

NOTES ON IMPORTANT SPECIES OF MOSQUITOES

THE GENUS *Aedes*

The genus *Aedes*, contains more than 500 species distributed from the polar regions to the tropics. Almost one-half of all North American mosquitoes belong to this genus, which includes many of the major pest species as well as important disease vectors. There are some 70 species of *Aedes* known from the United States of which about 40 may be rather common, at least in certain regions. In general the *Aedes* mosquitoes assume greater importance as one goes from the tropics northward. In the northern United States, as well as in Canada and Alaska, many species of *Aedes* occur and are often present in astronomical numbers.

Species of *Aedes* characteristically lay their eggs either singly on the ground, on the waterline, or slightly above the waterline in tree holes or containers. These eggs hatch after flooding and in some species they are able to survive long periods of drying. Many of the northern species have only one brood a year. Their eggs do not hatch until they have been subjected to periods of drying or cold. Other species are intermittent breeders and have several generations per year depending on rainfall or irrigation practices. *Aedes* species occurring in regions with cold winters pass the winter in the egg stage.

Larval habitats of *Aedes* are extremely variable. In general, they are found in temporary pools formed by rains, melting snow, or overflows. Some species occur in coastal salt marshes that are flooded at intervals by unusually high tides. Others have become adapted to irrigation practices. A few species occur in tree holes, rock pools, and artificial containers.

Practically all species of *Aedes* are blood sucking. Many species are vicious biters of

great economic importance. Their biting habits vary but they most frequently attack during evening hours. Some species, however, bite only during the day, and others bite either by day or by night. Flight ranges are extremely variable, being rather short for domestic and woodland species, and extremely long for many floodwater and salt-marsh species.

Aedes aegypti (Yellow fever mosquito)

The yellow fever mosquito is a small dark species that can be recognized by the lyre-shaped silver-white lines on the thorax and the white bands on the tarsal segments. It is the vector of urban yellow fever and dengue, and a pest of some significance when it occurs in large numbers (Fig. 8).

Ae. aegypti was originally a tropical

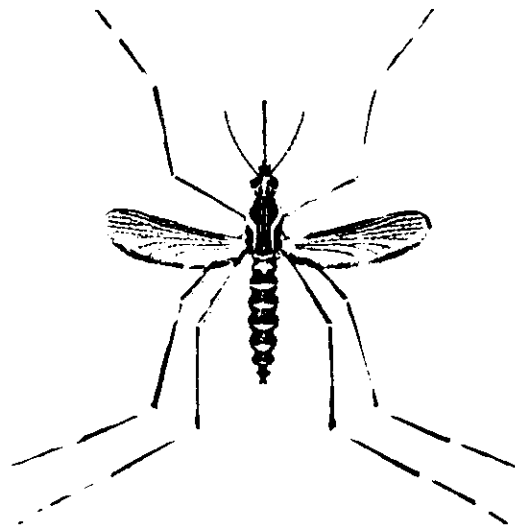


Figure 8. *Aedes aegypti*

species, thought to have been introduced into the Western World from Africa. Its current distribution in the United States includes the southeastern and southern states extending

northward to North Carolina, Tennessee and Arkansas. It was formerly an abundant species in most southern cities and extended northward along the Atlantic Coast probably into New England and in the Mississippi basin only as far north as Illinois.

Aedes aegypti is semi-domesticated. Its larval habitats are almost exclusively in artificial containers in and around human habitations. The eggs are laid singly on the inside of containers at or above the waterline, or less often on the water surface. They are able to withstand drying for several months and hatch quickly when containers are again filled with water. Hatching can take place in two or three days if temperatures are high. Typical artificial containers are flower vases, tin cans, jars, discarded automobile tires, unused water closets, cisterns, rain barrels, sagging roof gutters and tree holes.

The larvae can complete their development in 6 to 10 days under favorable conditions. In cool weather development is longer. The pupal period is about 2 days. The life cycle can be completed in 10 days, or it may vary as long as three weeks or more. This mosquito breeds throughout the year in the tropics, where generations succeed each other rapidly. In the southern United States, the reproduction rate is slower during the winter. The eggs sometimes remain dormant for several weeks or months. This species is very susceptible to cold and usually does not survive the winter in the northern United States.

The adults apparently prefer the blood of man to that of other animals. *Aedes aegypti* enter houses readily, even those that are well screened. This mosquito bites principally during the morning and late afternoon. It attacks quietly and prefers to bite about the ankles, under coat sleeves, or at the back of the neck. It often becomes a troublesome pest. The adults live four months or more in the laboratory. Their usual flight range is from

100 feet to 100 yards, but longer distances have been recorded.

Aedes albopictus (Asian tiger mosquito)

The Asian tiger mosquito was introduced many times into the United States, usually as eggs or larvae in used tires from Asia. It became established and was detected in Houston, Texas in 1985 and has since spread to 21 states and 257 counties. Known infestations have been reported as far east as Florida and Georgia, north to Maryland and Delaware in the east and Chicago, Minnesota and Nebraska in the west. *Aedes albopictus* has been reported as a vector of dengue in Hawaii, the Philippines, and Southeast Asia. It is a competent vector of *Dirofilaria immitis*, the heartworm of dog. It has been found infected with the virus of eastern equine encephalitis in Florida (Mitchell, *et al.*, 1992). *Ae. albopictus* strains established in the United States are efficient vectors the viruses of dengue and LaCrosse encephalitis in the laboratory (Francy *et al.*, 1990; Mitchell, 1991).

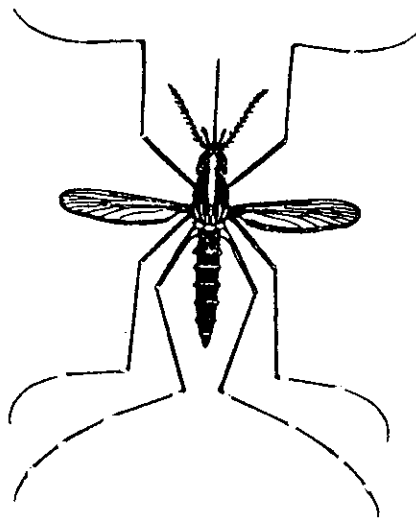


Figure 9. *Aedes albopictus*

The Asian tiger mosquito resembles the yellow fever mosquito (*Ae. aegypti*) in having bright silvery thoracic and abdominal markings and white-banded legs. *Ae. aegypti* has a characteristic silvery lyre-shaped marking on the scutum whereas *Ae. albopictus* has a single longitudinal silvery stripe in the middle of the scutum hence its name (Fig. 9). The larvae of both species, and the treehole mosquito (*Ae. triseriatus*) are found in water-holding containers, particularly used tires, but differ in the shape of the comb scales and other characters as discussed by Darsie (1986). The biology of *Ae. albopictus* is described in detail by Hawley (1988). The mean development time from egg hatch to pupation takes 5 to 10 days at temperatures near 25° C (77 °F) but may take longer at lower temperatures or with suboptimal larval food. Adult females live longer than males. Females live from 4 to 8 weeks in the laboratory but may survive up to 3-6 months, particularly if water, sugar from flowers, or blood is available. In some parts of southeastern United States *Aedes albopictus* is replacing *Aedes aegypti* and is becoming more abundant than *Ae. aegypti*.

Aedes atlanticus

These brownish mosquitoes with a white stripe on the scutum (Fig. 10) can be separated from *Ae. tormentor* only in the larval stage or by the male genitalia. They are distributed throughout the southeastern states. The species is typically a "woodland" floodwater species whose larvae are found in flooded woodland bottoms or temporary grass pools in or near woods.

Aedes canadensis (Woodland pool mosquito)

This dark mosquito has the tarsi with white at both ends of the segments. It is widely distributed in the United States and is particularly common in the northern states. It is often a serious pest in woodland situations

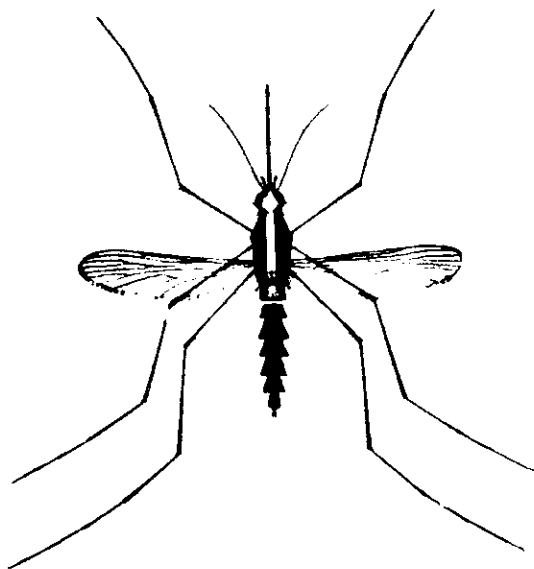


Figure 10. *Aedes atlanticus*

but rarely migrates far from its larval habitats. The viruses of LaCrosse and Eastern Equine encephalitis have been isolated from this species. It has been incriminated in the transmission of dog heartworm (Crans and Feldlaufer 1974).

Aedes canadensis is one of the first mosquitoes to appear in early spring. The larvae live in woodland pools filled by melting snow or by spring rains. This mosquito prefers pools with a bottom of dead and decaying leaves, although larvae are also found in roadside puddles, sink holes, wooded swamps, and isolated oxbows of small woodland streams. There can be more than one generation per year. The adults live for several months. They usually occur from March until October, although they become less abundant in late summer and early fall.

