INTEGRATION OF CHEMICAL AND BIOLOGICAL CONTROL AGENTS AGAINST NATURAL POPULATIONS OF *CULEX TARSALIS*.

TAKESHI MIURA, C. H. SCHAEFER AND F. S. MULLIGAN, III

University of California Mosquito Control Research Laboratory, 5544 Air Terminal Drive, Fresno, California 93727

ABSTRACT. Data obtained from field studies showed that the combined effect of methoprene (Altosid® 1 briquet/9.3m²) and insect predators suppressed *Culex tarsalis* Coquillett populations. Chemical treatment caused no deleterious effects on the activities of *Notonecta unifasciata* Guerin and *Buenoa scimitra* Bare so that the predation produced an additive effect.

The effectiveness of methoprene as a mosquito larvicide is well documented (Schaefer and Wilder 1972, 1973, Steelman and Schilling 1972, Mulla et al. 1975). Stewart (1977) and Schoeppner (1977) used methoprene (4% briquet formulation) successfully to control *Culex* populations in small bodies of waters such as septic tank systems, catch basins, swimming pools and irrigation ditches. Furthermore, Miura and Takahashi (1973) reported that the rates of methoprene used to control mosquitoes did not interfere with predatory activities of *Notonecta unifasciata* Guerin. Thus, the selectivity of methoprene provides potential for the integration of chemical and biological agents against mosquitoes.

The objective of this study was to investigate the effectiveness of the combined activities of methoprene briquets and notonectid bugs against *Culex tarsalis* Coquillett populations in natural breeding habitats.

MATERIALS AND METHODS

Ponds in the Tracy Experimental plot were used for this study. The plot is located near the south end of Jerry slough, ca. 7.4 km northeast of Buttonwillow and 37 km northwest of Bakersfield. The surrounding area comprises reclaimed, irrigated farmland and undeveloped wasteland used by private gun clubs.

Vegetation in the plot area was scant, but saltgrass [*Distichlis spicata* (L.) Greene] and tumbleweed (*Amaranthus* sp.) were common on dry land. The wet area around the water-line of the ponds was occupied by barnyardgrass [*Echinochloa crusgallis* (L.) Beauv.], bearded sprangletop [*Leptochloa fascicularis* (Lam.) Gray], and bermudagrass [*Cynodon dactylon* (L.) Pers.]. In the early season, vegetation was sparse in the basin, but stone wort (*Chara* sp.), water net algae [*Hydrodictyon reticulatum* (L.) Lagertheim] bermuda-grass and spike rush (*Eleocharis* sp.) become abundant as the season advanced.

The ponds used were rectangular shaped, semi-natural, and had a surface area of ca. 0.01 ha (0.024 acre). They were first filled with water on June 6, and a water depth of 20 to 25 cm was maintained by filling twice a week from an irrigation ditch fed by a well.

Methoprene (briquet formulation) was used because of its narrow spectrum of activity (Schaefer and Wilder 1972, 1973), and the rates used to control mosquitoes did not affect nontarget organisms associated with mosquito breeding habitats (Miura and Takahashi 1973). The briquets contained 4% active ingredient, impregnated in charcoal. This formulation was designed to release methoprene over a 30 day period according to the manufacturer.

To study the effects of multiple treatments, on June 21, July 21 and August 19, 1977 briquets were applied at a rate of

1/9.3 m^2 of surface area to pond "B". Pond "A" was left untreated as the experimental check.

Population densities of natural enemies were estimated by trapping twice a week using modified minnow traps (Miura and Takahashi 1975). Populations of immature mosquitoes were estimated by dipping with a long handled dipper (450 ml) from 10 fixed collecting sites. Initially, the efficacy of methoprene treatments was planned to be evaluated by collecting 4th instar larvae and pupae from the ponds and transferring them to the laboratory for emergence checks. However, so few 4th instars and pupae were present in the ponds that the numbers collected were insufficient to yield meaningful information. Therefore, the efficacy of the 2nd and 3rd treatments was estimated by bioassaying the water. Two 500 ml samples of the water were taken from along the east and west banks of each pond. In the laboratory 100 ml subsamples of each water sample were put in a triplicated series of Pyrex® custard cups. Then twenty 4th instar larvae of the southern house mosquito (*Culex pipiens quinquefasciatus* Say) were added. The cups were kept at room temperature (ca. 21°C) until completion of the assay.

