

ARTICLES

STRATIFICATION OF SOME PRAIRIE AND FOREST MOSQUITOES IN THE LOWER AIR¹L. BURGESS² AND W. O. HAUFE³

The vertical stratification of mosquitoes on the western prairies and in the eastern forests of Canada has been studied recently with traps operated at five, twenty-five and fifty feet above the ground. This work was undertaken to provide information for those planning control measures against adult mosquitoes, and to aid in the interpretation of host-preference, biting rate and abundance studies.

Of the stratification studies reported in the literature, most deal with mosquitoes in forests, although MacCreary (1941) gives an account of trapping conducted from a light-tower in the suburbs of a city and from one in the midst of extensive salt-marshes. In both areas he found that catches in the traps high above ground were small in comparison with those in traps near the ground. In forested areas, however, Haddow *et al.* (1947), Deane *et al.* (1953), Snow (1955), Snow and Pickard (1957), and Love and Smith (1958) have shown that while some mosquitoes are most abundant near the forest floor, others are most abundant at various levels within the forest. Bates (1949) suggests that stratification of mosquitoes within the forest may be influenced by vertical gradients of temperature, humidity and light, behaviour associated with mat-

ing and oviposition, and the location of larval habitats. Love and Smith (1958) feel that the location of hosts might also be an important factor.

MATERIALS AND METHODS. Traps possessing a moving striped pattern to attract mosquitoes (Haufe and Burgess 1960) were suspended at heights of 5, 25 and 50 feet on a prefabricated metal tower. In the early morning and late afternoon of each day, the traps were lowered to the ground with rope and pulleys and the catches were removed. The traps operated continuously and the catches were automatically divided into hourly samples. The traps were not illuminated at night. This avoided the attraction of mosquitoes from one level to another by light sources.

The trapping site on the prairie was a field of open flat grassland near Brooks, Alberta (Fig. 1), where the traps were operated from June 13 to September 14, 1956. Catches from August 5, 6, 23 and 24 were excluded because of failure of the sample-separating mechanisms.

In the forest, the tower was set up in a marshy area near Marmora, Ontario, and the traps were operated from May 31 to July 27, 1957. The predominant trees were white ash and American elm. There was a luxuriant ground cover of grass and herbs, three to four feet high. Above this, willows and alders extended to a height of 20 to 25 feet. The general tree-top level lay just even with the 50-foot trap, although a few trees extended beyond this height. Foliage was dense up to the 25-foot level. Above this it was

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thin and scattered, with sizeable openings between the tops of the larger trees.

Positive identification of the trapped mosquitoes could usually be made. Some difficulty did arise in the separation of damaged specimens of *Aedes dorsalis* (Meigen) from those of *Aedes campestris* Dyar and Knab. The catches plotted as *A. dorsalis* in Fig. 2 may thus include some *A. campestris*. A few males of *Aedes melanimon* Dyar were caught (Burgess 1957) and it is possible that females of this species were also mistaken for *A. dorsalis*. Of the forest-inhabiting mosquitoes, *Aedes stimulans* (Walker) could not be separated with certainty from *Aedes fitchii* (Felt and Young).

In the graphical presentation of the data (Fig. 2 and Fig. 3) the total hourly catches of each species are plotted with reference to the time of the hourly catch during which sunset occurred, rather than with reference to clock time. This procedure was necessitated because of the change in the actual time of sunset during the trapping studies.

STRATIFICATION OVER THE PRAIRIE. Of the fifteen species caught on the prairie, females of *Aedes dorsalis* (Meigen), *Aedes vexans* (Meigen), *Aedes spencerii* (Theobald), *Culiseta inornata* (Williston), and *Culex tarsalis* Coquillett, were caught abundantly (Fig. 2). *Culiseta inornata* was taken only in the traps at the 5-foot and 25-foot levels. On a night not included in the study, one specimen was taken at the 50-foot level. Each of the four other species was caught at all three levels. For each species, the total numbers caught decreased with increased height of the trap above the ground. Of the total number of female mosquitoes caught, 78 percent were taken at the 5-foot level, 13 percent at the 25-foot level and 9 percent at the 50-foot level.

