Avoidance of Pesticides by Untrained Mosquitofish, *Gambusia affinis*[1]

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Some fish possess the capacity to avoid polluted water, (1, 2, 3, 4), but their ability to avoid pesticides has not been extensively studied. In experiments at this laboratory (5), sheepshead minnows, Cyprinodon variegatus, avoided DDT, endrin, Dursban®, and 2,4-D but did not avoid malathion or Sevin®. In this paper we report the results of similar experiments conducted to determine if mosquitofish, Gambusia affinis, could avoid these same pesticides.

Experimental Procedure

Mosquitofish, 20-45 mm total length, were taken from local fresh water ponds and ditches. Fish were acclimated for at least five days in 20°C fresh water before they were used in experiments.

The avoidance response was tested in a plastic apparatus designed to allow fish to move from a holding area into either a section which contained water without pesticide or one which contained water with pesticide (Figure 1). A gate located at the intersection of the two sections and the holding area was lowered to trap fish for counting at the conclusion of a test. Filtered and aerated tapwater maintained at 20°C entered the upper end of each of these two sections at the rate of 400 ml per minute and flowed to a drain in the holding area. Pesticides in an acetone stock solution were metered through stopcocks into the incoming water in one of the two sections. An acetone control was not used because preliminary tests showed that mosquitofish did not avoid acetone at the concentration tested (0.25%).

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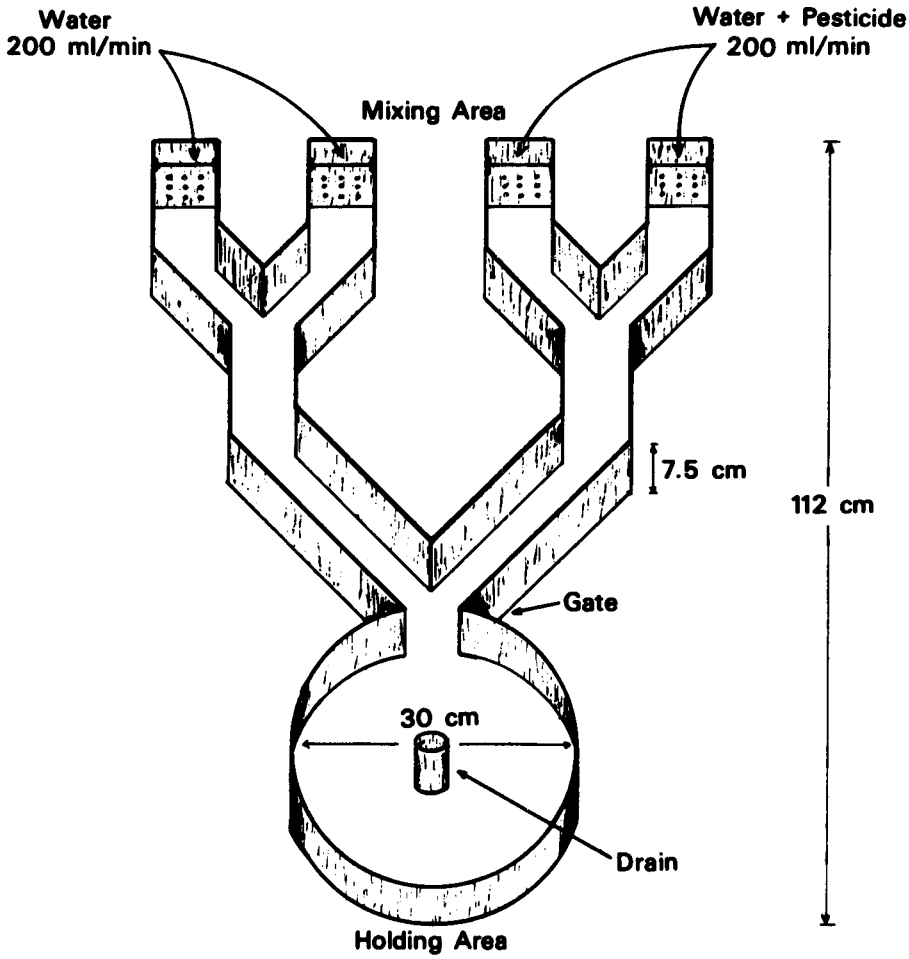

Figure 1. --Apparatus used to test the ability of mosquitofish to avoid pesticides.

One herbicide and five insecticides (two organochlorines, two organophosphates, and a carbamate) were used (Table 1). Initially three concentrations of each pesticide were used; one was higher and two were lower than the concentration that produced a 24-hour LC_{50} in static water bioassays. Concentrations were not checked by chemical analysis. When avoidance was observed, other concentrations were tested to determine the limits that elicited a response to the test fish.

TABLE I

Descriptions of chemicals tested and 24-hour LC_{50}'s for mosquitofish.

Pesticide	Type	Percentage active ingredient	24-hour LC_{50} (ppm)
DDT	Organochlorine	99	.042
Endrin	Organochlorine	97	.007
Dursban	Organophosphate	99	4.0
Malathion	Organophosphate	95	2.0
Sevin (carbaryl)	Carbamate	98	irritated at 10.0
2,4-D (butoxyethanol ester)	Herbicide	70 (acid equivalent)	7.0

This investigation was conducted in two phases. First, the ability of mosquitofish to choose between water which contained a pesticide and water free of pesticide was tested. Tests at each concentration were repeated at least four times; two with the pesticide entering one section of the apparatus and two with the pesticide entering the other section. For each test, fifty fish were placed in the holding area with the gate lowered for 1/2 hour. The gate was then raised to give the fish access to both sections. After one hour, the gate was closed and the number of fish in each section was recorded. When necessary, additional tests were conducted to increase statistical reliability of the conclusions. Fish were used only once.

