# BASELINE DATA ON *AEDES AEGYPTI* POPULATIONS IN SANTO DOMINGO, DOMINICAN REPUBLIC[1]

M. A. TIDWELL,[2] D. C. WILLIAMS,[3] T. CARVALHO TIDWELL,[4] C. J. PEÑA,[2] T. A. GWINN,[3] D. A. FOCKS,[5] A. ZAGLUL[2] AND M. MERCEDES[6]

ABSTRACT. Baseline field studies were conducted from April 1987 to July 1988 on *Aedes aegypti* in Santo Domingo, an endemic area for dengue fever. Premise, container and Breteau indices were measured in one treated area and 2 nearby control areas. These indices averaged 69.6, 46.3 and 142.1, respectively. The principal larval habitats of *Ae. aegypti* were 208-liter (55-gal) concrete-lined drums. The estimated daily adult production was approximately 60 per house. Adult mosquito populations were monitored using oviposition traps and by sweep net collections. There was no correlation between adult abundance and the larval indices. Monitoring the natural adult densities was more efficient for evaluating the impact of ULV malathion application than the use of standard bioassay procedures.

## INTRODUCTION

In April 1987, studies were begun as part of a United States Agency for International Development funded project in collaboration with the Dominican Republic National Malaria Eradication Service to establish baseline data on *Aedes aegypti* (Linn.) and to evaluate the impact of adult and larval control measures in selected areas of Santo Domingo, Dominican Republic.

Santo Domingo, the capital, encompasses approximately 260 km$^2$ and has a population of over 1.6 million inhabitants (64/ha). The climate is tropical with temperatures averaging between 22°C and 28°C, and rainfall averaging 140–150 cm per year (De la Fuente 1975). Rainfall is usually heaviest during May–October. As is common in tropical climates, most houses are open to the outdoors with windows and doors unscreened.

Highest human population densities are found in lower middle and lower class sections of the city. Because many of these areas lack or are irregularly supplied with piped water, 208-liter (55-gal) drums and other types of containers are commonly used to store water. These containers serve as larval habitats for *Ae. aegypti*, the vector of dengue fever in the Dominican Republic. Previous surveys in the Dominican Republic and Haiti (U.S. Department of Health, Education and Welfare 1981) reported high endemicity for dengue fever with antibody rates of approximately 70% in children under 10 years of age. In April 1988, approximately 40% of the blood samples from febrile children in Santo Domingo tested positive and all 4 dengue serotypes were present in the area (Ellen Koenig, SESPAS National Viral Laboratory, Santo Domingo, Dominican Republic, personal communication). Since June 1988, there have been 4 cases of dengue hemorrhagic fever (DHF) with 2 deaths in the Dominican Republic.

In a study designed to gather baseline data on *Ae. aegypti* abundance in Santo Domingo and to evaluate control measures between 1977 and 1980, house (premise) indices ranged from 12 to 49% and Breteau indices from 25 to 724 (Moore and Ganan[7]). Larval abundance was related to the number of water-filled containers. There was a weak negative correlation between rainfall and larval abundance. In 1985 house (premise) indices as high as 100% were reported in some areas adjacent to Santo Domingo (Matute G.[8]).

Peña and Zaglul (1986) collected *Ae. aegypti* throughout Santo Domingo and stated that it was the most widely distributed and commonly collected mosquito (48% of all larvae and adults) in the city. The larvae were taken from all classes of artificial containers and drains as well as from natural pools, holes in coralline rock, tree holes and bromeliads.

*Aedes aegypti* densities have traditionally been estimated indirectly by ovitraps and by the use of the common indices; premise or house (percentage of houses positive for *Ae. aegypti*

---

[1] Supported by USAID Vector Control Project 517-0235.

[2] Vector Control Project AID, Pontificia Universidad Catolica Madre y Maestra, Apartado 822, Santiago, Dominican Republic.

[3] University of South Carolina, International Center for Public Health Research, P.O. Box 699, McClellanville, SC 29458.

[4] Leave of absence from Gerencia de Controle de Vetores, COMLURB, Rio de Janeiro, Brazil.

[5] U.S. Department of Agriculture, Agricultural Research Service, Insects Affecting Man and Animals Research Laboratory, P.O. Box 14565, Gainesville, FL 32604.

[6] Servicio Nacional de Erradicacion de la Malaria, Santo Domingo, Dominican Republic.

[7] Moore, C. G. and N. Ganan. *Aedes aegypti* surveillance and control measures in Santo Domingo, Dominican Republic. Poster presentation at 29th annual meeting of the American Society of Tropical Medicine and Hygiene. Atlanta; 1980 November 4–7.