The catches of males were small. Except for *A. vexans*, the density of males decreased as height above ground increased. *A. vexans* males were caught in relatively large numbers in the 50-foot trap and never in conjunction with females at this

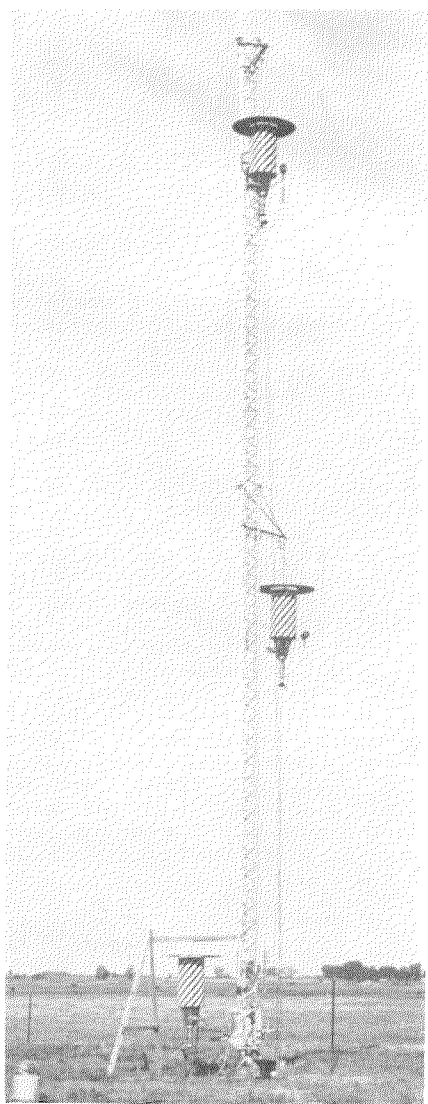


FIG. 1.—Mosquito traps suspended from a tower at heights of 5, 25 and 50 feet above the prairie near Brooks, Alberta.

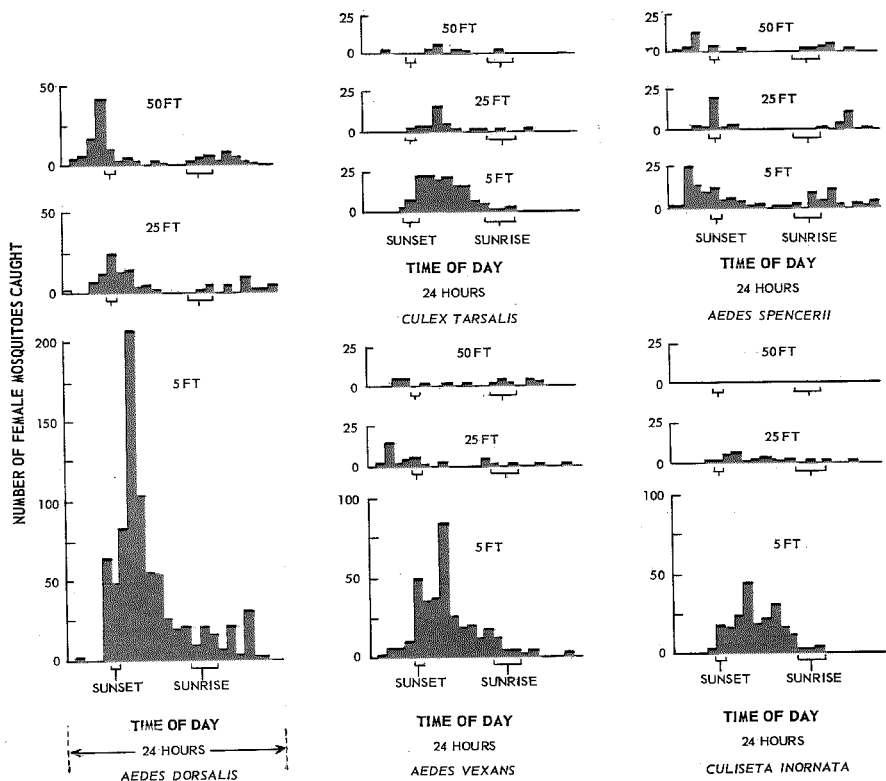


FIG. 2.—The stratification and daily activity of some prairie mosquitoes as shown by the total hourly catches taken in traps at 3 heights above the prairie at Brooks, Alberta, from June 13 to September 14 (exclusive of August 5, 6, 23 and 24). All catches are plotted with reference to the time of sunset.

height. In trapping at the same location in the previous year, 28 males of this species were caught in one hour at the 50-foot level.

