AEROSOLS OF PERMETHRIN AND PROPOXUR FOR CONTROL OF ADULT MOSQUITOES[1]

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ABSTRACT. Field trials with ULV aerosols indicated that 2 formulations of permethrin (3-phenoxyphenyl) methyl *cis, trans* - (±)-3 - (2,2-dichloroethyl) - 2,2-dimethylcyclopropane carboxylate), ICI-PP 557 and FMC-33297, and a new formulation of propoxur (*o*-isopropoxyphenyl methylcarbamate, Baygon® ULV) were highly effective against caged adult females of *Aedes taeniorhynchus* (Wiedemann) and *Anopheles quadrimaculatus* Say. Droplet sizes of ICI-PP 557 and Baygon ULV were determined: volume median diameters of 8 and 9 μm were obtained for flow rates of 58 and 272 ml per min of ICI-PP557 and Baygon ULV, respectively. Additional tests with these same flow rates showed that these formulations would not cause damage to acrylic lacquer automotive paints, even with gross over exposure. All aerosol applications were made with a Leco® HD aerosol generator operated at 4 psi nozzle air pressure.

Our laboratory has continued to test adulticides that have potential usefulness against OP-resistant mosquitoes. Two adulticides that hold promise as ultralow volume (ULV) aerosols for such use are permethrin (3-phenoxyphenyl) methyl *cis, trans* - (±) 3-(2,2-dichloroethenyl)-2,2 - dimethylcyclopropanecarboxylate and propoxur (*o*-isopropoxyphenyl methylcarbamate). Permethrin is a recently developed synthetic pyrethroid that has a high level of toxicity to both OP-susceptible and -resistant strains of mosquitoes (unpublished data). Propoxur has been available for use in adult mosquito control for a number of years as a high volume application but has never been registered for use as a ground ULV aerosol. Recently, Mount et al. (1975a) showed that a commercial formulation of propoxur (Baygon® MOS) was suitable for ULV aerosol application against adult mosquitoes. In 1976 a more concentrated formulation of propoxur (Baygon® ULV 1.67 lb AI/gal ULV) became available for testing.

In this paper we summarize the research of comparisons of 2 commercial formulations of permethrin (ICI-PP 557 and FMC33297) and the new Baygon ULV formulation of propoxur; a ULV formulation of fenthion (*0,0*-dimethyl *0*[4 - (methylthio)-*m*-tolyl) phosphorothioate) registered by EPA for use in Florida and Texas was utilized as a standard in the tests with caged mosquitoes. The study included (1) field assays against caged adult mosquitoes, (2) determination of aerosol droplet size and (3) exposure of acrylic lacquer-coated panels for determination of potential damage to automotive paints.

The ICI formulation of permethrin (2 lb AI/gal EC) was used in all three types of tests; the FMC-33297 formulation of permethrin (3.2 lb AI/gal EC) was used only in the field assays because a limited quantity was available to us at the time of the tests.

A Leco® Model HD aerosol generator was used to disperse the formulations. The instrument panel for the generator was mounted in the cab of the truck carrying the generator so that liquid flow rate, liquid temperature, and blower air pressure (4 psi) could be monitored during application. Flowmeter calibrations were made at about the same temperature as encountered during application. These

[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 for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

calibrations were usually confirmed either just before or after actual field applications.

CAGED MOSQUITO ASSAYS

These tests with caged mosquitoes were performed in a fairly level, open field near Gainesville, FL, during April and May 1976. Applications were made between 1800 and 2030 hr on 8 evenings. Air temperatures 5 ft above the ground ranged from 73 to 81°F and averaged 78°F. Wind velocities at the same level ranged from 2 to 10 mph and averaged ca. 6 mph.

Adult female *Aedes taeniorhynchus* (Wiedemann) and *Anopheles quadrimaculatus* Say from laboratory colonies were exposed in 16-mesh galvanized screen wire cages as described by Mount et al. (1975a). Mortality counts were made 12 hr after the exposures. Cages of mosquitoes not exposed to the aerosols but handled in an identical manner showed averages of 4 and 12% mortality for *Ae. taeniorhynchus* and *An. quadrimaculatus*, respectively.

The results (Table 1) indicated that the formulations of permethrin and propoxur were highly effective against adult mosquitoes when dispersed as ULV aerosols. (Data from both permethrin formulations were combined for probit analysis since paired tests showed no difference in mosquito kill.) The effective doses (ED_{90}, lb AI/acre) and 95% confi-

Table 1. Efficacy of insecticidal aerosols against caged adult female mosquitoes

Dose (lb AI/acre)	Flow rate (ml/min)	Dispersal speed (mph)	No. of tests	Average % 12 hr mortality for indicated species[a]	
				Aedes taeniorhynchus	*Anopheles quadrimaculatus*
Permethrin (FMC–33297, 3.2 lb AI/gal EC)					
0.005	35	10	1	83	100
.01	35	5	3	79	88
.02	35	2.5	4	96	96
.04	70	2.5	2	96	97
Permethrin (ICI-PP 557, 2 lb (AI/gal EC)					
.00125	29	20	1	7	92
.0025	29 & 58	10 & 20	3	66	95
.005	58	10	3	91	99
.01	58 & 116	5 & 10	5	85	97
.02	58	2.5	4	99	100
.04	116	2.5	2	100	100
Propoxur (Baygon ULV, 1.67 lb AI/gal)					
.0025	68	20	1	9	44
.005	68	10	2	64	78
.01	68 & 136	5 & 10	2	91	99
.02	272	10	1	100	100
.04	272	5	2	99+	100
Fenthion (Baytex ULV, 9.67 lb AI/gal)					
.0065	30	20	1	77	82
.013	30	10	4	86	92
.026	30	5	3	93	99+