[8] Matute G., J. V. 1985. Unpublished Pan American Health Organization report.

larvae), container (percentage of water-filled containers that are positive), and Breteau (number of positive containers at 100 premises) (Tinker 1967, Brown 1971, Moore et al. 1978, Chan 1985). The use of these methods for estimating populations is generally due to the impracticality of making time consuming biting collections or labor intensive resting captures (U.S. Department of Health, Education and Welfare 1979, Tinker 1967).

The principal objectives of this preliminary study were: 1) to obtain baseline data on *Ae. aegypti* population dynamics in Santo Domingo, and 2) to develop a practical adult *Ae. aegypti* monitoring system. The latter was particularly important in order to have a reliable method for assessing the impact of ultra low volume insecticide applications and other control methods on the adult mosquitoes. This paper includes baseline data obtained using traditional means of estimating *Ae. aegypti* populations as well as sweep net captures of adults inside the houses.

## DESCRIPTION OF STUDY SITES

Location of the study sites is shown in Fig. 1. Ensanche Espaillat, a lower middle class barrio encompassing ca. 41 ha (100 acres) in the northeast sector of Santo Domingo, was selected as the principal study site. Ensanche Espaillat is representative of many of the older lower middle class barrios of the city and, in addition, initial inspections revealed substantial populations of *Ae. aegypti*. The estimated population density in this area was 435 persons per ha. The majority of the dwellings are single story, cement block construction, although an occasional 2 or 3 story structure may be present. The houses usually have 4 or 5 rooms and occupy approximately 70 $m^2$. This barrio has an average of 6.3 persons per house and 69 houses per ha. Water is provided to this sector several times a week although there may be periods of 1–4 weeks when the piped water is not available and water must be purchased from tank trucks. The small backyards of adjoining houses (Fig. 2) usually have fruit trees or various shrubs. Mejoramiento Social, a nearby barrio with similar characteristics, was selected as the second study site.

A third area, Gualey, contiguous with E. Espaillat was selected for a comparative study of adult densities with selected larval indices. Gualey, a lower class barrio adjacent to the Rio Ozama, is characterized by small (48-$m^2$) wooden/tin shacks. These are densely packed (approximately 174 per ha) (Fig. 3). These shacks are loosely constructed and usually have one access door, few window openings, open eaves and tin roofs. Approximately 6.2 persons reside per house and a rough estimate of the population density for this area is 1,100 persons per ha. Close to the river, few access roads are available; entry into the area is usually by foot. Open sewer ditches cross the area and drain into the river. This barrio is similar to most of the

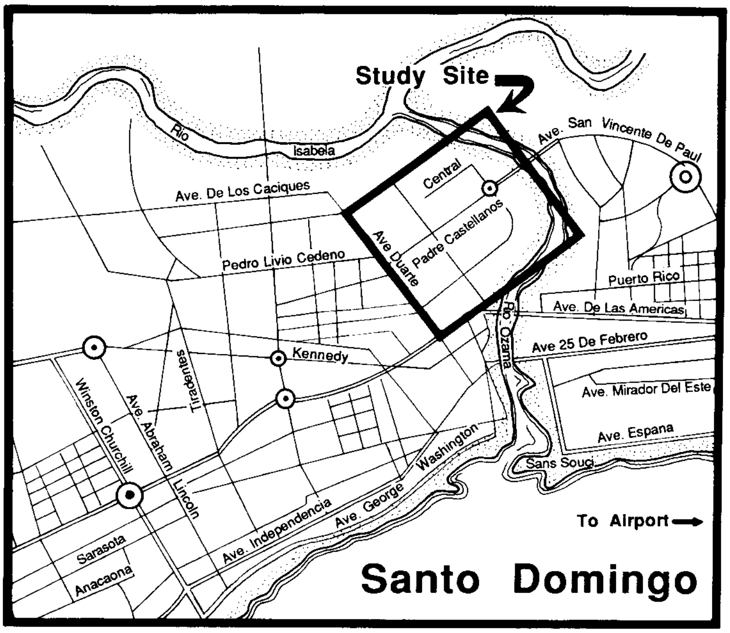


Fig. 1. Map of Santo Domingo, Dominican Republic, with study site indicated.

