EFFECTIVENESS OF LOW-VOLUME AERIAL SPRAYS FOR MOSQUITO CONTROL [1]

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Since the advent of low-volume aerial spraying as described by Messenger (1963), numerous tests have been conducted to determine the value of this method of application in controlling mosquitoes. The effectiveness against adults and larvae of various species has been demonstrated by Knapp and Roberts (1965), Glancey *et al.* (1965), Moore (1965), Knapp and Pass (1965), Mulhern *et al.* (1965), and Stevens and Stroud (1965). This technique of application is still new and further improvements of the method, as well as experiments to evaluate new materials are needed.

Control of mosquitoes by directing treatments towards the larvae is probably the best method. For this to be effective however, all mosquito breeding sites must be treated. Some of these sites are in areas which are inaccessible to ground equipment, and some are well protected by dense foliage. Therefore, tests were conducted in central and western Kentucky during the summer and fall of 1965 to determine the effectiveness of several insecticides against mosquito larvae, when applied as low-volume sprays over various types of vegetation. Observations on adult control were made whenever possible.

MATERIALS AND METHODS. A Piper Model PA–18–A Super Cub airplane equipped for low-volume spraying was used in these tests. Insecticides used were: fenthion; fenthion-Bayer 39007 (Baygon®) (*o*-isopropoxyphenyl methylcarbamate) mixture, and AC 52,160 (Abate®) (0,0,0′0′-tetramethyl 0,0′ thiodi-*p*-phenlyene phosphorothioate) and trichlorfon. The formulations were 4 lb. of

[1] The investigation reported in this paper (No. 66–7–28) is in connection with a project of the Kentucky Agricultural Experiment Station supported partially by the Chemagro Corporation, Kansas City, Mo. and the American Cyanamid Co., Princeton, New Jersey and is published with the approval of the Director.

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toxicant per gallon, except fenthion which was 8 lb. per gallon. Each formulation was calibrated and applied at an air speed of 80 m.p.h. and a pump pressure of 40 lbs. psi. All insecticides were applied through flat fan Tee Jet® (Spraying Systems Co.) nozzles.

A small-mesh sieve was used to collect 3rd and 4th instar larvae from infested areas. These were used to determine the foliage-penetrating capabilities of insecticides. Waxed paper cartons were filled with water from a local source and 25 larvae added to each. (Some pupae were placed in the cartons but were not counted as test specimens.) Twelve-ounce cartons were used in the western Kentucky tests, whereas in the central Kentucky tests tall 32-ounce cartons were used. One carton containing the mosquito larvae was covered and placed at each location to serve as an untreated control. From preliminary studies it was found that solid covers were more suitable than clear plastic covers, especially when exposed to the sun. The heat from the sun, intensified by the clear plastic, created an environment unsuitable for larval survival. Mortality counts were made at 15 and 24 hours after treating. The criterion for mortality was the inability of the larvae to surface.

In areas where larval infestations were numerous enough to conduct tests, 10 dips were taken with a 4-inch diameter water dipper before and at intermittent intervals after treatment. Comparison of the average number of larvae per dip before and after treatment was used as the criterion of effectiveness. Adult counts were made before and after treating by counting the number of adult mosquitoes on and in the immediate vicinity of a person within 30 seconds. To accomplish this two persons would stand facing each other and count the mosquitoes on or around the opposite person. This was repeated in 10 locations within each test area.

Fenthion at the rate of 0.1 lb. (1.6 fluid oz.) per acre was applied in 6 different areas. Treatments were designed to determine the effectiveness of fenthion against mosquito larvae protected by various types of vegetative growth. Two 8001-nozzles, one located on each side of the plane, were used in these treatments. One treatment was made in central Kentucky against *Culex pipiens* (L.) larvae. The 32-oz. waxed cartons, containing 25 third instar larvae in tap water, were placed under tall trees (maple), tall grass (foxtail and reed), low-growing shrubs (wild cherry and scrub oak), and in open areas for comparison. Two cartons were placed at each of four locations within the treatment area. One carton was covered during treatment and served as an untreated check. Application was made at dusk from an altitude of 50 feet, obtaining a calculated swath width of 100 ft. Weather conditions were considered good, with winds at 1 to 2 m.p.h.