Aedes cantator (Brown saltmarsh mosquito)

The brown salt-marsh mosquito is a rather large, brown species with indistinct white bands on the abdomen and tarsi. It is important along the North Atlantic Coast from Maine to Virginia. *Aedes cantator* is an abundant and severe pest in the coastal marshes of Massachusetts, Rhode Island, Connecticut, New York and New Jersey. Its habits are generally similar to those of *Ae. sollicitans*, though it is not as active during the day and is primarily an evening mosquito. Broods frequently migrate considerable distances, invading shore towns and summer resorts. It is often the dominant species of the salt marshes early in the season but yields this position to *Ae. sollicitans* later in the summer.

Aedes cinereus

This small brown species occurs sparsely throughout most the United States. It is occasionally important as a pest mosquito in some of the northern states. The flight range of *Ae. cinereus* seems to be limited and it is usually found in the woods near larval habitats. It is usually single brooded. The larvae occur in shallow woodland pools and along margins of large ponds.

Aedes dorsalis

This is a medium-sized mosquito that varies in color from dark brown to a whitish straw color. The upper surface of its abdomen is marked with a longitudinal stripe of pale scales. The hind tarsi have both ends of each segment banded with pale scales (Fig. 11). *Aedes dorsalis* is a severe pest of humans and cattle throughout the arid and semi-arid regions of the western United States and has been shown to be a vector of Western equine encephalitis. It occurs over most of the country, but is rare and unimportant in the eastern and southern states. Another western species, *Ae. melanimon* is very similar to

Aedes dorsalis.

A typical floodwater species, the larvae develop in the salt marshes of the Pacific Coast and in irrigation and floodwaters of the interior. They are particularly abundant in irrigated pastures and in waste-water pools. Several broods are produced each year in irrigated areas, each flooding being followed by a brood.

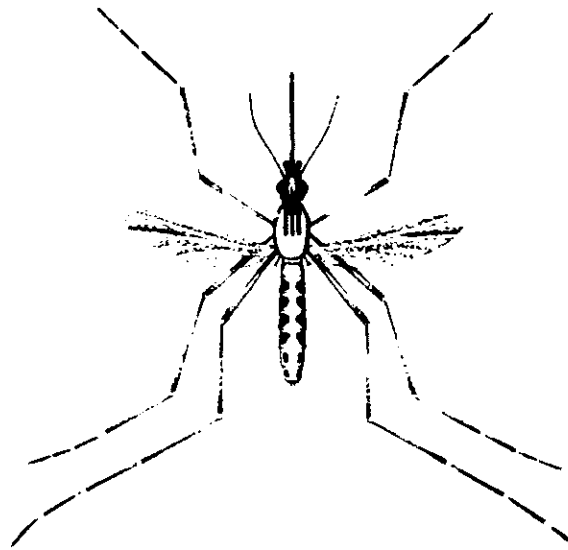


Figure 11. *Aedes dorsalis*

The females of *Ae. dorsalis* are vicious biters that attack by day or night. They are particularly active in the evening or on calm, cloudy days. They are strong fliers and occasionally migrate in large groups. They are often found miles from their larval habitats. The females, and at times the males, are taken in great numbers in light traps. Overwintering takes place in the egg stage. Some eggs can remain viable for several years.

Aedes nigromaculis

This medium-sized mosquito has a longitudinal line of yellowish-white scales on

the upper surface of its abdomen. It has a broad band of white scales at the base of each tarsal segment (Fig. 12). This floodwater species is an important pest mosquito throughout the western plains from Minnesota west to Washington and south to Texas and Mexico. Since World War II it has become prominent in the irrigated pastures of the West, especially in the Central Valley of California. The remarkable spread of this species is indicated by the fact that it was not known to be in California until 1937. It now occurs over most of the state at the lower elevations and is rapidly replacing *Ae. dorsalis* in open sunlit pools of irrigation waste water and other intermittent water.

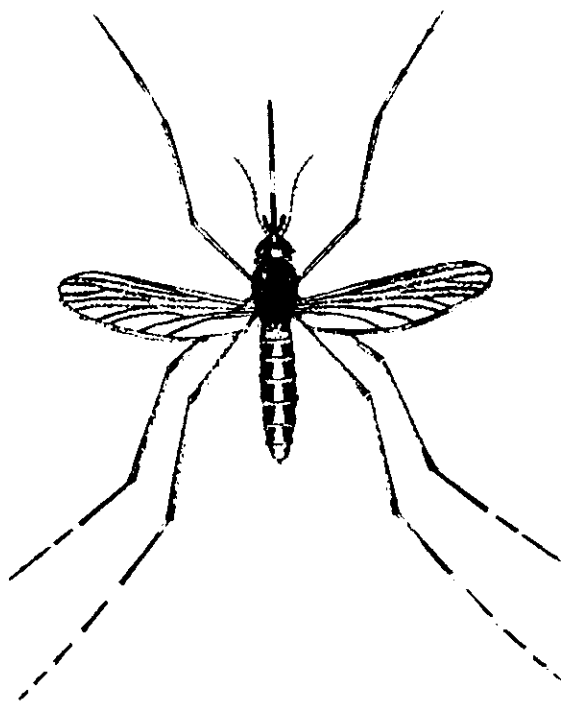


Figure 12. *Aedes nigromaculis*

This species is extremely well adapted to pasture irrigation. The eggs will hatch within 2 to 6 days after flooding. It is able to produce a brood following each irrigation (usually at

intervals of 8 to 12 days) in the Central Valley of California. Under favorable conditions, a brood can be produced in 5 days, and as many as 20 broods can occur in one year. The adult is a very annoying pest of man and animals; it attacks readily and inflicts a painful bite. The viruses of WEE, CE and SLE are associated with this species.

Aedes punctor (and related species)

This group of dark-legged *Aedes* includes such species as *Ae. abserratus*, *Ae. pullatus*, *Ae. communis*, *Ae. hexodontus*, and *Ae. cataphylla*. They are important woodland pests in the northeastern states and in the mountainous regions of the West. The females of these species are difficult to identify. The group is well represented throughout the northern United States, Canada, and Alaska.

All species of this group have a single generation per year. The larvae develop in temporary pools formed by melting snow and along the grassy margins of lakes, ponds, and streams. The flight range of adults is probably less than a mile. Females often cause great annoyance in recreational areas near their larval habitats.

Aedes sollicitans (Saltmarsh mosquito)

Aedes sollicitans, the most important of the saltmarsh species (Fig. 13), can be recognized by the golden color of the upper side of the thorax and longitudinal stripe of white or yellowish-white scales on the abdomen. The proboscis and tarsi also have wide pale bands.

The eggs of this species are laid on the mud or on plants in marshes where they remain until flooded by high tides or rains. Larval production generally occurs on the parts of the marsh not covered by daily tides; usually pot holes and depressions of various size are utilized, but sometimes large numbers of larvae are found over rather extensive level areas.

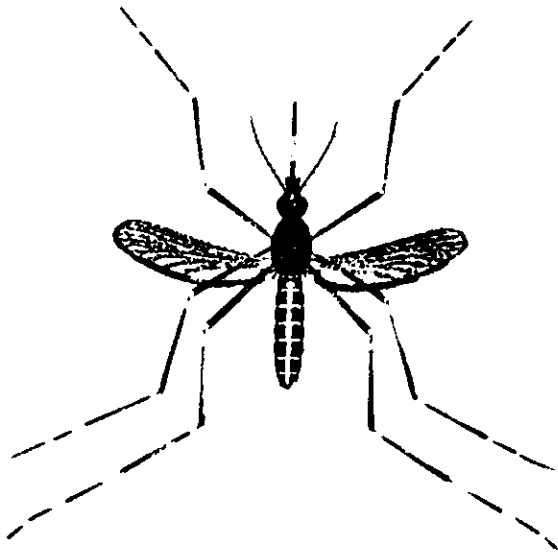


Figure 13. *Aedes sollicitans*

After the eggs have been dry for a week or two, they hatch within a few minutes if covered with water. The development of the larvae and pupae to the adult stage requires 7 to 10 days during warm weather. Several generations are produced each year in the northern states. In South Florida breeding is continuous throughout the year.

The adults of *Ae. sollicitans* are strong fliers that often migrate in large swarms from the marshes to cities and towns many miles away. They often fly 5 to 10 miles and can travel 40 miles or more. The migratory flights begin just before dark and frequently consist of tremendous numbers of mosquitoes. In the daytime they rest on vegetation, and will readily attack anyone who disturbs them, even in full sunlight. They are fierce biters and have been a very severe deterrent to the development of some of the coastal resort areas. Large numbers of females and males are often collected in light traps, but the adults

do not often invade houses.

This mosquito species is considered to be an important accessory vector responsible for the transmission of Eastern equine encephalitis from birds to humans and horses.

Aedes spencerii

This species, along with its close relative *Ae. idahoensis*, is an important pest mosquito of the prairie regions of Minnesota, North Dakota, and Montana, extending northward into Canada and southward to Illinois, Iowa, Nebraska, and Utah. The females are fierce biters, attacking during the day, even in bright sunlight. They are serious pests of humans and livestock. They often migrate into cities and towns, but their flight range has not been determined. There is probably only one generation a year. The larvae are found in surface pools filled by melting snow or spring rains.

