RICE FIELD MOSQUITO CONTROL STUDIES WITH LOW VOLUME DURSBAN® SPRAYS IN COLUSA COUNTY, CALIFORNIA. IV. EFFECTS UPON AQUATIC NONTARGET ORGANISMS

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ABSTRACT. The effects of three low volume applications of Dursban on nontarget organisms were studied in rice fields in Colusa County, California. Evaluations were made by observing caged insect and fish populations during and after treatments, by pre- and post-treatment sampling of the field insect populations by dipping and aquatic light trapping, and by maintaining throughout the summer a weekly schedule of sampling by dipping of 40 rice fields in a treated area and 57 fields in an untreated area. From observations, primarily on the cage tests, we concluded that *Siphlonurus* (mayfly), *Laccophilus* (diving beetle) and *Lepomis macrochirus* (bluegill) suffered adverse effects from .0125 and .0167 lb/acre Dursban LV. On a season-wide basis, however, some insect species showed greater abundance in the treated than in untreated areas.

A major concern in implementing the mosquito control operational plan previously discussed (Womeldorf and Whitesell, 1972) was the effects of the pesticide material on nontarget organisms. Minimal adverse effects on this group of organisms were observed in four rice fields studied over a 6–7 week period (Linn, 1968; Washino *et al.*, 1968), but since this study was preliminary in nature and limited in scope, it was concluded that further evaluation was necessary. Although several recent studies in experimental ponds provided valuable guidelines (Mulla, 1970; Hurlbert *et al.*, 1970) a major effort was made in our study to conduct *in situ* observations to assess the insecticide effects on the nontarget organisms in a rice field.

METHODS. The effects of the three applications of Dursban on nontarget organisms were studied by three methods. One method of evaluating the acute effects of Dursban, was to place immature and/or mature forms of seven species of aquatic insects in screened cages for observation in treated and untreated rice fields during the first (June 8–15) and second (July 15–20) treatments. Post-treatment counts were made at 24 and 72 hours.

A second method, primarily to determine the acute effects of the Dursban, included dipping and light trap collections to obtain pre- and post-treatment estimates of the aquatic insect population. During the first treatment (June 8–15) four sampling stations were designated in rice fields in area A, and 2 in fields located in area B (See below). Sampling stations for evaluating the second treatment were limited to four in area C. At each station, aquatic light trap (See Washino and Hokama, 1968 for description) and dipping (50 dips) collections were made less than 24 hours prior to treatment, 24 hours after treatment, and in addition (where possible), 72 hours after treatment.

To study the effects of treatments on the seasonal activity of the most common aquatic insects, dipping collections were made in 40 rice fields throughout the growing season. For comparison, 40 rice fields in the same areas were similarly checked in 1969 when little or no treatment was made. Details of the subdividing of the Colusa Mosquito Abatement District into 4 subareas (A, B, C and D) and sampling 10 rice fields from each (total, 40 fields) at weekly intervals, were described previously (Washino *et al.*, 1972). The same procedure was followed from June through August or September for 14 consecutive

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weeks in 1969, 15 in 1970. In addition, six other rice fields in Colusa County outside the treated area were inspected for 9 consecutive weeks starting in July. In two counties east of Colusa (Sutter and Yuba), 51 rice fields with little or no chemical control were observed for 14 consecutive weeks. These observations were part of a separate study, but the results (in part) are included for comparison.

To determine the acute effects of the Dursban treatment on fish, observations were made on bluegill (*Lepomis macrochirus*) and the mosquito-fish (*Gambusia affinis*). Five cages, each of which contained 5 bluegills with an average weight of 20 gms, were placed in 5 fields prior to treatment. A sixth cage, also containing 5 fish, was observed in a field receiving no treatment. For *Gambusia affinis,* 20 one-cubic-foot screened cages were placed in 10 fields (8 fields receiving treatment, 2 fields receiving no treatment) during the period of the first two treatments. Each cage contained 5 males and 5 females. Post-treatment counts were made for 5 consecutive days.

