LOW VOLUME AIRPLANE SPRAYS FOR THE CONTROL OF MOSQUITO LARVAE [1]

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The amounts of spray material required to control mosquitoes are a matter of real concern to all responsible mosquito control personnel. This is particularly true in California because of the necessity for economy in the treatment of nearly 1½ million acres each season. Also, most of the spraying is done over privately owned irrigated agricultural areas where any damage to the plants, livestock, workers, equipment, water or soil could result in claims or lawsuits for damages.

Through a gradual reduction of volume of spray materials applied, with adjustments of the concentration to keep the amount of toxicant constant, an application rate of 1 gallon per acre of water-emulsifiable spray was in general use by 1963. In that year, 37 aircraft were used by 23 agencies. They flew a total of 8,839 hours in applying liquid larvicides, averaging just under 150 acres per flight hour. The usual swath width was about 60 feet, and the planes flew from 6 to 15 feet above the fields.

Air applications made during the early morning hours, while temperatures are low and the air movement minimal, are generally successful throughout the Central Valley of California. By mid-morning the temperature may approach 100° F., with a wind velocity of 10 mph or more, so that spraying becomes ineffective and must be stopped. Lost time resulting from unsatisfactory meteorological conditions is thus a matter of major concern (Mulhern, 1959).

Much thought has been given to means by which the airspray day can be lengthened, or the effective capacity of present aircraft increased. Night spraying by floodlights, as practiced by some agricultural operators, has been considered, but not evaluated. It would appear likely to have only limited application in mosquito control operations. Consideration has been given to the use of larger or faster aircraft and heavier loading of the present aircraft. Moderate changes of this sort have somewhat increased production but the improvement is not great, for with heavier aircraft, wider turns are necessary and the time lost may actually be increased. There is much variation in efficiency, depending upon local conditions. Frequently, with an application rate of 1 gallon per acre, about 20 minutes is required to discharge a load of 100 gallons, plus another 20 minutes to ferry back to the base, reload the plane, and return to the field to be sprayed.

It is obvious that if the per acre volume could be reduced by 50 percent, the frequency of loading could be reduced proportionately, and the most desirable time could be utilized in spraying instead of in loading and ferrying. If the application rate per acre could be reduced to the point where the plane could operate continuously on spraying for a period limited only by the capacity of the fuel tank (usually about 2 hours), then the plane could treat six times as much area with one load, thus eliminating five of the loading periods. Continuing the projection a little further, if a plane carrying 100 gallons were to start flying at 5:00 a.m., applying ⅙ gallon per acre and averaging 100 acres in 20 minutes, by 7:00 a.m. it would have treated 600 acres. After loading, it

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could be back spraying by 7:20, and by 9:20 it would have treated a total of 1,200 acres for the morning. This is to be compared with a theoretical maximum of 650 acres that could be treated in the same period at the 1 gallon per acre rate.

Mosquito abatement district managers and pilots have pointed out that in operational practice, such high rates of production are rarely achieved at the 1 gallon rate, and the seasonal average is much less. This is due to the fact that many of the treated areas are small, often including 5 acres or less. This limitation will continue to apply, even at ultra-low volumes. There is also quite general agreement that the endurance of the pilot may prove to be the most important factor limiting the length of flights, since the low flying necessary in spraying demands so much concentration as to suggest that individual spray flights be limited to not more than 1½ or 2 hours of continuous flying between short rest periods. There is also general agreement that the smaller and lighter loads which may generally be carried when applying low-volume rates should contribute to safer operation.

Another approach that had been considered is that of continuing to spray later into the day. However, experience has shown that the water emulsible sprays cannot be depended upon to give consistently reliable results, probably because droplets evaporate to a size so small that they can drift out of the target area before settling to the ground. There is good evidence to indicate that nonevaporative sprays of relatively large droplet sizes may allow spraying to be done later in the day, and under less favorable wind conditions, as well as allowing the successful use of lower volumes. Motor oil has been used by U.S.D.A. workers, as a viscosity and evaporation control additive with DDT oil solutions, but it was not considered a suitable additive to apply over agricultural crops in California.