RESULTS AND DISCUSSION

Overall results are shown in Fig. 1. The data indicate that the combined effect of methoprene briquet treatments and notonectid bugs suppressed *Cx. tarsalis* populations in the breeding sites, and the treatments did not affect the reproductive, developmental or predatory activities of *Notonecta unifasciata* Guerin and *Buenoa scimitra* Bare.

A sudden population decline between July 2 and 9 was probably due to an increase in predation rate because both treated and untreated mosquito populations declined at the same time, and coincidentally during this period a great increase in notonectid populations occurred. The results of bioassays, however, indicate some degree of inhibition of emergence after each treatment (Table 1). The bioassay data clearly show that the methoprene treatments alone were insufficient to provide a satisfactory control.

During the study period, densities of immature mosquito populations in the ponds remained low, especially older instars (3rd and 4th) and pupae. However, densities of 1st and 2nd instars fluctuated with the prevailing population trend in the vicinity (cf. Fig. 1 and 2).

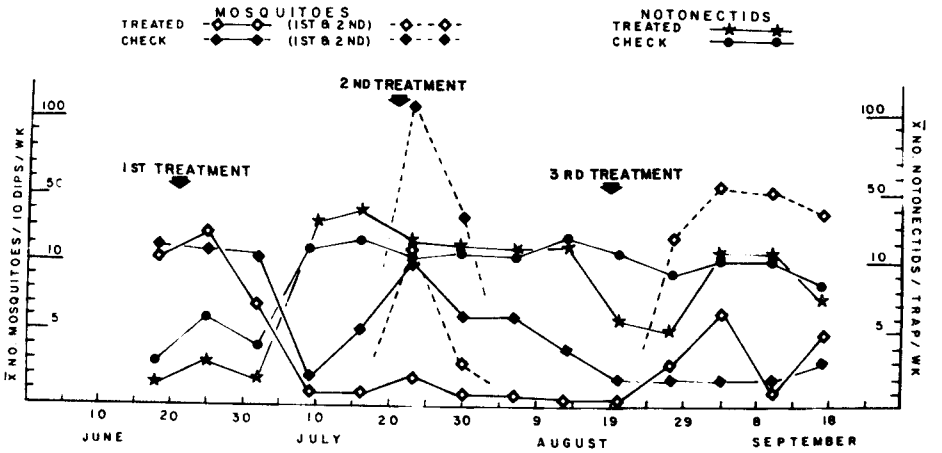

Figure 1. Weekly average number of mosquitoes and notonectid bugs per sample unit from treated and untreated ponds.

Table 1. Bioassay of water from the pond treated with 1 briquet/9.3m² on July 21 and August 19, 1977[a].

Date	Post-treatment time (day)	Side of pond sampled		Check
		East	West	
		Second treatment		
7/21	3(h)	0	5	0
7/22	1	82	31	0
7/31	10	20	8	0
8/10	20	16[b]		0
8/19	29	3[b]		0
		Third treatment		
8/19	2(h)	48	7	0
8/20	1	2	2	0
8/23	4	30[b]		0
8/26	7	0[b]		0
8/31	12	11[b]		0
9/ 2	14	0[b]		0

[a] In % total inhibition of adult emergence of the southern house mosquito larvae.
[b] Composite sample from both sides of pond.

An interesting phenomenon was noticed during the study: Notonectid adults probably learn to avoid traps when the traps are left in the sites for a prolonged period. This conclusion was made because adult notonectids appeared immediately after flooding on June 6, and steadily increased in numbers, but the trapping record did not indicate this increase (Fig. 3).

Data in Fig. 3 also indicate that methoprene has no effect on the reproductive and developmental activities of notonectid bugs; in both ponds the bugs reproduced and developed without noticeable differences (cf. Fig. 1 and 3).

The most frequently collected predacious insects, other than notonectids, were *Tropisternus lateralis* (F.), *Laccophilus* spp., and *Thermonectus basillaris* (Harris). These

