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EVALUATION OF A VECTOR SOURCE REDUCTION PROJECT IN THE TICUIZIAPA ESTERO

by

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I. PROTOCOL FOR THE TICUIZIAPA ESTERO WATER MANAGEMENT PROJECT

A. Project Outline

The Ticuiziapa Water Management Project is the first of several source reduction projects planned as part of a national program to reduce the anopheline mosquito population in the coastal esteros of El Salvador. It is hoped that proper regulation of estero water levels will reduce the need for the application of pesticides and, at the same time, reduce the malaria transmission.

This project is the first attempt to provide a permanent solution to the continual problem of malaria transmission in the area. It is important because the experience and information obtained from this pilot study can be applied to other esteros along the coast of El Salvador. In addition, this project can serve as a model for other Central American countries with similar malaria transmission problems. Finally, the water management or source reduction approach to the problem of malaria transmission in El Salvador may help alleviate the problems associated with the long-term application of pesticides such as, the contamination of the environment, rapid development of vector resistance to the insecticides, and the rising cost of insecticides.

Historically, the Ticuiziapa estero has been a high malaria transmission area, requiring year round malaria control efforts involving the application of adulticides and larvicides in order to maintain low transmission levels. For this reason, the estero has been selected as the site for the pilot project. In addition, Ticuiziapa is an example of a simple estero system; it has only one source of fresh water, the San Antonio River. Consequently, the engineering solution, in terms of source reduction, should be straight forward.

The purpose of this project is to prevent, during the dry season, the San Antonio River from causing the estero to overflow its margins. After the rainy season, the river continues to flow into the estero; however, its volume is insufficient to maintain the estero open to the ocean. When the wave action of the ocean closes the estero, it overflows its natural boundaries and creates an ideal larval habitat for Anopheles albimanus. This mosquito is the major vector of malaria in Central America and is thought to be responsible for most of the malaria transmission in the area.

The project will involve the construction of a low dam (70 cm high) near the mouth of the San Antonio River. The building of this dam will divert the flow of water from the river directly into the ocean during the dry season, via a concrete bypass pipe. The bypass pipe will have a gate that can be opened and closed in order to regulate the amount of river water going into the ocean. During the wet season, the gate will be opened manually allowing the river to flow, uninterrupted, into the estero. The construction of this project will regulate the estero water levels during the dry season only; therefore, the practice of manually opening the estero during the wet season, to allow draining of the estero and the inflow of sea water, will continue. In addition to the construction of the dam, a series of canals will be constructed to allow neighboring lowlands to drain during the rainy season. These canals will drain into the river and will serve to reduce mosquito breeding sites, not directly associated with the estero, during the wet season. The construction for this project is expected to begin in October 1987, at the beginning of the dry season, and completed by March 1988.*

B. Objectives

The objective of the present study is to gather base line data to determine the seasonal characteristics of the estero and the associated mosquito vector population. In order to evaluate the impact of the project after its completion, this information will be gathered before construction begins. After construction is completed and the bypass is in operation, the study will continue to monitor the effects on the estero, the mosquito population, and malaria transmission. Finally, the information obtained in the study will attempt to separate the effects of changes in water salinity and the effect of water level on the *An. albimanus* population.

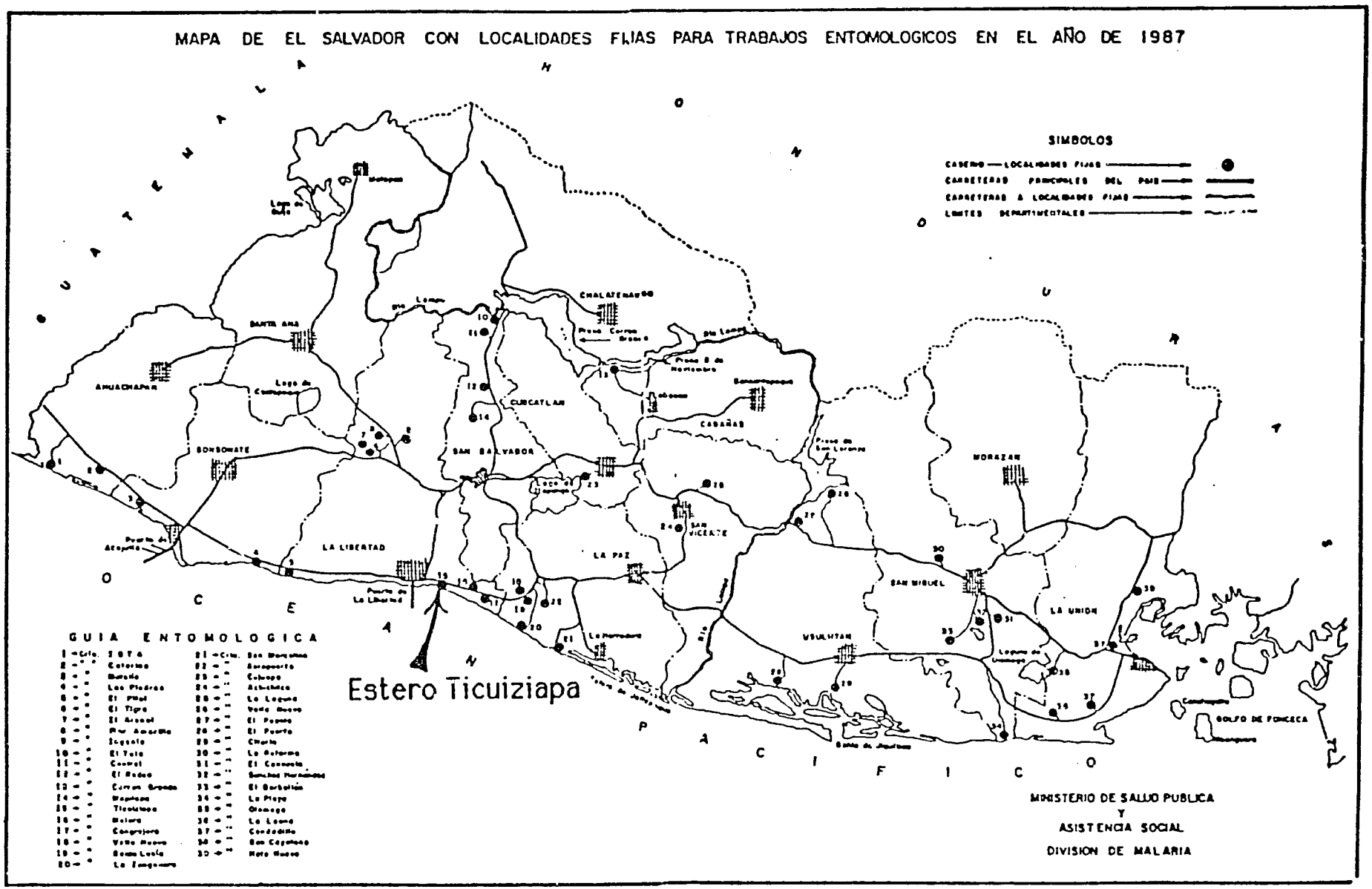
C. Site Description

El Salvador's Ticuiziapa Estero is on the Pacific Coast of El Salvador about 3 km east of the port of La Libertad, and about 36 km by road from San Salvador, the capital. Map 1 indicates the study location in relation to the rest of El Salvador. The estero is a small (250 by 1750 m) and shallow (20-150 cm) body of water surrounded on several sides by dense mangrove vegetation. One hundred meters to the north of the estero is a steep cliff, approximately 50 m in height, which is part of a coastal mountain range. The Pacific highway runs between the estero and the cliffs allowing easy access to all sections of the estero.

*The construction will be financed by funds from Public Law-480.

MAP 1

THE LOCATION OF ESTERO TIGUIZIAPA



El Salvador has two well defined seasons, a wet season that usually extends from early April until late October or early November with almost daily rains, and a dry season for the remainder of the year. Figure 1 presents the twelve year average rainfall recorded at a weather station in San Diego, which is approximately 3 km from the study site. Figure 2 shows the twelve year average of the number of days that had greater than or equal to 0.1 mm of rainfall per day.

The Ticuiziapa Estero has only one major source of fresh water, the San Antonio River. During the dry season, the estero is closed to the ocean. If the estero is not opened manually, it remains closed until several months after the rainy season has begun. By June, the estero is usually so full from the continued inflow of water from the San Antonio River that it breaches the sand bar and empties into the sea. At this time, the river has sufficient volume to keep the estero opened, despite continued wave action from the ocean to form a new sand bar. Around September to the middle of October, after the peak of the heavy rains, the ocean again closes the estero. Often the estero does not open by itself. When the estero begins to overflow its banks, the villagers, in an effort to reduce the overall mosquito population, open the estero either by hand or with the assistance of heavy equipment.

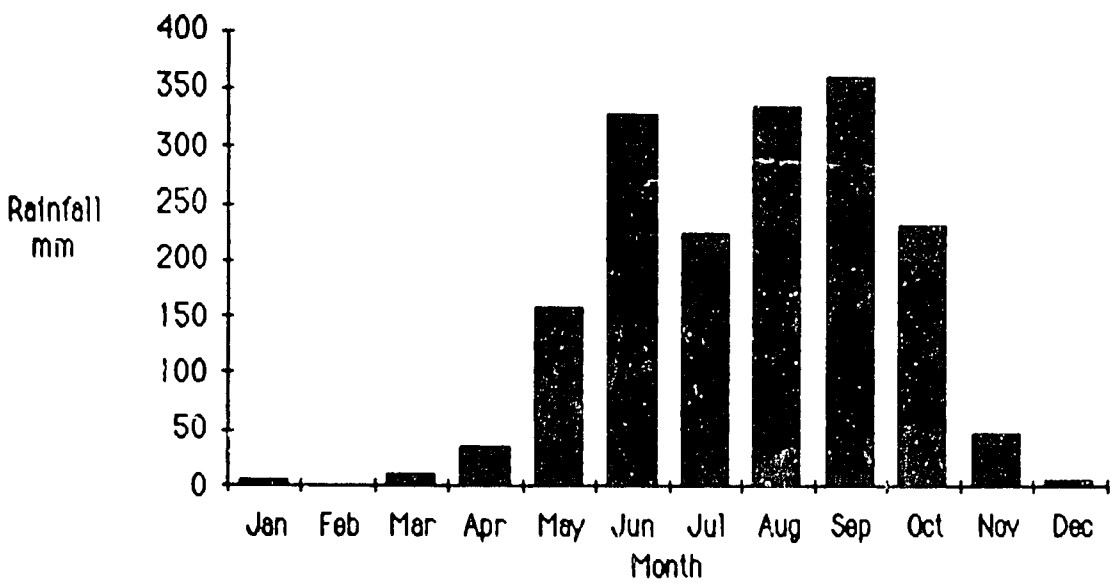
During the dry season, unlike several rivers in the area, such as the Jute River (Annex 1-Photographs), which dry up completely, the San Antonio River continues to flow (Annex 1-Photographs), albeit at a greatly reduced volume. The reduced flow is insufficient to open the estero to the ocean, and the continued input from the river causes the estero to overflow its natural boundaries and flood neighboring pastureland, creating extensive breeding sites for An. albimanus in the vegetation along its banks.

The estero area experiences two population peaks of An. albimanus. The first population peak occurs before the onset of the rainy season when the estero has swollen as a result of the continued input from the San Antonio River. The second peak takes place at the end of the rainy season when the estero again closes and begins to fill up with water from the river.

The estero, historically, has been agricultural with the major cash crops being cotton, sugarcane, and pastureland. A private organization has constructed tourist facilities in the form of swimming pools, a tennis court, a soccer field, and picnic areas at the mouth of the San Antonio River in the center of the estero. The estero is also used by the local residents

FIGURE 1

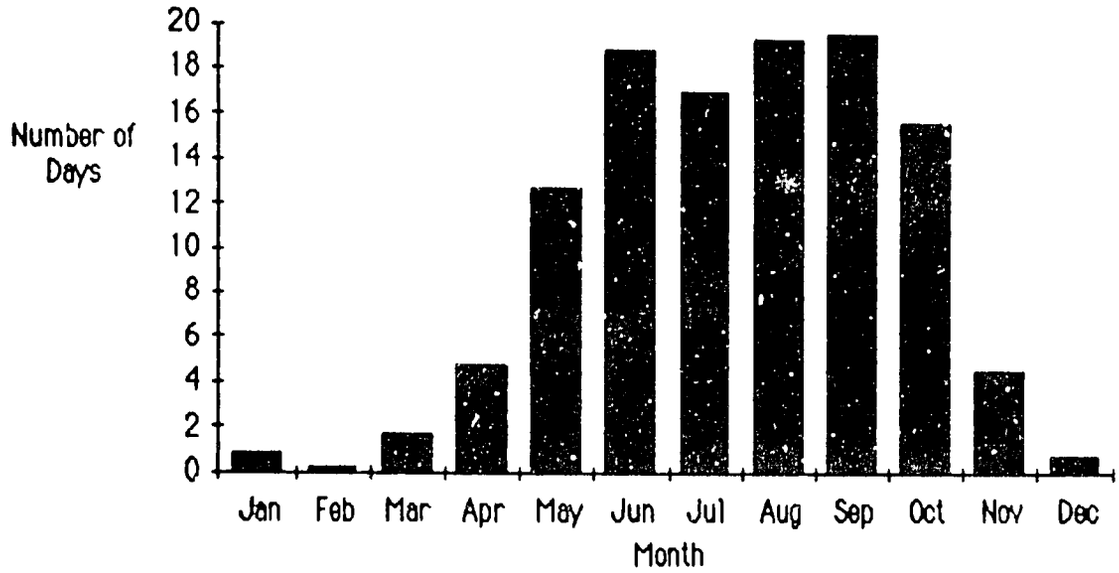
AVERAGE MONTHLY RAINFALL IN THE METEOROLOGICAL STATION ESTERO SAN DIEGO, LA LIBERTAD, EL SALVADOR (1969-1981)



Source: Climatology Division, Government of El Salvador.

FIGURE 2

AVERAGE NUMBER OF DAYS THAT HAD GREATER THAN OR EQUAL TO 0.1 MM OF RAINFALL/DAY IN ESTERO SAN DIEGO, LA LIBERTAD, EL SALVADOR (1969-1981)



Source: Climatology Division, Government of El Salvador.

for recreation and as a source of shrimp and small fish that is used for local consumption.

D. Historical Background

In order to better understand the mosquito problems of the coastal esteros, and the attempts to control these problems, a brief review of previous studies conducted in the area is presented.

In February 1969, the Central American Malaria Research Station (CAMRS), which was then part of the National Communicable Disease Center (CDC), began an investigation in the San Diego Estero, located about 3 km from the Ticuiziapa estero, to determine the effect of salinity on the breeding of anophelines. The study indicated that during the rainy season, between May and October, the estero was open to the ocean and subject to tidal exchange twice a day. In that year, the estero closed in January and sampling of larval populations began in February. Although the salinity of the estero was as high as 18 parts per thousand (ppt), the collected samples indicated that the sample sites were positive for larvae. The sites remained productive through March, April, and May while a gradual decrease in salinity, from an average of 16.72 to 9.38 ppt, was noted. In fact, as the salinity decreased, the number of larvae increased.

In June, the estero opened and the average salinity increased rapidly to 20.9 (range 11.62-30.24), while the water surface area at low tide decreased by approximately 75% (three days after the opening of the estero, no larvae could be found despite the fact that the salinity at the sample stations were within the range where larvae had previously been found); no larvae were found in the area for the next eight months (July-February 1970).

In February 1970, the estero closed again and by March anopheline larvae were again encountered. Although the 1970 population increase was much slower than in 1969, no explanation could be given for the differences between the two years. The 1969 and 1970 percentages of the sites positive are presented below:

	1969 (% Sites Positive)	1970 (% Sites Positive)
March	100	21
April	89	66
May	83	80
June	0	100

In 1970, positive larval collections were made in water that had a salinity as high as 23.6 ppt or 69.5% of sea water (sea water was reported to be 33.95 ppt). All of the mosquito larvae collected were identified as An. albimanus.

By the end of 1970, CAMRS had determined that the estero was the major source of anopheline breeding during the dry season, and two attempts were made in an effort to alter the water level in the estero by opening it to the ocean. In 1971, the first attempt to alter the water level used dynamite. Up to 12 sticks of dynamite were buried 90 cm into the sand. The largest charge (using 12 sticks of dynamite) created a conical hole 1.2 m by 1.2 m. This technique was abandoned because it was expensive, and required too much time and effort to obtain any results. The second attempt was made about one month after the natural closing of the estero when the Civil Action Brigade of the Salvadoran Army was enlisted to open the estero to the ocean by hand. A 1.83 m wide channel was dug between the estero and the ocean. However, the incoming tide prevented the construction of a suitable downgrade through which the estero water could flow. As a result, ocean water entered the estero and the wave action closed the channel with the creation of a new sand bar. The following day the channel was expanded and a steeper grade created, but with the next high tide the opening was again closed. As a result of these experiences, CAMRS made the following recommendations:

1. The channel must be constructed with a suitable downgrade through which the estero water may flow.

2. The channel must be wide enough to prevent sand from the sides from being swept into the channel and impeding the flow of water.