Results. Mortality figures for seven common aquatic insects in cages exposed in treated and untreated rice fields are summarized in Table 1. Mayflies, *Siphlonurus* sp., showed high mortality in the 11 replicates (each with 10 nymphs) during the two treatments. Two adult dytiscid beetles, *Laccophilus* spp., were the only other aquatic insects that showed more than moderate mortality in the 10 replicates in the second treatment. Observations on caged fish exposed in treated and untreated rice fields are summarized in Table 2. Bluegills (*L. macrochirus*) showed 32 percent mortality, but very few *G. affinis* died.

The results of evaluating the acute effects of Dursban in the first and second treatment by pre- and post-treatment dipping and light trapping are summarized in Tables 3 and 4. In most instances, no consistent pattern of mortality was observed in either method of sampling.

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Table 1.—Effects of Dursban ® LV on aquatic insects in cages placed in rice fields, Colusa County, California, 1970.

Insect	Treatment No.[1]	Insects in treated fields: Total No.	Insects in treated fields: Percent mortality	Insects in untreated fields: Total No.	Insects in untreated fields: Percent mortality
Belostoma spp.	1	25	0	5	0
	2	40	2.5	5	0
Corisella sp.	1	35	0	5	0
Hydrophilus triangularis (larva)	1	5	0	2	0
Hydrophilus triangularis (adult)	2	5	0	1	0
Laccophilus spp. (larva)	2	30	0	10	1
Laccophilus spp. (adult)	2	50	32	10	0
Siphlonurus sp. (nymphs)	1	30	70	5	0
	2	80	52.5	10	0
Thermonectus basilaris (larva)	1	20	5	5	0
	2	30	0	5	0
Thermonectus basilaris (adult)	1	30	0	5	0
	2	70	0	10	0
Tropisternus lateralis (larva)	1	35	0	5	0
	2	35	0	5	0
Tropisternus lateralis (adult)	1	80	0	10	0
	2	50	0	10	0

[1] Treatment 1 = June 9–13; treatment 2 = July 15–20.

TABLE 2.—Effect of Dursban ® LV on *Gambusia affinis* and *Lepomis macrochirus* in cages placed in rice fields, Colusa County, California, 1970.

Fish	Fish in treated fields: Total No.	Fish in treated fields: Percent mortality (3–5 days)	Fish in untreated fields: Total No.	Fish in untreated fields: Percent mortality (3–5 days)
Gambusia affinis	170	0.5	30	0.0
Lepomis macrochirus	25	32.0	5	0.0

and/or mature insect species from 40 treated rice fields in Colusa County and 57 untreated rice fields in Colusa, Sutter and Yuba Counties is summarized in Figures 1 and 2. With the exception of dragonflies, *Belostoma* and *Laccophilus* (adults), the collections of many aquatic insects in the treated fields were as great or greater than in the untreated fields.

DISCUSSION. The savings in time and costs achieved with the low volume technique is important to vector control programs established during epidemics, or where economic restrictions prevent other methods of control. Lofgren (1970) surmised that hazards to nontarget organisms should not be greater than with conventional sprays. The economic advan-

TABLE 3.—Effect of Dursban ® LV on aquatic insects in rice fields, Colusa County, California, 1970. Evaluation by aquatic light trap.

Insect	Treatment number/ sub-area [1]	No. of insects [2]: Pre-treatment	Post-treatment (24 hrs.)	Post-treatment (72 hrs.)
Belostoma spp.	1A	1	3	..
	2C	30	53	26
Corisella sp.	1A	48	92	..
	1B	53	40	46
	2C	217	213	100
Hydrophilus triangularis (larva)	1A	12	15	..
	1B	28	26	6
	2C	8	4	8
Tropisternus lateralis (larva)	1A	8	6	..
	1B	7	86	7
	2C	55	35	0
Tropisternus lateralis (adult)	1A	26	85	..
	1B	14	0	6
	2C	169	167	44
Laccophilus spp. (adult)	1B	7	8	3
	2C	29	22	2
Thermonectus basilaris (larva)	1B	3	0	0
	2C	66	28	6
Thermonectus basilaris (adult)	2C	14	4	2

[1] 1A = First treatment in sub-area A, June 8–13; 1B = First treatment in sub-area B, June 9–13, adjusted totals for 24 hr. post-treatment sample due to light failure in one trap; 2C = Second treatment in sub-area C, July 14–21.

