LOW-VOLUME AERIAL SPRAYS FOR MOSQUITO CONTROL[1]

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Mosquito control is becoming more difficult and more expensive each year. Expanding programs, such as irrigation for crop production and coal strip mining in areas of Kentucky, have multiplied the number of breeding areas by blocking the natural drainage and creating brackish swamps. Increases in labor and material costs, plus an increasingly larger area to cover, deplete most state mosquito control funds in a very short time. New methods, therefore, are needed in order to keep mosquito control projects and abatement districts operating.

One new method that may prove to be a valuable tool is the development of low-volume aerial application of insecticides described by Messenger (1963). Knapp and Roberts (1965) reported very effective adult mosquito control with this method. Moore (1965) believed the method to be suitable in situations calling for an immediate relief of a mosquito problem but stated it would not give sufficient residual control. The results of tests with low-volume aerial application for mosquito control are reported herein.

MATERIAL AND METHODS. A Piper model PA-18-A Super Cub airplane, equipped for aerial spraying, was adapted for applying small volumes of special undiluted insecticides. Each formulation used was calibrated at air speeds of 80 mph and a pump pressure of 40 psi. The four special insecticide formulations utilized in these tests were malathion, 10.2 lbs/gal, American Cyanamid 52160 (0, 0, 0′, 0′ tetramethyl 0, 0′-thiodo-p-phenylene phosphorothioate, now known as "abate"), 4 lbs/gal; a malathion and AC 52160 mixture, 9:1 ratio; and fenthion, 8 lbs/gal. All treatments were applied over relatively uninhabited areas of Western Kentucky the week of June 19, 1965.

Malathion—AC 52160 mixture was applied with Minispin® (Buffalo Turbine Agric. Equip. Co.) nozzles; the malathion with both the flat fan Tee Jet® nozzles (Spraying System Co. No. 80015) or Minispin® nozzles. Both delivered 1 fl oz per nozzle. Fenthion was applied with only the flat fan Tee Jet nozzles (No. 8001). These delivered 0.8 fl oz per nozzle. AC 52160 was mixed with water at the rate of 1 fl oz/75 fl oz of water and this rate was applied per acre through 20 D-4 hollow cone nozzles.

The criterion used to determine the effectiveness of the treatments was the number of adult mosquitoes counted in the immediate vicinity of a person in 30 seconds, before and after the area was treated. To accomplish this, two persons stood facing each other and counted the adults on and around the opposite person. This was repeated in four or five locations within

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each test area. No specific time interval was scheduled for post treatment counts; therefore, counts were made as time and weather permitted. Because of the convenience, more observations were made in those areas in close proximity to the airfield.

In areas where mosquito larvae were found, 10 dips were taken with a 4 in. diameter water dipper, and the average number of larvae per dip was recorded. This was repeated in at least 10 locations within each larval test area immediately before treating and at various hours after treatment. Because the tests were conducted near the end of the larval stage, very few areas were suitable for larvicide testing. To compensate for the lack of larvae, 32-ounce cheese cartons containing 25 mosquito larvae each were placed in selected test areas. These larvae were in the 3rd or 4th instar at the time of treatment. Ten cartons were used at each area selected and were placed at various locations such as under low-growing shrubs, tall trees, deep grass and in open areas. Cartons used as untreated checks were placed within the same area but were covered during treatment. The criterion for post-treatment larval mortality in the cartons was the inability of the larvae to surface.

All mosquito larvae and adults collected were identified as *Aedes sollicitans* (Walker).

Because the terrain consisted of dense foliage and large swamp areas, no flagmen were used. The acreage treated was determined by timing. Adulticiding areas ranged from 150 to 200 acres and larviciding areas, when not in the same areas as the adult tests, ranged from 50 to 150 acres in size. Because of tree height in test plots, the plane was flown at an altitude of approximately 60–75 ft. Weather conditions were considered good for aerial application; the temperature was warm and the wind varied from practically 0 to 6–8 mph. Gusts of wind, in velocity of 15 mph, were recorded during one test.

LARVICIDING TESTS. AC 52160 was applied at the rate of 0.03 lb/acre of swamp land. Counts were made on each side of a road through the center of this area. Pretreatment larval dip counts averaged 19 larvae per dip. Results after 29, 48 and 60 hours showed 100 percent control of larvae. AC 52160 appeared to have no effect upon adults. Chironomid larvae were affected by this application but were not killed immediately. Most, however, were either dead or moribund within 60 hours after the treatment.

A malathion and AC 52160 combination (9:1) applied undiluted at the rate of 0.32 lb malathion and 0.036 lb AC 52160 per acre of swamp land resulted in 100 percent larvae control 48 hours after treatment. More 3rd and 4th instar larvae were seen dead in the water than were actually seen or found alive before treating. Chironomid larvae were killed more rapidly than by AC 52160 treatment alone.

Undiluted fenthion at 0.05 lb/acre was applied during a very calm period just before a rainstorm. Only one nozzle, located on the right boom, was used for this rate. Because water sources containing larvae were scarce in this area, 10 cartons of 25 larvae each were placed in various locations. Results 16 hours after treatment showed 100 percent control of larvae in all treated cartons as well as in the naturally infested water areas. In these same areas 69 hours after treatment, control was 84 percent. The larvae found at this time, however, were newly hatched as the result of the rainfall the day before.

