larvae. DDT oil solutions and water emulsions were about equally effective against *Aedes* larvae and superior to DDT and benzene hexachloride wettable powders and to DDT larviciding powder. These DDT formulations were also more effective than fuel-oil solutions of benzene hexachloride, chlordane, and toxaphene. DDT, TDE, and methoxychlor fuel-oil solutions were about equal in effectiveness. Against *Culiseta* larvae, DDT in fuel oil and in water emulsion was superior to fuel-oil solutions of chlordane, benzene hexachloride, and toxaphene. In the Anchorage area dosages of 0.1 to 0.2 pound of DDT per acre caused 88 to 97 percent kill of *Aedes*. A dosage of 0.1 pound per acre of DDT proved inadequate for control under conditions prevailing in the Eklutna area.

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THE EFFECTIVENESS OF DDT AND OTHER INSECTICIDES AS LARVICIDES AGAINST ARCTIC SPECIES OF *AEDES* [1]

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In 1947 and 1948 an experimental program was carried out at Ft. Churchill, Manitoba, Canada, by Canadian and United States entomologists to determine the applicability of present-day methods of mosquito control against arctic and subarctic species of *Aedes* mosquitoes. The program included studies on the effectiveness of prehatching treatments (McDuffie *et al.* 1949), adulticides (Goldsmith *et al.* 1949), and larvicides applied with ground and aerial equipment. The greatest effort was devoted to the study of larvicides, over 150 tests being made with DDT and 7 of the newer insecticides that had shown promise as larvicides in screening and field tests at Orlando, Fla. (Deonier *et al.* 1949). Although most of the tests were made on small plots to evaluate the various insecticides, sufficient tests were also made on large areas with aerial and ground equipment to determine the effectiveness of DDT on a practical scale. The results of the larvicidal investigations for the 2 years are given in this paper.

TEST CONDITIONS AND METHODS

Larvicidal treatments were applied during June on pools and grassy depressions in the tundra and along the margins of lightly forested areas. Several species were present in most of the plots, with *Aedes nigripes* (Zett.) and *A. punctor* (Kby.) predominating. Other species present and

[1] The results herein reported were obtained through the joint efforts of the Canadian Division of Entomology, on behalf of the Canadian Defense Research Board, and the U. S. Bureau of Entomology and Plant Quarantine, on behalf of the Army Committee for Insect and Rodent Control.

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[5] Acknowledgment is made of the valuable contributions of the following members of the joint U. S.-Canadian group: J. B. Goldsmith, Major, Sn.C., U. S. Army; B. Hocking, Douglas Peterson, John Rooks and R. W. Fisher, Canada.

identified in the larval form included *A. communis* (Deg.), *A. campestris* D. and K., and *A. excrucians* (Walk.). Tests were made when the majority of the larvae were in the fourth instar.

In 1947, 60 plots, 1,000 to 10,000 square feet each, were treated with 4 insecticides applied in the form of emulsions and fuel-oil solutions. Fuel-oil solutions at the rate of 1 or 2.5 gallons per acre and emulsions at 5 gallons per acre were applied with hand-pressure sprayers. The percentage of toxicant was varied to give the desired dosages. Swath intervals were 5 feet for the water-emulsion treatments and up to 15 feet for the smaller quantities of oil solution. In 1948, 95 tests were made on small plots with DDT and 4 other insecticides as oil solutions or as wettable powders. The desired dosages were applied in 1 gallon of oil or water per acre. Swath intervals of about 20 feet were maintained in applying treatments.

A large aircraft (R.C.A.F. C-47), equipped with cargo tanks and a vertical, gravity-flow discharge pipe (3 3/8 inches in diameter) extending 14 inches below the fuselage, was used to treat four plots 0.5 to 2.5 square miles in area, in open tundra and forested areas. A 5-percent DDT-fuel-oil solution was sprayed on two plots at swath intervals of 100 yards and on two at intervals of 200 yards to give dosages of about 2 and 4 imperial quarts of solution per acre. The height of flight in the first test varied from 125 to 185 feet, but thereafter it was maintained as nearly as possible at 100 feet. Dipping stations were established at 10 or more points throughout each test area.

Two tests were conducted on open tundra breeding areas of approximately 60 acres each, an old-type Hochberg-LaMer aerosol generator (LaMer and Hochberg 1945) being used for dispersing the DDT emulsion. In each test the generator was drawn back and forth along a front line of about 500 yards until the quantity of liquid necessary to give 0.1 and 0.3 pound of DDT per acre was dispensed. Larval dipping stations were established at regular intervals throughout for a distance of 600 yards downwind from the emission line. Dipping checks were made in these and all other larvicide tests before and at 24- and 48-hour intervals after treatment to determine the control obtained.

