AIRPLANE APPLICATION OF GRANULAR PARIS GREEN MOSQUITO LARVICIDE

ANDREW J. ROGERS AND CARLISLE B. RATHBURN, JR.[1]
Florida State Board of Health, Entomological Research Center

This is the third in a series of papers reporting on the development and application of a new granular formulation of paris green for control of both anopheline and culicine mosquito larvae. The first paper (Rogers and Rathburn, 1958) outlines early procedures for formulating paris green on vermiculite and gives test results against salt-marsh *Aedes*, *Psorophora*, and *Anopheles* larvae. The second paper (Rogers and Rathburn, 1960) describes improved methods of formulating this larvicide.

The light weight of the original formulation (12 pounds per cubic foot) makes it very desirable for application at ground

[1] The authors hereby gratefully acknowledge the indispensable cooperation of Mr. E. J. Beidler, Director, Indian River Mosquito Control District, and his staff in the conduct of this study.

level. However, because of the adverse effects of variable-velocity winds on dosage patterns when applied from the air, this light bulk density proved to be a disadvantage in airplane application. Therefore research was continued in 1959 to find satisfactory solutions to the problems associated with airplane application of this larvicide. This paper describes the methods and results of this research.

FORMULATION

The first objective was to make the formulation heavier. By reducing the vermiculite content on a hundredweight basis from 53 to 35 pounds and increasing the other materials proportionately, a balanced formula was obtained which weighs about 19 pounds per cubic foot or approximately 50 percent more than the original formula. The formula recommended for airplane application is as follows, per hundredweight.

Vermiculite	35
Emulsifiable oil	40
Powder	25
Total	100

MATERIALS

Vermiculite—The larvicide was further improved for airplane application by use of a more uniform, dust-free grade of vermiculite. Through co-operative efforts between the Florida State Board of Health and the Zonolite Company, there was produced at the Jacksonville, Florida plant of the Company in 1959 a special grade of vermiculite for use in the recommended airplane formula of granular paris green. This product, designated by the Zonolite Company as Florida Chemical Carrier No. 3, is a 10/30 mesh grade with approximately 85 percent by weight in the 10/20 mesh size; minimum weight is 23 pounds per four-cubic-foot bag. Accepted sieve analyses on this grade of vermiculite are shown in Table 1.

Oils and Emulsifiers—Recommended oils and emulsifiers were discussed in detail by Rogers and Rathburn (1960). These same materials are recommended for use in the airplane formula. The oils are all horticultural-type spray oils. They are: Standard Oil Co., No. 341 and No. 345; and Gulf Oil Co., No. 361 and No. 562. The emulsifier found to be most effective to date is Triton N-101. (Rohm & Haas Co.)

TABLE 1.—Percent by weight of Florida Chemical Carrier No. 3 grade vermiculite retained on U. S. Standard Sieves (percentages not accumulative)

Sieve No.	Minimum	Maximum
10	0.0	1.5
16	20.0	55.0
20	40.0	90.0
30	0.0	10.0
Pan	0.0	5.0

Paris Green Powder—In order to control the concentration of paris green in the airplane formula, the commercial-grade paris green is first diluted with an inert powder of similar particle size and weight. As shown in Table 2, 25 pounds of the proper blend then are used for each 100 pounds of formulation. Marble dust, a by-product of the marble industry, is one inert powder that is satisfactory for diluting the paris green.

Several of the commercially-available paris green powders have been tested against salt-marsh *Aedes* larvae in the development of this product, and all have been shown to be effective.

FORMULATING PROCEDURE

The method of mixing this formula is the same as previously outlined (Rogers and Rathburn, 1960). The vermiculite is placed in a rotating-drum mixer and the oil containing by volume 10 percent of Triton N-101 is sprayed over the vermiculite as it mixes. Since the Triton is not completely soluble in the oil, the mixture should be agitated as it is sprayed. The required blend of paris green powder is then added in smaller portions but at a total rate of 25 pounds per 100 pounds of formulation.

When the paris green is well mixed with the vermiculite, the larvicide may be bagged directly from the mixer for use or storage. Storage qualities appear to be

TABLE 2.—Diluting 90% paris green powder with inert diluent for use in making granular paris green mosquito larvicide

Paris green by weight desired in finished formulation (%)	Per 100 lbs. of blend use		Pounds of blend to use per 100 lbs. of formulation
	90% paris green-lbs.	Marble dust-lbs.	
2.5	12	88	25
5.0	23	77	25
7.5	34	66	25
10.0	45	55	25

excellent even for periods of several months duration; however, no specific studies have been made on storing of the larvicide.

