ACTIVITY OF ORGANOPHOSPHATE AND SYNTHETIC PYRETHROID INSECTICIDES AGAINST PESTIFEROUS MIDGES[1] IN SOME SOUTHERN CALIFORNIA FLOOD CONTROL CHANNELS[2]

ARSHAD ALI[3] AND MIR S. MULLA
Department of Entomology, University of California, Riverside 92521

ABSTRACT. In the laboratory, 5 organophosphorous (OP) and 4 new synthetic pyrethroid insecticides were bioassayed against 4th instar field populations of *Chironomus decorus* (Johannsen), *Dicrotendipes californicus* (Johannsen), *Cricotopus bicinctus* (Meigen), *Cricotopus sylvestris* (Fabr.), and *Tanypus grodhausi* Sublette collected from 2 flood control channel systems in southern California.

The OPs included chlorpyrifos, temephos, fenthion, malathion, and phenthoate, while the pyrethroids were FMC-45498 or decamethrin, FMC-45497, FMC-35171, and SD-43775 or fenvalerate.

On Coyote Creek midges, malathion was the most active OP against *Cricotopus* spp. (LC_{90}=0.35 ppm) and *C. decorus* (LC_{90}=0.21 ppm), while *D. californicus* was most susceptible to chlorpyrifos (LC_{90}=0.16 ppm) and least to malathion (LC_{90}=1.42 ppm). The LC_{90} values of chlorpyrifos and temephos against *T. grodhausi* were 0.0039 and 0.31 ppm, respectively. In general, the Coyote Creek midges were resistant to the OPs tested showing the highest resistance to temephos. However, these species were highly susceptible to the 4 pyrethroids. FMC-45498 and FMC-45497 were the 2 most active with LC_{90} values ranging from 0.00013–0.012 ppm.

The San Jose Creek species of *Cricotopus* and *D. californicus* were far more susceptible to the organophosphates (LC_{90} range of 0.009–0.11 ppm) than the same species in the Coyote Creek. FMC-45498 and FMC-45497 were also highly toxic to these midges showing much superior activity than chlorpyrifos, the most active OP insecticide against midges in the San Jose Creek.

INTRODUCTION

The network of man-made open channels in the metropolitan areas of Los Angeles and Orange Counties in Southern California are suitable habitats for breeding of chironomid midges. These channels, collecting domestic and industrial waste water and storm water amount to more than 650 km in each county. In the eutrophic environment of these channels, dense populations of chironomid larvae prevail almost throughout the year (Ali et al. 1977), and frequent outbreaks of adult midges pose severe nuisance, discomfort, and economic problems for the nearby residents and workers. The problems resulting from chironomid swarms have been previously outlined (Ali 1980, Grodhaus 1963, Mulla 1974).

To control midges in these waterways, several organophosphorous (OP) larvicides have been used for nearly 2 decades in some of these channels, but the development of resistance in midge larvae to some organophosphates has reduced the effectiveness of these chemical control agents (Pelsue and McFarland 1971).

This study was undertaken to elucidate the present status of the activity of a few commonly available organophosphorous insecticides against the pestiferous species of midges inhabiting some of the channels, and also to evaluate new substitute larvicides, such as the synthetic pyrethroids against these insects. Five OP insecticides and 4 pyrethroids were studied

[1] Diptera: Chironomidae.

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[3] Present address: University of Florida, IFAS, Agricultural Research and Education Center, P. O. Box 909, Sanford, FL 32771.

for their activity in the laboratory against field populations of 5 midge species during 1977.

MATERIALS AND METHODS

The organophosphates tested were chlorpyrifos, temephos, fenthion, malathion, and phenthoate. The synthetic pyrethroids included FMC-45498 or decamethrin (NRDC-161): [(−)−(Cyano)−3−phenoxybenzyl−(+) *cis*−3−(2, 2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylate]; FMC-45497 (NRDC-160): (±) *cis* and chloroanalogue of FMC-45498; FMC-35171 (NRDC-148: 3-Phenoxybenzyl (±) *cis*-3-(2,2-dichlorovinyl)-2, 2-dimethylcyclopropanecarboxylate]; and fenvalerate or SD-43775: ∝-Cyano-3-phenoxybenzyl 4-chloro-∝-(1-methylethyl)-phenylacetate.

For larval bioassays, 4th instars of 5 midge species, *Cricotopus bicinctus* (Meigen), *Cricotopus sylvestris* (Fabr.), *Dicrotendipes californicus* (Johannsen), *Chironomus decorus* Johannsen, and *Tanypus grodhausi* Sublette, were utilized. Since larvae of *Cricotopus* could not be separated into the 2 species due to taxonomic difficulties, a mixture of both species was tested. The test larvae were drawn from 2 separate drainage systems, the Coyote Creek and the San Jose Creek. The former habitat was described by Ali and Mulla (1976). It is concrete-lined and mainly drains East Whittier, La Mirada, and Fullerton areas of Los Angeles and Orange Counties, and empties into the Pacific Ocean at Seal Beach. The San Jose Creek, draining the Bassett area of Los Angeles County, is located near the interstate freeway 605 and Pomona freeway. It runs parallel to the San Gabriel River for some distance before emptying into that river.

