DROPLET SIZE AND KILL OF ADULT MOSQUITOES WITH ULTRALOW VOLUME AERIAL SPRAYS DISPERSED FROM A ROTARY-CYLINDER ATOMIZER [1]

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ABSTRACT. The Beeco, a rotary-cylinder atomizer, produced smaller and more uniform droplets of technical malathion and of fenthion than TeeJet® flat-fan nozzles. Also, when ultralow volume insecticidal aerosols produced by the two devices were tested against both natural and caged populations of adult salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wiedemann), the minimum dose could be reduced by about one-half by using the more efficient rotary-cylinder atomizer.

Recently, we (Mount *et al.* 1970a) reported that rotary-disc atomizers gave better atomization of technical insecticides and increased efficiency of adult mosquito kill as compared with flat-fan nozzles. Because of these encouraging results, we have searched for and evaluated other types of atomizers that could have practical use for mosquito control. We recently completed tests with a Beeco rotary-cylinder atomizer designed and manufactured by Beemer Engineering Company, Industrial Park, Fort Washington, Pa. This atomizer consists of a cylinder of sintered stainless steel which is attached to a 12-volt electric motor (see Fig. 1). Insecticide injected into the cylinder (the ends are sealed) is forced through the pores of the cylinder (20 μ) as it is rotated at a high speed (12,000 rpm).

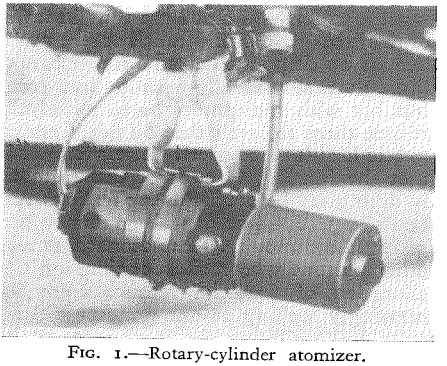

FIG. 1.—Rotary-cylinder atomizer.

ESTIMATES OF DROPLET SIZE. Insecticide droplets were collected from both aircraft application and simulated aerial dispersal using a technique we reported previously (Mount *et al.* 1970). The rotary-cylinders and flat-fans were either flown at a speed of 95 mph on a Stearman aircraft or placed in a 95 mph air blast of a Buffalo Turbine mist blower.

For the aircraft applications, the insecticide droplets were collected on silicone-treated glass microscope slides rotated on a battery-operated spinning device at a speed of 5 mph (to enhance impingement of the smaller spray droplets). With the mist blower, the slides were quickly passed through the air blast at a distance of 12 ft. from the nozzle. Droplets were collected on 6 glass slides for each ultralow volume (ULV) spray. A sample of 100 droplets was measured at 100 x magnification from each glass slide; thus a total of 600 droplets were sampled for each ULV spray.

The diameter of each droplet was determined with the aid of an ocular micrometer; the diameters of the original spheres were estimated by correcting the diameters of the droplets impinged on the slides for the amount of spread that had taken place. Spread factors for malathion and fenthion were 0.4 and 0.46, respectively. Mass median diameters

[1] Mention of a pesticide or a proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the U. S. Dept. of Agriculture.

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(mmd) were computed by the methods of Yeomans (1949) for estimating droplet size from impinged droplets.

A comparison of the malathion droplets produced by the flat-fans and the rotary-cylinders flown on the Stearman aircraft is given in Table 1. The flat-fan nozzles (8003's) produced droplet sizes ranging from <5 to 158 μ and an mmd of 32 μ; the rotary-cylinder atomizers produced droplet sizes ranging from <5 to 103 μ and mmd's of 27 and 30 μ at the flow rates tested. The mmd's for the two devices were therefore similar, but the maximum droplet size produced by the rotary-cylinder atomizer was definitely smaller (68 to 103 μ compared with 158 μ for the flat-fan nozzle), and the percentage of insecticide in droplets of 11 to 25 μ was 8 to 14 percent greater than with the flat-fan nozzle.

The data from the simulated spray tests showed greater differences in droplet spectra between the two spray devices than the data from the actual aircraft applications (see Table 2). However, the droplet data for the mist blower should be more reliable because less sampling error was involved and the problem of drift differential with droplets of different sizes was completely eliminated. With malathion, the flat-fan nozzles produced mmd's of 41 and 55 μ; the rotary-cylinder atomizers produced mmd's of only 26 and 29 μ. Also, the rotary-cylinder atomizers increased the amount of insecticide in droplets of 11 to 50 μ by 33 to 36 percent at equal flow rates of malathion. The data obtained for fenthion also showed a narrower droplet spectrum for the rotary-cylinder atomizers than for the flat-fan nozzles; in addition, the elimination of all droplets of >88 μ increased the volume of insecticide in droplets of 11 to 50 μ by 26 percent.

