STUDIES OF THE POTENTIAL EFFECTIVENESS OF ULTRA LOW VOLUME AERIAL APPLICATIONS OF INSECTICIDES AGAINST *AEDES AEGYPTI* (L.) LARVAE

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INTRODUCTION. In the fall of 1963, the United States Congress appropriated funds for the initiation of an Aedes aegypti Eradication Program. This Program was to extend over the infested areas of the southeastern United States, Puerto Rico, the Virgin Islands, and Hawaii. A pilot project, operated in Pensacola, Florida, from 1957 through 1961 (Morlan, unpublished data), showed that larval populations of *Aedes aegypti* could be reduced to extremely low levels by residual treatments with 2.5 percent DDT applied with power sprayers. This technique appeared to offer promising results as a major tool for use in the Eradication Program. Understandably, a program of this magnitude would require the utilization of numerous techniques used concurrently, with proper timing, and with entomological intelligence.

Preliminary trials in the summer of 1965 in Columbia, South Carolina,[5] showed that ultra low volume (ULV) aerial application of 4 to 6 fluid ounces of malathion per acre offered promise as an additional tool that could be employed in the Aedes aegypti Eradication Program. Based on these results, detailed studies were undertaken at the Aedes aegypti Eradication Program's Florida Field Research Activities at Perrine, Florida. These studies were designed to evaluate the potential usefulness of ULV aerial applications as a residual larvicide against *Ae. aegypti* larvae.

To fully evaluate the potential of the ULV technique, specific studies were designed:

1. To evaluate the relative effectiveness of various formulations and dosages of malathion as a residual larvicide when applied at intervals of varying frequency;
2. To determine the most effective particle size and number of particles per square inch;
3. To evaluate the comparative effectiveness of Abate,[6] Dursban, malathion, and Abate:malathion combinations as residual ULV larvicides; and
4. To determine the effects, if any, of the various toxicants and dosages on automobile paint.

PROCEDURE. The aircraft utilized in the Perrine studies was a twin-engined C18S Beechcraft. It was outfitted with a ULV system designed and operated by Marian Air Service, Savannah, Georgia. The system included an electrically driven pump capable of producing positive pressure up to 800 pounds per square inch. Four flat fan spray nozzles, two on each wing, were outfitted with Tee-jet diaphragm check valves in order to maintain constant boom pressure and to insure positive cutoff. The

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[6] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service or U.S. Department of Health, Education, and Welfare.

size of the spray tips varied with the dosage desired. The pump was controlled by solenoid switches and was operated only during the spray run. Pressure control and volume were regulated with relief and bypass valves. Except for specific studies, the system was generally operated at 90 psi. All tests were conducted with the aircraft flying at an altitude of 150 feet and 150 miles/hour. Under these conditions, with the aircraft flying crosswind, an effective swath width of 300 feet was selected. Although particles were recovered for considerable distances downwind, particle deposition rates were variable.

The following malathion formulations and dosages were applied to individual batches of 20 one-gallon containers at intervals of 1, 1.5, 2, 2.5 and 3 weeks: malathion (95 percent) at 4, 6, 8 and 10 fluid ounces technical grade/acre; 82 percent malathion at 4, 6, 8 and 10 fluid ounces technical grade/acre; and 57 percent malathion at 8 fluid ounces technical grade/acre. Subsequent studies included the evaluation of 0.5, 1 and 2 fluid ounces technical grade/acre of Abate; 2 fluid ounces technical grade/acre of Dursban and an Abate:malathion combination at a ratio of 1:2 ounces technical grade/acre. These dosages were applied at intervals of 1, 2, 3, and 4 weeks to specific groups of containers. In addition, initial studies were conducted with 6 and 8 fluid ounces/acre of Abate and with formulations of 2:2 and 4:4 fluid ounces/acre of an Abate: malathion combination.

On any one pass of the aircraft with a given dosage formulation, open-top cans in batches of 20 were placed in the center of the swath. Ten of the cans in each batch were dry; ten cans contained 2 quarts of water each.

Initially, attempts were made to utilize only one swath flown upwind over the containers; however, unpredictable shifts in wind direction and velocity caused difficulties with this procedure. After the first 3 days, all treatments were applied by using three swaths flown crosswind with the bioassay containers under the middle swath.

After treatment, 10 of the 20 cans in each batch were stored in the shade and 10 in the sun (five dry and five with water in each location). Twenty-four-hour bioassay tests with 20 third instar *Ae. aegypti* larvae/container were conducted approximately 48 hours prior to the next scheduled test.

