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# OBSERVATIONS ON THE BREEDING OF ANOPHELES ALBIMANUS IN BRACKISH WATERS IN EL SALVADOR, CENTRAL AMERICA

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Along the Pacific littoral in the Republic of El Salvador, numerous rivers flow across the coastal plain to empty into small estuaries. During the rainy season, sufficient water is carried by these rivers to keep the estuaries open to the ocean. When open, the estuaries are flushed by the tides every twelve hours. As the river flow decreases during the dry season, many of these estuaries are closed by the formation of sand bars created by wave action and form large bodies of impounded saline water. The continual discharge of river water into these impoundments results in a gradual decrease in salinity. Accompanying this is an expansion of the water surface into heavily vegetated areas and the subsequent development of larval populations of _Anopheles albimanus_ Wiedemann. Following the onset of the rainy season the water level continues to rise and the river flow becomes strong enough to cut a channel through the sand bar and these areas open naturally to the ocean once again.

The suitability of such brackish or saline waters as a breeding habitat for various anopheline species has been well documented. Both

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Darling (1910), and Simmons et al. (1939) reported breeding of A. albimanus in Panamanian waters with a salinity value of 80 percent sea water. However, Shropshire and Zetek (1927) reported an upper salinity tolerance for this species of only 57 percent sea water, also in Panama. In Puerto Rico, Hurlbut (1943) encountered field populations breeding in 80 percent sea water.

As part of an investigation on the ecology of A. albimanus in Central America, the breeding pattern of this species in such coastal habitats was studied between February 1969 and July, 1970.

Study Area: Estuary San Diego is located on the Pacific Ocean, 3 kilometers east of the port city of La Libertad. The rainy season generally begins in early May and the estuary opens to the ocean in June or July. With the termination of the rains in October, the estuary will close in January or February.

A total of twenty stations were established in the estuary for larval dipping and water sampling. In addition, weekly samples were taken along the boundary of the estuary. Figure 1 illustrates the general outline of the area and location of the sampling stations.

Methods: All stations were sampled on one day during the last week of each month at a time coinciding with a high tide. A total of ten dips were taken at each station. It was decided to sample at high tide for two reasons: (1) to allow for any influence of groundwater seepage or movement of the ocean water over the sand bar when the estuary was closed, and (2) to ensure that water was always present at the sampling locations when the estuary was open. Occasionally it was necessary to omit a station due to the difficulty of travel through the area.

The predominant species, and the only anopheline ever encountered, was A. albimanus although occasionally Culex sp. were found.

Water samples were collected each month in cork stoppered bottles from the surface level of the water at the time of larval dipping. Analysis for salinity of these samples was made following the procedure of Strickland and Parsons (1960). This technique is a titration process which measures the amount of halide halogen ions present by precipitation with silver nitrate. For each month samples were collected from the estuary, a sample was also taken from the ocean. The average halide halogen ion concentration for these ocean samples was 33.9, and this value was used to calculate the percent salinity of all estuary samples.

Results: The estuary closed to the ocean January 14, 1969. The presence of larvae was detected the following month at two separate stations (table 1). In March, all stations were positive for larvae. The decrease in salinity in April and May was accompanied by an observable increase in the number of larvae present, although a few stations were found to be negative.

The estuary was opened to the ocean artificially on June 13, 1969.

The authors did not witness this opening, but local residents indicated some type of tractor was used. The day following the opening, no larvae could be found at any station. This was attributed to the flushing action caused by draining water, followed by tidal exchange. As long as the estuary remained open, no larval populations were observed.

The estuary remained open to the ocean until February 18, 1970, at which time it was sealed by the formation of the sand bar. Salinity values for water samples collected during that interim closely paralleled those reported for the month of June, 1969 (table 1, Figure 2).

The first larvae were detected in the area during the last week of March, 1970, approximately five weeks after the estuary closed. The average salinity of the area at this time was 61 percent sea water, however at one of the positive collection stations, number 3, salinity was recorded at 70 percent sea water. This was the highest salinity value at which the species was ever found. The following month the average salinity of the water had decreased to 43 percent and there was an increase in the number of positive stations. Again, larvae were collected at station 3, where a salinity value of 68 percent sea water was recorded.

Breeding continued to increase each month thereafter as the salinity decreased. Unusually heavy rains fell during the first part of June and at the time of sampling the estuary was fast approaching the fresh water state, with an average salinity of 2 percent sea water. The day after sampling, the estuary opened spontaneously to the ocean and once again, beginning the day following the opening and subsequently, no larvae could be found at any station. The regular July survey showed an average salinity of 64 percent sea water.