TESTS WITH CAGED MOSQUITOES. The effectiveness of ULV sprays of technical malathion (95 percent) produced by the rotary-cylinder atomizer and by the flat-fan nozzles was compared by exposing caged adult female *Aedes taeniorhynchus* (Wiedemann) in an open plot (about 40 acres) near Gainesville, Fla. During the applications, air temperatures ranged from 70 to 84° F and averaged about 78° F. Wind velocities at ground level never exceeded 2 mph during any of the tests and were usually <1 mph.

Both spray systems were mounted on a trailing-wing boom on the lower wing of a Stearman aircraft equipped with a self-contained carbon dioxide pressurized spray system. Polyethylene tubing was used to carry the insecticide to the nozzles from a 2½ gallon stainless steel tank placed in the fuselage behind the cockpit. The aircraft was flown at a speed of 95 mph, an altitude of 50 to 75 feet, and at a swath interval of 200 feet.

The rotary-cylinder atomizers (one on each lower wing) were mounted parallel with the fuselage so the cylinder portion was in a trailing position; the insecticide was metered to the atomizers with Tee-Jet® diaphragm and check valve assemblies and with interchangeable orifice plates (No.'s 4916–41 and 4916–59). Line pressures used with the rotary-cylinders varied from 15 to 30 pounds per square inch, depending on the size of the orifice plate and the flow rate desired. The atomizers were powered from a separate 12-volt battery placed in the fuselage behind the cockpit of the aircraft. The rotational speed of the rotary-cylinders averaged about 12,000 rpm as measured by a photo-tachometer.

The flat-fan nozzles, 80015 and 8003, were positioned with two on each lower wing. They were set at a 45° angle forward to the thrust line of the aircraft and were operated at 34 psi.

The 3- to 7-day-old mosquitoes from the laboratory colony were exposed to the aerial sprays in 16-mesh copper screen wire cages (25 mosquitoes per cage) hung on stakes at 5 ft above ground and also placed on the ground at each of five stations 100 ft apart in a row perpendicular to the flight swaths and near the center of the plot. Three to four tests were made with each dose of malathion and each type of nozzle. Thirty minutes after each application, the mosquitoes were transferred to plastic

TABLE 1.—Comparison of droplets produced by TeeJet flat-fan and rotary-cylinder nozzles dispersing 95 percent malathion from a Stearman aircraft flown at 95 mph.

Type of nozzle	Flow rate (fl oz/min)	Percentage of total mass of droplets in indicated size range (μ)					Maximum diameter (μ)	Average diameter (μ)	Mass median diameter (μ)
		<5–10	11–25	26–50	51–100	100–200			
Flat fan (8003)	28	6	33	39	18	4	158	25	32
Rotary-cylinder	28	5	47	33	15	0	68	24	27
Rotary-cylinder	38	2	41	37	19	1	103	28	30

TABLE 2.—Comparison of droplets produced by TeeJet flat-fan and rotary-cylinder nozzles dispersing 95 percent malathion and 93 percent fenthion into the air blast (95 mph) of a Buffalo Turbine mist blower.

Type of nozzle	Flow rate (fl oz/min)	Percentage of total mass of droplets in indicated size range (μ)						Maximum diameter (μ)	Average diameter (μ)	Mass median diameter (μ)
		<5–10	11–25	26–50	51–100	101–200	>200			
					Malathion					
Flat-fan (80015)	14	7	29	22	23	15	4	228	29	41
Flat-fan (8003)	28	5	22	22	23	27	1	210	35	55
Rotary-cylinder	14	11	39	45	5	0	0	64	22	26
Rotary-cylinder	28	7	42	38	13	0	0	82	26	29
					Fenthion					
Flat-fan (8002)	24	7	23	22	23	23	2	218	34	50
Rotary-cylinder	12	10	28	43	19	0	0	88	26	39

tubes lined with clean paper. Except during exposure to the insecticide, the mosquitoes were held in insulated chests containing ice in cans. Absorbent cotton pads moistened with 10 percent (v/v) sugar-water solution were placed on the holding tubes when they were returned to the laboratory. Mortality counts were made 6 and 24 hr after exposure.

