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ADULT MOSQUITO KILL AND DROPLET SIZE OF ULTRALOW VOLUME GROUND AEROSOLS OF INSECTICIDES[1]

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ABSTRACT. Ground applications of ultralow volume insecticide aerosols against caged adult female *Aedes taeniorhynchus* (Wiedemann) showed that Pennwalt TD-8550 (methyl (mercaptoacetyl)methylcarbamate *S-ester* with *O*-methyl methylphosphonodithioate), synergized pyrethrins, Dowco® 214 (*O,O*-dimethyl *O*-(3,5,6-trichloro-2-pyridyl) phosphorothioate), chlorpyrifos, Plant Protection PP-511 (*O*-[2-diethylamino)-6-methyl-4-pyrimidinyl] *O,O*-dimethyl phosphorothioate), naled, and resmethrin were the most effective of 13 chemicals tested. Correlation of droplet size with adult mosquito kill indicated an optimum size range of 11 to 20 μ for naled, chlorpyrifos, and Plant Protection PP-511 with mass medium diameters (mmd's) from 8 to 17 μ.

We have continued to evaluate promising insecticides for adult mosquito control with the ultralow volume (ULV) ground aerosol method. This report gives the results obtained with an additional 13 chemicals tested during 1971.

TESTS WITH CAGED MOSQUITOES. These tests were conducted in an open field near Gainesville, Florida, in April, May and June. The tests were performed between 6 and 9 pm when climatic conditions were favorable. Temperatures 5 feet above the ground ranged from 74° to 84° F and averaged about 79° F. Wind velocities ranged from <2 to 10 miles per hour (mph) and averaged about 4 mph.

The insecticides tested were as follows:

Chevron RE-11775 (58 percent *m-sec*-butylphenyl methyl(phenylthio)-carbamate mixture with 29 percent and 5 percent *O*-isomers)
Chlorphoxim
Chlorpyrifos
Dichlorvos
Dowco® 214 (*O,O*-dimethyl *O*-(3,5,6-trichloro-2-pyridyl)phosphorothioate)
Lethane® 348 (2-(2-butoxyethoxy) ethyl thiocyanate)
Malathion
Naled

[1] This paper reflects the results of research only. Mention of a pesticide or a commercial or proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the U.S. Department of Agriculture.

Resmethrin
Pennwalt TD-8550 (methyl (mercaptoacetyl)methylcarbamate *S*-ester with *O*-methyl methylphosphonodithioate
Plant Protection PP-511 (*O*-[2-(diethylamino)-6-methyl-4-pyrimidinyl] *O*, *O*-dimethyl phosphorothioate)
Propoxur
Pyrethrins

A Leco ULV (Model HD) cold aerosol generator was used to disperse the concentrated insecticides. The machine instrument panel was located in the cab of the truck on which the machine was carried so that insecticide flow rate, air pressure, and insecticide temperature could be monitored while test applications were being made. All flow meter calibrations were made for a temperature range of 76° to 82° F so the viscosity of the insecticides would be about the same as during actual application.

The dose of each insecticide was changed by varying either flow rate and/or vehicle speed. Flow rates ranged from 0.57 to 7 fluid ounces per minute, and vehicle speeds ranged from 5 to 20 mph.

Initially, we planned to evaluate all of the insecticide formulations with a nozzle air pressure of 4 pounds per square inch (psi). It soon became apparent that several of the formulations were being overatomized at this air pressure; therefore, additional tests were made using air pressures of 2.5 and 1.5 psi with some of the insecticide formulations.

Adult female *Aedes taeniorhynchus* (Wiedemann) 2- to 5-days-old were exposed in 16-mesh galvanized screen wire cages (25 per cage) suspended on stakes 150 and 300 feet downwind in two rows perpendicular to the line of travel of the generator. After the passage of the generator, the mosquitoes were transferred to plastic tubes lined with clean paper. Except during exposure to the aerosols, the mosquitoes were held in insulated chests containing ice in cans and moist cotton. Absorbent cotton pads moistened with 10 percent sugar-water solution were placed on the holding tubes when they were returned to the laboratory. Mortality counts were made 18 hours after the mosquitoes were exposed to the aerosols.

