PAPERS AND PROCEEDINGS OF THE 26TH ANNUAL MEETING

of the

AMERICAN MOSQUITO CONTROL ASSOCIATION

and the

ANNUAL MEETING

of the

NORTHWEST MOSQUITO AND VECTOR CONTROL ASSOCIATION

Portland, Oregon, February 22–25, 1970

Part II

DROPLET SIZE AND MOSQUITO KILL WITH ULTRALOW VOLUME AERIAL SPRAYS DISPERSED FROM A ROTARY-DISC NOZZLE[1]

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Our studies of the relationship between droplet size and the kill of adult mosquitoes have indicated that droplets with diameters of 10 to 25 microns (μ) are probably most effective (Mount 1970; Weidhaas *et al.* 1970). However, nozzles used on aircraft produced droplets with a much wider range of size. For example, Mount *et al.* (1970) reported that the majority of droplets produced by flat-fan tips are 10 to 125 μ in diameter and that the mass median diameter (mmd) of the spectrum of total spray ranges from 30 to 60 μ. Thus, as we have suggested previously, increased efficiency of aerial sprays must await a breakthrough in nozzle design (Mount *et al.* 1970). We have therefore made an effort to evaluate types of nozzles when they became available. This paper reports the results we obtained when we tested the Turboero rotary-disc nozzle designed and manufactured by Micron Sprayers Limited, Birmingham, England.

ESTIMATES OF DROPLET SIZE. In the tests to determine droplet size, aerial dispersal was simulated with ground equipment (Mount *et al.* 1970). Thus, the rotary-disc and flat-fan nozzles were positioned in a 95 m.p.h. air blast of a Buffalo Turbine mist blower. Undiluted malathion (95 percent) or fenthion (93 percent) was fed to the nozzles through a polyethylene line from a stainless steel tank pressurized with carbon dioxide. Insecticide droplets were collected on silicone-treated glass microscope slides by waving the slide through the air blast at a distance 12 feet from the nozzle. Droplets were collected on 2 or 3 glass slides for each ultra-low-volume (ULV) spray during each test. The fenthion sprays were replicated twice and the malathion was unreplicated. A sample of 100 droplets was measured at 100X magnification from each glass slide which gave a total of 200 to 600 droplets sampled for each ULV spray.

The diameter of the droplets was determined with the aid of an ocular microm-

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

eter, and the diameter of the original spheres was estimated by correcting the diameters of the impinged droplets for the amount of spread. The spread factors for malathion and fenthion were 0.4 and 0.46, respectively. Mass median diameters were computed according to the methods presented by Yeomans (1949) for estimating droplet size from impinged slides.

Measurements of droplets produced with 95 percent malathion dispersed from the rotary-disc nozzle are presented in Table 1. At flow rates of 10 to 17 fluid ounces per minute, the droplets ranged in size from <5 to 84 μ, and the mmds ranged from 22 to 28 μ. In contrast, Mount *et al.* (1970) reported that No. 80015 flat-fan TeeJet nozzles dispersing 14 fluid ounces per minute of 95 percent malathion produced droplets ranging in diameter from <5 to 213 μ and that the mmd of the total spray was 36 μ.

Table 2 compares the size of droplets produced by rotary-disc and flat-fan nozzles dispersing 93 percent fenthion. The rotary-disc nozzle produced a narrower range of droplet sizes and no droplets larger than 100 μ, and the elimination of the large droplets increased the amount of insecticide in droplets less than 100 μ by 13 to 16 percent.

CAGED MOSQUITO TESTS. An evaluation of the effectiveness of fenthion sprays produced by the two nozzles was made with caged mosquitoes in an open plot of about 40 acres near Gainesville during June and July 1969. Applications were made between 7:00 and 8:45 a.m. when climatic conditions were very favorable: air temperatures ranged from 80 to 87° F and averaged about 84° F; wind velocities never exceeded 2 m.p.h. during any tests and usually were <1 m.p.h.

The nozzles were mounted on a Stearman (PT-17) aircraft equipped with a self-contained spray system pressurized with carbon dioxide. Polyethylene tubing was used to carry the insecticide from a 2½ gallon stainless steel tank (placed

TABLE 1.—Droplet production of a Turboero rotary-disc nozzle dispersing 95 percent malathion into the air blast (95 m.p.h.) of a Buffalo Turbine mist blower.

Flow-rate (fluid ounces/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			
10	13	49	34	4	0	84	22	22
13	10	40	36	14	0	84	23	25
17	7	42	38	13	0	73	25	28

TABLE 2.—Comparison of droplet production of Turboero rotary-disc and a TeeJet flat-fan nozzle No. 800067 dispersing 93 percent fenthion into the air blast (95 m.p.h.) of a Buffalo Turbine mist blower.