Containers used in the initial studies were new 1-gallon metal cans. These were color coded and numbered for identification as to dosage received and interval of treatment. To facilitate handling, the containers for each flight were placed on plywood pallets and were set out on the ground just prior to the flight.

Determinations of particle size were made on representative flights with various dosage formulations. Droplets were collected on glass microscope slides coated with a formulation of Dri-film SC-87[7] and acetone (1:9) prior to treatment. The prepared slides were placed on the ground adjacent to the test containers. Impinged droplets were counted and measured and the mass median diameter (MMD) was calculated. Determinations of particle size were made using the techniques described by Yeomans, 1949.

RESULTS AND DISCUSSION. Results of the tests are shown in Tables 1, 2 and 3. Bioassays at 3, 7 and 11 days after treatment showed erratic results at dosages below 10 fluid ounces/acre. Results of bioassays of initial treatments applied at intervals of 2 weeks or more are not included in the tabular data, as mortalities were insignificant. Two treatments were applied the first week, and the bioassay was made 3 days later. The higher mortalities obtained on the first bioassay were probably because of the tests being conducted only 3 days after the treatment (Table 1).

After treatment, the containers that had been exposed were divided into lots of five

[7] A commercial silicone manufactured by General Electric Corporation, Silicone Products Department, Waterford, New York.

TABLE 1.—Twenty-four hour percent mortality of 3rd instar *Ae. aegypti* larvae after exposure to ULV malathion treated 1-gallon metal cans. Containers previously treated with indicated dosage and formulations.

Formulation (Percent)	Oz. Tech./Acre	Spray Interval (Weeks)	Percent Mortality* Dry Shade	Dry Open	Wet Shade	Wet Open	Control	Interval of Bioassay After Treatment (Days)
95	4	1.0	16	5	40	36	0	3
	6	1.0	69	19	79	97	0	3
	8	1.0	90	45	99	34	0	3
	10	1.0	100	98	85	95	0	3
	4	1.5	25	1	5	1	1	7
	6	1.5	58	2	24	4	1	7
	8	1.5	77	3	35	33	1	7
	10	1.5	93	9	58	21	1	7
82	4	1.0	13	0	55	63	0	3
	6	1.0	48	40	100	85	0	3
	8	1.0	83	14	100	100	0	3
	10	1.0	100	89	100	100	0	3
	4	1.5	23	0	4	6	1	7
	6	1.5	73	2	73	95	1	7
	8	1.5	36	10	99	100	1	7
	10	1.5	77	34	82	77	1	7
57	8	1.0	100	96	100	100	0	3
	8	1.5	100	4	81	100	1	7
	8	2.0	10	0	11	2	3	11
	8	3.0	19	0	19	2	1	17

* Bioassay made on day prior to next treatment.

cans each and held either in the shade or exposed to the sunlight. In general, containers exposed to the sunlight produced slightly lower mortalities than those held in the shade (Table 1). In addition, substantially lower mortalities were obtained from cans treated dry and exposed to sunlight than from those treated wet and held either in the shade or in the sunlight.

Because of the poor residual results with malathion on the initial flights, there was concern that the insecticide was not getting into the containers, even though dye cards showed that fairly good coverage was being obtained. Larvae in containers that were exposed to the aerial application, however, showed an average mortality of over 80 percent at 24 hours after exposure, whereas 7 days later the highest mortality of larvae in these same containers was only 30 to 35 percent. This indicated that a good initial kill was obtained but that there was little residual effect.

Evaluation of the immediate and residual effects of a single application of various formulations and dosages of malathion ULV aerial applications against *Ae. aegypti* larvae are shown in Table 2. These data show that satisfactory immediate results were achieved with most formulations and dosages tested, but that no residual effect was obtained. Even at 3 days, many of the dosages and formulations evaluated provided mortalities below 75 percent and none gave 100 percent. Bioassays at 5 days after treatment showed that after only two treatments mortalities exceeded 50 percent.

Table 3 shows results of evaluations to determine the cumulative residual effectiveness of weekly ULV aerial applications of malathion applied to the same containers and bioassayed at weekly intervals just prior to the next scheduled treatment.

TABLE 2.—Residual effectiveness of ULV aerial applications of various formulations and dosages of malathion, expressed as percent mortality of third instar *Ae. aegypti* larvae after 24-hour exposure at indicated days after treatment.

