ULTRA-LOW VOLUME NONTHERMAL AEROSOLS OF MALATHION AND NALED FOR ADULT MOSQUITO CONTROL [1]

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Recently, investigators (Knapp and Roberts, 1965; Glancey *et al.*, 1965 and 1966; Knapp and Pass, 1966a and 1966b; Stevens and Stroud, 1966; Kilpatrick *et al.*, 1967; Mount and Lofgren, 1967) showed that ultra-low volume (ULV) aerial sprays of several insecticides will effectively control adult mosquitoes. However, adult mosquito control with ULV aerosols applied with ground equipment has not been reported. Such application would have several advantages: (1) it would eliminate or reduce to a minimum the need for carriers, solvents, and additives, (2) it would reduce the amount of spray solution or mixture that has to be carried and applied, (3) it would eliminate mixing and diluting insecticides, and (4) it would permit a reduction in the size of the equipment. The tests reported here were made: (1) to develop a means of producing aerosols from undiluted technical insecticide, (2) to correlate particle size of ULV aerosols with kill of adult mosquitoes, and (3) to compare the effectiveness of ULV nonthermal aerosols with that of high volume thermal aerosols on both caged and free-flying adult mosquitoes.

METHOD FOR PRODUCING ULV AEROSOLS. ULV insecticidal aerosols were produced by a nonthermal aerosol generator (Curtis Model 55,000) modified by replacing the standard 10-nozzle boom with a 3-nozzle boom or head (Figure 1) and replacing the insecticide pumping system with a CO_2 pressurized system. Also, a small needle valve was placed in the insecticide line between the tank and atomizing nozzles to permit precise calibrations of flow rates.

We do not want to imply this method of producing aerosols is the only means possible. Undoubtedly other apparatus could be used, and other modifications of the cold fogger are possible.

CORRELATION OF PARTICLE SIZE WITH MOSQUITO KILL. Different particle sizes could be obtained with the ULV aerosol generator by varying the volume of air and, to a lesser extent, by regulating the quantity of insecticide passing through the atomizing nozzles. Particles of malathion were then collected on silicone (General Electric SC-87 Dri-Film) treated glass microscope slides by waving the slides through the spray at a distance of 25 ft from the point of discharge. Mass median diameters (mmd) were determined according to the methods of Yeomans (1949); particle size was determined for four rates of air discharge and three doses, a total of 12 combinations. Rate of air discharge was measured on the manometer that is an integral part of the nonthermal aerosol generator and is reported as inches of differential height of mercury in the two columns of the manometer. Each inch of mercury differential represents ½ p.s.i.

Effect of particle size on mosquito kill was evaluated with caged female *Aedes taeniorhynchus* (Wiedmann) from the laboratory colony. The females were exposed to the aerosols by placing cages 5 ft above the ground on stakes 150, 300, and 600 ft downwind of the path of the aerosol generator. From 2 to 3 replications of three cages of 25 mosquitoes each were tested with each combination, and percentage mortality was determined 18 hours posttreatment.

[1] Mention of a proprietary product does not necessarily imply endorsement of this product by the USDA.

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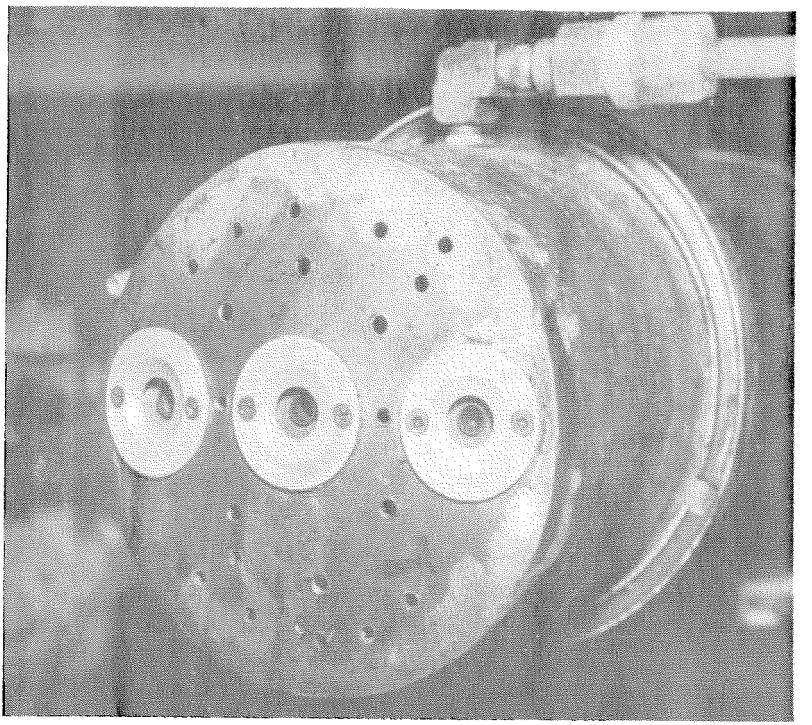