3. The estero should be opened at low tide so that water may pour out during the first tidal cycle.

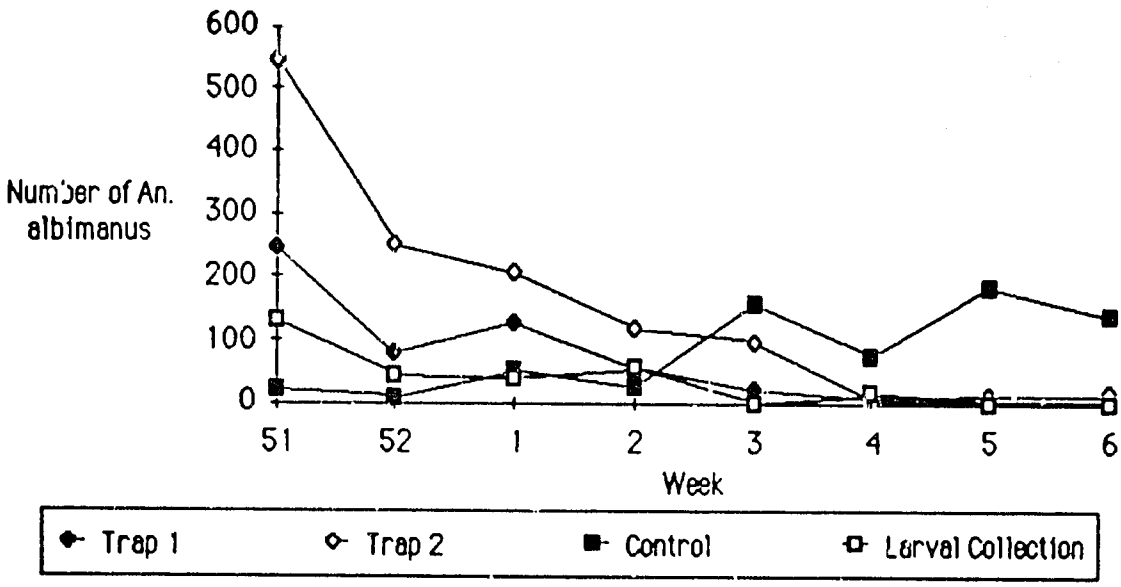
4. Heavy equipment should be used to open the estero so that the channel may be dug below the water table and opened wide enough to prevent closure.

In addition to the investigation conducted at the San Diego Estero, the Ticuiziapa Estero was also the subject of several investigations. For example, Bailey et al. (1981) conducted a series of experiments to determine the effect of salinity on An. albimanus. They reported that the Ticuiziapa estero closed in mid-October 1978, after the cessation of the heavy rains. Based on data obtained from calf baited traps and stable collections, they found that the population of An. albimanus was steadily

increasing. On January 6, 1979, the estero was opened by bulldozer; however, it stayed open for less than 48 hours. During the short period of time that the estero remained open, the water level receded to its normal boundaries, and the areas that had been flooded dried up. In order to ensure that the estero water levels remained low for the study period, it was opened to the ocean every day for five days to allow the estero to drain, and closed every evening to prevent the ocean from entering. These efforts allowed the estero to drain for about nine hours and prohibited the inflow of salt water. The investigators found that the population densities of An. albimanus dropped dramatically after the opening of the estero. The decline in An. albimanus occurred while the salinity content of the estero should have remained relatively constant. Figures 3 and 4 show this decrease in the An. albimanus populations and the increase in the control populations, which were located in another estero that remained closed.

FIGURE 3

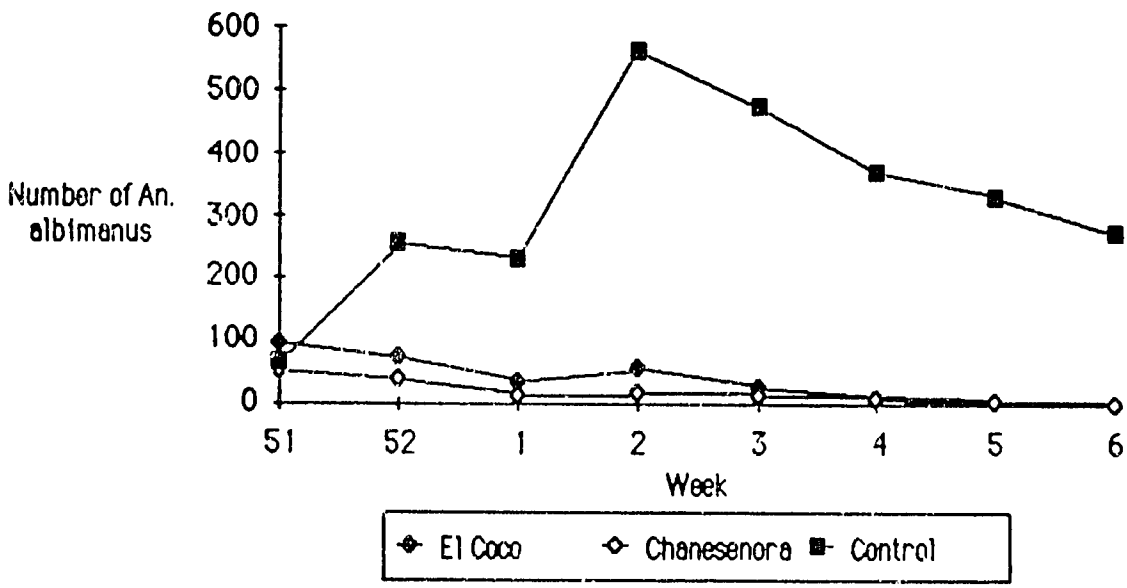
DENSITY OF ANOPHELES ALBIMANUS FOUND IN CALF BAITED TRAPS AND LARVAL COLLECTION IN THE ESTERO TICUIZIAPA (DECEMBER 1978 - FEBRUARY 1979)*



*Bailey et al. 1981 (Mosq. News 41:161-167)

FIGURE 4

DENSITY OF ANOPHELES ALBIMANUS FOUND IN CORRAL COLLECTIONS IN THE ESTERO TICUIZIAPA (DECEMBER 1978 - FEBRUARY 1979)*



*Bailey et al. 1981 (Mosq. News 41:161-167)

II. PRELIMINARY STUDY AT TICUIZIAPA

A. Historical Background

During 1986, a preliminary study was conducted by the Malaria Division entomologists at Ticuiziapa. Throughout most of 1986, regular weekly larval collections were made, and adult populations were monitored using four New Jersey (NJ) light traps and morning corral collections. The results of these collections are presented in Annex 2. While the mosquito populations were being monitored, numerous attempts were made to control the estero water level.

In 1986, the Ticuiziapa estero was opened to the ocean eight times, seven times by man and once by the force of the river; it was maintained open for approximately 154 days. On February 21, 1986, the company, Rio-Mar, placed a 70 m culvert made of steel barrels through the sand bar to drain the estero. By March 19th, three weeks after completion of the project, the culvert ceased to function and the estero was again closed. Two weeks later, the culvert was flattened and removed by wave actions from the ocean. The estero remained closed and gradually filled up with water due to the continual input of water from the San Antonio River.

On May 7th, the estero was opened by bulldozer after about three hours of work. However, the wave action of the ocean closed the estero three days later. On May 26th, the canal was again opened by bulldozer. This time, the estero was opened in only one and a half hours because heavy rains had increased the water level of the estero. By June 11th, the estero was again closed by the ocean. On June 17th, the estero was reopened by a crew of laborers using shovels (a bulldozer could not be used because the sand appeared to be too soft to support the weight of heavy equipment). The estero remained open for two days before it was again closed by wave action from the ocean. By June 26th, the rains had increased the outflow of the San Antonio River sufficiently to open the estero by its own forces. Until July 16th, the estero remained open, then the ocean again closed the sand bar.

After July 16th, the estero gradually filled with water and remained closed until August 13th when a crew of men manually (the bulldozer could not be used because it was sold by the company that owned it) opened the estero to the ocean in three hours. On October 14th, the ocean closed the estero and it remained closed for six weeks. It was reopened on November 26th by a crew with shovels after the estero had reached very high levels. The estero closed a short time later and was reopened

manually on December 12th. During the last week of December, the estero was again closed by the ocean and remained closed until February 10, 1987. On this date, 20 men from the local fire department opened the estero with shovels in ten hours. Their efforts were frustrated when the estero closed in two days. On March 16th, these men attempted to reopen the estero; however, before they could complete the project, the ocean closed the canal.

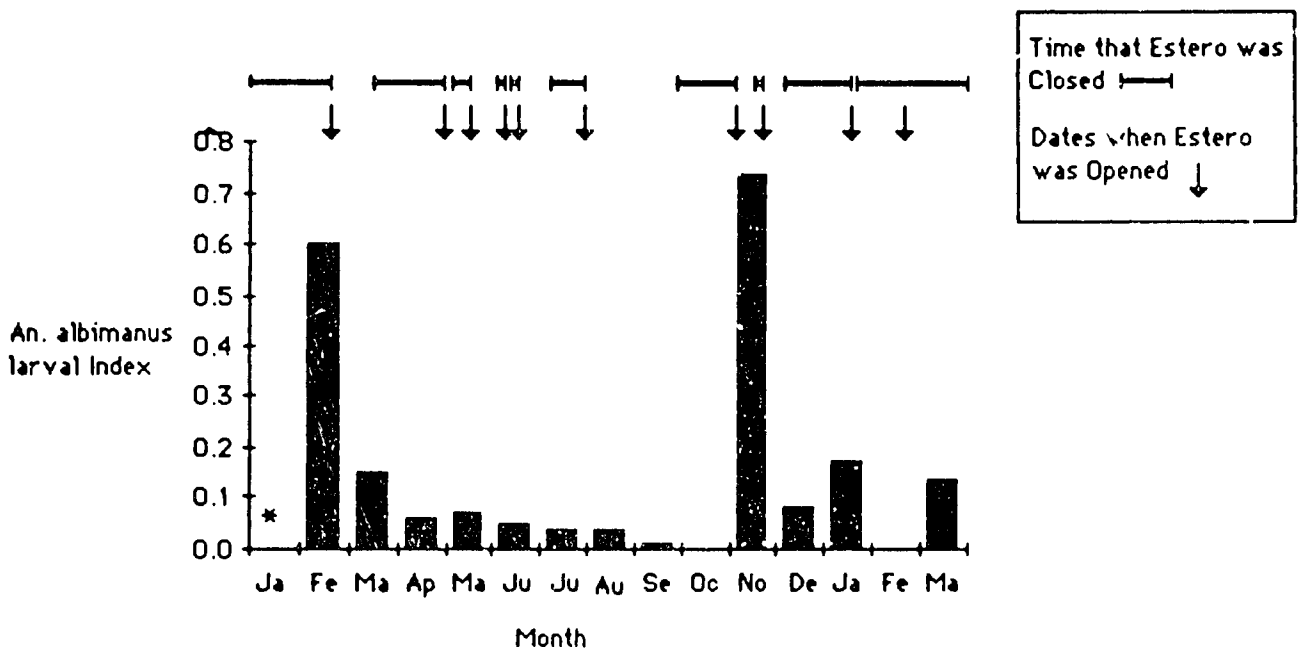
On May 14th, the local Malaria Department health promoter organized a group of 35 workers to open the estero. This work was accomplished in five hours. When the site was inspected, it was observed that the ocean was entering the estero and the water level was rising. This was the opposite effect that the workers desired (Annex 3-Photographs). At the same time, the tide was high enough for waves to pass over the sand bar (Annex 4-Photograph), and the estero closed shortly thereafter. After the estero closed, salinity readings were taken. The readings indicated that the estero had risen from an average of 4 ppt to 9 ppt. On May 18th, a crew of four local residents tried to open the estero; however, they abandoned their efforts after digging a very narrow canal in six hours.

Figure 5 shows the dates the estero was opened, and the results of larval collections of An. albimanus during 1986-87. At no time were larval densities found to be high. The An. albimanus index, defined as the number of 3rd and 4th instar larvae per dip, was always less than 1.0. Although the densities were low, certain trends were seen. In February, the larval populations were relatively high until the estero was opened, then a sharp drop was noted. In fact, the larval population was unable to increase because the estero was opened frequently. At the end of the rainy season, the estero closed again and the larval population increased rapidly because the river flowed continuously into the estero. When it was opened to the sea in November, the population densities again fell to low levels. This time, the mosquito population appeared to be unable to increase rapidly, probably as a result of decreased input from the river.

Figure 6 illustrates larval densities in breeding sites that were not connected to the estero. The effect of the opening of the estero was less obvious in some months, but higher population densities were found in these breeding sites than in the areas directly connected with the estero. Figure 7 illustrates the light trap collection data. Although the relationship was not very clear, the effect of the opening of the estero was clear in the month of November.

FIGURE 5

ANOPHELES ALBIMANUS LARVAL INDEX
IN THE ESTERO TICUIZIAPA, LA LIBERTAD
(1986-1987)

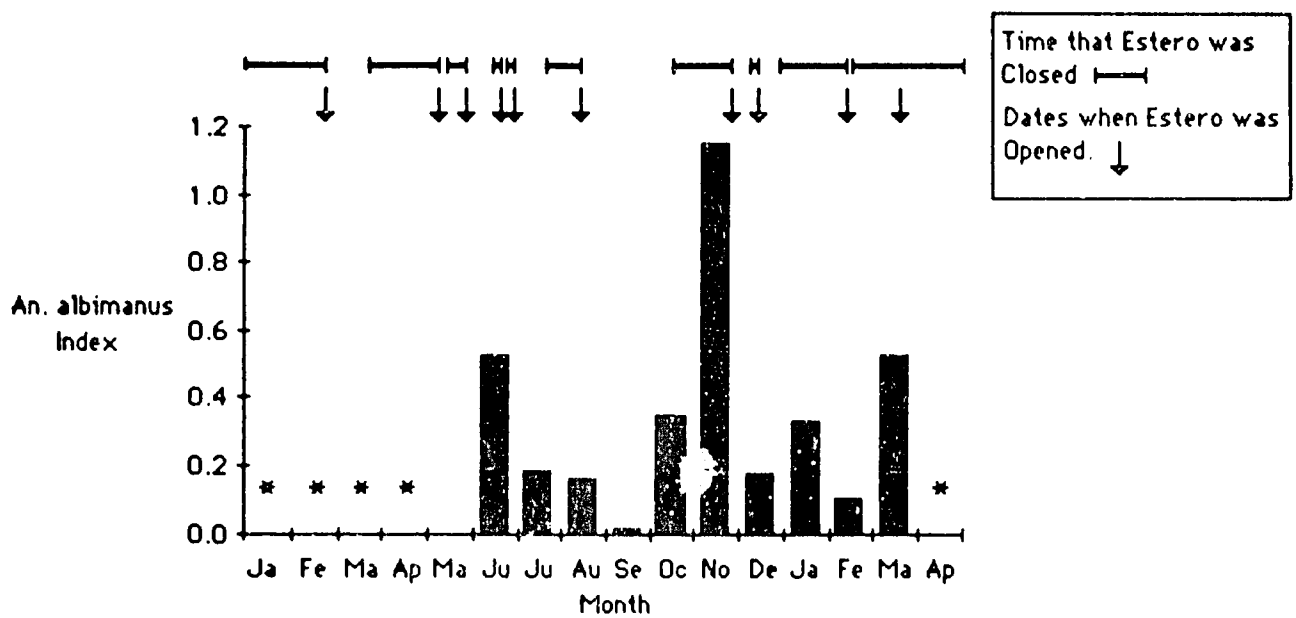


* No collections were made this month.

Source: Malaria Division, Ministry of Public Health, El Salvador.

