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AERIAL APPLICATIONS OF A SAND FORMULATION OF METHOPRENE FOR THE CONTROL OF SALT-MARSH MOSQUITO LARVAE

C. B. RATHBURN, JR.[1], E. J. BEIDLER[2], GLENNON DODD[2] AND ALBERT ALFFERTY[2]

ABSTRACT. Aerial tests of a sand formulation of methoprene indicate that a rate of 0.015 lb AI/acre is required for 95% control of field populations of *Aedes taeniorhynchus* (Wied.). Desired gross application rates were either 5 or 7.5 lb/acre, but in practice there was considerable variation due to the inability of the aircraft distribution equipment to apply uniformly the desired small amount of material.

Previous data by Rathburn and Boike (1975 and 1977) and Rogers et al. (1976) indicated that effective control of *Aedes taeniorhynchus* (Wied.) was obtained with granular formulations of methoprene up to one-half the recommended dosage rate for liquid formulations. The need for using granular formulations to penetrate the dense vegetation associated with mosquito larvae habitats in Florida is obvious since liquid formulations commonly deposit on the surface of marsh vegetation with little reaching the water surface and mosquito larvae. Although earlier tests were conducted with vermiculite-based granules, the sand formulation was selected for these tests because of availability, lower cost and the ability to treat a larger area with a single aircraft load.

[1] West Florida Arthropod Research Laboratory, Florida Department of Health and Rehabilitative Services, Panama City, Florida.

[2] Indian River Mosquito Control District, Vero Beach, Florida.

METHODS

All tests were conducted in the coastal areas of Indian River County, Florida with the test areas ranging in size from approximately 15 to 300 acres. The methods of formulating, application, and the type of aircraft and application equipment were the same as reported by Rogers et al. (1976) except in tests 8 through 11 where a modified fixed-aperture gate in the aircraft distributor system was used in an effort to obtain a more uniform application rate.

The method of evaluation consisted of placing 1 to 2 gals of water and 100 to 300 late instar larvae in 5 gal plastic containers. In earlier tests, containers both with and without bottoms were used but in later tests only containers with bottoms were used. The containers with bottoms were found to be easier to use and were not affected by changes in the water level of the surrounding area. The containers without bottoms were pushed into the bottom soil in order to retain the water and larvae. Also, in later tests the containers with bottoms were lined with plastic bags to reduce the chance of contamination when reused. Depending on the size of the area, from 2 to 6 containers were used to assess the treatment in each area. A similar number of containers was also used in each area as untreated controls. During treatment, the control, or untreated containers, were covered with tight fitting lids which were removed soon after treatment. The larvae in all buckets were fed yeast daily until pupation began.

After the onset of pupation, pupae were sampled daily, placed on damp paper towelling in plastic petri dishes and returned to the laboratory where the petri dishes were fitted with plastic and paper funnels and plastic cups for use as cages to retain the emerging adults. The dead pupae, partially emerged adults, adults that emerged and died on the surface and the viable adults that were able to fly up into the cages were recorded but only the viable adults were used for determining percent emergence. Pupae were also sampled from the treatment area near the larval containers, returned to the laboratory in petri dishes and caged for emergence.

The amount of formulation that was applied to a particular area was determined in 2 ways. As in previous tests, a known quantity of formulated material was placed in the aircraft hopper before each test and weighed upon removal. Also, 24 x 24 x 4 in. trays were placed in the vicinity of the larval containers to catch the material discharged from the aircraft. This material was weighed and the rate per acre determined. Since some of the sand granules have a tendency to bounce out of the trays, a predetermined factor (1.1 times the sample weight) was applied to the total weight of the material caught in the tray. In later tests (8 to 11), 20 gal plastic trash cans were used to collect the granules thus eliminating the loss of granules and the need to apply a correction factor. (Table 1).

RESULTS

The pounds of active ingredient per acre obtained from the samples collected, the overall area output for each test, and the percent control (Table 2) were subject to probit analyses. The results of the analyses appear in Table 3. The probit analyses were conducted using all tests except test 1 in which no samples were collected, and tests 10 and 11 in which control could not effectively be evaluated because of poor pupal emergence in check samples. These tests, however, were included in the table because of the additional data they contain relative to the percent pupal emergence and the variation in the discharge rates obtained.

As shown in Table 3, the dosage rate for adequate control as expressed by the LD_{95} varied from 0.014 lb AI/acre for the overall output to 0.016 lb AI/acre for the sample collections; therefore, it is reasonable to assume that satisfactory control of *Ae. taeniorhynchus* should be obtained with a dosage of 0.015 lb AI/acre and a gross rate of 7.5 lb/acre under the conditions of

Table 1. Measurements of outputs of sand formulations of methoprene applied by aircraft for control of saltmarsh mosquito larvae, 1976–77.

Types of measurements	Test number										
	1	2	3	4	5	6	7	8	9	10	11
Desired output—											
pounds per acre—gross	5.0	5.0	5.0	5.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5
pounds per acre—AI	0.020	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Sample collections											
number of samples	—	8	4	10	6	6	5	12	15	8	4
pounds per acre—gross											
average	—	6.6	5.2	7.7	3.6	4.3	7.1	7.5	7.6	6.4	9.5
percent of desired	—	132	104	154	48	57	95	100	101	85	127
range—minimum	—	3.5	4.1	6.7	2.0	2.9	4.8	3.4	2.7	2.5	8.7
—maximum	—	9.6	6.6	9.1	4.7	6.4	9.8	10.5	11.7	10.0	11.0
pounds per acre—AI											
average	—	0.020	0.016	0.023	0.007	0.009	0.014	0.015	0.015	0.013	0.019
range—minimum	—	0.011	0.012	0.020	0.004	0.006	0.010	0.007	0.005	0.005	0.017
—maximum	—	0.029	0.020	0.027	0.009	0.013	0.020	0.021	0.023	0.020	0.022
Overall area output											
pounds per acre—gross	6.3	4.6	3.6	5.8	6.0	4.7	8.1	—	7.5	—	—
percent of desired	126	92	71	116	80	60	108	—	100	—	—
pounds per acre—AI	0.025	0.014	0.011	0.017	0.012	0.009	0.016	—	0.015	—	—

Table 2. Results of aerial applications of sand formulations of methoprene for control of salt-marsh mosquito larvae, 1976–77.

