lts with heptachlor and BHC. There ere slight differences with the other in- cticides, but these are not considered gnificant.

SUMMARY.—Extensive field tests were nducted in 1951 and 1952 to compare ie performance of several types of spray id fog machines when applying different secticides against adults of the salt- arsh mosquitoes *Aedes taeniorhynchus* Wied.) and *sollicitans* (Wlkr.).

In 1951 lindane was slightly more effec- ve than dieldrin and both were superior DDT regardless of the type of equip- ent used. A fog machine (Dyna-Fog) ave the best results when winds were ss than 5 miles per hour and the poorest wind speeds over 10 miles, whereas the verse was true with a jeep-operated mist sprayer. A Hession Microsol sprayer was most effective at wind speeds of 5 to 10 miles per hour.

In 1952 BHC (40% gamma) was slightly more effective than heptachlor, and both were considerably better than DDT, dieldrin, and chlordane. There was little consistent difference in effective- ness between the Lawrence Aero-Mist, Hession Microsol, and jeep sprayers and a Kyoritu fog machine at wind speeds of less than 1½ miles per hour, which pre- vailed throughout the tests.

Literature Cited

HUSMAN, C. N. 1953. A light, pneumatic sprayer for installation on vehicles. Mosquito News 13(2):134–8.

TESTS WITH GRANULATED INSECTICIDES FOR THE CONTROL OF SALT-MARSH MOSQUITO LARVAE [1, 2]

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Aerial spraying of insecticides fre- uently fails to give satisfactory control of ne larvae of *Aedes taeniorhynchus* Wied.) and *sollicitans* (Wlkr.) in salt- arsh breeding areas in Florida. Such reatments are ineffective largely because nly a small proportion of the spray pene- rates the vegetative cover and reaches he larvae in the water. The development f increased resistance in these species to he chlorinated hydrocarbon insecticides as further emphasized the need for get- ing adequate quantities of larvicide into he water.

In tests on the control of *Psorophora onfinnis* (L.-Arr.) and *discolor* (Coq.) in rice fields in Arkansas, Whitehead (1951) found that better penetration of thick stands of rice could be obtained by applying bentonite pellets coated with the larvicides. In view of the results, tests were made on salt marshes in Brevard County, Florida, to determine whether greater efficiency could be obtained with insecticides on granular carriers.

HAND APPLICATIONS.—Preliminary tests were conducted on small plots (100 to 7,000 square feet) with lindane, dieldrin, heptachlor, chlordane, TEPP, and para- thion on granular bentonite, in compari- son with emulsions of the same materials. All emulsions were applied at a concentra- tion of 1 percent with a small hand atomizer. The granular bentonite con- taining 0.5, 1.5, and 5 percent of toxicant was broadcast by hand. The emulsions and granulated insecticides were applied in various amounts to give dosages of 0.01, 0.025, 0.05, and 0.1 pound of toxicant

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[1] This work was conducted under funds al- otted by the Department of the Army to the Bureau of Entomology and Plant Quarantine.

[2] Presented at the meeting of the American Mosquito Control Association at Daytona Beach, Florida, April 12–17, 1953.

per acre. Their effectiveness was based on the difference in dipping counts of larvae before and 24 hours after application. Results of the tests are given in table 1.

and was more effective than chlordane TEPP showed only slight toxicity at the highest test dosage of 0.1 pound per acre At sublethal concentrations all the insecticides except chlordane were generally

TABLE 1.—Control of salt-marsh mosquito larvae with several insecticides applied by hand in granulated form and in emulsions. (Average of 2 replications.)

Insecticide and form	Percent of toxicant	Percent reduction at indicated dosage of toxicant per acre			
		0.1 pound	0.05 pound	0.025 pound	0.01 pound
Dieldrin:					
Granulated	0.5	..	99	100	86
	1.5	..	100	100	0
	5.0	..	100	88	40
Emulsion	1.0	..	100	100	93
Heptachlor:					
Granulated	.5	..	100	100	51
	1.5	..	100	94	10
	5.0	..	100	100	22
Emulsion	1.0	..	100	100	100
Parathion:					
Granulated	.5	..	100	74	29
	1.5	..	100	100	73
	5.0	..	100	100	91
Emulsion	1.0	..	100	100	80
Lindane:					
Granulated	.5	..	100	27	0
	1.5	..	99	53	27
	5.0	..	30	40	0
Emulsion	1.0	..	100	89	65
Chlordane:					
Granulated	.5	100	95	66	..
	1.5	99	100	32	..
	5.0	94	28	0	..
Emulsion	1.0	100	69	22	..
TEPP:					
Granulated	.5	31	21	0	0
	1.5	0	0	0	0
	5.0	0	0	0	0
Emulsion	1.0	49	0	0	..

