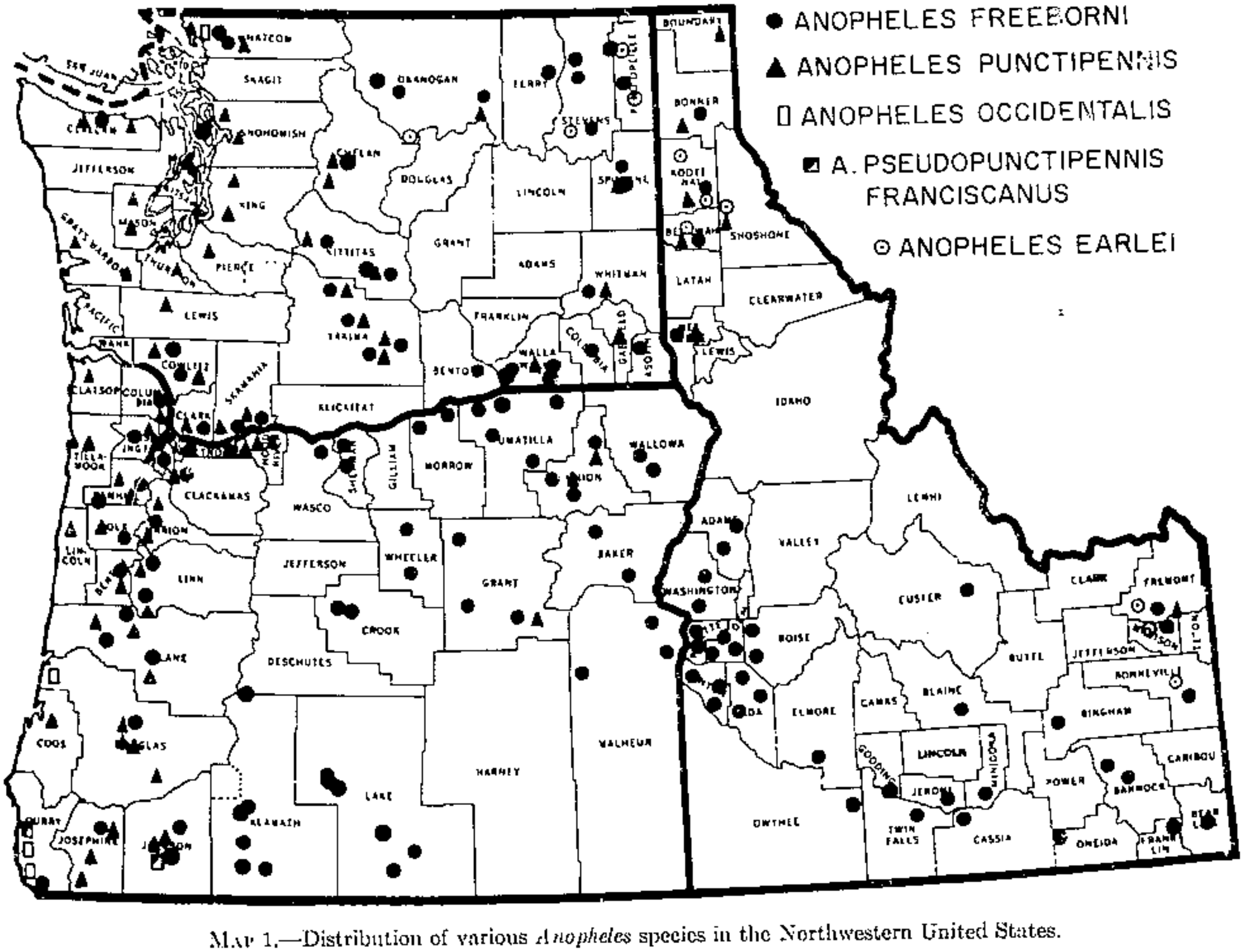
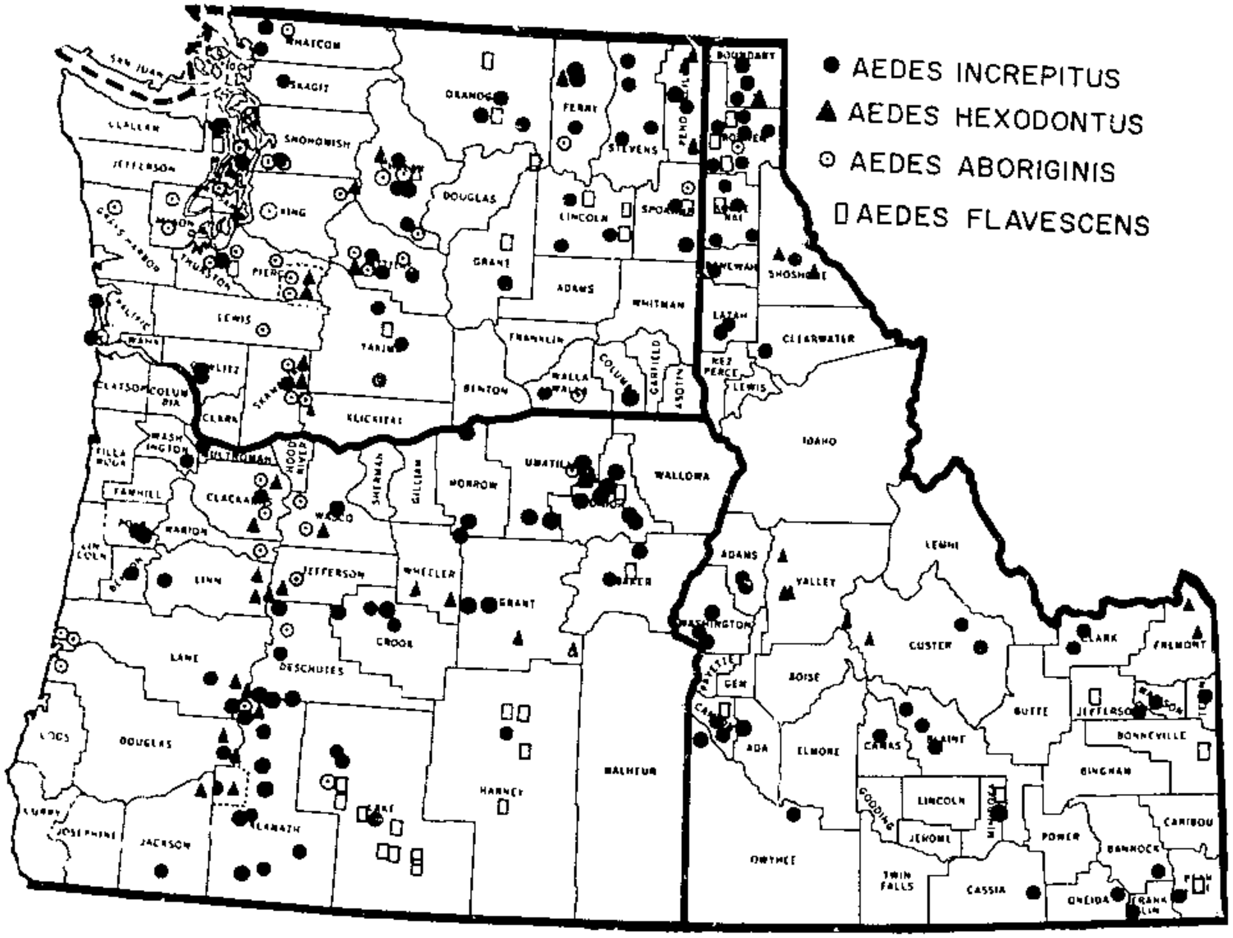