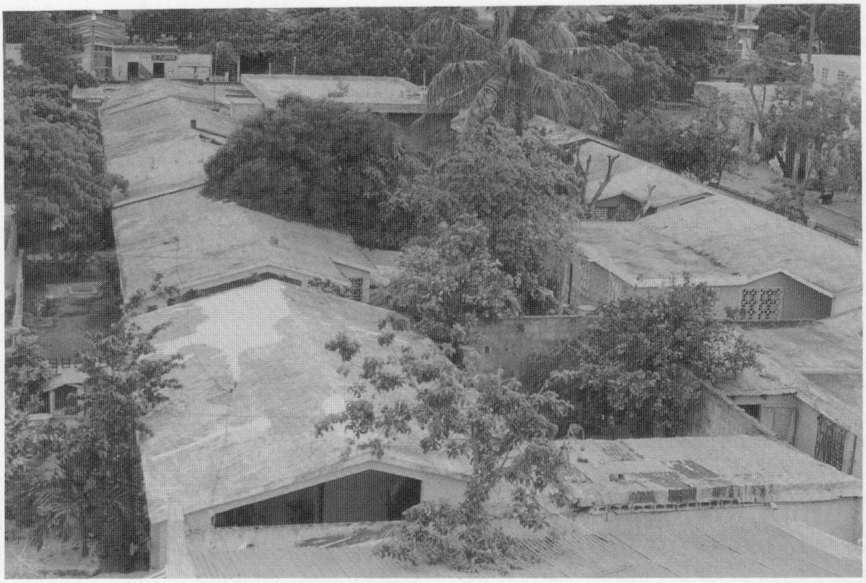

Fig. 2. Aerial view of *Aedes aegypti* study site in Ensanche Espaillat neighborhood in Santo Domingo, Dominican Republic, showing small, heavily vegetated backyards.

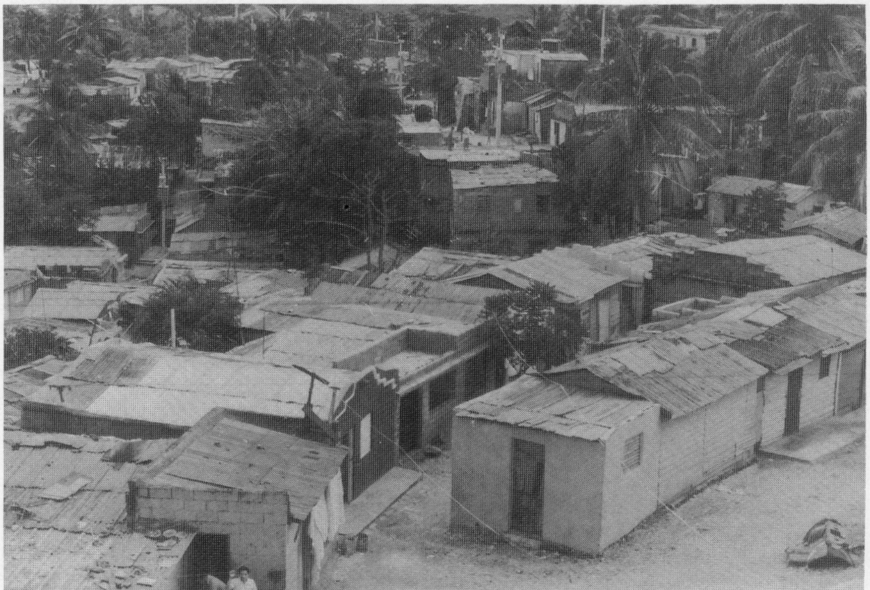

Fig. 3. Aerial view of *Aedes aegypti* study site in the Gualey neighborhood in Santo Domingo, Dominican Republic, showing closely clustered houses and lack of streets.

extensive poorer areas bordering the river on the eastern side of the city.

## MATERIALS AND METHODS

To determine premise, container and Breteau indices, 100 houses were selected at random from a 6-block zone in the center of a 24-block test area in both E. Espaillat and M. Social. Because Gualey lacked streets, 100 houses from the central portion of the barrio were selected at random. All potential mosquito-producing containers with water were categorized and those positive for *Ae. aegypti* immatures were recorded. Containers that were emptied on a daily basis such as kitchen and bath receptacles, etc., were not included. To determine the level of mosquito productivity in various breeding habitats, all water was removed from 15 containers on each of 3 days in 1988 (May 13, August 11 and 17) and the total number of immatures was recorded. These containers were located on randomly selected premises in E. Espaillat.

Twenty-five of 100 houses were selected at random for weekly monitoring of adult densities and as sites for 1-liter ovitraps (1 per house, filled and maintained from a single water source). Collections began at approximately 0900 h and terminated by noon. Adults were collected by 2 men working together in tandem, one using a 6-volt, hand-held mechanical aspirator and the other a 12-inch sweep net, or both using nets. They collected continuously for 5 min throughout the house—under tables, chairs, beds, in closets, etc. All male and feamle *Ae. aegypti* and *Culex* mosquitoes were recorded. The average number of female *Ae. aegypti* collected during 10 man-minutes (2 men × 5 min each) at each of the 25 houses represents the female density index. This index was then compared to the house, container and Breteau indices, from all 3 study areas on 3 separate dates. In addition to the female density index, an adult positive house index was used to indicate the percentage of houses positive for adult *Ae. aegypti*. Statistical analyses (SAS Institute Inc. 1985) were conducted to determine if adult density indices were correlated with larval indices.

