BEHAVIORAL CHANGES IN THE SALT MARSH MOSQUITO, *AEDES SOLLICITANS*, AS A RESULT OF INCREASED PHYSIOLOGICAL AGE[1]

WAYNE J. CRANS, JERE D. DOWNING AND MARC E. SLAFF

Mosquito Research and Control and Department of Entomology and Economic Zoology, New Jersey Agricultural Experiment Station, Rutgers—The State University of New Jersey New Brunswick, New Jersey 08903

ABSTRACT. Six broods of *Aedes sollicitans* (Walker) were monitored at a site 0.5 mi from a breeding marsh and a site 2 mi. inland. Light traps were used to measure populations; landing rates were used to measure nuisance levels; and ovarian dissections were made to follow the parous rate of the populations during the season. Data suggested that *Ae. sollicitans* moved inland shortly after emergence but tended to congregate near the breeding marsh after oviposition. Only a small portion of the population returned 2 mi. inland after the 1st gonotrophic cycle; the majority showed a reduced migratory tendency.

Landing rates and ovarian dissections revealed that nuisance persisted for less than 1 week at the inland site and that very few bites would be received from parous mosquitoes. When the nuisance level was high, the majority of the population was nulliparous. By the time parous levels increased, nuisance was minimal. The site closer to the marsh presented a contrasting picture. Nuisance persisted for nearly 3 weeks as the brood aged, primarily as a result of parous mosquitoes. Data indicated that the vector potential of *Ae. sollicitans* was substantially higher at the site closest to the marsh.

INTRODUCTION

The salt marsh mosquito, *Aedes sollicitans* (Walker), is New Jersey's most important pest species. Considerable sums of money are invested each year to control the multiple broods which emerge from the vast expanse of coastal wetlands in the southern portion of the State. Coastal communities are especially affected by this persistent daytime biter, and annoyance is often evident several miles inland. The nuisance inflicted by large populations of *Ae. sollicitans* in New Jersey is well documented by Headlee (1945) but health officials have been particularly concerned with its role in the transmission of disease. Attention has been centered on this mosquito as a vector of dog heartworm (Crans 1963; Beam 1965), and emergency control measures are directed against *Ae. sollicitans* whenever viral encephalitis activity is detected (Goldfield et al. 1968).

Most of the information available on the biting persistence and migratory abilities of *Ae. sollicitans* is based on observations taken during periods of peak population when the majority of individuals are seeking their first bloodmeal. No data are available to determine if behavior changes as individual broods age. Since vector control is conducted primarily to reduce parous and multi-parous specimens, information should be available to understand the composition and behavior of old residual populations.

During 1975, *Ae. sollicitans* was monitored throughout the breeding season to determine if behavior changed as individual broods aged. The results of this study are reported in this paper.

MATERIALS AND METHODS. *Ae. sollicitans* was monitored from May to November in 2 areas near West Creek, New Jersey. One site was located 0.5 mi. from a breeding salt marsh. A stand of dense hardwood and briar separated the study site from the marsh. The 2nd site was approximately 2 mi. inland from the nearest breeding marsh. At each site, studies were conducted at the edge of an open field where dense, low ground cover provided suitable resting sites for adult mosquitoes.

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Three standard New Jersey light traps were operated nightly to determine populations according to standard surveillance procedures. One trap was located at each site; the 3rd was placed at a point equidistant between the sites. Light trap data were plotted on a 5 point moving mean to minimize fluctuations due to weather conditions and adult control.

Landing rates were conducted twice weekly at mid-day to determine the nuisance level of the biting population. Immediately upon arrival at each site an investigator proceeded to a pre-designated area of the field, turned 180° and stood motionless for 1 min. Only mosquitoes which landed in view, below the waist were counted. Specimens which landed on the legs and moved to the upper torso were counted immediately. Mosquitoes remaining below the waist at the end of the minute were added to the total. The investigator then moved about and hand-aspirated at least 20 specimens into cardboard pint containers. A 2nd 1-min. landing rate was taken before leaving the area. A mean of the 2 landing values was calculated to determine the nuisance level. No repellents were used during any part of the study.