Flow-rate (fluid ounces/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			
	Rotary-disc (Turboero)								
7.3	9	34	19	38	0	0	90	27	33
12.5	7	34	31	28	0	0	96	29	32
	Flat-fan (TeeJet No. 800067)								
7.3	9	21	32	21	16	1	255	31	43
12.5	8	26	30	23	13	0	187	29	37

TABLE 3.—Kill of caged female *Culex p. quinquefasciatus* obtained with Turboero rotary-disc and TeeJet flat-fan nozzles dispersing 93 percent fenthion.

Size of Nozzles [a]	Pressure (p.s.i.)	Swath interval (feet)	Dose (pound/acre)	Volume (fluid ounce/acre)	No. of tests	Percentage mortality at indicated time and cage position					
						6 hours		24 hours			
						Stake	Ground	Stake	Ground	Avg	Range
				Rotary-disc (Turboero)							
	24	400	0.0075	0.1	1	48	0	64	22	43	
	50	400	.0125	.16	1	34	19	63	32	48	
	24	200	.015	.2	4	76	24	96	61	79	67–96
	50	200	.025	.32	3	84	54	98	93	96	90–99
				Flat-fan TeeJet							
800067	38	400	.0075	.1	1	34	0	34	0	17	
730116	52	400	.0125	.16	2	31	24	42	29	36	25–46
800067	38	200	.015	.2	2	44	16	74	38	56	40–73
730116	52	200	.025	.32	2	72	45	82	64	73	47–99
730116	52	200	.05	.64	2	70	67	99	97	98	96–99

[a] Mortalities were adjusted by Abbott's formula for check mortality which averaged 14 percent at 24 hours.

in the fuselage behind the cockpit) to the nozzles. Both types of nozzles were mounted on a trailing-wing boom just to the right of the aircraft fuselage. However, the rotary-disc nozzle was mounted parallel with the fuselage so the disc portion was in a trailing position, and the metering orifice of the nozzle was reduced to obtain the low flow rates desired (7.3 and 12.5 fluid ounces per minute). This reduction was accomplished by replacing the smallest orifice (1.5) supplied by the manufacturer with a Spraying Systems Flood Jet TK orifice (0.75). In contrast, the flat-fan nozzles were positioned at a 45° angle forward to the thrust line of the aircraft. With both nozzles, the aircraft was flown at a speed of 95 m.p.h., at an altitude of 50 to 75 feet, and at swath intervals of 200 or 400 feet.

Adult female *Culex pipiens quinquefasciatus* Say 3 to 5 days old were exposed in 16-mesh screen wire cages (25 per cage). Cages of mosquitoes were hung on stakes at 5 feet above the ground and on the ground at each of four stations 100 feet apart in a row perpendicular to the flight swaths and near the center of the plot. From one to four tests were made with each dose of fenthion and each type of nozzle. Except during exposure to the insecticide, the mosquitoes were held in insulated chests containing ice in cans. Fifteen minutes after application, the mosquitoes were transferred to plastic tubes lined with clear paper. Absorbent cotton pads moistened with 10 percent (volume/volume) sugar-water solution were placed on the holding tubes when they were returned to the laboratory. Mortality counts were made 6 and 24 hours after exposure.

The results are presented in Table 3. These data indicated that the rotary-disc nozzle produced droplets of insecticide that were more efficient in causing mortality of adult mosquitoes than those produced by flat-fans. The estimated LD_{90}'s for the rotary-disc and flat-fan nozzles were 0.019 and 0.033 pound per acre, respectively. These results tend to confirm our conclusion that the efficiency of mosquito control can be increased if the number of droplets in the optimum size range (10 to 25 μ) is increased.

SUMMARY. The Turboero, a rotary-disc nozzle, was compared with flat-fan nozzles for insecticide droplet production and efficiency in ULV dispersal of insecticides against adult mosquitoes. The data indicated a reduction in droplet size which resulted in increased efficiency of adult mosquito kill with insecticide dispersed with the rotary-disc nozzle as compared with flat-fan nozzles. Also, the rotary-disc nozzle produced insecticide droplet spectra near the optimum droplet size as suggested by Mount (1970).

The lower dose required would mean less insecticide delivered to target areas and considerable savings in the cost of adult mosquito control. Also, the elimination of droplets >100 μ with this nozzle should greatly reduce or eliminate the possibility of spotting painted surfaces with insecticide.

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