FIG. 1.—Three-nozzle head used to disperse aerosols of undiluted malathion and naled. Small holes drilled in face bleed off excess air volume.

Table 1 shows that with malathion the average mmd produced by the nonthermal generator ranged from 6 to 22.4 microns, depending on the rate of flow and air discharge. In general, the percentage mortality of mosquitoes increased when the mmd decreased at a given dose. For example, at a dose of 0.009 lb of malathion per acre, a mmd of 17.4 microns gave 71 percent average kill compared with 97 percent kill when the mmd was only 6.4 microns. These results probably reflect a tendency of the smaller particles to drift farther and thus to cause greater kill, especially at a distance of 600 ft.

COMPARISON OF ULV AND HIGH VOLUME AEROSOLS. The toxicity of ULV nonthermal and high volume thermal aerosols of malathion or naled (Dibrom 14) to caged and free-flying mosquitoes was compared. A Leco Model 120 calibrated to deliver 40 gal of fluid per hour and operated at a burner temperature of 850° F was used to disperse the thermal aerosols. The nonthermal aerosol generator (Curtis 55,000) was operated at a differential of 8 and 12 inches of mercury in the tests with malathion and naled, respectively.

Malathion was tested during the spring of 1967 against caged mosquitoes; naled was tested the following summer against both caged and free-flying mosquitoes. The procedures for the tests with caged mosquitoes were the same as those used in the tests of particle size.

The tests with malathion (Table 2) showed a slight difference in kill for the ULV and the high volume aerosols: the LD_{90} was 0.012 lb. of malathion per acre for the ULV aerosol and 0.018 lb. per acre for the high volume aerosol.

The data obtained with naled against

TABLE 1.—Effect of particle size on efficiency of kill of caged female *Aedes taeniorhynchus* (Wiedemann) with ultra-low volume nonthermal aerosols of undiluted malathion (95 percent).

Dose[a] (lb/acre)	Flow rate (gal/hr)	Air discharge (differential in in. Hg.)	Mass median diameter (microns)	Percent mortality after 18 hr at indicated distance (ft)			Average percentage mortality
				150	300	600	
0.0045	0.17	3.2	13.4	34	18	8	20
		5.2	11.6	34	38	18	30
		8	8.3	56	38	28	41
		12	6.0	50	38	38	42
.009	.34	3.2	17.4	90	52	70	71
		5.2	12.3	98	98	32	76
		8	9.7	100	100	88	96
		12	6.4	92	100	98	97
.018	.68	3.2	22.4	100	84	76	88
		5.2	14	100	100	100	100
		8	10.8	100	100	96	99
		12	7.6	100	100	100	100

[a] Based on a 600 ft swath and a truck speed of 5 m.p.h.

TABLE 2.—Comparison of ultra-low volume nonthermal and high volume thermal aerosols of malathion against caged female *Aedes taeniorhynchus* (Wiedemann).