EQUIPMENT

The new formula first was applied in swath and pattern studies on a grass airstrip. Crop-dusting Stearman airplanes equipped with commercially-available distributors were used in these tests and in subsequent tests against mosquito larvae. In the swath studies, the airplanes were flown 80 m.p.h. on a measured course with the airplane crossing at a 90° angle over a line of wooden trays placed on 5 or 10-foot centers on the grass strip. The trays were 3 inches deep and 2 feet square. The granular paris green caught in each tray was placed in individually numbered vials and weighed on an analytical balance. Dosage curves were then plotted from these data.

For economy and effective insect control, two factors stand out in airplane application of insecticides: uniform distribution of the insecticide and the width of the effective swath. The swath tests conducted in this study pointed up the vast differences in dispersing equipment as they relate to these two factors.

All of the early airplane tests with granular paris green, extending as far back as 1957, were made with two commercial distributors widely used for airplane crop dusting. The best average swath width that could be obtained with either of these distributors with granular paris green was about 30 feet. Also, the distribution within the swath was very erratic, often with gross overdosing or underdosing in "strips." This same irregular pattern was revealed in larvicide tests conducted in 1958 and early 1959, there being narrow "strips" in many test plots with 100 percent larval kill adjacent to "strips" with little or no kill. Results of this type obviously reflect poor application—not insecticide failure.

In June, 1959 the Indian River Flying Service of Vero Beach, Florida, owners and operators of the airplanes used in these tests, purchased a new Swathmaster[3] distributor and mounted it on a 450 h.p. Stearman airplane. This unit proved to be so much more effective than those previously used that the latter were not used again.

The Swathmaster unit distributed the granular paris green in an effective swath of 60 feet, with a total spread of about 100 feet. Fig. 1a. shows a typical dosage curve (actual) from a single swath and Fig. 1b. represents the dosage pattern obtained with multiple swaths flown on 60-foot flight centers with this unit. While these patterns might appear to deviate considerably from the theoretical horizontal dosage line representing 15 pounds per acre, the patterns are much superior to those obtained with the other distributors tested at half this swath width.

LARVICIDE TESTS

Tests were conducted in the summer and fall of 1959 against larvae of *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans*

[3] Distributed by Transland Aircraft, Torrance, California.

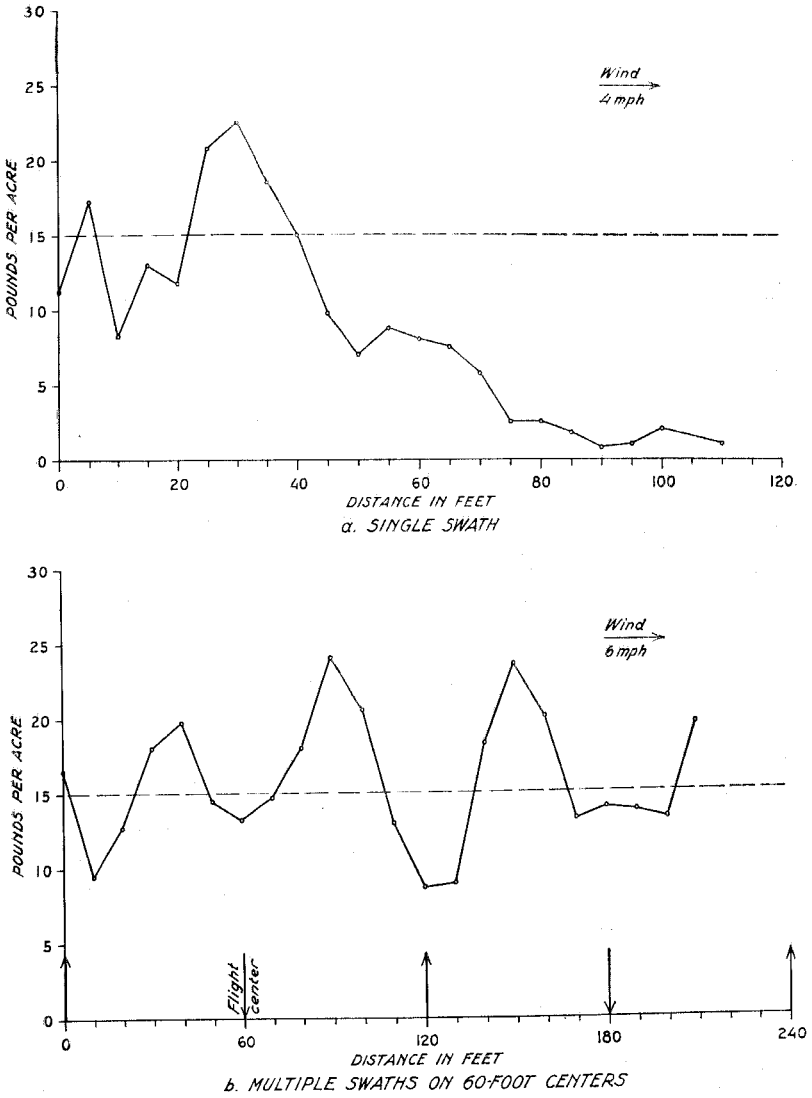

FIG. 1.—Typical dosage curves with granular paris green using a Swathmaster distributor mounted on a 450 h.p. Stearman airplane.

