ARTICLES

EFFECTIVENESS OF A PRE-HATCHING TREATMENT FOR THE CONTROL OF SALT-MARSH MOSQUITOES IN FLORIDA

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Salt-marsh mosquitoes are major pests of man in most of the coastal areas of Florida. *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Wlkr.) comprise the major populations along the Atlantic seaboard. These insects are not known to be vectors of any disease in this state, but they are a constant source of annoyance throughout the year.

In February and again in May 1955, the U. S. Air Force conducted a prehatching experiment in the vicinity of Patrick Air Force Base in Brevard County, Florida, to control salt-marsh mosquito breeding. Three chlorinated hydrocarbon insecticides were selected for use. These were dispersed by the USAF Special Aerial Spray Flight[1] over individual experimental plots at the rate of one pound insecticide per acre.

Researches on the residual toxicities of various insecticides and their value in preflooding or prehatching treatment for the control of mosquito larvae have been conducted in the past. This method was first used with favorable results by Wisecup and Deonier (1944) on small breeding places of *Psorophora* in Florida. Shortly afterward Wisecup, *et al.* (1945) found that prehatching treatments with DDT sprays applied by airplane effectively controlled mosquitoes in Arkansas rice fields. Poor control of the salt-marsh mosquitoes *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Wlkr.) was obtained in Florida with light applications of DDT (Wisecup *et al.* 1947), but in 1948, Deonier *et al.* concluded from their experiments using 10 percent DDT dust at one pound of DDT per acre that prehatching treatments with DDT dust might be very effective for use against the same species. This method was also effective against floodwater *Aedes* along the Columbia River in Oregon (Yates & Gjullin 1947). In New Jersey promising results against fresh-water swamp mosquitoes were obtained with DDT but not with benzene hexachloride (Hansens & Hart 1947).

Lindquist, *et al.* (1948) reported complete control of *Aedes* mosquitoes with DDT applied at the rate of 0.5 to 1 pound per acre in prehatching experiments conducted in Washington and Oregon against snow-water or mountain species. McDuffie *et al.* (1949) recorded the results of prehatching treatments for the control of Arctic mosquitoes. A series of insecticides in the chlorinated hydrocarbon group was tested in addition to parathion. The results obtained indicated that this form of treatment was applicable against *Aedes* mosquitoes in northern Canada. Comparable results were reported by Travis, *et al.* (1949) for tests conducted in Alaska during 1947 and 1948.

According to Deonier, *et al.* (1950), observations during June of 1949 in Brevard

[1] Commanded by Captain Russell J. Merriken, USAF, Langley Air Force Base, Virginia.

County, Florida, indicated that the conventional dissemination of DDT from aircraft was not controlling larvae or adults of the salt-marsh mosquitoes so well as in previous years. This was noticed particularly in the vicinity of Cocoa Beach, where DDT had been applied on a small scale as early as 1943 and 1944, and extensively since 1945. During the seasons of 1950–1952 small and large-scale tests with most of the available insecticides were carried out in this area against both larvae and adult mosquitoes. Benzene hexachloride (33 percent gamma isomer) has been used almost exclusively throughout the area for routine control of mosquitoes since 1951.

McDuffie and Keller (1952) offer a comprehensive review of mosquito control measures in Florida. This review includes the Cocoa Beach area. Extensive tests to compare the effectiveness of DDT, dieldrin, and toxaphene as prehatching agents were conducted during 1950 and 1951. Dieldrin was found to be slightly more effective than toxaphene and both were superior to DDT. It was concluded that prehatching treatments might be used advantageously against salt-marsh mosquitoes in areas that are inaccessible during the active season, or are too extensive for adequate coverage with limited equipment and personnel.

The purpose of the current series of experimental flights was to evaluate the comparative residual capacities of benzene hexachloride (42 percent gamma isomer), dieldrin, and lindane, and to determine their applicability as prehatching agents in this region. This is a preliminary study and it is anticipated that it will be a guide to further studies along the same line.

For the purpose of these experimental flights, C-47 aircraft assigned to the USAF Special Aerial Spray Flight based at Langley AFB, Virginia, were used. The dispersal equipment consisted of the boom spray system with the insecticide being dispersed under pressure.

