

ARTICLES

EFFECTIVENESS OF INSECTICIDES ON GRANULAR CLAY CARRIERS AGAINST MOSQUITO LARVAE¹

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Insecticides incorporated with granular carriers have been highly successful as larvicides against mosquitoes and sand flies, and have been particularly useful when the vegetative cover was too dense for penetration by sprays and dusts (Whitehead 1951, Keller *et al.* 1954a and b, and Labrecque and Goulding 1954). To determine whether the size or the composition of the granules has any effect on the efficiency of the finished material, various clays impregnated with insecticides were tested in the laboratory and in the field against larvae of *Anopheles quadrimaculatus* Say, *A. crucians* Wied., and *Aedes aegypti* (L.).

Laboratory Tests.—In the laboratory tests granules were dropped into quart jars containing 900 ml. of distilled water, 25 fourth-instar larvae were added, and mortality counts were taken after 24 and 48 hours. Unless otherwise stated, the granules were made by the authors by impregnating the carriers with acetone solutions of the insecticides.

Tests were conducted against larvae of *Anopheles quadrimaculatus* to determine the relative effectiveness of two attapulgitic products (A and B),² bentonite,³ diatomite,⁴ and pyrophyllite⁵ as granular carriers of dieldrin. The carriers were impregnated with 1 percent of dieldrin, dried, and separated by sifting into mesh sizes

of 5/10, 10/20, 20/30, 30/40, 40/60, 60/80, 80/100, and greater than 100. As the pyrophyllite was a finely ground powder, a small quantity of thin starch paste was added to form granules. The granules were tested at concentrations of 0.01, 0.1, and 1 p.p.m. of the insecticide, and each test was replicated 2 to 4 times. Mortality counts were made after 48 hours.

Based on an average for all tests run with each carrier, the diatomite and pyrophyllite preparations appeared to be the best of the group at the two lower concentrations. They produced kills of 87 and 93 percent at 0.1 p.p.m. and 48 and 60 percent at 0.01 p.p.m., compared with 65 to 77 percent at 0.1 p.p.m. and 27 to 38 percent at 0.01 p.p.m. for the other carriers. At a concentration of 1 p.p.m. the mortalities obtained with the various granules averaged 85 percent for the B sample of attapulgitic and between 95 and 98 percent for the other materials. No optimum mesh size was indicated.

In the tests to compare their effectiveness against *Anopheles quadrimaculatus* and *Aedes aegypti* larvae, only the 40/60-mesh granules were used and the concentration of dieldrin was 0.1 p.p.m. The results are given in table 1. *A. quadrimaculatus* larvae were more susceptible to most of the formulations than *aegypti*. Diatomite and pyrophyllite were again the most effective carriers against *quadrimaculatus*, and diatomite was the most effective carrier against *aegypti*.

Since mixtures of attapulgitic and bentonite granules are frequently used as carriers for dieldrin, tests were conducted to determine whether an optimum mixture of these carriers could be selected. The

¹ This work was conducted at the Orlando, Fla., laboratory of the Entomology Research Branch under funds allotted to the Branch by the Department of the Army.

² Florex S (A) and Attaclay A (B).

³ Volclay.

⁴ Pyrax ABB.

⁵ Celite 408.

TABLE 1.—Relative susceptibility of *Anopheles quadrimaculatus* and *Aedes aegypti* larvae to 1-percent dieldrin granules prepared with various carriers. (2 replications; 0.1 p.p.m. of dieldrin.)

Carrier	Percent mortality after 48 hours	
	<i>quadrimaculatus</i>	<i>aegypti</i>
Attapulgitc A	60	36
Attapulgitc B	52	34
Bentonite	64	38
Diatomite	76	76
Pyrophyllite	96	28

30/60-mesh granules were mixed in various proportions to obtain attapulgitc:bentonite ratios of 0:100, 25:75, 40:60, 50:50, 60:40, 75:25, and 100:0. Each combination was impregnated with 1 percent of dieldrin. Two tests were conducted with each formulation against larvae of *quadrimaculatus* at a concentration of 0.1 p.p.m. The 48-hour mortalities ranged from 60 to 84 percent, but the ratio of attapulgitc

to bentonite had no apparent influence on the effectiveness of the granules.

Tests were made with 30/60-mesh granules of the 25:75 attapulgitc-bentonite mixture impregnated with 1 percent of dieldrin to determine whether the toxicant diffused uniformly through the water. The granules were added, without stirring, to 900 ml. of water in a quart jar to obtain a concentration of 0.1 p.p.m. of dieldrin. The following day two 400-ml. portions were siphoned from the top of the jar, without disturbing the portion remaining in the bottom of the jar, and *quadrimaculatus* larvae were exposed in each 400-ml. portion. After 24 hours the mortalities were 22 and 26 percent in the two portions, and after 48 hours 44 percent in both, indicating equal diffusion of the toxicant.