FIGURE 6

INDEX OF ANOPHELES ALBIMANUS IN LOS PANTANOS
OF THE ESTERO TICUIZIAPA, LA LIBERTAD
(1986-1987)

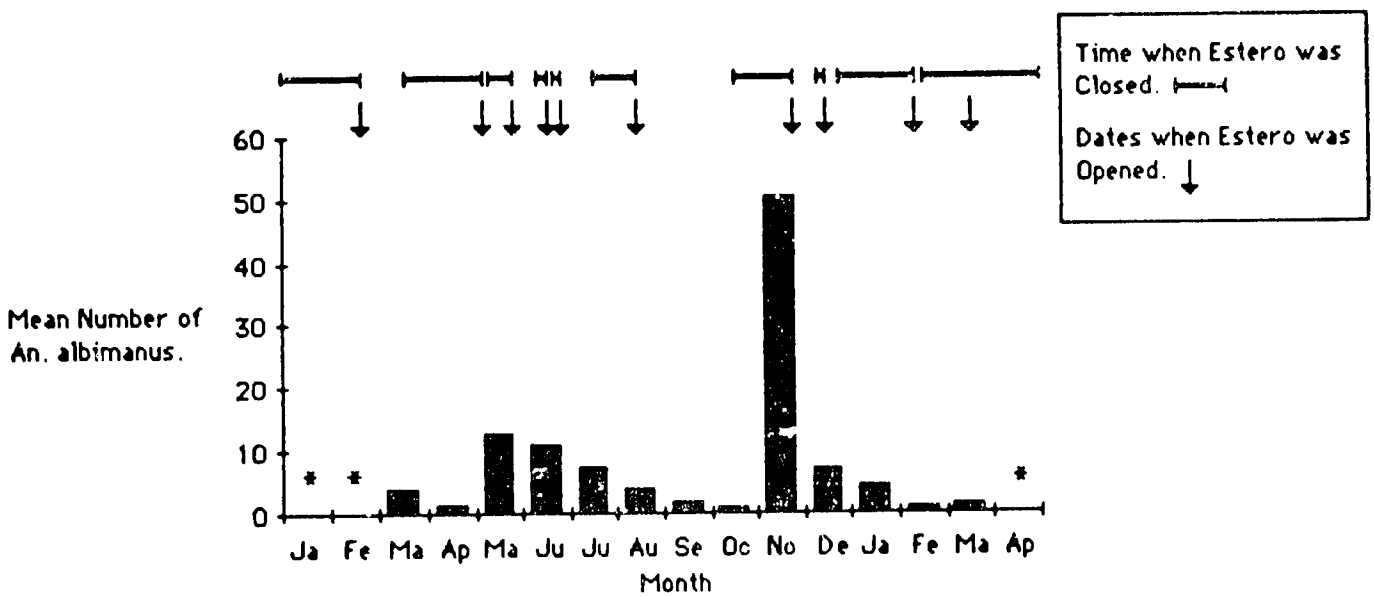


* No collections were made these months.

Source: Malaria Division, Ministry of Public Health, El Salvador.

FIGURE 7

AVERAGE NUMBER OF ANOPHELES ALBIMANUS FROM FOUR LIGHT TRAPS
IN THE ESTERO TICUIZIAPA, LA LIBERTAD
(1986-1987)



* No collections were made in these months.

Source: Malaria Division, Ministry of Public Health, El Salvador.

The preliminary study illustrates several problems that will complicate the pilot project. For example, malaria control activities in the form of larviciding and adulticiding using ULV were undertaken in the area. Although these control activities reduced the anopheline densities, they interfered with observations of mosquito density fluctuations that resulted from the manipulation of the water level of the estero. In addition, the estero was opened on numerous occasions, but the exact effects of the opening (i.e., change in estero surface area, depth, salinity) were not accurately noted. A more detailed interpretation of the study will be needed to take these factors into account, as well as rainfall and high tides which also affect the water level. Casual observations concerning the estero water level indicated that the tides exert an effect on the estero even when it is closed. High tides may raise the water table, causing the estero to expand briefly.

Unfortunately, the meteorological station in San Diego was closed in 1981 and rainfall data for the area was not available. Another problem that arose was that data collection of mosquito densities were not made with any consistent frequency to ensure reliability of the results. During most of the study, weekly collections were made; however, during certain periods, such as weeks 41-47 in 1986 and several weeks in 1987, no collections were made.

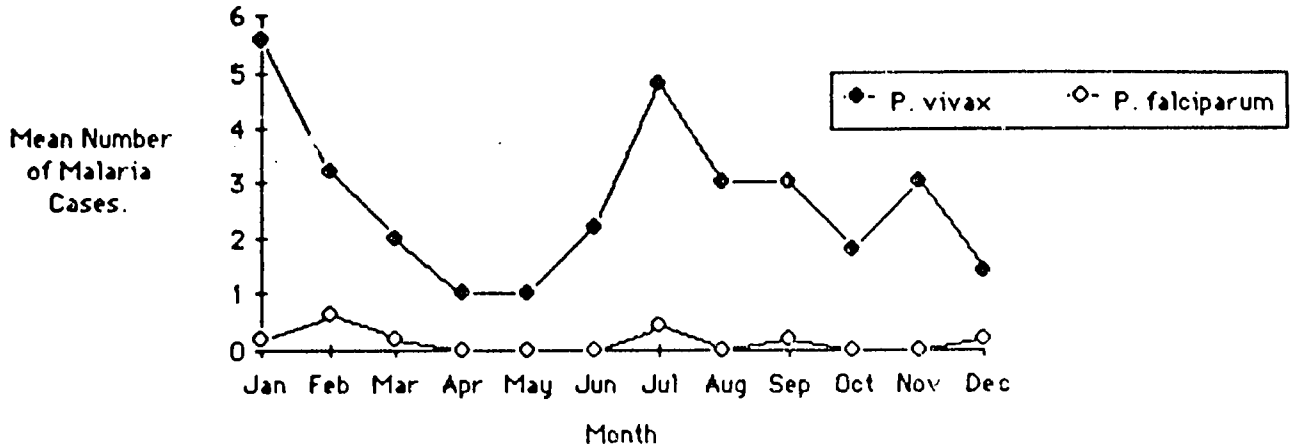
B. History of Malaria Transmission in Ticuiziapa

The malaria transmission for six caserios or reporting stations for 1982-86 is summarized in Annex 5. These caserios are all close to the Ticuiziapa Estero, and the majority of the malaria cases reported probably result from mosquitoes produced by the estero. The general trend in almost every caserio has been favorable since the number of malaria cases have decreased by half or more in the past five years. This trend coincides with a general trend that is occurring nationwide.

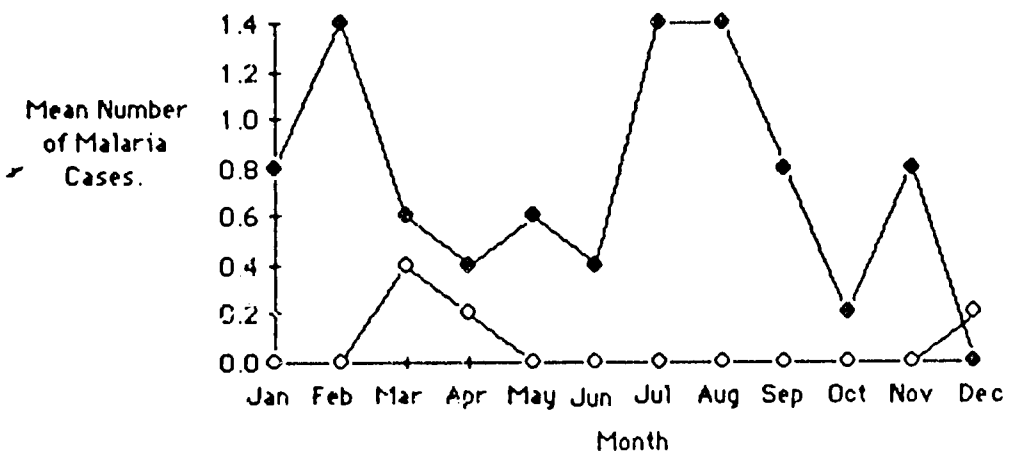
The seasonal transmission patterns in the caserios are indicated in Figures 8 and 9. As can be seen, a considerable amount of transmission occurs in the dry season. In some localities, such as El Jute, El Amatal, and Playa Las Flores, more transmission is actually occurring in January and February than in other months of the year. These cases reflect actual new cases and not relapses, which is suggested by the small, but noticeable, peak in *Plasmodium falciparum* cases during the dry season.

FIGURE 8

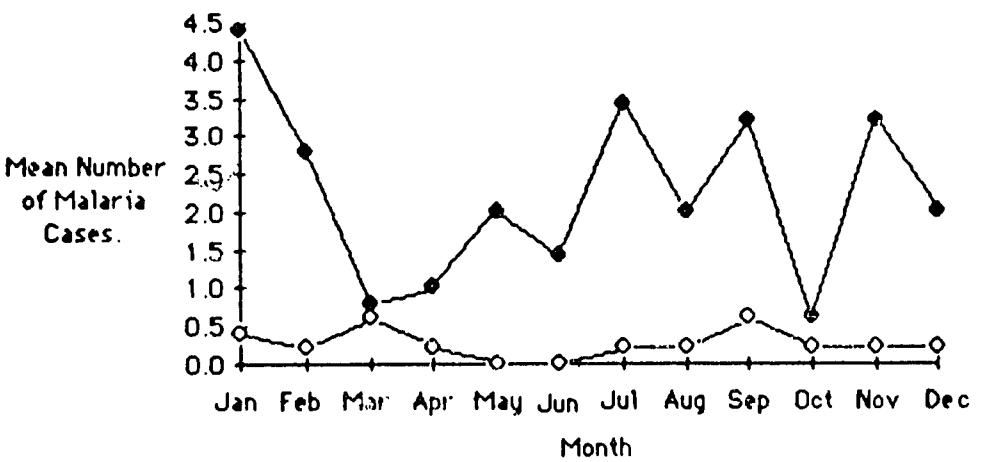
MEAN NUMBER OF CASES OF MALARIA REGISTERED IN CASERIO EL JUTE, EL AMATAL, AND PLAYA LAS FLORES MUNICIPIO LA LIBERTAD (1982-1986)



Mean Number of Cases of Malaria Registered in Caserio El Amatal, Municipio La Libertad . (1982-6).



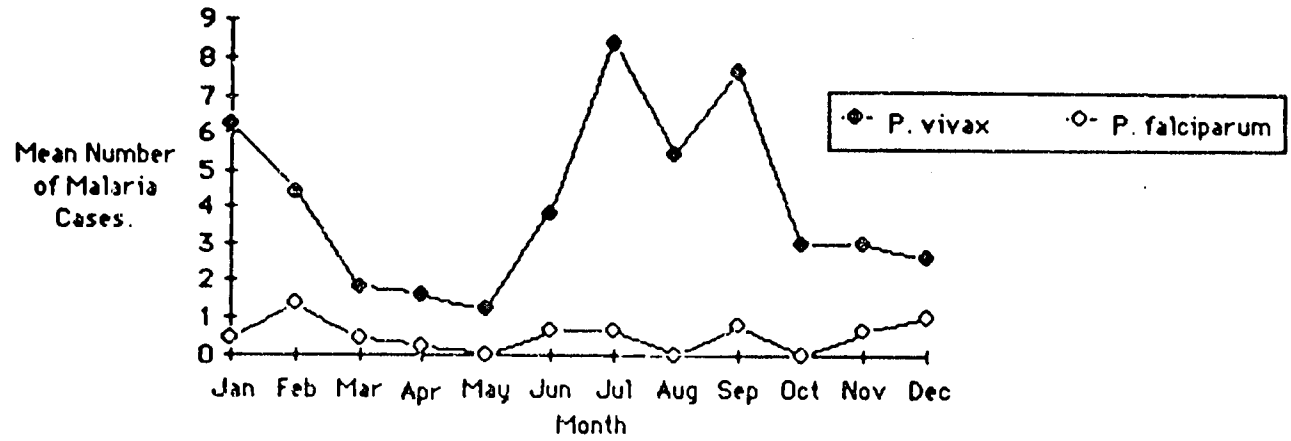
Mean Number of Cases of Malaria Registered in Caserio Playa Las Flores, Municipio La Libertad . (1982-6).



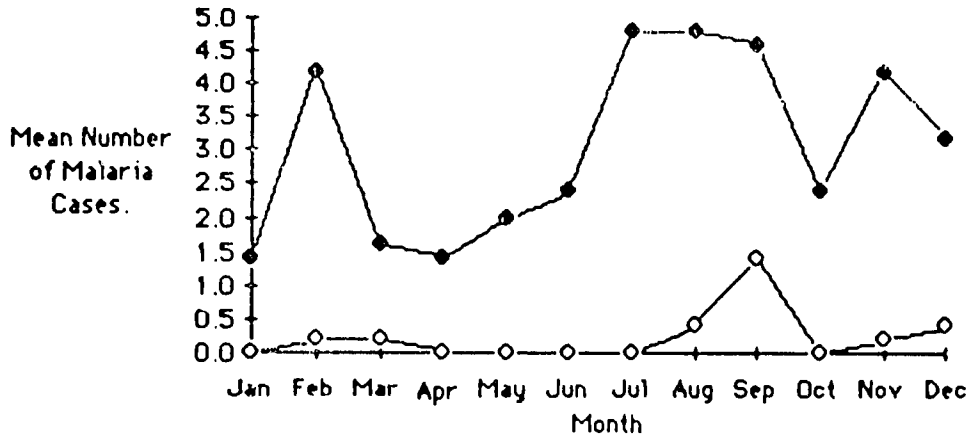
Source: Malaria Division, Ministry of Public Health, El Salvador.

FIGURE 9

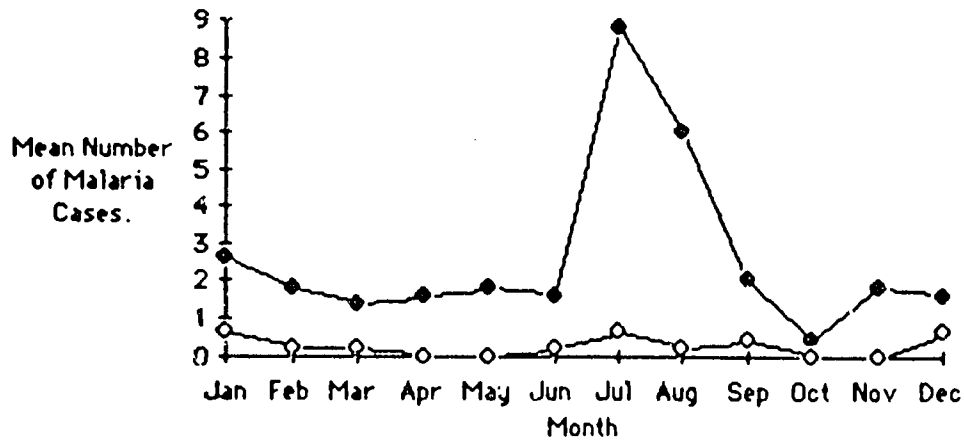
MEAN NUMBER OF MALARIA CASES REGISTERED IN CASERIO TICUIZIAPA, LA PLAYA AND HCDA SAN DIEGO MUNICIPIO LA LIBERTAD (1982-1986)



Mean Number of Malaria Cases Registered in Caserio La Playa, Municipio La Libertad. (1982-86).



Mean Number of Malaria Cases Registered in Caserio HCDA San Diego, Municipio La Libertad. (1982-86).



Source: Malaria Division, Ministry of Public Health, El Salvador.

C. Effect of the Dam and Bypass Pipe on the Estero's Flora and Fauna

The effect of the dam and bypass pipe on the natural flora and fauna of the estero will depend upon how the bypass pipe is operated. The dam will be low; therefore, it will not create a large reservoir of water behind it. When the bypass pipe is closed, the river will continue on its natural course into the estero through a floodgate. The San Antonio River is almost without any current during the dry season, so the dam should not change the dynamics of the river dramatically. Approximately 200 m of the San Antonio River will be affected by this construction. At present, a small weir under the highway bridge is hindering the movement of fish upstream.

The main factors that will alter the estero's water level are the bypass pipe and floodgate, which can be opened and closed to regulate the amount of fresh water entering the estero. The effect these structures have on the estero's flora and fauna will depend on the water level maintained in the estero.

During the dry season, the bypass pipe and floodgate can be opened all the time or closed for a period of time to adjust the water level of the estero to the desired height; thus, the flooding that normally occurs during the dry season is prevented. In order to have a minimal effect on the estero's biota, the estero must be opened manually or allowed to open by itself. This has been the case in the past during the rainy season, when the force of the San Antonio River is sufficient to maintain the opening of the estero.

At the present time, an accurate evaluation of the effect of the dam and bypass pipe on the estero's flora and fauna is probably beyond the capabilities and resources of the Malaria Department. For example, personnel, trained in plant and invertebrate identification, would need to do a species inventory. In addition, detailed samplings would have to be conducted routinely over one to several years in order to observe any changes. Changes in plant species, if any, would show a gradual shift from one species dominance to another, and changes in the invertebrate populations might be more pronounced. Any change that might occur will depend on how the estero is managed. In order to conduct this portion of the study, the Malaria Department could enlist the assistance of the Biology Department at the University of El Salvador (the project would be an excellent thesis topic for a highly motivated graduate student), or the cooperation of the Ministry of Agriculture.

III. METHODOLOGY

A. Introduction

The evaluation of the impact of this project will be divided into three sections: 1) the physical condition of the estero, 2) the mosquito populations and 3) the malaria transmission patterns. The following techniques will be utilized to evaluate these parameters.

B. Technique Used to Evaluate Estero Conditions

Detailed environmental observations of the estero were made and 18 sample collection stations were established. The following parameters: water characteristics, such as salinity, pH, temperature, water depth and bottom cover were recorded; these data are reported in Annex 6 (in Spanish). Once a month, the 18 sample sites will be checked and the parameters recorded. In addition, eight sites, which will be representative of the whole estero and easily accessible, will be selected for weekly monitoring*. The entomology personnel of the Malaria Department were equipped and trained to take these measurements.