(Walk.) using the 450 h.p. Stearman equipped with the Swathmaster distributor. All tests were flown on 60-foot flight centers and at an altitude of 40 feet above the highest horizontal surface. Plots varied in size from 5.5 to 17.6 acres and were in typical mangrove-pickleweed salt marshes in Indian River County, Florida. Treatments were applied at various times throughout the day, some when ground

winds were estimated to be 15 to 20 miles per hour. Since complete coverage is so important with this stomach-poison larvicide, a gross coverage of 15 pounds per acre was used in all tests and toxicant dosage was controlled by varying the concentration of paris green in the formulation. Treatments were replicated in time and in space, in order to include as much variability of marsh features as possible for each treatment.

Dispersing runs were all flagged at each end of the run in all plots. Treatments and results are shown in Table 3.

TABLE 3.—Test results with granular paris green larvicide applied by airplane against *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Walk.)

Formulation-% paris green	lb./a of toxicant [1]	Number of tests	Avg. No. larvae per dip		Percent reduction	Range
			Pretreatment	24 hours		
5	0.75	3	94.9	1.6	98.3	97.1–100
2-1/2	0.375	3	69.1	0.1	99.9	99.8–100
1-1/4	0.1875	1	75.5	28.0	62.9	——

[1] All treatments applied at a rate of 15 lbs. per acre gross.

Results shown in Table 3 indicate no significant differences in larval kill between .75 and .375 pounds per acre of paris green. The slightly lower percent reduction shown for the higher dosage actually does not represent poorer average larval kill throughout the treated area. In the plots treated with .75 pound per acre, 270 live larvae from a total of 324 found at 24 hours were counted in two dips from the same dipping station. A vertical obstruction in the marsh apparently diverted most of the larvicide from this station. No other live larvae were found in this 10-acre plot where the population averaged 243 per dip before treatment. Unfortunately, opportunity did not permit more than one test with the 1-1/4 percent formulation, but this test probably serves adequately to indicate that .375 pound per acre was near the minimum effective dosage in these tests.

DISCUSSION

The formula recommended in this paper for granular paris green to be applied from the air is a balanced formula requiring those specifications and materials outlined, or equivalents. The specified amount of emulsifiable oil, for example, on a hundredweight basis might be too large or too small a quantity if a different grade of vermiculite is used, making the finished formulation too oily or too dry. Therefore it is suggested that nonequivalent substitutions of materials be accepted only after adequate demonstrations of their effective use, both physically and biologically.

The most effective and economical operation with this larvicide in any given locality with regard to toxicant dosage, gross poundage for adequate coverage, effective swath, etc. probably can best be determined locally as these factors relate to local marsh conditions, available equipment, etc. It seems pertinent, however, to reemphasize certain factors that appear to be important in the successful use of this larvicide, whether applied at ground level or by airplane. Paris green apparently acts only as a stomach toxicant to mosquito larvae; therefore its effectiveness is directly related to the degree of coverage in application. This assumes, of course, that the particular mosquito species in question is one that can be controlled with paris green. It has been tested against only a few species of culicine mosquitoes, and its effectiveness against other species is yet to be determined.

During approximately 24 years of intensive, worldwide use as a mosquito larvicide prior to 1945, there was recorded for paris green an excellent record of safety for fish, wildlife, domestic animals, and man. The new granular formulation is

especially easy to apply and appears to present a minimum of hazard to mosquito control personnel.

Although history cannot in this instance be used as a basis to predict future performance with regard to the resistance problem, it does seem worthy of present note that no anopheline species was reported to become resistant to paris green during its long and intensive use in malaria control. It can be stated with confidence that granular paris green is currently very effective for controlling salt-marsh *Aedes* that are resistant to chlorinated hydrocarbon insecticides in Florida.

References

ROGERS, ANDREW J. and RATHBURN, CARLISLE B., JR. 1958. Tests with a new granular paris green formulation against *Aedes*, *Anopheles*, and *Psorophora* larvae. Mosquito News 18(2):89–93.

———. 1960. Improved methods of formulating granular paris green larvicide. Mosquito News 20(1):11–14.