EVALUATION OF ULTRA-LOW VOLUME AERIAL AND GROUND APPLICATIONS OF MALATHION AGAINST NATURAL POPULATIONS OF *AEDES AEGYPTI* IN PUERTO RICO

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ABSTRACT. Malathion ULV applied by airplane over the city of San Juan, Puerto Rico in 1978 was ineffective against *Aedes aegypti* as shown by the percentage of infested cement vases and the number of larvae and pupae in a large cemetery before and after treatment. Malathion ULV applied by LECO Fog Generators mounted on vehicles was also ineffective in 1979 against adults as shown by landing counts in a residential area before and after several treatments. The number of cases of dengue reported in 1977 and 1978 are listed with reasons for not giving much weight to such data in evaluating *Ae. aegypti* control programs in Puerto Rico.

Puerto Rico suffered an epidemic of dengue in 1977 and again in 1978 with many cases in San Juan and vicinity. To control *Aedes aegypti*, the Puerto Rico Department of Health, advised by the U.S. Public Health Service, maintained an intensive program of adulticiding with malathion ULV for the past 2 years. The city of San Juan was sprayed from the air in the fall of 1977, and again in the spring of 1978, and the air-sprays were supplemented by frequent ULV ground applications from truck-mounted dispensers.

Space-spraying against adult mosquitoes has been tried in the past in Puerto Rico, but if evaluations were made, they were not documented. Various papers indicate that aerial malathion ULV may be effective against *Ae. aegypti* in exotic places, but these reports deal with experiments, not complete evaluations. Authors differ in regard to the effect of aerial malathion ULV on immature stages: some indicate "little or no effect" (Anonymous 1977), while others claim a "continuous and substantial decline" in larval infestations (Eliason et al. 1970). Strickman (1979) evaluated malathion ULV from truck-mounted dispensers against 2 species of *Culex* and reported a reduction of about 50% during the night of treatment but subsequently no effect. I have found no published data on the effectiveness of this technique against natural populations of *Ae. aegypti*.

The purpose of this research was to ascertain (a) in 1978 the effect of the aerial and ground applications of malathion ULV on a segment of the natural population of *Ae. aegypti* represented by larvae and pupae in an area with many breeding places in the city of San Juan, and (b) in 1979 the effect of malathion ULV applied from truck-mounted dispensers against a segment of the natural population of adults in a residential section of the city.

MATERIALS AND METHODS

STUDY OF LARVAE AND PUPAE. The studies were made before and after the air-spray program of 1978, when a commercial firm, directed by federal and local public health officials, completed 3 cycles of repeated applications of malathion ULV over San Juan (Chiriboga 1978). For 3 months after the air-spray, P.R. Department of Health personnel applied malathion ULV near the study area at least once per month using newly purchased truck-mounted LECO Model HD ULV Fog Generators (Lowndes Engineering Co., Inc., Valdosta, Georgia 31601) dispensing malathion 96% at 2 gals/hr. The study area was a large cemet-

ery, the "Cementerio San José," centrally located in the city of San Juan in the section known as Villa Palmeras, Santurce (Fig. 1), where for many years the numerous cement vases (Fig. 2) have provided excellent *Ae. aegypti* breeding places (Fox 1975). Only those vases which could be lifted from the tomb and emptied into a pan were included in the study. When many specimens were present the entire contents of the vases were transported in cardboard containers to the laboratory for the count of larvae and pupae. If few specimens were present, the count was made on the spot. Each collection was from a different vase, accomplished by noting the name on the tomb and numbering the vases. Making collections weekly, I obtained data on the percentage of vases infested and the numbers of *Ae. aegypti* larvae and pupae present before treatment, and compared these data with those obtained during 3 months after treatment. A period of about one month prior to the air-spray operations, which ended June 16, 1978, was designated the Prespray period while the months afterwards were designated Spray + 1, Spray + 2, and Spray + 3.

Fig. 1. Map of the city of San Juan, Puerto Rico including Old San Juan, Santurce, and Rio Piedras to show the location of the "Cementerio San José" in Villa Palmeras, Santurce (black square) and the landing count site in Ocean Park, Santurce (black circle).

