LABORATORY EVALUATION OF ORGANOPHOSPHATE AND NEW SYNTHETIC PYRETHROID INSECTICIDES AGAINST PESTIFEROUS CHIRONOMID MIDGES OF CENTRAL FLORIDA[1]

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ABSTRACT. In the laboratory, 4 organophosphorous (OP) and 6 new synthetic pyrethroid insecticides were tested against field-collected 4th instars of *Glyptotendipes paripes* Edwards, *Chironomus decorus* Johannsen, *C. crassicaudatus* Malloch, *Goeldichironomus holoprasinus* (Goeldi), and *Tanytarsus* spp. midges.

The OPs tested were chlorpyrifos, temephos, fenthion, and malathion, while the pyrethroids included FMC-30980, FMC-33297, FMC-35171, FMC-45497, FMC-45499, and FMC-52703.

All the pyrethroids showed a very high level of activity against *G. paripes, C. decorus,* and *C. crassicaudatus* with LC_{90} values ranging from 0.00026-0.013 ppm; *G. paripes* was the most susceptible of the 3 species. FMC-52703 proved the most toxic to these species.

Among the 4 OPs, malathion was the most active against *G. paripes* (LC_{90}=0.0079 ppm), followed by temephos, chlorpyrifos, and fenthion. *Chironomus decorus* and *C. crassicaudatus* were generally tolerant to the OPs (LC_{90}=0.1-0.48 ppm).

Goeldichironomus holoprasinus and *Tanytarsus* spp. were also tolerant to the OPs, showing the most tolerance to chlorpyrifos (LC_{90}=1.2 and 2.4 ppm, respectively). However, these 2 midge groups were very highly susceptible to the pyrethroids. The LC_{90} level of FMC-52703 against *G. holoprasinus* was as low as 0.0004 ppm and that against *Tanytarsus* spp. was 0.000019 ppm.

INTRODUCTION

Chironomid midges have long been recognized as a serious nuisance in several waterfront areas of California, Florida, and in many other parts of the United States. In this country, one of the worst problem areas of midge nuisance is the central portion on the peninsula of Florida which contains hundreds of various size lakes supporting dense populations of midge larvae.

To control chironomids in Florida, a large number of insecticides including chlorinated hydrocarbons and organophosphates were tested against midge larvae in the laboratory during 1958–66, and field applications of some of these insecticides were also made (Patterson 1964, Patterson and Wilson 1966, Patterson and von Windeguth 1964, Patterson et al. 1966).

In the past decade, public annoyance and economic loss due to these pestiferous insects emerging from Lake Monroe, adjacent to the City of Sanford, Seminole County, Florida, has increased enormously. According to an economic impact study[2] by the Greater Sanford Chamber of Commerce, an annual loss of 3–4 million dollars for the City of Sanford results from chironomid swarms. The study also indicates that at least 10 counties of Florida are affected by midges. Thus, the 1978 session of the Florida legislature approved funds for midge research.

This paper reports the present status of activity of some conventional organophosphorous (OP) larvicides and new substitute larvicides, such as synthetic pyrethroids against midges. Four OP insecticides and 6 pyrethroids were studied for their activity in the laboratory against field populations of 5 species of midges.

[1] Florida Agricultural Experiment Stations Journal Series No. 2508.

[2] Economic Impact Statement, 1977, Blind Mosquito (Midge) Task Force, Sanford Chamber of Commerce, Seminole County, FL. 4 pp.

MATERIALS AND METHODS

The organophosphates tested were chlorpyrifos, temephos, fenthion, and malathion. The synthetic pyrethroids included FMC-30980: (Cyano) (3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl-2,2-dimethylcyclopropane-1-carboxylate; FMC-33297: (3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate; FMC-35171: (3-phenoxyphenyl)methyl *cis*-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate; FMC-45497((Cyano) (3-phenoxyphenyl)methyl *cis*-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate; FMC-45497: (Cyano) (3-phenoxyphenyl)methyl (1R, *3R*)-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate; and FMC-52703; (S)-(Cyano)3-phenoxyphenyl)methyl (1R,3R)-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-1-carboxylate.

For larval bioassays, 4th instars of the midge species, *Glyptotendipes paripes* Edwards, *Chironomus decorus* Johannsen, *Chironomus crassicaudatus* Malloch, *Goeldichironomus holoprasinus* (Goeldi), and *Tanytarsus* spp. were utilized. Larvae of *Tanytarsus* were composed of a mixture of 2 or 3 unidentified species.

The test larvae were drawn from 3 separate habitats located near Sanford; *G. paripes* and *C. crassicaudatus* were drawn from Lake Monroe, while *Goeldichironomus holoprasinus* and *Tanytarsus* spp. were taken from the earthen experimental ponds in Sanford (Ali and Lord 1980). *Chironomus decorus* was collected from 2 sewage ponds located in the northeast part of Sanford and managed by the Utility Department of the City of Sanford.