DROPLET SIZE ESTIMATES. Droplet sizes of some of the insecticide formulations were estimated to study the effect of nozzle air pressure and flow rate on atomization and correlate size with kill of adult mosquitoes. Thus, droplets were collected on silicone (General Electric SC-87 Dri-Film) treated glass microscope slides by rapidly waving the slides through the aerosol at a distance of 3 to 6 feet from the point of discharge. Two glass slides were used for each treatment, and a sample of 200 droplets (100 per slide) was measured with an ocular micrometer at 450× magnification. Also, diameters of the original spheres were estimated by correcting the diameter of the droplets impinged on the glass slides. Spread factors were determined by a direct measurement method similar to that used by Anderson and Schulte (1971) and described in detail by Mount and Pierce.[2] Spread factors were as follows: malathion (0.51), chlorpyrifos (0.49), 10 percent Dibrom 14 in Heavy Aromatic Naptha (HAN) (0.42), and Plant Protection PP-511 (0.49).

RESULTS AND DISCUSSION. The mortalities and estimated LD_{90}'s for each insecticide are presented in Table 1. Pennwalt TD-8550 was the most effective compound tested with an LD_{90} of 0.0048 pound per acre. Pyrethrins synergized with piperonyl butoxide was more effective than pyrethrins synergized with Tropital® (piperonal bis[2-(2-butoxyethoxy)ethyl] acetal) (LD_{90} of 0.008 vs. LD_{90} of 0.015 pound per acre). Dowco 214 and chlorpyrifos were slightly more effective than previously reported by Mount and Pierce (1971) and were just as efficient when atomized at 1.5 psi as when atomized at 3.5 to 4 psi. Plant Protection PP-511 was

[2] G. A. Mount and N. W. Pierce. Droplet sizes of ultralow volume ground aerosols as determined by three collection methods. (In manuscript)

TABLE 1.—Effectiveness of ultralow volume cold aerosols of insecticides against caged female *Aedes taeniorhynchus*.

Insecticide	A.I. (lb/gal)	Air pressure (psi)	No. of tests	Percentage mortality at 18 hours posttreatment with indicated dose (lb/acre) [a, b]						LD_{90} (lb/acre)
				0.1	0.05	0.025	0.0125	0.006	0.003	
Pennwalt TD-8550	8.5	4	6	...	..	..	100	95	67	0.0048
Pyrethrins+piperonyl butoxide (1:5 w/w)[c]	.7	4	7	...	..	..	95	84	74	.008
Pyrethrins+Tropital (1:5 w/w)[c]	.7	4	8	...	..	..	87	84	75	.015
Dowco 214	6	1.5	5	...	..	88	93	73	..	.0125
Chlorpyrifos	6	4	6	...	..	99	70	82	..	.0125
	6	1.5	6	...	..	94	92	69	..	.013
Plant Protection PP-511	3.9	1.5	6	...	..	95	76	66	..	.018
	3.9	4	5	...	..	68	78	..	..	>.025
10% (v/v) Dibrom 14 (naled) in HAN	1.4	1.5	7	...	..	94	80	..	..	.019
	1.4	2.5	2	...	..	67	..	..	..	>.025
	1.4	4	5	...	..	64	28	..	..	>.025
10% (v/v) Dibrom 14 (naled) in mineral seal oil	1.4	1.5	2	...	..	92	..	..	..	.022
	1.4	4	1	...	..	53	..	..	..	>.025
10% (v/v) Dibrom 14 (naled) in soybean oil	1.4	4	5	...	..	88	60	..	..	.027
Dibrom 14 (naled)	14	4	5	...	..	89	73	..	..	.025
	14	2.5	2	...	..	86	..	..	..	.03
Resmethrin	3.36	1.5	4	...	..	84	54	..	..	.045
	3.36	4	6	...	87	71	60	..	..	.058
Malathion+Lethane 384 (1:0.4 w/w)[d]	9.7	4	4	...	85	90	58	..	..	.045
Malathion	9.7	4	4	...	85	70	52	.	..	.06
Propoxur[e]	1.25	4	3	...	..	..	67	..	..	>.0125
Chlorphoxim	2	1.5	3	...	..	79	..	..	..	>.025
	2	4	1	...	..	57	..	..	..	>.025
Chevron RE-11775	4	5	3	...	..	69	..	..	..	>.025
	4	4	1	...	..	30	..	..	..	>.025
Dichlorvos	11.9	1.5	4	100	67	20	..	..	..	.078
Lethane 384	4	4	1	...	..	0	..	..	..	>.025

[a] The average mortality at distances of 150 and 300 feet; the average mortality of unexposed mosquitoes was 4 percent.