In the Coyote Creek, bioassay tests on all 5 species of midges were performed, whereas in the San Jose Creek, only populations of *C. bicinctus, C. sylvestris,* and *D. californicus* were available in sufficient numbers during the laboratory tests.

The procedures of bioassay employed during this study were the same as described by Mulla and Khasawinah (1969). The average percent larval mortality against different concentrations of an insecticide was noted after 24 hr and was corrected for mortality in the checks. The resulting data were subjected to log-probit regression analysis by using a Compucorp® 145 E computer to obtain the LC_{50} and LC_{90} values.

RESULTS AND DISCUSSION

The activity of the 4 OP insecticides, against 4th instars of *Cricotopus* spp., *C. decorus, D. californicus,* and *T. grodhausi* drawn from the Coyote Creek drainage is shown in Table 1. Susceptibility of each of these species to the 4 compounds varied considerably. Malathion was the most active against *Cricotopus* spp., followed by fenthion, chlorpyrifos, and temephos. Malathion was also the most active insecticide against *C. decorus* followed by chlorpyrifos, fenthion, and temephos. By contrast, *D. californicus* was most susceptible to chlorpyrifos and least to malathion (Table 1). The activity of chlorpyrifos and fenthion was similar against *Cricotopus* spp. and *C. decorus;* these species showed 4-200 times more tolerance to temephos than to chlorpyrifos, fenthion, and malathion. *Chironomus decorus* was 8-23 times more tolerant to chlorpyrifos, temephos, and fenthion than *Cricotopus* spp. Against *T. grodhausi,* chlorpyrifos and temephos were highly active with the former compound being much more active than the latter.

In general, the Coyote Creek midges were resistant to all organophosphates but showed exceptional resistance to temephos, especially *C. decorus* with an LC_{90} value as high as 42 ppm. As a general rule, if the LC_{90} of OPs is greater than 0.1 ppm (24 hr exposure) the organisms exhibiting such level of susceptibility are considered to be resistant for practical control purposes because of the higher costs of treatment and the possible

Table 1. Susceptibility of 4th instar[1] chironomid midges to various organophosphate insecticides in the laboratory.

	24 hr lethal concentration (ppm)							
	Cricotopus spp.[2]		*C. decorus*		*D. californicus*		*T. grodhausi*	
Organophosphates	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Chlorpyrifos	0.09	0.58	1.47	4.52	0.04	0.16	0.0015	0.0039
Temephos	0.18	1.82	7.22	42.14	0.14	1.09	0.029	0.31
Fenthion	0.13	0.54	1.90	4.72	0.11	0.39	—	—
Malathion	0.09	0.35	0.07	0.21	0.22	1.42	—	—

[1] Field populations drawn from the Coyote Creek, Orange and Los Angeles Counties, southern California (1977).

[2] Mixture of *C. bicinctus* and *C. sylvestris* (larvae could not be separated into the 2 species due to taxonomic difficulties).

adverse environmental implications associated with the higher doses of pesticides.

Table 2 shows effectiveness of the 4 synthetic pyrethroids against the Coyote Creek midges. The activity of all the pyrethroids tested was far superior than the organophosphates tested against the same species. FMC-45498 and its analogue FMC-45497 were very highly active with the former pyrethroid being almost 2–4 times more active than the latter against all the species except for *T. grodhausi*. FMC-35171 also showed high toxicity to all test species. Among the 4 pyrethroids, the least active material was SD-43775, however, this pyrethroid also showed higher activity against the Coyote Creek midges than the organophosphates, chlorpyrifos, temephos, and malathion.

The effectiveness of chlorpyrifos, temephos, fenthion, malathion, phenthoate, FMC-45498, and FMC-45497 against *Cricotopus* spp. and *D. californicus* inhabiting the San Jose Creek is shown in Table 3. In this channel system, chlorpyrifos was the most active organophosphate against *Cricotopus* spp. as well as *D. californicus*. Temephos and fenthion had somewhat similar toxicity to these species, and malathion was the least active OP insecticide against these species. The activity of phenthoate against *Cricotopus* spp. resembled that of temephos and fenthion but phenthoate was 2–4 times more effective against *D. californicus* than either temephos or fenthion.

The 2 pyrethroids, FMC-45498 and FMC-45497 had a very high level of activity against the San Jose midges. FMC-

Table 2. Susceptibility of 4th instar[1] chironomid midges to synthetic pyrethroids in the laboratory.

