SWARMING AND MATING OF *AEDES (S.) ALBOPICTUS* IN NATURE[1]

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ABSTRACT. Observations were made on the swarming and mating behavior of *A. albopictus* in nature. It was found that a swarm of males formed around the feet and ankles of a human observer immediately after entering the area. Females began arriving at the host some minutes later and were mated as they approached the host to feed. Swarming and mating activity both peaked between 5 and 10 minutes after the first males were noted; at 20 minutes, very few mosquitoes of either sex could be seen in the vicinity. Copulation always occurred in flight, usually at about 1 to 3 feet from the ground and lasted a median time of 7.9 seconds. Preliminary data suggest that most mating females are nulliparous; dissection of biting females show that most are parous and that nearly all of the latter females are inseminated. It is suggested that even though swarming is not necessary for mating of *A. albopictus,* it occurs frequently in the vicinity of the host and is an adaptation which insures a high insemination rate of females of this species in nature.

Recent advances in employing genetic technology to control vector populations have made it necessary to gain a better understanding of the behavior and biology of mosquitoes in nature. A knowledge of the mating behavior of natural populations is essential to the success of biological control programs using genetic techniques. Among the *Stegomyia* mosquitoes *Aedes aegypti* has received considerable attention because of its importance as a vector of urban yellow fever and dengue fever viruses, whereas most of the other species in this group are relatively unknown with regard to their behavior in nature. *Aedes albopictus,* in addition to its probable importance in maintaining a sylvatic cycle of the dengue fever viruses (Rudnick *et. al.,* 1967), has recently been shown to compete successfully with *Aedes polynesiensis* for the same ecologic niche under laboratory conditions (Gubler, 1970a, 1970b, 1971; Rozeboom, 1971; Ali & Rozeboom, 1971). Gubler (1970c) also found that mating occurred freely between male *A. albopictus* and female *A. polynesiensis* in cage populations resulting in effective sperm transfer and thus, cross-insemination sterility. The possibility exists, therefore, that *A. albopictus* might successfully compete with *A. polynesiensis* in nature and thereby provide an efficient and economic method of controlling aperiodic *Wuchereria bancrofti* on some islands of the South Pacific. A knowledge of the behavior of these species in nature is essential to understanding the possible interactions which might occur in a program of this type. This report describes observations made on a natural population of *A. albopictus* in its type locality, Calcutta, India.

MATERIALS AND METHODS. All observations on swarming and mating were made during the monsoon months of 1970. The study area was located in the Royal Agricultural and Horticultural Society Gardens in South Calcutta. *A. albopictus* was the dominant mosquito in the gardens and only rarely was *A. aegypti* collected. *A. aegypti* was never found breeding in the area and therefore, specimens of this species taken in biting collections probably strayed in from the surrounding urban environment. No other *Stegomyia* species was present.

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Observations were usually made in the early morning within 2 hours after daybreak and always from three sites chosen in the study area for this purpose. The observer stood in the center of a white muslin cloth measuring 1.2 x 1.7 meters. All mosquito activity was thus clearly visible against the light background. Comparisons made without the muslin cloth indicated that the white background did not have any noticeable affect on the behavior of this species. At each site observations were made for four consecutive 5-minute periods of time, for a total of 20 minutes, with particular attention being given to the time of onset of swarming, duration and size of the swarm, and the number, duration, height and location of copulation. Matings were timed with the aid of a stopwatch accurate to 0.1 second.

When possible, individual mating females were collected for dissection while still in contact with the male. These females plus biting females collected on human bait were transported to the laboratory in a cold box and held in a refrigerator to insure survival until examination. Dissections to determine parity and insemination were usually made on the same day, but always within 24 hours.

RESULTS. Immediately upon entering an observation site a swarm of *A. albopictus* males was attracted to the observer, usually around the feet and ankles. The numbers varied from 2 or 3 to as many as 30 or 40 depending on the population density at the time. During periods of low density in the study area, males were seldom observed. Occasionally swarms were observed at the base of trees or over a cane basket used for collecting; one was noted above the back of a dog. Congregations over other possible swarm markers may have been missed because of the poor illumination and dark background. Males attracted to the observer arrived individually, presumably from resting places on the low vegetation. Swarming activity reached a peak during the first 5 minutes of the observation period, remained high for about 10 minutes and then decreased rapidly.

