STUDIES OF FLIGHT RANGE AND SURVIVAL OF *ANOPHELES ALBIMANUS* WIEDEMANN IN EL SALVADOR. I. DISPERAL AND SURVIVAL DURING THE DRY SEASON[1]

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ABSTRACT. A series of studies of the flight range and survival characteristics of *Anopheles albimanus* were carried out at Zapotitan, El Salvador. Dispersal and survival of colony-reared mosquitoes were studied by the release and recapture of mosquitoes marked with fluorescent powders. This report presents a description of the study area, the methods used for marking, transporting, and recapturing the mosquitoes, and the findings during the dry season of 1973. A total of 85,750 males and females were released at three different locations in five separate releases, and 924 marked individuals were recovered by collections in stables and natural resting places. The maximum distance at which marked mosquitoes were recaptured was 3 kilometers from the release point, and the longest survival observed was the recapture of 11-day-old females. This survival time is of epidemiolgical significance since it is long enough to permit some female *A. albimanus* mosquitoes to become infective and to transmit malaria during the dry season.

Studies on the flight range and survival of malaria vectors have been carried out by many investigators in different parts of the world and the information derived from the studies has been important in delimiting control areas and in the selection of sites for civilian and military population concentrations. The two methods generally used for studying flight range have been (1) measuring dispersal of mosquitoes from single isolated breeding sources or (2) releasing mosquitoes marked with dyes, powders or radioactive compounds, then attempting to recapture them at varying distances from the release points.

In Middle America, observations on the flight range of *Anopheles albimanus* Wiedemann by releasing and recapturing mosquitoes stained with dyes were first made by Zetek (1915) in Panama. He recaptured stained mosquitoes at locations up to 1800 meters away from the point of release, but was able to find only one marked *A. albimanus* at the maximum distance. Fisher (1923) reported that invasions of *A. albimanus* and other anopheline species could be expected 3.2 km or more from breeding places. Migratory flights of this species in Panama were observed by Curry (1934). His conclusion was that migrations of 19 km or more occurred at the onset of the rainy season, but this was based only on the presence of mosquitoes at this distance from known breeding sites.

In September 1972, studies on the dispersal and longevity of *A. albimanus* were initiated in El Salvador by the Central America Research Station (CARS), Bureau of Tropical Diseases, Center for Disease Control, DHEW, in collaboration with the Insects Affecting Man Research Laboratory, ARS, USDA, Gainesville, Florida. The studies were continued in the spring and fall of 1973, with both normal and chemosterilized mosquitoes, and the objectives were: to measure the flight range and survival rates of *A. albimanus* during both the rainy and dry seasons, to study flight and survival characteristics of chemosterilized males compared with untreated males, and to observe seasonal fluctuations of the natural population densities of an area. Each phase of the study was completed by means of mark, release, and recapture techniques.

This report deals with observations on

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the flight range and longevity of normal untreated *A. albimanus* released into the natural population during the dry season of 1973, the methodology employed, and a description of the study area. The results have significance in relation to the epidemiologic investigation of malaria cases.

DESCRIPTION OF THE STUDY AREA

This project was carried out at Zapotitan, Department of La Libertad, El Salvador. The locality, in the center of the basin between the volcanoes of Santa Ana and San Salvador, averages 475 meters above sea level. A flat swampy area, covering approximately 4,130 hectares is being reclaimed for agriculture by a government drainage and irrigation project. This development has already provided the area with a good network of all-weather roads, as well as water for year-round crop production and pasture for dairy and beef cattle. However, the drainage system is not completed, and natural or man-made breeding sites of *A. albimanus* can be found in every month of the year.

The climate of this part of El Salvador is of the monsoon type, with marked rainy and dry seasons. The total rainfall at Zapotitan in 1972 was 1485 mm. The rainy season begins gradually in April, and the rains taper off in October with an average rainfall in the months of December through March of only about 6 mm. The monthly average temperature for March 1972 was 24.6° C and for April was 25.6° C. The monthly average relative humidity for March was 67 percent and for April was 71 percent. These were not very windy months with the monthly averages of wind velocity not exceeding 7.2 kilometers per hour.

