DISPERSAL STUDIES ON RADIOACTIVE-TAGGED *CULEX QUINQUEFASCIATUS* SAY

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INTRODUCTION. Military installations in the area of Pearl Harbor, Hawaii, for many years, have been plagued by invasions of *Culex quinquefasciatus*. Light trap studies conducted by Holway *et al.* (1957) indicated that the primary source of this species for the Pearl Harbor area was in the sugar cane fields of Waipio Peninsula. Their presence has also corresponded with the periods of sugar cane harvest. The method employed for harvesting the sugar cane involves the use of approximately 12,000,000 gallons of water daily to wash the cane. Most of this wash water, which is high in sugar and other organic matter, is utilized for irrigating the cane fields and provides an excellent medium for the production of *Culex quinquefasciatus*. Though much progress has been made toward eliminating this source of mosquito production, it has continued to be a problem. The intent of this study was to determine the range and direction of flight of *Culex quinquefasciatus* from Waipio Peninsula.

METHODS AND MATERIALS. Activities involved in this study included collecting *Culex quinquefasciatus* eggs and tagging the larvae, followed by the recapture of the tagged adults in light traps. A total of 70 light traps, distributed over the island of Oahu, were used for recapturing the adults. Thirty-two of the traps were concentrated within a 4-mile radius of the release point.

The need for obtaining eggs from a laboratory colony of mosquitoes was obviated by the presence of large numbers of eggs in the irrigation ditches of the cane fields. To insure that eggs would be available in sufficient quantities, the sugar company cooperated by withholding insecticide treatment of the area where the eggs were to be collected.

A quonset hut, located about 0.6 mile from the tip of Waipio Peninsula, was used as the rearing and release site. This site was considered highly desirable, since it was located in a U. S. Navy storage yard which provided adequate security and was in close proximity to the cane fields.

An estimated 566,800 eggs, or 2,600 egg rafts averaging 218 eggs per raft, were collected on May 14 and 15, 1962. Approximately 261,600 and 305,200 eggs respectively were collected between 0630 and 0900 on the two days. Each morning's collection was immediately transferred from the cane field to the quonset and placed in rearing trays. The rearing trays consisted of 16 plywood boxes 8′ x 1′ x 8″ and 3 plywood boxes 3′ x 1½′ x 8″, each with a polyethylene liner. The trays were filled with tap water to a depth of four inches. The eggs were stocked in the trays at a density of approximately 4,000 eggs per square foot of water surface.

Air temperature readings inside the quonset ranged from 71° to 89° F. The water temperature did not exceed 77° F.

The larvae were fed finely ground dog biscuits. The first feeding was on the second day and was at the rate of 0.2 mg. per larva. Thereafter, the food requirements were determined daily and the larvae were given enough food to last for the next 24-hour period. Results of previous tests showed that excessive amounts of food would cause scum to form on the surface of the water, resulting in suffocation of the larvae.

On the eighth day (May 21), approximately half of the larvae in the first group had reached the fourth instar and were prepared for tagging. This was accomplished in 8′ x 1′ x 8″ plywood trays with polyethylene liners. Four tagging trays were filled with tap water to a depth of

1 inch. An estimated 128,000 larvae were then transferred from the rearing trays to the tagging trays by means of rectangular shaped (6" x 8") plastic screen (18-mesh) dippers. With a combined area of 32 square feet in the four tagging trays, the larvae were concentrated at the rate of approximately 4,000 larvae per square foot of water surface.

During the late morning of May 21, the radioactive phosphorous ($H_3P^{32}O_4$) was diluted with tap water, mixed thoroughly, and introduced into the marking trays. The trays, already containing the larvae in 1 inch of water, were filled to a total depth of 4 inches with the radioactive solution. The resulting concentration of the P^{32} was 0.074 millicuries per liter of water. The above procedures were followed on the morning of the next day when the second group was marked. This group contained an estimated 160,000 larvae and, like the first group, larval concentration was at the rate of approximately 4,000 larvae per square foot of water surface. Five tagging trays were used with a P^{32} concentration of 0.079 millicuries per liter of water. In each case, the larvae were allowed to remain in the radioactive solution throughout the remainder of their development.

On the ninth day, an estimated 600 to 800 pupae were present and were emerging by the tenth day. This early emergence was attributed to the collection of first instar larvae when the eggs were gathered. Otherwise, pupation was considered to have started on the tenth day. By the twelfth day pupation was complete and approximately 2–5 percent emergence occurred. Adults which emerged on the twelfth day were predominantly males. By the end of the thirteenth day, emergence of the adults was complete.

With the adults emerging over a 2-day period, it was difficult to study the exodus from the quonset. However, it was obvious that the first to emerge were predominantly males. Departure from the quonset was not apparent during the day and is believed to have begun during the evening of the day of emergence. There continued to be large numbers of both sexes in the quonset through May 28, and noticeable numbers were present until June 1. Of 58 radioactive adults collected with a net in the quonset on June 1, there were 22 males and 36 females. Monitoring of the adults was accomplished with a Tracerlab Basic Ratemeter and Laboratory Monitor equipped with a thin window G-M tube detector.