Rainfall data for Santo Domingo was provided by the national weather service. Regression analyses of the various indices and ovitrap collections on rainfall were conducted.

## RESULTS

A summary of the container information for the 3 study areas is provided in Table 1. Surveys of water holding containers in the 3 study areas revealed differences in the types and proportions of receptacles present. In all 3 areas, essential water storage containers—drums, smaller tanks, and to a lesser extent basins and cisterns—were the most numerous. These represented 68% of all positive larval habitats for *Ae. aegypti*. Cement, metal and plastic drums with a holding capacity of approximately 76–208 liters (20–55 gal) represented 51% of the potential breeding sites and 55 to 64% of these were positive. Outdoor containers were more numerous than those found indoors except in the categories of flower vases, buckets and earthen jars. In the poorer barrio, Gualey, no water basins or cisterns were encountered. There were, however, greater proportions of earthen jars (< 4 liters and small containers).

From the 45 containers examined (3 collections of 15 containers each), 28,615 immatures were recorded: first and second instars represented approximately 44%, third and fourth instars, 47%, and pupae 9%. The pupal density index (mean number of *Ae. aegypti* pupae per house) was 127 and the larval density index (mean number of larvae per house) was 1,379.

The average number of immatures found in 30 drums (unlined and concrete-lined) was 807. However, the highest number of immatures in a concrete-lined drum was 1,943 and the highest number of pupae was 417. The average number of immatures for 6 containers holding 38 liters (10 gal) or less was 263. The average number of immatures from 5 positive tires was 206.

Table 1. Prevalence of container types indoors and outdoors with corresponding percent positivity for *Aedes aegypti* immatures in 3 barrios of Santo Domingo, Dominican Republic (April 1987, February and June 1988).[1]

| | Drums | | Flower vases | | Small container | | Buckets | | Earthen jars | | Water basins | | Cisterns | | Tires | | Others | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area (Site) | No. | % pos | No. | % pos | No. | % pos | No. | % pos | No. | % pos | No. | % pos | No. | % pos | No. | % pos | No. | % pos |
| Espaillat | 630 | 55.1 | 236 | 49.6 | 112 | 44.6 | 98 | 13.3 | 11 | 36.4 | 56 | 41.1 | 110 | 30.0 | 68 | 39.7 | 52 | 25.0 |
| (indoor) | 78 | 38.5 | 218 | 49.5 | 4 | 25.0 | 52 | 3.8 | 0 | — | 0 | — | 5 | 40.0 | 4 | 25.0 | 2 | 50.0 |
| (outdoor) | 552 | 57.4 | 18 | 50.0 | 108 | 45.4 | 46 | 23.9 | 11 | 36.4 | 56 | 41.1 | 105 | 29.5 | 64 | 40.6 | 50 | 24.0 |
| M. Social | 484 | 55.4 | 168 | 38.1 | 45 | 60.0 | 53 | 18.9 | 5 | 40.0 | 14 | 42.9 | 17 | 35.3 | 29 | 41.4 | 9 | 11.1 |
| (indoor | 89 | 51.7 | 152 | 35.5 | 5 | 20.0 | 21 | 38.1 | 4 | 25.0 | 0 | — | 0 | — | 0 | — | 0 | — |
| (outdoor) | 395 | 56.2 | 16 | 62.5 | 40 | 65.0 | 32 | 6.3 | 1 | 100 | 14 | 42.9 | 17 | 35.3 | 29 | 41.4 | 9 | 11.1 |
| Gualey | 175 | 64.0 | 34 | 44.1 | 68 | 26.5 | 41 | 12.2 | 22 | 36.4 | 0 | — | 0 | — | 9 | 44.4 | 7 | 85.7 |
| (indoor) | 67 | 62.7 | 30 | 43.3 | 33 | 18.2 | 34 | 11.8 | 22 | 36.4 | 0 | — | 0 | — | 3 | 0.0 | 4 | 75.0 |
| (outdoor) | 108 | 64.8 | 4 | 50.0 | 35 | 34.3 | 7 | 14.3 | 0 | — | 0 | — | 0 | — | 6 | 66.7 | 3 | 100 |
| Total | 1289 | 56.4 | 438 | 44.7 | 225 | 42.2 | 192 | 14.6 | 38 | 31.6 | 70 | 41.4 | 127 | 30.7 | 106 | 38.7 | 68 | 29.4 |
| (indoor) | 234 | 50.4 | 400 | 43.8 | 42 | 19.0 | 107 | 13.1 | 26 | 34.6 | 0 | — | 5 | 40.0 | 4 | 25.0 | 6 | 66.7 |
| (outdoor) | 1055 | 57.7 | 38 | 55.3 | 183 | 47.5 | 85 | 16.5 | 12 | 41.7 | 70 | 41.4 | 122 | 30.3 | 102 | 41.2 | 62 | 25.8 |

[1] Tabular data from Espaillat, M. Social and Gualey are the result of 382 premises inspected in 6 surveys, 215 premises in 3 surveys, and 225 premises in 3 surveys, respectively.