Samples	Test number 1	2	3	4	5	6	7	8	9	10	11
Treated											
number of containers	4	4	4	2	4	4	2	6	2	4	2
number of pupae sampled											
containers	325	86	557	600	761	481	90	58	200	83	0
area	165	345	0	270	26	0	371	270	239	436	215
total	490	431	557	870	787	481	461	328	439	519	215
percent emergence											
containers	0	0	4	0	11	26	9	26	0	2	—
area	0	0	—	0	4	—	4	18	0	7	0
total	0	0	4	0	10	26	5	20	0	6	0
Check											
number of containers	4	4	4	3	4	4	2	6	2	4	2
number of pupae sampled	422	770	715	292	1027	401	158	290	166	190	117
percent emergence	59	66	80	70	35	39	75	78	96	16	2
Percent control	100	100	95	100	71	33	93	74	100	—	—

these tests. Variations in the type of habitat may, of course, raise or possibly even lower the dosage required for satisfactory control.

The main problem encountered in these tests was the uneven dispersal of the sand formulation over the treated area. As shown in Table 1, the amount per acre rate as determined by the sample collections varied from 2.0 to 11.7 lb/acre for the desired discharge rate of 7.5 lb/acre. In practical applications, however, this discrepancy may not be as important as it seems since the larvae may be subjected to more uniform dosage rates by their movement in the water, or the movement of water by wind, thermal currents, or changes in water level. This seems to be indicated by the fact that the average percent emergence from the treated containers, some of which were treated with high dosages and some with low dosages (based on the variations received in the sample trays placed adjacent to larval containers) was very similar to that obtained in the area samples which were subjected to the mixing factors previously discussed.

The percent of the desired output at the 7.5 lb .acre rate for the earlier tests (5 to 7) with the standard gate varied from 48 to 95% for the sample collections and 60 to 108% for the overall area output. Using the modified fixed-aperture gate (tests 8 to 11) the discharge resulted in 85 to 127% of the desired output for the sample collections and about 100% in limited measurements with the overall out-

Table 3. Probit analyses of dosage mortality data from aerial applications of sand formulation of methoprene against salt-marsh mosquito larvae, 1976–77.

Mortality	Lethal dosage-pounds AI per acre: Sample collections – Dosage	Sample collections – 95% C. L.[1]	Overall output – Dosage	Overall output – 95% C.L.[1]
LD_{50}	0.0072	0.0067–0.0075	0.0094	0.0091–0.0097
LD_{90}	0.0136	0.0131–0.0142	0.0128	0.0125–0.0131
LD_{95}	0.0164	0.0156–0.0173	0.0140	0.0135–0.0145
LD_{99}	0.0232	0.0214–0.0250	0.0165	0.0156–0.0174

[1] Confidence limits.

put. The average discharge for the tests with the modified fixed-aperture gate, therefore, was significantly closer to the desired discharge than that obtained with the standard gate. This indicated that further work is needed on a gate modification in order to produce a more uniform discharge rate.

Although the preceding tests were conducted with little or no overhead vegetation, a simulated test (without mosquito data) in an open and in a wooded area at a desired 10 lb/acre gross discharge rate resulted in a real rate from actual collected granules of 13.8 lb/acre in the open and 12.4 lb/acre under the canopy. In the open treatment the standard deviation was 2.9 lb/acre, with a range of 7.2 to 17.5 lb/acre and under the canopy the standard deviation was 4.2 lb/a with a range of 4.5 to 20.9 lb/acre. In the test, a total of 24 samples was collected and consisted of 2 rows of sample containers within 20 ft of each other, one in the open and one under the canopy. The containers were spaced 7.5 ft apart. As a result of these tests, it appears that the sand formulation gives good penetration of an overhead canopy and would not require an increase in gross application rate when necessary to control mosquitoes in areas of heavy vegetation.

DISCUSSION

It should be emphasized that any recommendation for aerially applied sand-carried methoprene should stress the application method more than the mean dosage rate since the application rate obtained from sample collections of the granules placed adjacent to the bioassay containers in these tests indicated that a gross applciation rate of 5 lb/acre (0.010 lb AI/acre) will result in adequate kill when applied to water less than ca. 6 in. deep and to larvae in the late 3rd or 4th instar. Under more severe conditions of greater water depth and with earlier instar larvae, good kill was uniformly achieved at a gross rate of 7.5 lb/acre (0.015 lb AI/acre). The difficulty obviously involves the delivery of the gross rate consistently and uniformly over the entire treated area. Obtaining the desired mean dosage does not necessarily signify that dosages obtained in small areas cluster about the mean, since variations in dosage received by the small areas, as shown by the sample collection data, may vary more than 100%. Therefore, good coverage will require extensive aircraft equipment modification, flagging of all possible treatment areas and monitoring of field application rates. It may well be that each individual applicator will have to satisfy himself on the acceptable range of application rate obtained before deciding on an overall gross lb/acre rate.

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