[2] Total counts from 4 stations in 1A, 2 in 1B, and 4 in 2C.

TABLE 4.—Effect of Dursban ® LV on aquatic insects in rice fields, Colusa County, California, 1970. Evaluation by dipping.

Insect	Treatment number/ sub-area [1]	No. of insects [2] Pre-treatment	Post-treatment (24 hrs.)	Post-treatment (72 hrs.)
Siphlonurus sp.	1A	4	0	..
	2C	5	2	1
Belostoma spp.	1A	2	1	..
	2C	4	17	18
Corisella sp.	1A	22	2	..
	1B	17	8	7
	2C	0	2	0
Notonecta sp.	2C	13	0	0
Tropisternus lateralis	1A	9	11	..
(larva)	1B	4	10	3
	2C	32	40	14
Laccophilus sp.	1A	0	1	..
(adult)	2C	14	15	5

[1] 1A = First treatment in sub-area A, June 8–13; 1B = First treatment in sub-area B, June 9–13; 2C = Second treatment in sub-area C, July 14–21.

[2] Total counts from 4 stations in 1A, 2 in 1B, and 4 in 2C, 50 dips at each station.

tage derived from the low volume technique may, however, result in greater amounts of insecticides used with ultimately greater exposure and risk to nontarget organisms. Therefore, major efforts were expended to evaluate the effects of the low volume treatments on the nontarget organisms.

From observations primarily on caged populations (Tables 1 and 2), we concluded that at least three nontarget organisms suffered adverse effects from the Dursban treatments at dosage rates of .0125 and .0167 lb/acre. The mortality observed in *Laccophilus, Siphlonurus* (Table 1) and *Lepomis* (Table 2) was not as high as was observed for target organisms (Washino *et al.*, 1972), but considering the fact that all three were nontarget animals, the mortality was substantial enough to be considered serious. As a measure of the impact on the rice field ecology, mortality of any nontarget organisms raises some concern. In terms of impact on vector populations, however, effects on predators of the vectors becomes of even greater concern.

Since some evidence exists that *Laccophilus* beetles may serve as natural predators of mosquito larvae (Roberts *et al.*, 1967; Washino, unpublished), the mortality of these beetles may be of more significance than the mortality in the mayfly or bluegill species. Unpublished studies supporting the possibility that *Laccophilus* serves as a natural predator revealed a statistically significant association between the presence of the adult beetle and *C. tarsalis* larvae in rice fields in certain areas, in a 3-year study covering five California counties. In retrospect, the mortality of *Laccophilus* should not have been completely unexpected since concurrent laboratory studies showed that unlike most of the other beetles common in rice fields, this beetle is susceptible to Dursban at mosquito larvicidal dosage rates (Ahmed, unpublished). Comparison of adult beetles from dipping collections in treated and untreated rice fields in Colusa County in 1970 (Fig. 2) support the results of field (i.e., cage test) and laboratory tests. Comparisons with Colusa County from previous year (1969) and in neighboring counties (1970) do not show similar differences.

With the possible exception of *Thermonectus basilaris* and *Notonecta* sp., there were no indications from pre- and post-treatment dipping and light trap collections that most of the common insects suffered excessive mortality soon after treatment (Tables 3 and 4). The possibility that *T. basilaris* larvae or adults were adversely affected during the second treatment was not substantiated in cage tests (Table 1). The effects on backswimmers (*Notonecta*) were inconclusive due to their limited abundance. The observations of mayfly naiads (*Siphlonurus*) in dipping collections were too low for comparison with the results of cage tests (Table 1). The mortality of mayflies and possibly *Notonecta*, and the survival of *Tropisternus lateralis* support the results found in aquatic situations other than rice fields (i.e., experimental pond studies of Mulla, 1970; Hurlbert *et al.*, 1970). The dipping and light trap collections before and after treatment did not show the marked pattern observed with cage tests. The mortality observed in caged *Gambusia affinis* was slightly lower than in the experimental pond studies of Hurlbert *et al.* (1970). Observations on bluegills were limited (Table 4), but the results were consistent with previous observations in Colusa when higher dosage rates (0.05 lb/acre) were used (Linn, 1968).

