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Toxicity of Selected Insecticides (Thiodan®, Security®, Spartan®, and Sevin®) to Mosquitofish, *Gambusia affinis*

Syed M. Naqvi and Reanold Hawkins

Department of Biological Sciences & Health Research Center, Southern University, Baton Rouge, Louisiana 70813, USA

Adverse effects of several pesticides on non-target species have been investigated extensively using commercial fish as bioassay organisms, generally due to their unequivocal economic importance for humans. However, the role of non-commercial fish in a balanced aquatic ecosystem can hardly be over-emphasized.

Thiodan^{R} is a broad-spectrum cyclodiene insecticide used in Louisiana @ 0.68 kg 50% wettable powder/378.8 L of water(Louisiana Coop. Ext. Service, 1986). Its water solubility is 60-160 ug/L, but is very soluble in organic solvents. Rao and Murty (1980), Pyriamvada et al. (1981), and Rao et al. (1981) have reported toxicities of technical grade endosulfan to fish, Anabas testudineus, Channa punctata and Labeo rohita, respectively.

Security^{R} is a 56.1% formulation of malathion used in Louisiana for controlling cutworms, springtails, fungus gnats, aphids, mealybugs, leaf miners, thrips and cabbage loopers. Its application rate is 0.2 kg/ 0.4 hectare or 0.95 L 57% EC/378 L of water. The water solubility is 145 mg/L (Matsumura, 1975). It possesses a short life in mud and soil particulates (Tagatz et al. 1974).

Spartan^{R} is a synthetic pyrethroid (47% active ingredient and 53% xylene). The active ingredient is 3-phenoxybenzyl (±) cistrans 3-)2,2-dichlorovinyl)-2, dimethylcyclopropane carboxylate, which is very similar chemically to the active ingredient of Ambush^{R} and Pounce^{R} insecticides. They are recommended to be used in Louisiana @ 56.7g - 181.4g/189.4L water/0.4 hectare. (Louisiana Coop. Ext. Service, 1986).

Sevin^{R} is a carbamate insecticide containing 5% carbaryl (1-naphthyl N-methyl carbamate) and 95% inert

Correspondence author: Dr. Syed Naqvi, above address.

ingredients by weight. It is widely used in Louisiana for insects affecting ornamental and flowering plants, home vegetables, rice and a variety of fruit trees @ 0.9 kg wettable powder/378.8 L water.

The purpose of this study was to assess acute toxicity effects of the above-mentioned insecticides to non-commercial mosquitofish, Gambusia affinis. These fish are extremely abundant in lentic waters, particularly in the Southeastern United States. Their importance in the food-web of aquatic ecosystems is unquestionable. The insecticides chosen for toxicity assessment are also commonly used in the state of Louisiana, as well as in other states of this country.

MATERIALS AND METHODS

Thiodan® 3EC was obtained from FMC Corp., Midford, N.Y. Security® and Sevin-5 Ortho Dust were purchased from a local retailer. Spartan® 3.2 EC was obtained from Entomology Department, Louisiana State University. Adult mosquitofish (2-2.5 cm length) were collected from a ditch located approximately 1.6 km north of Southern University campus. This ditch is perhaps relatively pesticide free due to the fact that no spraying is observed throughout the year.

Fish were acclimated for laboratory conditions in 114 L aquaria for 96 h at 20±3°C, 6.5-7.0 mg/L dissolved oxygen and 7.8 pH for 96 h prior to testing. Aged tap water was used for acclimation as well as preparing test solutions. Tap water was continually aerated in 45 L Nalgene® carboys for 14 days prior to its use. In addition to the above-mentioned parameters, water hardness was 12 mg/L $CaCO_3$/100 ml sample. Aged tap water was not dechlorinated since we have noticed least mortalities of other freshwater **animals** in our previous studies (Naqvi et al. 1985; Naqvi et al. 1987).

Test solutions were prepared by diluting serially a freshly prepared 1% aqueous solution in water, since these insecticides are mixed with water for field application. Test solutions ranged from 0.0 to 2.5 ug/L Thiodan®, 0.0 to 25 ug/L Spartan®, 0.0 to 0.5 mg/L Security®, and 0.0 to 300 mg/L Sevin®. Fish were tested in groups of 10 in 37.5 L rectangular glass aquaria containing 10 L of the test solution. Six replicates of each group were conducted for each concentration, and mortality data were pooled to obtain percentages. Preliminary range-finding tests were done in order to establish a mortality range of 0 to 100%, suitable for calculating LC_5, LC_{50} and LC_{99} values on a Radio Shack TRS-80 computer, Probit

analysis program of Finney (1971) was used for this purpose, which was written for an IBM computer, later modified and copy-righted by Tom and Sandi Sparks of Louisiana State University. Fish were fed only during acclimation period. Mortalities were recorded after 96 h, but dead fish were removed from aquaria upon sight. They were considered as dead when there was a complete lack of response to probing at the gill region.

RESULTS AND DISCUSSION

Mosquitofish had an average weight of 0.289 ± 0.031 g and length 2.76 ± 0.09 cm. Percent mortalities of treated and control mosquitofish are given in Table 1. No mortality occurred in control fish for Thiodan® and Sevin®, and only 1.7% occurred for Security® and Spartan®. Spartan® treated fish exhibited signs of toxicity by swimming near the water surface erratically. Thiodan® and Security® treated fish had a loss of equilibrium and they twitched their bodies periodically.

Table 1. Percent mortalities of mosquitofish, Gambusia affinis exposed to various concentrations of pesticides.