Figure 2 summarizes the condition of the estuary and average salinity values in relation to development of larval populations during the entire study period. As illustrated, the salinity of the water was low during the months of July, August and September, 1969. This is indicative of the heavy rains which fell during that period. In general, the incoming tide forced the fresh water back into the vegetative areas with the resultant formation of a mixing zone between the fresh and salt water, the fresh water often overriding the salt water at this zone. This is reflected in the samples taken at this time and explains the lower salinity values recorded for this period.

Discussion: It can be noted that at station 3, the salinity was 81 percent sea water in February, 1970 after the area closed to the ocean. The following month, this station was positive with third and fourth instar larvae at a salinity of 70 percent sea water. The general trend was for the salinity of the water to decrease once the estuary closed to the ocean. It can therefore be surmised that the salinity at the onset of larval development was somewhat higher than that at which the larvae were found, falling between the values of 81 and 70 percent sea water. This places our results in close agreement with the findings of two authors and indicates an upper salinity tolerance for A. albimanus breeding in this estuary of approximately 75 percent sea water.

Stations located at the terminal ends of the estuary often had salinity values approximating fresh water where the estuary was open to the ocean. This would suggest a habitat suitable for breeding, whereas in actuality these findings serve to demonstrate the action of the incoming tide in holding and forcing the fresh water back. Visits to these stations at periods of low tides revealed areas completely free of standing water. The constant fluctuation in water levels during these periods is considered as the primary factor in preventing breeding and larval development.

Many stations which were positive one month would be negative the next month. This was attributed to a rising water level resulting in an inundation of the protective weed cover normally associated with larval populations. In addition, the absence of such weed cover made the area more subject to wave action and hence produced AN unstable environment. As vegetative growth continued, the area would once again develop into an acceptable habitat.

This study illustrates the ability of A. albimanus to propagate in waters of high saline content provided that the waters are not in a state of constant fluctuation. Careful consideration should be given to such areas as they become stabilized and methods of reducing the breeding potential utilized where possible.

Table 1. Relation of salinity, expressed as percent sea water, to breeding of *Anopheles albimanus* in Estuary San Diego, El Salvador, Central America[1]

| Station[2] | 1969 Feb. | Mar. | Apr. | May | June | 1970 Jan. | Feb. | Mar. | Apr. | May | June | July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 40(+) | 34 | 27(+) | 81 | 90 | 50 | 59 | 49 | 40 | 2(+) | 82 |
| 2 | - | 43(+) | 37 | 29(+) | 83 | 88 | 69 | 58 | 54(+) | 40 | 4(+) | 80 |
| 3 | - | 51(+) | 39(+) | 34(+) | 73 | 87 | 81 | 70(+) | 68(+) | 51(+) | 3(+) | 69 |
| 4 | - | 51(+) | 36(+) | 47(+) | 34 | - | - | 74 | 21(+) | 60 | - | 40 |
| 5 | - | 47(+) | 38(+) | 31(+) | 38 | - | - | 43 | 56(+) | 47(+) | - | 36 |
| 6 | - | 50(+) | 36(+) | 29(+) | 56 | 54 | 53 | 67(+) | 57 | 41(+) | 1(+) | 51 |
| 7 | 58 | 48(+) | 35(+) | 27 | 85 | 96 | 57 | 58 | 46 | 39(+) | 2(+) | 84 |
| 8 | 53(+)[3] | 40(+) | 35(+) | 37(+) | 84 | 94 | 55 | 58 | 49 | 38(+) | 3(+) | 90 |
| 9 | - | 40(+) | 34(+) | 27 | 86 | 91 | 53 | 58 | - | 39(+) | 3(+) | 87 |
| 10 | 58 | 47(+) | - | - | - | - | - | - | - | 11(+) | 3(+) | 87 |
| 11 | 45(+) | 30(+) | 27(+) | 20(+) | 64 | 41 | 41 | 51(+) | 35(+) | 38(+) | 1(+) | 70 |
| 12 | - | 48(+) | 39(+) | 20(+) | 1 | 99 | 89 | 76 | - | 51(+) | - | 3 |
| 13 | 65 | 48(+) | 39(+) | - | 5 | 100 | 86 | 74 | 38(+) | 45(+) | - | 12 |
| 14 | - | 46(+) | - | 30(+) | 9 | 96 | 92 | 68 | 40(+) | 54(+) | - | 14 |
| 15 | - | 42(+) | - | - | 78 | 98 | 87 | 69 | - | 39(+) | - | 19 |
| 16 | 11 | 22(+) | 17(+) | 11(+) | 79 | 58 | 52 | 34(+) | 15(+) | 50(+) | 1(+) | 82 |
| 17 | 47 | 36(+) | 31(+) | 19(+) | 89 | 73 | 74 | 58 | 45(+) | 32(+) | 2(+) | 87 |
| 18 | 53 | 41(+) | 32(+) | 27(+) | 79 | 90 | 82 | 64 | 45 | 35 | 2(+) | 91 |
| 19 | 53 | 52(+) | 33(+) | 34(+) | - | 92 | - | 65 | - | 41(+) | 3(+) | 98 |
| 20 | - | - | 23(+) | 23(+) | 88 | 78 | 75 | 56 | 22(+) | 30(+) | 4(+) | 89 |
| Avg. | 49 | 43 | 33 | 28 | 62 | 84 | 69 | 61 | 43 | 41 | 2 | 64 |