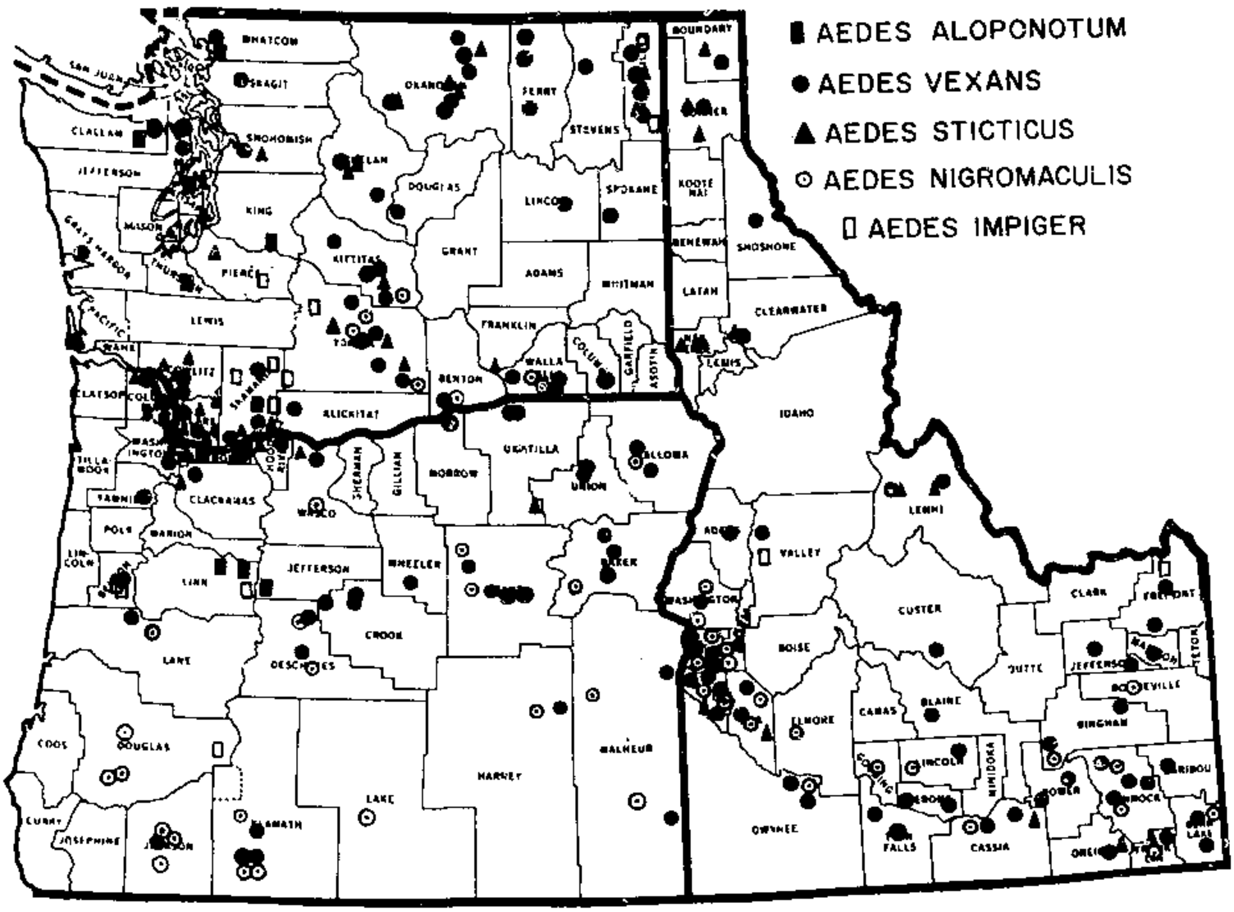
APPENDIX



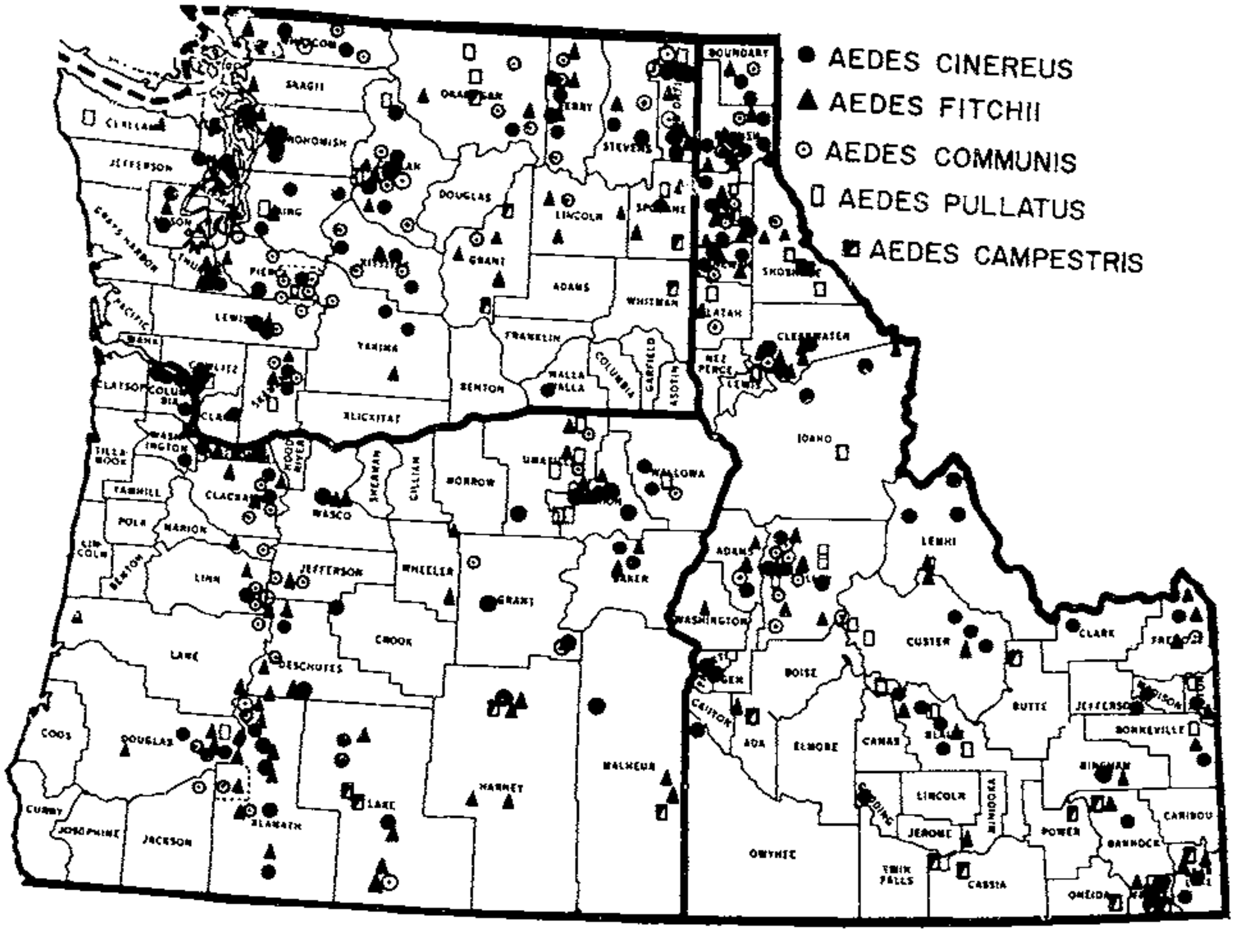
MAP 1.—Distribution of various *Anopheles* species in the Northwestern United States.