[a] Average for 150- and 300-ft exposures.

dence limits for permethrin, propoxur, and fenthion against *Ae. taeniorhynchus* were 0.011 (0.009-0.013), 0.009 (0.007-0.012) and 0.017 (0.012-0.030), respectively. The ED_{90}'s for permethrin, propoxur, and fenthion against *An. quadrimaculatus* were >0.00125 (92% kill at 0.00125 lb AI/acre), 0.006 (0.005-0.009), and 0.01 (0.005-0.015), respectively. Thus permethrin was ca. 10X more effective against *An. quadrimaculatus* than the fenthion standard, but was only slightly more effective than fenthion against *Ae. taeniorhynchus*. Tolerance of *Ae. taeniorhynchus* to pyrethroid insecticides was noted previously by Rathburn and Boike (1972), Mount and Pierce (1973) and Mount and Pierce (1975).

DROPLET SIZE DETERMINATIONS

ICI-PP 557 and Baygon ULV were analyzed for aerosol droplet size by using both the hand wave and settlement chamber methods described by Mount and Pierce (1972). However, the chambers used in the settling method in the present tests were 12 × 12 × 8 ft high and settlement time was reduced to 1 hr (unpublished data). We found that the spread factors for ICI-PP 557 and Baygon ULV on Teflon®-coated glass microscope slides were 0.7 and 0.6, respectively.

Table 2 indicates essentially the same results with both methods of determining droplet size. The volume median diameters (VMD) of 8 and 9 μm for ICI-PP 557 and Baygon ULV, respectively, were ca. the size determined to be necessary for maximum efficiency against adult mosquitoes (Mount et al. 1968, Mount and Pierce 1972, and Lofgren et al. 1973). In previous tests fenthion dispersed at 60 ml per min with a Leco HD nozzle at 4 psi had a VMD of 10μm (Mount et al. 1975b).

AUTOMOTIVE PAINT PANEL EXPOSURES

Acrylic lacquer painted panels were exposed to aerosols of ICI-PP557 (58 ml/min) and Baygon ULV (272 ml/min). These panels were 10 × 15 cm in size and were coated with 1974–75 automotive paints. The panels were taped on wooden stakes at a height of 4 ft above ground and exposed to aerosols dispersed from a distance of ca. 6 ft. Three types of exposures were made: (1) nozzle aimed horizontal (parallel to the ground) and aft with the truck moving at 10 mph, (2) the nozzle horizontal and aimed to the side of the truck toward the panels with the truck moving at 10 mph, and (3) the nozzle horizontal and aimed toward the panels with the truck stationary for 15 sec. Exposure type 1 represented actual operating conditions except that nozzles are usually aimed upward 45° to avoid direct blasting of vehicles that may be following too closely. In our test, the nozzle was kept horizontal so the aerosol cloud would not drift above the

Table 2. Droplet size distributions of insecticidal aerosols dispersed by a Leco HD nozzle operated at 4 psi.

Adulticide	Flow rate (ml/min)	No. droplets measured	% of total volume in droplets in indicated size range (μm) <5	5–20	>20	VMD (μm)
Hand-wave method						
Permethrin (ICI-PP 557)	58	301	17	81	2	8
Propoxur (Baygon ULV)	272	317	19	63	18	9
Settlement-chamber method						
Permethrin (ICI-PP 557)	58	501	7	93	0	8
Propoxur (Baygon ULV)	272	217	8	92	0	9

panels. Exposure types 2 and 3 represented overexposures that should not take place in actual operations; however, they provided an indication of what would happen if aerosols of these chemicals were applied improperly. The aerosols were all dispersed upwind of the panels; wind velocity was 1-3 mph. The panels were observed with the naked eye immediately after exposure and with 10X magnification at 18 hr after exposure.

Observations of the painted panels by naked eye revealed no spotting with exposure types 1 and 2 (aerosol generator moving). Exposure type 3 (generator stationary for 15 sec) produced a coating of the formulations on the panels. However, after 18 hr, the coatings of both formulations had completely evaporated. Thus the ICI-PP 557 and Baygon ULV formulations left no visible residue and caused no apparent damage to the painted panels.

CONCLUSIONS

We concluded that the ICI-PP 557 and FMC-33297 formulations of permethrin and the Baygon ULV formulation of propoxur were well suited to ULV ground aerosol dispersal. Both chemicals could provide satisfactory control of species of mosquitoes that have become resistant to organophosphorus insecticides. These formulations would not cause damage to surfaces painted with acrylic lacquer, even with gross overexposures.

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