Formulation	Oz. Tech./ Acre	Days After Treatment				
		1	3	5	7	11
57% EC[1]	8	100	94	54	33	6
82% EC	4	100	33	31	3	<1
82% EC	6	100	68	8	26	9
82% EC	8	69	74	42	25	2
82% EC	10	100	97	71	...	1
95% LVC[2]	4	83	24	16	8	<1
95% LVC	6	100	66	12	22	7
95% LVC	8	93	67	31	...	4
95% LVC	10	97	74	49	...	3
Untreated control	...	8	13	<1	16	1

[1] Emulsifiable concentrate.
[2] Low volume concentrate.

Results of the first bioassay (conducted after two treatments the first week), which was run 3 days after the treatment, showed mortalities ranging from 24 to 99 percent, depending on the dosage and formulation used. Subsequent bioassays conducted 5 days after each weekly treatment showed no buildup of residual malathion in the containers and, at the end of 6 weeks (seven treatments), larval mortalities were still very low.

Because of the results shown in Tables 1, 2, and 3, further studies with malathion as a residual larvicide were discontinued and were replaced with investigations on the residual effectiveness of various dosages and formulations of Abate, Abate: malathion combination, and Dursban.

Initial flights with Abate (6 and 8 fluid oz./acre) and Abate:malathion combination (2:2 and 4:4 fluid oz./acre) were very promising. Larval bioassays 17 days after treatment with both Abate:malathion formulations still resulted in 100 percent mortalities. The 6- and 8-ounce Abate formulations gave 90 percent mortalities 17 days after applications. Results are shown in Table 4.

More detailed studies were conducted with Abate (0.5, 1 and 2 fluid oz./acre), Abate:malathion (1:2 fluid oz./acre) and Dursban (2 fluid oz./acre) formulations to determine their residual larvicidal effectiveness as ULV aerial applications against *Ae. aegypti*. Bioassay results of larval mortalities obtained at intervals varying from 1 to 25 days after treatment are shown in Table 4. Results with Abate at dosages of 1 and 2 fluid ounces/acre and with Dursban at 2 fluid ounces/acre were quite comparable. Even 19 days after the treatment, larval mortalities of 61 and 70 percent were obtained with Dursban and Abate formulations, respectively. The Abate:malathion formulation (1:2 fluid ounces/acre) and the 0.5 fluid

TABLE 3.—Evaluation of the cumulative residual effectiveness of weekly ULV malathion treatments to the same containers, expressed as percent mortality of third instar *Ae. aegypti* larvae after 24-hour exposure. Bioassays made 5 days after each weekly treatment.

Formulation	Oz. Tech./ Acre	Percent Mortality After Weekly Treatments					
		1*	2	3	4	5	6
95%	4	24	2	20	27	16	22
	6	44	7	37	32	12	16
	8	67	7	78	36	31	...
	10	95	20	40	28	49	...
82%	4	33	3	9	14	31	19
	6	68	11	71	22	8	57
	8	74	29	35	13	42	...
	10	97	6	33	28	51	...
57%	8	99	39	33	26	52	...
Control	...	0	1	24	3	1	11

* Bioassay made 3 days after treatment. All mortalities based on 20 replicates.

TABLE 4.—Residual effectiveness of ULV aerial applications of various toxicants and dosages, expressed as percent mortality of 3rd instar *Ae. aegypti* larvae, after 24-hour exposure at indicated days after treatment.

Toxicant	Oz. Tech./ Acre	Days After Treatment								
		1	4	5	7	11	12	17	19	25
Abate	0.5	...	...	75	...	...	34	...	49	26
Abate	1.0	100	96	83	...	...	47	...	70	36
Abate:malathion	1:2	48	72	85	...	...	36	...	44	38
Abate	2.0	83	100	95	...	...	71	...	70	58
Dursban	2.0	98	96	88	...	...	52	...	61	36
Controls	...	...	9	3	...	...	<1	...	<1	...
Abate:malathion	2:2	100	100	...	100	...	...	100	...	...
Abate:malathion	4:4	100	100	...	100	100	...	100	...	...
Abate	6.0	100	100	...	100	80	...	90	...	...
Abate	8.0	100	100	...	100	85	...	90	...	...
Controls	...	3	<1	...	0	...	...	9	...	...

ounce/acre formulation of Abate showed substantial drops in mortalities 12 days after treatment. Satisfactory mortalities with all formulations were obtained up to 5 days after treatment, with mortalities ranging from 75–95 percent.