RESULTS

Tests with Hand Equipment.—The results of the larvicide tests with hand equipment, both in 1947 and 1948, are shown in Table 1. In 1947, DDT was the most effective of the four materials tested. Applications of 0.04 and 0.1 pound per acre gave good to complete control of mature larvae of the several species involved. The emulsions appeared to be slightly better than the oil solutions. Emulsions of chlordane and toxaphene were effective at dosages of 0.1 and 0.2 pound per acre, and gave better results than an emulsion of benzene hexachloride. With oil solutions, the order of toxicity of these three materials was inconsistent at different dosages, but none of them caused a high mortality at dosages of 0.2 pound per acre or less. Chlordane in oil caused 100 percent mortality at 0.4 pound per acre, (not given in table) and benzene hexachloride (20 percent of gamma isomer) as an emulsion was effective at 0.5 pound per acre. None of the treatments was effective against pupae.

In the 1948 tests parathion proved to be the most toxic of the five materials tested, although only slightly more so than DDT. Both of these materials as wettable powders gave nearly complete kills of mature larvae at a dosage of only 0.05 pound per acre. Parathion was also highly effective at only 0.01 pound per acre, but at 0.005 pound per acre gave only 52-percent control, or about the same as DDT at a dosage of 0.01 pound per acre. In tests with oil solutions DDT, with one exception, yielded greater control of larvae at each test dosage than the other materials, 0.1 and 0.2 pound per acre causing 90 to 100 percent mortality in 48 hours. Meth-

TABLE 1.—Percent mortality of mosquito larvae obtained with various toxicants applied with hand-pressure sprayers, Churchill, Canada. June 1947 and 1948. (Average of 2 to 5 replications at each dosage.)

Toxicant	Dosages applied (pound per acre)							
	0.005	0.01	0.02	0.04	0.05	0.1	0.2	0.5
1947 Tests								
Fuel-oil solutions								
DDT	...	...	...	83	...	100	100	...
Chlordane	...	...	...	80	...	66	66	...
Toxaphene	...	...	...	52	...	71	...	...
Benzene hexachloride (20% gamma isomer)	...	...	...	0	...	83	...	...
Emulsions								
DDT	...	...	73	96	...	100	...	...
Chlordane	...	...	...	49	...	98	100	...
Toxaphene	...	...	...	0	...	100	85	...
Benzene hexachloride (20% gamma isomer)	...	...	...	...	...	69	18	100
1948 Tests								
Fuel-oil solutions								
DDT	...	49	...	...	69	90	100	...
TDE	...	2	...	...	62	82	57	...
Heptachlor	...	0	...	...	68	56	73	...
Methoxychlor	...	0	...	...	44	97	92	...
Wettable powders								
DDT	...	57	...	...	99	100	...	...
Parathion	52	90	...	...	98	100	...	...

oxychlor was about as effective as DDT at these dosages, but was inferior at lower dosages. TDE and heptachlor appeared to be as effective as DDT at the 0.05 dosage, but were inferior both to DDT and methoxychlor at dosages of 0.1 and 0.2 pound per acre.

Fuel oil alone applied at rates of 1 and 2.5 gallons per acre was relatively ineffective as a mosquito larvicide. In occasional tests slight to moderate kills resulted from each of these dosages, but in most tests no control was indicated.

The results obtained from the tests with DDT in 1948 confirm those of 1947. The data for the 2 years also indicate that this insecticide is equally as effective against arctic species of mosquito larvae as against those of the temperate and tropical species, and that the dosage necessary for control is closely comparable.

Tests with Aerial Sprays.—The results of four airplane tests are presented in Table 2. Complete control of mature larvae was obtained with fuel-oil solutions of DDT dispersed at the rate of 0.44 and 0.48 pound of DDT per acre. These treatments also gave 100 and 72 percent control, respectively, of pupae. In two other tests dosages of 0.26 pound of DDT per acre yielded 91 and 97 percent control of larvae but were relatively ineffective against pupae.

The camp area was of special interest because the treatment was effective in spite of wind velocities of 10 to 28 m.p.h. The large droplet size produced by the equipment used (mass median diameter of about 330 microns) was probably of advantage under these conditions. With so coarse a spray, however, swath widths of 600 feet, as used in two tests, were

TABLE 2.—Results of four aerial spray tests with DDT against larvae and pupae of mosquitoes. June 27 to July 5, 1947.

