FURTHER STUDIES WITH WATER-SOLUBLE INSECTICIDES FOR THE CONTROL OF MOSQUITO LARVAE IN IRRIGATION WATER

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Previous tests by Gahan and Mulhern (1955) and Gahan and Noe (1955) demonstrated that water solutions of Dipterex (Bayer L 13/59), Phosdrin (Shell OS-2046), and parathion were effective against floodwater *Aedes* and *Psorophora* spp. in irrigation water. In California pastures Dipterex and Phosdrin at concentrations as low as 1 p.p.m. gave 99.9 to 100 percent control. Incomplete control was obtained with Dipterex at 0.1 p.p.m. In Arkansas rice fields 100 percent control was obtained at 0.5 p.p.m. with Dipterex, 0.25 p.p.m. with Phosdrin, and 0.01–0.02 p.p.m. with a solubilized parathion formulation. The greatest distance the chemically treated water was followed in California was ½ mile through fields, but in Arkansas it eliminated all *Psorophora* spp. in 10- to 17-acre blocks of rice after moving from 0.5 to 1.3 miles in a canal and as much as 2,500 feet through fields. None of the treatments had sufficient residual toxicity to be effective against *Anopheles* or *Culex* spp. after 1 week.

This study was continued in California pastures during May 1956 and in Arkansas rice fields during July and August 1956. Solubilized parathion was the only material studied in California, but all three materials were used in Arkansas. Chief emphasis was placed on determining the greatest distance treated water would flow across fields before it failed to cause 100 percent control.

In California the parathion was introduced inside standpipes into water that was being pumped from underground wells with large electric pumps. The treated

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water flowed from the standpipes into ditches that ran across the heads of the fields, and then was transferred to the fields through metal siphons. The area between two longitudinal levees that ran the full length of the field was included in each test. Twenty-four hours were required for flooding. The pH readings varied between 7.5 and 8.5 at various points along the water route.

Some of the treatments in Arkansas rice fields were also applied where large electric, Diesel, or gasoline pumps were emptying water from underground wells into pools, but others were added at some constricted point along the route of the irrigation water as it flowed between these pools and the fields. All the insecticides except Phosdrin passed through canals ranging in length from ⅛ to ¾ mile before entering the fields through cuts made in the canal banks. Phosdrin was introduced into a pool that adjoined the field. The rice plots treated ranged in size from 10 to 30 acres.

As in the 1955 tests, the chemicals were added to the irrigation water on a parts-per-million basis with the automatic applicator described by Gahan *et al.* (1955). Dipterex and Phosdrin were placed in the reservoir of the applicator as water solutions, but the parathion was used as a solubilized concentrate containing 1 part of parathion, 4 parts of Triton X-100, and water. The flow rate from all pumps was calibrated in gallons of water per minute, and the insecticide concentration in the reservoir was adjusted to obtain the desired dosage when the applicator was releasing 56 ml. of liquid per minute.

Effectiveness of the treatments was determined by dipping for larvae in treated and untreated plots on the first and second days after flooding. In the California tests, 200 dips were made in each plot. The number made in rice fields varied from 700 to 2,000 per field, depending on the acreage being treated. Examinations were made at 10- to 20-yard intervals until all sections of the field had been sampled. The density of larvae in two untreated rice fields was used for comparative purposes.

CALIFORNIA TESTS. Introductions of solubilized parathion into irrigation water being applied to the California pastures successfully eliminated all *Aedes* spp. breeding for distances as long as ⅜ mile, but gave complete control in only one field. Treatments at concentrations of 0.01, 0.02, and 0.05 p.p.m. killed all the larvae in 24 to 48 hours for ¼ mile, but 2 to 60 percent of those in the second ¼ mile survived. An application at 0.075 p.p.m. used in a field ⅜ mile long caused total mortality. Another at 0.1 p.p.m. caused above 99 percent kill for ⅜ mile but only 81 percent in the next eighth. At 0.005 p.p.m. parathion was completely effective for less than ⅛ mile, and no control was indicated beyond that point. (Table 1.)

Larvae were collected from untreated fields and introduced into water removed from fields treated with parathion at 0.05, 0.075, and 0.1 p.p.m. while irrigation was in progress. All died in 1 to 2 hours in water samples taken near the top of the plots and in 2 to 3 hours in others gathered from the middle. Samples from the lower end of the field treated at 0.075 p.p.m. caused 100 percent mortality in 3 hours, but those from the other two caused no knockdown in 24 hours.