STRATIFICATION IN THE FOREST. Females of *Mansonia perturbans* (Walker), *Culiseta morsitans* (Theobald), *Aedes stimulans* (Walker), and *Aedes punctor* (Kirby) were caught in abundance in the traps in the forest. Each species was caught at the three levels (Fig. 3). *A. punctor* was caught in about equal numbers in each of the lower two traps and in smaller numbers in the 50-foot trap, while each of the

other three species was caught in largest numbers in the trap at the 25-foot level. Twenty-nine percent of the total catch of female mosquitoes was taken at the 5-foot level, 53 percent at the 25-foot level and 18 percent at the 50-foot level. Sharp increases in the catches of *A. stimulans* and *A. punctor* were noted in the late afternoon and early morning. These increases correspond to the times when the traps were serviced, and thus may consist partially of mosquitoes attracted to the observers. Corresponding increases, however, were barely apparent in the catches of *M.*

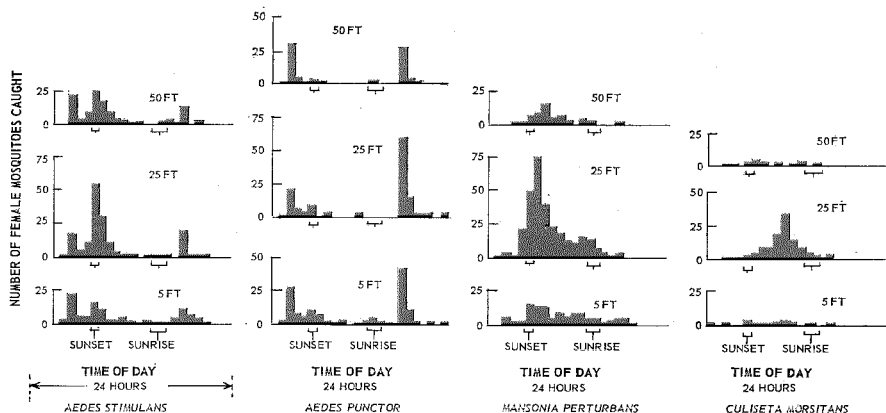


FIG. 3.—The stratification and daily activity of some forest mosquitoes as shown by the total hourly catches taken in traps at 3 heights above the ground in the forest at Marmora, Ontario, from May 31 to July 27, 1957. All catches are plotted with reference to the time of sunset.

perturbans, a species that also bites man readily.

Catches of males were small. Males of *A. stimulans* and *A. punctor* were caught in about equal numbers at all levels. Over 70 percent of the males of *Culiseta morsitans* were caught at the 25-foot level. Only five male *M. perturbans* were taken, all of these at the two upper levels.

GENERAL OBSERVATIONS. In both locations, appreciable catches of mosquitoes were taken only in the period from late afternoon to mid-morning. *Culiseta inornata*, *Culiseta morsitans* and *Culex tarsalis* were most active during darkness. The largest numbers of *A. vexans* and *M. perturbans* were obtained soon after sunset, but the numbers caught decreased with the onset of darkness. *A. spencerii* and *A. punctor* were almost completely inactive during darkness, their major activity occurring just before sunset and just after sunrise. The largest catches of *A. dorsalis* were taken after sunset in the lower trap, at sunset in the trap at the 25-foot level and before sunset in the top trap. The activity of *A. stimulans* reached its maximum at sunset, with secondary peaks

occurring several hours prior to sunset and several hours after sunrise.

On the prairie, large catches of mosquitoes were usually associated with evenings when it was warm and the winds were light. In the forest, large catches were likewise associated with warm evenings, but the effect of winds appeared to be reduced by the density of the forest cover.

A few mosquitoes that were engorged with blood were taken in each of the traps at both locations. A report that includes the identification of the blood meals will be published.

DISCUSSION. In both prairie and forest locations, the vertical distribution of female mosquitoes was similar to that found in comparable areas by previous workers. Over the prairie there was a general decrease in the density of all species as height above ground increased, whereas in the forest, some mosquitoes were found to be more abundant well up in the foliage than near the ground.