In the summer of 1962, airplane sprays of DDT in oil were found by the U.S.D.A. to be completely effective against grasshoppers at one pint per acre (Messenger, 1963). Subsequent tests of malathion with a solvent provided by the American Cyanamid Company led to the use of undiluted malathion. Mr. Arthur O. Jensen of that company then suggested that undiluted technical malathion be tested on mosquitoes. In collaboration with the Merced County Mosquito Abatement District, which supplied the planes, personnel, and a test site, preliminary tests were made in October, 1963 against larvae and adults of *Aedes nigromaculis*. A 150 hp Call-Air plane was used, with six No. 8001 Spraying Systems nozzles at 30 psi to discharge the 95 percent technical malathion, and six No. 8002 nozzles to deliver malathion 75 percent emulsifiable concentrate. Swath pattern distribution, as indicated by droplets caught on slides and by bioassay, was uneven, yet the results against both larvae and adults showed better than 95 percent control by the time evaluation was terminated four hours later.

The standard boom and nozzle arrangement was not satisfactory for test applications of such low volumes, so a detachable test unit was built. A 4-gallon Hudson hand sprayer tank was suspended in the hopper, as the source of supply. The boom, which was made of ½ in. diameter tubing, was clamped to the standard boom when in use (Fig. 1). The unit was equipped with a 12-volt motor-driven pump to serve the boom (Fig. 2).

Plans were made to resume testing during the summer of 1964, and the cooperative effort was joined by the Tulare, Kings, Fresno Westside, and Delta Districts.

RESULTS OF 1964 TESTS

Emulsions. As indicated above, one gallon per acre of emulsion spray is widely used in California for airplane applications against mosquito larvae. To determine if lower dosages would be effective, tests of 1 and 2 quarts per acre were made by reducing the number of spray nozzles by ¾ and ½, respectively. The size of the nozzles used in the different planes ranged from D-4 to D-6 and the original numbers of nozzles used varied from 22 to 24. Whirl plates were used in the nozzles of some planes. Pump pressure ranged from 15 to 18 psi.

Applications of ½ gallon of emulsion per acre containing 0.1 lb. of parathion or fenthion gave complete kill of larvae in all tests. The effectiveness of the 1-quart per acre applications containing 0.1 lb. of fenthion ranged from 75 to 100 percent (Table 1). Further evidence of the effectiveness of the half-gallon per acre application was provided by the Fresno Westside Mosquito Abatement District where 25,465 acres were sprayed at the half-gallon rate in August and September, and by the Eastside Mosquito Abatement District which treated about 10,000 acres at the same rate.

Fenthion-oil. Tests with fenthion-oil sprays were made with a 150 hp Call-Air plane. Eight No. 8001 flat spray nozzles were used on the 34-foot boom for most tests. The nozzles were placed at the ends of the booms and at distances of 5½, 11, and 14 feet from the ends. Nozzles were inserted in the boom so that they pointed backward at an angle of approximately 45° when the plane was on the ground. This arrangement of the nozzles produced what appeared to be quite even distribution of the spray droplets over a 66-foot swath width. A 60-foot swath was used for this series of tests.

The fenthion-oil spray was tested at an application rate of approximately 7 liquid ounces per acre, containing 0.1 lb. of fenthion. The 7-ounce volume was made up by adding to the required quantity of fenthion concentrate sufficient oil (Golden Bear Oil Company, 99.5 percent Aromatic Solvent, Code DMN, 0.9965 sp gr) and 8 percent B-1956 emulsifier. Technical fenthion was used for the first tests, and

Fig. 1.—150 hp Call-Air plane supplied by Tulare Mosquito Abatement District, showing special boom of ½″ tubing used in low-volume applications.

TABLE 1.—Airplane spray tests with low volume water emulsion insecticides at 0.1 lb./acre.

Insecticide	Quarts per acre	Type of plane	Cone spray nozzles No.	Cone spray nozzles Size	Location (District)	Type of crop	Species	Instar	Percent mortality
Fenthion	2	Pawnee 235	11	4 & 5	Tulare	pasture	*A. nigromaculis*	4th	100
"	"	"	11	"	"	alfalfa	"	3rd	100
"	"	"	11	"	"	pasture	"	4th	100
"	"	"	12	"	Kings	pasture	"	3rd & 4th	100
Parathion	"	Call-Air 235	12	6	Fresno Westside	rice	*C. tarsalis* *A. freeborni*	1st to 4th	100
"	"	" "	12	"	" "	"	*C. tarsalis*	"	100
"	"	" "	12	"	" "	"	*C. tarsalis*	"	100
Fenthion	1	Pawnee 235	6	4 & 5	Kings	pasture	*A. nigromaculis*	3rd & 4th	97
"	"	"	6	"	"	"	"	4th	60
"	"	"	6	"	"	"	"	3rd & 4th	100
"	"	"	6	"	"	"	"	"	75
"	"	"	6	"	"	"	"	"	99

TABLE 2.—Airplane spray tests with undiluted technical insecticide and with insecticide-oil-emulsifier solutions.

