A NEW ULTRA-LOW VOLUME COLD AEROSOL NOZZLE FOR DISPERSAL OF INSECTICIDES AGAINST ADULT MOSQUITOES[1]

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Mount *et al.* (1968) reported that ultra-low volume (ULV) cold aerosols of malathion and naled were highly effective against adult mosquitoes. To further evaluate the potentialities of ULV aerosols a commercially manufactured nozzle[2] that disperses liquid insecticide concentrates from ground equipment has been tested to: (1) determine the droplet size range produced by the ULV nozzle; (2) compare the effectiveness of aerosols produced by the ULV nozzle with aerosols produced by a high-volume thermal nozzle; (3) establish minimum doses for satisfactory adult mosquito kill with ULV cold aerosols of malathion, naled, and fenthion, and (4) determine the effect, if any, of dispersal speed on efficiency of adult mosquito kill with ULV cold aerosols.

Method and Materials. The Leco ULV cold aerosol nozzle was used on both a modified Leco 120 thermal aerosol generator and a modified Curtis 55,000 cold aerosol generator. Maximum air pressure with the Leco 120 at 3350 r.p.m. was 3.5 p.s.i. The Curtis 55,000 was also operated at 3.5 p.s.i. even though air pressures as high as 6 p.s.i. can be produced with this unit. Mount *et al.* (1968) showed greater atomization of technical malathion with increased air pressure using similar type venturi nozzles. A

[1] Mention of a proprietary product in this paper does not constitute an endorsement of this product by the USDA.

[2] Developed by Lowndes Engineering Co., Inc. (Leco), Valdosta, Georgia.

[3] Roger Gilmont Instruments, Inc., Great Neck, New York 11021.

Gilmont[3] flowmeter and a small brass needle valve were used to regulate the flow of concentrated or technical liquid insecticide from <1 to about 6 fluid ounces per minute at 3.5 p.s.i. tank pressure. No insecticide pump is necessary with the ULV system.

Droplet size estimates were made for flow rates of technical malathion ranging from 0.715 to 5.7 fluid ounces per minute. Droplets were collected on silicone (General Elecric SC–87 Dri-Film) treated glass microscope slides by waving the slides through the aerosol at a distance of 25 feet from the point of discharge. A sample of 200 droplets for each flow rate was measured with an ocular micrometer at 400× magnification. Diameters of the original spheres were estimated by correcting the diameter of the droplets impinged on the slides for the amount of spread that had taken place. (The spread factor for technical malathion was 0.4.) Mass median diameters were computed according to the methods presented by Yeomans (1949) for estimating size of impinged droplets.

Two series of tests were conducted with caged adult female *Aedes taeniorhynchus* (Wiedemann). The first series compared the effectiveness of ULV cold and high volume thermal aerosols of malathion. The cold aerosols were dispersed with the ULV nozzle mounted on the Curtis 55,000 (after high-volume nozzle assembly had been removed and insecticide pump disconnected). A Leco 120 calibrated to deliver 40 gallons of fluid per hour and operated at a burner temperature of 850° F was used to disperse the thermal aerosols. The ULV cold aerosols were dispersed at speeds of either 10 or 20 m.p.h., whereas the high-volume thermal aerosols were dispersed at 5 m.p.h. The doses of malathion tested ranged from 0.009 to 0.036 pound per acre based on amount of active ingredient used over a 600-foot swath. Since these are not residual treatments, we do not believe there is any need to be concerned about that portion of the insecticide which is deposited in the plot. However, those involved in mosquito control operations have to know how much insecticide is needed for a given acreage to obtain satisfactory mosquito kill.

The second series of tests was conducted to establish minimum effective doses of naled and fenthion that could be used for adult mosquito control. The ULV nozzle was mounted on the Leco 120 for these tests (after thermal nozzle and burner assembly were removed and insecticide pump was disconnected). Aerosols of naled and fenthion were dispersed at 15 m.p.h. Dosages tested were 0.006 and 0.012 pound per acre with naled and 0.0036 and 0.0072 pound per acre with fenthion.