Solutions of the three insecticides selected were prepared using No. 2 fuel oil as the vehicle. Actual formulations are listed in Table 1.

Three 267-acre plots were designated as the experimental areas. These were widely separated from one another so as to preclude drift of insecticide from one plot into the next. Experimental Plot I was sprayed with a 20 percent dieldrin solution. This area was located on the south end of Patrick Air Force Base and

TABLE 1.—Data on the application of the chlorinated hydrocarbon insecticides used in prehatching experiment. Brevard County, Florida. 1955.

Insecticides and Formulation (Solutions)	Rate of Application	Plot Number	Area Treated	Date of Treatment	Surface Temp. (°F)	Surface Wind (Knots)	Vegetation
20% Dieldrin in No. 2 Fuel Oil (1.68 lbs. dieldrin per gallon)	1 lb. dieldrin per acre	I	267 Acres	22 Feb 1955	67	11	Salt-marsh Bermuda; white
				12 May 1955	80	7	mangrove
20% Lindane in No. 2 Fuel Oil (1.68 lbs. lindane per gallon)	1 lb. lindane per acre	II	267 Acres	22 Feb 1955	67	11	Salt-marsh pickleweed some white
				12 May 1955	80	7	mangrove
8% Benzene Hexachloride in No. 2 Fuel Oil (0.66 lb. BHC per gallon)	1 lb. BHC per acre	III	267 Acres	22 Feb 1955	67	10	Salt-marsh pickleweed; some white
				12 May 1955	80	7	mangrove

on the Banana River side of the peninsula. Plot II was located about one mile south of the Cocoa Causeway. This plot was sprayed with a 20 percent lindane solution. Plot III was sprayed with an 8 percent benzene hexachloride solution. This area was located one mile north of the Cocoa Causeway and like the other two, faced on the Banana River. The untreated areas surrounding the experimental plots were used for control.

The plots were located in open areas and included marshes overgrown with pickleweed, *Batis maritima* L., or salt-marsh bermuda, *Distichlis spicata* L., with occasional stands of mangrove, *Rhizopora mangle*. Plot I contained a relatively heavy growth of mangrove with some salt-marsh bermuda while Plots II and III were covered primarily with salt-marsh pickleweed.

Pre-spray surveys were conducted on each of the three plots to establish existing adult and larval populations prior to treatment.

To determine the efficacy of the treatments and test the virility of the insecticides, both larval and adult mosquito counts were taken 21 days after the February application and 39 days after the May application. Collecting stations were established both within each of the experimental plots and in the control areas surrounding them. The locations of these stations are indicated by the circled numbers in Plate 1.

Survey procedures and count techniques were as follows: Larval dip collections were made daily at a pair of the stations inside the treated areas and the totals averaged. This figure was compared with a figure derived in a comparable manner from dips made from two stations in the adjacent control zone. The collecting points were varied from day to day so as to insure coverage of all stations once every five days. Adult biting counts were registered simultaneously and at the same stations with the larval counts. These collection figures are listed in Plate No. 2 and Plate No. 3 and the conclusions were based upon comparison of both the larva and adult population curves. The curves of those populations in the treated areas were compared first of all against those of their companion control areas and finally against one another to determine relative toxicities and residuals.

Collection data accumulated during the periods of observation included Ground Temperature, Surface Winds, and Total Precipitation in addition to insect counts. The statistical tabulations of the ecological factors may be summarized as follows:

Initial Application: 23 February through 15 March
- Ground Temperature
  - 0900 Hours
    - High: 76 F.
    - Low: 59 F.
    - Average: 70.2 F.
  - 1600 Hours
    - High: 86 F.
    - Low: 65 F.
    - Average: 73.4 F.
- Surface Wind (Average Velocity): 9.5 knots
- Precipitation: None

Second Application: 13 May through 20 June
- Ground Temperature
  - 0900 Hours
    - High: 85 F.
    - Low: 71 F.
    - Average: 80.4 F.
  - 1600 Hours
    - High: 84 F.
    - Low : 70 F.
    - Average: 80.7 F.
- Surface Wind (Average Velocity): 10.3 knots
- Precipitation (Average): 0.14 inches/24 hour period with ½ inch or better recorded on 15 May (0.52 in.), 22 May (0.72 in.), 12 June (0.60 in.), 17 June (1.04 in.), 19 June (0.72 in.), and 20 June (0.94 in.).