The results (Table 3) demonstrated that the rotary-cylinder atomizer produced droplets of malathion that were more efficient in causing mortality of adult mosquitoes than the droplets produced by the flat-fan nozzles. The estimated LD-90's (based on average 24-hr kill) for 95 percent malathion dispersed by the atomizers and the nozzles were 1.9 and 3.4 fluid ounces per acre, respectively.

TABLE 3.—Kill of caged female *Aedes taeniorhynchus* obtained with Beeco rotary-cylinder and TeeJet flat-fan nozzles dispersing 95 percent malathion from a Stearman aircraft.

Dose (pound/acre)	Volume (fl oz/acre)	No. of tests	Percentage mortality at indicated time and cage position					
			6 hr		24 hr			
			Stake	Ground	Stake	Ground	Average	Range
			Rotary-cylinder (Beeco)					
0.057	0.75	3	64	38	74	44	59	33–72
.115	1.5	4	85	70	91	81	86	77–100
.15	2	3	84	66	92	82	87	76–94
			Flat-fan (TeeJet)					
.115	1.5	4	65	54	76	65	71	60–86
.23	3	4	76	64	86	79	83	62–99

TESTS WITH NATURAL MOSQUITO POPULATIONS. The effectiveness of aerial sprays of 93 percent fenthion produced by the flat-fan nozzles and the rotary-cylinder atomizers was compared against natural populations of adult salt-marsh mosquitoes (predominantly *A. taeniorhynchus*) in plots of about 160 acres in citrus groves in Brevard County, Fla. Applications were made between 7:00 and 8:30 a.m. when meteorological conditions were favorable. At ground level, wind velocities never exceeded 2 mph during any of the tests and were usually <1 mph.

The nozzles were mounted on a Quail Commander aircraft (owned and operated by Brevard County Mosquito Control) that was equipped with a carbon dioxide pressurized spray system. Polyethylene tubing was used to carry the insecticide to the nozzles from a 2½ gallon stainless steel tank placed inside the aircraft's hopper. Both the flat-fan nozzles and the rotary-cylinder atomizers were mounted on a trailing-wing boom, one nozzle on each type of each wing boom. The rotary-cylinder atomizers were mounted parallel with the fuselage so that the cylinder portions were in a trailing position, and the insecticide was metered to them with TeeJet interchangeable orifice plates (No. 4916–41) at a pressure of 12 psi. The flat-fan nozzles (80015 and 8002) were positioned at a 45° angle forward to the thrust line of the aircraft and were operated at pressures of 23 and 52 psi. A stainless steel solenoid was used as a positive on-off switch for the insecticide flow. The aircraft was flown at a speed of 95 mph, an altitude of 50 to 75 ft, and at swath intervals of 200 feet.

The effects of the fenthion aerial sprays were evaluated by counts of mosquitoes made the day before treatment and 8 and 24 hours after treatment at 10 locations in each citrus grove plot by two observers

standing side by side and facing in opposite directions. After 30 seconds, each man counted the mosquitoes on the front of his clothing and on the back of the other man's clothing. Counting stations were arranged in a row near the center of each plot perpendicular to the flight swaths.

The results of the tests with natural populations of salt-marsh mosquitoes confirmed those obtained with caged adult salt-marsh mosquitoes (Table 4): the rotary-cylinder atomizer produced a droplet spectrum that was more efficient in controlling adult mosquitoes than the flat-fan nozzles. As a result, the minimum dose of fenthion needed for satisfactory control of adult mosquitoes could be reduced by one-half if ULV aerial sprays were applied with Beeco rotary-cylinder atomizers instead of standard flat-fan nozzles.

TABLE 4.—Control of adult salt-marsh mosquitoes obtained with Beeco rotary-cylinder and TeeJet flat-fan nozzles dispersing 93 percent fenthion from a Quail Commander aircraft.

Dose (pound/acre)	Volume (fl oz/acre)	No. of tests	Percentage control at indicated hr after treatment [a]	
			8 (Range)	24
		Rotary-cylinder (Beeco)		
0.025	0.32	1	71	43
.05	.64	4	89 (80–97)	67
		Flat-fan (TeeJet)		
.05	.64	1	44	58
.1	1.28	2	90 (82–97)	79

[a] Control values were adjusted for population variations in check plots by Abbott's formula.

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