Four permanent depth gauges were established by painting measurements on stone or concrete structures in the water. These sites will also be recorded each week during larval surveys. The location of the 18 sample collection stations and the four depth gauges are illustrated in Map 2 (the location of the depth gauges are not ideal; however, they are the only permanent features that are likely to remain fixed for the duration of the study). In order to determine the water table level, at least three wells, used by the local residents, will be measured. The sites of these wells will be at both ends of the estero and at Rio-Mar, which is situated in the center of the study site.

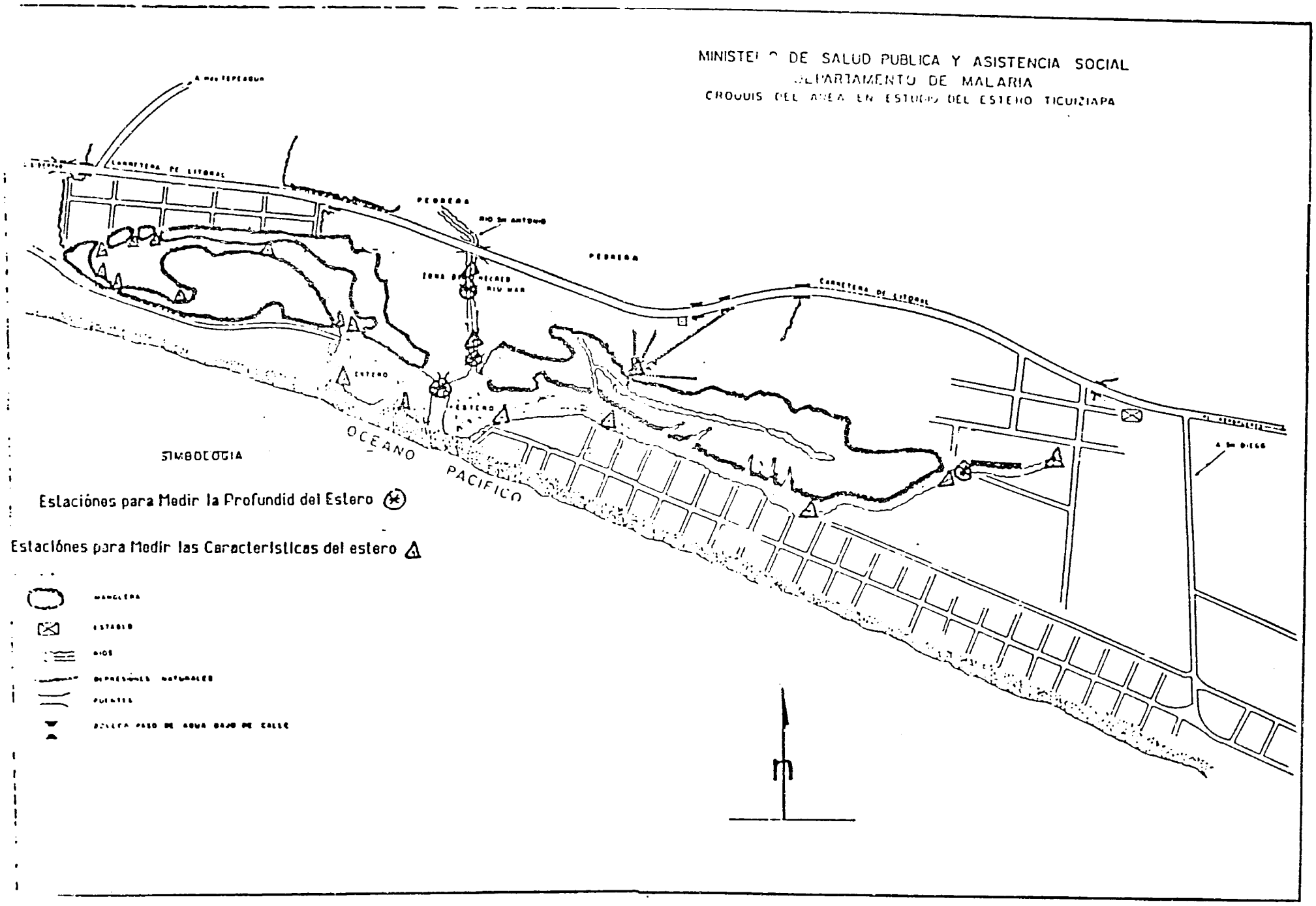
The dates on which the estero is to be opened to the ocean will be recorded, as well as how it was opened, how many people opened it, and the length of time it took to open it. The latter information will be useful in determining the cost-effectiveness of the engineering project.

A tide almanac for 1986 was obtained from the Naval Base in La Libertad; however, an almanac for 1987 and 1988 will also be needed to determine when high tides occur. This will be important when evaluating the estero levels.

*Many of these sites are also potential breeding sites and can be measured during larval surveys.

MAP 2

SAMPLE STATIONS TO MEASURE THE PHYSICAL CHARACTERISTICS
OF THE ESTERO TICUIZIAPA



C. The Estero's Flora and Fauna

Before any changes can be noted in the estero concerning the effect of the dam and bypass pipe on the flora and fauna of the estero, a detailed species inventory (divided into two parts: flora and fauna) must be conducted. This inventory will determine what species are present in the estero and the population density of the organisms. Since the estero is dynamic and subject to seasonal fluctuations, the inventory should be conducted over a period of one dry season and one wet season before any changes can be noted in the estero. The study should be continued for a least one year to observe and determine any changes.

1. Flora

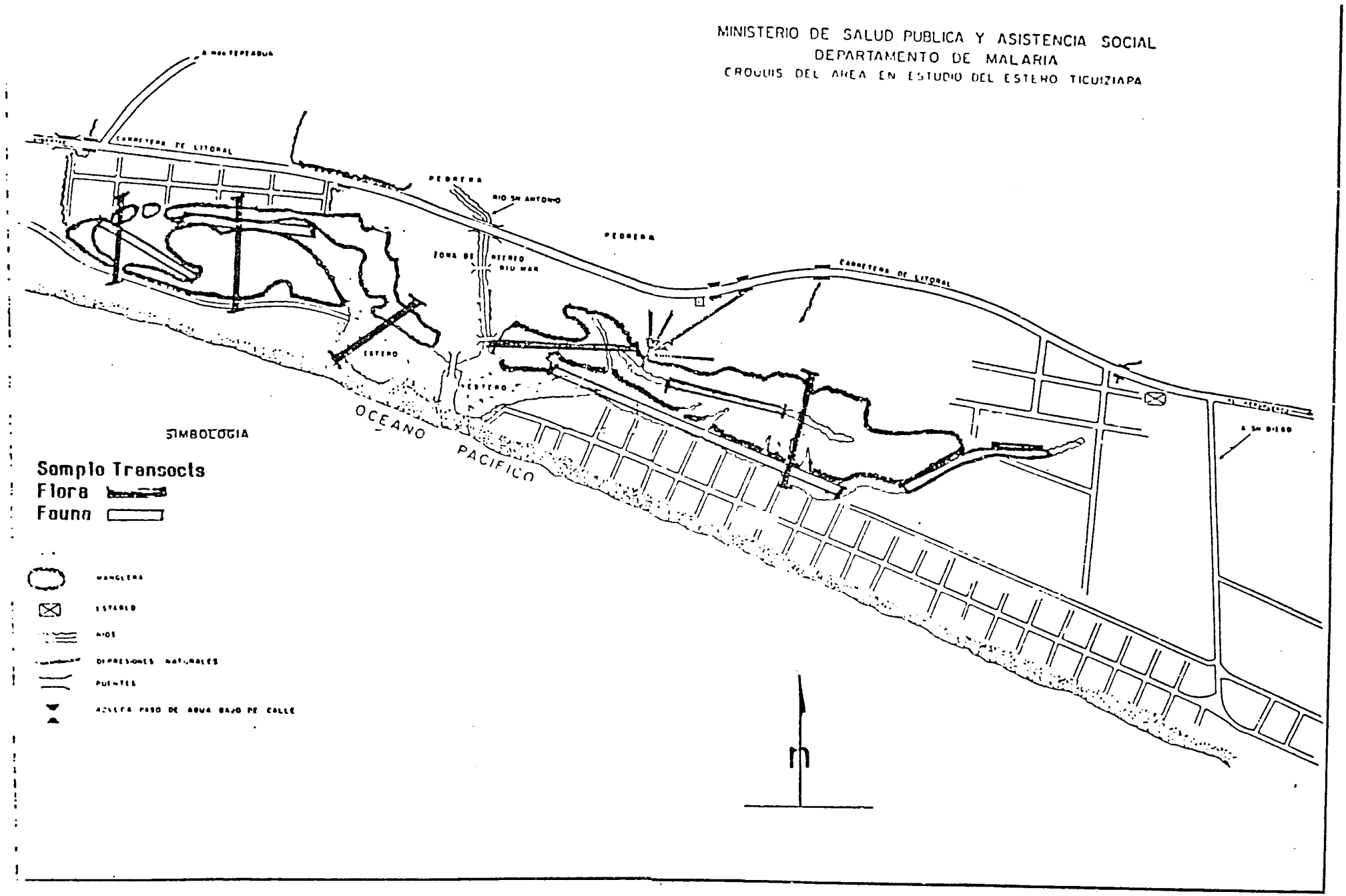
Five transects will be drawn across the estero running generally from north to south. The position of the transects are presented in Map 3, and these transects are representative of the various flora zones of the estero. Survey teams will follow the transects and mark them so that the teams can return to the sites at later sampling dates. A piece of string with one meter markings will be strung along the transect, and tied to a large tree, which will serve as the starting reference point. A technician will then proceed along the string and note the species of plants that touch or fall under the line, and their distance from the starting reference point. This procedure will develop a profile of the species encountered in the estero. Finally, the survey teams should also note where the water line starts.

The second survey will be conducted along the same transect to determine the population density of the species encountered. In order to do this, a one meter square hoop will be thrown randomly along the grid line. When it lands, all of the plants within the sample perimeter will be identified and counted (a hoola hoop could be purchased and used if the surface area within the hoop is calculated. The results of the sampling could then be converted to determine the density and diversity of plants per square meter). Finally, the presence of water and percent shade will be noted at the sample site.

Two indices will be calculated from this information. The first is a density index, which is defined as the number of plants of a given species per square meter. The second is a diversity index, which is defined as the number of different species encountered per square meter. The plants will be classified according to whether they are emergent, submergent, floating, or occurring on dry ground or wet soil.

MAP 3

TRANSECT LOCATIONS TO SAMPLE THE FLORA AND FAUNA OF THE ESTERO TICUIZIAPA



The flora sampling along the five transects will be conducted once every three months for the duration of the study period to provide an idea of the seasonal changes that occur within the estero.

2. Fauna

In order to sample macro fauna, such as shrimp and fish, a throw net will be used. The diameter of the net will be determined so that the sample area can be calculated. Again, five transects will be drawn across the estero; however, these transects will occur only from the edge of the estero to the opposite shore as indicated in Map 3. A technician will then proceed along the transect and toss the throw net every three meters. Then, the invertebrate samples will be counted and identified, and the density and diversity of the species encountered will be calculated per square meter.

To sample smaller invertebrates, an aquatic dip net made of fine mesh will be used. Again, the transects will be followed and sweeps made in the water every three meters. The volume of water sampled will be calculated based upon the size of the opening of the sweep net and the number of meters covered per sweep. The samples will be emptied into plastic bags and marked. They will then be sorted, identified, and counted. As with the other samples, the diversity and density of the species will be determined by the per cubic meter sampled. Since faunal samples undergo seasonal changes, they will be taken once a month for the duration of the sampling period.

At the bottom of the estero, a wide variety of benthonic organisms live in the top few cm of mud. Samples of these organisms will be taken to determine their number, species and distribution. Again, five transects will be drawn across the estero. This time, as the sampling team follows along the grid line, bottom samples will be taken using a metal pail, and the volume of the pail will be calculated. As the team proceeds along the grid line, a sample will be taken every three meters. As much mud as possible will be scooped into the pail. The contents of the pail will then be dumped into a fine mesh screen and the mud carefully washed off. All species found on the mesh screen will be placed in plastic bags, marked and taken to shore for sorting, counting and identification. The benthonic samplings will be conducted on the same days as the invertebrate samplings, and processed in the same manner as the other samples (including determining the density and diversity of the species encountered).

The results of the samplings will be recorded on field collection forms and later entered on a computer for analysis. The data will be analyzed, taking into consideration the physical characteristics of the estero (i.e., salinity, pH, temperature, water depth).

D. Mosquito Densities: Adult Collections

1. Corral Collections

In general, corral collections are considered to be one of the best indicators of the presence of An. albimanus populations. However, the effectiveness of the collections depends on the cattle raising practices of the local people. If the cattle are consistently brought into an enclosed area in the evening, the collections should be highly positive if An. albimanus is present in the area. On the other hand, if the animals are not concentrated in one area, the effectiveness of this type of collection is reduced since a proportion of the mosquito population will be feeding on the cattle in the field, and resting elsewhere. The collections will also fluctuate depending upon the number of cattle present.

In 1986, entomologists from the Malaria Department attempted to collect adult mosquitoes from corrals close to Ticuiziapa. The results of this collection were disappointingly low. Whether the low numbers were truly representative of low densities, or a function of other factors was not clear; however, the low densities seem to be supported by the low number of adults found in light trap collections.

Collections made in 1986 were made in the early morning. This hour of collection has been supported by Lowe and Bailey (1979) who found that collections made between the hours of 8 a.m. and 10 a.m. were 12.7% more effective than collections made in the evening between the hours of 7 p.m. and 9 p.m. This hour of collection may be feasible for some corrals, but not for others, depending upon the amount of shelter in the form of vegetation that is available for resting mosquitoes. In corrals with sparse vegetation, the mosquito population may seek more hospitable resting sites earlier in the morning before the sun becomes too intense. It is suggested that at the beginning of the study that collections be made from the various corrals included in the study at both times of day, morning and evening. By collecting at both times, it should be determined if the results are due to the population densities or special characteristics of the corral. If morning collections are found to be as effective as evening collections then they should be continued for the duration of the study.

The collection consists of collecting all anopheline adults resting on the low vegetation and fences, in and around the corral, for a period of two hours between 7 p.m. and 9 p.m. in the evening, or 7 a.m. to 9 a.m. in the morning. Collections should be made once a week preferably on the same day each week. Adults are captured individually with mouth aspirators, and counted and placed in wire holding cages that are covered with Surgitube gauze. The adults are then killed, identified, sexed, and recounted. If the collection is made in the morning, the cages can simply be placed in the sunny window of the car and allowed to dehydrate. Evening collections can be held until daylight and then processed. Care must be taken to ensure that ants do not get into the cages since they may consume a collection in a short period.

At least two collectors per corral will be used and, if possible, the same collectors should be used throughout the study in order to minimize collecting differences. The results of each collection will be recorded on the standard collection forms, along with meteorological data, which will include temperature, relative humidity, wind, and rainfall. The latter two parameters will be based on general observation rather than precise measurements and should record the preceding 12 hour conditions. Meteorological conditions directly affect mosquito flight activity, so it would be helpful, when interpreting the data, to note whether it was very windy or rained during the night. Precise meteorological information will be obtained from the Malaria Department in La Libertad, where a rainfall gauge and maximum/minimum temperature gauges will be maintained.

In addition to the meteorological data, information regarding the number of cattle present in a corral, and whether or not all the cattle are in one location, or free to roam about the field, will be noted. The results will be transferred to monthly report forms and the number of An. albimanus per man hour will be determined. If other anophelines are collected, they will be processed in the same manner. The results will be recorded, along with meteorological data, on weekly report forms, and once a month transferred to a monthly summary form and entered on a computer.

At least two corrals, which are close to Ticuiziapa, will be used as collection sites. If control efforts, such as ULV adulticiding and larviciding, will be continued at Ticuiziapa, then control sites must be selected for corral collections. Using corrals around the San Diego Estero as controls may be practical. As with Ticuiziapa, preliminary trials will be necessary to determine the optimum collection locations and time of captures. If no corral can be found at San Diego, collections may be made from Santa Lucia. The control corrals should be at least three

km from Ticuiziapa and they should have a high An. albimanus density. Finally, the estero that is closest to the control stable must be monitored to determine when it opens to the ocean.

2. Light Trap Collections

Six methods of determining An. albimanus densities in the Ticuiziapa-San Diego area were compared by Breeland (1972) who found that the New Jersey (NJ) light trap, fitted with a 60 watt bulb, was more effective than corral collections, human bait captures, indoor resting collections, natural resting site collection, or bridge collections. Breeland noted that light traps were not effective for An. pseudopunctipennis. In addition, three different types of light traps were evaluated by Wilton (1975) in several villages in El Salvador. He found that, in general, the CDC trap was ineffective except when placed inside dark areas of houses. Wilton's investigation determined that the NJ trap captured more mosquitoes; however, the most effective trap was a new design called the TDL/UV. This trap is a modified CDC trap that uses a 4 watt blacklight fluorescent lamp and an updraft fan for collecting mosquitoes. The TDL/UV trap was also tested by Sexton et al. (1986) on An. albimanus in Haiti. Sexton et al. found that the new trap was far more successful than biting collections or the CDC trap, and the authors provide instructions on how the CDC trap can be modified to become the TDL/UV trap in their paper.

