RESULTS OF SPRAYING WITH ULTRA-LOW-VOLUME MALATHION AT GROUND LEVEL IN PANAMA CITY[1]

Gilberto Echevers,[2] Milton Moura Lima,[3] Rafael Miranda Franco,[3] and Lelio B. Calheiros[3]

Several ultra-low-volume (ULV) sprayings of technical malathion (95 per cent) were carried out in Panama City. Their purpose was to find out how useful this ULV technique could be in helping to combat local mosquitoes, especially Aedes aegypti. *The results strongly indicate that thrice-weekly ground-level spraying of this kind can serve as a highly effective mosquito control measure.*

Introduction

In late 1973 the Ministry of Health of Panama, concerned about *Aedes aegypti* reinfestation of Panama City and an equine encephalitis outbreak near the capital, acquired two LECO cold aerosol generators (Model HD)[4] for spraying insecticides at ultra-low-volume (ULV). These were first used in February 1974, during an outbreak of jungle yellow fever in a region about 100 kilometers east of Panama City. To evaluate their effectiveness, trials were conducted in various parts of the city. This report describes the results of those trials.

Materials and Methods

Two residential zones were selected for testing purposes. One of these was an area in the San Francisco district near the shoreline of the Bay of Panama that contains many single-family dwellings and few high buildings. The other was El Cangrejo, a district situated some distance from the bay that is occupied primarily by high-rise apartments and several luxury hotels.

Spraying Procedures

The insecticide (technical malathion, 95 per cent) was sprayed at a rate of 90 ml per minute by one of the LECO generators mounted on a light truck moving at 16 km per hour (see photo). The nozzle was pointed toward the houses and upward at an angle of 45°. Spraying runs, made in the morning and late afternoon, entailed circling each block of the area to be treated. During these runs the temperature ranged from a high of 32° C (89.6° F) during a morning run to a low of 25° C (77° F) at the end of an afternoon run. There was little wind in El Cangrejo, but a light breeze (12-19 km per hour) prevailed in the San Francisco area.

Two types of trials were carried out in the San Francisco area, each of which involved only one application of insecticide. The first was designed to test the effect of ULV spraying on mosquitoes infesting the outsides and interior spaces of one or two story dwellings. The

---

[1] Also published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, Vol. LXXVIII, No. 5, May 1975.

[2] Entomologist, National Malaria Eradication Service, Ministry of Health of Panama.

[3] PAHO Technical Adviser.

[4] Manufactured by the Lowndes Engineering Co., Inc., Valdosta, Georgia, U.S.A.

Application of insecticide in a residential area of Panama City to combat Aedes aegypti. *The equipment being used is an ultra-low-volume cold aerosol generator mounted on a light truck.*

second sought to determine its effect on mosquitoes infesting a high-rise apartment house on the edge of the bay.

Only one trial was conducted in El Cangrejo, but this entailed three consecutive applications of insecticide on alternate days. Like the second San Francisco trial, its object was to determine the impact of ULV spraying on mosquitoes infesting high-rise buildings.

Biological Factors

All the trials employed both water containers with mosquito larva and rectangular wire cages (10 cm x 10 cm x 3 cm) containing adult mosquitoes. These were placed on the outside and in open interior areas of the houses and apartment buildings tested. In the case of the two apartment buildings, the cages and containers were situated at appropriate interior and exterior locations on the first ten floors.

In San Francisco, where only single applications were involved, the cages and containers were collected one hour after the run and the resulting mortality was tallied and recorded after 24 hours.

In El Cangrejo, which received three consecutive sprayings, dead mosquitoes and larvae were counted 24 hours after each run. All the containers with live insects were collected after the third application and a final count was made 24 hours later.

All the mosquitoes used in these trials were obtained from colonies at the insectarium of the National Malaria Eradication Service (SNEM). *Aedes aegypti* adults and larvae and *Anopheles albimanus* larvae were used in the trial covering single-family houses in the San Francisco district. The other San Francisco trial and that in El Cangrejo used only *An. albimanus* adults and larvae, because the insectarium's small *A. aegypti* colony had been exhausted.

The *An. albimanus* strain used is susceptible to DDT and malathion, while the *A. aegypti* strain is resistant to DDT, dieldrin, and HCH, but susceptible to malathion, ABATE, and fenthion.

Results

San Francisco

The first trial carried out in San Francisco yielded highly satisfactory results (see Table 1). All the adult mosquitoes (*A. aegypti*) in every cage were killed, regardless of whether the cages were placed outside or inside the houses

TABLE 1–*Effect on* A. aegypti *and* An. albimanus *of one ULV malathion application in an area of one and two story dwellings.*

Site: District of San Francisco
Date: 4 March 1974
Time: 5:30-6:30 P.M.