RESULTS. A review of the data for the February treatment (Plate No. 2), shows that the experiment was abortive due to the lack of breeding following treatment. The three 267-acre test plots were not

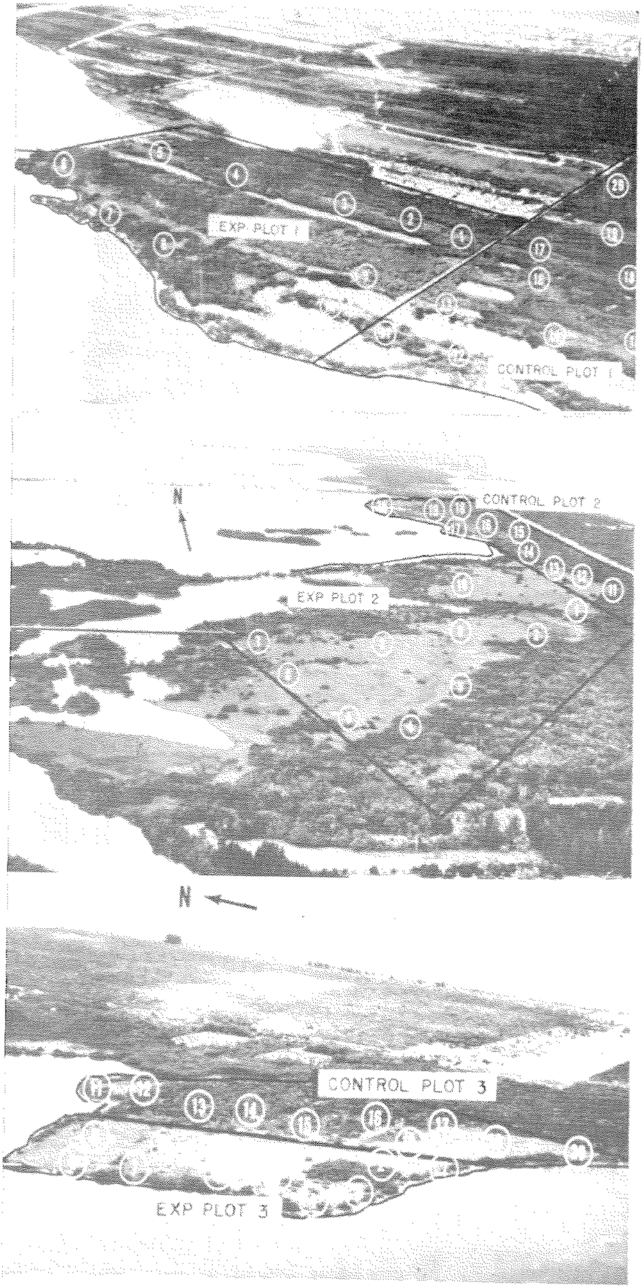
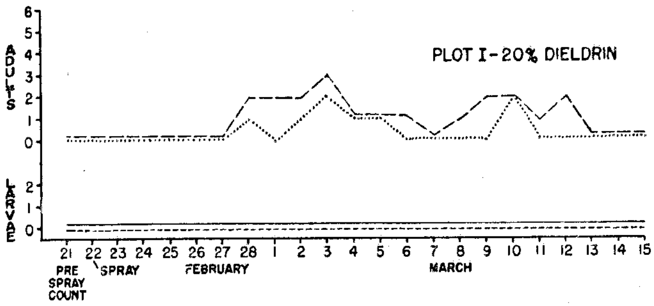


Plate 1. Aerial photograph showing the sites of both the experimental and control plots as well as the approximate locations of the adult biting and larva dip stations.



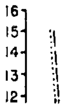


PLATE 2. MOSQUITO POPULATION COUNTS FOLLOWING THE INITIAL APPLICATION OF THE THREE CHLORINATED HYDROCARBON INSECTICIDES USED IN THIS PREHATCHING EXPERIMENT. BREVARD COUNTY, FLORIDA. FEBRUARY 1955.

