FIELD-STUDY COMPARISONS BETWEEN INSECTICIDAL GRANULES AND EMULSION CONCENTRATES AGAINST MOSQUITO LARVAE

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The successful use of granular formulations of insecticides in thick stands of rice plants was reported by Whitehead (1951). Bentonite pellets coated with any one of several insecticides were very effective against larvae of *Psorophora confinnis* (L.Arr.) and *P. discolor* Coquillett where conventional spray applications were of no value. Rees (1953) found that bentonite and diatomaceous earth granules containing heptachlor or dieldrin were superior to sprays in several respects, including rate of treatment and ease of handling. The results of Rees *et al.* (1953) demonstrate the superior control of *Aedes* and *Culex* larvae by granular formulations of insecticides in fields having dense and extremely matted vegetation. These authors also noticed the unusual residual effect of parathion, applied at the rate of 0.2 lb. actual toxicant per acre on diatomaceous earth granules, which retained effectiveness for more than 2 to 3 weeks after application. Keller *et al.* (1954) published the results of field tests of various granulated insecticides against larvae of *Aedes taeniorhynchus* (Wied.) and *Ae. sollicitans* (Wlkr.) in salt marshes with heavy vegetation. In these tests granules of bentonite were generally slightly more effective than those of attapulgite except at lower dosages. The results also indicated that aerial applications of granulated insecticides in salt marshes with heavy vegetation were more effective than spraying. The effects of size and composition of granules on larvicidal

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action were investigated by LaBrecque *et al.* (1956). Various types of clay granules were impregnated with several different kinds of insecticides and tested against the larvae of *Anopheles quadrimaculatus* Say, *A. crucians* Wied., and *Aedes aegypti* (L.). Pyrophyllite and diatomaceous earth granules were found to be slightly superior to attapulgite or bentonite as carriers. Granules of mesh sizes ranging from 5–10 to 100 were found to be equally effective carriers. Granules prepared with highly volatile solvents such as xylene and carbon tetrachloride were as effective as those prepared with solvents of low volatility such as fuel oil. Differences in the insecticides, their concentrations and the types of granules used in the formulation affected the rate and amount of insecticide released in water (Weidhaas, 1957). Lewallen and Brydon (1958) achieved satisfactory control of *Culex tarsalis* Coquillett and *Anopheles freeborni* Aitken larvae with Dylox and Guthion formulations on montmorillonite granules. Successful control of *Aedes, Anopheles,* and *Psorophora* larvae by the use of a new granular paris green formulation was demonstrated by Rogers *et al.* (1958). Mulla and Axelrod (1959) reported the results of studies of factors which influenced the rate of release of toxicants from granules in laboratory tests. In general, the investigations reported above utilized granular formulations alone and emulsion concentrates were not tested concurrently. The efficacy of granules can be more meaningfully assessed by carrying out parallel tests with spray formulations.

METHODS AND MATERIALS. All the tests reported herein were conducted on irrigated pastures situated in Fresno and Kings Counties, California, with 3rd and 4th instar larvae of *Aedes nigromaculis* (Ludlow) and *Culex tarsalis* Coquillett. Experimental plots of 1/32 acre were marked with red flags. The lengths and widths used were varied according to the size of the pasture check rows. An effort was made to select a uniform segment of pastureland with respect to larval density and vegetative growth. Despite this, variations in depth of water and height of vegetation could not be kept constant from one test to another. The pretreatment larval index was made by taking 20 dips at random in each experimental plot and this index was compared with post-treatment dips made 24 hours later. The ratio of the post- and pretreatment indices reveals the percentage control. All tests were run during the months of July, August, and September, 1959. Each test was replicated 3–5 times on different batches of larvae.

Application of Insecticides. Since the dosages required to give appreciable levels of larval mortality were very low, it was practically impossible to get a homogeneous distribution of the formulated granules over the experimental plots. To overcome this difficulty, appropriate types of untreated granules were used to dilute the weighed amount of the insecticidal granules. In order to attain a uniform pattern of distribution over the experimental plots the total weight of all the granular insecticides was kept constant at 100 gm./plot (about 7 lbs/acre). The insecticide granules and the untreated diluent granules were weighed out in ½ pint paper ice cream cartons and mixed thoroughly for at least 3 minutes.

The granules were broadcast by hand over the experimental plots. After a little experience a uniform pattern of distribution was attained.

Insecticidal Compounds. Descriptions of the insecticidal materials employed in these investigations are presented in Table 1.

The corresponding amounts of the spray formulations were measured out in 6 oz. glass bottles. Each spray sample was mixed in a 1-gallon spray tank with one-half gallon of tap water. The spray tank wand was equipped with a Teejet nozzle No. 8002. Spray applications were made at approximately 25–30 lb/sq. in. pressure.