In the productive, concrete-lined drums the pupae generally appeared to be of normal size. However, in one drum (not included in these data), which had the only mixed colony (approximately 2,500 immatures) of *Aedes* and *Culex*, the emerged male and female *Ae. aegypti* were abnormally small and approximately 10% could pass through the 16 × 18 mesh of a standard collapsible mosquito cage.

In a comparison of the house, container and Breteau indices with the average number of females per house (female density index), only the container indices were similar among the 3 barrios on the 3 dates (Fig. 4). The female density index increased in all 3 areas and varied from a low of 1.72 (Gualey) to a high of 9.43 (E. Espaillat). The adult positive house index recorded at the same time revealed an increase in the percentage of positive houses in E. Espaillat from 88 to 100% and in M. Social from 96 to 100%. In Gualey this percentage, 92%, remained constant.

The average number of female *Ae. aegypti* per house for all collection dates in E. Espaillat was 4.0 ± 6.8 (range 0–134) with most individual collections containing 1 or 2 female mosquitoes. With 107 collection dates between April 1987 and July 1988, the female density index per collection date varied from 1.22 to 15.04. The highest number of male *Ae. aegypti* recorded for a house in E. Espaillat was 77 with an average of 3.8 ± 6.0 (range 0-77). From 148 house collections in Gualey, the highest number of *Ae. aegypti* females taken from a single dwelling was 16. In some houses in E. Espaillat and M. Social, however, high populations of mosquitoes (>20 per collection) were present one or more times. From 2,153 house collections in E. Espaillat and M. Social, 53 samples (2.5% of all samples) from 18 houses had >20 female *Ae. aegypti*. Collections of >20 females were made on 2 or more occasions from 9 "mosquitogenic" houses and, in one house, 14 collections were made each having more than 20 mosquitoes. As many as 134 females were collected from a single dwelling. *Culex quinquefasciatus* Say were also readily collected: the highest number of females and males collected from a single house using sweep nets was 68 and 39, respectively. The average numbers of females and males collected per house per collection date and area were 3.2 ± 4.8 (range 0–68) and 3.0 ± 4.3 (range 0–39), respectively.

There were no significant relationships between adult densities and any of the 3 indices (Kendall correlation coefficients for adult densities with premise, container and Breteau indices were 0.36, 0.07 and 0.14, respectively).

Ovitrap collections were made in E. Espaillat from April 1987 to July 1988 (except for July 1987 and March, April 1988). During this period the average number of eggs collected per ovitrap per day was 12.9 ± 23.5 with daily trap collections ranging from 0 to 210. During all collections >50% of paddles were positive. Statistical analyses were conducted to determine if monthly average female density indices (1,600 samples) were correlated with monthly averages of the number of eggs per ovitrap per day (1,760 samples) and if individual premise female densities were correlated with number of eggs per ovitrap per day from the same premises (249 samples). Analyses revealed no significant correlations between egg numbers and adult collections either on a monthly average basis or a daily basis (Kendall correlation coefficients were 0.06 and 0.04, respectively).

Average daily rainfall per month in Santo Domingo ranged from 0.51 mm in July 1988 to 14.27 mm in December 1987 (an unusually wet December). Regression analysis of the different immature indices on rainfall accumulated 8 days prior to assessing the indices (based on the observed field development time of the larvae plus pupae, the number of days of rain which would contribute to the presence of immature *Ae. aegypti* on the date the indices were taken) indicated that rainfall did not explain a significant amount of the variations in the premise, container or Breteau indices ($r^2 = 0.19$, 0.25 and 0.14, respectively). Regression of average monthly adult density indices on average daily rainfall per month also indicated that rainfall failed to explain a significant portion of the monthly variations of adult densities ($r^2 = 0.02$).