Aspirated specimens were dissected for parity by the Detinova method of ovarian tracheolation (Detinova 1962) to determine the parous rate of the biting population. Light traps were inactivated at the end of September; landing rates and parity determinations were continued until biting activity ceased in November.

The populations studied during these investigations were regularly controlled by the Ocean County Mosquito Extermination Commission. Larval control with Abate® granules was conducted prior to the emergence of each brood and 8 aerial ULV treatments with malathion were administered during the season. Light trap data have not been altered beyond the 5 point moving mean correction but landing rates conducted within 2 days of an adult treatment have been omitted from the data. The immediate effects of control on the mosquito population will be presented separately.

RESULTS AND DISCUSSION

NUMBER OF BROODS IN THE STUDY AREA. Light trap data and parity dissection showed that 6 major broods of *Ae. sollicitans* occurred within the study area during 1975. Fig. 1 shows the seasonal succession and relative size of each brood measured by the 3 light traps. The parous rates obtained by ovarian dissections have been superimposed on the light trap data as an added indicator of each emergence. Enough specimens were available at the marsh edge to give a continuous analysis of parity throughout the season. Mosquitoes were numerous at the inland site after the emergence of each fresh brood but the numbers rapidly declined to the point where too few specimens were available for accurate assessment of the parous rate. The gaps in the parous curve at the inland site in Fig. 1 reflect the periods when mosquitoes were very scarce or entirely absent.

The 1st brood of the season began entering the light traps on May 16. Parity was 85% when dissections were initiated on June 5 and reached 100% at both sites 11 days later. Light trap data show that the 2nd brood of the season emerged on or about June 18 and peaked on June 21. Parity dissection confirmed the emergence; the sharp drop in the parous rate at each site showed the influx of nulliparous specimens. As the brood aged, the numbers of mosquitoes entering the light traps declined while the parous rates increased. Parity reached 100% at the marsh edge on July 7 when the brood had all but dissipated. Parous rates could not be followed beyond June 30 at the inland site when they were only 25%.

The 3rd brood of the season was abnormally large as a result of heavy rains and excessive flooding during late June and early July, but this population showed only a minor peak on July 14 because of an airspray application. However mosquitoes continued to enter the light traps until July 19. The initial emergence is

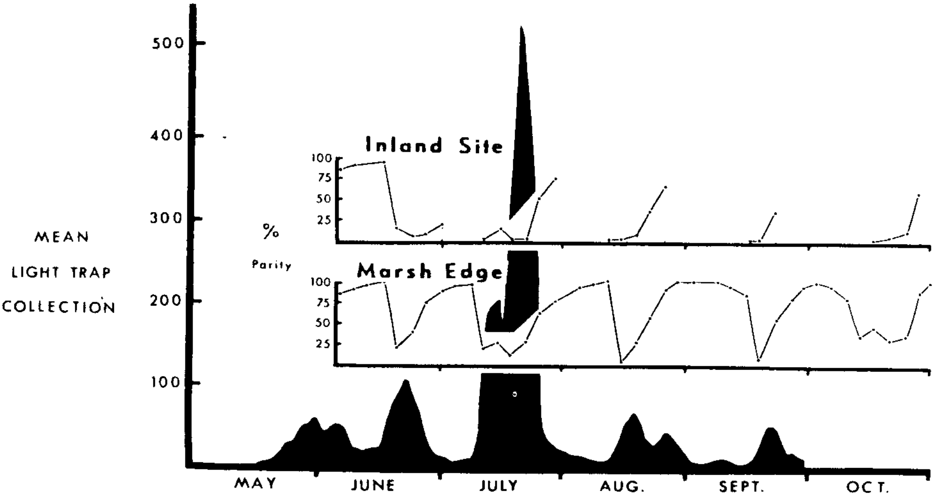

Fig. 1. The numbers of *Aedes sollicitans* collected by light trap within the study area during 1975 and the corresponding parous rates at 2 separate locations.

reflected by the sharp drop in parity at the marsh edge on July 10 and the corresponding 0% parity at the inland site. The minor depression in the parous rate at each site on July 17 showed the impact of the airspray on the physiological age of the populations. Data indicate that mosquitoes were killed during the treatment but they were quickly replaced by nulliparous specimens which were still emerging from the marsh and moving into the study sites. Parous rates steadily increased at the marsh edge after the airspray and reached 100% on August 11 when light trap collections were minimal. Parity also increased at the inland site but could not be followed beyond July 28 when it had reached 75%.