Testing of the homogeneity of the granular formulation dilution. Since very small amounts of the formulated granules were required at each dosage, it was believed necessary that the homogeneity of the

TABLE 1.—Types and sources of formulation used in tests

Insecticides	Type of formulation	Source
A. *Granular Materials*		
Di-syston	2.5%, on Attapulgite-LVM-A Size—20/40 mesh	Univ. of California Riverside [a]
Malathion	10.0%, on Attaclay-AAlum Size—24/48 mesh	Sunland Industries Fresno, California
Parathion	5.0%, on Attaclay-AAlum Size—24/48 mesh	" "
Thimet	5.0%, on Attaclay-AAlum Size—24/48 mesh	" "
Trithion	5.0%, on Attapulgite-RVM-A Size—30/60 mesh	Univ. of California Riverside [a]
B. *Spray Materials*		
Di-syston	2 lbs./gal. Emulsion Concentrate	Chemagro Chemical Co. New York 16, N. Y.
Malathion	57% Emulsion Concentrate	American Cyanamid Co. New York 20, N. Y.
Parathion	25% " "	" "
Thimet	47.5% " "	" "
Trithion	37% " "	Stauffer Chemical Co. New York 17, N. Y.

[a] Dr. M. S. Mulla.

diluted granules be tested. Malathion, parathion and Thimet granules were employed in these tests. Three to four replications were run by the standard method described above.

RESULTS AND DISCUSSION. The larval mortality figures of diluted granular formulations for each dosage in different replications are presented in Table 2. For all three insecticides, malathion, parathion and Thimet, there seems to be a consistent level of larval mortality obtained for each dosage and in all replicates. Based on the results of these experiments, all the granular insecticides used in parallel tests with spray applications were prepared by weighing out individual samples and diluting them with the untreated granules.

In Table 3 the comparative effectiveness of granular and spray applications of Di-syston, malathion, parathion, Thimet and Trithion against the larvae of *Aedes nigromaculis* are shown. Only a limited number of tests with parathion granules was conducted on *Culex tarsalis* because of the difficulty in finding appropriate testing sites for this species in 1959 (Table 4). As can be seen from the tables, there were no outstanding differences in the effectiveness of spray and granule formulations.

Although the performances of the two types of applications were similar, the granular materials were superior in ease of handling and rapidity of application. They may also prove to be much safer than liquid formulations. In case of accident the risk of poisoning is much less with granular than with spray formulations. The granular formulations also have a potential use in pre-irrigation treatments and may possibly have a longer toxic residual action to larvae. Further field experiments are required to establish these points.

SUMMARY. Bentonite and attapulgite granules coated with Di-syston, malathion, parathion, Thimet and Trithion were compared with sprays at similar dosages

TABLE 2.—Extent of variations in *Aedes nigromaculis* (Ludlow) larval mortality for malathion, parathion, and Thimet granules at varying dosage levels prepared by dilution with untreated granules

Insecticides and dosages (lb/acre of toxicant)	24-Hour percent mortality				Average Percent mortality
	Replicates				
	1	2	3	4	
Malathion					
0.500	100	100	97	—	99
0.250	95	99	100	—	98
0.125	86	99	78	—	88
Parathion					
0.100	100	100	100	100	100
0.050	100	100	100	100	100
0.025	99	98	100	100	99
0.0125	90	83	100	99	93
Thimet					
0.100	100	100	100	100	100
0.050	100	100	100	100	100
0.025	93	97	99	84	93
0.0125	95	100	93	41	82

TABLE 3.—Comparative percent larval mortality observed for a few organophosphorus insecticides in granular and spray field applications to *Aedes nigromaculis* (Ludlow) larvae

Compounds and dosages (lb/acre of toxicant)	Percent mortality [a]			
	Spray application		Granular application	
	Average	Range	Average	Range
Di-Syston				
0.50	94	87–100	74	53–94
0.25	43	23–63	82	82–82
0.10	54	25–76	43	42–43
Malathion				
0.500	98	96–100	99	96–100
0.250	96	88–100	99	98–100
0.125	93	83–98	92	78–100
0.0625	75	53–98	80	74–87
Parathion				
0.050	99	99–100	100	99–100
0.025	93	80–100	99	98–100
0.0125	92	77–100	94	83–100
0.00625	68	45–91	82	73–92
Thimet				
0.050	98	92–100	91	64–100
0.025	91	79–100	93	84–99
0.0125	76	38–99	78	41–100
0.0625	53	13–93	33	25–41
Trithion				
0.20	93	87–100	89	74–87
0.10	85	59–100	75	57–92
0.05	57	30–92	90	83–95

[a] Each dosage was replicated 3 to 5 times on different batches of larvae.

TABLE 4.—Larval mortality of *Culex tarsalis* with parathion in granular and spray applications in a single experiment

	Percent mortality [a]		
Dosage lb/acre	Spray application	Granular application	
0.100	100	100	—
0.050	100	100	95
0.025	100	78	—
0.0125	78	52	—

[a] Twenty-four-hour post treatment counts.

for the control of late instar larvae of *Aedes nigromaculis* and *Culex tarsalis*. The granular formulations were about as effective as the sprays.

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