## DISCUSSION

Drums, tanks and other essential water holding containers were the principal breeding habitats in the lower middle class and lower class areas where the water supply is inadequate. In middle and upper class areas other methods of water storage are more frequently employed when necessary, such as the use of cisterns and closed pressurized systems. While an occasional barrel may be found in these areas, preliminary surveys revealed that water-filled flower vases, tires and other small, usually nonessential water holding containers were the most frequently encountered larval habitats of *Ae. aegypti.*

The concrete tanks, which are usually metal drums lined with cement as rust hole leaks develop, represent a special problem. In addition to being numerous and uncovered, they are also much heavier than the original metal drums. Consequently, they cannot be dumped easily for draining or cleaning. Thus they retain at least some water and presumably offer a nearly continuous oviposition site. Also associated with the

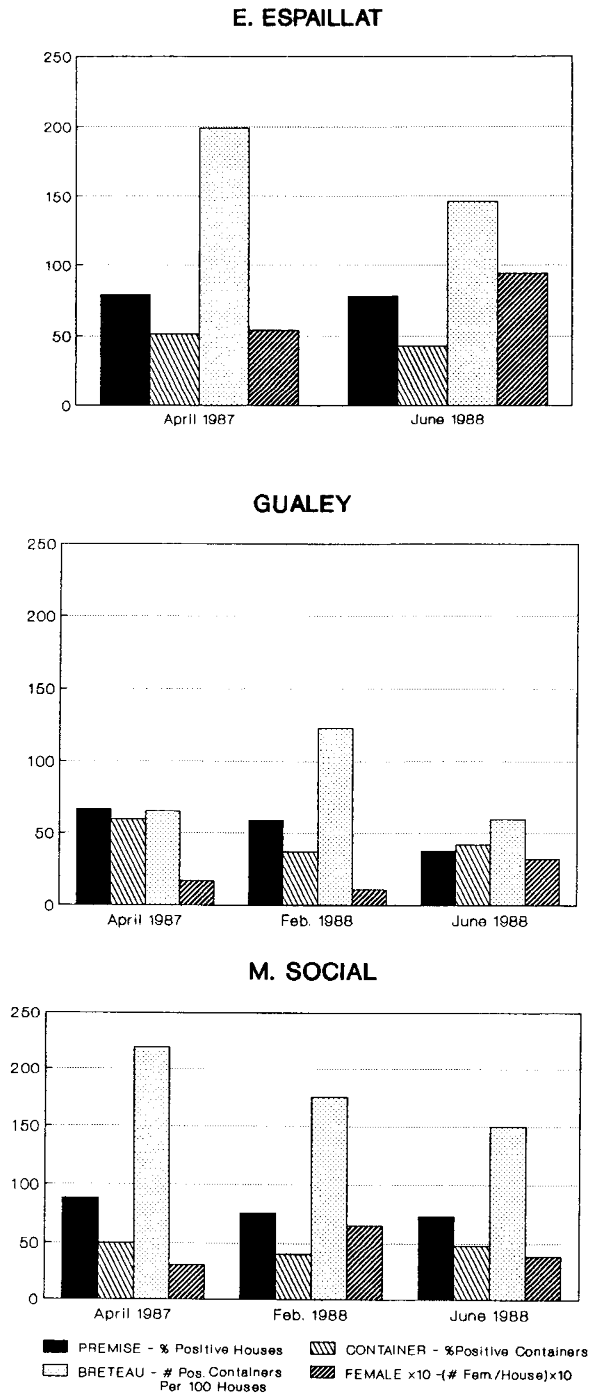


Fig. 4. Larval and adult *Aedes aegypti* indices from the barrios of Ensanche Espaillat, Gualey and Mejoramiento Social, Santo Domingo, Dominican Republic (April 1987 and June 1988).

uncleaned drums is an accumulating 0.5-5 cm layer of decomposing organic debris—a nutrient-enriched culture for the development of bacteria, fungi, algae, protozoa and other organisms which serve as larval food (Riviere 1985). It is possible that the rough, porous concrete surface provides a good substrate for microorganisms which serve as food for the mosquito larvae. This would help explain the larger proportion of pupae (with subsequent adults) recorded from concrete containers. These concrete tanks not only had high productivity but also the highest positivity rates—up to 77% contained immatures of *Ae. aegypti.*

Preliminary estimates of adult productivity were based on pupal counts made during the *Ae. aegypti* immature census of 45 containers from 19 premises in E. Espaillat. A pupal density index of 127 pupae was obtained using the counts from all positive containers. Of 280 randomly collected pupae from 5 containers, 97% emerged. Assuming that roughly ½ of the 127 pupae emerge as adults each day (observed pupal development time was 48 h), it is estimated that approximately 60 mosquitoes, or 30 females, were produced per premise per day in E. Espaillat with 83% of these coming from the drums. It is estimated that approximately 6,240 *Ae. aegypti* adults were produced daily from a 3-block area of this barrio or approximately 4,140 mosquitoes per hectare. With an average of 6.3 persons per house and 69 houses per ha it is estimated that approximately 10 mosquitoes are produced daily for each person in the barrio.