Due to the superiority of this trap design, as proven in both El Salvador and Haiti, it is strongly urged that they be used in the present study. In reviewing the light traps available in the Malaria Department, it was noted that several standard NJ type traps were used in Ticuiziapa and that four new NJ traps that use battery power are in storage. The standard NJ uses 110 VAC electricity and is, therefore, subject to the power fluctuations that are currently found in El Salvador. Power failure during trap operation would result in the loss of a weeks worth of data. Due to their reliance on AC electricity, their placement is also restricted to locations where electricity can be borrowed. This may not be the best solution, but a compromise must be made due to the power source.

The battery powered NJ traps that are in storage use the same light source as the CDC trap, but they have a stronger fan. Since light attracts the mosquitoes, the battery powered NJ traps will probably function with the same effectiveness as the CDC trap. In a study conducted by Odetoyinbo (1969), the CDC trap was found to have an effective range of about 5 m depending upon competing light sources. Therefore, if these traps will be used, their light source should be changed to a 15 cm 4 watt blacklight fluorescent lamp, or the bulbs should be replaced with halogen

bulbs which give off a more
plastic strips, which are available in local supermarkets, may be tried as a killing agent in the killing jars of the NJ traps.

The monitoring of the An. albimanus densities will depend heavily on light trap results; therefore, at least five to six light traps should be used. The suggested locations for placement of the light traps are presented on Map 4; however, the final locations will be determined after several nights of testing. Initially, the use of more light traps is advisable until suitable sites are located. Then, the number of traps can be reduced and emphasis placed on the most positive locations. Since the effectiveness of the traps depends upon the contrast of the light emitted with the background light, the location of the light traps will be very important. The traps should be placed away from competing light sources, in a sheltered location away from direct wind, and in an open area where the light can be seen from a distance. Traps placed in the open have the disadvantage of being less effective during the full moon.

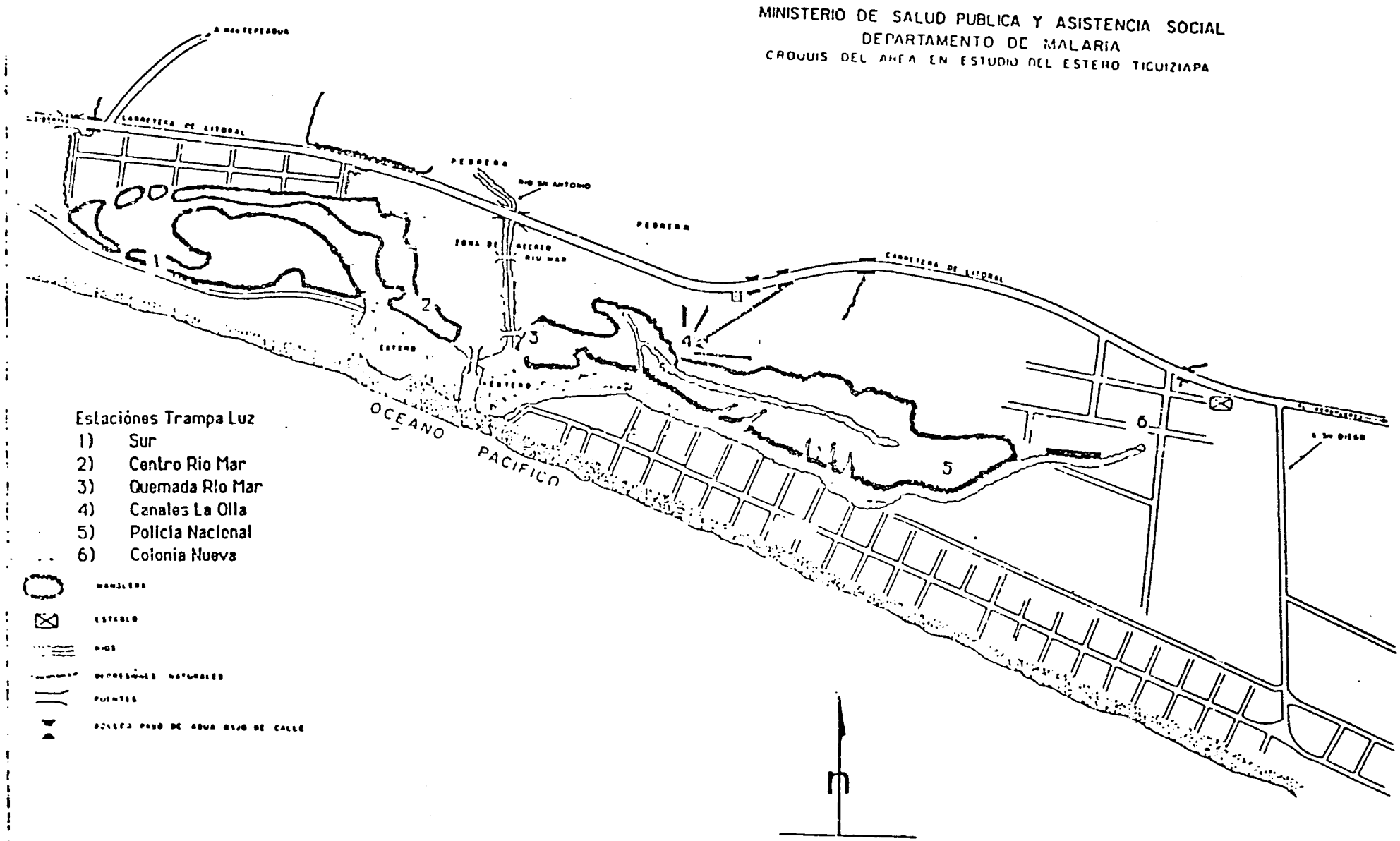
Another factor to be considered will be security of the light traps. If possible, the traps should be placed on private property behind a fence. The local health promoter should inform the local population of the importance of these traps in the evaluation of the project that will ultimately benefit the community.

If control efforts, such as ULV adulticiding and larviciding will occur at Ticuiziapa, then a control site must be selected for light trap operation. Four sites around the San Diego Estero may be practical locations for the control operation. As with Ticuiziapa, some preliminary trials will be necessary to determine the optimal placement of the light traps. A detailed record of any control efforts will have to be maintained at the control sites in order to determine if these efforts affect the control locations.

Light trap operation and corral collections will be conducted at the same time and frequency - that is one night per week with six traps operating from 7 p.m. to 7 a.m. The collected mosquitoes will be returned to the laboratory and identified. The number of male and female An. albimanus found in each trap will be recorded along with other species of Anopheles. The results will be placed on weekly report forms, along with meteorological observations, such as rainfall, wind conditions, and phase of the moon (i.e., full moon, 1st quarter, etc.). It should also be noted if the trap was operational all night. After the collections are completed, the traps will be returned to the Malaria Department in La Libertad, and the batteries recharged in preparation for the next weeks collection. Map 4

MAP 4

LIGHT TRAP LOCATIONS IN THE ESTERO TICUIZIAPA



weekly results will be transferred to monthly summary sheets and entered into the computer.

E. Mosquito Densities: Larval Samplings

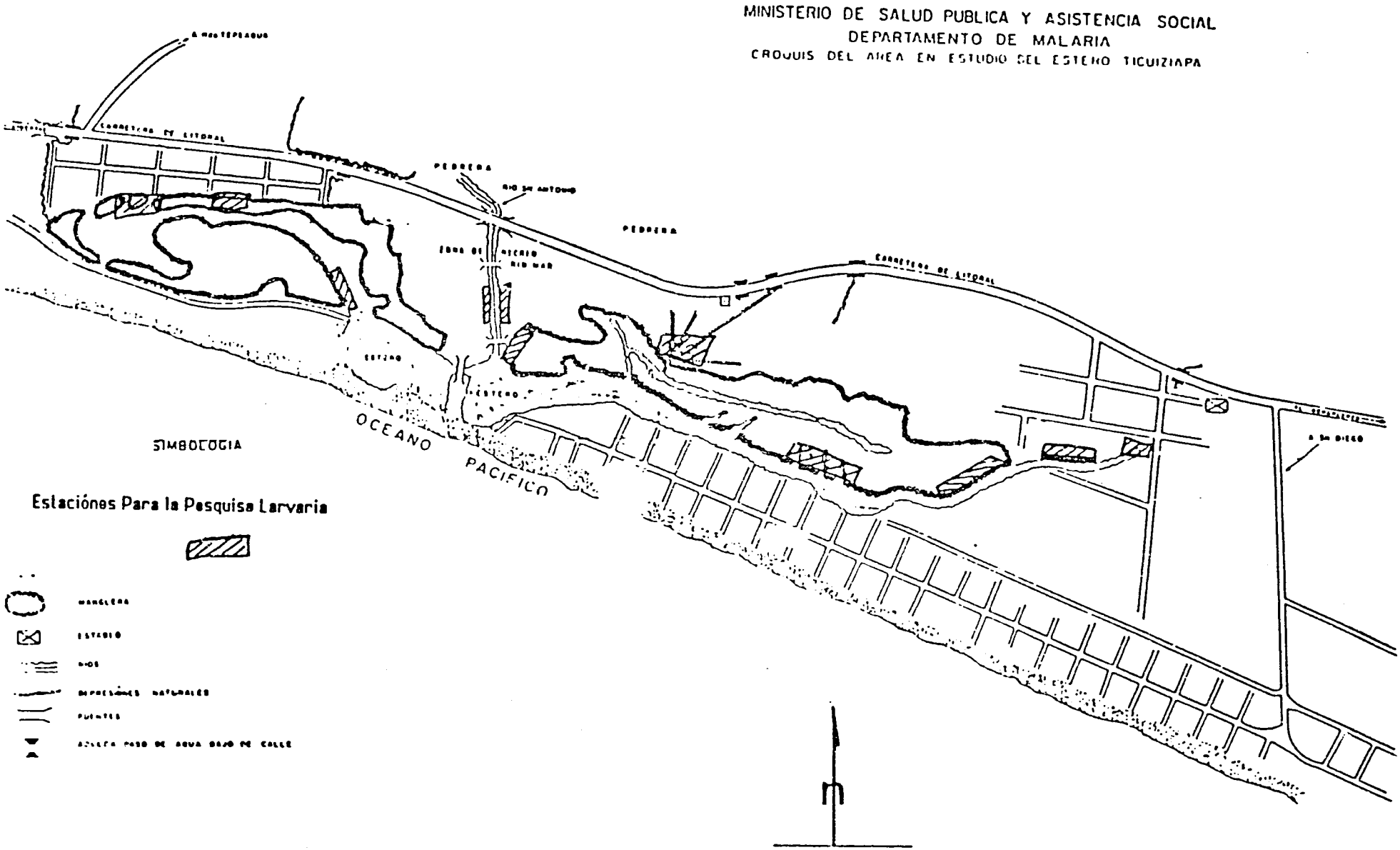
Designated breeding areas will be sampled once a week, preferably by the same persons, throughout the study period. The specific collection sites were chosen on the basis of previous samplings conducted by the Malaria Department entomologists during the 1986-87 study period. These areas showed that *An. albimanus* populations were present for at least part of the year. The same sites will be used and sites that have not been positive will be eliminated. Map 5 indicates the areas where larval samplings will be conducted.

Each sampling area consists of several sample sites which will be marked with colored flagging tape so that the exact location can be again found. These specific sample sites are areas where the highest larval densities have been found. There should be sufficient flexibility in the sampling program so that new sites can be added if highly positive locations are located, or if the area shifts slightly with the ebb and flow of the estero boundaries. At the same time, every effort should be made to maintain consistency in the samples so that valid comparisons may be made from one month to the next.

Forty samples, using the standard 350 ml dipper, which collect larvae from an estimated 750 cm^2 of surface area, will be taken from each sample site. All anopheline larvae collected will be counted and the number and instar for each dip recorded. The 3rd and 4th instars will be placed in marked vials of alcohol and returned to the laboratory for identification. The number and instar of culicines (i.e., *Aedes*, *Culex*, *Psorophora*, etc.) per dip will also be recorded. If time and manpower permit, these samples should also be placed in labelled vials and identified in the laboratory. At the beginning, this procedure may appear tedious; however, once the technician becomes familiar with the material and the keys provided, the process will proceed rapidly and the results will be of scientific interest. A list of species likely to be encountered is provided in Annex 7. In addition, environmental conditions of the breeding site will be noted (i.e., sun/shade, open/vegetation, presence of floating material, algae, etc.) and the presence of other life forms (i.e., fish, shrimp, etc.). will be identified. Finally, if the area appears to undergo any change in water level, this factor will also be noted.

MAP 5

LARVAL SAMPLING STATIONS IN THE ESTERO TICUIZIAPA



The results of the sampling will be recorded on the standard field forms and transferred at the end of each month to a monthly survey form so that rapid evaluation can be made. The results will be converted to the following indices:

1. An. albimanus Larvae Index

   - The number of 3rd and 4th An. albimanus per 100 dips.

2. Anopheline Larvae Index

   - The number of 3rd and 4th anophelines larval per 100 dips.

3. Total Anopheline Larvae Index

   - The total number of all anophelines of all instars per 100 dips.

4. Culicine Larvae Index

   - The total number of culicines of all instars per 100 dips.

These indices will give an indication of the productivity of the breeding site. Index #1 will be of major interest to this project; however, Index #2, when compared to Index #1, will indicate to what degree other anophelines are present. From previous reports, Index #1 will probably be equal to Index #2 on may occasions, since An. albimanus will often be the only anopheline present. Index #3 may be difficult to obtain, since the 1st and 2nd instars will not be as easily observed in the field; consequently, the findings may be inconsistent. However, every attempt should be made to determine all anophelines that are present, even early instars. In reviewing previous results, on several occasions, only 1st and 2nd instar anophelines were present; however, they did not appear in the monthly totals. Index #4 will indicate the presence of other pest species that often appear in a recently flooded area.

F. Epidemiological Evaluation

The general surveillance activities that are presently being conducted will be used as part of the basis for evaluating the effect of the Ticuiziapa Water Management Project, and no changes in these activities are recommended. Presently, malaria case detection is very good in this area and since the cost of medication is very high, automedication by the population is not

common. Therefore, the decline in the number of malaria cases is thought to accurately reflect the epidemiological picture.

The malaria transmission patterns in and around Ticuiziapa for the last five years are summarized in Annex 5. The seasonal transmission patterns are represented in Figures 6 and 7. This information will be used as base line data in the evaluation. The effects of the engineering project, if successful, will result in both a reduction in the total number of malaria cases reported each year, and in a decrease in the number of cases observed during the dry season.

G. Meteorological Conditions

An important part of this study will be to correlate certain meteorological conditions with estero water levels and mosquito density information. Meteorological information for the general area will be obtained from the Climatology Department of the Government of El Salvador. Since the meteorological stations are not in close proximity to Ticuiziapa, the project will have to generate meteorological information. A rainfall gauge and a maximum/minimum thermometer will be maintained at the office of the Malaria Department in La Libertad, which is situated 3 km from the study site.

During the nights when the entomological teams are present at the study site, general meteorological observations will be noted, such as rainfall, wind conditions, and fullness of the moon. In addition, temperature and relative humidity will be noted using a sling psychrometer when evening corral collections are being made.

H. Insecticide Application and Mosquito Control Activities

Attempts will be made to determine if aerial application of insecticides for crop protection is being carried out in the area. A record will be made of dates, locations and types of insecticides used.

It is suggested that the application of larvicides and ULV adulticides for malaria control not be undertaken for the duration of the study. However, intradomiciliary house spraying should be continued since the effect on the general mosquito population will be minimal. It is understood that intra-domiciliary house spraying with propoxur is scheduled to occur in the area.

It is also suggested that the estero not be opened manually for mosquito control activities. If the local residents open the estero on their own accord this cannot be prevented, however, the Malaria Department should not encourage the opening of the estero.

Although the discontinuation of spraying activities and the opening of the estero by local residents may not be practical due to political reasons, if these practices do continue, a detailed record of their occurrence must be maintained. The reason for this is that it will be difficult to determine the effect of the project unless a suitable control period is established. Larviciding and ULV application for mosquito control are recent innovations in malaria control. In most countries, malaria control programs rely on intradomiciliary house spraying and medication as the only methods for controlling transmission.

Another method of establishing a control would be to select another comparable estero and conduct similar monitoring activities. However, this will be difficult because patterns of mosquito production in other esteros in the area are different, and would require doubling the manpower and resources to complete the evaluation of the second estero. If a second estero is to be used, it may be most practical to use the San Diego Estero as the control site. Using this estero as a second control site would be advantageous because it is the site for the next water management project; therefore, the information gathered at San Diego could be used as base line data for the project and study scheduled for this area.

Probably the most feasible alternative, but least desirable, would be the careful monitoring of present control efforts. The results of this monitoring would be interpreted in light of these control activities. Fortunately, several studies have been conducted in this area in the past by CDC, and can be used as additional base line data.