Temperature: 26°C (78.8°F)
Wind velocity: 11 km/h

House No.	*Anopheles albimanus* (larvae)				*Aedes aegypti*							
					Adults				Larvae			
	Outside exposure		Interior exposure		Outside exposure		Interior exposure		Outside exposure		Interior exposure	
	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality
5	5	100	20	20	5	100	20	100	5	100	20	15
7	20	100	5	100	20	100	5	100	20	75	5	40
8	10	90	15	47	10	100	15	100	10	50	15	20
12	10	90	15	47	10	100	15	100	10	70	15	27
Bldg.*	15	100	–	–	25	100	–	–	–	–	–	–
Total	60	97	55	42	70	100	55	100	45	75	55	22

*Ground floor.

Controls	No. exposed	% mortality
Larvae		
A. aegypti	25	0
A. albimanus	25	0
Adults		
A. aegypti	25	0

involved. There was also 75 per cent mortality among *A. aegypti* larvae placed outside the houses and 22 per cent among those inside. For *An. albimanus* larvae the respective outside and inside mortality rates were 97 and 42 per cent.

Mixed results were obtained from the second San Francisco trial, in which *An. albimanus* adults and larvae were placed on the first ten stories of an apartment house (the ground floor through the ninth floor). Adult mortality, which was relatively low, averaged 22 per cent among those exposed in interior areas and 30 per cent among those exposed on the outside, ranging from zero to 80 per cent at different locations. The highest death rates (47 and 80 per cent) were found among mosquitoes outside on the seventh floor and inside on the eighth (see Table 2). Larval mortality was also lower, averaging 23 per cent on the outside and 15 per cent in the interior.

El Cangrejo

In El Cangrejo, *An. albimanus* adults and larvae were placed on floors 1 through 8 and on floor 10 of a representative apartment building.

The count made 24 hours after the first ULV application showed that all the adult mosquitoes at both exterior and interior locations had been killed (see Table 3). The adult portion of the trial was then repeated, using new cages of mosquitoes placed on floors 3 through 10; again there was 100 per cent mortality among the adults at all the exterior and interior locations.

Mortality among larvae at outside locations was generally lower than adult mortality, but higher than mortality among larvae at interior locations. Twenty-four hours after the first application this larval mortality outside ranged from 15 to 100 per cent, the average being 62

TABLE 2–*Effect on* An. albimanus *adults and larvae of one ULV malathion application near an apartment building.*

Site: District of San Francisco–Las Rocas Building
Date: 22 March 1974
Time: 9:00-10:00 A.M.

Temperature: 32°C (89.6°F)
Wind velocity: 12-19 km/h

Floor	Larvae				Adults			
	Outside exposure		Interior exposure		Outside exposure		Interior exposure	
	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality	No. exposed	% mortality
Ground floor	5	40	10	20	5	0	10	10
1	5	40	5	20	5	0	5	40
2	–	–	10	20	–	–	10	30
3	–	–	16	12	–	–	15	20
4	5	40	5	40	5	60	5	20
5	5	0	5	0	5	20	5	20
6	5	20	10	30	5	20	10	10
7	5	0	10	10	5	80	10	10
8	–	–	15	7	–	–	15	47
9	–	–	10	10	–	–	10	10
Total	30	23	96	15	30	30	95	22

Control: 26 larvae and 25 adults (mortality: 0).

TABLE 3–*Effect on* An. albimanus *adults and larvae of three ULV malathion applications around an apartment building.*

		Temperature	Wind velocity
Site: District of El Cangrejo	Application 1	28°C (82.4°F)	0-7 km/h
Dates: 1, 3, and 5 April 1974	Application 2	26°C (78.8°F)	0
Time: 5:00-5:30 P.M.	Application 3	28°C (82.4°F)	4-11 km/h

	Larvae							Adults			
	Outside exposure				Interior exposure				Outside exposure		Interior exposure	
	No. exposed	Cumulative mortality (%) after first run	after second run	after third run	No. exposed	Cumulative mortality (%) after first run	after second run	after third run	No. exposed	% mortality	No. exposed	% mortality
1	100	100	100	100	20	0	0	5	50	100	10	100
2	20	85	+	–	20	10	35	70	10	100	10	100
3	60	58	100	100	20	25	80	100	70	100	10	100
4	60	70	100	100	20	10	35	85	30	100	10	100
5	40	78	100	100	–	–	–	–	60	100	–	–
6	20	35	+	–	20	40	+	–	50	100	10	100
7	20	15	100	100	20	0	90	100	50	100	10	100
8	40	23	93	100	–	–	–	–	60	100	–	–
10	20	15	65	85	20	5	5	5	50	100	10	100
Total	380	62	97	99	140	13	41	61	430	100	70	100

Note: 6 of 20 larvae exposed on the first floor (interior) reached the pupal stage, as did 8 of 20 larvae exposed on the tenth floor (interior).

+ = Sample lost.
Control: One larvae of 80 died (1.3% mortality); 16 larvae pupated; 80 adults all survived.

per cent; after the second application cumulative mortality rates ranged from 65 to 100 per cent, the average being 97 per cent; and after the third application the average cumulative mortality rate was 99 per cent, 100 per cent mortality being observed on floors 1, 3, 4, 5, 7, and 8, and 85 per cent on floor 10 (see Table 3).

