STUDIES WITH ORGANOPHOSPHORUS COMPOUNDS IN THE CONTROL OF *PSOROPHORA* LARVAE IN MISSISSIPPI RICE FIELDS[1]

WILLIS MATHIS AND H. F. SCHOOF

Large scale tests in rice fields of the Mississippi Delta with dieldrin as a preflood larvicide during 1954 indicated that *Psorophora confinnis* (Lynch-Arribalzaga) could develop resistance to this material when it was used extensively over large areas (Mathis, *et al.*, 1955). Since other chlorinated hydrocarbon insecticides offered little promise against this species, further studies were confined to organophosphorus compounds, some of which had proved to be effective in the control of other resistant species (Keller, *et al.*, 1953; Gjullin, *et al.*, 1954).

METHODS. In 1955, laboratory tests were conducted in which acetone solutions of Chlorthion, malathion, Dipterex, and DDVP were added to water from wells or streams commonly used for irrigation purposes. Approximately 300 ml. of water were placed in pint jars and the toxicant added to give the desired dosage. Ten larvae were then placed in each jar and left for a 24-hour period, at the end of which time the mortality was determined. All larvae which failed to respond when probed were considered dead. Each dosage of each material was replicated at least three times and three checks were used for each series. In tests to evaluate the residual action of the treatment, larvae were placed in the jars at periodic intervals and 24-hour mortalities obtained. Between tests, covers were placed on the jars to prevent evaporation.

In the field tests (1955) Chlorthion and malathion were injected as emulsions into the discharge hose of a pump (200 g.p.m.) by means of a solution feeder. In the plots where the number of larvae was insufficient to determine the effectiveness of the material used, water samples were collected in pint jars and *Psorophora* larvae introduced therein to obtain 24-hour mortality levels.

Granular formulations also were tested on a field basis in 1955. Bentonite pellets impregnated with Chlorthion (10 percent), malathion (1 and 5 percent), Dipterex (5 percent), and DDVP (5 percent) were evaluated as preflood applications. In addition, malathion (5 percent) on tobacco stems was tested. Plots of approximately 1,000 square feet each were treated in triplicate at the rates of 0.2, 0.4, and 0.5 pound per acre with each of the materials. Chlorthion and malathion also were applied at the rate of 0.75 pound per acre. Plots were flooded immediately after treatment and larval counts made 24 and 48 hours later by means of a square foot sampler (Horsfall, 1942). Chlorthion also was applied to two plots at the rate of 0.2 pound per acre as a postflood treatment.

In field tests during 1956, parathion and Dipterex were injected directly into the irrigation influent by means of a metering device attached to a 55-gallon drum (Gahan, *et al.*, 1955). Technical parathion, "solubilized" by adding four parts Triton X-100 to each part of parathion, was applied at the rate of 0.02 p.p.m. Dipterex was introduced at a rate of 0.25 p.p.m. as a soluble powder. Since Dipterex is soluble in water up to 13 to 15 percent, no emulsifier was necessary.

RESULTS. Results of laboratory tests with Chlorthion, malathion, Dipterex, and DDVP are shown in Table 1. Chlorthion was the most toxic material tested, giving 100 percent mortality at a dosage range of 0.0125 to 2.0 p.p.m. when larvae were introduced immediately after treatment and exposed for 24 hours. Malathion and

[1] From the Communicable Disease Center, Bureau of State Services, Public Health Service, U. S. Department of Health, Education, and Welfare, Savannah, Georgia.

DDVP gave the same mortality at a dosage range of 0.1 to 2.0 p.p.m. while Dipterex gave essentially 100 percent mortality at a range of 0.25 to 2.0 p.p.m.

Chlorthion also remained toxic to the larvae for the longest period of time, killing all larvae at a dosage of 0.25 p.p.m. 14 days after being injected into the water. With DDVP and Dipterex, dosages of 1.0 and 2.0 p.p.m., respectively, were required to give 100 percent mortality at 14 days. At 2.0 p.p.m., malathion failed to kill all larvae 14 days after treatment.