The procedures for bioassay were those of Mulla and Khasawinah (1969). Technical grade material of each insecticide was utilized for preparing its 1% stock solution in acetone, and serial dilutions in acetone were made as needed. The required amount of a toxicant was added to 4-oz. waxed paper cups containing 10 larvae in 100 ml of tap water and 5 g of sterilized sand. Each test consisted of 5-6 triplicated concentrations of a test compound plus 3 untreated checks maintained under 14-hr photoperiod and 27° ± 2°C room temperature. Each chemical was tested on 3 different occasions. The average percent larval mortality at different concentrations of an insecticide was noted after 24 hr and was corrected for mortality in the checks. The corrected mortality was plotted against log concentrations on a probit log paper and the dosage response lines were fitted with the eye to obtain the LC_{50} and LC_{90} values in ppm.

RESULTS AND DISCUSSION

The activity of the 6 pyrethroids against *G. paripes, C. decorus,* and *C. crassicaudatus* is shown in Table 1. Susceptibility of each of these species to the pyrethroids varied considerably. Against *G. paripes,* FMC-52703 was the most active followed by FMC-45499, and then FMC-30980. FMC-45497, FMC-35171, and FMC-30980 were equally effective against *G. paripes* with LC_{90} values ranging from 0.0021-0.0026 ppm (Table 1). Among the pyrethroids tested against *G. paripes,* FMC-33297 was the least active (LC_{90}=0.0053 ppm), being 20 times less active than the most toxic pyrethroid, FMC-52703. The other 2 species, *C. decorus* and *crassicaudatus* were generally more tolerant to these pyrethroids than was *G. paripes.* However, FMC-52703 was also the most active against *C. decorus* as well as *crassicaudatus.* FMC-35171 exhibited the least activity against *C. decorus.* In general, all pyrethroids tested had a very high level of activity against the 3 midge species with LC_{90} values ranging from 0.00026-0.013 ppm.

Table 2 shows effectiveness of the 4 organophosphorous insecticides against *G. paripes, C. decorus,* and *C. crassicaudatus.* Among the 4 OPs, malathion was the most active against *G. paripes,* followed by temephos, chlorpyrifos, and fenthion. *Chironomus decorus* and *C. crassicaudatus* were generally tolerant to all 4 organo-

Table 1. Susceptibility of the 4th-instar chironomid midges to new synthetic pyrethroid insecticides in the laboratory.

	24-hr lethal concentration (ppm)					
	Glyptotendipes paripes[1]		*Chironomus decorus*[2]		*Chironomus crassicaudatus*[1]	
Pyrethroids	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
FMC-30980	0.0007	0.0021	0.0033	0.0097	0.0042	0.0098
FMC-33297	0.0024	0.0053	0.0045	0.011	—	—
FMC-35171	0.0009	0.0026	0.0065	0.013	—	—
FMC-45497	0.0007	0.0024	0.0018	0.0034	0.0012	0.0027
FMC-45499	0.00026	0.00076	0.00094	0.0026	0.0005	0.0018
FMC-52703	0.00012	0.00026	0.00067	0.0021	0.0004	0.0013

[1] Field populations drawn from Lake Monroe, Sanford, FL (1979–80).
[2] Field populations drawn from Sewage Oxidation Ponds, Utility Department, Sanford, FL (1979–80).

phosphates with LC_{90} values of the 2 species ranging between 0.1-0.48 ppm (Table 2). Generally, if the LC_{90} of OPs is greater than 0.1 ppm (24 hr exposure), the organisms exhibiting such levels of susceptibility can be considered resistant for practical control purposes because of the higher costs of treatment and the possible adverse environmental implications associated with the larger amounts of these insecticides.

The populations of *G. holoprasinus* and *Tanytarsus* spp. in the experimental ponds were highly tolerant to all 4 OPs showing the most tolerance to chlorpyrifos (LC_{90}=1.2 and 2.4 ppm, respectively) (Table 3). Malathion, fenthion, and temephos showed marginal activity against *Tanytarsus* spp. In contrast, the 2 midge groups were very highly susceptible to the test pyrethroids with FMC-52703 being the most toxic to both groups; the LC_{90} of this compound against *G. holoprasinus* was as low as 0.0004 ppm and that against *Tanytarsus* spp. was 0.000019 ppm. *Tanytarsus* spp. were 21-57 times more susceptible to FMC-52703, FMC-45497, and FMC-35171 than *G. holoprasinus.*

No previous laboratory data on the susceptibility of pestiferous chironomids of Florida, such as *G. paripes, C. crassicaudatus,* and *decorus* to OP insecticides are available. However, in field studies, it had been reported that fenthion (1%G) at 0.22-0.28 kg AI/ha, and 1%G of temephos applied at 0.06 kg AI/ha to some small central Florida lakes in Winter

Table 2. Susceptibility of 4th-instar chironomid midges to organophosphorous insecticides in the laboratory.