Aedes sticticus (Floodwater mosquito)

Aedes sticticus is a medium-sized species. The scutum is striped with dark-brown scales and the legs are speckled with white scales but are not banded. It is a floodwater species that occurs throughout most of the United States. It is an important pest mosquito in such widely separated areas as central New York and the Columbia River Valley of Washington and Oregon.

Aedes sticticus usually has only one brood annually. The eggs are laid on the ground particularly in the valleys of rivers and smaller streams. A loam soil with either dead or live vegetation or both, is preferred to bare areas exposed to the sun and wind. Eggs do not hatch until the spring or summer following the season during which they were deposited. If flooding does not occur eggs will survive 2 or 3 years. Larval development requires 10 days to 3 weeks depending upon temperature.

Adults are often very abundant following spring floods. The females are ferocious biters during the evening, and also during the day in cloudy or shaded situations. The flight range is extensive, possibly up to 25 or 30 miles. They may live as long as 3 months.

Aedes "stimulans" Group

This group includes four common and rather widely distributed woodland species: *Ae. stimulans*, *Ae. excrucians*, *Ae. fitchii*, and *Ae. increpitus*. Their habits are generally similar and the adult females are difficult to separate. They occur throughout most of the northern states from New England to the Pacific Coast, although *Ae. increpitus* apparently does not occur east of the Rocky Mountains. These species are among the most abundant and annoying of the woodland mosquitoes in many of the northern states. They bite readily in the daytime. There is only one generation a year but the adults may live most of the summer. The winter is passed in the egg stage, hatching with the melting of the ice and snow in early spring.

Aedes taeniorhynchus (Black saltmarsh mosquito)

This species, known as the black saltmarsh mosquito, has cross bands of white scales on the upper side of the abdomen, a white band on the proboscis, and white bands on the tarsi (Fig. 14). It occurs on the coastal plain from Massachusetts to Texas and on the Pacific Coast in southern California. It has also been reported from certain inland areas around salt pools in oil fields. It is the most abundant and troublesome salt-marsh species along the south Florida coasts and can be a severe pest as far north as New Jersey. It has been incriminated as a vector of dog heartworm.

Larval habitats are similar to those of *Ae. sollicitans*, but larvae are also found in fresh water pools near the salt marshes. The adults

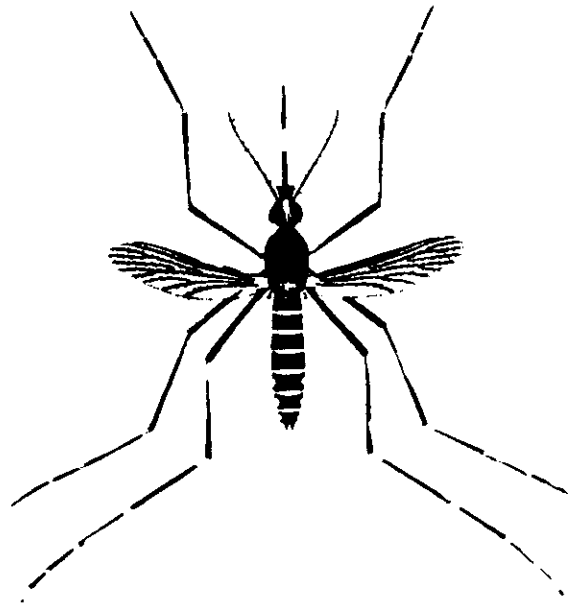


Figure 14. *Aedes taeniorhynchus*

are strong fliers and fierce biters, being active principally at night. They may be very annoying in the shade during the day, but are less likely than *Ae. sollicitans* to attack in bright sunlight. According to Elmore and Schoof (1963), 75 percent of the females in one release study were recovered within 4 miles of the release point, but some females were collected as far away as 18 miles.

Aedes triseriatus (Eastern treehole mosquito)

This tree-hole mosquito is blue-black and has silvery-white scales on the sides of its scutum (Fig. 15). It occurs throughout the eastern United States, the larvae developing principally in tree holes, old tires, tin cans, barrels, and other artificial containers. Larval development appears to be rather slow; nearly a month is required to reach maturity. Adults are fierce daytime biters in or near infested woods, and are also annoying around

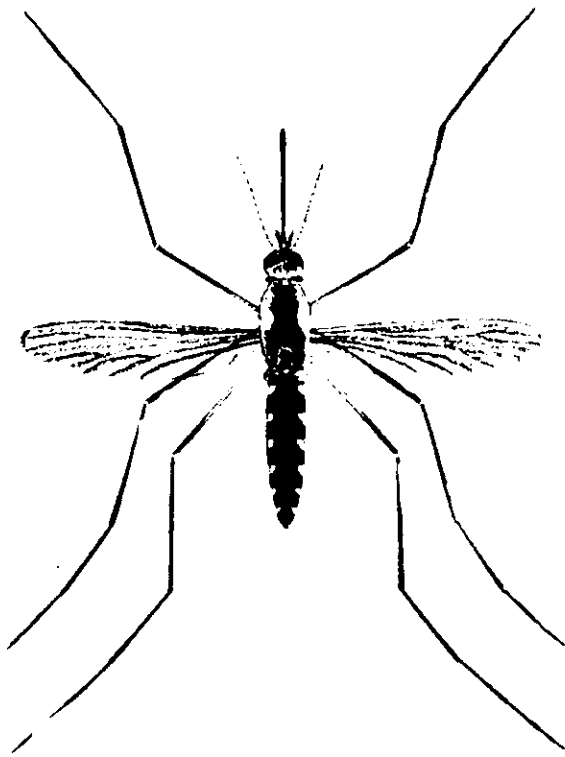


Figure 15. *Aedes triseriatus*

dwelling where larval development occurs in containers or tree holes. The flight range is characteristically short. This species is an important vector of LaCrosse encephalitis virus and dog heartworm.

Aedes trivittatus

Aedes trivittatus is widely distributed in the northern United States from Maine west to Idaho. It has been collected as far south as Georgia, Louisiana, and Arizona. It is a fierce biter and an extremely annoying pest in some of the northern states. The upper surface of the thorax is marked with two conspicuous whitish stripes. The larvae occur mostly in floodwater pools and temporary rain pools. The young larvae feed at the surface of the

water but the later instars spend most of their time concealed in the vegetation at the bottom of the pool. Perhaps it is for this reason that larvae are seldom encountered even though adults may be present in large numbers. Emergence of adults begins about 8 days after hatching. The adults rest on grasses and other vegetation during the daytime. They will bite when disturbed and are especially active in the evening. They do not appear to migrate far.

Aedes "varipalpus" Group (Western treehole mosquito)

Collectively, these western tree-hole mosquitoes are a group of small, dark species with brilliant white bands at both ends of each tarsal segment (Fig. 16). They occur in western North America from Arizona to British Columbia, and are important as pest species in some parts of California. At present, *Aedes sierrensis* is considered the correct name for the species on the Pacific Coast. *Aedes varipalpus*, *Ae. deserticola*, and *Ae. monticola* occur in other parts of the West. These species ordinarily breed in tree holes, but may also occur in rain barrels that contain a heavy sediment of decaying leaves. The adults are often so small that they can pass through ordinary window screens. However, they seem to bite less readily indoors than outdoors. *Aedes sierrensis* has been shown to be an experimental vector of WEE and vector of dog heartworm.

Aedes vexans (Inland floodwater mosquito)

Aedes vexans (Fig. 17), the inland floodwater mosquito, is a medium-sized, brown mosquito with narrow rings of white scales on the hind tarsi and with a V-shaped notch at the middle of each band of white scales on the upper surface of the abdomen. This is probably the most widespread species of *Aedes* in the United States and the most abundant and troublesome mosquito in many

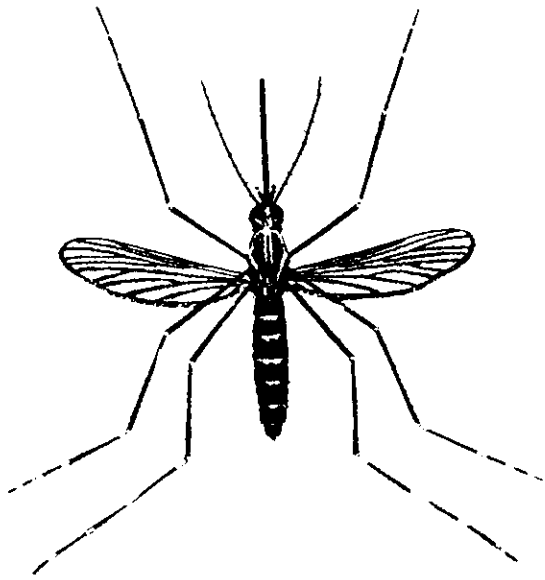


Figure 16. *Aedes sierrensis*

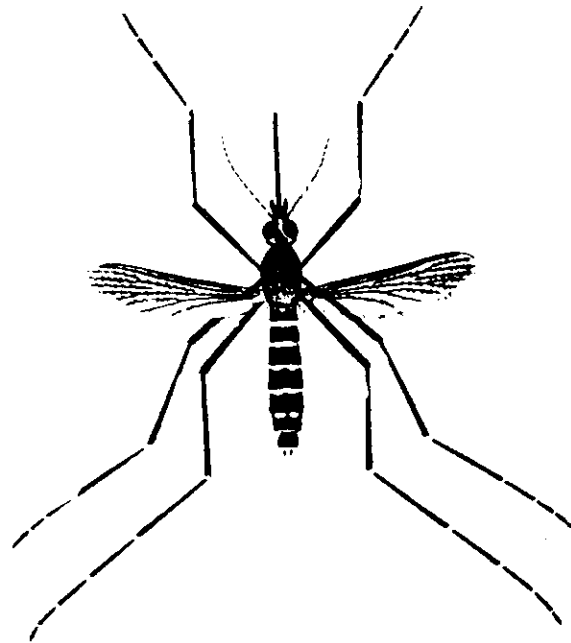


Figure 17. *Aedes vexans*

areas. It has been reported from every state, and is a major pest in most of the northern states from New England to the Pacific Coast. It is less abundant in the extreme South. This species has been found to be naturally or experimentally infected with several arboviruses including SLE, EEE, WEE and LAC.

