STUDIES ON THE CONTROL OF LARVAE OF *CULISETA MELANURA* (COQUILLETT) [1]

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Culiseta melanura (Coq.) is the only mosquito species from which eastern encephalitis virus has been isolated in Massachusetts (1), and it also has been associated with the virus in Louisiana (2), New Jersey (3, 4), and Alabama (5). This mosquito is generally considered to be the principal enzootic vector of eastern encephalitis in Massachusetts, and it also may be involved in transmission of the virus to man (6).

No effective method for the control of larvae of *C. melanura* has been described. As pointed out by Burbutis and Jobbins (7), control of this species presents an imposing problem because of the protected breeding habitats characteristically associated with the larvae in permanent fresh-water swamps and bogs. The larvae are not found in the open waters of the swamps and bogs, but develop in holes beneath tree roots or stumps, under rock edges, and beneath the root systems of aquatic plants. DDT fogging (*loc. cit.*) has reported to be ineffective for the control of *C. melanura*. Misting and aerial spraying of DDT in New Jersey (8) was reported to reduce the general mosquito populations for about a week, but most of the mosquitoes that survived these treatments were *C. melanura*.

This paper reports the results of studies on the control of larvae of *C. melanura* in Massachusetts fresh-water swamps.

MATERIALS AND METHODS. The insecticides used in the studies were dieldrin and heptachlor. On June 4, 1959, a 7 percent dieldrin emulsion was applied to a ¼ acre study plot at the rate of 1.0 pound of active ingredient per acre. A knapsack type pressure sprayer was used to apply the toxicant. The study plot was located in a small fresh-water swamp in Raynham, Massachusetts. The same area was treated on February 15, 1960 with a 2 percent dieldrin granular formulation at the rate of 5.0 pounds of active ingredient per acre. A crank-type spreader was used to apply the granules. On July 19, 1961 formulations of 2 percent dieldrin on 23/48 mesh attapulgite granules and of 2½ percent heptachlor on 20/35 mesh attapulgite granules were applied to ¼ acre study plots located in a portion of the Hockomock Swamp near Taunton, Massachusetts. Each insecticide was applied at rates of 0.5 and 1.0 pound of active ingredient per acre to individual study plots. A "Solo-Fix 60" [3] shoulder-mounted dusting machine was used to apply the granular material (Figure 1).

The study plots were covered with about 1 foot of water, and in numerous places the depth of the surface water exceeded 3 feet. Seven study plots were established adjacent to each other, 4 to be treated and 3 to be left untreated as controls, and 5 parallel paths were cut in each plot that

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[3] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service.

FIG. 1.—Application of granular insecticide formulation for the control of larvae of *Culiseta melan* in Hockomock Swamp, Massachusetts.

was to be treated. The paths were made wide enough to permit passage of a man carrying the dusting machine. Since the insecticide swath applied from the machine was 20 feet wide, it was possible to treat an area 10 feet wide on each side of the operator. To provide complete insecticide coverage without overlap the two paths near the borders of each plot were cut 10 feet in from the boundary, and the other three paths were cut at 20-foot intervals. The insecticide was applied to alternate plots; thus, there was a ¼-acre untreated area between the treated plots.

Prior to the application of insecticide, 35 holes containing *C. melanura* were located, 5 in each of the 7 plots. They were chosen, as nearly as possible, along a line that bisected all of the study plots. Each was assigned an identification number, which was painted on the trunk of a nearby tree. The holes in the plots to be treated were numbered consecutively from 1 through 20; those in the plots to be left untreated were numbered U-1 through U-15.

Ten days before application of the secticide an inspection was made to de mine the maximum number of larvae t could be obtained per dip from each nu bered hole. Using a 16-ounce dipper, l vae were obtained from all holes exc U-10, and the maximum number of th and fourth instar *C. melanura* per ranged from 1 to 13. The effectiven of the insecticide applications for cont ling *C. melanura* larvae was evaluated the basis of the number of the larvae instars) collected from the numbered h during inspections made several d weeks, and months after the treatmen