Dose[a] (lb/acre)	Concentration (%)	Flow rate (gal/hr)	Percent mortality after 18 hr at indicated distance (ft)			Average percentage mortality
			150	300	600	
		ULV (95 percent malathion, undiluted)				
0.0045	95	0.17	68	48	40	52
.009	95	.68	100	89	61	83
.018	95	.68	99	97	99	98
.036	95	1.36	100	100	90	97
		High Volume (malathion diluted in No. 2 fuel oil)				
.0045	0.5	40	52	52	16	40
.009	1	40	89	87	81	86
.018	2	40	88	97	87	91
.036	4	40	96	100	90	95

[a] Based on a 600 ft swath and a truck speed of 5 m.p.h. except for the ULV dose of 0.009 lb/acre which was dispersed at 10 m.p.h.

caged mosquitoes (Table 3) indicated that the ULV aerosol was definitely more effective. For example, at a dose of 0.009 lb. of naled per acre, ULV aerosols gave 87 percent kill compared to 47 percent kill for the high volume aerosols. During these tests, the high volume applications of naled layered out at 10 ft. or more above ground; the ULV aerosols appeared to remain closer to the ground, which probably accounts for the greater kill with this type of application. (The results with malathion and naled should not be compared because the two compounds were not evaluated at the same time and the weather conditions were noticeably less favorable in the tests with naled.)

The tests with naled against free-flying mosquitoes (predominantly *A. taeniorhynchus*) were conducted in citrus groves near Titusville, Florida in a plot of about 6 acres. The landing rate of mosquitoes was counted at six locations, two each 100, 200, and 300 ft. from the path of the aero-

TABLE 3.—Comparison of ultra-low volume nonthermal and high volume thermal aerosols of naled against caged female *Aedes taeniorhynchus* (Wiedemann).

Dose[a] (lb/acre)	Concentration (%)	Flow rate (gal/hr)	Percent mortality after 18 hr at indicated distance (ft)			Average percentage mortality
			150	300	600	
ULV (Naled, undiluted)						
0.0045	85	0.12	76	58	24	53
.009	85	.24	100	100	60	87
.018	85	.48	100	98	66	88
High Volume (Naled, diluted in No. 2 fuel oil)						
.0045	0.5	40	32	8	2	14
.009	1	40	64	52	24	47
.018	2	40	70	92	80	81

[a] Based on a 600 ft swath and a truck speed of 5 m.p.h.

sol generators, just before the application (<1 hr.) and ½ and 12 hrs. after application. Doses of 0.018 and 0.036 lb. per acre were applied with the ULV nonthermal aerosol generator, and 0.036 lb. per acre was applied with the Leco fogger between 7:30 and 8 p.m. The formulation used in the Leco consisted of 2 percent naled in No. 2 fuel oil containing 0.5 percent Ortho additive (mixed amide-amine oleate from modified fatty acids and polyamines). The results are shown in Table 4. At a dose of 0.036 lb. per acre, the ULV aerosol gave 95 percent control in ½ hr. compared with 74 percent control for the high volume aerosol; the ULV aerosols containing 0.018 lb. per acre gave 85 percent control in ½ hr. Reinfestation occurred after 12 hrs. (overnight) with all treatments.

SUMMARY. A nonthermal aerosol generator (Curtis Model 55,000) was modified to disperse ultra-low volume (ULV) aerosols of malathion and naled, and tests were conducted against both caged and natural populations of *Aedes taeniorhynchus* (Wiedemann). 1. At all doses tested, particles of malathion having mmd's of 6 to 10 microns were more effective than particles of 11 to 22 microns. 2. ULV nonthermal aerosols of malathion were at least as effective as high volume thermal aerosols against caged mosquitoes. 3. ULV aerosols of naled were more effective than high volume aerosols against caged and free-flying mosquitoes.

TABLE 4.—Comparison of ultra-low volume nonthermal and high volume thermal aerosols of naled against natural populations of salt-marsh mosquitoes, predominantly *Aedes taeniorhynchus* (Wiedemann).

Type of aerosol[a]	Dose (lb/acre)[b]	Concentration (%)	Flow rate (gal/hr)	Percentage control at indicated interval after treatment	
				½ hr	12 hr
Thermal, high volume	0.036	2	40	74	20
Nonthermal, ULV	.036	85	0.48	95	24
Nonthermal, ULV	.018	85	.24	85	0

[a] Naled was diluted in No. 2 fuel oil for high volume treatments and was undiluted for ultra-low volume treatments.

[b] Based on a 300 ft. swath and a truck speed of 5 m.p.h.

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