Although very good results were obtained with 2 ounces of Dursban, its toxicity, which is somewhat higher than that of malathion, would probably prohibit its use for widespread aerial dispersal over heavily populated areas. The combination Abate:malathion treatment (Table 4) appeared to be less satisfactory than the 2 fluid ounces of Abate, possibly due to some incompatibility between the malathion and Abate. The 2 fluid ounces Abate dosage yielded slightly better results than were obtained with the 1 fluid ounce Abate, but the 2-ounce application obviously would be more expensive. Although the 0.5 fluid ounce/acre Abate dosage gave fair kills, it is considered too low to be effective towards the eradication effort.

Attempts to correlate the particle size (MMD) and the number of particles/square inch recovered on oil red dye cards with the mortality of larvae presents numerous problems. First, techniques for rapid measurement of particle size have not been developed. Second, determinations of particle size and number of particles/square inch have to be based on those particles that impinge on the coated slide. In all probability, many small particles never impinge and these cannot be included in the evaluation. Third, numerous observations have shown that two dye cards or coated slides placed side by side during treatment may show a wide discrepancy in the number and size of droplets that impinge. Thus, individual data from dye cards or glass slides, although placed in close proximity to the larvae container, may not necessarily provide an indication of the quantity of insecticide that actually entered the container. Nevertheless, both tools may be used to advantage in large-scale tests or in operational programs where average droplets/square inch, as determined from large numbers of cards, can provide a useful indication of the quality of the treatment.

Table 5 shows results obtained with various Abate, Dursban, and Abate:malathion formulations expressed in terms of percent mortality of *Ae. aegypti* larvae as compared to the number of particles and the size of particle (MMD). In all of these tests, the minimum number of droplets/square inch was 12, with a maximum of 52. Particle sizes ranged from a low of 31 microns MMD to a high of 88.6 microns MMD. Larval mortality ranged from a low of 84 percent to a high of 100 percent. It is interesting to note that the lowest mortality (84 percent) was obtained with the treatment having the smallest particle size (31 microns MMD). This decreased mortality can be explained

TABLE 5.—A comparison of percent mortality of 3rd instar *Ae. aegypti* larvae in relation to particle size and number of particles per square inch. Containers received ULV aerial treatments 6 days before bioassay.

Insecticide	Oz. Tech./ Acre	MMD*	Droplets/ Sq. In.	Percent Mortality	Controls
Malathion:Abate	2:1	44.0	54	95	7
		88.6	52	96	<1
		47.0	40	100	<1
Abate	1.0	59.0	21	92	7
		36.4	12	95	<1
	2.0	53.0	23	97	7
		48.0	27	93	<1
		57.4	12	99	<1
	0.5	31.0	18	84	7
		55.5	..	94	<1
Dursban	2.0	47.8	..	94	<1
		47.5	30	99	<1

* Mass Median Diameter.

by the fact that a smaller quantity of insecticide actually entered the container. It is suggested, however, that this particular treatment with the smaller particle size might have been the most efficient treatment had it been evaluated as an adulticide. Although slight differences in larval mortality were obtained with the various treatments, no direct correlation can be drawn since all treatments provided high mortalities and the droplet spectrum in all instances exceeded 10 particles/square inch.

Table 6 shows the results obtained from one application of malathion at 3 oz./acre when containers of different types were placed in the field so that they would receive various amounts of the insecticide. This was accomplished by placing test containers upright in groups at selected

TABLE 6.—Effects of a single aerial application of malathion at 3 oz. tech./acre on 3rd instar *Ae. aegypti* larvae in various containers as related to varying number of droplets/sq. in.

Droplets/ Sq. In.	Percent Mortality in Individual Containers (20 Larvae/Container)					
	Tire	Metal Can	Pint Jar	Beer Can	Soda Bottle	All Containers
50	70	100	100	95	100	93
40	100	100	100	100	90	98
39	50	55	80	100	...	71
32	100	100	100	100	0	80
31	...	100	...	100	...	100
28	100	100	100	100	10	82
25	...	100	...	...	...	100
24	25	95	100	95	...	79
23	35	80	95	65	35	62
16	100	100	100	100	0	80
15	35	35	100	100	50	64
11	90	90	100	55	...	84
8	85	70	100	...	0	84
5	45	100	100	100	0	69
Average Mortality	70	88	98	93	32	78*

* Overall mortality based on a total of 1,180 larvae.

locations around and under buildings and shrubs that provided different degrees of shelter. Dye cards were placed among each group of containers to record the number of droplets impinging in each location. Results are expressed as percent mortality related to droplets/square inch. No determinations of droplet size were made on this test. Cursory observation, however, would indicate that, where high numbers of droplets/square inch were found, the greater proportion was in the smaller size ranges. The average number of droplets/square inch ranged from 5 to 50, with only two replications having droplets averaging less than 11/square inch. Mortalities of third instar larvae averaged 78 percent with a range of 62 to 100 percent. Because of the relatively high number of droplets obtained in most situations, positive comparisons could not be made; however, in general, the higher mortalities occurred in areas where an average of 25 or more droplets/square inch was obtained.