Tests against *quadrimaculatus* larvae were made with attapulgitc granules impregnated with 1 percent of dieldrin in

TABLE 2.—Toxicity of 25 granular larvicides against fourth-instar larvae of *Anopheles quadrimaculatus*. (Average of 2 tests.)

Larvicide	Percent mortality after 48 hours		
	0.1 p.p.m.	0.01 p.p.m.	0.001 p.p.m.
Parathion	100	98	88
EPN	100	96	36
Am. Cyanamid 4124	100	76	—
TDE	100	74	—
Am. Cyanamid 12008	100	60	—
Bayer 21/199	100	56	—
Am. Cyanamid 12009	100	54	—
Diazinon	100	28	—
Fluorine analog of DDT	96	26	—
DDVP	98	6	—
Ethyl homolog of DDVP	100	4	—
Bromine analog of DDT	84	—	—
Endrin	78	—	—
O,O-Diethyl N-carbethoxymethylphosphoramidothioate	76	—	—
Lindane	74	—	—
Dieldrin	64	—	—
Chlordane	60	—	—
Toxaphene	54	—	—
Methoxychlor	52	—	—
Propyl homolog of DDVP	50	—	—
o,p'-DDT	48	—	—
Heptachlor	44	—	—
Chlorinated isobornyl phenyl sulfone (66% chlorine)	40	—	—
Chlordane (refined)	34	—	—
Aldrin	24	—	—

various solvents of low and high volatility. The highly volatile solvents—carbon tetrachloride, heptane, acetone, benzene, and xylene—were used at the rate of 20 percent of the total weight of the ingredients, and those of low volatility—fuel oil, mineral spirits, and kerosene—at 35 percent. All the solvents were satisfactory and none appeared to be superior to the others.

Tests against *quadrifaculatus* larvae were conducted with 25 insecticides, all of high larvicidal activity, to evaluate their effectiveness in granular formulations. The results with attapulgit (Attacly AA RVM) granules containing 1 percent of the toxicant applied at various concentrations are given in table 2. Parathion and EPN at 0.01 p.p.m. and nine compounds at 0.1 p.p.m. were highly effective. The remainder were less than 85 percent effective at 0.1 p.p.m.

Field Tests.—The 11 granular larvicides that proved to be the most effective in the laboratory tests were further tested in roadside ditches infested with larvae of *Anopheles crucians* and *quadrifaculatus*. The water was covered with water hyacinth (*Eichornia crassipes*) and waterlettuce (*Pistia stratiotes*), and *crucians* was the dominant species. Attapulgit (Attacly AA RVM) granules containing 1 percent of the insecticide were applied to 10-by 20-foot plots at various dosages. The control was determined by 10 dipper samplings taken in each plot before treatment and after 24 hours. The results are presented in table 3. Parathion, EPN, and Bayer 21/199 were highly effective at 0.01 pound per acre, and all the insecticides except DDVP and its ethyl homolog were highly effective at 0.1 pound per acre.

Summary.—Laboratory tests against fourth-instar larvae of *Anopheles quadrifaculatus* Say with 1 percent dieldrin granules indicated that pyrophyllite B and diatomite were slightly more effective carriers than attapulgit A or bentonite, but all the carriers made satisfactory granules. Granules of mesh sizes ranging from 5/10 to >100 were all equally effective. Gran-

ules made with highly volatile solvents such as carbon tetrachloride and xylene

TABLE 3.—Effectiveness of various granular larvicides against larvae of *Anopheles quadrifaculatus* and *A. crucians* in roadside ditches.

Insecticide	Percent reduction in 24 hours at indicated dosage per acre		
	0.1 pound	0.01 pound	0.001 pound
Parathion	100	88	53
EPN	97	99	27
Bayer 21/199	99	98	21
TDE	98	73	—
Fluorine analog of DDT	97	79	—
Diazinon	99	64	—
Am. Cyanamid 4124	97	57	—
Am. Cyanamid 12008	92	82	—
Am. Cyanamid 12009	94	83	—
DDVP	66	42	—
Ethyl homolog of DDVP	62	72	—

and granules made with solvents of low volatility such as fuel oil were equally effective. Dieldrin diffused evenly through quart jars of water treated with granules. Larvae of *Aedes aegypti* (L.) were more resistant than larvae of *Anopheles quadrifaculatus* to dieldrin granules. Parathion and EPN were the most effective of 25 granular larvicides in laboratory tests against *quadrifaculatus*. Parathion, EPN, and Bayer 21/199 were the most effective in field tests against *quadrifaculatus* and *Anopheles crucians* (Wied.).

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