STUDY OF ADULTS. During the period of the study of adults, June 22 to July 17, 1979, the LECO fog generators sprayed the study area 5 times at intervals of 4 to 7 days. The study area was in the residential section of Santurce known as Ocean Park, which lies along the north coast about a mile from the "Cementerio San José" (Fig. 1). The specific landing count site was in the back patio of a house on a street where the LECO fog generators passed about 57 ft away. Here *Ae. aegypti* occurred about 6 in above the ground at the base of some banana plants, in the shade with no wind. A stand of ornamental plants as well as part of the house obstructed the way between the street and the site. Other places in the patio had adults, but no larvae were breeding there. I counted the number of mosquitoes landing on the bare legs and feet each day at about 5:00 pm over a 5 min period. The mosquitoes were easily disturbed by any movement leaving after a few seconds, and although the same ones may have landed several times, each landing was counted separately. At each session I collected a specimen by capturing it in a vial, and identified it under the microscope in the laboratory. The dates and times of the fogging were: June 22, 8:00 pm; June 26, 8:00 pm; July 4, 8:25 pm;

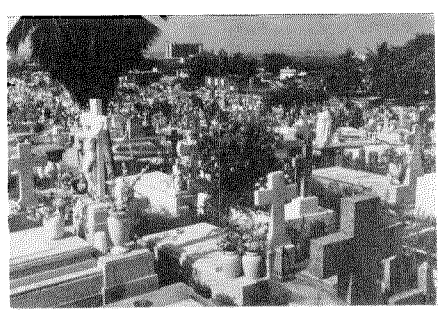

Fig. 2. The "Cementerio San José" in San Juan, Puerto Rico where the cement flower vases (left, foreground) provide abundant breeding places for *Aedes aegypti*.

July 7, 9:05 pm; and July 13, 1979, 7:15 pm. Landing counts were recorded before each fogging and on each of 4 days after each treatment.

RESULTS

The study of the larvae and pupae showed that 81% of the cement vases were infested with larvae and pupae in the prespray periods (Table 1). Chi-

Table 1. Percentage of cement vases with *Ae. aegypti* larvae and pupae in San Juan, PR before and after malathion ULV aerial sprays, 1978.

Month	No. of vases	Percent with larvae	Percent with pupae	Percent with larvae or pupae
Prespray	16	69	56	81
Spray + 1	28	75	50	75
Spray + 2	15	80	40	80
Spray + 3	21	76	33	76

square analyses of these data proved no significant difference ($P = 0.05$) in any comparison of infestation with larvae or pupae, with larvae alone, or with pupae alone, between the period before the air-spray and each of the periods after treatment. Table 2 indicates that the numbers of larvae and pupae did not decline after the air-spray, rather there was an increase in the average numbers of larvae and pupae per vase in the postspray periods, and there was also a significant increase in the number of larvae compared with the number of pupae.

The results of the landing counts are shown in Table 3. On the 1st day after each treatment (except No. 5) the landing count increased; on the 2nd day a slight reduction occurred, but by the 3rd or 4th days after treatment the landing counts were greater than before the treatments. The average of the 5 landing counts was slightly less on the 1st and 2nd days than the pretreatment count, the same on the 3rd day, and exceeded the pretreatment count on the 4th day. While making the landing counts shown in Table 3 and on other occasions I collected 32 specimens, all *Ae. aegypti*, of which 12 were males and 20 were females.

Table 3. Numbers of *Ae. aegypti* mosquitoes landing on a human for a period of 5 min before treatment (Day 0) and each of 4 days after treatment with ground malathion ULV fogging in San Juan, PR, 1979.

	Days after treatment				
Treatment	0	1	2	3	4
1	7	8	5	ND	8
2	8	11	7	1	20
3	10	ND	8	15	19
4	15	19	10	10	21
5	20	2	18	23	18
Avg.	12	10	10	12	17

ND = Not done due to rain.