	24 hr lethal concentration (ppm)							
	Cricotopus spp.[2]		*C. decorus*		*D. californicus*		*T. grodhausi*	
Pyrethroids	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
FMC-45498	0.00011	0.0005	0.00027	0.00088	0.0021	0.0073	0.00011	0.00024
FMC-45497	0.00047	0.0017	0.0007	0.0022	0.0046	0.012	0.00006	0.00013
FMC-35171	0.0045	0.011	0.0036	0.0068	0.019	0.05	—	—
SD-43775	0.08	0.42	0.011	0.033	0.044	0.16	—	—

[1] Field populations drawn from the Coyote Creek, Orange and Los Angeles Counties, southern California (1977).

[2] Mixture of *C. bicinctus* and *C. sylvestris* (larvae could not be separated into the 2 species due to taxonomic difficulties).

Table 3. Susceptibility of 4th instar[1] chironomid midges to various organophosphate and synthetic pyrethroid insecticides in the laboratory.

	24 hr lethal concentration (ppm)			
	Cricotopus spp.[2]		*Dicrotendipes californicus*	
Insecticides	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Chlorpyrifos	0.0035	0.009	0.007	0.017
Temephos	0.016	0.043	0.021	0.089
Fenthion	0.013	0.048	0.031	0.11
Malathion	0.03	0.08	0.08	0.26
Phenthoate	0.02	0.046	0.016	0.032
FMC-45498	0.00015	0.00045	0.0014	0.0037
FMC-45497	0.00032	0.0011	0.0034	0.0079

[1] Field populations drawn from San Jose Creek, Los Angeles County, California (1977).
[2] Mixture of *C. bicinctus* and *C. sylvestris* (larvae could not be separated into the 2 species due to taxonomic difficulties).

45498 was more effective against *Cricotopus* spp. as well as *D. californicus* than FMC-45497 (Table 3). Overall, the 2 pyrethroids proved 2–20 times more toxic to these species than the most active organophosphate chlorpyrifos.

It is evident from this study that the susceptibility levels of the midge fauna in the 2 drainage areas differ considerably. The same species in the 2 habitats (only 25–30 km apart from each other) exhibited different levels of tolerance to the organophosphate larvicides. The higher resistance to organophosphates in the Coyote Creek midges is probably due to the selection pressure resulting from the more frequent use of most of these organophosphates in the Coyote Creek than in the San Jose Creek. The Coyote Creek drainage area has been treated with insecticides more frequently than the San Jose Creek because the former habitat is surrounded by more residences and businesses than the latter. Thus, more midge complaints have emanated from the Coyote Creek area during the past 2 decades (Pelsue, personal communication).

While chlorpyrifos, temephos, and fenthion are not effective against the Coyote Creek midges even at rates as high as 0.5–1.0 kg AI/ha (Pelsue and McFarland 1971), the present study indicates that malathion would be effective against larvae of the nuisance midges in this shallow (<0.3 m deep) channel system at rates below 0.5 kg AI/ha. However, all 5 organophosphates are effective against *Cricotopus* spp. and *D. californicus* in the San Jose Creek and would produce satisfactory control of the midge larvae at rates below 0.25 kg AI/ha. The synthetic pyrethroids, particularly FMC-45498 and FMC-45497 offer a good potential as substitute larvicides for the OP resistant midges. The adverse effects of these pyrethroids on the aquatic nontarget invertebrates and fish (Mulla et al. 1978a, b) would be of minimal concern in these lotic storm drains.

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THE RELATION OF FEMALE POLYGAMY TO GONOTROPHIC ACTIVITY IN THE *ROCK* STRAIN OF *AEDES AEGYPTI*[1]

ROGER W. WILLIAMS AND AGNES BERGER

Division of Tropical Medicine and Division of Biostatistics, School of Public Health, College of Physicians and Surgeons, Columbia University, New York, N.Y. 10032

ABSTRACT. It is a widely held concept that the pheromone matrone acts to prevent a second insemination during the entire life of fully inseminated females of *Aedes aegypti*. We have demonstrated that females of the ROCK strain, inseminated at 4 days post emergence, which become chronologically old (28 days) but remain physiologically young by being denied blood, cannot be inseminated a second time. In contrast, some fully inseminated females which through the ingestion of human blood progressed through a number of gonotrophic cycles, becoming physiologically older, were inseminated a second time. Within groups of 100, second insemination occurred in 6% following the 4th cycle, 22% after the 5th, 38% after the 6th and 48% after the 7th.

INTRODUCTION

Craig (1967) demonstrated that when male accessory glands were implanted, or extracts of these glands were injected, into virgin females of *Aedes aegypti* (L.) these females remained refractory to insemination for life. The substance responsible is the pheromone matrone. It has become accepted that, once fully inseminated, a female of this species cannot again be inseminated during her lifetime. Gwadz and Craig (1970) noted that incomplete insemination resulted from copulation with partially depleted males or from interruption of copulation and that females involved in such procedures remain receptive to a second insemination.

Williams et al. (1978) found that when females of the ROCK (Rockefeller) strain of *Ae. aegypti* were injected with matrone its activity was associated with the dilution and not related to the amount of that dilution injected, i.e. the results in preventing a second insemination were the same for 1, 2, or 4 ul of a given dilution. It would, therefore, appear that the effect

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