There are approximately 3500 people living in six small villages and in houses scattered throughout the Zapotitan agricultural district. Malaria is endemic in the area, and the incidence of the disease was relatively high in 1972 with an annual attack rate of 208.2 cases per 1000 population.

MATERIALS AND METHODS

A colony of *A. albimanus* was established in late 1972 at the CARS laboratories with larvae, pupae, and adults collected from Zapotitan. Using the mass rearing methods described by Ford and Green (1972), the colony had increased within 3 months to a production of approximately 50,000 pupae per day.

Mosquitoes for field-release studies were placed as pupae in cages (64 x 64 x 42 cm.) containing cotton pads saturated with 2.5 percent sugar water and allowed to emerge. Twenty-four hours later, individual groups of about 1000 adults were removed from the cages with a battery-powered aspirator. Each batch was immobilized briefly in a —10° C freezer, transferred to plastic wide-mouth bottles coated lightly on the inside with Day Glo® [4] fluorescent powder, gently rotated for marking, and placed in cages for transport to the field. This technique provided excellent marking of all individuals. Seven different colors of fluorescent powders were available, making it possible to color-code serial releases or mosquitoes released in the same or different locations. Marked mosquitoes were carried to the field in expanded foam ice chests converted to insulated cages by covering the open tops with gauze, then placing damp paper towels over the gauze for humidity, and taping the top over this. Mortality from handling, marking, and transport was exceptionally low (<5%).

Five releases of marked mosquitoes were made during the period from March 24 to April 10, 1973, in the central part of the irrigation district (Fig. 1). Three different release points were used in the

[4] Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or by the U. S. Department of Health, Education and Welfare.

course of these studies, but each individual release was from a single point. A total of 85,750 normal untreated colony *A. albimanus* were released, of which approximately 50 percent were male and 50 percent female. All releases were made immediately after sundown, which is about 6:30 p.m. during March and April.

Stables and cattle corrals as well as natural resting places such as bridges, irrigation culverts, vegetation and buttressed tree trunks were used as capture stations. Twelve stables and six natural resting places were routinely searched, and the distribution and numbering of these is shown on Figure 1. The maximum distance from release to recapture points was about 5.5 kilometers. These capture stations were searched twice daily by one collector: from 9:30 to 10:30 a.m. and then again from 6:30 to 7:30 p.m. for 2 days after the release. Starting on the third day after release, the capture stations were searched once daily from 9:30 to 10:30 a.m., and the searches continued until marked individuals failed to appear in the catches for 2 consecutive days. In addition, human biting captures were done on the nights of the releases by men stationed at the cardinal compass points 100 to 250 meters from the release point. Only anopheline mosquitoes were captured, and they were placed in individual shell vials for return to the laboratory, where each mosquito was indentified to species. The vials containing *A. albimanus* were examined under UV light to detect individuals marked with fluorescent powder.

RESULTS AND DISCUSSION

The percentages of recovery for the five releases of marked adults varied from 0.75 to 2.92 percent for females and from 0.07 to 0.26 percent for males (Table 1). These data include captures from all capture sta-