The 4th brood began entering the light traps on August 11 and appeared to be minor in size. The population peaked on August 16 and showed a 2nd peak 10 days later. The sharp drop in parity from 100% to nearly 0% at the marsh edge on August 14 reflected the initial emergence but parity data did not indicate a 2nd influx of nulliparous mosquitoes after August 16. Data indicate that the bimodal peak in the light trap collections was not the result of a separate emergence but rather the effects of adult control, environmental conditions or some unknown factor. Parity reached 100% at the marsh edge on August 28 and remained at 100% well into September. Parity could not be followed beyond August 25 at the inland site because of the low numbers of specimens, but it had reached 65% by that time.

The light trap collections showed a slight increase in numbers beginning on September 5, and ovarian dissections from specimens collected at the marsh edge showed that some newly emerged specimens had entered the study site. The influx depressed the parous rate only to 80% over the next week and the total numbers of mosquitoes remained low. The main emergence of this brood did not take place until September 16 when light trap collections increased substantially and parity levels dropped to nearly 0% at each site. This 5th brood of *Ae. sollicitans* also appeared small and reached peak numbers 3 days later on September 19. Very few mosquitoes from this brood migrated inland and parity could not be followed at the inland site beyond September 22 when it was 40%. Parity reached 100% at the marsh edge within

2 weeks. The brood was well into its decline by this time and the light traps were disconnected for the season.

Parity dissections were continued at both sites throughout October and revealed the emergence of a staggered 6th brood late in the season. No light trap data were available to measure the relative size of this population, but parity reached 65% at the inland site on October 27 and 100% at the marsh edge on October 30 when collections were terminated.

LANDING RATES IN THE STUDY AREA. The landing rates for *Ae. sollicitans* at the 2 sites have been superimposed on the light trap data for the entire season in Fig. 2. The number of mosquitoes landing per min at the site located 2 mi. inland clearly reflects the 6 broods which emerged during the year. Nuisance was pronounced shortly after each emergence but landing rates diminished rapidly and mosquitoes were absent for long periods of time between broods.

The number of broods cannot easily be discerned from the landing rates taken at the site closer to the marsh. Each emergence was accompanied by an increase in the number of mosquitoes landing per min but subsequent counts gave an erratic curve with peaks and depressions over the next 20–30 days. Mosquitoes were absent for only very brief periods of time close to the marsh and in many cases, nuisance appeared to increase as individual broods aged.

To clarify the difference between the 2 sites, the June, July and August broods were treated as replicates and mean landing rates were plotted against time. Figure 3 compares the mean number of *Ae. sollicitans* landing per min at the 2 sites before and after the light trap at each location indicated a major population peak. Landing rates at the site located 2 mi. inland showed a distinct peak which directly corresponded with the peak light trap collection at that site. Nuisance then rapidly diminished with time, and landing rates were very close to zero within 5 days. Landing rates at the site close to the marsh showed a similar but higher peak which also corresponded with the peak light trap collection at that site. Nuisance then declined over a 4-day period but slowly increased again as the brood aged before the counts dropped to near zero. Data indicate that *Ae. sollicitans* were all but absent from the inland