RESULTS. The initial study on the c trol of *C. melanura* conducted during 1 revealed that the larvae of *C. melan* were controlled for about one month lowing an application of dieldrin emul at the rate of 1.0 pound of active ingred per acre to a small study area. Since peated treatments of dieldrin at this would not be practical, a granular form

tion of dieldrin was tested during 1960. A heavy application of granular dieldrin, at the rate of about 5 pounds per acre, was applied to the same study plot in February 1960. Complete control of the larvae was obtained in the treated area through July 18, whereas in an untreated study plot nearby, larvae of *C. melanura* were readily found on June 8 and July 18. Due to a lack of rain, the study plots became dry by August 8, and inspections revealed no larvae in either the treated or the untreated area during the remainder of 1960. Reinspection in August 1961 showed the treated area still devoid of mosquito larvae, whereas *C. melanura* larvae could be collected throughout the nearby untreated plot.

A summary of the data obtained in 1961 to evaluate the effectiveness of the granular dieldrin and granular heptachlor applications for controlling larvae of *C. melanura* is given in Table 1. The most effective control was attained in the plot treated with 1.0 pound (active ingredient) of granular heptachlor per acre, where essentially complete control was achieved for 62 days. An application rate of 0.5 pound per acre also achieved complete control for the same period of time in 3 holes, but in 2 other holes (numbers 12 and 15) a few larvae were collected 26 days after the treatment. Dieldrin was less effective than heptachlor, controlling larvae in only one hole (number 6) throughout the 62-day period. At 1.0 pound per acre, dieldrin gave essentially complete control for 26 days; but at 0.5 pound per acre, it gave this degree of control in only 2 of the 5 holes in the plot thus treated.

It is possible that the residual effect of the insecticide would have been much greater than indicated by these studies, since excellent control in the heptachlor-treated areas was attained until the torrential rains associated with the hurricane "Esther" occurred on September 25, 1961. The unusually heavy rainfall caused a flooding and flowing of the swamp water that carried many larvae into the study plots and also flushed out the residual insecticide. This was indicated by the sudden appearance of large numbers of fourth instar larvae of *C. melanura* at the time of the September 26 inspection, following the storm, and by the loss of control of larvae thereafter.

DISCUSSION. The results obtained in these studies indicate that control of *C. melanura* is possible using readily available insecticide formulations applied by standard methods. The effect of the insecticides in controlling the larvae of *C. melanura* in the 20 numbered holes of the treated plots was clearly indicated by the contrasting indices obtained in the 15 numbered holes in the untreated plots. Larvae of *C. melanura* in the untreated plots continued to develop throughout the study, and only 8 of the 180 inspections of untreated holes were negative.

Hole number 6, which was in the plot treated with dieldrin at the rate of 0.5 pound per acre, was negative each of the post-treatment inspections for the 62-day period prior to the hurricane rains. This equaled the control attained in most of the heptachlor plots and was the best control observed in any of the numbered holes in the dieldrin-treated areas. The complete control attained in hole number 6 may have been due to an inadvertent overdose of insecticide at that location, since that hole was situated on one of the paths along which the operator walked while applying the insecticide.

The results obtained in these studies indicate that larvae of *C. melanura* can be controlled with granular formulations of insecticides, whereas previous efforts to control the species by other methods have been unsuccessful. The effectiveness of the granular formulations in controlling larvae of *C. melanura* is probably due to their superior ability to penetrate foliage and reach the water surface in a reasonably uniform pattern of distribution. Once in the water, the granules sink to the bottom, and the insecticide is released. The subsurface release of the insecticide enhances the diffusion of the toxicant into the holes that contain the larvae.

In many areas of the northeastern United States, a winter application of 50 percent

TABLE 1.—Maximum number of larvae of *Culiseta melanura* per dip at indicated intervals before and following applications of granular insecticides to quarter-acre study plots in the Hockomock Swamp, Massachusetts

