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INFLUENCE OF GROUND ULV DROPLET SPECTRA ON ADULTICIDE EFFICACY FOR *AEDES TAENIORHYNCHUS*

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ABSTRACT. A series of 76 field trials in a vegetated habitat with caged adult *Aedes taeniorhyncus* mosquitoes determined that ground ultra-low volume treatment efficiency was significantly influenced by droplet size. Small droplets (7-μm volume median diameter [VMD]) produced the lowest mosquito mortality at all test distances (100–500 ft.). A VMD of 26 μm was effective at 100–300 ft., but was not effectual at 400–500 ft. Droplets in the 15-μm range were the most effective overall, at the distances evaluated.

INTRODUCTION

It is commonly acknowledged that efficient adult mosquito control is difficult to achieve with ground-applied ultra-low volume (ULV) insecticides in vegetated habitats (Curtis and Mason 1988, Rathburn and Dukes 1989). The cited studies identified the need for higher than normal dosage rates to achieve adequate adult control in vegetated environments compared to dosages required in open situations.

The influence of droplet size on mosquito mortality has been the object of several investigations (Latta et al. 1947, Weidhaas et al. 1970, Mount et al. 1968, Mount 1970, Haile et al. 1982a). However, most of these investigations were conducted under laboratory conditions or in open field habitat, not in vegetated habitats, as are often encountered in mosquito control operations. Rathburn and Dukes (1989) reported the significant reduction of total malathion droplets in a vegetated habitat versus an open field. The object of the present study was to evaluate the effectiveness of three different ULV aerosol droplet size spectra on adult mosquito mortality in a vegetated habitat.

MATERIALS AND METHODS

Study area: All field tests were conducted in a mature 580-acre (234.7-ha) citrus grove in Vero Beach, FL. This moderately densely vegetated habitat was selected because it represented a uniformly vegetated environment suitable for repeatable experimentation.

This typical double-bedded citrus grove is configured with 2 rows of trees per bed with the rows being 25 ft. (7.6 m) apart. Trees are spaced at 20 ft. (6.1 m) centers and tree height is about 12 ft. (4 m). Each bed is separated by a furrow that is 25 ft. (7.6 m) wide. The overall length of the grove is about 1,320 ft. (402.3 m).

Test procedures: Testing was conducted as previously described (Curtis and Mason 1988). Three to 6-day-old laboratory-reared FLAMINGO strain *Aedes taeniorhynchus* (Wiedemann) females were caged (25/cage) in modified WHO cages (Haile et al. 1982a). Before testing, caged mosquitoes were held in insulated chests and provided with water. Immediately following insecticide exposure, mosquitoes were mechanically transferred to clean holding cages, returned to the chests, and provided with 10% sucrose. Survival/mortality data were tabulated 12 h following treatment. Additional cages used for control were handled identically to the test cages except for insecticide exposure. These controls were used for mortality adjustment (Abbott 1925). If the control mortality was greater than 10% in any particular test, we eliminated that event from the data set. Typically, 4 or 5 individual tests were conducted beginning at sunset with each testing event.

The test plot consisted of 2 parallel transects 50 ft. (15.2 m) apart. Mosquito cages were hung atop 4-ft. (1.2-m) polyvinyl chloride stakes spaced at 100, 200, 300, 400, and 500 ft. (30.5, 61, 91.4. 121.9, 152.4 m) from the application point. Test cages were positioned so they were beside the citrus trees. Cages were not protected within a tree's individual canopy cover. The test plot's dimensions were 500 ft. (152.4 m) by 800 ft. (243.8 m). Both sets of cages were positioned in the center of the test plot. When the wind was not parallel to the plot, the cages were placed off center to insure insecticidal coverage at that wind angle. Perimeter roads around the grove allowed us to apply insecticide with all wind directions; the selection of ULV truck travel direction was the one that would reduce the angle of the insecticide drift to the test cages.

All tests were conducted using a 4-nozzle Curtis Dyna-Fog Cyclotronic® ULV machine. The chemical flow rate was adjusted using a MicroGen® electronic control device and a Fluid Metering Inc. (FMI) pump.

Calibration: All trials were conducted with 57% permethrin (Punt®) applied at 0.005 lb/

Table 1. Overall percent mortality of *Aedes taeniorhynchus,* evaluated by droplet size.

	Droplet size (volume median diameter):		
	7 μm	15 μm	26 μm
Mean	14.4	34.6	26.9
Maximum	83.4	100	100
Minimum	0	0	2.2
SD	19.4	23.2	24.1
n	10	44	22

Table 2. Percent mortality of *Aedes taeniorhynchus* evaluated by distance at each of the test droplet sizes.

Distance (ft.)	Droplet size (volume median diameter):		
	7 μm	15 μm	26 μm
100	19.9	47.4	40.2
200	18.5	38.6	30.7
300	10.6	28.1	27.5
400	7.8	32.9	22.7
500	15.4	28.9	13.2

acre AI (0.006 kg/ha). Before each test the ULV machine discharge was calibrated for insecticide volume output and correct droplet size spectrum production. Vehicle speed was maintained at 10 mph (16.1 km/h) in all tests. Three droplet size spectra were selected for evaluation: 7, 15, and 26 μm volume median diameter (VMD). The droplet spectra were tested before each experiment using the Teflon®-coated slide swinging technique (Beidler 1975). Blower pressure was regulated to maintain the desired droplet VMD. The insecticide reservoir on the truck was replaced with a gravity-fed graduated cylinder. This allowed accurate (±5 ml) measurement of actual chemical applied in each trial. In each test the insecticide was applied over a measured 800-ft. (243.8-m) route. Vehicle speed was electronically timed so mathematical corrections could be made for actual insecticide dosage.