Table 7 shows comparative mortalities after third instar *Ae. aegypti* larvae were exposed to either 1 ounce of technical Abate or 3 ounces technical malathion/acre. These mortalities were derived after the larvae were exposed to aerial treatments having droplet densities ranging from 1 to 17 particles/square inch. In the 1 fluid ounce/acre Abate treatment, 100 percent mortality of larvae was obtained with a droplet count of 6 or more/square inch, whereas with the 3 fluid ounce/acre malathion treatment, only 65 percent mortality was obtained with 6 droplets/square inch; however, with a droplet count of 11 or more droplets of malathion/square inch, 90 to 100 percent mortality was obtained.

TABLE 7.—A comparison of 24-hour percent mortality of 3rd instar *Ae. aegypti* larvae exposed to ULV aerial application of Abate or malathion where the number of impinged droplets/sq. in. varied.

Droplets/ Sq. In.	Toxicant and Dosage: Abate 1 Oz./Acre	Toxicant and Dosage: Malathion 3 Oz./Acre
17	100	100
16	100	...
14	100	...
12	...	90
11	...	95
10	...	80
8	100	61
7	100	61
6	100	65
1	25	60

In order to evaluate the potential damage to automobile paint from ULV aerial applications of insecticides, painted panels[8] were exposed during representative flights and observed for damage. Half of the 4- by 12-inch panels had been painted with enamel and the other half with acrylic lacquer applied under normal assembly line conditions. Enamel colors tested were black, white, pale blue and red. Acrylic lacquer colors used were black, white, dark green and maroon. The panels had been prepared approximately a month before they were exposed to the aerial applications. Both enamel and acrylic lacquer paints of all colors showed damage from all formulations of malathion that were tested. The damage was proportional to the dosage of malathion applied and to droplet size. Dosages above 4 ounce/acre of any toxicant caused evidence of damage. Droplets with a MMD of 50 microns or below caused no detectable damage if applied at dosages below 4 ounce/acre. Droplets of all toxicants tested with an MMD of over 60–75 microns caused small raised spots or blisters where each droplet hit the panel. Close observation showed that the raised spots were much softer than the undamaged paint. The surface of each spot had a shiny appearance similar to the original finish.

Initially, there was little difference in damage to enamel or acrylic lacquer; however, observations 2 months after the exposure revealed that spots on enamel had

[8] Panels painted with either enamel or acrylic lacquer (as used on new automobiles) furnished by General Motors Corporation, Detroit, Michigan.

been reduced in elevation and were much less apparent than they had been originally. At the same time, spots on the acrylic lacquer had been somewhat reduced in size and had taken on a glazed appearance. Cursory examination revealed little noticeable damage on the enamel panels 2 months after they had been sprayed, while a spotted appearance on the acrylic lacquer was quite noticeable. Damage from the 4 oz./acre malathion treatment, although detectable, was minor. In no instance was the observed damage severe enough to cause actual blisters or to eat through the finish coat of paint to the primer.

Several special flights were made to apply malathion diluted with fuel oil, water and emulsifiers, but damage was not reduced. One panel of acrylic lacquer and enamel was taken to Lee County where an aerial fog using malathion was applied with the Lee County Mosquito Control airplane. The acrylic lacquer panel showed no noticeable damage from the aerial fog; however, very small spots were seen on the enamel panel where each droplet had hit. At the end of 2 months, no damage could be seen on the acrylic lacquer, and the damage to the enamel panel was very difficult to detect.