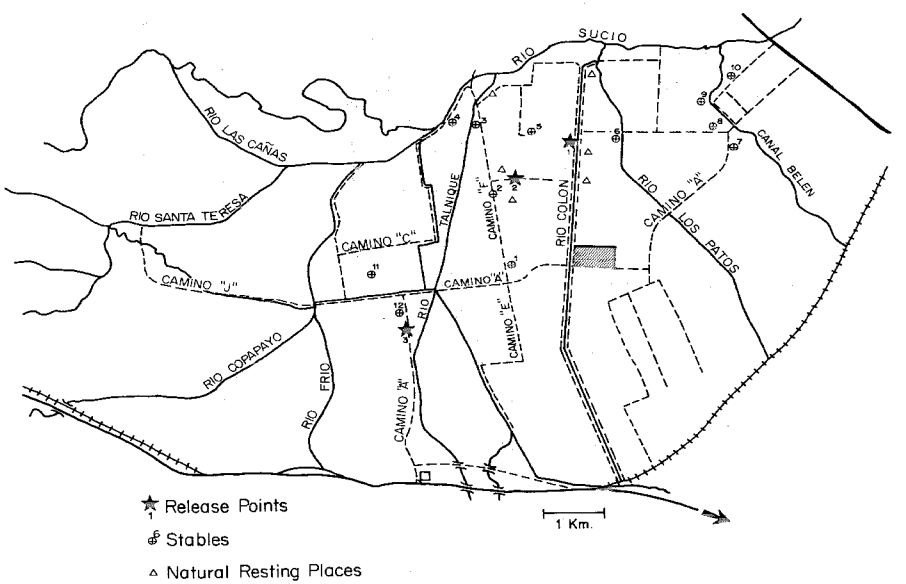

FIG. 1. Zapotitan Irrigation District, El Salvador, showing release points and capture stations.

TABLE 1. Marked *Anopheles albimanus* recaptured in stables and natural resting places after five releases at Zapotitan, El Salvador, March–April 1973.

Release	Date of release	Number released *	No. recaptured ♂	No. recaptured ♀	Percent recaptured ♂	Percent recaptured ♀	Maximum survival	Maximum dispersal
A	21 March	17,250	7	65	0.08	0.75	8.5 days	1 km.
B	24 March	11,500	15	168	0.26	2.92	8.5 days	2 km.
C	29 March	17,750	6	119	0.07	1.34	6.5 days	3 km.
D	3 April	25,500	16	359	0.12	2.82	11.0 days	1.5 km.
E	10 April	13,750	8	161	0.12	2.34	7.5 days	1.75 km.

* Each release consisted of approximately 50 percent males and 50 percent females.

tions but exclude the human biting captures conducted on the nights of release. It was not unexpected that higher percentages of females than males were recovered, since many of the collections were made in stables which probably attracted female *A. albimanus* mosquitoes in search of a blood meal. Daily searches of the six natural resting places resulted in the collection of relatively few adult males.

The maximum distance at which marked mosquitoes were recaptured was 3 km from the release point, and the maximum observed longevity was of 11-day-old females recaptured 10 days after release. It was not surprising that the largest number of marked individuals were collected at the human biting stations on the evenings of release, since these were nearest the release points, and the mosquitoes were unfed. For five releases, the average distance at which marked individuals were recovered, by all methods, was 548 meters for females and 460 meters for males.

These findings indicate that female *A. albimanus* can fly at least 3 km and can survive for 11 days during the dry season in a habitat comparable to that at Zapotitan. It is not unrealistic to suspect that some exceeded these limits but were not detected due to the limitations of this study. This survival time is of epidemiological significance, since the minimum duration of the cycle of the *Plasmodium vivax* malaria parasite in mosquitoes in El Salvador has been considered to be 8 days. It appears that some female *A. albimanus* mosquitoes survive long enough during the dry season to transmit the disease. Anthony *et al.* (1972) published a population model relating the survival of *A. albimanus* to malaria transmission and calculated the number and percentage of infective females that would be found in populations characterized by various gonotrophic or biting cycles at different daily mortality rates. According to their model, even with high mortality rates similar to those during dry seasons, a small percentage of females can survive long enough to be vectors.

The methodology used in these studies for rearing, marking, transporting and releasing large numbers of *A. albimanus* proved to be efficient, with an overall adult mortality of less than 5 percent. Individuals marked with the fluorescent powders were clearly identified for at least 10 days after field release, and the number of marked individuals of both sexes that were recaptured was sufficient to make valid observations on the longevity and flight range of this species. In addition, this release-recapture technique may be useful to calculate natural mosquito populations by comparing the ratio of marked with unmarked adults recaptured after releasing known numbers of adults.

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