Mosquitoes from trees

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The western treehole mosquito breeds in tree cavities as high as 20 feet above ground, making it difficult to study and control. Author John Anderson siphons water from treehole to take larva count.

Nearly everyone knows that mosquitoes breed in places like swamps, rice fields, and irrigated pastures, but as its name implies, the western treehole mosquito (*Aedes sierrensis*) breeds naturally in water-holding places, crotches, and stumps associated with many kinds of trees. Each year as such cavities are filled by rains and melting snow water, the eggs laid by females begin to hatch. Newly hatched larvae then proceed to feed (and grow) on the teeming populations of bacteria and other microorganisms present.

Control of this mosquito is often difficult because it is very time-consuming, and next to impossible, to find all the naturally camouflaged mosquito-producing cavities in an area, especially when many of the holes occur at 10 to 20 feet above ground. In one field experiment 4 percent of the eggs were laid at ground level, 21 percent at 3 feet, and 75 percent at 6 feet above ground level. Because of its unique dependence upon trees this mosquito is one of the common parkland and home yard pests of people and pets.

Studies on the biology of the western treehole mosquito revealed that the females live longer than most other kinds of mosquitoes. A female may lay up to six separate batches of eggs before dying, and a fresh blood meal is needed for each batch of eggs produced. Another study showed that unhatched eggs in dry treeholes were unattractive to predators such as ants and beetles, but that such eggs could be killed by a 1- to 3-day exposure to certain fumigants.

Although fumigants are effective and inexpensive, the overall cost of treatment may be high because of the labor required to initially find and treat the many widely scattered treeholes. In Marin County, however, studies revealed that most mosquitoes were produced from only a few select treeholes. This was because most treeholes dried out, or the larvae in them died from various natural causes, before adults were produced. Also, because males develop faster than females, some treeholes produced only non-bloodsucking males before drying out. In well-studied areas, therefore, brief exposure to a fumigant could kill all eggs in known highly productive treeholes and markedly and economically reduce the number of biting females.

In searching for other methods of controlling the treehole mosquito, investigators have studied its reproductive biology, population dynamics, and natural pathogens. Several pathogens have been found thus far, including two fungi, a protozoan, and a mermithid worm. Although representing but one of several possible natural causes of mortality, these pathogenic agents have the potential of being mass-produced in the laboratory for application to treeholes.

Research on the population dynamics of immatures in a walnut orchard adjacent to natural oak woodland in Solano County showed that eggs laid in spring and early summer hatched after the first major rainfall in mid-November. Larvae reached maturity by mid-December, but they did not pupate until early March. Subsequent rainfall as late as mid-January hatched additional eggs, which also developed to mature larvae by late February. Current studies on the variables controlling pupation should allow us to predict the population status of the treehole mosquito at any time based on rainfall and temperature data. This information may enable us to predict the size of the population each year and when adults will be produced.

Other studies are concerned with how far adults fly to lay eggs or find blood meals. By marking adults with different colored fluorescent dusts and then releasing them, researchers can later recapture some of the marked mosquitoes. Such studies revealed that in some habitats most adults flew less than 100 yards, but that in the montane Sierra Nevada foothills some flew a mile.

In conjunction with possible genetic control of this mosquito, it became necessary to understand its reproductive biology and to develop the technology necessary for mass-rearing it in the laboratory. Since experiments in large field cages have revealed that sterilized and normal (fertile) males were equally accepted by females and that females mating with the former laid sterile eggs, area-wide periodic mass releases of sterilized males might be used to reduce populations of this mosquito. Thus far we have found that some females seek blood meals and mate when 36 to 72 hours old, but that others may not take their first blood meal until they are a few weeks old. Although most biting activity occurs around sunset, hungry opportunistic females will attempt to suck blood at almost any time of day that a warm-blooded host enters a shady wooded area. As the meal is digested, eggs can be produced in as little as 5 to 7 days and, as recently determined, treehole water is a powerful stimulus for egg laying. Studies on reproduction revealed that virgin females mated only once, regardless of whether mating with a fertile or sterilized male.

In establishing a mass rearing program, techniques have been developed for long-term storage of eggs and for chemically reducing the dissolved oxygen in water to obtain about a 90 percent synchronous hatch of eggs with little larval mortality. The mass rearing techniques have contributed to a series of laboratory and field experiments assessing the potential of sterile males to suppress populations of the treehole mosquito.

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Winter mosquitoes go underground in summer

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In the lower desert and inland valleys of southern California, the winter mosquito, *Culiseta inornata*, disappears completely during the summer and aestivates: no adults or larvae are encountered. This mosquito, however, constitutes a large proportion of mosquito fauna in the cooler months in the Sonoran desert valleys in California. Light-trap collections consist predominantly of this species, and larval breeding occurs in most of the mosquito breeding sources.

Studies were initiated to gather basic information on the physiological ecology of this species in the Coachella Valley, to characterize pre- and post-aestival populations, and to clarify its resting and feeding behavior.

Culiseta inornata was colonized in the laboratory so that effects of photoperiod on blood-feeding and fat content could be determined. Adult populations were sampled in the field. To study rhythms of pupation and emergence, experimental breeding ponds supporting heavy populations of this mosquito were utilized. Blood-feeding cycles were studied, using large mammals.

Feeding activity varied with season, consisting of two broad peaks in the fall, one at dusk and the other near midnight. In the spring only a single sharp peak occurred at dusk. No blood-feeding activity, however, occurred at any time after sunrise in this species.

Daily cycles of pupation and emergence of *Cs. inornata* were studied under field conditions. Two peaks of pupation occurred: one at 0400 hours and the second (the main peak) at 1600 hours. A distinct daily pattern of emergence of males and females was also noted: a single combined peak occurred daily at around 1600 hours. Emergence correlated significantly with fluctuations in water temperature, but other environmental conditions, such as solar radiation, cloud cover, wind, and air temperature, exerted no observable effect on pupation and emergence.

Photoperiod and temperature were important factors in determining blood-feeding activity; short periods induced blood-feeding, while long photoperiods did the reverse. Blood-feeding activity by females reared under long days decreased as temperature increased.

Exaggerated growth of fat tissue occurred in females reared under long-day conditions; subnormal growth of this tissue, however, was apparent in short-day females.

No significant difference in fat-body development occurred between females that had laid eggs and those that had not, when reared under long-day conditions. A significantly greater amount of fat developed in short-day females at 15° C than at 20° and 25° C. The primary stimulus for exaggerated fat-body growth, thus, appeared to be long-day conditions, and this process was not influenced by variation in temperature in the range of 20° to 30° C.

To determine the summer resting sites, observations were made in a variety of niches. Adult *Cs. inornata* were found in burrows and at the bases of trees, likely sites for aestivating during the hot summer months. In the Coachella Valley, aestivating adults fly out from the resting sites during periods of temperature inversion at the soil surface and subsurface. When temperatures at these levels are lower than those at greater depths (90 cm or more), substantial aestivating adult activity ensues. The aestivating adults appearing in early October are all inseminated, gravid, and non-blooded females. These females start the first brood, which emerges in December-January and gives rise to the second brood in March-April. The females of this brood go into aestivation during the hot summer months.

These studies have materially increased our knowledge of the ecology of this mosquito and have provided answers to many questions posed by public agencies participating in large-scale mosquito control operations.

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