All light traps used in the recovery of the radioactive mosquitoes were operated nightly. Those operated in a 5-mile radius of the release point were checked daily except Sunday. Other traps were checked 3 to 5 times per week. Operation of the traps began on May 23 and continued through July 2.

RESULTS. A total of 634 marked mosquitoes were recovered in the light traps. Of the total number recovered, 614 were captured in a single trap (No. 1) located within 150 yards of the quonset from which the mosquitoes were released. Originally, this trap was located about 0.6 mile southeast of the release point. It was moved on May 28 and was operated for two nights just outside the quonset. On May 29, 41 females and 106 males were recovered, followed by a catch of 64 females and 92 males on May 30. The trap was relocated on May 30 at a point 150 yards south of the quonset, where it remained until the end of the experiment. At the latter location, a total of 164 females and 147 males were recovered. Each collection was positive for this trap through June 19, although the catches for June 4, 6, 12, and 19 represented combined recoveries for 2, 2, 4 and 4 days respectively. The final recovery at this location was the capture of a single male on June 25. This was the only trap operated within a 0.5 mile radius of the release point. The purpose of locating a trap near the quonset hut was to study the movement of the tagged mosquitoes from the immediate area.

Twenty radioactive specimens (14 fe-

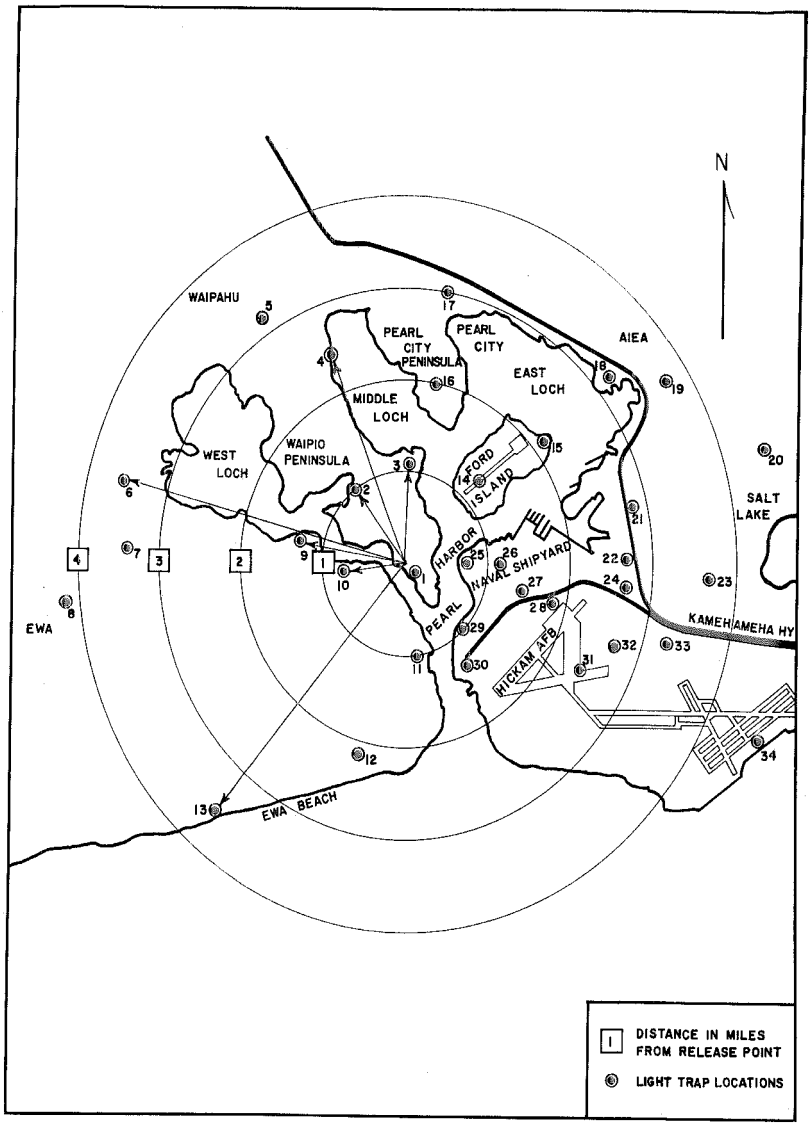

FIG. 1.—Map of study area showing flight range and distribution of *Culex quinquefasciatus*.

males and 6 males) were recovered outside the 0.5 mile radius (Fig. 1). Nineteen were recovered in a 90° sector northwest of the release point. A single female was recovered in a southwestern direction.