ARKANSAS TESTS. In rice fields larvae were eliminated completely from areas of 10 and 30 acres with parathion at 0.05 p.p.m., 20 acres with Dipterex at 0.5 p.p.m., and 5 acres with Phosdrin at 0.25 p.p.m. The maximum distance the treated water moved through the field before any larvae survived 48 hours of flooding varied from approximately ¼ mile for the parathion, 1.8 miles for Dipterex, and at least ½ mile for Phosdrin. The only treatment that gave complete control over an entire field was parathion on the 10-acre plot. Owing to failure of the pump, introduction of this insecticide was discontinued in the other field after 30 acres had been covered. In the remaining 21 acres of the field treated with Dipterex, the larval density averaged 0.09 per dip,

TABLE 1.—Control of *Aedes* larvae in California pastures with solubilized parathion.

Concentration of Parathion (p.p.m.)	Length of Field (miles)	Section of Field Examined	Percent Control
0.005	0.5	Upper and lower halves	0
.01	.5	Upper half	100
		Lower half	80
.02	.5	Upper half	100
		Lower half	40
.05	.5	Upper half	100
		Lower half	98.7
.075	.375	Upper and lower halves	100
.1	.5	First quarter	100
		Second quarter	100
		Third quarter	99.7
		Fourth quarter	81

whereas two untreated fields in the same general area averaged 4.5 and 10 per dip. The total distance traversed by the Dipterex was approximately 3 miles. In the second 5 acres of the field flooded with Phosdrin, the larval density averaged 0.25 per dip in the low part where the water eventually became at least 12 inches deep, but on the high areas, where the water depth never exceeded 4 inches, the average was 5.12 per dip.

DISCUSSION. Factors other than solubility of the chemicals in water obviously control the distance the treatments remain effective. Water solutions of Dipterex and parathion do not hydrolyze rapidly under normal conditions, for they have been stored in the laboratory for 20 weeks without losing their effectiveness (Gahan *et al.*, 1955). Yet under field conditions parathion lost much of its toxicity in less than 1 day and Dipterex failed to give complete control within 5 days. The tests conducted in 1955 by Gahan and Noe showed clearly that the toxicity of these two materials was not destroyed while moving 0.5 to 1.3 miles through canals. Also in all the field tests that have been conducted with Dipterex at 0.5 or 1 p.p.m., parathion at 0.01 or 0.02 p.p.m., and Phosdrin at 0.25 or 0.5 p.p.m., the insecticides were highly toxic when the treated water entered the field.

The greatest loss in effectiveness apparently occurred as the water moved across the field. In low areas of the pastures where the water became deep, larvae were seldom collected even at the foot of the field. They were most numerous in areas where the water was shallow. In rice fields the highest densities occurred close to the levees or on high parts of the field. Water that had seeped through the levees was never highly effective, even at distances less than 200 feet from the applicator. Larvae were always found breeding in this seepage and averaged as many as 12 per dip outside the borders of one field. Many of them were killed later on portions of the fields that were flooded intentionally. Larvae found outside the borders were not included in the evaluation of the treatments.

Adsorption of the chemical onto soil particles is the most obvious explanation for this loss in effectiveness. Other factors that may have some adverse effect are high water temperature, aeration, or pH. Any shortening of the distance the treated water must trickle across the fields in a shallow stream, by extension of the canal system, should be of assistance in reducing the importance of these factors. The water level in the canals can be maintained at sufficient depths so that a rapid flow occurs and the insecticidal particles contact the soil less frequently.

SUMMARY. Introductions of solubilized parathion at concentrations of 0.01 to 0.1 p.p.m. into irrigation water being applied to California pastures eliminated all *Aedes* spp. breeding for distances as long as ⅜ mile, but survivors were found in the lower parts of all fields except one. A gradual loss in toxicity as the treated water moved across the field was indicated in tests conducted in samples removed from the top, middle, and lower portions of the test plots.

Psorophora larvae breeding in Arkansas rice fields were eliminated completely from areas as large as 10 to 30 acres with parathion at 0.05 p.p.m., 20 acres with Dipterex at 0.5 p.p.m., and 5 acres with Phosdrin at 0.25 p.p.m. The maximum distance the treated water moved through the field before any larvae survived was approximately ¼ mile for parathion, 1.8 miles for Dipterex, and at least ½ mile for Phosdrin.

Factors other than solubility of the chemical in water obviously control the distance the treatments remain effective. Adsorption of the chemical onto soil particles is believed to be important. High water temperature, aeration, or pH may also have some adverse effect.

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