Insecticide Type	Insecticide lb./acre	Ounces per acre	Number of acres	Nozzles No.	Nozzles Size	Location (District)	Type of crop	Species	Instar	Percent mortality
Fenthion	0.1	7	20	8	8001	Tulare	pasture	*A. nigromaculis*	3rd & 4th	100
"	.107	7.5	16	"	"	Kings	"	"	"	100
"	.11	7.6	11	"	"	"	"	"	"	100
"	.1	7	35	10	8001[1]	Tulare	"	"	"	80
"	.07	6.4	20	7	8002	"	"	"	"	98
"	.12	11	30	12	8001[2] 8002	"	"	"	"	100
Malathion	.5	6	20	4	8001	Merced	ungrazed grassland	*C. tarsalis*	1st to 4th	60
"	.5	6	10	"	"	"	pasture	*A. nigromaculis*	3rd & 4th	67

[1] Number of nozzles increased to 10 because of partial pump pressure failure.
[2] Ten 8001 and two 8002 nozzles.

the 8-lb. per gallon commercial fenthion was used after the technical fenthion supply was exhausted. No difference in effectiveness was noted as a result of using the two types of fenthion. With each formulation the emulsifier was added locally.

A series of four tests of the 7-ounces-per-acre formula were made on third and fourth instar *A. nigromaculis* larvae in irrigated pastures. The areas used ranged in size from 11 to 35 acres. The plane flew at heights ranging from about 5 to 12 feet. The time of spray applications ranged from 6 a.m. to 1:30 p.m. Tests were made in both the Tulare and Kings Mosquito Abatement Districts. The larvae in a number of test plots were highly resistant to parathion and some were also partially resistant to fenthion. Eighty to 100 percent kill of larvae was obtained on these tests in 24 hours (Table 2).

The results of two preliminary tests that preceded the 7-ounces-per-acre application are also shown in Table 2. These were applied with different sizes and numbers of nozzles. Good kills were obtained in these tests even though plugging of some of the nozzles caused a greatly reduced dosage in one test. Plugging of the nozzles in the earlier tests was apparently due to material that scaled off the fiberglass surface of the spray tank. This problem was almost completely eliminated by sanding and refinishing the tank surface and by installing a screen filter in the line between the tank and the spray boom.

One type of oil (Golden Bear DMN) was used as an extender to build up the volume in all of these tests. This type of