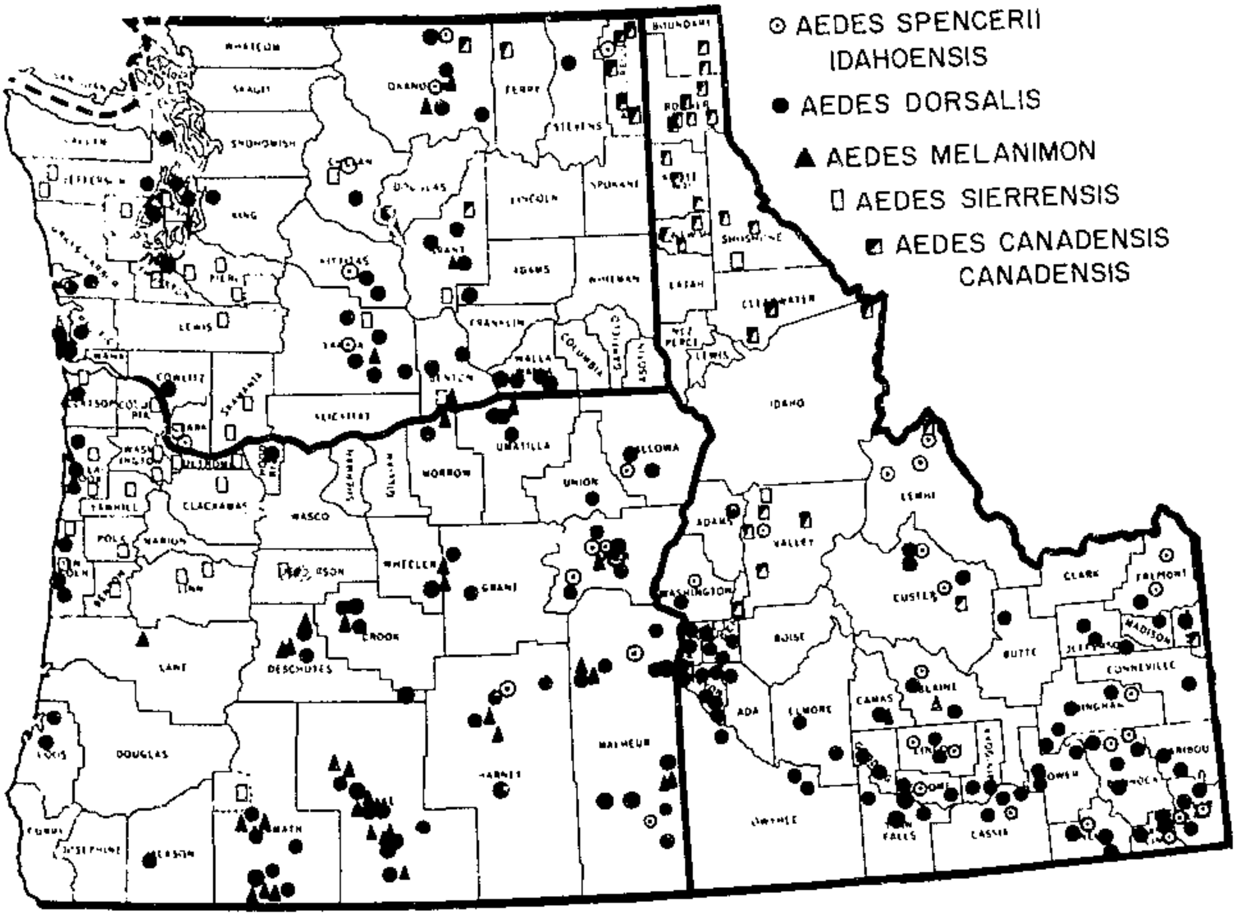
MAP 2.—Distribution of various *Aedes* species in the Northwestern United States.