1 - Salinity was determined following the method of Strickland and Parsons (1960). Percent salinity was calculated using 33.9, the average salinity value for sea water collected from the ocean in the area of the estuary during the course of this study. In 1969, the estuary closed January 14 and opened June 13. In 1970, the area closed February 18 and opened again July 1.

2 - See Figure 1.

3 - (+) following salinity value indicates the presence of larvae.

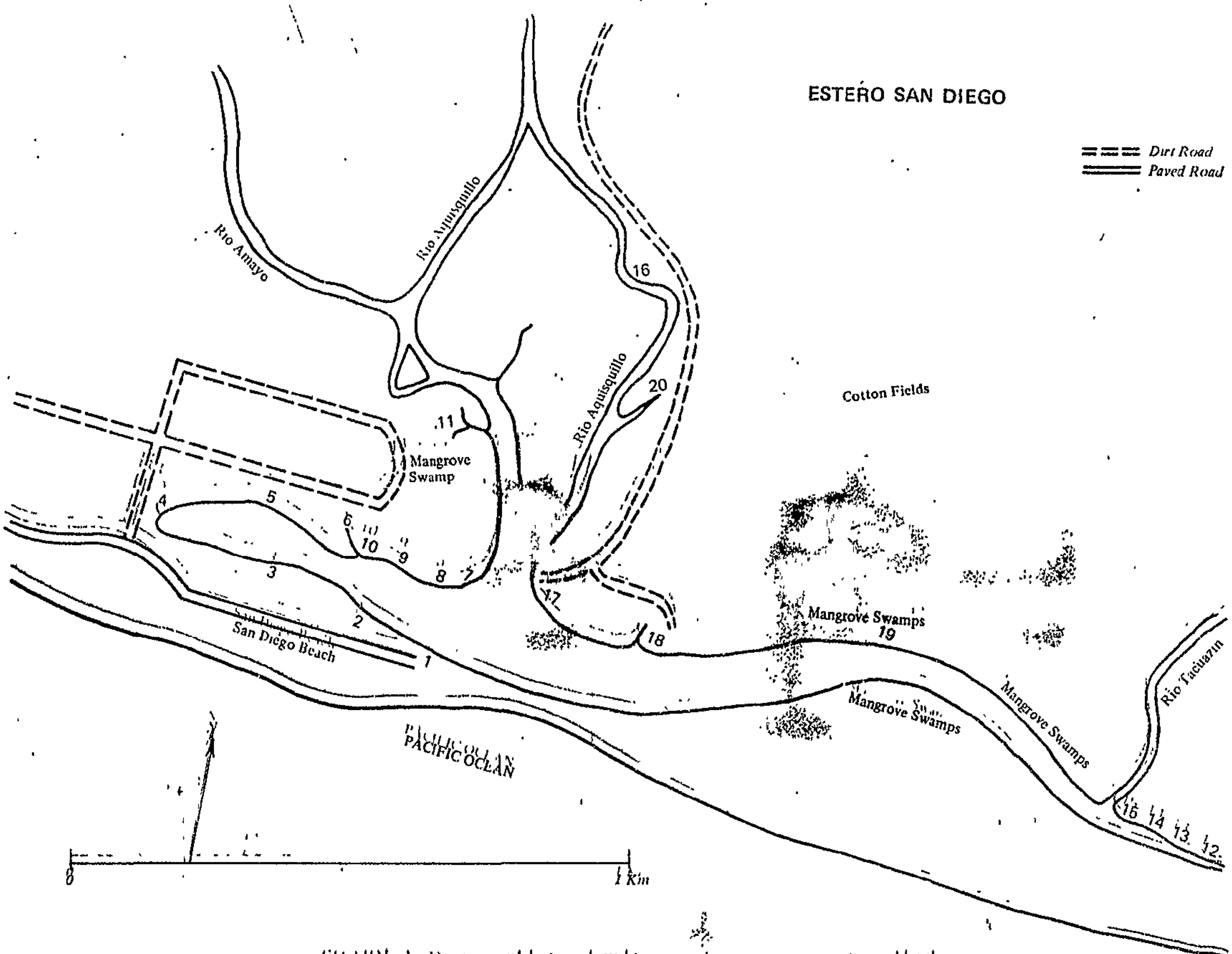
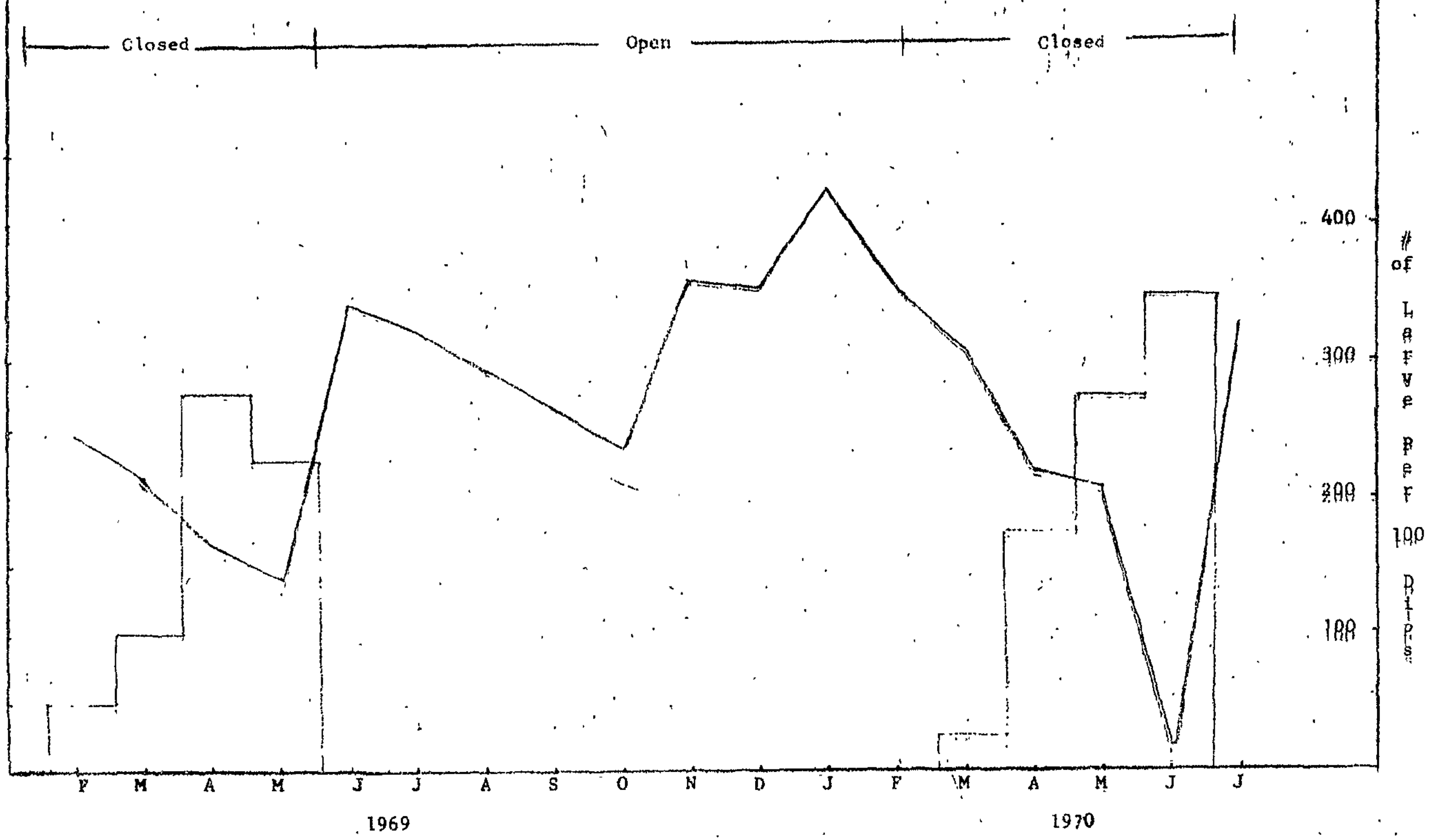



FIGURE 1. Diagram of Estero San Diego and Location of Stations Used in Water Sampling and Larval Dipping.

Figure 2 Topographical Condition of Estero San Diego and related Salinity Values in Relation to Larval Populations



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