The first recovery to occur beyond 0.5 mile from the release point was a female, which was captured in a trap (No. 10) located 0.75 mile west on May 31. This was followed by the recovery of a male in the same trap on June 1. Also, on June 1, one female was recovered at the

U. S. Navy Inactive Service Craft Facility (trap No. 4), 2.5 miles NNW of the release point. Further recoveries from trap No. 4 included one female on June 4, and another on June 15. From trap No. 9, 1.3 miles WNW, one female and one male were recovered on June 4, and one female on June 12. On June 5, one male specimen was recovered from a trap (No. 3) located at the U. S. Navy Degaussing Station, one mile north of the release point. Four radioactive females were recovered from the same trap in a combined catch of June 6 and 7. Trap No. 2 located one mile northwest, was positive on June 5 (1 male) and in a combined catch of June 6 and 7, one female was recovered. On June 4, one female was captured in trap No. 6, which was located 3.5 miles WNW. This was followed by the recovery of one male on June 6, one male on June 7, and a female on June 12. One other recovery (1 female) occurred on June 12 in a trap (No. 13) 3.5 miles southwest of the release point.

A daily study of the wind movements was conducted from the time of emergence of the tagged mosquitoes through June 15. Except for one night (June 1), when the wind was from the SSE, the prevailing winds were consistently from the northeast. In addition to the northeastern land breeze that entered Pearl Harbor, there was a sea breeze from the south which occurred during the same time. This condition caused a clockwise swirling movement of the wind in the study area. Sailboat operators reported that a calm occurred nightly in West Loch between 1800 and 2300 hours with a duration of 15 minutes to two hours.

DISCUSSION. The flight of the radioactive specimens (6 females and 4 males) recovered from traps No. 6, 9, 10 and 13, involved crossing a body of water which had a minimum width of 800 feet. If they had flown around the body of water to reach the above mentioned traps, the distances covered would range from 5 to 8.5 miles. However, the latter is considered unlikely.

Sex did not appear to be a factor in the distance covered by the adults, since the specimens recovered at the maximum distance of 3.5 miles included 3 females and 2 males. With the exception of the single male that was recovered on June 25 from trap No. 1 (150 yards from the release point), no males were recovered after June 7, 12 days after emergence of the first group. The last female to be recovered was on June 15, 20 days after emergence.

The 20 tagged specimens recovered outside the 0.5 mile radius were captured in seven traps. The percentage distribution of these 20 specimens at the different distances was as follows: at 0.75 mile, 10 percent; at 1 mile, 35 percent; at 1.3 miles, 15 percent; at 2.5 miles, 15 percent; and at 3.5 miles, 25 percent. Of the same specimens, the percentage recovery in respect to time after emergence was as follows: at 5 days, 5 percent; at 6 days, 10 percent; at 9 days, 20 percent; at 10 days, 10 percent; at 11 days, 5 percent; at 12 days, 30 percent; at 17 days, 15 percent; and at 20 days, 5 percent. Recoveries on 12 and 17 days were from combined collections of 2 and 4 days respectively. The day of emergence was considered as day zero and is based on the day in which emergence occurred in the first group.

SUMMARY AND CONCLUSIONS. Previous studies have shown that Waipio Peninsula is the primary source of *Culex quinquefasciatus* for the Pearl Harbor area. From the release of 275,000 P^{32}-tagged mosquitoes on the peninsula, 634 were recovered from distances up to 3.5 miles. Twenty specimens were recovered beyond the 0.5 mile radius of the release point. During this study, the wind movements in the release and recovery area were in a clockwise direction. There is little doubt that this action of the wind influenced the flight of the tagged mosquitoes in a direction away from Pearl Harbor. From this study, it can be concluded that from Waipio Peninsula this mosquito species is capable of flights of at least 3.5 miles, which places practi-

cally all of Pearl Harbor within its range.

It is hoped that this study will stimulate further research in order to evaluate more thoroughly the range and direction of flight of *Culex quinquefasciatus* from Waipio Peninsula. The author believes that the release of marked mosquitoes from a point approximately two miles northwest of the release site used in this study would be extremely beneficial. This would be in the general area where heavy mosquito production normally occurs.

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LARVAL HABITAT OF *AEDES AEGYPTI* (L.) IN THE UNITED STATES

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Probably more workers in mosquito control and related fields are familiar with the *Aedes aegypti* (L.) than with any other species of mosquito. This familiarity results from the widespread use of *Ae. aegypti* as a laboratory insect; its occurrence, always near human habitations, throughout a large area of the United States; and from the many publications concerning its role as the urban vector of yellow fever and dengue.

In spite of this voluminous literature, very little information is available on the exact habitats of the larvae. King *et al.* (1960) mention some of the types of receptacles in which the larvae have been found. Porter, Evans, and Hughes (1961) have discussed the importance of tree holes as a habitat. More information is available for Africa (Teesdale, 1955, Surtees, 1959 and 1960) and for Malaya (MacDonald 1956).

During the years 1956 through 1962, the Communicable Disease Center conducted surveys in 440 communities in 262 counties to determine the distribution

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