Test plot No.	Type of vegetation in area	Size of plot (acres)	Average Temperature (°F.)	Wind speed (m.p.h.)	Height of flight (feet)	Swath interval (feet)	Dosages per acre		Per cent control in 48 hours	
							DDT (pound)	Oil [1] (gallon)	Larvae	Pupae
1	Dwarf birch and willow; scattered spruce-larch	310	54	2.5–5	123–202	600	0.26	0.51	91	0
2	Spruce-larch forests 85%, bush 15%	728	60	4–8	50–180	300	.48	.96	100	72
3	Mixed spruce-larch forest and bush	654	52	8–10	45–90	600	.26	.51	97	40
4	Camp area; sparsely wooded ridge and tundra	1,781	64	10–28	50–180	300	.44	.89	100	100

[1] Dosages calculated on a basis of imperial gallons containing 5% of DDT.

evidently too great to permit uniform coverage.

Tests with Hochberg-LaMer Aerosol Generator.—Of the two tests conducted with a Hochberg-LaMer aerosol generator, only one yielded positive results. The data for this test are condensed in Table 3. Control of larvae was excellent for 100 yards downwind from the line of insecticide emission but declined as the distance from the emission line increased. At 500 to 600 yards only 50 percent control was indicated in 24 hours and 63 percent in 48 hours. The mean mortality over the surveyed area after 48 hours was 82 percent. In the other test, which involved a dosage of approximately 0.10 pound of DDT per acre, control was negligible, even within 100 yards of the emission line. The difficulty in towing the machine over the marshy terrain and the vagaries of the wind in the Churchill area render this method of dispersal of doubtful value for practical use in such areas.

SUMMARY

Studies were conducted at Ft. Churchill, Manitoba, Canada, in 1947 and 1948 by United States and Canadian entomologists to compare the effectiveness of DDT and seven new insecticides against arctic species of mosquito larvae, and to determine

TABLE 3.—Percent control of mosquito larvae with DDT applied at a rate of 0.30 pound per acre by means of a Hochberg-LaMer aerosol generator. June 1947.

Distance downwind from emission line (yards)	Number of stations	Control in	
		24 hours	48 hours
0–100	3	96	96
100–200	6	62	80
200–300	10	81	88
300–400	3	43	86
400–500	3	66	73
500–600	4	50	63
Mean mortality		63	82

whether the present methods of applying larvicides are feasible and effective under arctic conditions.

In comparative tests on small plots with hand sprayers, DDT and parathion as wettable powders gave nearly complete kills of mature larvae at a dosage of 0.05 pound per acre. Parathion was also highly effective at 0.01 pound per acre, but at this dosage DDT gave only 57 per cent control. Emulsions and wettable powders of DDT at 0.1 pound per acre were equally effective, and both gave somewhat higher kills than oil solutions. In comparative tests with oil solutions DDT, with one exception, yielded slightly to considerably greater kills of larvae at each test dosage than the other six materials tested, 0.1 to 0.2 pound per acre providing 90 to 100 per cent kills in 48 hours. Methoxychlor in oil solution was nearly as effective as DDT at these dosages but was inferior at lower dosages. TDE and heptachlor were about as effective as DDT at a dosage of 0.05 pound per acre but were inferior at both higher and lower dosages. Chlordane and toxaphene were less toxic in oil solutions than DDT, but gave comparable kills as emulsions at a dosage of 0.1 pound per acre. Benzene hexachloride (20 per cent gamma isomer) gave erratic and generally poor results, except as an emulsion at a dosage of 0.5 pound per acre. Fuel oil alone applied at rates of 1 and 2.5 gallons per acre was relatively ineffective as a mosquito larvicide. None of the materials, at the dosages tested, was effective against pupae.

In airplane tests nearly complete control of mature larvae was obtained with DDT in oil dispersed at the rate of 0.26 pound per acre, and complete control at rates of 0.44 and 0.48 pound per acre. In the last two tests pupal mortality was 100 per cent and 72 per cent. A dosage of 0.3 pound of DDT per acre applied by a Hochberg-LaMer aerosol generator gave good larval control for a distance of 300 to 400 yards downwind from the emission line, but a dosage of 0.1 pound per acre was ineffective.

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ANNUAL MEETINGS

American Mosquito Control Association with Virginia Mosquito Control Association

SEE PAGE 180