Fenthion, diluted with Panasol AN-2® (American Oil Co.) plus an emulsifier Toximul MP® (Stepan Chemical Co.), was also applied at the rate of 0.05 lb/acre (4 fluid oz). Mosquito larvae reduction was 97 percent at 9 hours; 80 percent at 32 hours; and 96 percent at 49 hours after treatment. Similar results were obtained in another test area with the same treatment. No cartons were used in these tests.

Ten cartons of 25 larvae each were placed in the test site sprayed with 0.3 lb of malathion per acre (4 fluid oz). Cartons placed under foliage showed a 30 percent

reduction of larvae compared with a 100 percent reduction in cartons in the open.

Results of cartons placed in an area treated with 0.1 lb of fenthion per acre (1.6 fluid oz) showed a 76 percent reduction of larvae in cartons placed under foliage and 87 percent reduction in cartons in the open. This application was one of the last made, and gusts of wind up to 15 mph were recorded at the time of treatment.

ADULTICIDE TESTS. Undiluted fenthion and diluted fenthion applied at the rate of 0.1 lb/acre showed little difference in control although control was obtained in a shorter period of time with the larger volume (Table 1). At the lower dosage of 0.05 lb/acre, control was slightly better with the lower volume of 0.8 fl oz/acre than the 4 fl oz/acre. In general, no appreciable control was achieved with any fenthion treatment in less than 10 hours.

Very little difference could be seen in the malathion application with either the Minispin or flat fan nozzle (Table 2). A comparison of the two nozzle types at the lower dosage, however, was not possible because one test area was resprayed by mistake 24 hours later. The 0.30 lb/acre treatment compared favorably with the higher dosage of 0.46 lb/acre and also with the malathion and AC 52160 mixture.

DISCUSSION. The combination of malathion and AC 52160 apparently gave better control of larvae than AC 52160 alone, possibly because of less foliage in the area. The combination of these two compounds would seem to make an excellent treatment for both adults and larvae since malathion alone is a rather poor larvicide. The effectiveness of malathion on chironomid larvae is another advantage for this combination. Although 0.8 oz of undiluted fenthion per acre gave good larval and adult control, this rate is considered close to the minimum dosage because of the ideal conditions needed for successful application. Indications are that applications of a larger volume with an emulsifier added will enhance larval kill. It is believed, however, that between 0.05 and 0.1 lb of fenthion (diluted or undiluted) per acre and between 0.3 lb and 0.5 lb malathion per acre are the correct dosages to be used in dense foliage areas as encountered in Western Kentucky. In areas where little or no foliage is a factor, lower dosages of both compounds probably would be effective.

It is apparent that both fenthion and malathion need an additive compound for rapid knockdown of adults as both require approximately 9 to 12 hours for any appreciable kill even at higher dosages, the lower dosages requiring much longer.

Weather conditions are important factors in low-volume application and influence the effectiveness of the treatment. Under ideal conditions, minute amounts of insecticide can be applied with excellent results. With even the slightest wind, however, minute amounts are carried beyond the intended area; thus a larger volume per acre may be advisable under certain conditions.

Under the conditions of these tests we

TABLE 1.—Low-volume aerial application of fenthion for control of adult mosquitoes.

lb/acre	Fluid oz/acre	Number of nozzles[a]	Percent reduction—hours after treatment							
			10	15	24	30	36	48	54	72
0.1[b]	1.6	2	32	..	80	93	86	92	63	..
0.1	4[c]	6	100	..	..	85	96	..	..	95
0.05	0.8	1	..	100	90	..	..	..	..	100
0.05	4[d]	6	80	..	..	83	..	83	..	83

[a] Spraying system flat fan Tee Jet® #8001.
[b] Average of 2 test plots.
[c] 1.6 fl oz of fenthion and 2.4 fl oz of panosol.
[d] Average of 2 test plots. 0.8 fl oz of fenthion + 0.1 fl oz of panasol and 3.1 fl oz of emulsifier.

TABLE 2.—Low-volume aerial application of technical malathion alone and combined with AC 52160 for control of adult mosquitoes.

lb/acre	Fluid oz/acre[b]	Type Nozzle	Percent reduction—hours after treatment							
			15	24	30	36	48	54	72	108
0.46	6	flat fan[c]	96	100	..	98	74	..	..	100
0.46	6	Minispin[d]	99	99	97	..	..	..	87	96
0.30	4	flat fan	97	..	..	97	..	..	98	..
0.15	2	Minispin	..	75	..	98	75	55	..	50
0.15	2	flat fan	..	80[e]	..	..	..	..	..	..
0.32 malathion + 0.036 AC 52160	6	Minispin	..	..	97	97	85	100	..	100

[b] Corresponds with number of nozzles used.
[c] Spray System Co. Tee Jet® #80015.
[d] Buffalo Turbine Co.
[e] Sprayed by state mosquito control personnel after first count.

can conclude that *A. sollicitans* can be adequately controlled by treating large areas with either malathion alone or in combination with AC 52160 or fenthion. A control program, however, would be directly correlated with weather since after each rain a new generation of *A. sollicitans* would emerge, unless, of course, complete eradication had occurred.

The advantage of using Minispin nozzles in mosquito control work was not established in these tests.

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