

of 90 psi was placed on the tank containing 40 gallons (two-thirds full) and when, during the course of spraying activities, the pressure dropped to around 50 psi the operator would pull into a convenient service station and restore the pressure to 90 psi. It was found that only one service station stop was necessary to empty the tank.

Toledo is relatively flat and observations thus far suggest that this type of unit would not prove successful in hilly areas. The scooters are not very satisfactory hill climbers, especially when fully loaded. Should anyone contemplate the use of such a scooter for catch basin spraying, it

is suggested they first test it out fully loaded with 300 to 400 pounds (including tank) in addition to the driver and under conditions comparable to which it would be required to operate during spraying activities, including stopping and starting on hills. It is further suggested that the tank size be reduced to 40 gallons and that the larvicide load be limited to 25 gallons to conserve weight. Tanks should also be provided with baffles.

NOTE: The engineering and installation of the air compressor hookup was done largely by Mr. Frank Irons and his staff of the Bureau of Soils and Agricultural Engineering.

## COMPARATIVE TOXICITY OF DDT AND SOME OF THE NEWER INSECTICIDES TO ADULTS OF SALT-MARSH MOSQUITOES<sup>1</sup>

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In tests conducted by Madden *et al.* (1945) and Lindquist *et al.* (1945), DDT sprays applied from airplanes and on the ground showed promise as a means of control for adults of salt-marsh mosquitoes. Similar tests, made during August and September 1946, in which DDT was compared with benzene hexachloride, technical chlordane, and chlorinated camphene, are reported in this paper. All these materials had shown considerable toxicity to house flies and mosquitoes (Slade 1945; Kearns *et al.* 1945). Two samples of benzene hexachloride (gamma isomer contents

of about 6 and 12 per cent) were available.

The tests were made in Florida, in densely wooded areas bordering Mosquito Lagoon, just south of New Smyrna Beach, in equally dense jungle bordering Banana River, just north of Cocoa Beach, and in areas at the head of the Indian River near Oakhill and Shiloh. *Aedes taeniorhynchus* (Wied.), *A. sollicitans* (Walk.), and *Psorophora confinnis* (L.-Arr.) were present, the first species being predominant. A few other species, such as *Psorophora ciliata* (F.), were also found in the test areas, but their numbers were insignificant.

Counts of the adult mosquito landing rate (number landing on one man per minute) were made on each plot the afternoon prior to treatment, as a check on the uniformity of the population. Un-

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<sup>2</sup> Albert N. Davis and E. Nottingham assisted in making these tests.

treated check plots were used to estimate the variation in mosquito populations during the period of the tests. Posttreatment counts were made at various intervals, and the percentage reductions in the treated areas were calculated from the populations in the check plots on the same day.

#### AIRPLANE APPLICATIONS

**Experimental Procedure.**—A series of six paired airplane tests were made in densely wooded areas. Each area was bisected by a road leading to a fishing camp along the water front. One side of the road was sprayed with DDT and the opposite side with the insecticide that was to be compared. Each test area included approximately 60 acres.

Except for the benzene hexachloride containing 12 per cent of the gamma isomer, which was compared with DDT at a concentration of 10 per cent (w/v), all the sprays were applied as solutions containing 5 per cent of the insecticide (w/v) in No. 2 fuel oil. At the higher concentration a small amount of cyclohexa-

none was added as an auxiliary solvent. The applications were made from an N3N-3 airplane equipped with spray bars under the wings. The delivery rate was 2 quarts per acre, and the swath width 100 to 110 feet. Applications were begun at sunrise and finished before weather conditions became too unfavorable for spraying.

Counts were made 2, 6, 10, and 24 hours after the insecticides were applied. They were also made on subsequent days, but these results are not included since the number of mosquitoes infiltrating into the test areas was erratic.

**Results.**—The results of these tests are given in table 1. In the tests comparing DDT with benzene hexachloride, the percentage reduction in the mosquitoes 2, 6, and 10 hours after treatment was approximately the same for both materials, but after 24 hours DDT was considerably more effective. Apparently this difference is attributable to differences in the residual effect of the two insecticides. The lower reductions for both compounds in the first pair of tests on August 14 were prob-

TABLE 1. Comparative effectiveness of sprays containing DDT and other insecticides when applied by airplane for the control of adult salt-marsh mosquitoes. Delivery rate 2 quarts per acre; 5 per cent solutions in fuel oil unless otherwise indicated.

Date applied	Insecticide	Pretreatment counts (number per man per minute)	Per cent reduction at indicated time following treatment			
			2 hours	6 hours	10 hours	24 hours
1946						
August 8	DDT	97	99	99	99	90
	Benzene hexachloride, gamma isomer 6 per cent	107	99	94	92	29
14	DDT	90	48	57	57	71
	Benzene hexachloride, gamma isomer 6 per cent	103	64	67	37	46
14	DDT <sup>1</sup>	107	85	93	94	94
	Benzene hexachloride <sup>1</sup> , gamma isomer 12 per cent	103	86	94	94	68
August 22	DDT	38	85	92	97	87
	Chlorinated camphene	88	17	42	59	27
22	DDT	40	85	92	97	87
	Technical chlordane	80	59	..	85	70
Sept. 11	DDT	292	48	59	77	59
	Technical chlordane	296	38	41	57	50

<sup>1</sup> 10 per cent solution.

ably due to inversion conditions, as the sprays did not settle properly. Technical chlordane was more effective than chlorinated camphene, but both these materials were less effective than DDT.