The remaining five treatments with fenthion were conducted in western Kentucky and were against *Aedes sollicitans* (Walker). To supplement natural infestation, 3rd and 4th instar larvae were collected and placed in cartons under various vegetative cover as previously described. Five cartons and a covered control carton were located at each site. Not all types of vegetation were found at one test area. In some instances, naturally infested waters were available for examination of effectiveness of the treatment. Weather conditions were good during all applications. Some test areas were as small as 200 x 2000 ft.

Bayer-39007 was mixed with fenthion and applied at two rates to determine if the mixture would increase the rate of fenthion knockdown of adults. One rate was applied from an altitude of 50 ft., using 3 8001-nozzles. A mixture consisting of a ratio of 1.1 fenthion to Bayer 39007 was applied at a rate of 2.4 oz. per acre to obtain a total of 0.1 lb. (0.05 lb:0.05 lb.) of actual toxicant per acre. Approximately 200 acres were treated, and counts were made within the center of the area. Because the treatment was made at dusk, adult counts had to be made by use of flashlights. A second treatment was made the next morning over about 300 acres. In this treatment the ratio was 5:2 fenthion to Bayer 39007. The applica-

tion was made with two 8000I-nozzles at a volume of 1.6 oz. per acre so as to obtain a total of 0.0875 lb. (0.0625 lb: 0.025 lb.) of actual toxicant per acre. Natural larval infestations were found at this test site.

Approximately 128 acres of swamp area were treated with 0.031 lb. of AC 52,160 per acre. One ounce of AC 52,160 was mixed with 24 ounces of water, and this volume was applied per acre from an altitude of 50 ft. Eighteen 80015-nozzles were used for the application. Larval counts were made at 2 and 24 hours after treatment.

Trichlorfon was applied over pasture and timber at the rate of 0.1 lb. (3 fluid oz.) per acre. Three 8001-nozzles were used to apply the spray from an altitude of 65 feet. A small 15 x 30 ft pond partially hidden on three sides by tall timber was used to determine the effectiveness of trichlorfon against *Culex pipiens* (L.) and *Aedes vexans* (Meigen) larvae. Adult counts of *A. sollicitans* were made as in previous tests. When the plane left the airstrip weather conditions were good, but by the time it had reached the test site, wind velocity had increased to 10 to 15 m.p.h. Because further adverse weather conditions were predicted, we proceeded with the test.

RESULTS AND DISCUSSION. Larval control in natural infested waters with four treatments is shown in Table 1. The 5:2 fenthion-Bayer-39007 mixture at the rate of 0.0875 lb. per acre was ineffective against larvae. However, fenthion at 0.1 lb. per acre showed better than 89 percent reduction of larvae 24 hours after treatment. It is possible that fenthion-Bayer-39007 mixture would have been effective in reducing larvae if it had been diluted to provide more volume per acre and/or an emulsifier had been added to achieve better dispersion of the material in the water.

Trichlorfon, although applied under adverse conditions at a low dosage of 0.1 lb. per acre, gave excellent control of both *Culex pipiens* and *Aedes vexans* larvae Table 1). The volume of 3 fluid ounces per acre and the wind direction may have aided in penetrating the dense foliage covering the small pond.

AC 52,160, at 0.031 lb. per acre gave the most rapid larval kill. Although Table 1 shows a 95.4 percent reduction 24 hours after treatment, examinations 2 hours after application revealed a 100 percent reduction of larvae. The decrease in percent reduction at 24 hours as compared to 2 hours, was due to live larvae drifting into the test area from untreated sites. No live larvae could be found 54 hours after treatment. It is possible that lower dosages of AC 52,160, applied in smaller volume, would be equally effective.

