

Flit-gun sprayer characteristics¹

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ABSTRACT

Six flit-gun sprayers were tested for possible use in mosquito adulticide programs where inexpensive nonmotorized application technology may be required. An analysis of variance for differences in droplets ≤ 24 microns (μ), droplets $\geq 48 \mu$, droplets/cm², volume median diameters, and mosquito mortality is provided. As shown by these data, good results can be achieved with this equipment.

Aedes aegypti (L.) has been shown to be a highly endophilic mosquito capable of surviving spray eradication programs that do not focus on interior spaces. Thus, house-to-house indoor spraying is suggested for dengue control.

In a preliminary study, outdoor spraying with a hand-held or backpack sprayer killed few mosquitoes beyond the first row of a block of 16 domiciles arranged in a 4 × 4 grid (unpublished data). Based on this experience, it was inferred that individual houses must be treated if the desired mosquito mortality of >80% is to be obtained. Flit-guns were considered to be a potentially good option for such spraying based on their sales history and low cost relative to motor-

ized hand-held, backpack, or truck-mounted equipment. In addition, their simple technology makes them practical for use in remote sites.

The goal of the present study was to evaluate flit-guns for spraying houses to control resting mosquitoes. A review of the entomological literature indicated that the most frequently evaluated parameters for insecticide sprayers were droplet size, drops/cm², and mosquito mortality. Therefore, the authors chose these parameters to evaluate the effectiveness of flit-gun sprayers.

Sixteen one-room houses located at the Wedge, a former research station of the University of South Carolina located in McClellanville, SC, served as the study sites. The houses were wooden frame structures sided with chipboard and covered by a gabled galvanized steel roof. Each house measured 3.7 m wide × 3.7 m deep × 4.9 m from the ground to the base of the roof. There were two windows, one on each side, measuring 0.6 m × 0.6 m situated 1.2 m above the ground and 2.4 m from a corner, so that they were slightly offset from one another. The doors, measuring 0.9 m wide × 2.0 m tall, were located in opposite

corners of the house front and back. The houses were separated from adjacent units by 1.2 m on the side and by 3.1 m in front and back. The houses each had a total interior volume of 2 304 ft³, including the gabled arch.

Exposure cages were constructed of 3.8 × 10.2 cm inner diameter polyvinyl chloride (PVC) pipe covered with nylon tulle held in place by PVC bands.

Mosquitoes used in the tests were colony-reared adult female *Aedes aegypti* (L.) which had emerged 3–5 days earlier and which derived from the eggs of an insecticide-susceptible colony at the USDA Medical Entomology Laboratory in Gainesville, Florida. Mosquitoes were removed from their rearing cages by means of a mouth aspirator and transferred to exposure cages. Prior to exposure, cages and mosquitoes were placed in an ice chest lined with moist paper towels. Following exposure, cages were carried back to the laboratory in plastic trash bags. Mosquitoes were then transferred to holding cages made of 0.24 L paper cans with nylon tulle covers held in place with lid bands. Each bioassay cage contained approximately 25 adult female mosquitoes.

¹ The opinions and assertions contained herein are the authors' and are not to be construed as reflecting the views of United States Department of the Navy, the Naval Service, or the University of South Carolina.

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Exposure cages were suspended from nails driven into the frame of the test house. For each series of tests, four control cages were placed in a second house remote from the test house. If the test house had been sprayed within the previous week, controls were placed in it for 15 minutes prior to the test to measure potential residual effects of the previous treatment (none was found).

After each spraying, the exposed mosquitoes and holding cages were placed in an ice chest for 24 hours before final mortality readings were taken. During this period, they were offered a 10% sugar solution on polyester fiber balls which had been squeezed dry and placed on the cage screening. Maximum and minimum temperatures were recorded inside the ice chest during the holding period. Mortality was scored at 24 hours post-treatment.

Flit-guns were loaded with Scourge® (resmethrin 4% + piperonyl butoxide 1382 12%) (AgrEvo, Montvale, New Jersey). Aerosol droplets were collected with rotating impingers (John W. Hock Company, Gainesville, Florida) using Teflon®-coated slides. Impingers and slides were placed in the center and all corners of the one-room house. The flit-gun was primed by pulling back on its pump, then discharged from the doorway into the house towards the center of the room. Two tests were conducted, one with and one without mosquitoes.

Fifteen minutes were allotted for the aerosol cloud to disperse. The Teflon®-coated slides were sealed in a standard slide box and most were read within 4 hours. Slides not able to be read within 4 hours were covered with a paper gasket and an additional plain glass slide, taped to prevent evaporation of the insecticide droplets (1), and read within 1 week.