DISCUSSION

The results of the studies on larvae and pupae suggest that the aerial and ground malathion spraying program of 1978 was not effective. There was no decline in the percent of infested breeding places in a large area in the center of the city of San Juan after a thorough spraying from the air, nor did a decline occur during a postspray period of 3 months when frequent ground applications of malathion ULV were made. The increase in the av-

Table 2. Density of *Ae. aegypti* larvae and pupae in cement vases before and after malathion ULV aerial sprays in San Juan, PR, 1978.

Month	No. of vases	No. of larvae	No. of pupae	Total	Average no./vase
Prespray	16	421	69	490	31
Spray + 1	28	1180	148	1328	47
Spray + 2	15	1627	72	1699	113
Spray + 3	21	1598	218	1816	86

erage number of larvae during the postspray period as compared with the prespray period indicates that a flourishing adult population existed with many females ovipositing continuously.

The studies on adults indicated that malathion ULV applied by generators on vehicles in the street were also ineffective against *Ae. aegypti* in back patios of houses. Aerial and ground ULV spraying seem to be unsuitable technologies for the conditions in Puerto Rico. It is not likely that the insecticide could reach in sufficient concentration the adult mosquitoes close to the ground in habitats protected by plants. Nevertheless, the evidence given here shows only that adulticiding with malathion ULV is ineffective; it is possible that some other insecticide would be effective. Control failure with malathion may have been due to resistance (Fox 1973).

In evaluating *Ae. aegypti* control programs in Puerto Rico it is unwise to give much weight to declines in the reported cases of dengue (Table 4). Since many more cases occurred than were reported, the true incidence of the disease was uncertain. The 1977 epidemic was caused by dengue virus type-2 and type-3, but that of 1978 was due to dengue type-1, therefore, immunity may have been more important than abundance of the vector. In spite of the fact that *Ae. aegypti* is continuously present in great numbers, severe outbreaks of dengue are rare in the city of San Juan. Peaks and recessions in the disease must be due to factors additional to the abundance of the vector. For example, in March through September, 1973, 86% of 113 cement vases studied in the "Cementerio San José" were infested with *Ae. aegypti* but no case of dengue was reported from the city of San Juan during the entire year. In 1978, however, during the same period, 77% of 90 vases were infested and more than 2,000 dengue cases were reported.

Table 4. The number of cases of dengue reported from Puerto Rico as a whole (P.R.) including those from San Juan and vicinity (S.J.) in 1977 and in 1978.[a]

	1977		1978	
Month	P.R.	S.J.	P.R.	S.J.
January	17	5	160	35
February	25	2	167	42
March	23	17	119	30
April	22	14	297	64
May	16	8	912	312
June	36	10	3,883	1,452
July	63	37	2,823	605
August	927	232	1,421	236
September	4,696	1,493	919	176
October	4,422	933	745	130
November	1,072	196	467	72
December	547	92	276	75
Total	11,882	3,039	12,189	3,229

[a] Source, *Informe Epidemiologico*, Puerto Rico Department of Health, Vol. 3 (1977) and Vol. 4 (1978). Population estimate: P.R., 1977, 3,319,200; 1978, 3,357,800. S.J., 1977, 975,600; 1978, 987,200.

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References Cited

Anonymous. 1977. Control of dengue. Vector Topics, No. 2, 39 pp., U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, Bureau of Tropical Diseases, Vector Biology and Control Division, Atlanta, Georgia 30333.

Chiriboga, J. 1978. Follow-up on outbreak of dengue-Puerto Rico, 1978. Mortality and Morbidity Weekly Report 27:225.

Eliason, D. A., J. W. Kilpatrick and M. F. Babbitt. 1970. Evaluation of the effectiveness of ultra low volume aerial application of insecticides against *Aedes aegypti* (L.) in Florida. Mosquito News 30:430–436.

Fox, I. 1973. Malathion resistance in *Aedes aegypti* from pressure on adults. Mosquito News 33:161–164.

Fox, I. 1975. *Aedes aegypti* reared from dry artificial habitats during drought in Puerto Rico in 1974. Mosquito News 35:202–203.

Strickman, D. 1979. Malathion as ground-applied ULV evaluated against natural populations of *Culex pipiens* and *Cx. restuans*. Mosquito News 39:64–67.