The effectiveness of low-volume sprays on mosquito larvae protected by various types of foliage was demonstrated by the use of fenthion at the rate of 0.1 lb. per acre, as shown in Table 2. In general,

TABLE 1.—Mosquito larval control with low-volume aerial application of special formulated insecticides.

Compounds	Dosage lb./acre	Larvae per dip		% Control
		Pre-treatment	24 hour Post treatment	
Fenthion-Bayer 39007 mixture	0.875	8.3	13.4	0
Fenthion[a]	0.1	10.7	1.1	89.8
Trichlorfon	0.1	7.5	0.3	96.0
AC 52, 160	0.031	18.9	0.8	95.4[b]

[a] Average of three tests.

[b] 100 percent reduction of larvae at 2 hours. Live larvae found at 24 hours drifted into sampling area from untreated area. At 54 hours no live larvae could be found.

TABLE 2.—Effect of 1.6 fluid ounce of fenthion (0.1 lb./acre) on mosquito larvae located under various vegetative growths.

Plane altitude	% control							
	Open area		Low shrubs		Tall grass		Tall trees	
	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.	15 hr.	24 hr.
50 ft.[a]	100	100	34	72	90	96	69	92
40 ft.[b]	...	100	..	78	..	100	..	76
50 ft.[b]	...	100	..	..	..	...	..	98
50 ft.[b]	...	100	..	20[c]	..	0[c]	..	48[c]

[a] *Culex pipiens* larvae—3rd and 4th instar—central Kentucky. All cartons in this test were 32 ounce tall waxed containers.

[b] *Aedes sollicitans* larvae—3rd and 4th instar—western Kentucky. All cartons used in this test were 12 ounce squat waxed containers.

[c] Heavy growth of shrubs and vines.

low-growing shrubs afforded more protection than did tall grass and tall trees. No control was obtained under places of heavy growth such as dense shrubs and vines.

The addition of Bayer 39007 to fenthion aided greatly in increasing the knockdown of adult mosquitoes. In earlier tests, Knapp and Pass (1965) found that fenthion took 10 hours for any appreciable adult knockdown. Table 3 shows that an application of a mixture of 0.05 lb. per acre of fenthion and Bayer 39007 gave virtually 100 percent control of mosquitoes 2 hours after treatment. Application of a 0.0625 lb. fenthion and 0.025 lb. Bayer 39007 mixture per acre effected a marked reduction of mosquitoes 2 hours after treatment. The increase in adults after the peak reduction in both treatments was found to be caused by newly emerged adults, as each treatment was made just prior to the end of pupal stage. It was not determined if these newly emerged adults were controlled.

Some adult control was obtained in the trichlorfon and fenthion larviciding areas. However, these areas were not considered large enough for any adequate control of the constant migration of adults from untreated sites. None of the compounds used in these tests was found to be effective against pupae.

TABLE 3.—Percent control of adult mosquitoes with low-volume aerial applications of fenthion-Bayer 39007 mixtures.

Dosage—lb./acre		Percent control-hours after treatment			
Fenthion	Bayer 39007	2	3	12	24
0.0625	0.025	86.8	96.7	93.4	0
0.05	0.05	99.9+	..	82.8	0

All compounds and formulations used in these tests were effective against chironomid larvae.

SUMMARY. These tests show that low-growing shrubs and vines give mosquito larvae more protection from low-volume sprays than do tall trees and grasses. The tests also showed that small areas may be successfully treated for larvae, but these small plot treatments will reduce adult numbers very little. The addition of Bayer 39007 to fenthion decreased the time required for adult knockdown. Trichlorfon shows promise as a low-volume spray material and merits further study. All compounds were effective against chironomid larvae. None of the compounds or formulations used was effective against mosquito pupae.

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