The first field treatment was made with malathion at an estimated dosage of 0.5 p.p.m. Due to improper water management, only one terrace of approximately 0.25 acre was flooded directly by the pump. Sampling in this terrace failed to reveal any larvae 24 hours after flooding. Pint samples of water taken 12 hours after flooding from five different locations in the terrace gave 99 percent 24-hour mortalities of *P. confinnis* larvae introduced therein. No additional water entered the terrace for the following 24 hours. Water samples taken at this time were not toxic to *P. confinnis.*

A single terrace also was flooded with water treated with Chlorthion at the rate of 0.05 p.p.m. An insufficient number of larvae were present in the terrace to determine the effectiveness of the treatment. As the terrace was being flooded, sufficient water seeped through the lower dike to flood a part of the next terrace. Paired samples of water were then taken from the terrace flooded directly and from the terrace containing the seepage water. In five samples of water from the terrace flooded directly, the 24-hour mortality of *P. confinnis* larvae was 99 percent. In the same number of samples from the terrace with seepage water, no mortality occurred. After 24 hours, samples from both terraces gave mortalities essentially equivalent to those of untreated samples.

In a second test with Chlorthion, it was applied at a rate of 0.025 p.p.m. in an 8-acre rice field. Larval sampling 24 and 48 hours after flooding indicated that control was obtained only in the terrace into which the pump discharged. Below this point the larval densities were irregular but development continued. In a third plot of 3 acres, a dosage of 0.074 p.p.m. of Chlorthion gave control only in the first acre flooded.

The "solubilized" parathion was injected at a dosage of 0.02 p.p.m. into the flood water used to irrigate 94 acres of rice. For the first 4 days, all water from the pump (2,200 g.p.m.) entered a 31-acre portion (field 1) and fully flooded it. After this, only enough water entered this field to keep the soil covered.

In field 1, plot A (7.8 acres) was first sampled for larvae on a line following the field road (figure 1) about 12 hours after the intial introduction of the water. Small larvae were found in all terraces except those into which the water flowed

TABLE 1.—Percent mortality of third or fourth instar larvae of *Psorophora confinnis* exposed for 24 hours to different dosages of four organophosphorus compounds

Chemical	Percent Mortality — Parts per Million								
	2.0	1.0	0.5	0.25	0.1	0.05	0.025	0.0125	0.00625
Chlorthion [a]	100	100	100	100	100	100	100	100	90
Malathion [b]	100	100	100	100	100	97	57	[c]	[c]
DDVP [b]	100	100	100	100	100	73	0	[c]	[c]
Dipterex [b]	100	100	100	99	93	60	7	[c]	[c]

[a] Six tests at all levels except for three at 0.00625.
[b] Six tests at 2.0–0.25 p.p.m.; three at 0.1–0.025 p.p.m.
[c] No tests run.

directly from the canal. On the second day of flooding, second-instar larvae were found in terraces 1, 2, and 3 (figure 1). None were found beyond terrace 3 until terrace 11. Other terraces were only partly flooded by seepage water and no samples were made.

On the third day, plot A was fully flooded and water was running over the top of many terraces. Two square-foot samples per terrace on the third and fourth days revealed one third-instar larva in terrace 1 with other samples negative until terrace 8 was reached. Larvae were numerous in terraces 9 through 14. Samples also were made on the opposite side of field on same date, and from location of larvae in both lines of sampling the shaded area was made (figure 1).

