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The Effect of some Selected Pesticides on the Growth and Reproduction of Fresh Water *Oreochromis niloticus*, *Chrysicthys nigrodigitatus* and *Clarias gariepinus*

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Abstract Studies were carried out to determine the toxicity of some selected pesticides on fresh water fish in a tropical environment. The uptake of the pesticides lindane, pentachlorophenol (PCP), and propoxur, which are frequently used on farms, and in industries as well as by loggers and timber men on wood were studied in concrete ponds at the University of Cape Coast, in Ghana. The fish used for the study were *Oreochromis niloticus*, *Clarias gariepinus*, and *Chrysicthys nigrodigitatus*. They were obtained from cultured ponds in the Cape Coast and Mankessim districts in the Central Region and Weija Dam, in the Greater Accra region of Ghana. Single high lethal concentration (SD) or acute treatment and cumulative/chronic (or multiple minor) lethal concentration (CD) treatment were employed in administering the pesticides to the fish via water. Gas chromatograph electron capture detector analysis was done on the dead fish to see the extent of ingestion. The LC_{50} values obtained for lindane on the three fish samples were as follows: Chrysicthys – 0.38 mg L^{-1}; Oreochromis – 0.42 mg L^{-1}, and Clarias – 1.2 mg L^{-1}. Mortalities occurred in fish within 3–5 days of application. For the PCP on Chrysicthys, Oreochromis, and Clarias species the LC_{50} values were 0.42, 0.32 and 0.64 mg L^{-1}, respectively, for over a 2- to 3-day period. For a three-time influx period of propoxur the LC_{50} for Chrysicthys, Oreochromis, and Clarias, were 22.0, 30.40, and 45.04 (all in mg L^{-1}), respectively. The results obtained indicated that the pesticides had adverse effects on the general growth and reproduction of fish as shown by gonadosomatic indices.

Keywords *Oreochromis niloticus* · *Chrysicthys nigrodigitatus* · *Clarias gariepinus* · Lindane pentachlorophenol · Propoxur and Mankessim

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Pesticides, though useful have been found to cause havoc long after they have been applied to intended targets (Morley and Dyer 1985). The San Francisco Bay Estuary Institute tested contamination levels in seven species of fish and found out that all showed levels that could be considered hazardous to human health (Davies 1999). A few women and babies tested for traces of pesticide residues also proved positive.

Shellfish have also been found to contain lindane at the level of 2.5 mg/kg on a fat basis. Other studies have found that developing vertebrate embryo is sensitive to the effects of chemical pollutants and that cardiovascular defects are particularly common in such vertebrates (Mizell et al. 1996). The effects of the highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxinn (TCCD) have been described in several fish species. They include pericardial edema, yolk sac edema, menigial edema, hemorrhage and retarded or congested blood flow often culminating in death (Mizell et. al. 1995; Stanier and Fishman 1994).

Some pesticide pollution has also occurred in fresh waters. Here, levels in the region of one part per billion, arising from effluents of factories and sand run-off from farmlands have caused fish kills and death to many invertebrate animals. This is because the animals breathe the oxygen dissolved in water and at the same time adsorb into their bodies the pesticide contained in the enormous volume of water passing over their gills (Stanier and Fishman 1994).

Whereas there is abundant documented data on pesticide residues, knowledge of pesticide residues and their effects is rarely available in many developing countries. Thus, there is a need to generate sufficient data for the tropics of the effects of pesticides on target and non-target organisms. The selected freshwater fish species are favourite sources of protein in most Ghanaian homes. The principal objective of this research has been to generate comprehensive data on how pesticides affect freshwater fish. Pesticides residue extracts were analysed by G.C. to determine threshold, and incipient concentrations of the applied pesticides – viz lindane, pentachlorophenol (PCP) and propoxur. Of particular interest were the effects of the named pesticides on general body development and development of the gonads, with respect to body size.

Materials and Methods

All reagents used in the analysis were of analytical grade from B.D.H of UK Standard analytical instrument including TOA CM-40V electrical conductivity meter, a Twin pH meter and dissolved oxygen meter were used.

Juvenile fish for the experiment were obtained from artificial ponds and natural waters around the central region of Ghana. Fish were kept in holding tanks for periods of 2 months to eliminate all transport induced stress and mortalities.