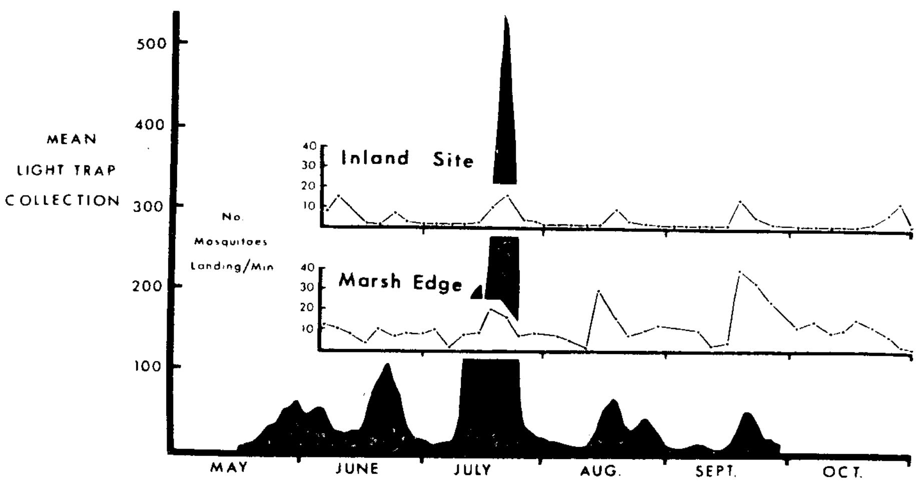

Fig. 2. The numbers of *Aedes sollicitans* collected by light trap within the study area during 1975 and the corresponding landing rates at 2 separate locations.

site within 5 days of their initial appearance but continued to cause annoyance for nearly 3 weeks at the site closer to the marsh.

Since *Ae. sollicitans* is a migratory species which breeds on the coastal marshes and moves toward the upland in quest of a bloodmeal, these data may reflect the inland migration following emergence and the return to the marsh for oviposition. Landing rates at the marsh edge peaked rapidly and declined over the next 4 days. If this were due only to natural mortality, the curve would have continued to drop with time. Data in Fig. 3 show that landing rates at the marsh edge did not continue to decline but actually increased for more than 1 week after the initial drop. The increase may represent an influx of individuals which have returned from their inland migration to oviposit on the salt marsh. If this is the case, the percentage of the population which returns inland after the 1st gonotrophic cycle appears minimal. Landing rates at the inland site remained low after the initial influx after emergence. Data indicate that the majority of parous *Ae. sollicitans* remained close to the marsh after oviposition.

AGE COMPOSITION OF POPULATION WITHIN THE STUDY SITE. Data in Fig. 1–3 suggest that the age composition of *Ae. sollicitans* at the 2 sites was quite different. Fig. 1 shows that the parous rates increased at both sites after the emergence of a brood but the percentage of parous mosquitoes in the population was always higher close to the marsh on any given date. Fig. 2 and 3 show that mosquitoes at the inland site were present only shortly after the emergence of a brood while mosquitoes continued to land on a host at the marsh site 3 weeks after the brood emerged. The small numbers of individuals present at the inland site did not allow an accurate assessment of parity as the brood aged, but enough mosquitoes were present at the site close to the marsh to follow every brood to maximum parity.

To clarify the differences in the age composition of *Ae. sollicitans* collected from the 2 habitats, the mean parous rate