The observed differences in stratification patterns in the two areas are possibly manifestations of basic behavioural differences in the species involved. Behavioural differences of considerable magnitude

existed even between the species in one area, e.g., the stratification of *A. punctor* and that of *Culiseta morsitans* in the forest. Love and Smith (1958) found that the different species present in one single wooded area exhibited four different types of stratification.

Differences in the nature of the two habitats probably also contribute to differences in the patterns of stratification between the two areas. Both the work of MacCreary (1941) and our present study, showed that the density of female *A. vexans* decreased with increased height in the open; while in the woods, Love and Smith (1958) caught more female *A. vexans* at the 25-foot level than at the 50-foot level or a 6-foot level. Certainly, temperature, humidity and light gradients, air movement, and the location of hosts are likely to differ between forest and prairie. In the forest, a mosquito flying at any level below the tree-tops remains in close proximity to solid, visible objects. Potential resting sites are thus abundant well above the ground. Over the prairie, however, a mosquito must descend to the ground when it becomes inactive, unless it happens to be carried aloft by rising air currents. Likewise, if birds are acceptable hosts, the forest-dwelling mosquito may also obtain a blood meal without descending, although it must later descend to oviposit. The physiological condition of a mosquito can thus conceivably affect the height at which it flies.

The daily periodicity in the activity of the various species as indicated by the size of the hourly catches, contributes little new information to that already documented by Carpenter and LaCasse (1955), Rempel (1953), Horsfall (1955), Matheson (1944), McLintock (1944), and others.

Comparisons of the times of activity of a species at the three elevations would be desirable. Simultaneous catches from the three traps at a particular time, necessary if such comparisons are to be valid, were usually small, however. Fig. 2 and Fig. 3 represent data summed from many days. Nevertheless, several general relationships can be observed. On the prairie, fewer

mosquitoes were taken at the higher levels after darkness than were taken at these levels at or just before sunset. This may indicate a relationship between the height of voluntary flight and a perception of a ground pattern, or may be a negative phototactic response to light from the sky by nocturnal species. In the forest, the times of peaks in catch size at the different levels coincided closely, and there did not appear to be an upwards and downwards migration of mosquitoes at different times of the day. Snow and Pickard (1957) found *Mansonia perturbans* to migrate upwards into the foliage at dusk and downwards at dawn in the woods in Tennessee.

The capture of relatively large numbers of *A. vexans* males at the 50-foot level over the prairie is interesting. Possibly the males had formed a mating swarm at this height, although females were never caught in conjunction with them. MacCreary (1941) and Blakeslee, Axtell and Johnston (1959) reported substantial catches of *A. vexans* males in the upper trap of a series.

The present studies have shown that a considerable number of mosquitoes can be expected to occur at heights of 25-50 feet above the prairie, and that, in the forest, even a preponderance of the population may be found at levels well up in the foliage. Therefore, studies of the adult mosquitoes in a particular area will be incomplete if attention is paid only to the mosquitoes that are within the reach of an observer on the ground. When insecticidal control measures against adult mosquitoes are being planned, the desirability of reaching also the mosquitoes that are at the higher levels should not be overlooked.

SUMMARY. Catches of mosquitoes in traps operated at elevations of 5, 25 and 50 feet are reported for a prairie and forest location.

Females of *Aedes dorsalis*, *Aedes vexans*, *Aedes spencerii*, *Culiseta inornata* and *Culex tarsalis* were caught in appreciable numbers over the prairie. The density of each species decreased with increased height above ground. All species were

well represented in the catches of each trap, except for *Culiseta inornata*, of which only one specimen was ever taken in the trap at the 50-foot level. Male mosquitoes showed a distribution similar to that of the females, except that the majority of the males of *A. vexans* were caught at the 50-foot level.

Females of *Aedes punctor*, *Mansonia perturbans*, *Aedes stimulans* and *Culiseta morsitans* were caught in appreciable numbers in the forest. The latter three species were caught most abundantly in the trap at the 25-foot level, while *A. punctor* was caught in about equal numbers in each of the lower two traps, and in smaller numbers in the 50-foot trap. Catches of males were small.

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