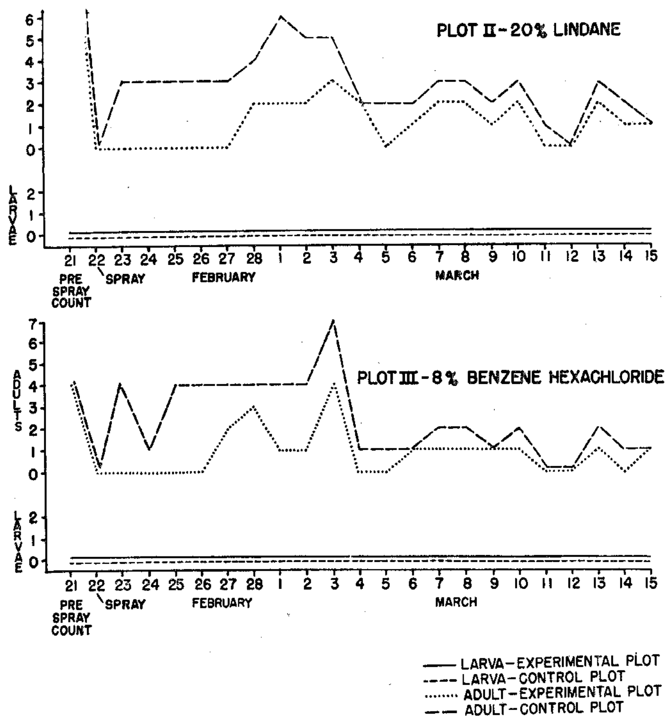
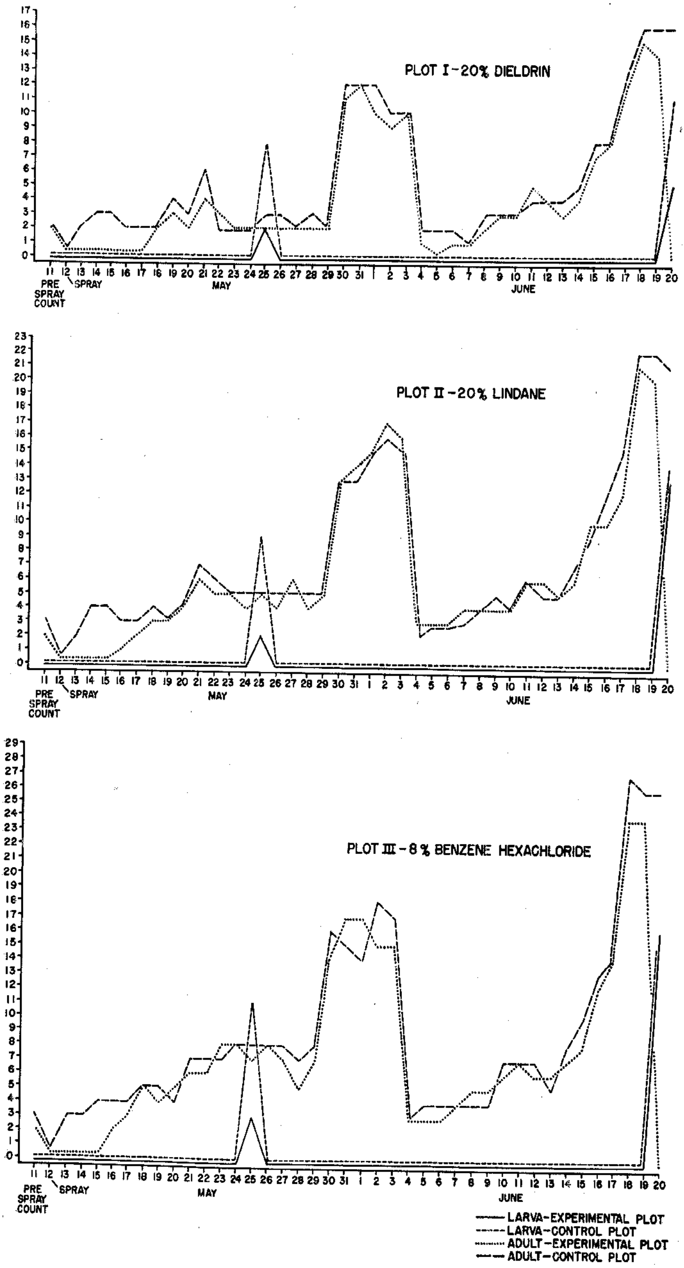