I. Work Schedule

The project will require five field personnel, one field supervisor and four technicians. Two days a week will be required for data collection in the field for the duration of the project. On the first day in the field, larval collections and estero conditions will be monitored. In the evening the light traps will be set up and corral collections made. On the second day, corral collections will be made (when indicated), light trap collections processed and the larval collections and estero conditions will be completed. The collection material (i.e., traps, dippers, etc.) will then be stored at the Malaria Department in La Libertad, and the samples returned to their

office in San Salvador. On the third day, the samples will be sorted and identified by a technician and the data tabulated. Daily meteorological observations will be made by personnel from the Malaria Department in La Libertad. In addition, these personnel will be responsible for recharging the batteries of the light traps.

Note: If control efforts such as ULV adulticiding and larviciding are going to occur at Ticuiziapa, a control site must be selected for light trap placement and corral collections. A extra day in the field will be required to make the corral collections and set up the light traps.

The following presents an outline of work to be completed over a period of one week:

Monday - Preparation for field work

Tuesday

A.M. - Leave for Ticuiziapa early in the morning.
- Begin the larval collections and monitoring of the esteros conditions.

P.M. - Set up light traps and conduct corral collections.

Wednesday

A.M. - Conduct corral collections and collect light traps.

P.M. - Complete larval collections and monitoring of the estero's conditions. Store equipment in La Libertad and return to San Salvador with samples.

Thursday

- Identify samples and complete reports.
- Recharge the light trap batteries (responsibility of the Malaria Department personnel in La Libertad).

Friday

- Identify samples and complete reports.

J. Data Reporting

The weekly data collections will be put on the standard collection forms and these will be summarized on monthly summary sheets by the field supervisor and submitted to the principal investigators, who will summarize the results quarterly on a computer. A written copy of the quarterly report will be

submitted to each of the investigators, and to the malaria consultant for A.I.D. At the termination of the project, a written report will be submitted by the principal investigators. Every effort should be made to publish the results of this project.

K. Materials Required

Several items and some equipment will be needed for the project. The most important items needed for the project will be the updraft UV light traps. Ten light traps should be purchased, six for Ticuiziapa, and four for the control site. In order for these light traps to operate, 12 motor cycle 6 volt batteries will be needed (ten to be used and two to be held in reserve in case of loss or damage). Five battery chargers will be required to charge the batteries when they are not in use.

A good quality dissecting scope is needed to identify the mosquito samples. The one presently in use is unserviceable. In addition, two more Nester pH pens should be purchased since one of the pens malfunctioned after an hour of use and had to be returned.

There does not appear to be a meteorological station situated close to the estero. The station that existed in San Diego closed down in 1981. In order to obtain accurate meteorological information during the study, it will be necessary to obtain a rainfall gauge and a maximum/minimum thermometer that will be maintained at the Malaria office in La Libertad. Baygon placettes can be purchased locally to be used in the collection container of the NJ light traps (if used). The updraft traps do not require these since they capture mosquitoes alive. Finally, a refrigerator will be needed in the entomology laboratory of the Malaria Department for preserving specimens, until identification is completed, and for storing chemical reagents. The following table presents an itemized list of the equipment needed for the project:

Equipment	Number of Items Needed
Updraft UV light traps	10
6 Volt Motor Cycle Batteries	12
Battery Chargers	5
Dissecting Scope, Olympus	1
Nester pH pens	2
Rainfall Gauge	1
Maximum/Minimum Thermometer	1
Baygon Tablets (Available Locally)	100
Refrigerator (17 cu. ft. capacity)	1

Annexes 8-12 presents detailed instructions in Spanish on how to use the available equipment.

IV. REFERENCE LIST

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ANNEX 1

COPY OF PHOTOGRAPHS OF THE JUTE AND SAN ANTONIO RIVERS
DURING THE DRY SEASON - MAY 14, 1987

Photo 1a
The Jute River during the dry season. May 14, 1987.

Photo 1b
The San Antonio river during the dry season. May 14, 1987.

ANNEX 2

ESTERO TICUIZIAPA-AREA SAN DIEGO-CAPTURAS 1986

	SEMANAS														
CRIADERO ESTACIONES	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38
Estero Sur		0	0		1.2								0	0	
Estero Zacatosa		0	0.5		1.5								0	0	
Estero Soleada		0	0		0								0	0	
Estero Central		0	0		1.35								0	0	
Rio San Antonio		0	0.25		1.1								0	0	
Canales La Olla		0.05	0.4		0								0	0	
Estero Quemada		0	0.5		1.3								0	0.1	
Estero Policia Nacional		0.05	0.15		1.95								0	0	
Estero Colonia Nueva		0	0.1		1.2								0	0	
Cuneta La Pedrera		0	0		0								0	0	
Cuneta La Montaña		0	0		0								0	0	
La Pilona		0	0		0								0	0	
Estero Norte		0	0		0								0	0	
TOTAL		0.1	1.9		9.6								0	0.1	
PROMEDIO		0.008	0.146		0.738								0	0.008	
Pantano Los Tubos		0	0		Seco								0	Seco	
Pantano La Olla		Seco	0.6		1.25								0	0	
Pantano Güiscoyol		Seco	0.75		1.2								0.15	0	
Pila El Establo		0.02	0		1								1.4	0	
Charco La Pedrera		Seco	Seco		Seco								0.2	Seco	
TOTAL		0.02	1.35		3.45								1.75	0	
PROMEDIO		0.01	0.338		1.15								0.35	0	
TRAMPA LUZ															
Policia Nacional		2	1		55								0	0	
Rio Mar Oeste		--	12		18								0	0	
Estero Mar Este		6	3		61								0	0	
Los Enanos		7	20		68								2	1	
TOTAL		15	36		202								2	1	
PROMEDIO		5	9		50.5								0.5	0.25	
CONDICIONES DEL ESTERO															
Estero Abierto/Cerado		Ab	Ab		Ab								Ab	Ab	
Nivel de Agua elev/bajo		Bajo	Elev		Elev								Bajo	Bajo	
Fecha Destapada			12 Dic		26 Nov										
Fecha Tapada	25 Dic?		8 Dic?								14 Oct				
Lluvias															

ANNEX 2 cont.

37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20
0		0	0	0		0.05	0	0	0	0	0	0.45	0	0	L	0	0
0		0	0	0		0.05	0	0	0	0	0	0	0	0	L	0.05	0
0		0	0	0		0	0	0	0	0	0	0	0	0	L	0	0
0		0	0	0		0.15	0	0	0	0	0	0.25	0	0	L	0.15	0
0		0	0	0		0.05	0	0	0	0	0	0	0	0	L	0.05	0
0		0	0	0.15		0	0	0	0	0	0	0	0.05	0	0.05	0.9	0.65
0		0	0	0.3		0.1	0	0	0	0	0	0.2	0	0	0	0	0.05
0		0	0	0.4		0.75	0	0.1	0.1	0.1	0.1	0	0	0	0	0.35	0
0		0	0	0.5		0	0.45	0.25	0	0	1.05	0.15	0.2	0	0	0.25	0.1
0		0	0	0		0	0	0	0	0	0	0	0	0	L	0	0
0		0	0	0		0	0	0	0	0	0	0	0	0	L	0	0
0		0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
0.05		0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
0.05		0	0	1.35		1.15	0.45	0.35	0.1	0.1	1.15	1.05	0.25	0	0.05	1.75	0.8
0.004		0	0	0.104		0.088	0.035	0.027	0.008	0.008	0.088	0.081	0.019	0	0.008	0.135	0.062
Seco		0	0	0		Seco	Seco	Seco	0.1	0.15	--	0.1	0	0.4	0	0	--
0		0	0	0		0.3	0	0.1	0	0.15	0.25	0	0	1	0	0	--
0.05		0.25	0.4	0		0.85	0	0	0	0.5	1.25	0.4	0	2.2	0	0	--
0		0.2	1	0		--	--	--	--	--	--	--	--	--		--	--
Seco		0	--	--		--	--	--	--							--	--
0.05		0.45	1.4	0		1.15	0	0.1	0.1	0.8	1.5	0.5	0	3.6	0	0	--
0.017		0.09	0.4	0		0.575	0	0.05	0.033	0.267	0.75	0.167	0	1.2	0	0	
2		3	1	3		10	8	1	12	6	18	3	11	12	23	0	1
2		0	2	6		10	2	0	14	6	7	1	15	7	0	7	5
6		0	6	14		0	4	6	7	1	1	2	21	9	115	12	2
1		3	3	2		4	9	0	33	11	6	2	36	25	3	9	3
11		6	12	25		24	23	7	66	24	32	8	83	53	141	28	11
2.75		1.5	3	6.25		6	5.75	1.75	16.5	6	8	2	20.75	13	35.25	7	2.75
Ab		Ab	Ab	Ab		Cer	Cer	Cer	Ab	Ab	Ab	Cer	Cer	Ab	Ab	Cer	Cer
Bajo		Bajo	Bajo	Elev		Elev	Bajo	Bajo	Bajo	Bajo	Elev	Elev	Elev	Bajo	Elev	Bajo	Bajo
				13 Ago							26 Jun	17 Jun			26 Mayo		
								16 Jul				19 Jun	11 Jun				
				+++			++	++	++		+++	+++	++		+++		

ANNEX 2 cont.

	SEMANAS														
CRIADERO ESTACION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
Estero Sur	0	0		0			0				0.05		0		0.05
Estero Zacatosa	0.05	0.15		0			0				0.1		0		0.3
Estero Soleada	0	0		0			0				0		0		0
Estero Central	0	0.05		0			0				0		0		0.05
Rio San Antonio	0.05	0		0			0				0		0		0.05
Canales La Olla	0.6	0		0			0				0		0.05		0.65
Estero Quemada	0.5	1		0.6			0				1.3		1		4.4
Estero Policia Nacional	0.75	0.6		0.25			0				0		0.15		1.75
Estero Colonia Nueva	0.5	0.35		0.2			0				0.25		0.45		1.75
Cunata La Pedrera	0	0		0			0				0		0		0
Cunata La Montaña	Seco	Seco		0			0				0		Seco		0
La Ilona	0	0		0			0				0		0		0
Estero Norte	0.15	0.35		0			0				0		0		0.5
TOTAL	2.6	2.5		1.05			0				1.7		1.65		9.5
PROMEDIO	0.217	0.208		0.081			0				0.131		0.138		
Pantano Los Tubos	Seco	Seco		Seco			Seco				Seco		Seco		0
Pantano La Olla	Seco	Seco		Seco			Seco				Seco		Seco		0
Pantano Güiscoyol	Seco	Seco		Seco			Seco				Seco		Seco		0
PilaEl Establo	1	9p		0			2i-ii				0		0.6		1.6
Charco La Pedrera	Seco	Seco		Seco			Seco				Seco		Seco		0
Cunata El Casco	X	X		X			0.1				0.1		1.4		1.6
TOTAL	1	0		0			0.1				0.1		2		3.2
PROMEDIO	1	0		0.00			0.10				0.05		1.00		
TRAMPA LUZ															
Polbia Nacional	2	0		0			0				1		1		4
Rio Mar Oeste	16	7		3			1				0		1		28
Estero Mar Este	0	0		0			0				4		1		5
LosEnanos	12	2		9			1				0		1		25
TOTAL	30	9		12			2				5		4		62
PROMEDIO	7.5	2.25		3			0.5				1.25		1		15.5
CONDICIONES DEL ESTERO															
Estero (abierto/cerrado)	Cer.	Cer.		Cer.			Cer.				Cer.		Cer.		
Nivel Agua (Elev./Bajo)	Elev.	Elev.		Elev.			Bajo				Elev.		Mediano		
Fecha Destapada					10 Feb					16 Mar					
Fecha Tapada					12 Feb					no destapada					
LLuvias															

ANNEX 2 cont.

19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	TOTAL
0	0.05	0	0.25	0	0		0.05			1								3.05
0	0.05	0	0	0	0		0.05			1.5								3.7
0.05	0	0	0	0	0		0			0								0.05
0	0.1	0	0	0	0		0			0.1								2.1
0	0	0	0	0.15	0		0			0								1.6
0.85	1	0.2	0.9	0.35	0		--			--								5.55
0.05	0.15	0	0	0.5	0		1			2.2								6.45
0	0	0	0	0	0		0			0								4.05
0	0.1	0	0	0	0		0.1			0								4.45
0	0	0	0	0	0		--			--								0
0	0	0	0	--	--		--			--								0
0	0	0	0	--	--		--			--								0
0	0	0	0	--	--		--			--								0.5
0.95	1.45	0.2	1.15	1	0		1.2			4.8								31.5
0.073	0.112	0	0.088	0.1	0		0.15			0.6								2.4231
--	--	--	--	--	--		--			--								0.75
--	--	--	--	--	--		--			--								3.65
--	--	--	--	--	--		--			--								8
--	--	--	--	--	--		--			--								3.62
--	--	--	--	--	--		--			--								0.2
--	--	--																16.22
																		3.244
3	0	0	0	0	0		2			--								177
3	5	1	1	0	0		6			--								130
13	7	0	8	1	0		3			--								303
4	0	1	0	0	0		--			--								253
23	12	2	9	1	0		11			--								863
5.75	3	0.5	2.25	0.25	0		3.667											217
Ab	Cer	Cer	Cer	Cer	Cer		Cer			Ab								
Bajo	Elev	Elev	Elev	Elev	Bajo		Bajo			Bajo								
7 Mayo											21 Feb							
10 Mayo							19 Mar											
	++	++																

ANNEX 3

COPY OF PHOTOGRAPHS - THE OPENING OF THE ESTERO TICUIZIAPA
MAY 14, 1987

Photo 2
The opening of the estero Ticuiziapa, May 14th, 1987. Note that the ocean is at high tide and therefore water is entering the estero instead of leaving.

Photo 3
The opening of the estero Ticuiziapa, May 14th, 1987. Note that the ocean is at high tide and therefore water is entering the estero instead of leaving.

ANNEX 4

THE SAND BAR SEPARATING THE ESTERO TICUIZIAPA FROM THE OCEAN
MAY 14, 1987

Photo 4
The sand bar separating the estero Ticuiziapa from the ocean. May 14th, 1987. Note that the ocean is at high tide and waves are crossing the sand bar and entering the estero.

ANNEX 5

MALARIA TRANSMISSION FOR SIX CASERIOS (1982-1986)

Caserio Ticuizlada

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	1	13	3	8	1	1	1	1	0	3	3	8	3	23	0	4	1	10	0	6	3	8	3	4	107
83	1	13	1	3	1	1	0	2	0	0	0	0	0	4	0	9	2	8	0	4	0	2	1	1	53
84	0	0	0	1	0	1	0	1	0	1	1	8	0	9	0	8	1	8	0	4	0	1	0	1	45
85	0	2	3	6	0	3	0	2	0	0	0	1	0	2	0	3	0	3	0	1	0	4	0	4	34
86	0	3	0	4	0	3	0	2	0	2	0	2	0	4	0	3	0	9	0	0	0	0	1	3	35
Subtotal	2	31	7	22	2	9	1	8	0	6	3	19	3	42	0	27	4	38	0	15	3	15	5	13	275
TOTAL	33		29		11		9		6		22		45		27		42		15		18		18		275
PROMEDIO	0.4	6.2	1.4	4.4	0.4	1.8	0.2	1.6	0	1.2	0.6	3.8	0.6	8.4	0	5.4	0.8	7.6	0	3	0.6	3	1	2.6	

Caserio La Playa

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	0	2	1	5	0	1	0	2	0	3	0	4	0	3	0	6	1	2	0	6	0	7	1	4	43
83	0	0	0	2	0	1	0	2	0	1	0	3	0	7	0	3	0	0	0	0	1	5	0	1	26
84	0	1	0	0	1	4	0	0	0	0	0	1	0	14	0	14	6	17	0	5	0	7	1	7	78
85	0	4	0	10	0	1	0	3	0	6	0	1	0	0	0	0	0	2	0	1	0	0	0	2	32
86	0	0	0	4	0	1	0	0	0	0	0	3	0	0	2	1	0	2	0	0	0	2	0	2	17
Subtotal	0	7	1	21	1	8	0	7	0	10	0	12	0	24	2	24	7	23	0	12	1	21	2	16	169
TOTAL	7		22		9		7		10		12		24		25		30		12		22		18		169
PROMEDIO	0	1.4	0.2	4.2	0.2	1.6	0	1.4	0	2	0	2.4	0	4.8	0.4	4.8	1.4	4.6	0	2.4	0.2	4.2	0.4	3.2	