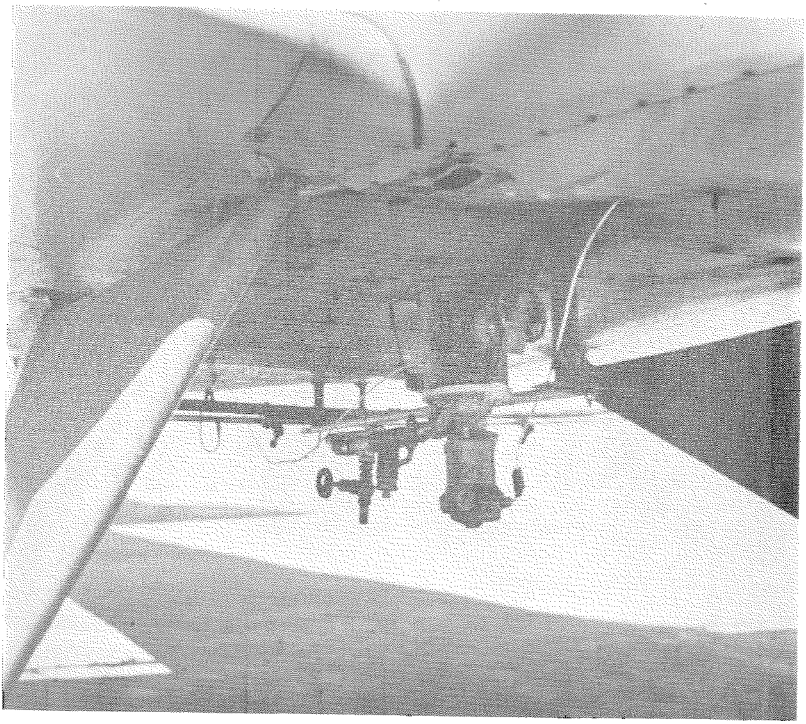

FIG. 2.—Electrically driven pump and 12 volt d.c. motor mounted on dump-valve door of Call-Air 150 hp plane used in tests in Tulare and Kings mosquito abatement districts.

oil seemed to give good results, but an oil with a lower specific gravity might be even more effective.

The results obtained in these tests suggest that application of 8 to 10 ounces per acre of this fenthion-oil-emulsifier combination may be effective in routine spray applications against *A. nigromaculis* larvae.

Malathion. A Call-Air plane equipped with four flat spray nozzles was used to apply undiluted technical malathion against mosquito larvae in the Merced area. The 33-foot boom had nozzles inserted 29 and 117 inches from the ends. Partial kills of mosquito larvae were obtained in tests in which malathion was applied at 6 ounces (0.5 lb.) per acre (Table 2). Addition of an emulsifier to the insecticide in future tests will probably increase its effectiveness.

Technical malathion was shown to be highly effective against adult mosquitoes in tests made during the summer of 1964 (Knapp and Roberts, 1965; Glancey *et al.,* 1965).

For the 1965 season, several additional mosquito abatement districts have already indicated that they will employ the half-gallon rate of water-mixed emulsible sprays, with large orifice flat spray nozzles to form the droplets. Additional testing of the nonevaporative sprays will be done, probably using a rate of 8 to 12 liquid ounces per acre, this larger volume being employed instead of the minimum successful 7-ounce rate tried in 1964. The larger volume will be employed as a means of avoiding some of the mechanical difficulties of 1964 which resulted from nozzles plugging.

Other aspects of this problem which will receive attention will be the search for suitable extenders for the other toxicants commonly in use. The objective will be to develop formulations which will be compatible with the various toxicants, stable in concentrate or tank mixes, and which will disperse well in the water of the mosquito source, even when highly alkaline or organic.

Improvements in the boom and nozzle arrangements for both fixed wing aircraft and helicopters will be undertaken by a cooperative project in the Department of Agricultural Engineering of the University of California at Davis.

SUMMARY. Airplane applications of fenthion-oil spray containing 0.1 lb. fenthion and 8 percent emulsifier gave complete kill of third and fourth instar *Aedes nigromaculis* larvae in three tests at 7 liquid ounces per acre and 80 percent kill in a fourth test. The spray was applied with eight No. 8001 flat spray nozzles on a 34-foot boom.

Preliminary tests with technical malathion at 0.5 lb. per acre gave kills of 60 to 67 percent against *Culex tarsalis* and *A. nigromaculis* larvae. Four No. 8001 flat spray nozzles were used on a 33-foot boom in these tests.

Applications of 1 and 2 quarts per acre of water emulsion sprays containing 0.1 lb. parathion or fenthion were completely effective against several species of fourth instar larvae. Six and 12 No. 8002 nozzles were used, respectively, for the 1 and 2 quart applications.

References Cited

GLANCEY, B. MICHAEL, LOFGREN, C. S., SALMELA, JACK, and DAVIS, A. NELSON. 1965. Low volume aerial spraying of malathion for control of adult salt-marsh mosquitoes. Mosquito News 25(2):135–7.

KNAPP, FRED W., and ROBERTS, W. W. 1965. Low volume application of technical malathion for adult mosquito control. Mosquito News 25(1):46–7.

MESSENGER, KENNETH. 1963. Low volume aerial spraying will be boon to applicator. Agr. Chem. 18(12):63–6.

MULHERN, THOMAS D. 1959. Airspraying for mosquito control in California. Processed report, Agricultural Aircraft Pilots and Operators short course, Univ. California, Davis.

TRAVIS, B. V., APPLEWHITE, K. H., and SMITH, NELSON. 1950. Control of mosquito larvae in Alaska with DDT. J. Econ. Entomol. 43(3): 350–3.