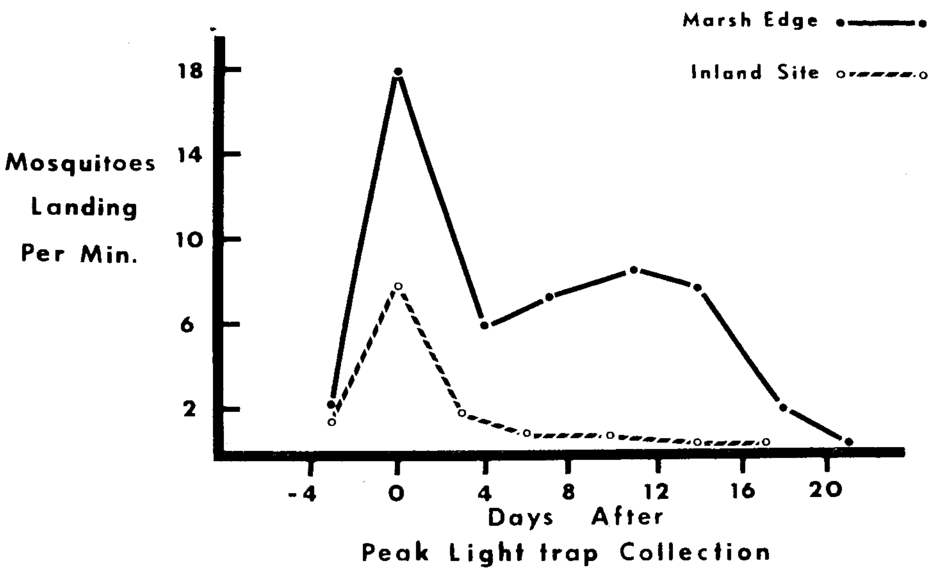

Fig. 3. Mean landing rates for the June, July and August broods of *Aedes sollicitans* at 2 sites in Ocean County during the summer of 1975.

of specimens aspirated between landing counts for the 3 summer broods was also plotted against time. Fig. 4 compares the progression in parity at the 2 sites from the time that light traps indicated peak numbers at each site to the point where maximum parity was reached. In the inland population, parity was zero when light traps collected the greatest numbers and remained below 5% for the next 3 days. Parity then rapidly rose to about 75% on the 10th day before small numbers prevented further assessment. The mean parous rate for the 3 summer broods at the site near the marsh was 20% when light traps showed peak populations. Data indicate that the parous specimens that were present were residual mosquitoes from a prior brood. Parous rates at the marsh edge then showed a geometric increase with time for nearly 3 weeks. Parity was 55% on the 4th day, 80% on the 7th day, 92% on the 11th day, 95% on the 14th day, and 98% on the 18th day. These data give added support to indicate that parous and multiparous *Ae. sollicitans* have a reduced migratory tendency. The mosquitoes which have oviposited appear to congregate close to the marsh rather than migrate inland for subsequent bloodmeals.

Vector Potential Within the Study Area. The differences in nuisance and parity at the 2 sites have considerable public health significance. Nulliparous specimens cause annoyance but are not important as vectors of disease. The parous portion of the population has obtained at least one prior bloodmeal and contains the specimens which can function as vectors of disease. The number of parous mosquitoes which come to bite is a direct indication of the vector potential of the population.

The number of parous mosquitoes which land per min can be calculated by multiplying the landing rate by the parous rate of the population at the time of each collection (Crans 1976). The figure excludes the nulliparous specimens and reveals the numbers of parous and multi-parous mosquitoes which are coming to bite.

The mean parous landing rate for the

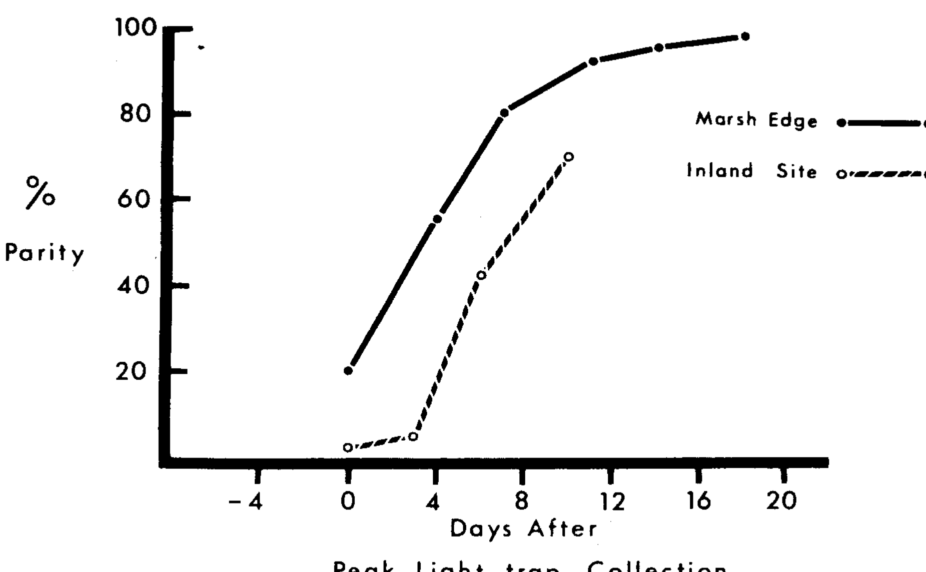

Fig. 4. Mean parous rates for the June, July and August broods of *Aedes sollicitans* at 2 sites in Ocean County during the summer of 1975.