Crude benzene hexachloride has a strong musty odor, and in these tests it was found that the odor remained in workers' clothing after repeated launderings. Headaches reported by personnel were attributed to this material.

#### GROUND APPLICATIONS

**Experimental Procedure.**—Two series of tests were made in which sprays were applied to 1-acre plots in jungle areas having a high adult-mosquito population. One series was made on August 15, in the vicinity of Shiloh, and the other on September 5, near Mims. Each plot was separated from adjoining plots by a 30-yard buffer strip of untreated area. Trails were cut along the margins of the plots to facilitate application of insecticides and subsequent population sampling. The sprays were applied with a 3-gallon pressure sprayer.

Except for two tests, one with a DDT emulsion (25 per cent DDT-xylene emulsion concentrate diluted to 5 per cent by addition of water) and the other with a DDT suspension (5 per cent suspension in water made from 50 per cent wettable DDT dust), all the sprays were applied as solutions containing 5 per cent of the insecticide in No. 2 fuel oil, at the rate of 1 pound per acre of active ingredient. This dosage was lower than the amount needed for a long-lasting residue, but was desirable for experimental purposes in making comparative tests. Two men applied the insecticide while a third directed operations to insure thorough coverage of the ground litter and low-growing vegetation.

Counts were made after 24 hours, and after 4, 5, and 11 days. The counts were made in the afternoon rather than in the morning so that the mosquitoes that had infiltrated into an area during the previous night would be exposed to the residue for a longer time. The investigator took care

not to carry into the plots mosquitoes that had been attracted to him while he was in the untreated areas.

**Results.**—The results of these tests are shown in table 2. In all the plots at Shiloh fairly high reductions occurred within 24 hours after treatment and persisted for 4 to 5 days. Chlorinated camphene seemed to be the least effective. After 11 days none of the treatments except DDT in oil solution and in suspension were effective. Heavy rains during the period of the test may have been responsible for these results. Because of a rapidly declining adult-mosquito population in the general area of Shiloh after 11 days, the observations were terminated.

At Mims dry weather prevailed throughout the observation period except for a rain just after the sprays were applied. In contrast to the tests at Shiloh, all the treatments gave some evidence of residual effect for 11 days. However, the tests at Mims were also terminated after 11 days because of a rapid decline in the mosquito population.

The comparative value of the four compounds as residual treatments appeared to be in the following order: DDT, benzene hexachloride, technical chlordane, and chlorinated camphene.

**Summary.**—DDT in oil solution, applied as sprays from an airplane, controlled adult salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.), more effectively than did benzene hexachloride, technical chlordane, or chlorinated camphene. Benzene hexachloride of both 6 and 12 per cent gamma isomer content gave immediate reduction of mosquito populations equal to those given by DDT, but after 24 hours the DDT was considerably more effective.

When sprayed on the ground and on low-growing vegetation, during periods of heavy rainfall, 5 per cent of benzene hexachloride, technical chlordane, and chlorinated camphene in No. 2 fuel oil and a 5 per cent DDT emulsion were effective against mosquitoes for 4 to 5 days. DDT applied at the same strength as a suspen-

TABLE 2. Comparative effectiveness of sprays containing DDT and other insecticides applied from the ground for the control of salt-marsh mosquitoes; 5 per cent solutions, in fuel oil unless otherwise indicated.

Treatment	24-hour count		4- to 5-day count		11-day count	
	Number per man per minute	Per cent reduction	Number per man per minute	Per cent reduction	Number per man per minute	Per cent reduction
<i>Tests at Shiloh — August 15</i>						
DDT:						
Oil solution	11	92	18	85	14	78
Emulsion	16	89	14	89	85	0
Suspension	22	84	12	91	7	89
Chlorinated camphene	50	64	42	68	63	0
Benzene hexachloride, gamma isomer 6 per cent	11	92	30	77	79	0
Technical chlordane	28	79	22	83	87	0
Checks (untreated)	106	..	108	..	29	..
	150	..	130	..	88	..
	150	..	150	..	95	..
Average	135.3	..	129.3	..	70.6	..
<i>Tests at Mims — September 5</i>						
DDT	6	87	9	82	9	77
Chlorinated camphene	24	53	24	52	28	28
Benzene hexachloride, gamma isomer 6 per cent	18	65	42	16	15	61
Technical chlordane	18	65	21	58	23	41
Checks (untreated)	46	..	55	..	40	..
	56	..	44	..	38	..
Average	51.0	..	49.5	..	39.0	..

sion and in oil solution was effective for at least 11 days under the same conditions. With more favorable weather all four compounds reduced mosquito populations for 11 days, and their comparative value as residual treatments appeared to be in the following order: DDT, benzene hexachloride, technical chlordane, and chlorinated camphene.

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