Caserio MODA San Diego

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	0	1	0	1	0	2	0	1	0	2	1	4	2	27	0	9	0	2	0	0	0	4	2	5	62
83	1	4	0	0	1	0	0	5	0	1	0	1	0	7	1	6	0	3	0	0	0	1	0	0	31
84	0	1	0	0	0	3	0	0	0	0	0	3	1	10	0	11	1	3	0	1	0	2	0	1	37
85	1	1	0	7	0	2	0	1	0	6	0	0	0	0	0	1	0	1	0	0	0	1	1	1	23
86	1	5	1	1	0	0	0	1	0	0	0	0	0	0	0	3	1	1	0	1	0	1	0	1	18
Subtotal	3	12	1	9	1	7	0	8	0	9	1	8	3	44	1	30	2	10	0	2	0	9	3	8	172
TOTAL	16		10		8		8		9		9		47		31		12		2		9		11		172
PROMEDIO	0.6	2.8	0.2	1.8	0.2	1.4	0	1.6	0	1.8	0.2	1.6	0.6	8.8	0.2	6	0.4	2	0	0.4	0	1.8	0.6	1.6	

Caserio Amatal

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	0	1	0	0	0	2	1	0	0	1	0	0	0	2	0	2	0	0	0	0	0	1	1	0	11
83	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3
84	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3	0	0	0	1	0	1	0	0	7
85	0	0	0	5	0	0	0	0	0	1	0	1	0	1	0	2	0	1	0	0	0	2	0	0	13
86	0	3	0	2	1	1	0	1	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	14
Subtotal	0	4	0	7	2	3	1	2	0	3	0	2	0	7	0	7	0	4	0	1	0	4	1	0	48
TOTAL	4		7		5		3		3		2		7		7		4		1		4		1		45
PROMEDIO	0	0.8	0	1.4	0.4	0.6	0.2	0.4	0	0.6	0	0.4	0	1.4	0	1.4	0	0.8	0	0.2	0	0.8	0.2	0	

Caserio Playa Las Flores

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	0	8	0	4	2	1	0	1	0	3	0	4	1	6	0	0	3	8	0	0	0	5	1	5	52
83	0	5	0	2	0	1	0	3	0	3	0	0	0	2	1	2	0	5	1	0	0	4	0	4	33
84	2	3	0	4	0	0	0	0	0	2	0	0	0	6	0	6	0	1	0	1	1	3	0	0	29
85	0	0	1	2	1	2	0	1	0	2	0	2	0	2	0	2	0	1	0	1	0	2	0	1	23
86	0	6	0	2	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	2	0	0	15
Subtotal	2	22	1	14	3	4	1	5	0	10	0	7	1	15	1	10	3	16	1	3	1	16	1	10	147
TOTAL	24		15		7		6		10		7		16		11		19		4		17		11		147
PROMEDIO	0.4	4.4	0.2	2.8	0.6	0.8	0.2	1	0	2	0	1.4	0.2	3.4	0.2	2	0.6	3.2	0.2	0.6	0.2	3.2	0.2	2	

Caserio El Jute

	Ene		Feb		Mar		Abr		May		Jun		Jul		Ago		Sep		Oct		Nov		Dic		
Año	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	P.f.	P.v.	TOTAL
82	0	14	0	7	0	4	0	0	0	1	0	7	1	13	0	4	1	5	0	4	0	4	1	5	71
83	1	6	0	2	0	1	0	3	0	3	0	1	0	3	0	2	0	1	0	4	0	7	0	1	35
84	0	3	1	3	1	3	0	0	0	0	0	1	1	2	0	6	0	7	0	1	0	1	0	1	31
85	0	0	2	4	0	2	0	1	0	0	0	2	0	1	0	2	0	0	0	0	0	1	0	0	15
86	0	5	0	0	0	0	0	1	0	1	0	0	0	5	0	1	0	2	0	0	0	2	0	0	17
Subtotal	1	28	3	16	1	10	0	5	0	5	0	11	2	24	0	15	1	15	0	9	0	15	1	7	169
TOTAL	29		19		11		5		5		11		26		15		16		9		15		8		169

ANNEX 6

DESCRIPCION DEL ESTERO TICUIZIAPA EN LA COSTA PACIFICO DEL EL SALVADOR

En el 5 de Mayo 1987 entre los horas de 10:00 a 15:00 las condiciones del estero Ticuiziapa fueron medidas. El que sigue es una descripción breve de los 18 estaciónes para facilitar medidas en los mismos lugares durante el estudio. El estero Ticuiziapa es 1.750 m por largo y de ancho desde 4 m hasta 250 m. Hay solomente un Rio que entra en el estero, el Rio San Antonio. Durante la epoca de sequia el estero esta cerado al mar porque el Rio no tiene suficiente agua para mantenterse abierto, el mar no tiene una marea muy grande y la acción de las olas son tan fuertes que ellos crecieron un bar de arena. Con las lluvias el rio se aumenta hasta abrir el estero al mar.

Tomamos muchos estaciones en este estero para tener una perfil completa del estero durante la epoca de sequia. Los estaciones son enumerados de 1 a 18 y son como sigue:

1) Esta estación es en la parte norte del estero oeste. Esta cerca de un arbol grande de mango y es un lugar donde el ganado llega para tomar agua y hay muchos mangles. No es muy profundo (15 cm), tiene bastante lodo en el fondo y muchas plantas acuaticas (*Typha*, hierba etc.) Tiene sombra pero parece un criadero para *Anopheles albimanus*. Es una estación que se vuelve potencial cuando el estero se llena y negativo cuando hay poca agua por su condición como brazo del estero.

2) Este es 100 m oeste del numero 1 y es un otro lugar donde el ganado toma agua. Tambien hay mucho mangles y el agua tiene una profundidad de 45 cm. Hay arena en el fondo pero como 10 metros en el estero la profundidad es mucho mas (150 cm) y el fondo es lodo.

3) Este es un otro lugar donde el ganado toma agua. Hay muchos mangles y el agua tiene una profundidad de 51 cm y arena en el fondo. Como 10 metros en el estero la profundidades mucho mas (150 cm) y el fondo es lodo.

4) Esta estación es en la esquina del estero, en el parte mas oeste.

Es muy cerca del camino y hay un arbol grande sobre esta estación. No es muy profundo (35 cm) y tiene arena en el fondo. Hay varias casas cerca.

5) Esta estación esta en el centro del estero oeste donde hay algunas ramas de un arbole en el agua. El fondo es puro lodo y tiene una profundidad de 70 cm.

6) Esta estación es en el otra esquina del estero oeste. Esta cerca de la casa "Los Enanos" y el camino. Tiene mucho hierba, es abierto al sol, tiene lodo en el fondo y un profundidad de 35 cm. Parece un criadero por *An. albimanus*.

7) Esta estación es en el canal que es en la parte mas norte del estero. Hay mangle en ambos lados y el canal es 10 m de ancho. No es profundo (10 cm) pero tiene mucho lodo (50 cm).

8) Esta estación esta cerca del final del camino oeste y tambien del mangles. Es en un lugar bajo de arboles y tiene mucho hierba. No es muy profundo (17 cm) y el fondo es de lodo.

9) Esta estación está cerca del número 8 pero es en el centro del canal del estero. Tiene una profundidad de 70 cm y el fondo es de lodo.

10) Esta estación está muy cerca del mar, formado por una pequeña bahia. Es un lugar con arena y lodo en el fondo y muchos hoyos de congrejos. Tiene una profundidad de 15 cm. Carece de vegetación y es muy soleada.

11) Esta estación está en la parte mas sur del estero. Es un pequeño bahiá que tiene profundidad de 15 cm. El fondo es de arena y es muy soleada.

12) Esta estación está en la bocana del Rio San Antonio, en un puente. Ambos lados del rio tiene hierba. El fondo es lodo y arena y tiene una profundidad de 90 cm.

13) Esta estación está en el Rio San Antonio en el segundo puente que está al norte 150 m de la bocana del rio. Tambien hay hierba por los dos lados. El fondo es de arena y lodo y tiene una profundidad de 37 cm.

14) Esta estación es a un lado del estero cerca de las primeras casas de la Playa San Diego. Hay una pared de piedras. El fondo es de lodo, no hay

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plantas por este lado y tiene una profundidad de 35 cm.

15) Esta estación está cerca del Rancho de Recreo de la Policia Nacional donde se termina el camino. Hay muchas aguas negras entrando al estero de varios casas. No hay plantas y el fondo es lodo. La muestra fue de una profundidad de 20 cm pero mas adentro lo hondo del estero alcanza los 50 cm.

16) Esta estación está en el final del camino. Hay varias bases de piedra ahi para construir un puente. El estero es mas como un charco con plantas en los dos lados pero no hay corriente. El estero no es muy profundo en esta parte, el máximo es como 50 cm pero donde tomamos la muestra fue 30 cm. El fondo es mas arena que lodo.

17) Esta es el punto del estero y es muy cerca del camino. Hay pequeño árboles, *Typha*, y hierba. El fondo es lodo y tiene una profundidad de 30 cm.

18) Esta estación es cerca de la Carretera del Litoral. Es una serie de canales construidos por CNAP para canalizar las aguas hacia el estero . La estación donde se tomó la muestra fue en la union de los cuatro canales que forman el canal principal. El fondo es de lodo (40 cm) mas 30 cm de agua. Es muy soleada y parece buen criadero por *An. albimanus* . Posee abundant vegetación acuática.

Estación	pH	Temp (°C)	Salinidad (*)	Profundidad (cm)
1	7.3	28.5	4.1	15
2	-	30	4.8	45
3	-	31	4.9	51
4	-	31.5	4.6	35
5	-	30	4.8	70
6	-	32	4.8	35
7	8.0	31	4.5	10
8	7.2	30	3.9	17
9	7.7	29.5	4.2	70
10	-	32	3.0	15
11	-	32	4.0	15
12	7.1	32	3.7	90
13	7.4	28	0.0	37
14	7.7	32	3.9	35
15	8.3	34	3.9	20
16	8.3	32	4.0	35
17	7.6	32.5	3.0	30
18	7.7	32.5	4.2	15* partes por mil.

Análisis Quimico del Agua del Estero Ticuizlapa 1986-7
por Jacobo Solórzano e Alberto Escobar

FECHA	Abr. 18/86
CRIADERO ESTACION	Salinidad*
Estación Estero Ticuizlapa	1 4.67
Estación TWD	2 5.47
Estación	3 4.35
Estación Estero	4 5.47
Estación Margen De. Rio	5&6 0.35
Estación	7 14.75
Estación Estero	8 7.87
Estación Estero Ticuizlapa	9 3.39

* partes por mil

FECHA	Ene 13-5/87			Feb 27/87			Mar 31/87		
CRIADERO ESTACION	pH	Cloruros*	Salinidad*	pH	Cloruros*	Salinidad*	pH	Cloruros*	Salinidad*
Estero Sur	8.2	3.50	6.3475	7.2	2.30	4.1815	8.1	2.20	4.001
Estero Zacatosa	8.1	2.90	5.2645	8.3	1.90	3.4595	8.0	1.80	3.279
Estero Soleada	8.3	2.20	4.001	8.2	0.80	1.474	8.4	0.80	1.474
Estero Central	8.3	2.10	3.8205	8.0	0.80	1.474	8.2	0.60	1.474
Rio San Antonio	7.5	3.30	5.9865	7.4	2.10	3.8205	7.9	1.20	2.198
Canales La Olla	7.9	2.20	4.001	7.9	1.00	1.835	8.4	0.20	0.391
Estero Quemada	7.7	3.10	5.6255	7.8	1.20	2.196	7.7	9.50	17.178
Estero Policia Nacional	7.8	3.90	7.0695	7.9	2.40	4.362	8.1	1.50	2.7375
Estero Colonia Nueva	7.9	3.70	6.7085	8.0	2.70	4.9035	8.3	1.90	3.4595
Estero Norte	7.5	3.30	5.9865	7.6	2.40	4.362	8.1	2.40	4.362

* partes por mil

Nota: Los datos originales fueron con Cloruros. Para convertirlos a Salinidad debes usar la siguiente formula.
Salinidad = 0.03 + 1.805 (Cloruros)

ANNEX 7

THE MOSQUITOES OF EL SALVADOR

The following is a brief review of several classical entomological studies that were conducted in El Salvador. They have been included to give orientation as to what species of *Anopheles* are present in El Salvador and in particular what species can be expected to be found during the present study in Ticuiziapa. As can be seen the studies are quite old and this should stress the importance of updating the data with the collections that are going to be made in Ticuiziapa. It is important to note that *An. argytarsis* has been recorded in the study site area. This species can be easily confused with *An. albimanus* and therefore careful identification of the specimens collected is needed. The two can be easily separated by the lack of a black band on the hind tarsimere of *An. argytarsis*. A brief pictorial key in included to illustrate the differences. Several copies of the MOSQUITOES OF GUATAMALA have been left with the Malaria Department entomologists to assist them in the identification of the specimens collected.

The earliest study published that described the *Anopheles* found in El Salvador was by Lardé Arthes (1921). He found 5 species which included *An. albimanus, An. apicimacula, An. strigimacula, An. pseudopunctipennis* ,and *An. tarsimaculatus*. His *An. strigimacula* was probably *An. punctimacula* and his *An. tarsimaculatus* was probably a mixture of *An. albimanus* and *An. argytarsis*. Sutter (1939) found 5 species of Anopheles which included *An. albimanus, An. apicimacula, An. argytarsis, An. pseudopunctipennis*, and *An. punctimacula*.

Kumm and Zúniga (1942) made extensive collections throughout 134 localities in El Salvador and found the same species as Sutter. In addition they also found *An. eiseni*, *An. hectoris*, and *An. neomaculipalpus* in very low numbers. Over 25,000 adults and 3,100 larvae were identified in one and a half years of collections. Of these *An. albimanus* made up 87.6% of the 485 mosquitoes collected in house collections and 67.9% of the 14,994 mosquitoes collected in stable trap collections. *An. pseudopunctipennis* (11.9%) and *An. neomaculipalpus* (0.4%) made up the remainder of the house collections. In the stable trap collections *An. pseudopunctipennis* accounted for 31.2% of the *Anopheles* collected and the remaining *Anopheles* accounted for less than 1%.

From the La libertad area the following species of mosquitoes were collected and can therefore be expected to be encountered in the present study:

Species	Type of Capture
Ae. taeniorhynchus	intradormicillary captures, stable traps, daytime biting in woods, horse bait at sunset.
Ae. terrens	tree hole breeder, stable trap, daytime biting in woods
Anopheles albimanus	sunny ditches, borrow pits, seepage areas, quiet pools along steams, rivers, with *Spirogyra* 54.4% of time.
An. argytarsis	in stable traps, never in houses, sunny ditches, borrow pits, seepage areas, quiet pools along steams, rivers, with *Spirogyra* 70.0% of time.
An. pseudopunctipennis	ground pools, edges of slow running streams, with green *Spirogyra* 98.5% of time.
An. punctimacula	rare, found in shaded seepage areas.
Culex conspirator	tree holes, sunny pools in streams,
Cx. pipiens quinquefasciatus	intradormicillary captures, stable traps, horse bait at sunset.
Cx. trifidus	sunny pools in streams with *Spirogyra*
Cx. pilosus	sunny ditch
Deinocerites pseudes	crabholes, intradormicillary captures, stable traps,
Haemagogus regalis	larvae in treeholes, coconut husks
Mansonia titillans	intradormicillary captures, stable traps, daytime biting in woods, horse bait at sunset.
Psorophora varipes	stable traps, human bait
Sabethoides chloropterus	daytime resting sites
Uranotaenia lowii	crab holes

References:

1) Lardes Arthes, C. R. 1921. Anopheles de El Salvador y profilaxia palúdica. Medical Graduation Thesis at the University of El Salvador.

2) Sútter, V. A. 1939. Primer informe de los trabajos del Quinto Departamento (Malariologia) Boletin de San. e Hig. Púb. (San Salvador) , 8 , 21-24. pp. 225-98.

3) Kumm H.W. and H. Zúniga .1942 .The Mosquitoes of El Salvador. Amer. J. Trop. Med. 22: 399-415.