3 summer broods of *Ae. sollicitans* is presented in Fig. 5. Data show that parous mosquitoes were all but absent from the inland site. When annoyance was high soon after the emergence of a brood, parity was close to zero, thus, all bites were the result of nulliparous specimens. By the time that parity began to rise at the inland site, the landing rates had dropped substantially and the number of bites from parous mosquitoes was minimal.

site occurred 10–14 days after the light traps indicated a population peak. During this period as many as 8 mosquitoes which had previously blood-fed were coming to bite each minute. Parous *Ae. sollicitans* were detectable at the marsh site for nearly 3 weeks. In most cases, a fresh brood emerged by this time and longevity could not be followed further by the methods employed in these investigations.

This pattern was observed with every

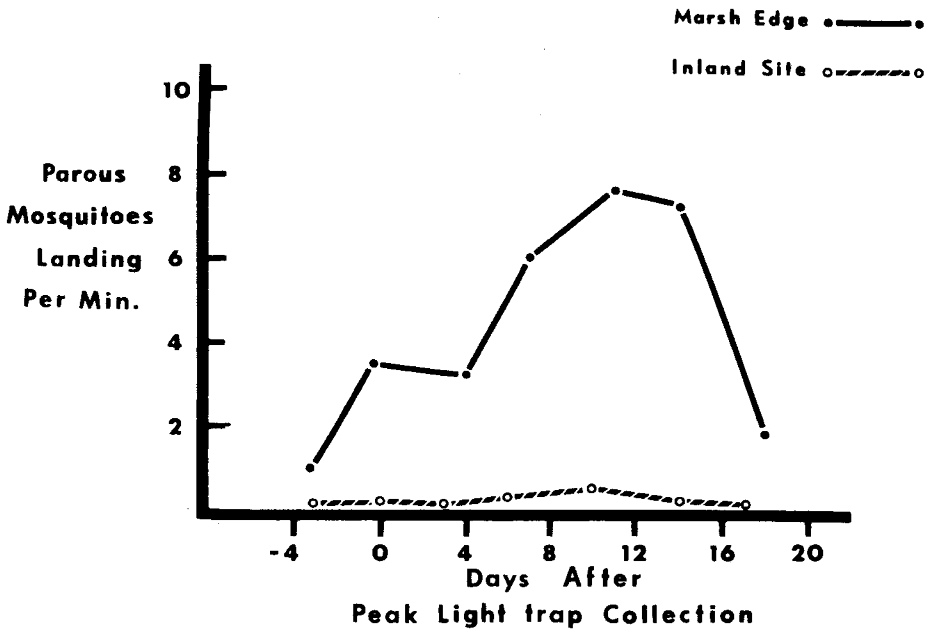

Fig. 5. Mean parous landing rates for the June, July and August broods of *Aedes sollicitans* at 2 sites in Ocean County during the summer of 1975.

The site near the marsh presented a contrasting picture. Parous mosquitoes were present in small numbers prior to peak light trap collections as a result of residual populations from a prior brood, thus, older mosquitoes were mixed in with each fresh emergence. As the brood aged, the numbers of parous *Ae. sollicitans* seeking a host close to the marsh increased for nearly 2 weeks. Data indicate that maximum vector potential in the study

brood of the season. Fig. 6 compares the numbers of parous *Ae. sollicitans* landing per min at the 2 sites throughout the season. The parous landing rates are superimposed on the light trap collections to compare periods of peak vector potential with periods of mosquito abundance. In most cases, the potential for *Ae. sollicitans* to transmit disease was at its lowest point when light traps were collecting the greatest numbers of specimens.

