BIOLOGY OF THE PACIFIC COAST TREE HOLE MOSQUITO *AEDES VARIPALPUS* (Coq.)[1]

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DISTRIBUTION. The tree hole mosquito *Aedes varipalpus* (Coq.) is found on the Pacific Coast from Lower California to British Columbia, and in the states of Arizona and Nevada. It has been collected from sea level to an altitude of 7,200 feet (7). Only in the state of California does it occur in large enough numbers to cause a serious problem as a pest.

The following distribution records have been compiled from the literature and various other sources. County names are given, where known; otherwise the locality is named.

I. *Arizona* (3 records): Catalina Mts., Sabino Basin, and Cococino Co.

II. *British Columbia* (19 records): Capilano, Caulfields, Coquitlams, Davis Lake, Deroche, Ft. Langley, Harrison, Hatzie Prairie, Hope, Kalso, Kilgard, McConnell Creek, Mission, Nanaimo, Steelhead, Terrace, Vancouver, Victoria and Wellington.

III. *California* (45 records): Alameda Co., Amador Co., Butte Co., Calaveras Co., Colusa Co., Contra Costa Co., Del Norte Co., Eldorado Co., Fresno Co., Humboldt Co., Kern Co., Kings Co., Lake Co., Los Angeles Co., Madera Co., Marin Co., Mariposa Co., Mendocino Co., Merced Co., Modoc Co., Monterey Co., Nevada Co., Orange Co., Plumas Co., Riverside Co., Sacramento Co., San Bernardino Co., San Diego Co., San Joaquin Co., San Luis Obispo Co., San Mateo Co., Santa Barbara Co., Santa Clara Co., Santa Cruz Co., Shasta Co., Siskiyou Co., Solano Co., Sonoma Co., Stanislaus Co., Tehama Co., Trinity Co., Tulare Co., Ventura Co., Yolo Co., and Yuba Co.

IV. *Lower California* (2 records): Laguna, and Sierra Laguna (Cape Region).

V. *Nevada* (1 record): Glenbrook.

VI. *Oregon* (14 records): Ashford, Clackamas Co., Clatsop Co., Columbia Co., Jefferson Co., Klamath Co., Lincoln Co., Linn Co., Multnomah Co., Polk Co., Rockaway, Tillamook Co., Washington Co., and Yamhill Co.

VII. *Washington* (10 records): Jefferson Co., King Co., Kitsap Co., Lewis Co., Longmire Co., Mason Co., Pierce Co., Sakamania Co., Thurston Co., and Yakima Co.

LARVAL HABITATS. *Aedes varipalpus* breeds most commonly in holes in oak trees, but collections have been recorded for 17 different species of trees including sycamore, cottonwood, maple, buckeye, bay, elderberry, black walnut, English walnut, white fir, olive trees, eucalyptus, willow and California laurel. Although the true habitat of this mosquito is tree holes, on several occasions it has been taken from rock pools, barrels, and watering troughs (16); cemetery urns, and tin cans (12); sawed-off stumps (3); and a five-gallon paint can. All of the above mentioned cases were located near or beneath trees, and each had a heavy sediment of leaves which would seem to indicate that the species cannot survive without the elements supplied by either the trees or their leaves.

ASSOCIATIONS. Because of its restricted habitat, *Aedes varipalpus* is rarely found associated with other species of mosquitoes. Reeves (17) reports fiinding it on several occasions associated with *Orthopodomyia californica* Bohart, and *Culex quinquefasciatus* Say in tree holes. The

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writer has also found it associated with *Culiseta maccrackenae* Dyar and Knab in a five-gallon paint can.

DEVELOPMENT. Under optimum conditions *Aedes varipalpus* may pass through its life cycle in as short a time as 15 days. The duration of the pupal stage is five days. Hatching of the eggs occurs within about 12 hours; the eggs that do not hatch during this period will not hatch until they have been dried and flooded again. Normally, the breeding conditions in the field are so crowded that the emerging adults may be small enough to pass through an ordinary 18-mesh screen. On the other hand, if the food supply is sufficient for the number of larvae, larvae and adults may be comparable in size to the more common *Aedes* species.

SEASONAL OCCURRENCE. The seasonal occurrence of this species depends entirely upon weather conditions, and varies considerably in the different states. In many parts of the country there is usually no more than one brood a year, but under the proper conditions of rainfall as many as five distinct generations are possible as has been shown in a laboratory colony. Normally the adults reach a peak of abundance during the months of April and May. In California, adults have been collected every month of the year except November and December (7). Stage *et al.* (19) report that in Washington and Oregon west of the Cascades, larvae can be found almost any time of year. During the summer months, when rain is sporadic, larvae may survive for several weeks in the moist debris at the bottom of the tree hole (13), and this ability may enable them to survive until rain refills the hole.

In 1954, at Fort Baker (Marin County), California, adults did not begin to appear until the last of February, and reached a peak in numbers during April. The last larvae disappeared during the month of May. This might possibly indicate two generations for the year.

In the fall of 1954, the first rain sufficient to fill the tree holes in the Fort Baker area came in the early part of November. A group of selected tree holes was checked at this time and hundreds of first instar larvae were observed. These larvae remained in the holes until the following spring before completing development. The larvae that over-winter do not all transform to adults at the same time; thirty or more days usually being required before all the adults emerge. Larvae reared in the laboratory began hiberation during the first of November in 1954 and remained in the larval stage until the first of February 1955, at which time a few began to pupate. Pupation continued until the latter part of March 1955. Mortality was very low during the three to five months they were in the larval state.