Aedes vexans larvae are found in rain pools, floodwaters, roadside puddles, and practically all temporary bodies of fresh water. Eggs are laid on the ground, hatching when flooded. In receding waters larvae may frequently be concentrated so that 500 or more are found to each pint of water. Development of the aquatic stages requires 10 to 21 days, depending on temperature. They are single-brooded in some areas in the western states where flooding occurs only in the spring. In most of the *Ae. vexans* range there are several generations per year.

Adults migrate long distances from their

breeding places 5 to 10 miles being rather common. The adults are vicious biters and are especially annoying at dusk and after dark. Studies in Oregon have shown that the adults live for nearly 2 months. They are attracted to light, and both males and females are frequently taken in light trap collections. They rest during the day in grass and other vegetation, and only rarely are found in shelters of the type used for evaluation of anopheline populations. Clarke and Wray (1969) published an important article indicating that *Ae. vexans* migrated several miles into cities in Illinois about 15 days after flooding by rain of an inch or more in a 24-hour period. Their studies on light trap collections, temperature, and rainfall as they relate to fogging for adult mosquito control contain important information for operational personnel.

GENUS ANOPHELES

Anopheline mosquitoes are distributed throughout the United States. One or more species is present in every state except Hawaii. Most anophelines have spotted wings while most culicines have no wing spots. Female anophelines have the palpi about as long as the proboscis, whereas female culicines have the palpi much shorter than the proboscis. Anophelines rest with the head, thorax, and abdomen all in a straight line, held at an angle of 40 to 90° to the surface on which they are sitting. Culicines usually rest with the thorax and abdomen somewhat parallel to the surface on which they are sitting (Fig. 4).

The eggs of anophelines are always laid singly on the water surface and are supported by lateral floats. The female lays her eggs in batches of 100 or more. Each female can lay several such batches in her lifetime--a total of 400 to 500 eggs or more. The eggs hatch in two to six days. Larval production is continuous during the warm seasons of the year.

Anopheline larvae are found in many different types of water, but mainly in permanent bodies of fresh water. Larvae of two species, *Anopheles atropos* and *An. bradleyi* are found in salt or brackish waters. Larvae of all other anophelines in this country develop in fresh water. The larval stages last from 6 to 7 days to several weeks, depending upon the species and environmental conditions, especially water temperature. The larvae feed just beneath the water surface where they ingest microscopic animal and plant life.

Most anophelines favor water that contains aquatic plants, and larvae are often abundant where aquatic plants provide protection from fish and other predators. Most adult anophelines are active at night. They spend the daytime hours resting in dark, damp shelters. They are most active just after dark and again

just before daylight. The flight range varies from less than one mile to several miles. Most anophelines need a blood meal before they can produce fertile eggs. The species in the United States feed more frequently on the blood of domestic animals than on man. The winter is usually passed as hibernating, fertilized females. *Anopheles walkeri* overwinters in the egg stage. Anophelines were formerly highly important as malaria vectors in the United States. Currently, however, malaria transmission in this country is a rarity, although anopheline vector populations still exist in many areas. Anophelines have been found infected with encephalitis viruses and might have a role in their transmission.

Anopheles albimanus

This species is the major vector of malaria in the Caribbean Region and in Central America, but has been found only in southern Texas and the Florida Keys in the United States. It is the only anopheline in the continental United States with a broad white band on the hind tarsus.

Anopheles crucians

This anopheline has areas of pale and dark scales on the wings and three prominent dark spots on the last wing vein. The palpi are banded with white (Fig. 18). It has not been considered an important vector of malaria. However, it is susceptible to infection in the laboratory and may have been the vector of a case of malaria contracted in Georgia in 1968. It bites humans readily but is not ordinarily significant as a pest. It occurs throughout the southeastern United States and northward along the coastal plain to Massachusetts. It is most abundant on the Atlantic and Gulf Coastal Plains.

Anopheles crucians larvae are often found in the acid water typical of cypress swamps and ponds in coastal Florida and Georgia.

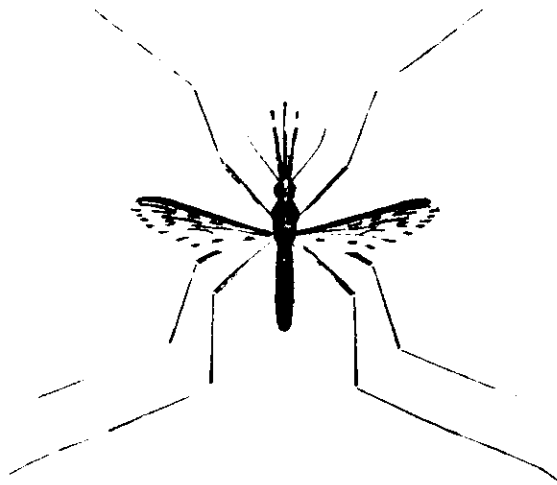


Figure 18. *Anopheles crucians*

Larvae are also found in many other habitats such as lake margins, wheel ruts, and sluggish streams. Adults are found in shelters of the same type frequented by *An. quadrimaculatus*. They are often taken in great numbers in light traps. Their flight range may be somewhat greater than one mile, especially in areas where they are abundant. Two other species in the *An. crucians* complex are *An. bradleyi*, typically a salt-marsh breeder, and *An. georgianus*, whose larvae are found in fresh water seepage.

Anopheles franciscanus

Anopheles franciscanus is similar to *An. pseudopunctipennis* in appearance and habits. It occurs along the Pacific Coast from southern Oregon into Mexico and eastward into Nevada, Arizona, and New Mexico. It is often present in great numbers in certain localities but is not believed to have been an important malaria vector. *Anopheles franciscanus* is often found at the mouths of rivers entering the Pacific and their larvae occur in abundance in the shallow pools of sandy arroyos. Their

larval habitats are similar to those of *An. pseudopunctipennis*.

Anopheles freeborni

This species is similar in appearance to *An. quadrimaculatus*, and was the most important vector of malaria in the western United States. It enters houses and animal shelters readily and bites avidly at dusk and at dawn. This species occurs over most of the area west of the Continental Divide, from southern British Columbia to Lower California. East of the Divide it is found from eastern Montana to western Texas and eastern New Mexico.

The aquatic stages of *An. freeborni* are found in permanent or semipermanent waters that are at least partially exposed to sunlight, and contain vegetation or flottage. Clear, clean, slightly alkaline water is preferred. Larvae are also found in slightly brackish water near the ocean or in desert pools. This species usually avoids water polluted with sewage or other organic materials. Habitats may be very similar to those in which *An. quadrimaculatus* is found, but it has for the most part adapted itself to seepage areas, borrow pits, hoof prints, improperly irrigated fields, and the edges of streams or irrigation canals. Rice fields are a particularly favored site for this species. This mosquito is well adapted to the semi-arid region in which it occurs. The midseason flight range of *An. freeborni* females is usually restricted to a one-mile radius. In cases of very large populations in rice fields, longer flights up to 2 1/2 miles have been reported. Males, however, are seldom found more than one-quarter mile from their larval habitats.

In California, *An. freeborni* leave their hibernating places in February, take a blood meal, and lay eggs for the first generation. Because of the abundance of water areas at this time of year, and the scarcity of predators, large broods develop. Succeeding

generations are greatly reduced in range and size by the recession of waters, except where irrigation waters maintain their habitats. In late fall at the end of the dry season, females migrate long distances, sometimes 10 to 12 miles, finding shelter in outbuildings, homes and cellars. During the winter season they are in a state of semi-hibernation from which they emerge on warm days and nights for feeding. This winter feeding is seldom to repletion and usually does not result in the development of eggs.

Anopheles hermsi

Adults of *Anopheles hermsi* closely resemble those of *Anopheles freeborni* as described by Barr and Guptavanij (1988). Studies by Fritz, *et al.* (1991) indicate that at present there are no reliable anatomical characters that distinguish eggs, larvae, adults, or X-chromosome of *An. hermsi* from those of *An. freeborni*. These authors wrote "Crossing studies or examination of rDNA restriction enzyme profiles, are presently the only means of identifying *An. hermsi*." *Anopheles hermsi* occurs in California south of the Tehachapi and west of the Coast Range as far north as San Mateo county. *An. freeborni* has a wide distribution in the western third of the United States. *Anopheles hermsi* was probably the vector of malaria from Mexican immigrant agricultural workers to other migrants and a few residents who had never been out of the country in San Diego county, California in 1986 (27 cases) and in 1988 (30 cases).

Anopheles pseudopunctipennis

This species is similar in appearance to *A. punctipennis* except that the palpi are banded with white (Fig. 19). It occurs in south central United States, extending into Mexico, Central and South America. *Anopheles pseudopunctipennis* is considered an important vector of malaria in foothill regions of Mexico

and parts of South America.