Damage to enamel paint from various dosages of Abate was possibly a little more severe than malathion damage to enamel surfaces. On acrylic lacquer, however, Abate caused about the same amount of spotting as was observed on the enamel, but the surface of each spot had a glazed appearance. It also was noted during these tests that the Abate:malathion combination did not produce as much of a glaze on the surface of the elevated spots of acrylic lacquer paint as seen with the same application on enamel surfaces. Waxing of the panels, once damage had occurred, was of no benefit in reducing the spotted appearance of either type of paint. It is apparent that some minor spotting of new automobile paint may be expected and that the lowest possible dosage of insecticide/acre should be used in order to reduce such spotting to a minimum.

A number of vehicles having paint over 1 year old were exposed to as many as 20–30 spray applications during a 3-month period. No spotting or damage to the paint of these automobiles could be detected.

SUMMARY. Studies designed to evaluate the residual larvicidal effectiveness of various dosages of malathion, Abate:malathion, Abate and Dursban against *Ae. aegypti* larvae when applied as ultra low volume aerial applications revealed the following results:

1. Residual activity of malathion at dosages below 10 fluid ounces of toxicant/acre was erratic for 3 days or more after application. Bioassays conducted 24 hours after treatment showed slight but insignificant differences in mortalities regardless of dosage or formulations. Repeated weekly treatments for 6 or more weeks failed to build up any residual activity.
2. High dosages of Abate:malathion combinations (2:2 and 4:4 fluid ounces/acre) showed excellent residual activity up to 17 days. Lower dosages of the combination (1:2 fluid ounces/acre) showed effective residual activity for a maximum of only 5 days. Dursban at 2 fluid ounces/acre showed residual effectiveness for 5 days.
3. A positive correlation between droplet size and larval mortality could not be decisively determined. The MMD is a function of mass of the particle and, in turn, the larval effect is related to the total mass of toxicant directed into the container rather than to the size of individual particles.
4. Larval mortality in containers exposed to 3 fluid ounces of ULV malathion was at or above 90 percent with deposits of more than 10 droplets/square inch. Abate applied at 1 fluid ounce/acre gave mortalities of 100 percent with a droplet spectrum of 6 or more droplets/square inch.
5. Evaluation of the effects of the toxicants on painted surfaces showed that when dosages were above 4 oz/acre, where impinged particles showed a MMD of

over 75 microns, damage to those surfaces could be expected. Little or no damage was observed with dosages at 4 oz./acre or below, when the MMD of particles was 50 microns or below.

References

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RESIDUAL EFFECTIVENESS OF SOME NEW INSECTICIDES AGAINST *ANOPHELES QUADRIMACULATUS*[1]

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Residues of DDT and dieldrin have been used extensively throughout the world in control programs against anopheline mosquitoes. However, some species have already developed resistance to these insecticides, so there is a need for substitute materials. Therefore, the Entomology Research Division has maintained a continuing program at Orlando, or Gainesville, Florida to evaluate new insecticides for use as residual treatments against mosquitoes for the past 26 years. The latest results are published periodically.

Since the last report by Gahan *et al.* (1967) on the results of these laboratory tests, we have screened 186 compounds. This paper discusses the 29 that produced better than 70 percent mortality in 24 hours for at least 8 weeks. All were obtained for testing from commercial sources. The company designation, chemical name, and acute LD_{50} in rats (based on information received from the manufacturer) are given in the accompanying list.

METHODS AND MATERIALS. Acetone solutions, water suspensions, or emulsions of the compounds were sprayed on plywood panels at the rate of 1 gram per square meter, and enough panels were sprayed with each insecticide to avoid the necessity of using any surface twice. The panels were tested one week after treatment, again after 4 weeks, and then every 4 weeks thereafter for 24 weeks or until they became ineffective. In each test, twenty 1- to 2-day-old female *Anopheles quadrimaculatus* Say were exposed on the treated surfaces under each of two half sections of petri dishes for 60 minutes; then they were transferred to cylindrical screen cages, provided with a sugar-water solution in pads of absorbent cotton, and held for 24-hour mortality counts. Also, knockdown counts were taken after exposures of 30 and 60 minutes during the one-week test. Panels were considered ineffective when they failed to produce at least 70 percent mortality in 2 consecutive tests. Those compounds that remained effective for at least 6 months were scheduled for field tests against natural populations of *A. quadrimaculatus* in small buildings near rice fields in the vicinity of Stuttgart, Arkansas.

RESULTS. Thirteen compounds (six carbamates, five organic phosphorus compounds, one thioacetimidate, and one cyclopropanecarboxylate) killed all mosquitoes for the entire 6 months. Five carbamates (Bay 62862, CIBA C-9643,

[1] Mention of a pesticide in this paper does not constitute a recommendation of this product by the USDA.