The winter is passed in both the egg and larval stages, but it appears that most of the eggs hatch by spring as a result of the several successive wettings and dryings which occur during the fall and winter months. Stage *et al.* (19) report that the larvae may be found in midwinter in the northwestern states if freezing temperatures do not prevail for long periods. In the higher altitudes and in most northern states where such conditions prevail, the few eggs that do not hatch during the fall rains are probably the only stage that survives the winters. This may be one of the primary reasons why this species has never been able to establish itself in large numbers in these states.

MATING HABITS. During the daytime the males are attracted to warm-blooded animals. They form small swarms around the animal and mate with the female when she approaches to feed. The males do not necessarily have to be swarming when mating takes place. On several occasions the males were observed alighting near a female at rest, and as the female went into flight the male would fly out and catch her. Copulation generally takes place place while in flight; the act usually lasts from 30 to 60 seconds. On several occasions copulation was observed while the female was at rest feeding.

FEEDING HABITS. Very little is known of the feeding habits of *Aedes varipalpus.*

The females begin to take blood one to two days after emerging. They are vicious biters, and in some situations such as parks and summer camps located near wooded areas, the females are very troublesome. Feeding usually takes place during the daytime. Literature records many instances of this mosquito feeding on warm-blooded animals, but the kind of animal is never specified. The writer does not know of any host preference other than man, and it is assumed that any warm-blooded animal in the forested areas might be a source of blood for this species.

EGG LAYING. Eggs are laid five to six days after a blood meal has been obtained. Usually the female feeds at least twice during this period. The female lays her eggs singly on the side of the hole just above the water surface. The maximum and minimum numbers of eggs recorded for an individual female at one oviposition are 135 and 60 respectively. The total production of eggs recorded for an individual is 321 (16). The writer believes that under normal conditions a female is capable of producing many more than this. A small group of about fifteen females were kept alive in the laboratory for a period of 76 days. During this time they were fed raisin juice and rabbit blood. A large but undetermined number of eggs were obtained each day from this group.

RESTING AND FLIGHT HABITS. Apparently nothing is known of the resting habits of this species. Stage *et al.* (19) report that the adults have a restricted flight range.

ECONOMIC IMPORTANCE. The species has been found experimentally to be a vector of Western equine encephalomyelitis (19). It is also becoming a very important pest species in California.

STUDY OF IMMATURE STAGES. To facilitate study of the immature stages, a colony was established from larvae taken from tree holes, and was maintained throughout the year 1954. The adults were kept in cages 24 inches square. They were fed both human and rabbit blood. The females showed a marked preference for human blood. The males were provided with soaked raisins suspended from the top of the cage.

Three types of containers were used in the first series for oviposition: A 400 milliliter beaker with moist cellucotton; a flat bottom feeding dish six inches in diameter and three inches in depth, containing damp wooden chips; and two well-dried bamboo joints approximately three inches in diameter and fourteen inches in depth with a small amount of water in the bottom. For the first series all larvae that hatched from these containers were counted; approximately 80,000 larvae were obtained. The bamboo joints proved much more successful than the other two. This was probably due to the dark, damp resting place it provided for the females, or to some undetermined factor. The only disadvantage found with the bamboo joints was the impossibility of counting the eggs produced. The containers were left in the cage for approximately three weeks and then flooded every seven to eight days thereafter. At the time of flooding the containers were removed from the cage, filled with water and allowed to set for twenty-four hours, then the water was poured into an enamel pan and the larvae were taken out. The containers were then returned to the cage along with the eggs that did not hatch. Each time the bamboo joints were flooded a number of eggs that did not hatch were washed loose. These eggs were filtered and placed in petri dishes with damp cotton for further conditioning. After this conditioning most of the eggs hatched. The productivity of this mosquito in the bamboo joints is shown by the following data from a single bamboo joint used in the first series. The data do not include larvae which hatched from eggs filtered and kept in petri dishes. The dates are the dates of flooding, the figures are the number of larvae which hatched: May 17: 304; May 25: 1679; June 7: 6200; June 14: 2632; June 23: 5903; July 8: 3000; July 19: 5023.

Studies have shown that for embryonic

development the eggs require a period of two to three weeks under moist conditions. At the end of this period approximately 95 percent of the eggs are viable and will begin hatching within 15 to 20 minutes after flooding with correctly prepared water. In a moist condition the eggs will remain viable for many months, or possibly years, but if allowed to dry they will remain viable for only a very short period. To show this difference in viability between dried eggs and eggs kept moist, Reeves (16) reports that eggs which had undergone the period of embryonic development were dried for nine months; at the end of this time most of the eggs were dead, but after one and one-half years eggs which had been kept moist were still 95 percent viable.

In order to prepare water for hatchings, dry leaves were collected from beneath trees, and a few leaves were placed in large metal pans of water for approximately five days. If the water was used two to three days after the leaves had been added, a much lower percentage of hatching occurred. Lowe (13) reports successful hatchings of eggs in tap water. Reeves (16) in a later paper states that "Distilled water or tap water does not hatch eggs regardless of being dried or kept moist." The writer was also unsuccessful in his many attempts to hatch eggs in tap or distilled water.

Larvae were reared in water prepared in the same manner as for hatching of eggs. After the leaves had been in the water for at least four days, freshly hatched larvae were placed in the pan. The protozoa and other aquatic life produced by the infusion leaves, provided sufficient food for the 15 to 20 days the larvae were in the pans. Larvae fed in this way were very healthy, and completed their life cycle in a very short time. If the water remained in the pans for more than 30 days all larvae remaining were transferred to new water. Other types of food such as dog biscuit and yeast were tried, but did not give satisfactory results. A light scum formed on the surface of the water, but this was removed each day by drawing a paper towel over the surface.

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