[b] Based on active ingredient (A.I.) used over a 300-foot swath.

[c] Indicated dose based on pyrethrins only.

[d] Indicated dose based on malathion only.

[e] Wettable powder (75%) suspended in No. 2 fuel oil.

equally as effective as naled and slightly more effective at 1.5 psi than at 4 psi. The most effective formulation of naled was 10 percent (v/v) Dibrom 14 in HAN; the LD_{90} was 0.019 pound per acre at 1.5 psi air pressure. (This formulation gave much poorer kill at higher pressures.) The 10 percent Dibrom 14 formulations in mineral seal oil and soybean oil were about equal to Dibrom 14. Resmethrin was much less effective than naled but was about equal to malathion. The effectiveness of resmethrin was about equal when atomized at 1.5 or 4 psi air pressure. The effectiveness of malathion was only slightly enhanced by the addition of Lethane 384, and Lethane 384 was completely ineffective when it was used alone. Propoxur, chlorpyrifos, Chevron RE-11775, and dichlorovos were only moderately effective and do not appear promising. However, the effectiveness of dichlorvos was en-

TABLE 2.—Effect of nozzle air pressure and flow rate on the droplet size of insecticides atomized with an ultralow volume cold aerosol generator.

Insecticide	Flow rate (fl oz/min)	Air pressure (psi)	Percent of total mass in indicated range of droplet size (μ)					Mass median diameter (μ)
			<5	5–10	11–20	21–40	>40	
Malathion	3	5	6	28	50	16	0	14
	3	4	3	14	47	35	1	18
	1.5	4	7	29	51	13	0	14
	3	2.5	3	10	35	48	4	21
	1.5	2.5	2	7	38	49	3	22
10% Dibrom 14 (naled) in HAN	7	4	37	59	4	0	0	5
	7	1.5	8	26	36	28	0	15
Chlorpyrifos	3.2	4	12	38	47	3	0	10
	3.2	1.5	4	18	45	33	0	17
	1.6	4	15	47	38	0	0	9
	1.6	1.5	4	21	48	27	0	15
Plant Protection PP-511	2.5	4	27	52	21	0	0	8
	2.5	1.5	4	26	39	29	2	15

hanced considerably at an air pressure of 1.5 psi compared with previous results at air pressure of 3.5 psi (Mount and Pierce 1971).

Droplet size estimates are presented in Table 2. The mmd's for malathion ranged from 14 to 22 μ depending on insecticide flow rate and air pressure. These estimates were slightly higher than those reported previously by Mount *et al.* (1970) because of the difference in the spread factor determination, rather than from any real difference in atomization. With 10 percent Dibrom 14 in HAN, there was a distinct difference in droplet sizes between air pressures of 1.5 and 4 psi (5 μ mmd for 4 psi vs. 15 μ mmd for 1.5 psi), and the kill of caged mosquitoes (Table 1) indicated over-atomization at 4 psi. Chlorpyrifos and PP-511 also showed considerable differences in droplet size at air pressures of 1.5 and 4 psi (mmd's ranged from 8 to 17 μ), but the efficiency of chlorpyrifos was unaffected though PP-511 appeared to be slightly overatomized at 4 psi. Except for 10 percent Dibrom 14 in HAN and PP-511 atomized at 4 psi, the average percentage of total mass of droplets in the 11 to 20 μ size range was 44 percent, and the data suggest that this range was optimum for Dibrom 14 diluted in HAN, chlorpyrifos, and PP-511. Mount (1970) previously suggested an optimum range of 5 to 10 μ mmd based on results with technical malathion. In the present test, the average percentage of total mass in the 5 to 40 μ size range was 93 percent, which indicated a narrow droplet spectrum being produced by the Leco ULV (Model HD) cold aerosol generator.

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