Analyses of the results of surveys conducted in April 1987 and June 1988 in the 3 barrios demonstrated no significant correlations between the female density index and any of the 3 larval indices (Fig. 4). While the larval indices declined in June, there was an increase in the female density index. There was also an increase in the positive house index, except in Gualey which remained at 92%. Although there was a reduction in the overall number of positive containers, there was an increase in the total number of positive barrels per house in E. Espaillat. The number of positive barrels per house remained essentially unchanged in the other 2 areas. The decrease in nonessential water storage containers was associated with a 2-month period of reduced, scattered rainfall when the average monthly precipitation was approximately 60 mm. While the largest increase in the June 1988 female density index occurred in E. Espaillat and might be attributed, at least in part, to the increase in positive drums, the increase in the female densities in the other 2 areas is not as readily explained.

Moore et al. (1978) reported high correlations between seasonal rainfall and larval density indices reflecting the importance of rain-filled containers, relative to the number of essential or deliberately filled water storage containers, in more affluent Puerto Rico. During the current study in the Dominican Republic, there were periods without rainfall lasting from a few weeks to several months and no significant relationship was shown between rain and adult *Ae. aegypti* densities. This is probably due to the mosquito production from the essential water storage containers masking the rain associated production (Tonn et al. 1969, Yasuno and Tonn 1970).

These data demonstrate the difficulty in estimating adult populations based on the premise, container or Breteau larval indices. It is suggested that if adult populations cannot be sampled directly then container productivity and the pupal density index would be better indicators of population fluctuations especially when obtained at regular intervals during the season. While pupal production may be variable depending on availability of larval food and other factors, repeated weekly samples will help clarify population estimates.

For adult monitoring, Fox and Specht (1988) suggested that 5-min landing counts by observation may be practical for evaluating the presence of *Ae. aegypti* in areas of high mosquito density. In their study, however, adult monitoring was confined to only one site with 2 stations approximately 3 m apart and may not have accurately reflected population variations from different habitats in other parts of their study area (Morris 1960).

In the current study, the indoor use of the 2-man sweep net technique at 25 randomly dispersed collecting sites in an area, provided an efficient monitoring system for both *Ae. aegypti* and *Cx. quinquefasciatus.* Using this system, variation between areas, as well as variation between houses or months, could be detected. In addition, monitoring adult populations before and after ULV adulticide applications revealed that a reduction in the natural *Ae. aegypti* populations could be readily detected using the sweep net technique. While there was no significant difference in the results obtained using either the small hand aspirator or the sweep net (based on a $t$-test, $P < 0.01$, comparing side by side samples using aspirator and sweep net), the net was preferred for its economy since it did not require the constant replacement of batteries.

It was noted that some houses had much higher populations of *Ae. aegypti* females (>20 adult females per collection) than other similar types of houses. During the course of 91 surveys in E. Espaillat and M. Social, approximately 36% of the sample houses had at least one collection with more than 20 *Ae. aegypti* females and 18% of the houses had 2 or more of these high collections. One house had 134 females netted in 10 min. These "mosquitogenic" houses generally do not share any obvious characteristics such as proximity to each other, special construction, number of inhabitants, or highly productive breeding sites on or adjacent to the premises that might account for the increased populations. The ecology of such houses and their contribution to disease transmission warrant further study.

In Gualey, as mentioned above, the houses were of a different construction, less substantial and smaller. In addition they had 14% fewer barrels than the other 2 areas. It is possible that these factors contributed to the relatively low *Ae. aegypti* densities as well as the lack of high density mosquito houses noted during the 148 collections in this barrio.

In a comprehensive 3-year study on the adjacent island of Puerto Rico, Moore et al. (1978) examined 21,306 premises for larval breeding, reporting that the average premise, container and Breteau indices were approximately 17, 9 and 26, respectively. In the 3-year period these authors noted that an increase in dengue transmission occurred when the average Breteau indices rose above 20. This corresponds to a density figure of 4 on the scale of 1–9 developed by Brown (1971).

During the current study in both E. Espaillat and M. Social, the premise, container and Breteau indices were at times approximately 80, 50 and 200 or higher, which would correspond to a density figure of 9. This is the highest category on the scale; as such, it could lead to high adult densities with the potential for substantial transmission of dengue. With open houses and contiguous small shaded back yard areas, mosquito dispersal among dwellings can readily occur. This could facilitate dissemination of dengue virus throughout the area.

High *Ae. aegypti* densities are found throughout the Dominican Republic. *Aedes aegypti* was approximately twice as numerous as other species (mainly *Cx. quinquefasciatus*) collected from the houses in M. Social and E. Espaillat, while *Cx. quinquefasciatus* was more commonly collected in Gualey. The lack of adequate waste disposal and the open sewer ditches found in this area help provide the high *Culex* populations.