Mortality among larvae at interior locations was generally lower. After three applications it averaged 61 per cent, ranging from 5 per cent on floors 1 and 10 to 100 per cent on floors 3 and 7.

Particle Size

To measure the size of the aerosol particles generated by the two LECO machines, spray samples were collected on silicone-coated glass slides placed 5 meters away from the nozzle of each machine. The average size and mass median diameter (MMD) of the malathion particles generated by one machine were 17.5 microns and 18.3 microns, respectively; and the average size and MMD of those produced by the other machine were 14.7 and 15.9 microns, respectively.

Discussion and Conclusions

The Panama City trials described in this report suggest that ground-level ULV spraying with malathion can serve as another method for combatting mosquitoes in both the larval and adult stages. The procedure employed in all three of these trials proved effective, even under adverse weather conditions.

The only trial not producing entirely satisfactory results was the one at the apartment house in San Francisco, where adult mortality rates of up to 80 per cent outside the building and 47 per cent inside were obtained. In this trial the insecticide was sprayed into a light wind at a time when the temperature was about 32° C (89.6° F). The low mortality may also be attributed to the fact that the building was back some distance from the street and therefore received the effect of only one application.

When the spraying is done under conditions in which the area to be covered receives insecticide not only from the application directed at it, but also from applications in neighboring areas, the result is highly satisfactory—as demonstrated by the test in El Cangrejo. In this latter case, there was 100 per cent mortality among adult mosquitoes on all floors—outside as well as inside—after a single application.

Although ULV spraying is not considered an effective anti-larval measure, acceptable results against larvae were also obtained. In San Francisco's one and two story dwellings, mortality rates of 75 per cent (outside) and 22 per cent (inside) were found after only one application. With three successive applications on alternate days (at the El Cangrejo apartment building) larval mortality averaged 99 per cent outside the building and 61 per cent inside—including the upper floors.

It was natural to find lower mortality among larvae placed inside the buildings, since their containers were far from the street and were therefore protected against the effects of the aerosol.

The mass median diameter of the aerosol particles generated by each machine (18.3 and 15.9 microns) was larger than that called for by malathion manufacturers (14 microns); but it was smaller than the particles with 26 micron MMD's that were employed by C.P. Pant in Thailand with satisfactory results (*1*). It is also likely that the size of the particles was influenced by the high temperatures at which the spraying was done.

There is thus every indication that ground-level ULV spraying with malathion, applied at thrice-weekly intervals, can serve as an additional highly effective mosquito control measure. A research project is now underway, supported by the Pan American Health Organization, for purposes of confirming this finding —with the aim of hastening *A. aegypti* eradication and facilitating control of other Culicidae.

Finally, the Panama City trials obtained satisfactory results in buildings up to 30 meters tall. This indicates that the procedure used is effective in urban areas containing apartment buildings of this kind, as well as being less costly than aerial spraying.

SUMMARY

Several ultra-low-volume (ULV) sprayings of technical malathion (95 per cent) were carried out in Panama City. Their purpose was to find out how useful this ULV technique could be in helping to combat mosquitoes, especially *Aedes aegypti*.

Two residential areas were selected as sites for the trials. One of these was San Francisco, a district near the shoreline of the Bay of Panama with many individual houses and a few tall buildings. The other was El Cangrejo, a district further inland containing numerous multi-story apartment buildings and several luxury hotels.

Two trials were conducted in San Francisco, both involving a single application of insecticide. One of these tested the effect of street spraying on mosquitoes and larvae left inside and outside of one and two story dwellings, while the other involved similar testing of the effects on ten floors of a high-rise apartment building.

There was only one trial in El Cangrejo, but this employed three applications of insecticide at two-day intervals. Like the second San Francisco trial, it tested the effect of the spray on mosquitoes and larvae left in a high-rise apartment building.

All the mosquitoes used were obtained from the insectarium of the National Malaria Eradication Service. *A. aegypti* adults and larvae and *Anopheles albimanus* larvae were used in the first San Francisco trial. Thereafter, because available supplies of *A. aegypti* were exhausted, *An. albimanus* adults and larvae were used alone.

The results of these trials were very satisfactory. All adult mosquitoes were killed in most cases, the only exceptions being mosquitoes exposed to a single application that was made under adverse conditions. Fairly high rates of larval mortality were also obtained. Overall, the results strongly indicate that thrice-weekly ground-level ULV spraying with malathion can serve as a highly effective mosquito control measure.

REFERENCES

(*1*) Pant, C. P., *et al.* Ultra-low-volume ground aerosols of technical malathion for the control of *Aedes aegypti* L. *Bull WHO* 45: 805-817, 1971.

(*2*) American Cyanamid Company. *Modern Mosquito Control* (Third edition). Princeton, New Jersey, 1972, p. 25.