No attempt was made to follow the

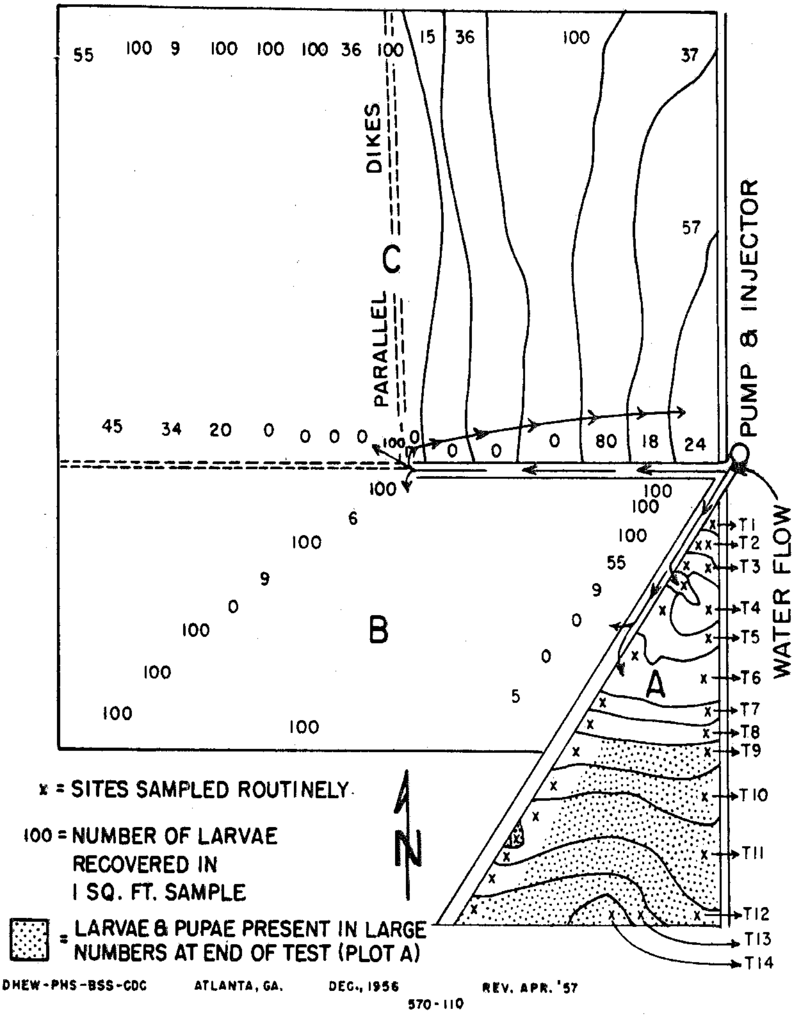

FIG. 1.—Plan of field 1 showing plot A (7.8 acres) and plots B and C (23.4 acres) and routine sampling sites and spot collection sites for mosquito larvae.

development of larvae in field 1 plots B and C (23.4 acres). However, 3 days after water entered plot B, samples were taken immediately after crossing each terrace along lines indicated in figure 1. Of 16 samples taken, only three were negative, several samples having over 100 larvae per square foot. The northern portion of the field, plot C, was sampled on the fourth day in a similar manner. Twenty-nine square-foot samples were made but only eight were negative. In this plot, 100 second-instar larvae were found in one sample at the end of the parallel dikes, about 20 feet from the discharge of the main canal. This area was flooded entirely by means of seepage water.

In field 2, plot A (figure 2) the water, after flowing through the canal, partially flooded the first 11 terraces within 24 hours. Subsequent flow of water was reduced and the remainder of the plot flooded more slowly. On the second day, square foot samples indicated small larvae in terraces 5, 7, and 8. Beyond this point, water was present only in the terrace ditches. On the third day, sampling of terraces 1 through 11 showed only the first three negative. On the fourth day these terraces were again sampled and larvae were present in the same locations. The numbers of larvae ranged from 9 to