Portions of E. Espaillat and M. Social were included in 1978 and 1979 larval surveys made by CDC and SNEM staff. During these surveys the house indices in these areas ranged from approximately 30 to 40% (C. G. Moore, Centers for Disease Control, Fort Collins, CO, personal communication). Since that time a deterioration of the piped water system (T. Santana, SNEM, personal communication) and the increasing use of open containers to store water have contributed substantially to an increase in mosquito populations in these as well as other areas of Santo Domingo.

*Aedes aegypti* control programs have operated in Santo Domingo (Cabrera 1979), but due to political and economic constraints they have not been continued. In view of the high population densities of *Ae. aegypti*, the endemicity of all 4 dengue serotypes, and the continuing use of essential water storage containers, it is probable that Santo Domingo will experience a serious epidemic of dengue with increased incidence of dengue hemorrhagic fever. Considering this impending threat and the limited resources available for vector control, it is suggested that community education and participation programs directed toward reducing mosquito populations be strongly encouraged.

## ACKNOWLEDGMENTS

The authors would like to thank the following people for suggestions, assistance in carrying out these studies and/or reviewing the manuscript: Yilma Mekuria, David Mandeville, Margaret Tidwell, Richard Darsie, Gary Ross, Robert Tonn, Allen Wooldridge, Dan Haile, Oscar Fultz, Chester Moore, Gary Clark, Paul Reiter, Ray Parsons, Fernando Agudelo, SNEM personnel (Junior Felix, Rogaciones Germán, Teófilo Santana, Gaurín Tolentino, Juan Rodriguez, Beato Fermín) and the Dominican Republic National Meterological Service (Rosa Sanchez and Cocco Quezada).

## REFERENCES CITED

Brown, A. W. A. 1971. World wide surveillance of *Aedes aegypti*. Pap. Proc. Calif. Mosq. Control Assoc. 42:20–25.

Cabrera, F. 1979. Observations on dengue endemicity in the Dominican Republic, pp. 44–45. *In:* Dengue in the Caribbean, 1977. Scientific Pub. 375. Pan American Health Organization, Washington, DC.

Chan, K. L. 1985. Methods and indices used in the surveillance of dengue vectors. Mosq.-Borne Disease Bul. 1:79–88.

De la Fuente G., S. 1975. Geografia Dominicana S. de la Fuente G., Santo Domingo, Dominican Republic.

Fox, I. and P. Specht. 1988. Evaluating ultra-low volume ground applications of malathion against *Aedes aegypti* using landing counts in Puerto Rico, 1980–1984. J. Am. Mosq. Control Assoc. 4:163–167.

Moore, C. G., B. L. Cline, E. Ruiz-Tiben, D. Lee, H. Romney-Joseph and E. Rivera-Correra. 1978. *Aedes aegypti* in Puerto Rico: environmental determinants of larval abundance and relation to dengue virus transmission. Am. J. Trop. Med. Hyg. 27:1225–1231.

Morris, R. F. 1960. Sampling insect populations. Annu. Rev. Entomol. 5:243–264.

Peña, C. J. and A. Zaglul. 1986. Los mosquitos de la Ciudad de Santo Domingo. Ciencia y Sociedad 11:176–187.

Riviere, F. 1985. Effects of two predators on community composition and biological control of *Aedes aegypti* and *Aedes polynesiensis*, pp. 121–135. *In:* L. P. Lounibos, J. R. Rey, and J. H. Frank (eds.), Ecology of mosquitoes: proceedings of a workshop.

Florida Medical Entomology Laboratory, Vero Beach, FL.

SAS Institute Inc. 1985. SAS users guide: statistics, version 5 edition. Cary, NC.

Tinker, M. E. 1967. Measurement of *Aedes aegypti* populations. J. Econ. Entomol. 60:634–637.

Tonn, R. J., P. M. Sheppard, W. W. McDonald and Y. H. Bang. 1969. Replicate surveys of larval habitats of *Aedes aegypti* in relation to dengue hemorrhagic fever in Bangkok, Thailand. Bull. W. H. O. 40:819–829.

U.S. Department of Health, Education and Welfare, Public Health Service, Centers for Disease Control. 1979. Biology and control of *Aedes aegypti*. Vector Topics No. 4, 39 pp.

U.S. Department of Health, Education and Welfare, Public Health Service, Centers for Disease Control. 1981. Dengue surveillance, reference and research 1981 report. 12 pp.

Yasuno, M. and R. J. Tonn. 1970. A study of biting habits of *Aedes aegypti* in Bangkok, Thailand. Bull. W. H. O. 43:319–325.