Spray tests were conducted and droplets collected between 1 000 and 1 530 hours. The environmental conditions for the tests were: relative humidity, 45%–80%; wind speed, 2–5 mph; ambient temperature 24–28 °C. A minimum of 100 droplets were mea-

TABLE 1. Flit-gun droplet spectra analysis

Flit-gun type	Size range	Impinger location within house					Mean ± S.D.
		1	2	3	4	5	
Cloud	≤24 μ	25.3	35	50	33	36	35.9 ± 10.3
	>48 μ	25.3	10	17	10	15	15.2 ± 6.3
	VMD (μ)	41.1	31.2	35.9	32.6	34.2	35 ± 3.8
	Gtts/cm ²	630	606	875	788	1 575	895 ± 396
6119 (1 mL)	≤24 μ	21.7	28	33.3	37	16.4	27.3 ± 8.4
	>48 μ	10.4	29	11.1	6.7	30.8	17.6 ± 11.4
	VMD (μ)	35.3	43.8	31.2	30.7	43.6	36.9 ± 6.4
	Gtts/cm ²	17.5	113	7.1	35	38	73.6 ± 68.9
6119	≤24 μ	—	54	46.7	17.3	0.9	29.7 ± 24.9
	>48 μ	—	7	0	28.6	92.4	32 ± 42.1
	VMD (μ)	—	27.5	25.8	42.5	68.3	41 ± 19.7
	Gtts/cm ²	—	242	150	630	630	413 ± 253
6419	≤24 μ	11.1	12.9	8	39.2	4.9	15.2 ± 13.7
	>48 μ	49.5	11.9	32	14.7	42.2	30.1 ± 16.5
	VMD (μ)	35.3	34.8	41.2	31.8	46.7	37.9 ± 5.9
	Gtts/cm ²	175	1 969	525	175	1 969	962.6 ± 929.8
Misty	≤24 μ	17.1	50.9	86	82.2	45.7	56.4 ± 28.4
	>48 μ	22.9	0	0	1.9	3.8	5.7 ± 9.7
	VMD (μ)	40	26.9	17.3	17.7	28.1	26 ± 9.3
	Gtts/cm ²	630	60	23	19	175	181.4 ± 258.6
Continuous	≤24 μ	16.2	18	27.7	54	49.6	33.1 ± 17.7
	>48 μ	17.1	9	.9	0	.9	5.6 ± 7.4
	VMD (μ)	36.9	34.3	30.1	24.8	26.1	30.4 ± 5.2
	Gtts/cm ²	225	450	197	50.4	525	289.4 ± 194.5

sured on each slide with a compound microscope. The number of droplets occurring per cm² was calculated as described in Brown et al. (2).

The total volume of a droplet sample was calculated and divided into two equal volumes. The volume median diameter⁵ (VMD), is the value at the halfway point, so that half the volume will have droplets that are smaller than the VMD number and half will have droplets that are larger. In our study VMD were calculated using the Vector® software program (VecTec, Inc., Orlando, Florida). An analysis of variance was conducted for differences in droplets ≤24 μ, ≥48 μ,

droplets/cm², volume median diameters and mosquito mortality (3). Droplet size should show a reasonable distribution around the VMD. A large number of very small or large droplets outside the 5–25 μ range indicates inappropriate atomization (1). Usually some adjustment to the flow rate or other machine operating characteristic will be required to establish the correct range. Incorrect atomization, either too small or too large, results in waste of insecticide and in personnel and environmental hazards. Correct adjustment of the insecticide application means correct atomization leading to less waste of insecticide and enhances personnel and environmental safety.

All flit-guns were manufactured and provided by H.D. Hudson Manufacturing Company (Chicago, Illinois). The flit-guns used were of the following types:

⁵ The VMD, which is expressed in microns (μ), is a standard industry droplet measurement parameter and is included in every insecticide label.

- 1) 6419 Hydra-Gun® Intermittent Sprayer (large), 60 oz. adjustable nozzle sprayer;
- 2) 6119 Hydra-Gun® Intermittent Sprayer, 30 oz. adjustable nozzle sprayer;
- 3) 6119 Hydra-Gun® Intermittent Sprayer modified to deliver 1 mL spray;
- 4) Continuous, 30 oz. tin plate sprayer that delivers spray with each stroke of the pump handle;
- 5) Cloud® Intermittent Sprayer, 32 oz. high density all-polyethylene sprayer with a pump made of polyvinylchloride;
- 6) Misty, 18 oz. high density polyethylene sprayer.

One-way analysis of variance of the results obtained with the different flit-guns yielded the following results (Table 1): For droplets ≤ 24 microns (μ) (1), there was a significant difference in droplet size between flit-guns (Table 2, $df = 5$; $F = 2.87$; $P \leq 0.04$). The range in droplets $\leq 24 \mu$ was 15.2 ± 13.7 (6419 Hydra-Gun) to 56.4 ± 28.4 (Misty). Of the six flit-guns tested, clearly the 6419 sprayer atomized the most efficiently. There was no significant difference between machines in the generation of droplets $\geq 48 \mu$ (Table 3; $df = 5$; $F = 1.93$; $P \leq 0.13$) (2).

