LARGE AREA TESTS OF ULTRA LOW VOLUME NALED FOR CONTROL OF ADULT MOSQUITOES

D. J. TAYLOR[1] AND C. B. RATHBURN, JR.[2]

Preliminary results of nighttime application of ULV Dibrom (naled) by a C-47 aircraft for the control of adult mosquitoes were presented by Shepard and Gorman (1969) who cited Blanton *et al.* (1950) as reporting more effective kill of adult mosquitoes by nighttime spraying with a C-47 aircraft. The idea of nighttime spraying was further pursued during the summer of 1969. During this time of day under Florida conditions, thermal convection currents and wind speeds are more favorable for maximum fall of droplets and minimum drift away from the target area of the smaller droplets, which are more effective in killing mosquitoes.

MATERIALS AND METHODS Three tests in Hillsborough County, Florida, are reported here: August 13 at Ruskin, August 28 at Citrus Park, and September 11 at Citrus Park. Results were assessed in terms of percent reduction and percent control based on pre- and posttreatment mosquito collections in CDC miniature light traps baited with dry ice, on mortality of mosquitoes exposed in screened cages, on droplet distribution as sampled by 3 x 5 inch potassium iodide-methanol cards, and by pre- and posttreatment landing rates.

Dibrom 14 concentrate was used at rates of 0.55, 0.80, and 0.70 fluid ounces per acre (.05, .09, .08 lb. per acre) respectively for the three tests. All tests were flown at 500 feet altitude and 150 miles per hour (Table 1).

The aircraft was a C-47 equipped with a 165-gallon fiberglass tank, Oberdorfer pump, plastic distribution lines, stainless steel flushing tank, and spray nozzles mounted on the underside of each wing tip.

The application data for all tests are shown in Table 1. For all three tests, the aircraft was flown at a right angle to the wind direction. Applications were made between 3:58 and 5:20 a.m. Starting at the downwind side of the area to be treated, swaths were marked by a flashing "Instant Visual Identification Strobe"[3] light. This white light, operated off the truck battery, was mounted on a telescoping pole 15 feet above the ground on the rear of a pickup truck. When clear of nearby obstacles, the light could be seen 6 to 8 miles by the pilot. The truck was also equipped with a foot-meter for accurate measurement of distances.

TABLE 1.—Application data for aerial spray tests with naled, Hillsborough County, Florida, 1969.

Test No.	Vol. Fl./oz.	Dosage lbs./acre	Nozzle No.	Nozzle Size	Swath Feet	Alt. Ft.	Speed mph.	Wind Velocity-mph surface	Wind Velocity-mph 500 ft.	acres
1	0.55	0.05	7	80015	600	500	150	2	8	17,920
2	0.80	0.09	7	80015	600	500	150	1	5	2,880
3	0.70	0.08	8	8003	1,000	500	150	<1	5	2,485

[1] Hillsborough County Mosquito Control, Tampa, Florida

[2] West Florida Arthropod Research Laboratory, Panama City, Florida

[3] In-Flight Devices Corporation, Columbus, Ohio.

RESULTS. The results of all tests are shown in Tables 2 and 3. In test 1, pre- and posttreatment collections from CDC light traps in the target area indicated 81 percent reduction of *Culex nigripalpus,* a St. Louis encephalitis vector, with a corresponding 6 percent reduction in an untreated area as measured by a New Jersey light trap (Table 2). There was only a 44 percent mortality of *Culex nigripalpus* in cages that were placed in varied conditions of vegetation in the target zone. Ten indicator cards averaged 27 droplets per card in the target area; however, ½ to 2 miles downwind from the first swath there were 10 to 39 droplets per card. This showed that much of the spray came to the ground at least 2 miles downwind.

In test 1 (Table 3), *Psorophora confinnis* averaged over 8,000 mosquitoes per trap in the pretreatment counts in the target area and showed an 87 percent reduction; *Psorophora ciliata* averaged 173 per trap at pretreatment and were reduced 85 percent; and *Aedes taeniorhynchus* averaged 1156 pretreatment and showed a 40 percent reduction, but there was only 9 percent kill of the latter species in cages. Percent control of the four species in test 1, shown in Tables 1 and 2, was obtained by correcting the percent reduction of each species to the percent reduction in the control trap by means of Abbott's formula. Since the control trap in test 1 was a New Jersey trap and the traps in the target area were CDC miniature light traps, the figures shown as percent control may not be truly representative.