Second, the capacity of fish to discriminate between concentrations avoided in the first phase was investigated by giving the fish a choice between two concentrations of the same pesticide.

Avoidance of pesticides by the fish was evaluated statistically by the chi-square test on the assumption that if the fish could not discriminate they would leave the holding area and enter each section with equal frequency. Distributions of fish in tests where avoidance was not observed substantiated this assumption; 49.7% entered one section and 50.3% entered the other. Avoidance or preference was considered significant if the probability that observed distributions would occur by chance was 0.05 or less.

TABLE 2

Capacity of mosquitofish to seek water free of pesticides.
N.S. = not significant. χ^2 = P(3.84 = 0.05; 6.63 = 0.01; 10.83 = 0.001).

Pesticide	Concentration (ppm)	Number of tests	Number of fish *		Percentage in water	χ^2 value if significant
			In water	In pesticide		
DDT	1.0	4	55	33	62.5	5.50
	0.1	8	100	70	58.8	5.29
	0.01	4	42	45	48.3	N.S.
	0.001	8	73	66	52.5	N.S.
Endrin	0.01	4	49	39	55.7	N.S.
	0.001	4	37	41	47.4	N.S.
	0.0001	4	35	44	44.3	N.S.
Dursban	10.0	4	110	8	93.2	118.00
	1.0	4	74	36	67.3	13.13
	0.1	12	142	95	59.9	9.32
	0.01	4	48	42	53.3	N.S.
Malathion	5.0	4	53	51	51.0	N.S.
	0.5	4	56	26	68.3	10.98
	0.05	12	153	120	56.0	3.99
	0.005	4	48	63	43.2	N.S.
Sevin	10.0	4	58	38	60.4	4.17
	1.0	4	48	54	47.0	N.S.
	0.1	4	47	64	42.3	N.S.
2,4-D	10.0	4	121	8	93.8	98.98
	1.0	4	69	18	79.3	29.90
	0.1	4	46	44	51.1	N.S.

* Does not include fish in the holding area.

TABLE 3

Response of mosquitofish exposed to two different concentrations of a pesticide.

N.S. = not significant. χ^2 = P(3.84 = 0.05; 6.63 = 0.01; 10.83 = 0.001).

Pesticide	Concentrations (ppm)		Number of tests	Number of fish *		Percentage in low concentration	χ^2 value if significant
	High	Low		In high conc.	In low conc.		
DDT	1.0	0.1	8	82	107	56.6	N.S.
	1.0	0.01	4	58	42	42.0	N.S.
	0.1	0.01	8	45	24	34.8	6.39
Dursban	10.0	1.0	4	12	126	91.3	94.17
	10.0	0.1	4	3	129	97.7	120.27
	10.0	0.01	4	9	127	93.4	102.38
	1.0	0.1	8	47	94	66.7	15.67
	1.0	0.01	8	22	124	84.9	71.26
	0.0	0.01	8	57	72	55.8	N.S.
Malathion	0.5	0.05	4	45	43	48.9	N.S.
	0.5	0.005	4	39	40	50.6	N.S.
	0.05	0.005	4	52	40	43.5	N.S.
Sevin	10.0	1.0	4	19	20	51.3	N.S.
2,4-D	10.0	1.0	4	11	134	92.4	104.34
	10.0	0.1	4	7	87	92.6	68.08
	1.0	0.1	4	39	37	48.7	N.S.

* Does not include fish in the holding area.

Results

Mosquitofish avoided one or more concentrations of DDT, Dursban, malathion, Sevin, and 2,4-D, but did not avoid endrin (Table 2). Except for DDT, the concentrations of each pesticide avoided were less than the 24-hour LC_{50}. Other than 10 ppm 2,4-D and 10.0 and 1.0 ppm Dursban, those concentrations avoided were avoided by less than 70% of the fish. Thus, the capacity of mosquitofish to seek water free of pesticide, while real, was usually not pronounced.

Mosquitofish given the choice between two concentrations of the same pesticide either did not discriminate between them or avoided or preferred the higher concentration (Table 3). These fish avoided 10.0 ppm 2,4-D and 10.0 and 1.0 ppm Dursban by seeking the lower concentration. When given a choice between 0.1 and 0.01 ppm DDT mosquitofish selected the higher concentration. Preference for the higher concentration of DDT, while unexpected, was also observed in similar experiments using sheepshead minnows (5). Mosquitofish did not discriminate between any of the tested concentrations of malathion or Sevin, nor between the other tested concentrations of DDT, Dursban, or 2,4-D.

Our studies indicate that fish can avoid some pesticides in laboratory experiments but do not prove that fish in nature would take advantage of this capacity. Sprague and Drury (3) found in laboratory tests that Atlantic salmon spent about 90% of the time in clean water when given a choice between clean water and concentrations of copper and zinc avoided in streams. This percentage avoidance was noted in our study with 10 ppm Dursban and with 10 ppm 2,4-D, a pesticide which repelled fish after a field application (6). Mosquitofish also discriminated between concentrations of these pesticides and probably could follow concentration gradients to water free of high concentrations of these chemicals in nature. We conclude that while five of six pesticides tested were avoided by mosquitofish, Dursban and 2,4-D would be most likely to produce an avoidance response in populations of these fish in the field.

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