Investigations into the Acute Toxicity And Some Chronic Effects of Selected Herbicides And Pesticides on Several Fresh Water Fish Species

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INTRODUCTION - Many chemical pesticides and herbicides have been introduced into the environment since the advent of DDT. Research has later shown that the first generation reagents had many undesirable side effects that could be traced to exposure to sub-lethal residues as well as to misuse of the reagents.

A second generation of reagents has been developed which are generally more specific and shorter lived. These reagents are now being introduced into the environment.

Two of these reagents are the herbicides 2,4,dichlorophenoxy acetic acid (2,4,D) and 2,4,5,trichlorophenoxy acetic acid (2,4,5,T). This work deals with an attempt to evaluate some possible effects of these reagents. For comparison, 2,4,D and 2,4,5,T are evaluated with aldrin, malathion and methyl parathion.

METHODS AND MATERIALS - Fish specimen - Hudson River fish specimen were captured using a shore seining technique. The guppies were obtained locally from a pet store. The bioassay tanks were maintained as described previously (REHWOLDT et al. 1972).

Reagents - All reagents, with the exception of 2,4,5,T were obtained from Analabs, Inc. in 1000 ppm solutions and were not purified. The 2,4,5,T was purchased from Eastman Chemical Co. and was recrystallized from ethanol-water.

Analytical methods - Phosphate concentrations were determined using an ion selective electrode and acetylcholinesterase brain levels were determined colorimetrically using the HESTRIN(1949)method. Other pesticide levels were monitored with standard techniques. Water quality was maintained as described in Table I.

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TABLE I

Water Quality Characteristics

Temperature 20°C. D.O. 6.0 mg/l
pH 7.2 Hardness as $CaCO_3$ 50 mg/l

Toxicity Studies - The results from the Tl_m experimentation can be found in Table II. As expected, toxicity varies with fish species. In all species, however, 2,4,D and 2,4,5,T were the least toxic. It is important to note that the 2,4,5,T was recrystallized before use, thus eliminating the possible quinone contaminations.

TABLE II

Species	Reagent	Tl_m^* 24 hr.	Tl_m 48 hr.	Tl_m 96 hr.
striped bass	Aldrin	0.020	0.011	0.010
(Marone	2,4,D	85.6	70.2	70.1
saxatilis	2,4,5,T	27.3	22.1	14.6
	malathion	0.091	0.070	0.039
	methyl parathion	16.8	14.2	14.0
banded killy-fish	Aldrin	0.049	0.040	0.021
	2,4,D	306.2	261.1	26.7
(Fundulus	2,4,5,T	69.9	32.7	17.4
diaphanus)	malathion	0.38	0.29	0.24
	methyl parathion	24.9	18.6	15.2
pumpkinseed	Aldrin	0.21	0.09	0.02
	2,4,D	120.0	118.3	94.6
	2,4,5,T	46.3	31.1	20.0
	malathion	0.92	0.60	0.48
	methyl parathion	4.9	3.6	3.6
white perch	Aldrin	0.10	0.091	0.042
(Roccus	2,4,D	55.5	48.2	40.0
americanus)	2,4,5,T	36.9	21.2	16.4
	malathion	2.1	1.9	1.1
	methyl parathion	22.4	18.6	14.0
American eel	Aldrin	0.072	0.058	0.016
(Anguilla	2,4,D	427.2	390.2	300.6
rostrata	2,4,5,T	73.2	61.1	43.7
	malathion	1.6	0.71	0.50
	methyl parathion	42.6	37.2	6.3

carp (Cyprinus carpio)	aldrin	0.19	0.10	0.004
	2,4,D	175.2	100.2	96.5
	2,4,5,T	70.6	57.3	41.1
	malathion	2.6	2.1	1.9
	methyl parathion	27.6	21.2	14.8
guppy (Libistes reticulatus)	Aldrin	0.12	0.08	0.02
	2,4,D	76.7	81.2	70.7
	2,4,5,T	43.1	29.2	28.1
	malathion	2.2	1.8	1.2
	methyl parathion	12.2	9.4	6.2

*Concentrations expressed in mg/l

Chronic Exposure Studies - long term, 10 month, exposure studies were performed with malathion, methyl parathion, 2,4,D and 2,4,5,T. Fish were subjected separately to aquaria concentrations of 0.1 ppm 2,4,D and 2,4,5,T, and methyl parathion. A concentration of 0.01 ppm was chosen for malathion because of its increased toxicity.

Fish captured from the Hudson were young of the year. This was a conscious decision in that using young fish usually precludes any breeding but does allow one to study the early, and perhaps most rapid, growth stages. The difficulties in breeding the native fish, with the exception of Fundulus were considered insurmountable.

RESULTS AND DISCUSSION - Chronic exposure to 2,4,D or 2,4,5,T resulted in no observable physiological symptoms. No histological work-up was performed, however, therefore it is not possible to eliminate neural damage which has been associated with chronic exposure to other chlorinated hydrocarbons (ANDERSON 1968).

Chronic exposure to chlorinated hydrocarbons such as aldrin have also been shown to generate a raising of the toxic level in certain fish (FERGUSON 1964). This was not observed with either 2,4,D or 2,4,5,T. Tl_m values were not significantly different after exposure to sub-lethal amounts of these reagents. There were no substantial differences in weight/time relationships between the exposed fish and the control fish.

It was possible, however, to conduct breeding experiments with the guppy. Table III contains a comparison of these results. All data is based upon four females and an excess of males. Data is expressed as ratio of experimental offspring to control offspring.

TABLE III

Reagent	Ratio using control as 1
Control	1
2,4,D	1.2
2,4,5,T	0.9
malathion	0.8
methyl parathion	1.3

Chronic exposure to the organic phosphorous pesticides did not cause any noticeable overt physiological effects with the Hudson River fish. However, after months of exposure the fish were sacrificed and brain acetylcholinesterase levels were measured. Acetylcholinesterase levels have long been associated with exposure to organic phosphorous (HOLLAND et al. 1967). The results can be seen in Table IV.

TABLE IV

Fish	% Reduction
banded killyfish	27
striped bass	21
white perch	16
American eel	35
pumpkinseed	28
carp	31

All fish experienced substantial reductions in acetylcholinesterase levels. Reductions up to 40% with no apparent effects in normal functioning have been observed before (WILLIAMS & SOVA (1966). It is planned to carry out 2nd generation breeding studies with the chronically exposed guppies.

Chronic studies also indicated that these reagents do not have any noticeable physiological effect upon the young fish tested. It should also be noted that the exposure levels for the chronic studies were far in excess of those levels in run-off or in surface waters.

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