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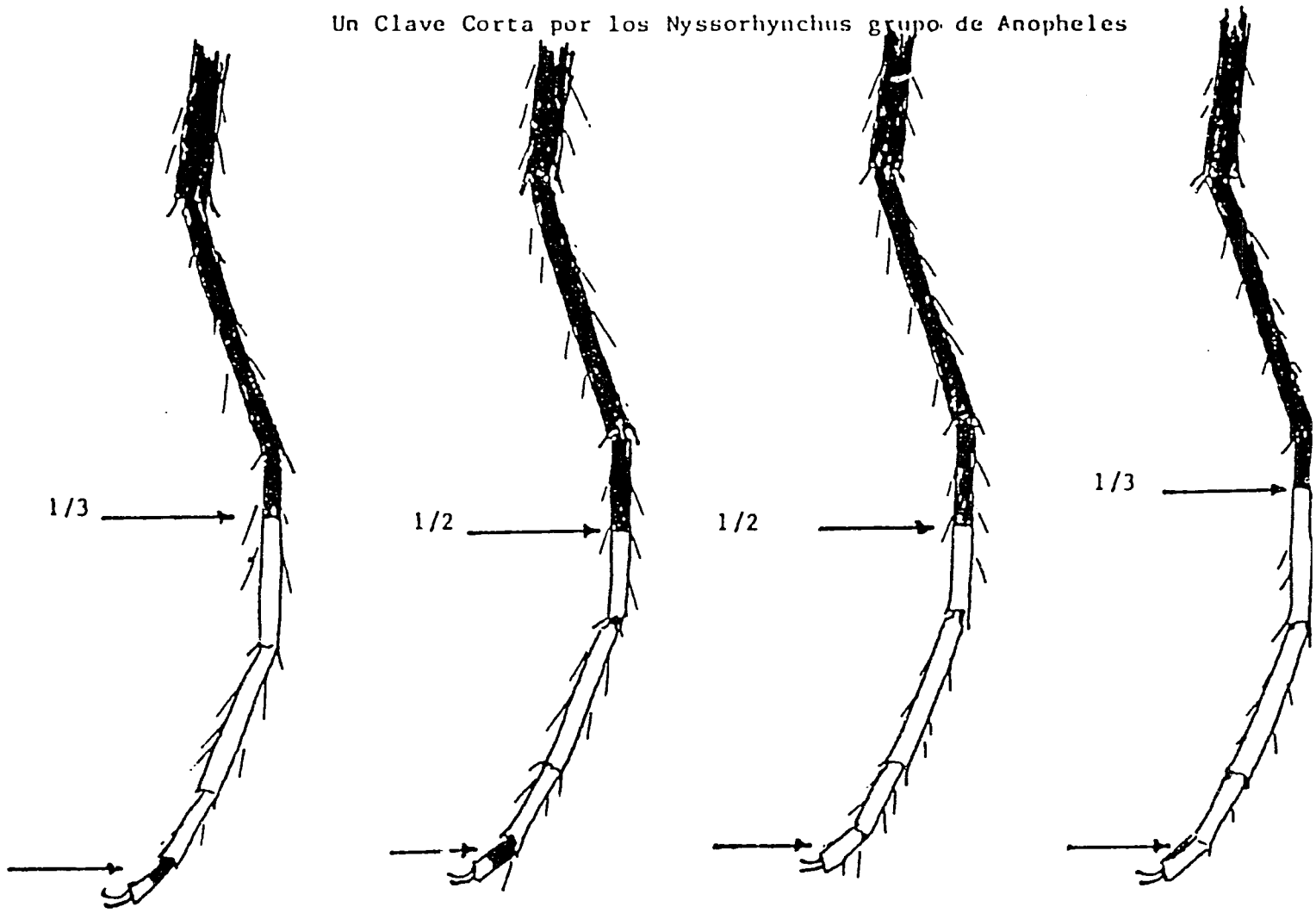
ANNEX 7 cont.

Un Clave Corta por los Nyssorhynchus grupo de Anopheles



An. strodei An. albimanus An. darlingi An. argyritarsis

por Chris Frederickson

ANNEX 8

Instrucciónes para el uso del Salinometro Modelo "YSI Model 33"

Usos:

Para medir en agua la : 1) Temperatura
2) Salinidad
3) Conductividad

Modos de Operación:

1) Calibración

(Nota: Antes de usarlo siempre debe calibrarlo)

i) Conecte el electrodo en el toma del aparato en el lado derecho.

ii) Para calibrar el aparato: Con el aparato apagado, la aguja debe estar marcando el cero en la escala negra de conductividad (0-500). Si no marca cero, entonces se calibra con un destornillador en el tornillo negro ubicado en la parte baja de la pantalla. Mobiendolo muy suave hasta hacerlo llegar al punto cero.

iii) Encienda switch **MODE** hasta **RED LINE** (linea roja). La aguja debe llegar hasta la linea roja ubicada sobre la escala negra de conductividad (0-500). Para ajustar la aguja con la linea roja, use la perilla de **RED LINE**.

(**Nota**: Es un buen idea probar el aparato en el campo con una muestra de agua del mar cada vez que va tomar medidas del estero. El agua del mar debe registrar arrededor 33.5-35.0 partes por mil. Si tiene este resultado se sabe que el aparato esta funcionando bien.)

2) Operación:

i) Introdusca el electrodo dentro del agua a la profundidad deseada para medir, nunca en el lodo.

ii) Ponga el switch **MODE** en la linea **TEMPERATURE** y lea la temperatura en la escala mas baja de **°C** (50 hasta -2) observando que la aguja esté quieta. Marque la temperatura obtenida usando la perilla mas

grande °C, para calibrar el aparato.

iii) Después de ajustar la temperatura, ponga el switch en **SALINITY (0/00)** y lea el resultado de salinidad en la escala roja (0-40). El resultado es en partes por mil (0/00) que es la norma para salinidad.
(**Nota**: Partes por cien o porcentaje es 0/0 pero partes por mil se escribe como 0/00)

3) La Conductividad

Para leer, ponga el switch **MODE** en **x100** primero, para obtener el rango de la conductividad entre (0-500). Si el resultado es entre 50-500 dejelo en esta escala. Si el resultado es menor de 50 entonces pase el switch **MODE** a **x10**. Ahora la escala en la pantalla es (0-50) en vez de (0-500). Si la aguja marca menos de 5 o no marca nada entonces debe poner el switch **MODE** en **x1**. En esta caso la escala marcara (0-5) en vez de (0-500).

Switch MODE	Escala
x100	0-500
x10	0-50
x1	0-5

4) Al Final

Después de finalizar la medicion apague el switch **MODE**. Observe el electrodo por dentro después de cada muestra para asegurarse que no hay lodo en su interior. Si hay lavelo con agua. No introdusca nada de metal adentro. Al final del trabajo lave el electrodo con suficiente agua dulce para eliminar cualquier residuo de agua salada.

Instrucciónes para el uso del Aparato Chemcadet pH/ION/Temp Meter

Usos:

Este aparato se utiliza para medir pH, conductividad, y temperatura.

1) Identificación de Controles

i) Switch de **FUNCTION**

Este tiene 4 posiciónes: apagado **OFF** conductividad **mV**, **pH**, y temperatura **°C**. La función de los otros switches depende en que posición se encuentre este switch.

ii) Switch de **TEMP °C**

Se puede adjustar la temperatura en este aparato en dos maneras: automaticamente o manualmente. Si utiliza el electrodo de **ATC/TEMP** no es necesario adjustar la temperatura pero si no se utiliza este, se debe adjustar la temperatura manualmente con el switch de **TEMPERATURE**. Adjuste este switch hasta a la temperatura de su muestra antes de determinar el pH o la conductividad.

iii) Switch de **STANDARDIZE**

Este control se utiliza cuando el switch de **FUNCTION** esta marcando **pH** y es para calibrar el aparato a pH 7.0. Con el electrodo de pH/conductividad **pH/mV** de color azul adentro de una muestra de buffer pH 7.0 y el switch en **FUNCTION** marcando **pH** ajustar el Switch **STANDARDIZE** hasta que en la pantalla se lea el numero 7.0. Nota: Antes de hacer esto debe ajustar el aparato a la temperatura del agua.

iv) Switch de **SLOPE**

Este switch se utiliza para calibrar el aparato a un segundo pH. Por ejemplo si quiere medir el pH de una solución que tiene alrededor de 10. Primero use el switch de **STANDARDIZE** y calibrelo a 7.0 con un buffer de 7.0, como esta explicado arriba. Para obtener un resultado mas preciso debe ajustar el aparato con un segundo buffer que este mas cerca de su muestra. Con el electrodo introducido en un buffer de 10 ajuste la lectura en la pantalla hasta leer 10 con el switch de **SLOPE**. Después introdusca el electrodo en la muestra de solución y lea el pH respectivo. En breve, si nesecita el pH de una solución que es major que 9 o menor que 5 entonces

debera ajustar el aparato dos veces, la primera vez con un buffer de pH 7.0 y luego con un buffer mas cerca de su muestra (por ejemplo con buffer de pH 10 o pH 4). En el caso de agua normal calibrelo una sola vez nada mas porque va tener un pH aproximado de 7.0 (entre 6-8.5). Nota: Antes de hacer este procedimiento debera ajustar el aparato a la temperatura del agua.

2) Identificación de Conectores

i) EXT. POWER energía electrica externa. Este toma es para un convertidor COLE-PALMER del tipo 117 VAC (voltios corriente alterna) y 9 VDC (voltios corriente directa).

ii) pH/mV es para el electrodo color azul con cable coaxial que se utiliza para medir el pH y la conductividad.

iii) ATC/TEMP- Este electrodo es el control automático de temperatura. En el se conecta la espiga grande del electrodo de vidrio que tiene contenido blanco adentro y que sirve para medir la temperatura.

iv) Bateria- Usar una pila de 9 voltios o el aparato convertidor. Pero siempre que utilize cualquiera de estas dos fuentes de energía, el switch de **FUNCTION** debera estar en **OFF** (apagado) antes de usarlo; una vez la fuente de energía sea conectada, entonces se puede encender

v) REC.OUT Estos tomas hembras, color rojo (positivo) y negro (negativo) no deben utilizarse pues son para otro tipo de electrodos.

Modos de Operación

3) Calibración

(Nota: Antes de utilizar el medidor siempre debera ser previamente calibrado.)

i) Conectar los electrodos **ATC/TEMP** y **pH/mV**.

ii) Poner el electrodo **ATC/TEMP** adentro de la solución buffer con pH 7.0 y poner el switch de **FUNCTION** en **°C**. Leer la temperatura correspondiente en la pantalla. Si el electrodo **ATC/TEMP** no funcióna lea la temperatura utilizando un termómetro y luego marque la temperatura obtenida con el switch de **TEMP °C**.

iii) Marque la temperatura que obtuvo en la pantalla, con el switch de **TEMP °C**. Deje el electrodo de temperatura dentro del buffer y luego introduzca la punta del electrodo **pH/mV** de color azul en la solución buffer.

iv) Cambie el switch de **FUNCTION** hasta la posición de **pH** y luego con el switch de **STANDARDIZE** ajuste en la pantalla hasta 7.0.
(Nota si su muestra tiene un pH mayor de 9 o menor de 5 debera calibrarlo otra vez con buffer de pH 10 o 4 respectivamente como sigue. Si no continue con el paso **vi**.)

v) Para obtener un resultado mas preciso debera ajustar el apartato con un segundo buffer que este mas cerca de su muestra. Con los electrodos en un buffer de 10 ajuste la pantalla hasta leer 10 con el switch de **SLOPE**. Después de esto puede poner los electrodos en su muestra de solución y leer el pH respectivo de su muestra. En resumen si nesecita el pH de una solución que esta mayor que 9 o menor que 5 debera ajustar el aparato dos veces; la primera vez con un buffer de pH 7.0 y la segunda vez con un buffer mas cercano a su muestra (por ejemplo con buffer de pH 10 o pH 4). En el caso de agua normal debera calibrarlo una vez nada mas por que esta va tener un pH alrededor de 7.0 (entre 6-8.5). Una vez completados los pasos anteriores el aparato estara calibado y listo para medir su muestra. (Nota: Si la temperatura de su muestra es muy differente debera repetir los pasos **i-iii** otro vez con su muestra)

vi) Ahora que el aparato esta calibrado podra leer su muestra. Lavando antes los electrodos con agua destilada. Luego introdusca los dos electrodos de **ATC/TEMP** y **pH/mV** en la muestra y con el switch de **FUNCTION** en **pH** lea el pH de la muestra a medir.

vii) Deje los electrodos en la muestra y ponga el switch de **FUNCTION** en **mV** para medir la conductividad de la muestra.

4) ASEO

i) Debera lavar los electrodos después de utilizarlos con cada muestra. Esto se hara con agua destilada por que las muestras en el laboratorio son tan pequeñas que un residuo de una muestra puede alterar el resultado de las otras muestras.

ii) Inmediatamente después de utilizarlos debera lavar los electrodos con suficiente agua destilada y guardar el electrodo de **pH/mV** en su

copita de agua destilada para mantenerlo mojado. **Si este electrodo se llegara seco no va a funcionar mas.**

Instrucciones para el uso de la pluma pH Nester pH Pen

Usos:
Para medir el pH del agua.

Modos de Operación

1) Como colocar las baterias:

i) Colocar cuatro baterías pequeñas (de reloj de puño) union carbide 392.

ii) Quitar la base corriendola hacia abajo.

iii) Deslizar cuerpo protector (color negro) hasta la mitad de la base color blanco y tendrá al descubierto la cámara donde se colocan las cuatro bateriás en serie quedando totalmente ajustados.

iv) Las cuatro baterías se colocan en serie en donde el polo negativo será al lado derecho y el polo positivo será al lado izquierdo y encenderá la pantalla.

v) Subir nuevamente el protector negro y seguidamente la base, quedando la pantalla apagada.

2) Calibración:

i) Quitar la base totalmente.

ii) Poner dentro de la muestra de agua de buffer pH 7.0, la mitad de la parte blanca del aparato pluma pH. **(Nota: Siempre pone solomente el punto en el agua. Si metes mas el aparato no va a funcionar mas)**

iii) Aprete y deje el botón que está ubicado abajo del rótulo Nester pH. Luego, esperar durante un minuto observando la pantalla hasta ver que ésta alcance el pH 7.0

iv) Si la pantalla no muestra el pH 7.0 debes ajustarla con un

desarmador. Quitar totalmente la base y correr hacia abajo el cuerpo protector hasta el nivel de la cámera de las baterías y aparece el tornillo color blanco que sirve para ajustar la pantalla hasta 7.0. Ajustarlo y pruebelo otro vez.

v) Ya calibrado el pH a 7.0 puede usarlo para medir el pH. Nota que si va medir el pH de una solución que tiene un pH mayor que 9 o menor que 5 debera calibrarlo otro vez con un buffer mas cerca al pH que quiere medir.

4) Operación:

Para evitar el problema de poner el aparato demasiado profundo en el agua (que va a destruir el aparato) es mejor saca una muestra de agua con un cucharón y toma el pH en el cucharón.

i) Quitar totalmente la base.

ii) Introdusca la mitad de la parte blanca de la pluma pH en el agua que se va a chequear. **(Nota: Siempre pone solomente el punto en el agua. Si introduce mas el aparato no va a funciónar mas)**

iii) Aprete y deje el botón que está ubicado abajo del rótulo Nester pH y observe la pantalla. Lea el resultado cuando los numeros el la pantalla estan estable.

iv) Poner nuevamente la base del aparato que pone apagada la pantalla. **Es muy importante que no permite que el punto del aparato sr llegara seca entonces inmediatemente depués de medir la muestra debe ponerla en la base.**

5) Modo de Proteger el Aparato:

Al final de cada jornada de trabajo se le debe poner agua limpia en el asiento de la base donde hay colecada una esponja con el propósito de mantener mojada el electrodo que sirve como sensor. Es muy sensitivo y por esta razon no debe tocarlo tampoco

ANNEX 11

Instrucciónes para la preparación del Buffer usando la Mezcladora: Cole Palmer Portable Magnetic Stirrer Model 4804-00.

Usos:

Para mezclar el buffer. Trabaja con energía de dos baterias de 1.5 voltios.

Modos de Operación de la Mezcladora

1) Se destapa para colocarle dos baterias cilindricas medianas (tamaño C) de 1.5 voltios cada uno. Se enciende el switch a la velocidad deseada.

2) Tiene una bobina que es accionada con la fuerza de las baterias y hace girar una pieza magnetica. Esta causa una cápsula metálica que se llama el pescado hacer vueltas cuando esta colocado sobre el aparato. Si este pescado esta en un recipiente de una solución tiene el effecto de agitarlo.

3) Colocar un recipiente de plástico que contiene 100 ml de agua destilada sobre la mezcladora. Romper una capsula de buffer que quiere preparar (por ejemplo pH 4, 7, o 10) y poner el polvo en el agua con el pescado. Enciende el switch a la velocidad que es sufficiente para mezclarlo bien.

4) Después de algunas minutos observar que todo el polvo esta disolvado. Pone esta buffer en un frascito con tapa y marca el pH del buffer y la fecha. Generalmente los buffers dura por varios meses pero después de un mes debes probarlo. Se usa los buffers para calibrar los aparatos que medir pH.

Instrucciónes para el uso del Psicrómetro

Usos: Para medir la humedad relativa.

Modos de Operación

1) Antes de usarlo, meta la mecha y la tapa del depósito en agua limpia.

2) Llene la tapa del depósito con agua y ajústelo lo suficiente para impedir filtración.

3) Asegúrese que la mecha cubre la punta de mercurio del extremo mojado del termómetro.

4) Hale el termómetro hasta sacarlo del tubo para que pueda rotar.

5) Sosteniendo el tubo hágalo rotar 2-3 revoluciones por segundo, (120-180 rpm por minuto) por 1.5 minutos.

6) Lea la temperatura del exremo mojado y después la del extremo seco.

7) Coloque el termómetro dentro del tubo para leer la escala de cálculo que es tipo regla de cálculo.

8) Alinear la temperatura del extremo mojado (wet bulb) con la temperatura del extremo seco (dry bulb) y leer el % de humedad relativa indicada con la flecha en la escala más baja.

Mantenimiento:

1) Mantenga la mecha limpia.
2) Cuando se ensucie córtela y hale unpoco hacia afuera.