There were significant differences in overall volume median diameter (Table 3; $df = 5$; $F = 1.81$; $P \leq 0.15$) with the Misty producing the smallest (26 μ) and the 6119 producing the largest (41 μ). There was also a significant difference in droplets/cm² (Table 3; $df = 5$; $F = 3.69$; $P \leq 0.013$), with the 6419 generating more droplets/cm² relative to the other sprayers. The 1 mL sprayer produced only 41 droplets/cm². Mosquito mortality generated by the six machines differed significantly (Table 3; $df = 5$; $F = 4.36$; $P \leq 0.09$). The 6419, 6119, Continuous, and Cloud sprayers generated $\geq 80\%$ mortality, and the Misty and 1 mL sprayers generated $\leq 57\%$. These findings may be related to the flow rate differences and consequent droplets/cm² as shown in Table 2. One hundred percent mortality was obtained with a 6.2–4.7 mL/sec flow

TABLE 2. Flow rates, volume median diameters (VMD), droplets/cm², and mosquito mortality for selected flit-gun treatment of houses

Flit-gun type	Flow rate (mL/sec)	VMD ^a (μ)	Mean droplets/cm ² ^b	Impinger loc ^c	Mortality ^d (No.)	Mean mortality (%)
6419	4.7	92.6	1 754	1	100	100
				2	100	
				3	100	
				4	100	
6119	6.2	43.3	969	1	100	100
				2	100	
				3	100	
				4	100	
Continuous	2	68.3	1 733	1	100	97 \pm 5.5
				2	100	
				3	100	
				4	89	
Cloud	1	47.1	825	1	100	80 \pm 40
				2	100	
				3	100	
				4	20	
Misty	1	31.7	125	1	100	57 \pm 40.7
				2	38	
				3	80	
				4	10	
6119 (1 mL)	1	69.9	145	1	60	40 \pm 16
				2	40	
				3	40	
				4	20	

^a Mean VMD for the four impinger locations.

^b Mean droplets/cm² for the four impinger locations.

^c Impinger 1 is nearest the door sprayed through. Impinger number proceeds in a counter clockwise direction around the room with an impinger in each corner.

^d Control mortality = 0%.

TABLE 3. Analysis of variance for differences between the flit-guns in small drops, large drops, volume median diameters (VMD), droplets/cm² and mosquito mortality

Factors (mean values)	Flit-gun type					
	Misty	Cloud	Continuous	6119	1 mL	6419
Droplets $\leq 24 \mu$ ^a	56.4 ab	35.9 ab	33.1 ab	28.6 b	27.3 b	15.2 b
Droplets $\geq 48 \mu$ ^c	5.7 a	15.5 a	5.6 a	30.8 a	17.6 a	30.1 a
Volume median diameter (μ) ^d	26.0 b	35.0 ab	30.4 ab	41.0 a	36.9 ab	37.9 ab
Droplets/cm ² ^e	181.4 c	894.8 ab	289.5 bc	413.0 abc	42.1 c	962.6 a
Mosquito mortality ^f	57.0 bc	80.0 ab	97.3 a	100 a	40.0 c	100 a

^a Error mean square: 322.04; $df: 5$; $P: 0.04$; $F: 2.87$.

^b Means followed by the same letter within column are not significantly different (Duncan's multiple range test, CoStat 1990).

^c Error mean square: 321.1; $df: 5$; $P: 0.13$; $F: 1.93$.

^d Error mean square: 82.5; $df: 5$; $P: 0.15$; $F: 1.81$.

^e Error mean square: 195 995.88; $df: 5$; $P: 0.013$; $F: 3.69$.

^f Error mean square: 591.0; $df: 18$; $P: 0.009$; $F: 4.36$. Control mortality = 0%.

rate. A flow rate of 2 mL/sec (continuous sprayer) generated 97.3% mortality. A flow rate of 1 mL/sec produced more variable, 40%–80% mortality.

Given these results, the Hudson 6419 flit-gun seemed preferable for insecticide deposition in programs to control resting mosquitoes.

The flit-gun has been used in a variety of pest management situations for some time. It may still be an affordable tool for the application of insecticides by a minimally trained work force.

These data show what can be obtained with flit-gun deposition of small amounts of insecticide in individual residences.

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RESUMEN

Atomizadores de compresión activados a mano

Se pusieron a prueba seis atomizadores de compresión activados a mano a fin de evaluar su utilidad para programas de exterminio de mosquitos adultos en que se necesitan tecnologías no motorizadas de bajo costo. Se hace un análisis de la varianza en cuanto a partículas ≤ 24 y ≥ 48 micras (μ), partículas/cm², diámetro del volumen mediano, y número de mosquitos muertos. Los datos confirman que pueden obtenerse buenos resultados con aparatos de este tipo.