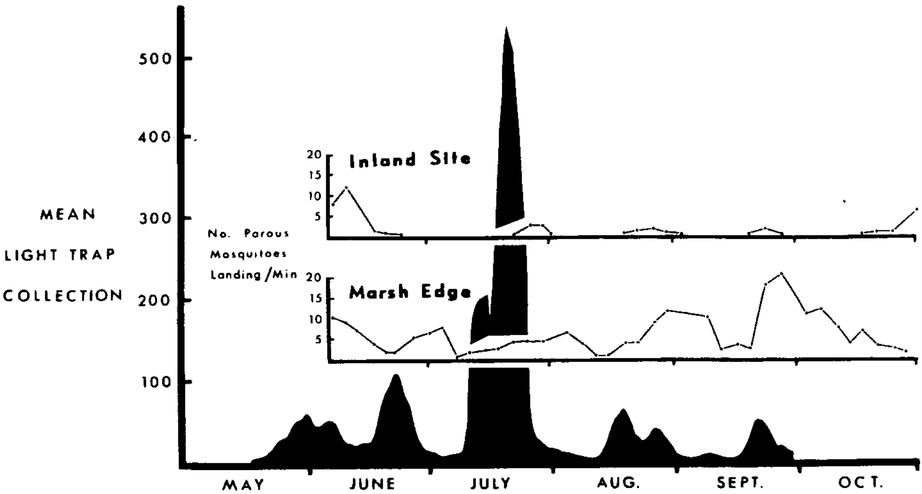

Fig. 6. The numbers of *Aedes sollicitans* collected by light trap within the study area during 1975 and the corresponding parous landing rates at 2 separate locations.

As the light trap collections diminished, the numbers of parous mosquitoes seeking a host increased and vector potential was greatest when light traps were collecting the fewest mosquitoes.

Parous mosquitoes were consistently more numerous at the site nearest the marsh throughout the season and appeared to increase with each brood regardless of brood size as measured by light trap. The numbers of parous mosquitoes coming to bite near the marsh in August and September are particularly striking since light trap records indicate that these were very minor broods. These data suggest that the late season broods either did not move far from the breeding site or did not readily enter light traps. Landing counts show that numerous mosquitoes were present and would attempt to feed.

The greatest numbers of bites from parous mosquitoes in the study area would have been contracted from mid-August through late September. This corresponds exactly with the period of greatest concern for the transmission of eastern equine encephalitis to humans. EEE virus was active in New Jersey during 1975 and emergency *Ae. sollicitans* control was conducted over the study area on several occasions during the period. The high landing rates of parous mosquitoes during the fall were obtained in the presence of these control operations. No data were available to determine the parous landing rates which might be expected in the absence of control.

CONCLUSIONS

Data from these investigations suggest that the behavior of *Ae. sollicitans* does change as the physiological age of the population increases. Migration appears to be a function of the younger portion of the population; parous *Ae. sollicitans* appear to rest and feed closer to a breeding marsh.

Data from these studies show that newly emerged *Ae. sollicitans* will migrate at least 2 mi. inland in quest of a bloodmeal and cause considerable annoyance shortly after emergence. As the physiological age of the population increases, however, nuisance abates further inland and a very small percentage return for subsequent bloodmeals. While annoyance is reduced over a broad geographic area, the numbers of mosquitoes seeking blood appears to increase in a band close to a breeding marsh. These investigations did not define the width of the band, but suggest that annoyance can be extreme during periods of low population at least 0.5 mi. from the marsh edge. Ovarian dissections revealed that most of these mosquitoes had oviposited and were seeking blood to complete a subsequent gonotrophic cycle. As a result, the vector potential of *Ae. sollicitans* was substantially greater in areas close to a breeding marsh.

Considerably more information is needed to assess the public health significance of these findings and the best methods to control populations for the prevention of disease. Parous and multiparous *Ae. sollicitans* appear to behave differently from their nulliparous counterparts. It is conceivable that they may also require separate control.

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