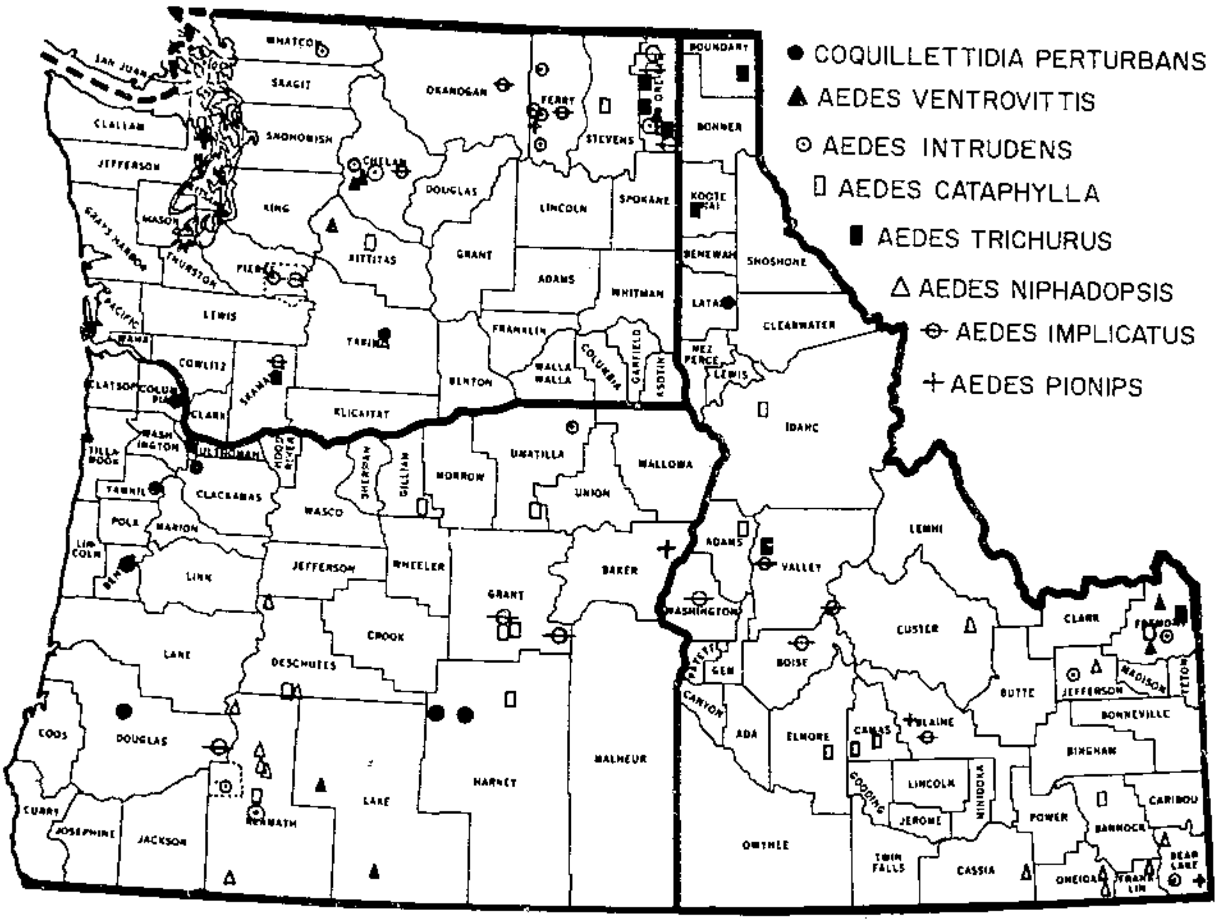
Map 3.—Distribution of various *Aedes* species in the Northwestern United States.



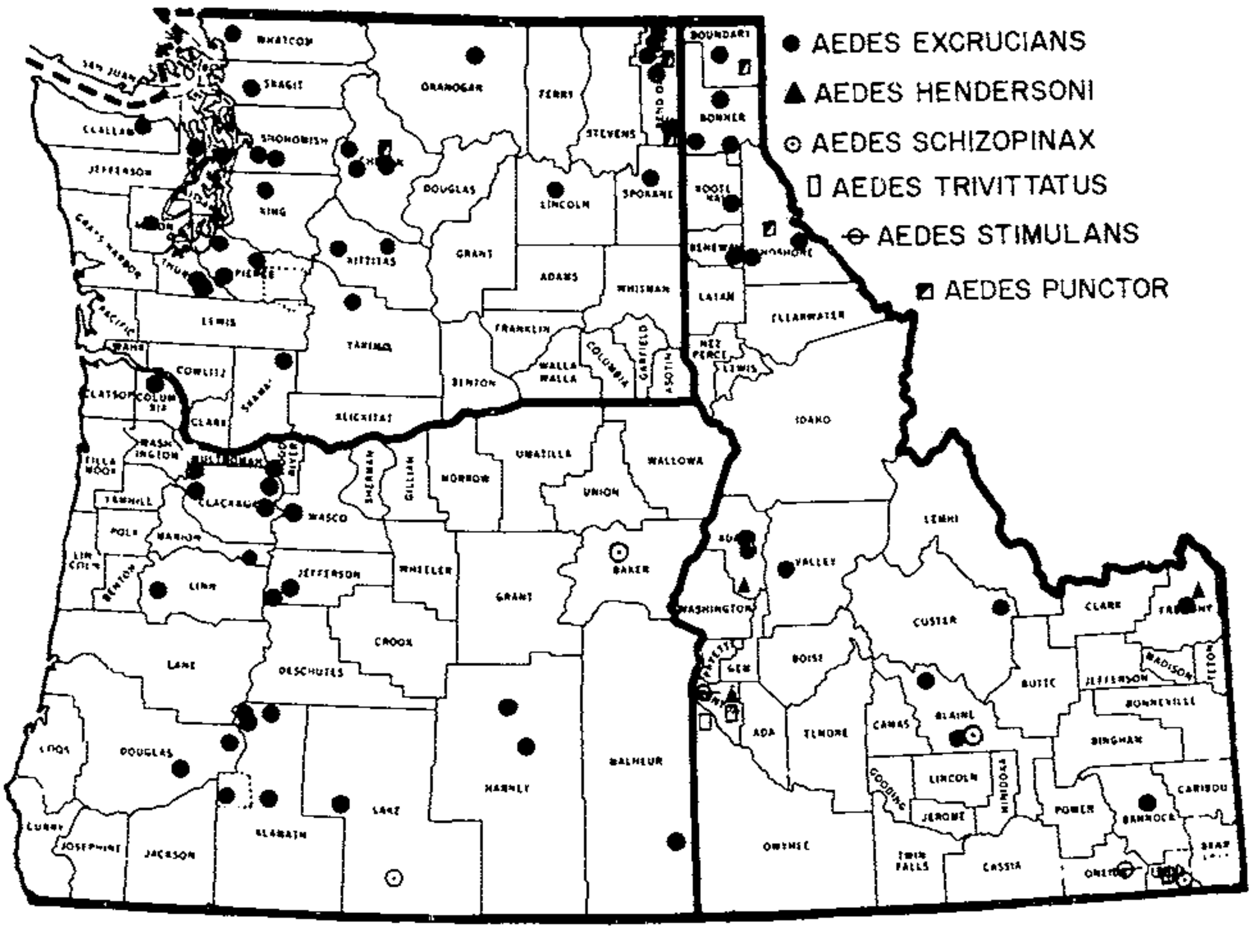