Within a few minutes after the swarm of males had formed, females began approaching the host to feed. As they flew close to the ground, as did the males, they probably also had been resting in low vegetation. Most of the females entered the swarm to get to the host. Copulations occurred when the females came in contact with a male while flying through the swarm. Mating activity peaked between 5 and 10 minutes after observation began and then fell off rapidly, probably as a result of the decreased swarming of the males. Very little activity was observed after 15 minutes.

As the female approached the host, contact with a male appeared to be accidental, but once it was made, the pair would fly out of the swarm in tandem and hover almost motionless, copulating in flight. The males were always underneath, flying upside down and with their abdomen arched up in contact with the female. This position was maintained until copulation had been completed at which time the male released his hold and fell down and away from the female; the latter then usually returned to the host to feed. Very few mating pairs were observed to land and most of those that did touch a surface broke contact immediately. This is in contrast to caged populations where the majority of matings occur on the side of the cage. Most of the matings occurred within 1 to 3 feet of the ground, but occasionally a pair was seen at 5 or 6 feet and one mating was observed at 15 feet. The duration of contact was timed for 68 matings; the longest copulation was 101.2 and the shortest 2.5 seconds while the majority lasted 5 to 10 seconds (Figure 1).

As noted above, contact between an approaching female and the swarming males appeared to be accidental. However, the dissection of mating females suggested that there might be a selection

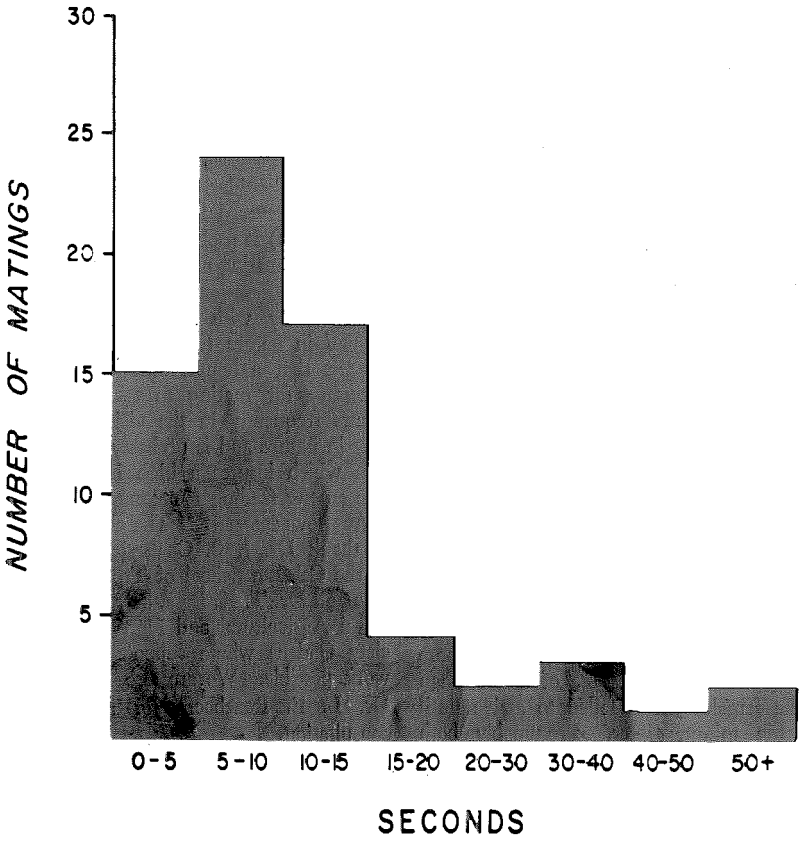

FIG. 1.—Duration of mating contact of *A. albopictus* in nature.

process; of 24 mating females caught while still in contact with the male and dissected, 8 were parous while 16 were nulliparous. Thus twice as many nulliparous as parous females were being mated around the host even though the majority of the females coming to feed were parous (Table 1). Nearly 56 percent of 1988 biting females collected had laid 1 or more batches of eggs. Moreover, 99.5 percent of this group of mosquitoes was inseminated, probably before they had deposited their first batch of eggs. Of the nulliparous biting females, 85.9 percent were inseminated. Thus, about 15 percent of this group were virgins, suggesting that this proportion of the females are inseminated in the vicinity of the host. Overall, 93.5 percent of feeding mosquitoes were inseminated.