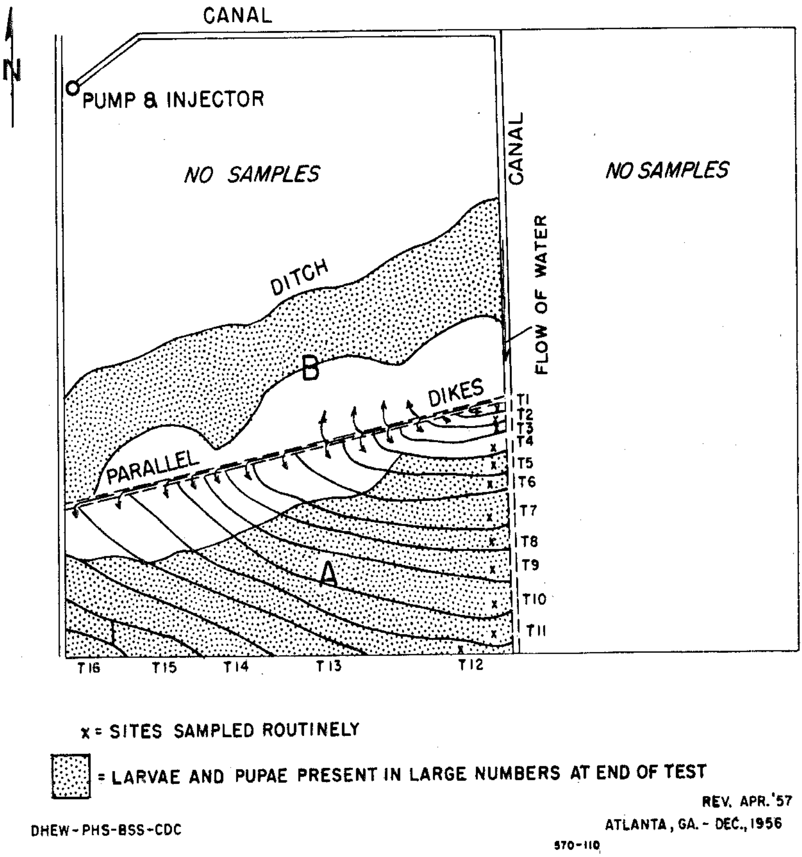

FIG. 2.—Plan of field 2 showing routine sampling sites for mosquito larvae.