MAP 4.—Distribution of various *Aedes* species in the Northwestern United States.



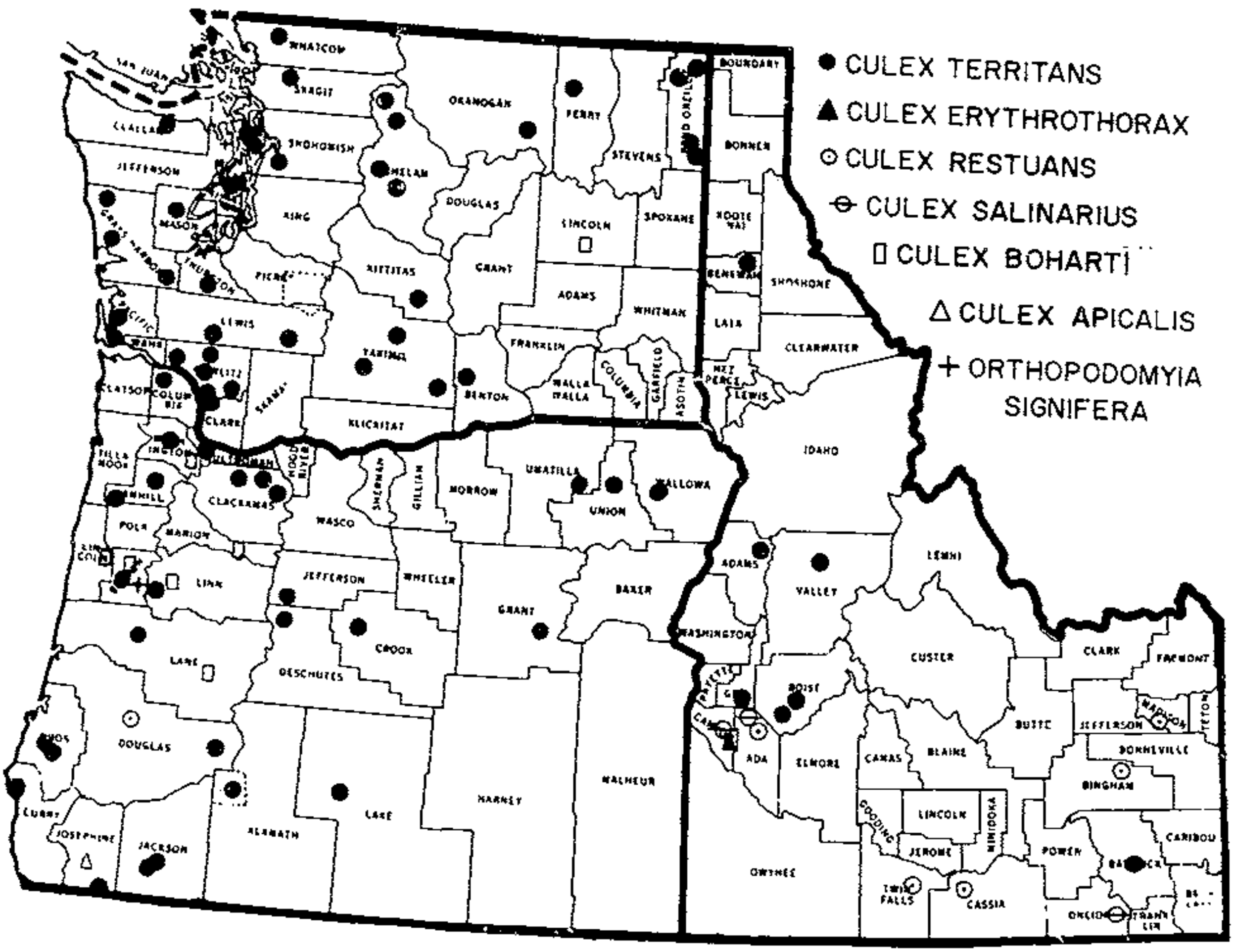
MAP 5.—Distribution of various *Aedes* species in the Northwestern United States.