In both series of tests the mosquitoes were exposed to the aerosols by placing cages 5 feet above the ground on stakes 150, 300, and 600 feet downwind of the path (¼ mile in length) of the aerosol generator. From 2 to 3 replications of 6 cages of 25 mosquitoes each were tested with each dose of each insecticide and each type of aerosol. Percent mortality was determined 18 hours posttreatment. Mosquitoes taken to the field and handled in the same manner, but not exposed to the insecticide aerosols, showed an average mortality of 5 percent.

Weather conditions were about the same for both series of tests against caged mosquitoes. Air temperatures ranged from 73° to 83° F and averaged about 80° F. Wind speeds at 5 feet above the ground ranged from <1 to 6 m.p.h. and averaged about 2.5 m.p.h.

RESULTS AND DISCUSSION. Droplet size data for technical malathion dispersed from the Leco ULV cold aerosol nozzle operated at 3.5 p.s.i. are presented in table 1. With flow rates from 0.715 to 5.7 fluid ounces per minute, mass median diameters ranged from 11 to 16 μ. These droplet size estimates indicated that the Leco ULV nozzle was about equal in atomization efficiency (ability to produce small droplets) to the 3-nozzle head used by Mount *et al.* (1968) and the double air-liquid vortical nozzles used by Stains *et al.* (1969). With the exception of the 5.7

TABLE 1.—Droplet sizes produced by 4 flow rates of technical malathion (95 percent) dispersed from a Leco ULV cold aerosol nozzle operated at an air pressure of 3.5 p.s.i.

Flow rate (fluid ounces/ minute)	Percent of total mass in indicated droplet size range					Maximum diameter (μ)	Average diameter (μ)	Mass median diameter (μ)
	<5 μ	5–10 μ	11–15 μ	16–20 μ	>20 μ			
0.715	5	40	32	20	3	27	9	11
1.43	2	32	38	17	11	30	10	12
2.85	3	23	34	24	16	27	11	13
5.7	2	12	28	28	30	39	14	16

fluid ounces per minute flow rate, droplet spectra were close to the optimum of 5 to 10 μ mass median diameter as suggested by Mount (1970).

Table 2 shows a comparison between ULV cold- and high-volume thermal aerosols of malathion against caged mosquitoes. Higher kills were obtained consistently with the ULV cold aerosols with all three doses of malathion. Estimated LD_{90}'s were 0.025 and >0.036 pound per acre for ULV cold- and high-volume thermal aerosols, respectively. Kills obtained with ULV cold aerosols of malathion dispersed at speeds of 10 and 20 m.p.h. were about equal at identical doses.

Table 3 gives the results obtained with ULV cold aerosols of naled and fenthion dispersed at 15 m.p.h. against caged mosquitoes. The doses tested were based on LC_{90}'s for 300-foot swaths which were reported by Mount *et al.* (unpublished data) for high-volume cold aerosols. For naled the dosage of 0.012 pound per acre (2 fluid ounces per minute) is equivalent to a 1.3 percent (w/v) formulation dispersed at 40 gallons per hour and at 5 m.p.h. The dosage of 0.0072 pound per acre (1.73 fluid ounces/minute) for fenthion is equivalent to an 0.8 percent (w/v) formulation dispersed at 40 gallons per hour and at 5 m.p.h. Using the ULV cold aerosol nozzle, naled and fenthion gave average kills of 90–94 percent over 600-foot swaths with these dosages (0.012 and 0.0072 pound per acre, respectively). At one-half the LC_{90} for high-volume aerosols, naled produced from 97 percent to 98 percent kill and fenthion produced from 83 to 90 percent kill at distances of 150 and 300 feet.