On a season-wide basis, many insects, with the possible exception of dragonflies, *Belostoma,* and *Laccophilus* (adult), showed no obvious impairment from the insecticide treatments (Figs. 1 and 2). If anything, many species showed greater abundance in the treated rather than in the untreated areas. Possible explanations include the likelihood that many aquatic insects are tolerant of Dursban LV, or that these insect populations vary sufficiently from one area to another, and from one year to another, so that valid com-

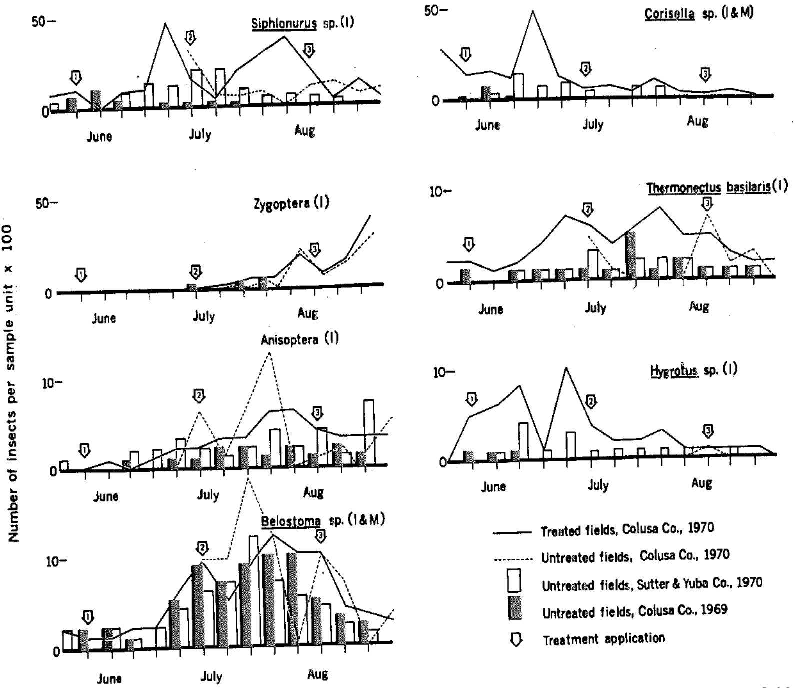

FIG. 1.—Average number of aquatic insects per sample unit from treated and untreated rice fields (I = immature; M = mature).