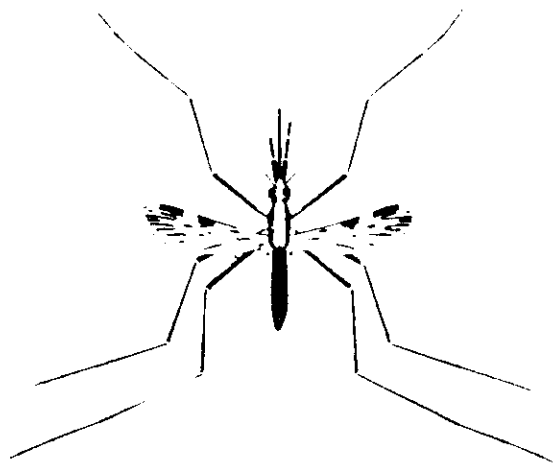


Figure 19. *Anopheles pseudopunctipennis*

Anopheles pseudopunctipennis larvae are found in pools in shallow or receding streams, especially those in full sunlight containing luxuriant growth of green algae. They also are found in other ground pools, ponds, and occasionally in artificial containers such as fountains and tanks. They are often found in water that is warm to the touch, much too warm for other anophelines. Their flight range is usually a mile or less.

Anopheles punctipennis

This mosquito has the wings conspicuously marked with spots of pale and dark scales (Fig. 20). The palpi are entirely dark. It probably occurs in all of the contiguous states. This species is not known to be a natural vector of malaria although it may be infected in the laboratory. It is a rather vicious biter out-of-doors, but apparently does not enter homes as readily as do *An. quadrimaculatus* and *An. freeborni*.

Anopheles punctipennis larvae occur in a wide variety of habitats. Larvae are often found along with *An. quadrimaculatus* in

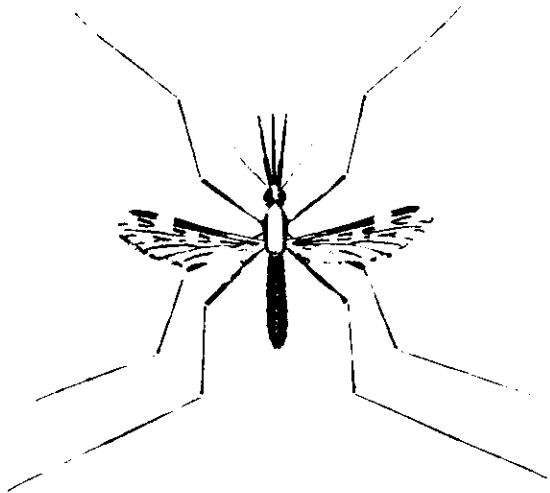


Figure 20. *Anopheles punctipennis*

permanent pool situations, or in rain barrels, hog wallows, grassy bogs, spring pools, swamps, and along margins of streams. They seem to prefer cool water and are the first anophelines to appear in the spring. They are the most abundant during the spring and fall in the southern states but are found in more uniform numbers throughout the summer in the northern states.

Anopheles quadrimaculatus (Common malaria mosquito)

This fairly large, dark brown mosquito has four dark spots near the center of each wing. The palpi and tarsi are entirely dark (Fig. 21). This species was the most important vector of malaria in the United States. It is the anopheline most frequently found in houses and is, with the possible exception of *An. freeborni*, more likely to attack humans than any other anopheline of the United States. *Anopheles quadrimaculatus* has probably been responsible for the transmission of almost all human malaria that has occurred east of the Rocky Mountains.

This species is distributed from the southeastern United States northward to southern Quebec and Ontario and westward to the Dakotas, central Nebraska, Kansas, Oklahoma, and Texas. It also occurs in Eastern Mexico as far south as Vera Cruz. It is most abundant in the South Atlantic and Gulf Coastal Plains and the lower Mississippi River Valley. It may also become abundant at times in areas as far north as Minnesota, Michigan, New York, and New England.

Anopheles quadrimaculatus larvae are found chiefly in permanent fresh water pools, ponds, and swamps which contain aquatic vegetation or floating debris. It is most abundant in shallow waters. In some areas it appears to favor open sunlit waters while in others it is found in densely shaded swamps. This species shows a preference for clear, quiet waters which are neutral to alkaline and does not usually occur where the pH is lower than 6. It seldom occurs in stagnant waters heavily polluted with plant or animal matter. Some of the common habitats are lime-sink ponds, borrow pits, sloughs, bayous, sluggish streams and shallow margins, and backwater areas of reservoirs and lakes. Production is greatest in waters with aquatic vegetation or flottage of twigs, bark and leaves.

The most favorable temperature for the development of *An. quadrimaculatus* is between 85 and 90° F at which temperature only about 8 to 14 days are required. The larvae can withstand rather low temperatures, but do not complete their development at temperatures below 50 to 55° F and no appreciable development takes place until the water temperature reaches 65 to 70° F. Even at these temperatures from 30 to 35 days may be required for development of the aquatic stages. The males emerge first, remaining near the larval habitats. The females mate soon after emergence, often during their first day, either before or after the first blood

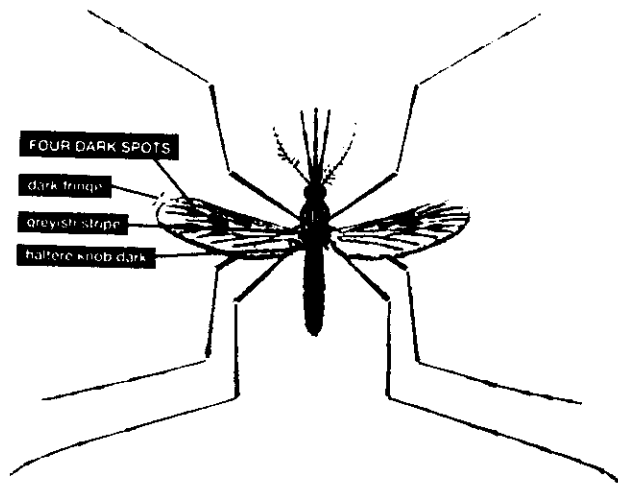


Figure 21. *Anopheles quadrimaculatus*

meal and egg laying begins from 2 to 3 days after the first blood meal. A single female may deposit a total of over 3,000 eggs in as many as 12 batches.

During the daytime adults remain inactive, resting in cool, damp, dark shelters, such as buildings, caves, and under bridges. Feeding and other activity occurs almost entirely at night. They enter houses and readily feed upon humans but they feed more frequently on other warm-blooded animals such as cows, horses, mules, pigs, and chickens. Normally, most adults fly not more than one-half mile from their larval habitat and only a small percentage fly farther than one mile. *Anopheles quadrimaculatus* is not ordinarily taken in light traps in great numbers. In the most southern part of the country, *An. quadrimaculatus* production occurs continuously throughout the year. Over most of its range, however, it spends the winters as fertilized adult females in caves, hollow trees, basements, and other protected places. In all but the most northern areas females may emerge from hibernation and move about and take blood meals on warm

days during the winter. In the spring, the females emerge, take a blood meal and deposit their eggs. There may be as many as 9 or 10 generations each season. Populations often reach a peak during July or August and decline rapidly in September and October. Hibernating females may survive from 4 to 5 months.

Anopheles walkeri

This species resembles *An. quadrimaculatus*, though it is somewhat darker and has narrow white rings on the palpi. It is widely distributed in eastern United States, extending from southern Canada southward to Vera Cruz, Mexico, and as far west as Minnesota, Nebraska, Kansas, and Texas. *Anopheles walkeri* readily bites humans and is a good laboratory vector of malaria. Its past epidemiological importance in relation to malaria is undetermined.

Anopheles walkeri larvae are often found in sunny marshes, or along lake margins, among thick growths of aquatic vegetation such as cattails and sawgrass. It may also be found along the grassy edges of slow-flowing swamp streams and in bordering pools. In the northern states it produces a distinctive type of egg known as the "winter egg" in which stage it passes the winter. The adults often rest during the day on the lower part of the stems of sedges and grasses and other emergent vegetation of their larval habitats. *Anopheles walkeri* is frequently collected by the hundreds or thousands in light traps.

THE GENUS *CULEX*

The genus *Culex* includes about 300 species, most of which occur in the tropical and subtropical regions of the world. Some 29 species have been reported in the United States although only 12 of these are at all common. The group includes several important pest

species and disease vectors.

Culex mosquito larvae are found in quiet waters of almost all types, from that in artificial containers to large bodies of permanent water. Water in which there is considerable organic material, including sewage, is often a favored larval habitat. The eggs are deposited in rafts of 100 or more. They remain afloat on the water surface until hatching occurs some 2 or 3 days later. Larval development continues throughout the warm season with several generations a year in the southern states. The adult females are generally inactive during the day, biting at night.

Culex erraticus, (and the subgenus *Melanoconion*)

Culex erraticus, *Cx. peccator*, and *Cx. pilosus* are rather small and dark species found in the southeastern states. The females are difficult to determine. Larvae of *Culex erraticus*, the most common species of this group, occur in grassy permanent pools and ponds often in association with anophelines. They have been reported in great numbers in the rice fields of Arkansas. The adults are persistent and painful biters, though they are said to prefer the blood of fowls. They bite principally in the evening.