Toxicant	Dose lb./acre	Hole number	Larvae per dip on day indicated before (–) or after treatment [1]											
			–10	5	12	19	26	40	48	55	62	70	76	81
Dieldrin	1.0	1	1	1	0	0	1	20	4	25	32	18	39	53
	1.0	2	4	1	0	0	1	4	1	1	1	18	20	0
	1.0	3	12	0	0	0	0	2	0	2	10	19	51	14
	1.0	4	5	0	1	0	0	0	0	2	4	16	22	0
	1.0	5	6	0	0	0	0	2	0	0	3	30	42	27
Untreated	–	U-1	11	7	9	9	19	11	9	22	13	0	55	30
	–	U-2	3	4	4	9	6	17	17	25	35	27	57	84
	–	U-3	4	15	37	15	9	34	6	7	4	59	45	55
	–	U-4	6	3	12	22	15	10	30	16	1	9	96	68
	–	U-5	3	5	3	3	17	61	9	30	16	181	131	144
Dieldrin	0.5	6	5	0	0	0	0	6	0	0	0	21	16	8
	0.5	7	7	4	0	0	0	4	4	3	1	9	45	39
	0.5	8	2	4	4	3	0	9	9	4	4	22	93	77
	0.5	9	5	0	1	3	0	16	9	5	8	24	51	14
	0.5	10	3	1	1	30	40	38	37	40	29	158	58	57
Untreated	–	U-6	3	0	8	12	12	3	9	16	4	80	75	157
	–	U-7	3	2	3	9	4	1	10	0	8	177	99	81
	–	U-8	2	2	0	3	14	5	1	1	4	141	144	129
	–	U-9	2	1	3	3	12	10	13	7	3	131	72	73
	–	U-10	0	0	3	3	3	1	2	3	8	118	56	48
Heptachlor	0.5	11	5	0	0	0	0	0	0	0	0	16	8	10
	0.5	12	6	3	0	0	1	7	1	0	1	12	7	3
	0.5	13	0	0	0	0	0	0	0	0	0	6	12	12
	0.5	14	2	0	0	0	0	0	0	0	0	2	0	0
	0.5	15	5	0	0	0	2	3	2	4	3	6	3	0
Untreated	–	U-11	13	1	6	6	3	7	6	10	9	5	3	0
	–	U-12	3	5	6	7	0	6	1	5	6	62	11	81
	–	U-13	12	4	12	15	20	40	45	42	25	181	49	35
	–	U-14	6	1	1	3	5	6	18	23	21	19	20	32
	–	U-15	2	4	3	6	10	30	30	25	26	125	54	36
Heptachlor	1.0	16	6	1	0	0	0	0	0	0	0	153	27	32
	1.0	17	12	0	0	0	0	0	0	0	0	29	10	15
	1.0	18	2	0	0	0	0	0	0	1	0	57	32	32
	1.0	19	1	0	0	0	0	0	0	0	0	39	39	103
	1.0	20	13	0	0	0	0	0	0	0	0	110	32	63

[1] Third and fourth instar larvae of *C. melanura* counted in pretreatment inspection, but all instars identified in post treatment inspections.

wettable DDT dust, at the rate of 1 to 2 pounds (active ingredients) per acre, is applied to the surface of frozen swamps as a prehatch mosquito control measure. Although such treatment is effective in reducing the spring brood of *Aedes* spp., it does not control subsequent broods of *Culex* spp. and *Culiseta* spp., and an aerial spray application of DDT is usually applied in the spring to control these species. Because of the long-term residual effect of the granular heptachlor noted in these studies, investigations should be made of its value as a winter prehatch treatment for control of various species. If it proves effective through spring, the higher initial cost of the granular heptachlor would be offset by elimination of the need for the two DDT treatments.

Finally, consideration of the use of the granular formulations of insecticides for control of larvae of *C. melanura* is merited for the emergency control of the species during outbreaks of eastern encephalitis. Such outbreaks usually occur in the late summer when a thick plant canopy covers the breeding areas and renders applications of mists and sprays ineffective.

SUMMARY. Granular formulations of dieldrin and heptachlor were applied during the summer of 1961 to ¼-acre study plots in a Massachusetts fresh-water swamp at the rates of 0.5 and 1.0 pound of active ingredients per acre. Heptachlor was more effective than dieldrin in controlling larvae of *C. melanura*. Essentially complete control was attained for 62 days in the plot treated at the rate of 1.0 pound heptachlor per acre. The results indicated that studies on winter applications of granular heptachlor are needed, and that consideration of the use of granular formulations of insecticides for emergency control of larvae of *C. melanura* during outbreaks of eastern encephalitis is merited.

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