Parathion, heptachlor, and dieldrin gave complete or nearly complete kills at a dosage of 0.025 pound per acre, in granulated form and in emulsions. Kills were somewhat erratic at the 0.01-pound dosage, parathion being slightly superior to dieldrin and heptachlor in the granulated form and slightly inferior in the emulsions. Lindane gave excellent control at 0.05 pound per acre except in one test, more effective when applied in emulsions than in granulated form. As the breeding areas were fairly open, there was little difference in the amount of toxicant that reached the water surface; so the difference in results is attributable to more uniform dispersion of the emulsion.

Additional tests were made to compare granulated insecticides containing dieldrin, heptachlor, EPN, chlordane, or DDT as

the toxicant and attapulgite or bentonite as the carrier. The granules were impregnated with 5 percent of insecticide and were broadcast by hand in the amounts necessary to give dosages ranging from 0.01 to 0.1 pound of toxicant per acre. The results are shown in table 2.

centration on 16/30-mesh bentonite. Heptachlor and dieldrin were tested at 2.5-percent concentration on 30/60-mesh attapulgite. BHC (40 percent gamma isomer) was used at a concentration of 1 percent of gamma isomer on tobacco stems and at 5 percent on bentonite. The

TABLE 2.—Control of salt-marsh mosquito larvae with hand applications of several granulated insecticides with attapulgite and bentonite as the carriers. (Average of 2 replications.)

Insecticide	Dosage (pound per acre)	Percent reduction in 24 hours	
		Attapulgite	Bentonite
EPN	0.01	30	84
	.025	95	100
	.05	96	100
	.1	99	100
Dieldrin	.01	72	22
	.025	19	77
	.05	67	93
	.1	96	100
Heptachlor	.01	99	74
	.025	99	66
	.05	82	97
	.1	92	99
Chlordane	.01	7	53
	.025	71	16
	.05	93	98
	.1	87	98
DDT	.01	54	0
	.025	61	..
	.05	42	45
	.1	24	74

EPN was the most effective material tested, followed in order by heptachlor, dieldrin, chlordane, and DDT. All the insecticides were more effective with bentonite than with attapulgite at the practical dosages of 0.05 and 0.1 pound per acre. At lower dosages the results were somewhat erratic, particularly with attapulgite, and no clear-cut difference between the two carriers was apparent.

AERIAL APPLICATIONS.—Large-scale tests on typical pickleweed salt marshes were conducted to compare the effectiveness of 10 insecticides prepared with various granular carriers applied by airplane. EPN, parathion, heptachlor, dieldrin, aldrin, chlordane, toxaphene, malathion, and DDT were used at a 5-percent concentration on 16/30-mesh bentonite. Heptachlor and dieldrin were tested at 2.5-percent concentration on 30/60-mesh attapulgite. BHC (40 percent gamma isomer) was used at a concentration of 1 percent of gamma isomer on tobacco stems and at 5 percent on bentonite. The materials were applied at rates of 1 to 5 pounds per acre.

All applications were made with a Stearman airplane flying at a speed of 80 miles per hour and at an altitude of 75 feet. The plane was equipped with a belly tank duster, which had been modified to apply granulated materials. The unit could be adjusted to deliver 1 to 5 pounds per acre, but was not entirely satisfactory because the effective swath was only about 20 feet.

Applications were begun early in the morning and continued throughout the day. Meteorological conditions were generally unfavorable, as high winds of about 25 miles per hour persisted throughout the period of application. The effects of

the wind were offset to some extent by flying with and against it. However, even then it would have been impossible to apply sprays or dusts satisfactorily. The results of these tests are shown in table 3.

TABLE 3.—Effectiveness of aerial applications of several granulated insecticides against salt-marsh mosquito larvae.