DISCUSSION. Swarming of male mos-

TABLE 1.—Insemination and parous rates of biting female *A. albopictus* in nature.

	Biting Females		
	No.	%	% inseminated
Parous	1112	55.9	99.5
Nulliparous	876	44.1	85.9
Total	1988	100.0	93.5

quitoes in the vicinity of the host is not an uncommon occurrence. Although there is some question as to whether species of the subgenus *Stegomyia* actually do swarm or whether it is just an arhythmic activity (Nielsen and Haeger, 1960; Clements, 1963), it is known that males of certain species of this group congregate around host animals and that mating occurs when the females approach to feed. Such activity has been described for *A. aegypti, A. albopictus, A. scutellaris* and *A. polynesiensis* (Banks, 1908; O'Connor, 1923; Forbes & Horsfall, 1946; Hartberg, 1970; Ali & Rozeboom, 1971). In our Calcutta study area, male *A. albopictus* were immediately attracted to a person as he walked past their resting places; if he stopped, several males would start to swarm around the feet and ankles. These have been termed "following swarms" by Rozeboom (Ali & Rozeboom, 1971). Unlike *A. aegypti* males which arrived at the host about the same time as the females (Hartberg, 1970), *A. albopictus* males appeared to be much more sensitive to the presence of a host than the females which failed to arrive until some minutes later. Presumably both sexes rest in similar places in the low vegetation. It may be that the swarming males play some part in attracting females to the host where they are mated, generally before feeding. Mating before feeding is not always the case however, since one fully blooded female was observed copulating in flight for 4.9 seconds. Unfortunately, this female was not dissected to determine parity. It is not known whether the males actually choose certain females to mate or whether copulation is the result of a chance meeting of the sexes during their flight activity around the host. Many females are not bothered by males when they approach the host and preliminary data suggest that the majority of females contacted were nulliparous. Only 24 mating females were dissected, however, and these data may not present an accurate picture of the age of mating females in nature.

The duration of copulation of *A. albopictus* was similar to that observed in *A. aegypti* by Roth (1948) who found that it ranged from 4 to 59 seconds with an average of 16 seconds. Although the range was much greater for *A. albopictus* (2.5 to 101.2 seconds), the mean was 12 seconds. Considering the wide variation that occurred however, the median (7.9 seconds) is probably a more accurate estimate of mating contact.

These observations on *A. albopictus* agree closely with those made on *A. aegypti* in nature (Hartberg, 1970) and suggest that although swarming is not necessary for mating to take place, it occurs frequently in the vicinity of the host in nature and is probably an adaptation which insures a high insemination rate among feeding females.

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A REVISED LIST OF THE MOSQUITOES OF OHIO WITH SOME NEW DISTRIBUTION AND SPECIES RECORDS [1]

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Venard and Mead (1953) published an annotated list of mosquitoes which presented distribution records and notes on the relative abundance of mosquitoes known in Ohio up to that time. In 1965 the Ohio Department of Health's Encephalitis Field Unit initiated a state-wide California Group arbovirus surveillance, and since that time 736,021 mosquitoes have been collected and identified to be tested in virus studies. These data have resulted in a better knowledge of the abundance and distribution of Ohio mosquitoes, and have established new records for three mosquito species.

In a review of the recent literature on North American mosquitoes, Carpenter (1970) listed several species from an unpublished list of Ohio mosquitoes by Dr. Carl E. Venard: *Aedes dupreei, A. implicatus, A. mitchellae, A. riparius, A. spencerii,* and *Culex tarsalis.* All of these species are rare or uncommon and, with the exception of *A. mitchellae* and *C. tarsalis,* have not been found in our collections. A total of 52 species is reported in this article.

Methods of mosquito collections as described by Sudia and Chamberlain (1967) were used in these studies. Briefly these methods included the use of the CDC light trap (Sudia and Chamberlain, 1962), supplemented by dry ice (Newhouse *et al,* 1966); human biting collections were also made. Primarily female mosquitoes were collected by these methods.

Symbols used in the following revised list of Ohio mosquitoes are: species new in Ohio are shown by (*); distributions are indicated as (W) widespread or (L) local; the relative abundance is listed as (A) abundant, (C) common, (U) uncommon, (R) rare, and (I) insufficient data.

NEW OHIO RECORDS

The number of individuals collected

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