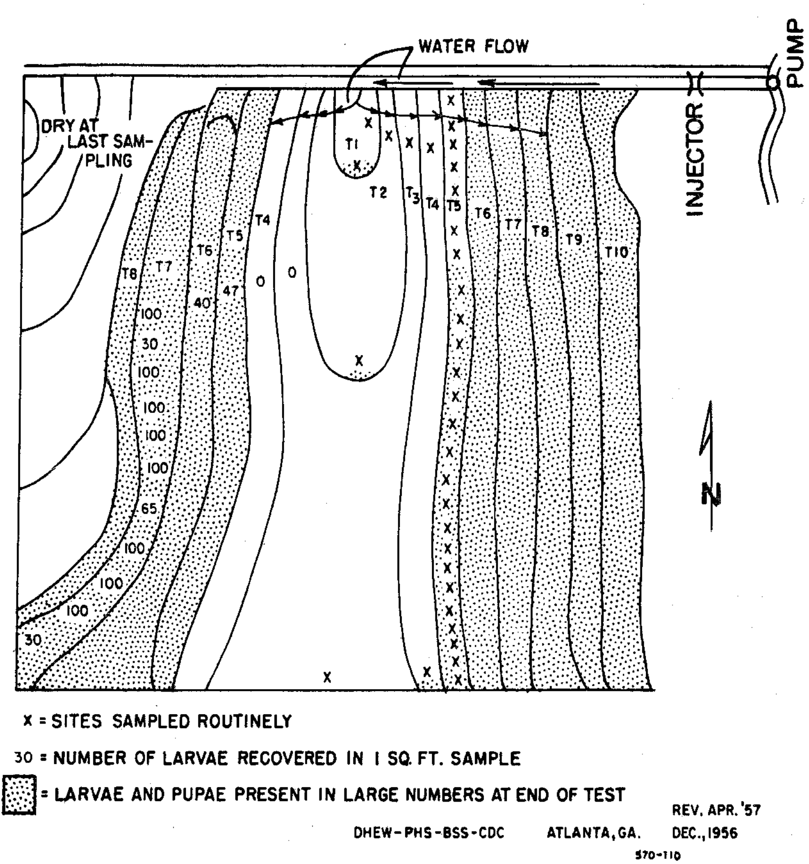

Fig. 3.—Plan of field 3 (28 acres) showing routine sampling sites for mosquito larvae.

over 100 per square foot in terraces 4 through 11. The shaded area indicates the area in which larvae were visible in terrace ditches on the seventh day. No square-foot samples were taken in field 2, plot B, but the location of the larvae on the seventh day was noted as in Plot A.

A 28-acre rice field was treated with Dipterex at 0.25 p.p.m. However, the delivered dosage was considered to be greater than 0.25 p.p.m. since the pump (1,600 g.p.m.) failed to deliver the rated discharge.

Flooding of the field began 5 hours before the Dipterex was introduced into the water. At this time, terrace 1 (figure 3) was fully flooded and water was flowing into terrace 2. On the second day, water was flowing through terraces 1, 2, and 3, with terraces 4[2] and 5 being flooded by subsurface seepage. Larvae were found in each terrace, being numerous in terrace 5. On the third day as many as 33 larvae per sample were found at the end of terrace 1 farthest from the water entrance. No larvae were found in terraces 2, 3, and 4 but in terrace 5 breeding was heavy with many counts of over 100 larvae per square foot. On the fifth day, all ter-

[2] Subsequently surface water entered terrace 4.

races on the east side of the field were flooded. Terraces 1, 2, and 4 had larvae and pupae at the extreme south end. Terrace 3 was negative. In the northern third of terrace 5 the larvae had been killed from water overflowing into it from terrace 4. Beyond this point, counts as high as 100 larvae per square foot were found. On the sixth day, terrace 5 contained mostly pupae in locations sampled the previous day but the counts were lower.

Sampling of the west side of the field on the sixth day showed no larvae up to terrace 5. Beyond this terrace, larvae and pupae were numerous, densities as high as 100 specimens per square foot being found.

The preflood applications of granular preparations of Chlorthion, DDVP, malathion, or Dipterex to field plots failed to give any appreciable degree of control of breeding at the dosages applied. In the two plots treated with Chlorthion as a postflood treatment at the rate of 0.2 pound per acre, the 24-hour mortality of *P. confinnis* larvae was essentially 100 percent.

Discussion. Although laboratory tests with Dipterex, Chlorthion, DDVP, and malathion indicated that *P. confinnis* larvae could be killed with low dosages (0.25 p.p.m. or less) subsequent field tests with Chlorthion (0.074 p.p.m.) and Dipterex (0.25 p.p.m.) in which normal flooding practices were followed failed to give satisfactory control over plots of 3 and 28 acres, respectively.

A similar field test with "solubilized" parathion at 0.02 p.p.m. also failed to give satisfactory control of breeding in a 94-acre field.

The most obvious reason for the failure of these compounds to control larvae under field conditions is the fact that when water containing these toxicants passes through soil as in subsurface seepage, the toxicant is either removed or rendered inactive. Definite proof of this detoxification was obtained in tests with the emulsifiable Chlorthion concentrate, "solubilized" parathion, and soluble Dipterex powder. The soil on which rice is usually grown in the Mississippi Delta has a tendency to crack when dry. Since many growers follow a practice of draining their rice fields about 1 month after the initial flooding and allowing them to dry thoroughly, a great deal of seepage occurs when these fields are reflooded. Since treated water which has passed through the soil of a contour terrace has been shown to be nontoxic to larvae, a dilution factor frequently begins after the first terrace is flooded and is increased as each lower terrace is flooded. If the dry fields had been saturated with water by rainfall just prior to the flooding, subsurface seepage would decrease and, presumably, the effectiveness of the treatment would increase.