Culex nigripalpus

This is chiefly a tropical mosquito but occurs as far north as Tennessee and North Carolina. It is quite common in Florida where it is an important pest species in flooded fields. Larvae are also found in ditches and grassy pools. *Culex nigripalpus* was the vector of St. Louis encephalitis virus in the Tampa Bay, Florida, outbreak in 1962 (Chamberlain, 1987), and in Florida in 1990.

Culex stigmatosoma

This is a western species similar in

appearance to *Cx. tarsalis*. Larvae are found in almost all types of ground pools and artificial containers. In California tremendous numbers of larvae have been reported in oxidation ponds. *Culex stigmatosoma* rivals *Cx. tarsalis* in abundance in the Pacific Coast states, but apparently seldom bites humans. It has been found infected with western equine encephalitis virus.

Culex pipiens Complex (Northern and southern house mosquitoes)

The northern and southern house mosquitoes are closely related and difficult to separate. They are brown mosquitoes of medium size with cross bands of white scales on the abdominal segments but without other prominent markings. *Culex pipiens pipiens*, the northern house mosquito, occurs throughout northern United States and is found as far south as Georgia and Oklahoma. *Culex pipiens quinquefasciatus*, the southern house mosquito, (Fig. 22) occurs in all southern states from coast to coast and is found northward to Nebraska, Iowa, Illinois, and Ohio. One or both of these mosquito species are found in every state. In many published articles from outside the United States, this mosquito is referred to as *Culex fatigans*.

In the United States, members of the *Culex pipiens* complex are important vectors in urban epidemics of St. Louis encephalitis.

Culex pipiens pipiens and *Cx. pipiens quinquefasciatus* develop prolifically in rain barrels, tanks, tin cans, and practically all types of artificial containers.

Other important sources of these mosquitoes are storm-sewer catch basins, poorly drained street gutters, polluted ground pools, cesspools, open septic tanks, and effluent drains from sewage disposal plants. Heavy production is often found in water with high organic content.

House mosquitoes lay their eggs in clusters

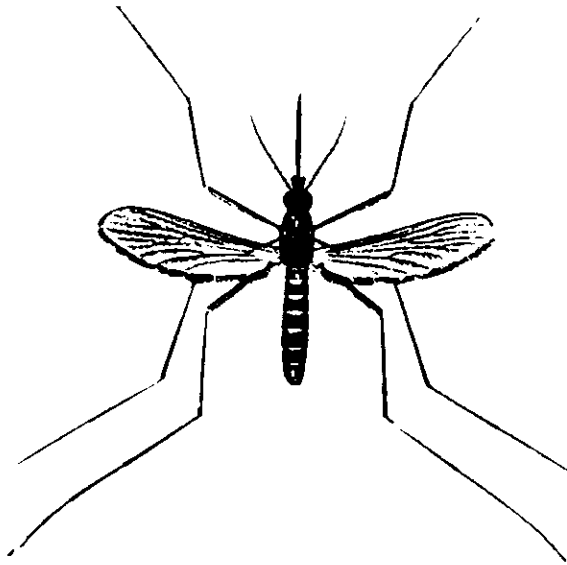


Figure 22. *Culex pipiens quinquefasciatus*

of 50 to 400. These clusters, known as egg rafts (Fig. 4), float on the surface of the water. The eggs hatch within a day or two in warm weather. From 8 to 10 days are required for completion of the larval and pupal stages. In somewhat cooler weather of early spring or late fall, these aquatic stages may require weeks or more. Larval production continues throughout the warmer months of the year. Some strains can survive and produce fertile eggs without a blood meal (autogeny).

House mosquitoes migrate only short distances unless great numbers are produced. Ordinarily, when adults are present, larvae will be found nearby. These species are active only at night and may be found resting during the day in and around houses, chicken houses, outbuildings, and various shelters near their larval habitats. They are attracted to light traps, but the numbers collected may not represent an accurate index of their actual abundance.

Culex restuans (White dotted mosquito)

This species is widely distributed east of the Rocky Mountains from the Gulf of Mexico into Canada. Some observers report that it is often abundant and annoying in the eastern states, while others say that it rarely bites man. It is similar in appearance and habits to *Cx. pipiens* although it is not usually as important a pest and is more rural in its occurrence. It is distinguished from *Cx. pipiens* by the two silvery dots on the scutum (Fig. 23) and by the pattern of bands on the abdomen.

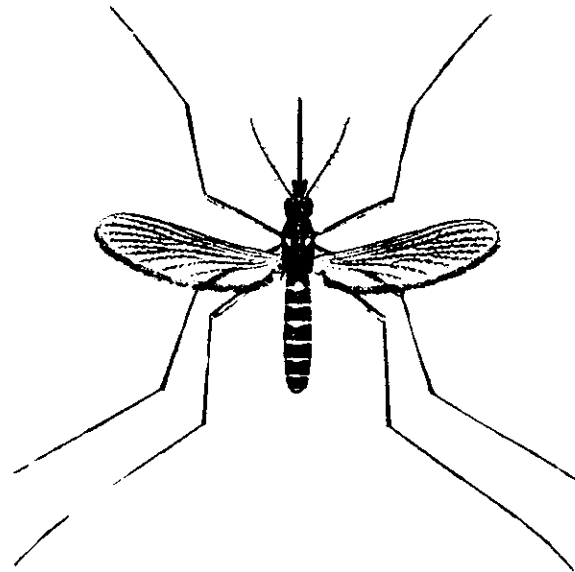


Figure 23. *Culex restuans*

Culex restuans larvae often are found in rather foul water such as that containing decaying grass or leaves. Favored larval habitats are woodland pools, ditches, pools in streams, rain barrels and tin cans. It appears early in the season and continues development throughout the summer.

Culex salinarius (Unbanded saltmarsh mosquito)

Culex salinarius occurs throughout most of

eastern United States. It is especially common along the Atlantic and Gulf Coasts. It bites readily out-of-doors at night and is at times a fairly important pest. Larvae are found in grassy pools of both fresh and brackish water, along lake margins, and in marshes, cattail bogs, ponds, and ditches.

Culex tarsalis

Culex tarsalis mosquito (Fig. 24) is a medium-sized, dark species with a broad, white band at the middle of the proboscis and white bands at each end of the tarsal segments. It is an important pest species in some parts of its range. It is most active soon after dusk and may enter buildings in search of blood.

Culex tarsalis has been found naturally infected with the virus of both St. Louis and Western equine encephalitis and laboratory experiments have also demonstrated its ability to transmit both diseases. *Culex tarsalis* is considered to be the most important vector of encephalitis to man and horses in the western states (Reeves 1990).

Culex tarsalis is widely distributed and abundant west of the Mississippi River. It occurs less commonly east to Ohio, Rhode Island, Virginia, and Florida, and in southwestern Canada and northern Mexico.

Larvae of this species develop in a wide variety of aquatic situations. In the arid and semi-arid regions, they utilize almost all types of water and are most frequently found in temporary to semipermanent bodies of water associated with irrigation. These include canals, ditches, borrow pits, impoundments, ground pools, and hoof prints. Larvae develop in effluent from cesspools and other waters containing large quantities of organic material from human wastes, and in artificial containers of various types such as cans, jars, barrels, drinking troughs, ornamental ponds, and catch basins. Females deposit egg rafts that contain from 100 to 150 or more eggs each. The eggs

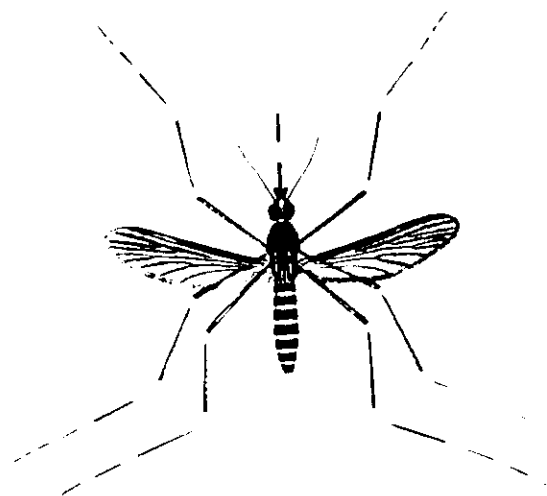


Figure 24. *Culex tarsalis*

usually hatch within 48 hours. The larval and pupal stages develop rapidly. Larval production continues from early spring until late fall.

Adult females hibernate in the northern areas of the United States. Adults are active chiefly from dusk to dawn. During daylight hours the adults remain quietly at rest in secluded spots. They can frequently be found on porches, on shaded sides of buildings, in privies, or under bridges. The majority, however, rest in grass and shrubs, in rodent burrows, or along cut banks of streams. It has a wide range of hosts, showing some preference for birds, but also feeding on cows, horses and humans. Dispersion studies have shown that *Cx. tarsalis* will fly at least 11 miles, although the majority probably remain within a mile of their breeding places. They are taken in considerable numbers in light traps and in traps using dry ice (carbon dioxide) as the attractant (Sudia and Chamberlain 1967).

Culex territans

Culex territans is widely distributed in the United States, having been reported from nearly every state. The larvae are found in ponds and marshes that are well supplied with aquatic vegetation, preferably in rather cool waters. The adults apparently do not bite man.

THE GENUS *CULISETA*

Members of this genus are somewhat similar in appearance and habits to *Culex*. There are 8 species in the United States of which 5 are fairly widespread. They are relatively unimportant as pests. Two species have been found naturally infected with encephalitis virus but their relation to the epidemiology of these diseases is not known.