Landing rate data based on counts made the day before and the day following treatment indicated an overall mosquito reduction of 82 percent in the target area. When the reduction in the control area was considered, however, the landing rate was reduced by only 55 percent. The species sampled by this method were mostly *A. taeniorhynchus* and *P. confinnis.*

In test 2, as shown in Table 2, trap collections in the target area showed a 64 percent reduction of *C. nigripalpus;* however, when corrected for the 58 percent reduction obtained in the control area, this was reduced to 14 percent. Only 3 percent mortality was obtained with caged *C. nigripalpus* in the target area where an average of 34 droplets per card was obtained. One, 1½, and 2 miles downwind of the target area, the percent control of the trapped mosquitoes dropped from 55 to 5 to 0 percent respectively, but the mortality of caged *C. nigripalpus* increased to 58 and 59 percent at 1½ and 2 miles, and the number of droplets per indicator card increased to 101 and 64 droplets respectively. Droplets on the downwind cards were noticeably much smaller than those obtained on the cards in the treated area.

Trap counts of *Psorophora confinnis, Aedes infirmatus,* and *Anopheles crucians* in the target area (Table 2) were reduced 93, 81, and 51 percent respectively. Except for *A. infirmatus,* however, the untreated trap counts were also lower, showing generally poor control of these species.

Data of test 3 for the target area were divided into "upwind" and "downwind" portions. The "upwind" portion of the target area, presumably not well covered by the spray due to drift, showed 26 percent control of *C. nigripalpus* by trapping while the "downwind" portion of the target area showed 55 percent control. The mortality of caged *C. nigripalpus* in the "upwind" and "downwind" portions of the target area was 5 and 93 percent respectively, and the number of droplets per card averaged less than 1 and 14 respectively. Trap collections ½ and 1½ miles "downwind" showed 29 and 13 percent control, 100 percent mortality of all caged mosquitoes, and 57 and 67 droplets per card, respectively. At ½ mile west of the target area, trapping showed 48 percent control of *C. nigripalpus;* also, there was 76 percent mortality of this species in cages and 3 droplets per card in that area.

These results demonstrate a condition similar to that experienced in test 2; however, the reduction in trapped mosquitoes

TABLE 2.—Results of ULV aerial spray tests of naled against adults of *Culex nigripalpus* Theob., Hillsborough County, Florida, 1969.

Test No.	Area	C.D.C. Trap Collections					Caged Mosq.		KI Cards
			Mosq./trap [1]						
		No. Traps	Pre	Post	Percent Reduction	Percent Control [2]	No. Cages	Percent Mort.	No. Cards	Av. No. drops/card [3]
1	Treated	4	736	141	81	80	10	44 [2]	10	27
	0.5 mi. Downwind								2	34
	0.8 mi.								2	10
	1.2 mi.								2	30
	2.0 mi.								2	39
	Control	1	168	158	6	..	14	1	2	4
2	Treated	2	7312	2660	64	14	6	3 [2]	16	34
	0.3 mi. Downwind						1	4	2	10
	1.0 mi.	1	2900	540	81	55	1	7	2	64
	1.5 mi.	1	1256	506	60	5	2	58	2	101
	2.0 mi.	1	2036	1656	18	0	2	59	2	64
	2.4 mi.						1	11	2	60
	2.7 mi.						1	6	2	64
	3.4 mi.						3	9	6	28
	Control	1	3056	1292	58	..	12	1	2	0
3	Treated—all	4	2931	473	84	50	18	85 [2]	20	9
	"Upwind"—0.3 mi.				77	26	4	5 [2]	4	<1
	"Downwind" 0.3 to 1.7 mi.	3	3011	427	86	55	14	93 [2]	16	14
	Downwind, 30°									
	0.5 mi.	1	848	185	78	29	1	100	2	57
	1.5 mi.	1	1844	492	73	13	1	100	2	67
	Crosswind, 60°									
	0.5 mi.	1	4808	772	84	48	5	76	5	3
	1.5 mi.	1	2304	1508	35	0	11	23	11	<1
	Control	4	5269	1631	69	..	9	14	6	0