Other factors such as the distance the water travels through the field and the time required (2 to 14 days) also may influence larval mortality but it was not always possible to separate these elements from the seepage and dilution factors in the tests conducted.

The above data contrast with those of Gahan and Noe (1955) who reported solubilized parathion at 0.02 p.p.m. to give complete control of *Psorophora* larvae in a 17-acre field in Arkansas. In their studies, the test plots selected had the irrigation canals along one edge at right angles to most of the transverse levees whereas in the Mississippi tests, the irrigation water usually entered the highest terrace and then progressively moved through the field to the lowest terraces. The latter type of irrigation is the usual practice followed by rice farmers. However, the significance of the seepage factor is emphasized by absence of control even in terraces flooded directly from the canals (figure 2). From these data, it is apparent that while parathion treated water can move through irrigation canals for distances up to 4,800 feet without marked loss of toxicity, the passage of the water through the rice field is the factor which determines the effectiveness of the application.

With the impregnated bentonite pellets

which were applied as a preflood treatment, it is assumed that the first water which entered the field carried the insecticide into the soil. Thus the toxicant was removed before sufficient water was available to flood the plot and hatch the mosquito eggs.

Summary. Laboratory tests with Chlorthion, malathion, DDVP, and Dipterex at the rates of 0.0125, 0.1, 0.1, and 0.25 p.p.m., respectively, gave 100 percent mortality of *Psorophora confinnis* larvae when they were introduced into treated water and exposed for 24 hours. Chlorthion introduced into irrigation water of 8 and 3 acre fields at the rates of 0.025 and 0.074 p.p.m. failed to give satisfactory control of *P. confinnis* larvae.

Field tests with "solubilized" parathion applied at the rate of 0.02 p.p.m. and Dipterex (soluble powder) applied at the rate of 0.25 p.p.m. gave satisfactory control of larvae only near the entrance of the water into the fields. The regular irrigation practices were not altered in any way in these tests.

The failure of these materials under field conditions was believed to be caused largely by the detoxification of the treated irrigation water as it percolated through the soil of the dikes thus inducing a dilution factor. Water in terraces flooded by subsurface seepage was found to be nontoxic to mosquitoes.

Small plot tests with granular formulations of Chlorthion, malathion, Dipterex, and DDVP applied as preflood applications at the rates of 0.2, 0.4, and 0.5 pound per acre failed to give satisfactory larval control. The same formulation of Chlorthion applied as a postflood treatment at the rate of 0.2 pound per acre gave essentially 100 percent control of larvae.

Literature Cited

Gahan, J. B., Labrecque, G. C., and Bowen, C. V. 1955. An applicator for adding chemicals to flowing water at uniform rates. Mosquito News 15(3):143–147.

Gahan, James B., and Noe, John R. 1955. Control of mosquito larvae in rice fields with water-soluble phosphorus insecticides. Jour. Econ. Ent. 48(6):665–667.

Gjullin, C. M., Isaak, Lewis W., and Smith, Gordon F. 1953. The effectiveness of EPN and some other organic phosphorus insecticides against resistant mosquitoes. Mosquito News 13(1):4–7.

Horsfall, W. R. 1942. Breeding habits of a rice field mosquito. Jour. Econ. Ent. 35(4): 478–482.

Keller, J. C., and Chapman, H. C. 1953. Tests of selected insecticides against resistant saltmarsh mosquito larvae. Jour. Econ. Ent. 46(6): 1004–1006.

Mathis, Willis, Elmore, Christopher, and Schoof, H. F. 1955. Further studies on the chemical control of rice field mosquitoes in Mississippi. Mosquito News 15(3):148–153.

See page 218 for notice of next annual meeting of the American Mosquito Control Association.