Culiseta incidens

This is the most common culicine mosquito with spotted wings in the United States. It is principally western in distribution and is reported from Texas, Oklahoma, Nebraska, and all states in the west. In some areas it is a troublesome pest while in others it seems timid about biting man. It is reported as feeding more frequently on domestic animals. *Culiseta incidens* larvae are found in a wide variety of habitats, from the brackish water pools on the Pacific Coast to spring water and snow pools in the mountains. It has also been taken in reservoirs, ornamental ponds, hoof prints, rain barrels, and discarded automobile tires.

Culiseta inornata

This is a large, grayish-brown mosquito with broad, pale-scaled wings (Fig. 25). It has been reported from almost all the states except in upper New England. In the northern and western states it breeds throughout the spring and summer; in the South it is more common during the winter. This mosquito does not usually attack man, but it does feed on

domestic animals and is sometimes a considerable annoyance to livestock. *Culiseta inornata* has been found naturally infected with western equine encephalitis virus and Jamestown Canyon virus. In laboratory experiments it has been shown capable of transmitting WEE virus. However, since it seldom feeds on humans, it is unlikely to be an important vector of WEE to humans.

Larvae of *Cs. inornata* are frequently found in cold water. The hibernating females come out during warm spells of the winter and early spring even while snow is still on the ground. They are sometimes referred to locally as snow mosquitoes.

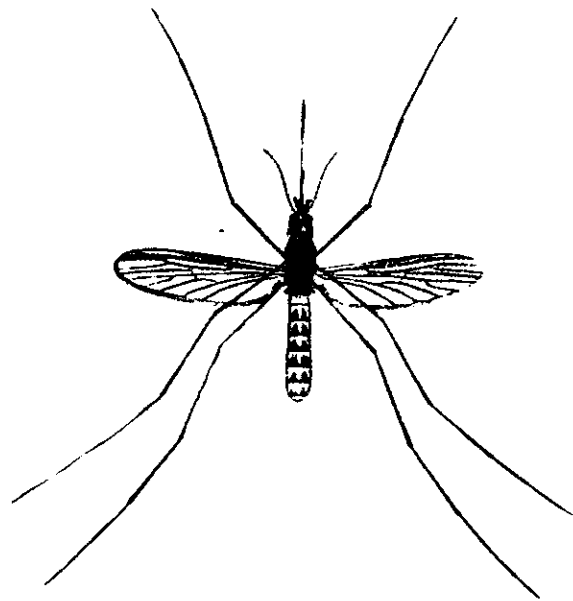


Figure 25. *Culiseta inornata*

Culiseta melanura (Blacktailed mosquito)

Culiseta melanura (Fig. 26) is a small dark species that resembles members of the *Culex* group more closely than do other species of *Culiseta*. It occurs throughout most of the eastern United States from the Gulf States to

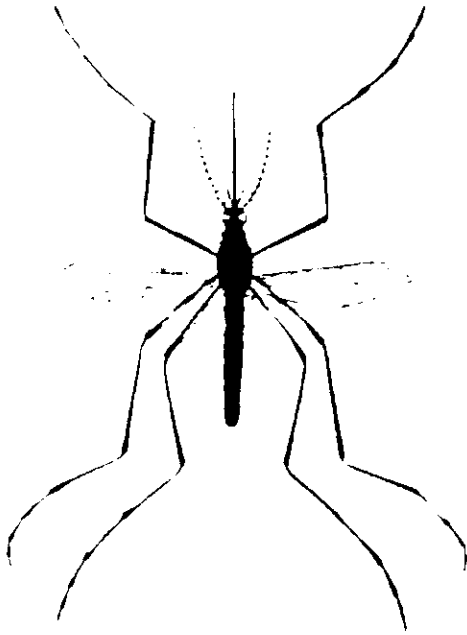


Figure 26. *Culiseta melanura*

Canada. The larvae develop in water beneath stumps and roots of trees in wooded swamps. Adults have been taken in considerable numbers in light traps and to a lesser extent in daytime resting stations. This mosquito has often been found naturally infected with the viruses of Eastern equine, Highlands J and California encephalitis. *Culiseta melanura* is considered the primary vector of EEE virus from bird to bird. Since it rarely bites man it is not the vector of EEE virus to humans (Chamberlain 1987).

THE GENERA *MANSONIA* AND *COQUILLETIDIA*

These closely related genera include three species in the United States, one of which is widespread and common. They are vicious biters in many areas. They lay their eggs in rafts on marshes or lakes. After hatching, the

larvae descend below the surface of the water and insert their air tubes into the stems or roots of aquatic plants. They remain below the water surface throughout the larval and pupal stages and obtain air from the plants. Because of this unique habit, these larvae cannot be controlled by the use of ordinary surface larvicides.

Coquillettidia perturbans (formerly *Mansonia perturbans*) (Irritating mosquito)

This is a rather large, speckled, brown and pale mosquito (Fig. 27). It has characteristic pale bands at about the outer third of both the hind femur and the hind tibia. This species is found in the southern and eastern states from the Gulf Coast to Canada. It is also known from some of the Great Plains and Rocky Mountain states and from the Pacific Coast states. This species has been found naturally infected with the virus of eastern equine encephalitis in many states from Florida to New York. It may be a primary vector in many inland areas.

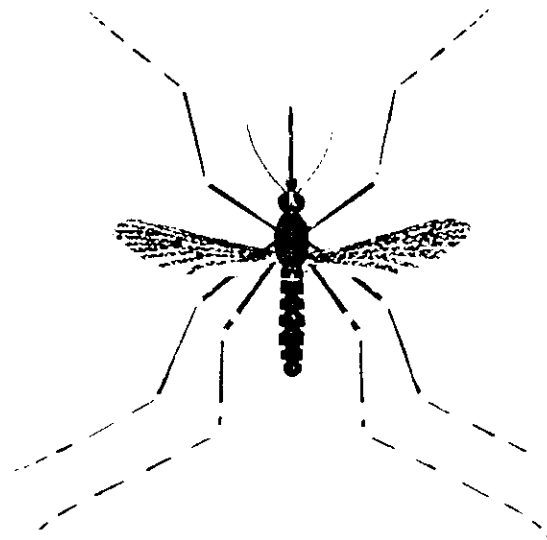


Figure 27. *Coquillettidia perturbans*

Coquillettidia perturbans larvae are found in marshes, ponds, and lakes that have a thick

growth of aquatic vegetation. Larval development is unusually slow. The larvae that hatch in any one season do not ordinarily complete their development until the following spring. Although they may detach from their host plants and move about, the larvae remain below the water surface during the entire larval period. The pupae also have breathing tubes adapted for penetrating plant tissues, and they too attach to plants from which they get their air. The pupal state requires 5 to 6 days. The adults emerge in late spring or early summer. There appears to be only one generation per year throughout most of the range of this species. It is possible that a smaller second brood may be produced in Florida. Larvae have been found attached to a number of different kinds of plants, particularly pickerel weed, cattail, water lettuce, arrowhead, aquatic sedges, and swamp loosestrife.

The females bite during the daytime in shady, humid places but are much more active in the evening and early part of the night. They readily enter houses and bite viciously. These strong fliers are frequently taken in light trap collections.

Mansonia titillans

This tropical species is fairly common in Florida and has also been reported from south Texas. It has been found in nature infected with Venezuelan equine encephalitis virus. The adults are severe biters and fairly important pests in Florida. The eggs of *Ma. titillans* are laid on the under surface of the leaves of water lettuce. The larvae and pupae attach to the roots of this plant, developing in the same manner as described for *Cq. perturbans*. The adults are frequently taken in light traps.

THE GENUS *PSOROPHORA*

Fifteen species of *Psorophora* are found in the United States, ten of which are widely

distributed in the southern and eastern states. Two species, *Ps. columbiae* and *Ps. discolor*, probably were important vectors of Venezuelan equine encephalitis virus during the Texas outbreak in 1971 (Sudia and Newhouse 1975). Many species of *Psorophora* are fierce biters. The larval habitats of this group are similar to those of the typical *Aedes*, to which they are closely related. Females lay eggs on the ground. These eggs can withstand drying and lie dormant for months. They hatch quickly upon being flooded and the larvae develop rapidly.

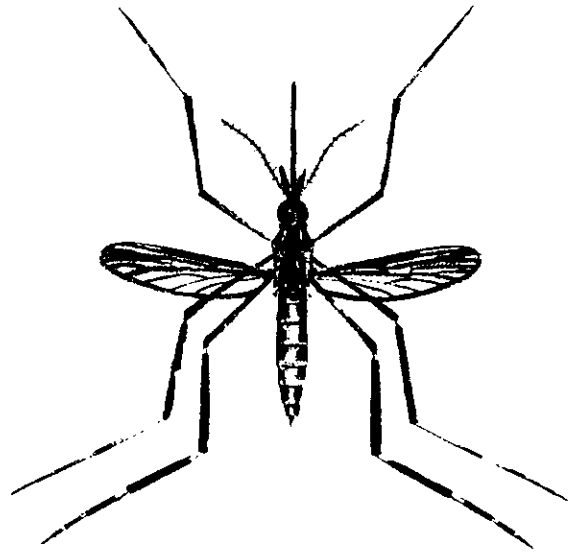


Figure 28. *Psorophora ciliata*

Psorophora ciliata (Gallinipper)

This is a very large, yellowish-brown mosquito with conspicuous scales on the hind tibia (Fig. 28). It is commonly known as the gallinipper. Because of its vicious bite and large size, this is one of the most formidable mosquitoes. *Psorophora ciliata* is widespread through the eastern United States from Mexico to Canada. It is locally abundant in the South and the Midwest. When present in numbers, it is a very annoying pest that attacks both by

day and by night. *Psorophora ciliata* is one of the few species whose larvae feed on other aquatic insects, including mosquito larvae. These larvae are found in temporary pools, often in association with *Ps. columbiae* and *Aedes vexans*, upon which they feed. A fourth instar larva of *Ps. ciliata* can consume three or four other larvae in one day. *Psorophora ciliata* larvae are easily recognized in the field as they are two or more times as long as larvae of most other species. They hang almost straight down from the water surface. The larval and pupal stages are short as is characteristic of this genus of mosquitoes. The eggs are laid on the surface of drying soil. They hatch when flooded as do *Ps. columbiae*. Overwintering takes place in the egg stage.