[1] Average number of mosquitoes per trap per night. All pretreatment collections in test one and downwind pretreatment collections in test two were picked up at 2 to 4 a.m., all others full night collections. Control trap for test one was New Jersey light trap, all others CDC miniature light traps.
[2] Corrected for percent reduction in control by Abbotts formula.
[3] Three x five inch cards approximately 4 sq. in.

was greater and the mortality of caged *C. nigripalpus* was significantly increased. From the trap, caged mosquito, and card data shown in Table 2, it is apparent that the area covered by the spray began ½ mile south and ½ mile west of the "upwind" edge of the target area and extended at least 1½ miles in a southwest direction from the "downwind" edge of the target area, the spray drifting southwesterly with a northeast wind. In test 3, the surface wind was only 1 mile per hour while for test 2 it was 2 miles per hour. Also, the wind for the third test was only about 30 degrees off the flight direction, while it was variable (45° to 110°) during the second test. This had the effect of shifting the spray pattern in test 3 to the longer dimension of the plot, thereby keeping more of the spray in the target area.

CONCLUSIONS. The results of these tests indicate that the ULV spray contacted the ground from ½ to 3 miles "down-

TABLE 3.—Summary of trapping results of ULV aerial spray tests of naled against several mosquito species, Hillsborough County, Florida, 1969.

Test No.	Species	Area	No. Trap	Mosq./Trap [1] Pre	Mosq./Trap [1] Post	% Red.	% Control [2]
1	*Psorophora confinnis*	Treated	4	8388	1128	87	72
		Control	1	142	65	54	...
	Psorophora ciliata	Treated	4	173	26	85	70
		Control	1	4	2	50	...
	Aedes taeniorhynchus	Treated	4	1156	698	40	29
		Control	1	80	68	15	...
2	*Psorophora confinnis*	Treated	2	483	36	93	56
		Control	1	1072	176	84	...
	Aedes infirmatus	Treated	2	144	28	81	95
		Control	1	4	14	+250	...
	Anopheles crucians	Treated	2	468	228	51	0
		Control	1	420	82	80	...
3	*Psorophora confinnis*	Treated 0.5 miles	4	26	2	92	81
		Downwind 1.5 miles	1	28	0	100	100
		Downwind 0.5 miles	1	6	2	67	23
		Crosswind	1	16	2	87	70
		Control	4	7	3	57	...
	Culex (Mel.)spp.	Treated 0.5 miles	4	137	81	41	0
		Downwind 1.5 miles	1	164	29	82	28
		Downwind 0.5 miles	1	100	60	40	0
		Crosswind	1	328	195	41	0
		Control	4	317	79	75	...
	Anopheles crucians	Treated 0.5 miles	4	90	149	+66	0
		Downwind 1.5 miles	1	160	48	70	0
		Downwind 0.5 miles	1	96	20	79	16
		Crosswind	1	320	83	74	0
		Control	4	177	44	75	...

[1] Average number of mosquitoes per trap night, (CDC Miniature Light Trap with dry ice) except Test No. 1, N.J. Light.

[2] Corrected for percent reductions in control area by Abbott's Formula.

wind" from the "upwind" edge of the target area at surface wind velocities of less than 2 mph. Since some of the spray, particularly the larger droplets, were deposited in the target area, the "downwind" displacement observed had the effect of increasing the size of the area treated, resulting in an under-dosing of the entire area.

It was shown that the three evaluation methods used (CDC light traps with dry ice, caged mosquitoes, and potassium-iodide cards) do not entirely support each other. It appears that trapping resulted in a more accurate indication of the control obtained than either the caged mosquitoes or cards. The cards did not sample the smaller droplets, which are probably responsible for most of the kill of mosquitoes; and kill of caged mosquitoes did not accurately reflect reduction of the natural population as measured by trapping. Nevertheless, these tests have shown that for effective control in a target area with ULV spray, a correlation of the direction and speed of the wind with the altitude and swath width of the plane is necessary. Using this information it may be possible actually to place a desired dosage in a particular target area. However, before this could be done with confidence, many additional data are needed on spray drift of a particular operation at various wind velocities. It must be concluded that the operation used in these tests is still experimental and cannot be recommended at the present time for reliable control of adult mosquitoes in areas similar to those where the tests were conducted.

Literature Cited

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