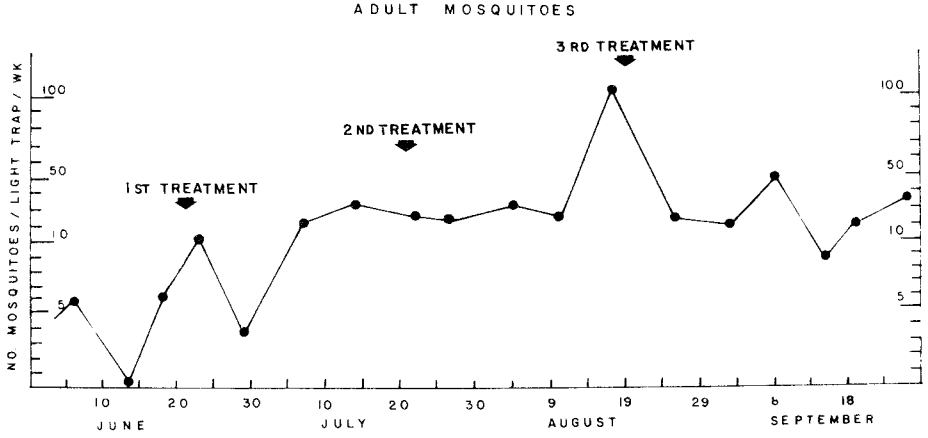

Figure 2. *Cx. tarsalis* light trap collection in the vicinity of the experimental plot (ca. 3.7km south of the plot. Data kindly supplied by the Kern Mosquito Abatement District, Bakersfield, Ca.)

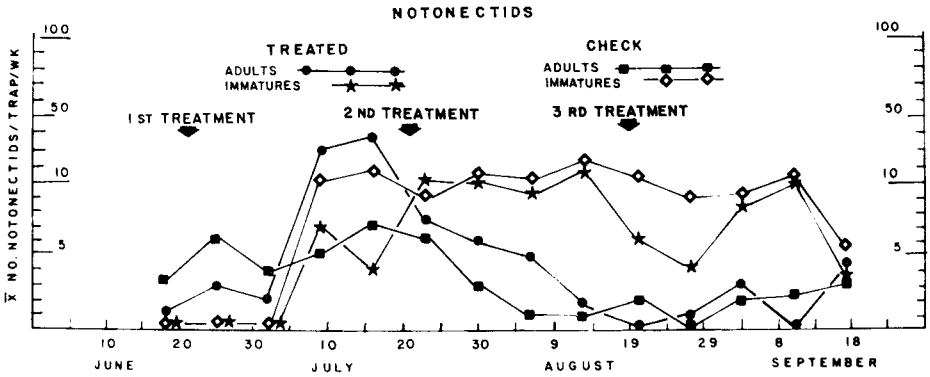

Figure 3. Weekly average number of notonectid bugs per trap from treated and untreated ponds.

predators are important in mosquito control (Bay 1974), but the trapping catches during this investigation were not large enough to yield useful information on population densities. The microsporidan [*Amblyospora californica* (Kellen and Lipa)] is a common protozoan pathogen of *Cx. tarsalis* in California (Kellen 1963). Our unpublished records show that levels of apparent infection with this pathogen in the Tracy Experimental plot ranged from 3% to less than 1%. Since infected larvae were sporadically collected from the treated pond, methoprene treatments probably had no deleterious effect on the pathogen.

Thus, the study clearly showed that selective chemical agents can complement the action of natural enemies to achieve satisfactory control of *Cx. tarsalis* in permanent or semi-permanent waters.

References Cited

Bay, E. C. 1974. Predatory—prey relationships among aquatic insects. Annu. Rev. Entomol. 19:441–53.

Kellen, W. R. 1963. Research on biological control of mosquitoes. Proc. Calif. Mosquito Control Assoc. 31:23–5.

Miura, T. and R. M. Takahashi. 1973. Insect developmental inhibitors. 3. Effects on nontarget aquatic organisms. J. Econ. Entomol. 66:917–22.

Miura, T. and R. M. Takahashi. 1975. Effects of the IGR, TH6040 on nontarget organisms when utilized as a mosquito control agent. Mosquito News 35:154–59.

Mulla, M. S., H. A. Darwazeh and R. L. Norland. 1975. Insect growth regulators—evaluation procedures and activity against mosquitoes. J. Econ. Entomol. 67:329–32.

Schaefer, C. H. and W. H. Wilder. 1972. Insect developmental inhibitors: a practical evaluation as mosquito control agents. J. Econ. Entomol. 65:1066–71.

Schaefer, C. H. and W. H. Wilder. 1973. Insect developmental inhibitors. 2. Effects on target mosquito species. J. Econ. Entomol. 66:913–16.

Schoeppner, R. F. 1977. Methods used to suppress mosquito populations in a bayside community. Proc. Calif. Mosquito Control Assoc. 45:194–96.

Steelman, C. D. and P. E. Schilling. 1972 Effects of a juvenile hormone mimic on *Psorophora confinnis* (Lynch-Arribálzaga) and non-target aquatic insects. Mosquito News 32:350–354.

Stewart, J. P. 1977. Field testing of methoprene (Altosid®) briquets for *Culex* mosquito control. Proc. Calif. Mosquito Control Assoc. 45:149–151.