Insecticide Concentration	Thiodan®	Security®	Spartan®	Sevin®
0.0	0.0	1.7	1.7	0.0
0.5 ug/L	8.3			
1.0 "	31.3			
1.5 "	55.0			
2.0 "	81.6			
2.5 "	100.0			
5.0 "			11.6	
10.0 "			36.6	
15.0 "			58.3	
20.0 "			83.3	
25.0 "			100.0	
0.1 mg/L		16.6		
0.2 "		36.6		
0.3 "		65.0		
0.4 "		83.3		
0.5 "		100.0		
100.0 "				6.6
150.0 "				21.6
200.0 "				41.6
250.0 "				73.3
300.0 "				100.0

Dead fish turned bluish-grey in color and many of them were observed live nematode worms protruding from the

body-wall and anus of the fish. Hoffman (1970) has reported immature adults of Camellanus sp. to be parasitic in the alimentary canal of several fish species including G. affinis. We observed that even the maximum concentrations of insecticides which caused 100% mortality of mosquitofish failed to kill these worms. Indubitably, worms were more tolerant to insecticides than their primary host. Possibly, these compounds caused irritation which prompted these worms to protrude through the body-wall. Normally, they are known to protrude from the anus of fish (Hoffman, 1970). Since all fish were not parasitized by Camellanus sp. the impact of infestation on susceptibility of fish to various insecticides could not be assessed. However, further investigations on this subject would certainly be informative.

The comparison of toxicity data revealed that Thiodan® was the most toxic compound, followed by Spartan®, Security® and Sevin® insecticide (Tables 2 and 3). LC_5 and LC_{99} values for insecticides (Table 3) also exhibit the toxicity of these compounds in the same sequence, Sevin® being the least toxic to mosquitofish.

Table 2. LC_{50} values and 95% fiducial limits for various insecticides tested on mosquitofish, Gambusia affinis (96 h exposure).

Insecticide	LC_{50} values	Fiducial Limits (Lower)	(Upper)
Thiodan®	1.3 ug/L	1.14	1.43
Spartan®	12.0 "	10.52	13.34
Security®	0.2 mg/L	0.19	0.25
Sevin®	204.0 "	190.00	223.00

Table 3. LC_5, LC_{99} values and 95% fiducial limits for various insecticides tested on mosquitofish, Gambusia affinis (96 h exposure).

Insecticide	95% Fiducial Limits And LC_5 Values	LC_{99} Values
Thiodan®	(0.33 - 0.60)	(3.8 - 8.5)
	0.48 ug/L	5.1 ug/L
Security®	(2.70 - 5.30)	(39.1 -90.7)
	4.10 ug/L	53.1 ug/L
Spartan®	(0.04 - 0.09)	(0.8 - 2.04)
	0.07 mg/L	1.14 mg/L
Sevin®	(80.00 - 120.0)	(422.0 -821.0)
	103.00 mg/L	536.00 mg/L

Very high toxicity of Thiodan® insecticide to freshwater fish has been documented for Anabas testudineus

from India by Rao and Murty (1980), having a 96-h LC_{50} of 1.6 ug/L. Our mosquitofish had a similar tolerance to Thiodan® but were more tolerant than another edible fish in India, Labeo rohita. The LC_{50} for it is 0.33 ug/L (Rao et al. 1981). Pickering and Henderson (1966) established the 96 TL_m values for bluegills, Lepomis macrochirus and guppies, Lebistes reticulatus as 3.3 and 3.7 ug/L, respectively. Thiodan's toxicity to mosquitofish might not be as far reaching as for most other chlorinated insecticides, from an environmental point of view. This assumption is made since many other compounds have greater persistence than Thiodan® (Buchnel, 1983). Secondly, the minimum solubility of this insecticide in water would result in greater potential for bioaccumulation.

Security® (56% malathion) was found to be more toxic to mosquitofish (LC_{50} = 0.2 mg/L) than another freshwater fish, Tilapia mossambica. The LC_{50} value for this fish has been reported by Basha et al. (1983) as 0.37 mg/L malathion. Partially, this difference could be attributed to the 44% inactive ingredients as well as the genetic differences in fish species. Since malathion is medially soluble in the water (145 mg/L) as noted by Matsumura (1975), careless use of Security® or malathion containing insecticide should be avoided. However, the use of Security® insecticide might not cause long-lasting adverse effects. Tagatz et al. (1974) reported that malathion has a very short life in mud and soil. They found that malathion spraying @ 420 g/ha only left 5.2 ug/L residues in water and none in the sediment. This occurred within 24 h of spraying malathion.

The only relevant information for toxicity of Spartan® is available for a similar compound Pounce®. The reported LC_{50} values for largemouth bass and mosquitofish are 8.5 and 15.0 ug/L (Jolly et al. 1978). The toxicity of Spartan® to our mosquitofish falls within the same range as reported in the literature.

Sevin® was the least toxic insecticide to mosquitofish. However, published information on the active ingredient of Sevin® (carbaryl) shows that the a.i. itself is much more toxic than the formulated compound. Basha et al. (1983) reported the 96 h LC_{50} for Tilapia mossambica as 5.5 mg/L carbaryl. Since Sevin® dust contains only 5% carbaryl and 95% inert ingredients, the extensive difference in our LC_{50} value (103 mg/L Sevin®) and that of carbaryl could be explained. Based on our results, we feel that Sevin® insecticide might turn out to be as one of the safest broad-spectrum insecticides that could be used in the vicinity of natural

waters containing mosquitofish populations. This especially would be true if the application rate recommended by the manufacturer is strictly enforced.

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