PLATE 3. MOSQUITO POPULATION COUNTS FOLLOWING THE SECOND APPLICATION OF THE THREE CHLORINATED HYDROCARBON INSECTICIDES USED IN THIS PREHATCHING EXPERIMENT. BREVARD COUNTY, FLORIDA. MAY 1955.



flooded at the time the insecticides were applied; only small quantities of water were present in isolated depressions or potholes. Precipitation during the subsequent 29 day period was negative, and no breeding was observed. No conclusions could be made with respect to larval mortality due to this condition. No adult mosquitoes were collected from Plot I until 6 days following application of dieldrin. Both lindane and benzene hexachloride were effective adult control agents. In Plot II lindane provided immediate reduction and complete control for 5 days following application. Benzene hexachloride (Plot III) was only slightly less toxic in that the adult population was negative until the fifth day following treatment.

Analysis of the May-June treatment shows two flood periods. One occurred 10 days and the second 36 days following the date of application of the insecticides. Buildup of larval populations in each experimental plot was observed 3 days subsequent to each flooding date. Negative larval counts were made in each experimental plot on the fourth day following the initial flooding. This reduction in larval counts can be attributed to the rapid run-off and absorption which quickly restricted larval environments to small, protected pockets of water and precluded collection at the designated stations.

While the larvae collection curves were negative for both the control as well as the experimental plots between floodings, the population differentials for each pair on the third day following flooding were marked. Counts made following the floodings were:

Plot	Insecticide	Experimental Plot No. (aver. larvae/dip)	Control Plot No. (aver. larvae/dip)	Differential
	Initial Flooding			
I	Dieldrin	2	8	75.0%
II	Lindane	2	9	77.8%
III	Benzene Hex.	3	11	72.8%
	Second Flooding			
I	Dieldrin	5	11	54.6%
II	Lindane	13	14	7.1%
III	Benzene Hex.	16	15	6.2%

On the basis of these data, each of the three insecticides showed a comparable degree of effectiveness after the first flooding. Only dieldrin, however, was effective in the control of larvae after the second flooding.

Comparison of the adult mosquito population curves shows an immediate reduction for each treated plot followed by rapid buildup and then close individual paralleling for each pair of control and experimental plots beginning the sixth day following treatment. Since the adult populations are similar in number and pattern for each of the three areas, it appears that they reflect a generalized distribution of itinerant populations infiltrating from the adjacent untreated areas.

The insecticides had no obvious effect on the adult populations in any of the experimental plots following the 22 May flooding. It is significant, however, that the adult population counts for each experimental plot were abruptly reduced to zero on the third day following the 17 June flooding. This would indicate that while none of the insecticides other than dieldrin was effective as a prehatch larvicide past the initial flooding, each of the insecticides was present in sufficient residual to poison all of the adults in each experimental plot after the second flooding.

SUMMARY. Field tests were conducted in Brevard County, Florida, during February and May of 1955, to determine the comparative residual effectiveness of three chlorinated hydrocarbon insecticides (benzene hexachloride, lindane, and dieldrin) against the larvae of salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Wlkr.). These poisons were applied under pressure at the rate of one pound per acre in No. 2 fuel oil as a prehatch treatment from a C-47 type aircraft equipped with underwing discharge booms.

The test plots contained 267 acres each and were located in typical salt-marsh breeding areas covered with pickleweed, *Batis maritima* L., salt-marsh bermuda, *Distichlis spicata* L., or white mangrove, *Rhizopora mangle*. The February treatment was followed by a comparative drought. Treatments were repeated in May. Only the data from the second treatments which were effected ten days prior to the first flooding are considered in this report.

All three of the insecticides tested gave effective control of larvae after the first flooding. Surveys made following the second flooding which occurred 27 days after the first showed extensive breeding in the plots originally treated with lindane and benzene hexachloride while the plot treated with dieldrin showed a 55 percent differential in larvae.

Results of this experiment indicate a variation in the comparative residual capacities of the three chlorinated hydrocarbon insecticides tested when the latter are applied as aerial sprays over salt-marsh areas.

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