Meteorological data collection: Meteorological data were collected at 1-sec intervals with a recording anemometer (Weather Measure #2010) and a recording wind vane (Weather Measure #2005) coupled to a portable IBM PC computer. Temperature was measured at 5 ft. (1.5 m) and 32 ft. (9.8 m) above the ground to determine stable conditions. These data were later analyzed in concert with the mosquito mortality information.

Mortality correction: All mosquito mortality data were corrected according to the procedure described by Curtis and Mason (1988). This correction is based upon distance traveled by the insecticide droplets using wind speed and direction. As wind angle changes, the distance the droplets travel varies from the established test plot distances. This correction normalizes the distances within tests for statistical evaluation between experiments.

RESULTS AND DISCUSSION

The efficiency of 57% permethrin was evaluated over the 3 predetermined VMDs in a series of 76 individual trials. A summary of the overall effectiveness, over all distances in the test plot (100–500 ft.) is presented in Table 1.

Obviously, the data show that droplet size is a critical determining factor in the overall effectiveness of this material. Table 1 shows that droplets in the 15-μm size range produced the highest overall mortality of the 3 droplet size spectra tested (34.6%). The 7-μm (14.4%) and the 26-μm (26.9%) droplets both had significantly lower mortality than the 15-μm droplets (Tukey HSD, $P = 0.0001$). The overall mortality produced by the 7-μm droplets (14.4%) was also significantly lower than that produced by the 26-μm droplets (Tukey HSD, $P = 0.0001$).

Dissimilarities of the 3 droplet size spectra are apparent when the mosquito mortality data are reviewed by droplet size at each of the discrete distances tested (Table 2). The 15-μm droplets produced the highest mortality at each of the test distances. This mortality was significantly higher than that of the 7-μm droplets at all cage locations (Tukey HSD, $P = 0.001$) and was significantly higher than the 26-μm droplets at 400 and 500 ft. (Tukey HSD, $P = 0.001$). The smallest VMD tested, 7 μm, was uniformly ineffective at all distances. Even at the nearest test cage position (100 ft.) the mean mortality was low (19%); this statistically contrasts with the 15-μm droplets' mortality at 30.5 m of 60%. The 7-μm droplets were significantly lower than either of the 2 other test VMDs at all test distances, except 500 ft. (Table 2).

The 26-μm droplets showed an interesting mortality distribution: the effectiveness at 100–300 ft. was statistically similar to that of the 15-μm droplets. However, from 400 to 500 ft. the measured mortality declined rapidly with distance from the insecticide discharge point. The mortality dropped to 22.7% at 400 ft. and 13.2% at 500 ft., both significantly lower than that of the 15-μm droplets (Tukey HSD, $P = 0.002$ and $P = 0.001$, respectively).

Many factors determine the efficiency of a ground adulticiding application. These include insecticide toxicity, dosage rate, droplet size, meteorological conditions, habitat treated, and potential exposure of the mosquito to the insecticide aerosol. Lofgren et al. (1973) reported that droplets in the 1 to 16-μm spectra were most readily collected on the bodies of mosquitoes. However, in vegetated habitats the small droplets that may be collected on mosquitoes may not physically be capable of reaching adult mosquitoes with ground-applied ULV insecticides. Rathburn and Dukes (1989) reported that the effective dosage rate from ground application is reduced by 3.24 times in vegetated areas as compared to open. Their study certainly illustrates the difficulties of ground ULV droplet penetration of vegetated locations. This current investigation has demonstrated droplet size influences on caged mosquito mortality in vegetated environments. The maximum efficiency of the 57% permethrin is produced when the VMD is maintained at 15 μm. This agrees with the study of Haile et al. (1982b) that concluded that malathion droplets in the 10–15-μm range were the most effective. Droplets with the smallest VMD evaluated (7-μm) were the least lethal at all distances observed. The reasons for this are unclear. Possibly, these small droplets disperse vertically through the test plot, missing the cage positions. They may lack sufficient impinging momentum to penetrate the cages and affect the test mosquitoes. Large droplets (26-μm) are lethal at the near distances, that is at 100–300 ft.; however, beyond that distance the particles are inefficient. Wind will only carry these droplets short distances before they either impinge on vegetation or succumb to gravity. Gravity is most likely responsible for inefficiency of these large droplets beyond 300 ft.

In this study we maintained the dosage at 0.005 lb/acre AI. In past studies we have investigated the role of application rate on mosquito mortality (Curtis and Mason 1988). It bears discussion here to stress that treatment with a low dosage rate will be ineffective no mater how optimal the droplet size spectrum. Operationally, there is a strong temptation to apply permethrin at low rates (<0.001 lb/acre AI) because of cost. However, treatments at low rates will most likely be ineffective, especially in vegetated habitats, and will require reapplication. The same logic applies if care is not exercised in calibrating the ULV generator to produce the proper droplet size. This material has low viscosity and is easily atomized into droplets that are smaller than the most effective droplet size spectra. ULV generators must be carefully maintained and calibrated to insure optimum droplet size. If the drops are too small (7 μm) or too large (26 μm), even an effective dosage rate may be degraded to unacceptable levels requiring retreatment.

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