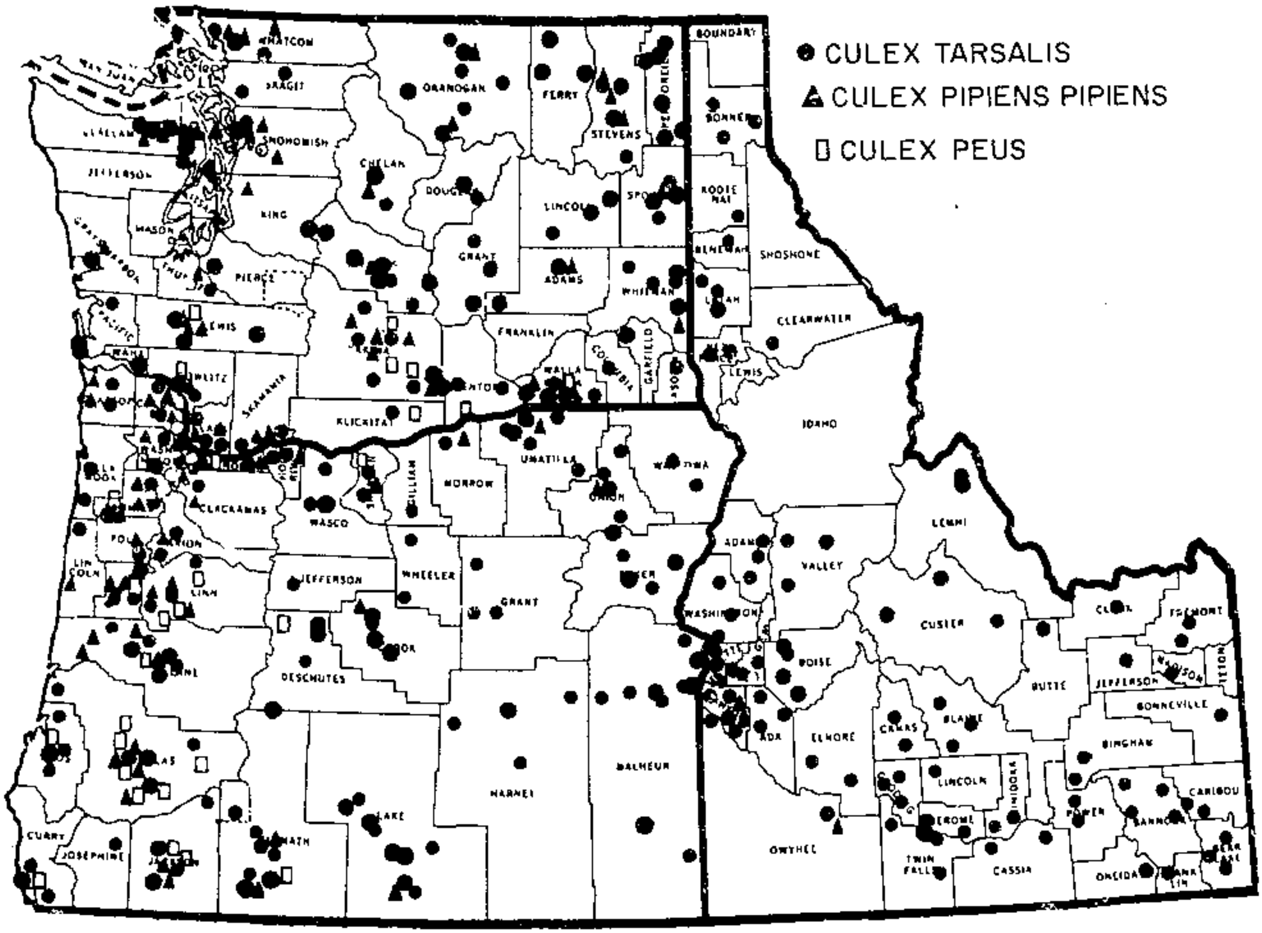
MAP 6.—Distribution of various *Aedes* species and one *Coquillettidia* species in the Northwestern United States.