Based on results presented in tables 2

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

Dosage (pound/ acre[a])	Dosage (fluid ounces/ acre)	Malathion concentration (percent)	Flow rate (gallons/ hour)	Flow rate (fluid ounces/ minute)	Vehicle speed (m.p.h.)	Percent mortality after 18 hours at indicated distance (feet) 150	300	600	Average percentage mortality
Leco ultra-low volume cold aerosol									
0.009	0.12	95	0.68	1.43	10	88	46	72	69
.009	.12	95	1.36	2.85	20	100	60	70	77
.018	.24	95	1.36	2.85	10	93	93	93	93
.018	.24	95	2.72	5.7	20	80	84	95	86
.036	.48	95	2.72	5.7	10	89	88	99	92
Leco 120 high-volume thermal aerosol									
.009	14	1	40	85	5	74	82	40	65
.018	14	2	40	85	5	51	61	66	59
.036	14	4	40	85	5	93	88	74	85

[a] Based on A.I. used over a 600-foot swath.

and 3, estimated LD_{90}'s for malathion, naled, and fenthion were 0.025, 0.0095, and 0.0072 pound per acre, respectively. For a dispersal speed of 15 m.p.h. the respective flow rates for 300- and 600-foot swaths are as follows: malathion (9.7 pounds A.I./gallon)—3 and 6 fluid ounces per minute; naled (14 pounds A.I./gallon) —0.8 and 1.6 fluid ounces/minute; and fenthion (9.67 pounds A.I./gallon)—0.87 and 1.73 fluid ounces minute.

Our tests were not designed to determine maximum swaths possible with ULV cold aerosols. We believe that swath width is a function of insecticide dose, droplet size, and weather conditions. Stains *et al.* (1969) demonstrated that it is possible to obtain swaths up to 1–2 miles with high wind conditions (6–8 m.p.h.) and flow rates of 33 and 37.2 ounces per minute of naled (Dibrom® 14) and Dursban® (*o, o*-diethyl *o*-3,5,6-trichloro-2-pyridyl phosphorothioate) (6 pounds A.I./gallon), respectively, dispersed at 5 m.p.h. Taking into consideration the difference in dispersal speed, this represents a flow rate of Dibrom 14 which is 50 times greater than what we used to obtain a 600-foot swath under low wind conditions (2.5 m.p.h.).

TABLE 3.—Effectiveness of ultra-low volume cold aerosols of naled and fenthion dispersed at 15 m.p.h. against caged female *Aedes taeniorhynchus* (Wiedemann).

Dosage[a] (pound/acre)	Dosage[a] (fluid ounce/acre)	Insecticide concentration (percent)	Flow rate (gallon/hour)	Flow rate (fluid ounces/minute)	Percent mortality after 18 hours at indicated distance (feet): 150	300	600	Average percentage mortality
Naled (Dibrom®—14 pounds A.I./gallon)								
0.006	0.056	85	0.475	1	98	97	33	76
.012	.112	85	.95	2	99	99	83	94
Fenthion (Baytex®—9.67 pounds A.I./gallon)								
.0036	.049	93	.412	.87	90	83	64	79
.0072	.097	93	.824	1.73	99	94	78	90

[a] Based on A.I. used over a 600-foot swath.

SUMMARY. A commercially available ultra-low volume (ULV) cold aerosol nozzle was used to disperse malathion, naled, and fenthion against caged adult female *Aedes taeniorhynchus* (Wiedemann). Droplet size estimates of technical malathion ranged from 11 to 16 μ mass median diameter, depending on flow rate. Aerosols of malathion produced by the Leco ULV nozzle were consistently more effective than those produced by high-volume thermal nozzle. The estimated LD_{90}'s for malathion, naled, and fenthion were 0.025, 0.0095, and 0.0072 pound per acre, respectively, based on the amount of active ingredient used per acre. There was no difference in the effectiveness of ULV cold aerosols of malathion dispersed at 10 and 20 m.p.h.

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