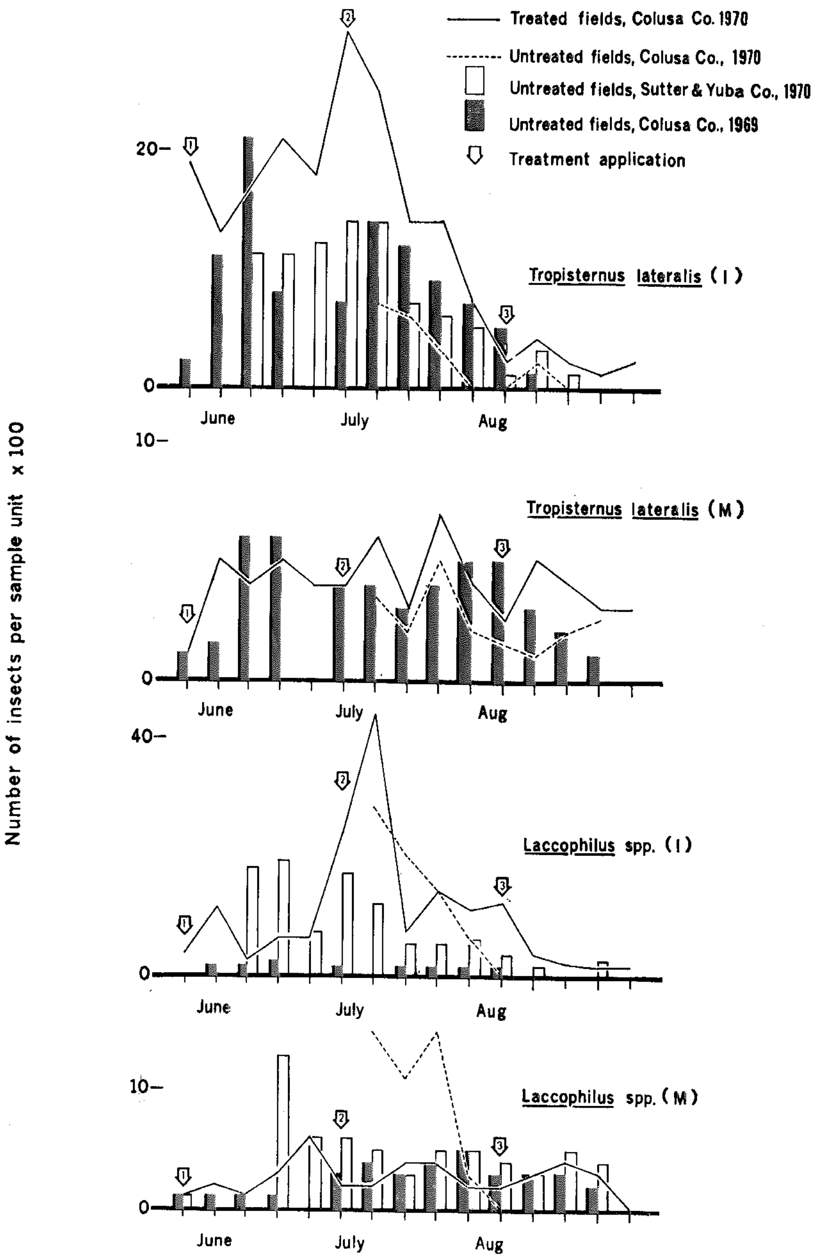

FIG. 2.—Average number of aquatic insects per sample unit from treated and untreated rice fields (I = immature; M = mature).

parisons cannot be made with the evaluation methods used in the present study. Another possibility is that organisms in the higher trophic levels might have been killed resulting in lessening of predator pressure on surviving members lower in the food chain. Evidence to support such a possibility is the mortality in the two most predaceous organisms in this habitat—bluegills (Table 2) and *Belostoma* spp. (see Fig. 1: Colusa County population in treated and untreated areas, 1970). Until further studies are done, however, no explanation can be given on the rather high population levels on a seasonal basis of the nontarget organisms in the treated area.

We have concluded from this study that some nontarget organisms did, and some did not, show a decline after LV treatments of Dursban. We also concluded that evaluation of the effects of any pesticide on nontarget organisms *in situ* is extremely difficult and that most conclusions cannot be reached on the basis of any single evaluation procedure. For example, results of cage tests, and weekly dipping for the entire breeding season agreed with laboratory tests and supported the contention that *Laccophilus* adults were severely affected by Dursban. Pre- and post-treatment evaluation by dipping, and light trap collections, did not show similar agreement. In addition to *Laccophilus,* mayflies and bluegills also showed adverse effects (i.e., cage test) from Durban. With several other insects observed (i.e., *Notonecta* sp.) there were indications of adverse effects, but population levels were too low to permit even tentative conconclusions. No evidence of adverse effects was observed in many nontarget organisms including *Tropisternus lateralis, Corisella* and *G. affinis.*

ACKNOWLEDGMENTS. We thank Mr. E. E. Kauffman for his cooperation in the study; and Dr. A. A. Grigarick and Mr. J. R. Walker for helpful criticism of the manuscript.

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