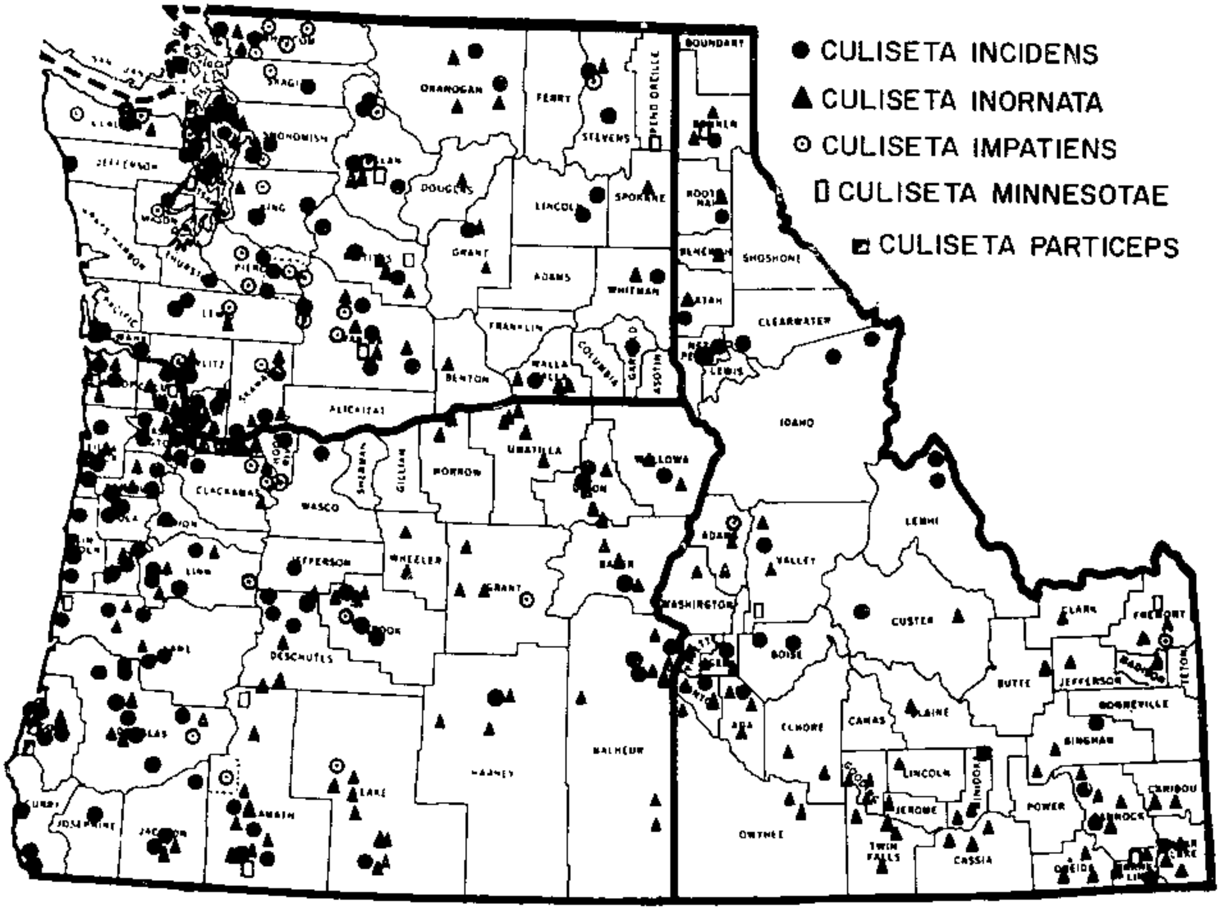
MAP 7.—Distribution of various *Aedes* species in the Northwestern United States.



MAP 8.—Distribution of various *Culex* species and one *Orthopodomyia* species in the Northwestern United States.



MAP 9.—Distribution of three *Culex* species in the Northwestern United States.



MAP 10.—Distribution of various *Culiseta* species in the Northwestern United States.

INDEX

(Valid mosquito species names in roman type; synonyms, genera, and species not occurring in the Northwestern States in italic. Figures in boldface type refer to the main reference for the genus or species.)

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