Insecticide	Carrier	Dosage (pounds per acre)		Pretreatment count	Percent reduction in 24 hours
		Granules	Toxicant	Larvae per dip	
EPN	Bentonite	1	0.05	94	98
Parathion	do.	1	.05	68	97
Heptachlor	do.	1	.05	36	95
	Attapulgite	2	.05	17	88
BHC (gamma)	Tobacco stems	5	.05	10	91
	Bentonite	1	.05	33	90
Dieldrin	do.	1	.05	44	89
	Attapulgite	2	.05	22	0
Toxaphene	Bentonite	2	.1	23	89
Malathion	do.	4	.2	12	88
Aldrin	do.	2	.1	47	87
Chlordane	do.	4	.2	14	81
DDT	do.	4	.2	111	76

Applications of 0.05 pound per acre of EPN, parathion, and heptachlor on bentonite gave nearly complete kills of larvae. Dieldrin and BHC on bentonite and BHC on tobacco stems were only slightly less effective at this dosage. Toxaphene and aldrin on bentonite at 0.1 pound and malathion at 0.2 pound gave reductions of 87 to 89 percent, and were somewhat more effective than chlordane and DDT at 0.2 pound per acre. Heptachlor was slightly less effective on attapulgite than on bentonite. Dieldrin on attapulgite was completely ineffective, but the reasons for the poor results were not determined.

DISCUSSION.—Excellent control of salt-marsh mosquito larvae can be obtained with low dosages of insecticides applied by hand, but in aerial spraying of typical salt marshes higher dosages are usually necessary to compensate for the loss of spray through impingement on pickleweed, mangrove, or other vegetative cover. Tests have indicated that at least 50 percent of the spray fails to penetrate the moderate densities of pickleweed and to reach the water. Thus, in aerial spraying, 0.1 pound per acre of lindane, heptachlor, or dieldrin is required for effective control of salt-marsh larvae (Keller and McDuffie 1951). The results given in this paper indicate that satisfactory control can be obtained with half this amount when the insecticide is applied in granulated form. The difference in effectiveness is believed to reflect the difference in the amount of insecticide actually reaching the water. Since the aerial applications of granulated insecticides were about as effective as hand applications of emulsions, it would appear that virtually all the granulated material penetrated the vegetation and reached the water.

These tests indicate that granulated insecticides have exceptional possibilities for treating salt-marsh breeding areas having heavy vegetation. Not only do they insure penetration of vegetative cover and proper coverage of such areas, but they

permit successful application under meteorological conditions in which aerial spraying or dusting would be useless. These advantages are offset to some extent, however, by the fact that applications must be made in narrow swaths to insure proper coverage; thus the flying time necessary to treat a given area is three to five times as long as in spraying. Better equipment for planes should provide a wider swath, but it is unlikely that the swath can be increased to more than half that obtained with sprays.

SUMMARY.—Field tests were conducted in Brevard County, Florida, to determine whether effective control of larvae of *Aedes taeniorhynchus* (Wied.) and *sollicitans* (Wlkr.) in salt-marsh breeding areas having heavy vegetation could be obtained with various granulated insecticides applied by airplane.

In preliminary tests with hand applications parathion, heptachlor, and dieldrin were highly effective at a dosage of 0.025 pound per acre, both in emulsions and on granular bentonite. Similar results were obtained with lindane at 0.05 and chlordane at 0.1 pound per acre, but TEPP showed only slight toxicity at these dosages. In additional tests with attapulgite and bentonite granules, EPN was effective at 0.025 pound per acre, and heptachlor, dieldrin, and chlordane at 0.05 or 0.1 pound. DDT gave relatively poor control at 0.1 pound per acre. At these dosages all the insecticides were slightly more effective with bentonite than with attapulgite, but at lower dosages no clear-cut difference between the two carriers was apparent.

In tests on typical pickleweed marshes aerial applications of 0.05 pound per acre of EPN, parathion, and heptachlor on bentonite gave nearly complete kills of larvae, and were slightly more effective than similar applications of dieldrin or BHC on bentonite or of BHC on tobacco stems. Toxaphene and aldrin at 0.1 pound and malathion at 0.2 pound gave nearly 90-percent control, and were slightly more effective than chlordane and DDT at 0.2 pound per acre. Heptachlor was less effective on attapulgite than on bentonite. Dieldrin on attapulgite was ineffective.

Results of these tests indicate that the aerial application of granulated insecticides in salt marshes with heavy vegetation is more effective than spraying, and has exceptional possibilities in practical operations under Florida conditions.

Literature Cited

KELLER, J. C., AND W. C. MCDUFFIE. 1951. Resistance of salt-marsh mosquitoes to insecticides in Florida. N. J. Mosquito Extermin. Assoc. Proc. 38:54–7.

WHITEHEAD, F. E. 1951. Rice field mosquito control by pellet-borne insecticides. Ark. Agr. Expt. Sta. Bul. 511, 30 pp.