	24-hr lethal concentration (ppm)					
	Glyptotendipes paripes[1]		*Chironomus decorus*[2]		*Chironomus crassicaudatus*[1]	
Organophosphates	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Chlorpyrifos	0.012	0.049	0.045	0.3	0.052	0.14
Temephos	0.01	0.022	0.024	0.1	0.065	0.19
Fenthion	0.011	0.052	0.12	0.38	0.16	0.48
Malathion	0.004	0.0079	0.032	0.12	0.056	0.16

[1] Field populations drawn from Lake Monroe, Sanford, FL (1979–80).
[2] Field populations drawn from Sewage Oxidation Ponds, Utility Department, Sanford, FL (1979–80).

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

	24-hr lethal concentration (ppm)			
	Goeldichironomus holoprasinus		*Tanytarsus* spp.	
Insecticides	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Chlorpyrifos	0.38	1.2	0.6	2.4
Temephos	0.08	0.2	0.029	0.08
Fenthion	0.14	0.42	0.021	0.05
Malathion	0.028	0.11	0.032	0.09
FMC-30980	0.0005	0.0012	—	—
FMC-33297	0.0014	0.0031	—	—
FMC-35171	0.0008	0.0018	0.000033	0.000075
FMC-45497	0.0006	0.0012	0.000012	0.000021
FMC-45499	0.00025	0.00059	—	—
FMC-52703	0.00019	0.0004	0.000009	0.000019

[1] Field populations drawn from the experimental ponds, Aquatic Research Facility, University of Florida's Agricultural Research and Education Center, Sanford, FL (1979–80).

Haven provided satisfactory control of the principal pest, *G. paripes* (Patterson and Wilson 1966). In the same area, low volume aerial sprays of malathion at 0.14-0.27 kg AI/ha were very effective in controlling adult *G. paripes* (Patterson et al. 1966). The present study indicates that among the species studied, *G. paripes* is the most susceptible to the OPs, such as temephos, fenthion, and malathion. These organophosphates, particularly malathion, applied as larvicides at rates ranging from 0.25-0.5 kg AI/ha would be effective in controlling *G. paripes* in <2 m deep lakes, but in lakes deeper than 2 m, higher rates of these OPs would have to be employed for achieving the desired lethal level (in ppm) of the insecticide to obtain satisfactory midge control. The other species, *G. holoprasinus, C. decorus,* and *crassicaudatus,* however, would not be controlled by these OPs at practical and economical rates of application.

The synthetic pyrethroids studied here were extremely toxic to almost all midge species. One of these compounds, FMC-52703, was several hundred times more potent than the most active organophosphate. The present findings are in complete agreement with previous studies of Ali and Mulla (1978, 1980), and Ali et al. (1978) where some of these pyrethroids had shown a very high level of activity against several pest midges of California. These pyrethroids thus offer a good potential as substitute larvicides for the OP resistant midges. However, it should be pointed out that some of these pyrethroids at appropriate rates may have severe adverse effects on aquatic nontarget invertebrates and fish (Mulla et al. 1978a,b). Therefore, these compounds would be useful only in certain midge habitats, such as storm drains and sewage oxidation ponds where environmental concerns resulting from such insecticides would be minimal.

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EFFECTS OF SALINITY ON *ANOPHELES ALBIMANUS* OVIPOSITIONAL BEHAVIOR, IMMATURE DEVELOPMENT, AND POPULATION DYNAMICS

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ABSTRACT. Laboratory tests showed that 2 strains of *Anopheles albimanus* Wiedemann. when given a choice of oviposition medium of 0, 25, 50, or 100% sea water, laid ca. 40% of their eggs in fresh water, but laid ca. 10% in pure sea water. Subsequent laboratory rearing showed that higher salt content of the rearing medium definitely reduced the development and survival of both strains in the immature stages, but 1 strain produced pupae in water with as high as 15.075 parts per thousand (ppt) salt. The salinity of the medium did not significantly affect percentage emergence in either strain of those insects that reached the pupal stage. Since high salinity affects larval development in the laboratory, we could expect the same to be true in estuarine habitats. However, field observations suggest that breeding in brackish water probably is associated with the presence of favorable breeding sites in areas with much vegetation, rather than with the reduced salinity of the water.

INTRODUCTION

Many species of mosquito are capable of larval development in salt water, and several species prefer oviposition sites that contain relatively high levels of salt (Wallis 1955). In general, these species inhabit estuaries or salt marshes near sea coasts, salt lakes, or other inland bodies of salt water. Other species, such as *Anopheles albimanus* Wiedemann, typically are fresh water breeders, but can tolerate various levels of salt (Nicolson 1972), and thus can be found in salty or brackish water. *An. albimanus* is the primary vector of malaria in El Salvador, Central America, and high populations of this species occur there, especially along the Pacific coastal plain. The larval habitat of *An. albimanus* is extremely varied, but generally it is fresh water, e.g., river pools separated from the main river current, within river currents where vegetation is present, flooded fields, marshes, or in irrigation or

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