Psorophora columbiae (formerly *Psorophora confinnis*) (Dark rice field mosquito)

This species is known as the glades mosquito in Florida and the dark rice field mosquito in Arkansas and adjacent rice-producing areas. It is a medium to large dark species and has a narrow ring of white-scales near the tip of each femur (Fig. 29). *Psorophora columbiae* is the most widespread and important species of *Psorophora* in the United States. It occurs throughout the southern United States, extending westward to southern California and northward to Nebraska, Iowa, New York, and Massachusetts. It reaches its greatest abundance in the Florida Everglades and in the rice fields of Texas, Arkansas, and Mississippi. The females are fierce biters, attacking anytime during the day or night. When present in great numbers they occasionally kill livestock and make it almost unbearable for people to remain outdoors. This species was incriminated in the transmission of Venezuelan equine encephalitis virus during the epidemic in Texas in 1971 (Sudia and Newhouse 1975). Other viruses isolated from the species include WEE and CE.

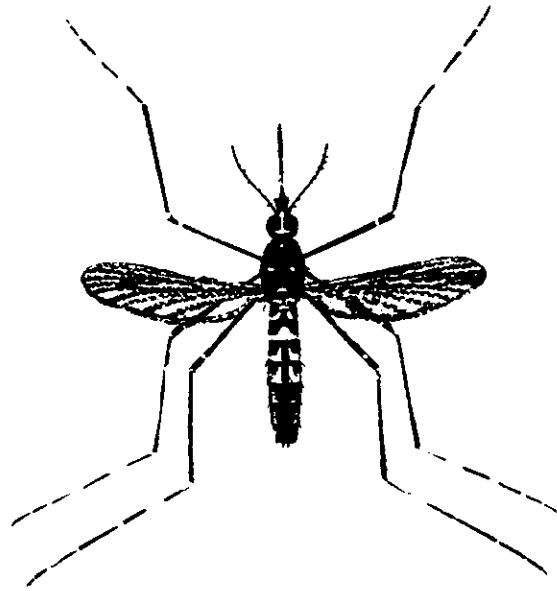


Figure 29. *Psorophora columbiae*

Psorophora columbiae larvae develop in temporary rain pools, irrigation waters, and seepage pools. Eggs are not laid on water surfaces but on ground that is subject to flooding from rainfall, overflow, or irrigation. Soil with low, rank vegetation seems to be ideal for egg deposition. Drained rice fields are one of the preferred sites for egg laying. If eggs remain on the surface of the soil for 2 or 3 weeks or longer, and are then flooded, hatching can begin within a few minutes. This species overwinters in the egg stage. During the midsummer in Arkansas, the larval stages can be completed in as few as 4 days. The average time at a mean temperature of 79° F is slightly over 5 days. The pupal stage lasts 1 or 2 days. The number of generations per season is from one to many, depending on how often suitable hatching conditions occur. Areas which dry up and are then flooded a few days later can produce a brood with each flooding. Such conditions are provided with certain types of irrigation, particularly wet rice culture. Many adults live only a week or two:

some live as long as a month or two. The flight range is at least 10 miles.

Psorophora cyanescens

This metallic blue species has entirely dark tarsi. It has been reported from all the southern states north to Illinois and Indiana. It is abundant in Oklahoma and Arkansas, as well as in certain areas of Alabama, Mississippi, Louisiana, and Texas. It is a vicious biter and attacks during either the day or night. In Arkansas and Oklahoma, it has on occasion become extremely numerous and pestiferous after rains in July and August. It breeds in temporary rain pools and its life history is similar to that of *Ps. columbiae*. It was a most annoying pest in the Rio Grande Valley in Texas following the floods of 1967.

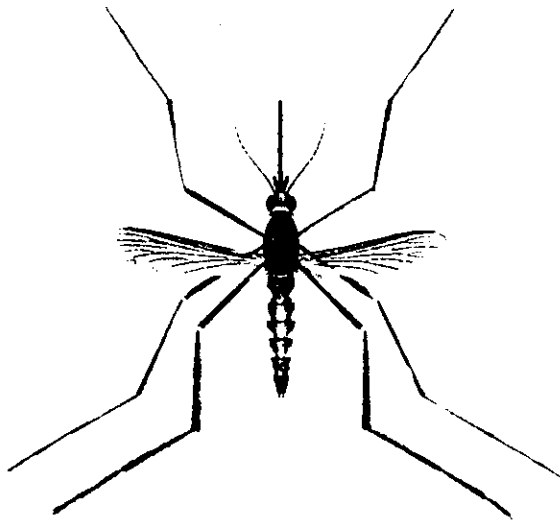


Figure 30. *Psorophora ferox*

Psorophora ferox (White-footed woods mosquito)

This brilliant blue-purple mosquito is known as the white-footed woods mosquito because the last two segments of the hind tarsi are entirely white (Fig. 30). It occurs in swampy woodlands in most of the states from Texas to Nebraska and eastward. It is a persistent and painful biter that attacks readily during the day. The larvae, which develop in temporary pools, are easily recognized by their antennae which are longer than the head.

Psorophora signipennis

This is a common species in the central United States from Montana and North Dakota to Texas. It is very abundant in Oklahoma, Nebraska, and Kansas. This species inflicts a painful bite, but does not appear to be as severe a pest as the numbers taken in light traps might indicate. Both LAC and WEE viruses have been isolated from this species. *Psorophora signipennis* is well adapted to breeding in temporary ground pools in arid regions. Its development from egg to adult can be completed in 5 days under favorable conditions.

Other Species of *Psorophora*

A number of other species of *Psorophora* can be annoying at times, particularly in the southern states, and one or more may be important in disease transmission. These include *P. discolor*, *P. horrida*, *P. varipes*, and *P. howardii*. The latter is very similar to *P. ciliata* in both larval and adult habits. The other three species have breeding habits similar to *P. columbiae* but are rarely as abundant.

OTHER MOSQUITOES

Five other genera of mosquitoes occur in the United States. Four species of *Uranotaenia* larvae are found in ground pools, the grassy margins of lakes, and occasionally in tree holes and pot holes. *Uranotaenia sapphirina* is a tiny species with brilliant iridescent scales on some wing veins and the thorax. It is taken readily in light traps. Four species of *Wyeomyia* larvae develop in small collections of water in the leaves of pitcher plants and bromeliads, in other living or dead plants, and in tree holes. *Deinocerites cancer*, *De. mathesoni*, and *De. pseudes* comprise an interesting genus of mosquitoes whose larvae are found in salt water in crab holes in southern Florida

and Texas. *Orthopodomyia signifera* and *Or. alba* are highly ornamented species that differ chiefly in their larval stages. Their larvae develop in water in tree holes and in water in leaf bases of bromeliads. *Orthopodomyia* sometimes are collected in large numbers in artificial containers, such as old refrigerators, when abundant organic matter is present. They often share the containers with *Culex restuans*, *Cx. pipiens quinquefasciatus*, and *Aedes triseriatus*. The two *Toxorhynchites* subspecies, *rutilus* and *septentrionalis*, are large, brilliantly colored, nonbloodsucking mosquitoes. The huge, clumsy larvae prey upon other mosquito larvae in tires, tree holes, bromeliads, and other water-holding containers.

MOSQUITO SURVEYS

INTRODUCTION

Surveys are essential for the planning, operation, and evaluation of any effective mosquito-control program, whether for the prevention of mosquito-borne diseases or the lowering of populations of these biting insects to a level permitting normal activities without undue discomfort.

Two types of surveys are widely used:

1. **The original basic survey** determines the species of mosquitoes, and their sources, locations, densities, and flight ranges. It can also include information on life cycles, feeding preferences, larval habitats, adult resting places, transmission of human and animal diseases, susceptibility to insecticides, recommendations for a control program, and the setting up of immediate aims and long-term objectives

2. **The operational survey or surveillance** is a continuing evaluation, which is extremely valuable in the daily operation of a mosquito-control program. It furnishes information on the effectiveness of control operations and data for comparison throughout a season or from year to year.

Such surveys do not determine the absolute population of mosquitoes as is done in the human population census. Rather, an index of population is obtained to show relative fluctuations in mosquito abundance throughout the period of the survey or in different areas in the control zone.

MOSQUITO CONTROL MAPS

Reasonably accurate and comprehensive maps are essential in planning a mosquito control operation, in field survey and control operations, in program evaluation, and in