The experiment was in two parts. In the first experiment, large doses of pesticides were administered at once into test ponds containing fish until a concentration at which about 50% of the population under study died. Observations of behaviour of fish and effects of pesticides were observed with all pesticide administrations. Thus the experiment was termed the acute or single dose (SD) experiment. In the second experiment, water containing test fish were spiked with minimal amounts of pesticides over a period of 2 months on alternate days. This was termed the chronic or cumulative dose (CD) set up.

In the acute or single dose experiment there were three replica ponds all containing effective volumes of 30 L each. There were three sets of such ponds for the three different pesticides and three types of freshwater fish under investigation. Control ponds were also attached to each set of replica ponds. One set of three ponds was spiked with 4.8 mg of lindane each. In another set of three, ponds were spiked with 3.75 mg of PCP each. A last set of three replica ponds were each spiked with 83.25 mg of propoxur. These amounts of pesticides were all administered at a go in each of the respective ponds and their effects on the fish observed at hourly intervals. The experiment was replicated. The fish tolerated the pesticides for close to 6 months while the intended 50% mortalities were not observed. Higher doses were then administered till doses, which gave close to 50% mortalities were obtained. These higher doses were 9.00 mg of lindane, 5.50 mg of PCP and 115.00 mg of propoxur, all per 30 L of water. Each of these 30 L ponds contained 30 fishes. In all cases pesticides were administered directly into test ponds.

In the chronic/cumulative experiments to determine toxicity, increasing amounts of pesticides were administered intermittently. Every fourth day, amount of 0.0355 mg of lindane, 0.0345 mg of PCP and 0.0.8889 mg of propoxur were administered into respective 1,110 L ponds with effective volumes of 1,000 L of water each. After every second application of a dose the amount was increased for two subsequent applications in each of the respective ponds as indicated below in Table 1.

The rates of fish mortalities were analysed statistically using a one-way variance to determine LC_{50} values. Gas chromatographic analysis of pesticide extracts from fish also gave comparative LC_{50} values. Also, the gonads of pesticide fish were weighed and compared to body weights of fish so as to obtain gonadosomatic index (G.S.I.) values. Water parameters were also studied for the experimental ponds.

Results and Discussion

The results indicated that high doses of pesticides had adverse effects on fish, particularly if it was an instant high

Table 1 Data on cumulative application of pesticides

Day of application	Specific doses administered (g)			Cumulative doses (g)		
	Lindane	PCP	Propoxur	Lindane	PCP	Propoxur
1	0.036	0.035	0.89	0.006	0.036	0.889
5	0.036	0.035	0.89	0.071	0.071	1.777
9	0.071	0.069	1.78	0.142	0.140	3.555
13	0.071	0.069	1.78	0.213	0.209	5.332
17	0.107	0.104	2.67	0.320	0.313	7.998
21	0.107	0.104	2.67	0.427	0.417	10.66
25	0.107	0.104	2.67	0.533	0.520	13.33
29	0.107	0.104	2.67	0.675	0.660	16.88
33	0.142	0.140	3.56	0.817	0.800	20.44
37	0.142	0.140	3.56	0.995	0.973	24.88
41	0.178	0.173	4.44	1.173	1.145	29.33
45	0.178	0.173	4.44	1.351	1.318	33.77
49	0.178	0.173	4.44	1.528	1.491	38.21
53	0.213	0.207	5.33	1.742	1.698	43.54
57	0.213	0.207	5.33	1.955	1.905	48.86
61	0.213	0.207	5.33	2.168	2.112	54.207

dose. The accumulation of pesticides by fish depended on type of fish, type of pesticide administered and relative potency of the pesticide. Regression analyses of the data on mortalities showed that both the concentration and the time of exposure were significant criteria ($p < 0.05$). Gonadosomatic index analyses showed frequency of probability (F.Pr) or p values of less than 0.05 for the varieties body weight, gonad weight and G.S.I. for all contaminated fish.

G.S.I. = gonad weight × 100 (Asabere-Ameyaw 2001).

Body Weight of Fish

Obtained data on G.S.I. studies indicated that female fish were more affected. The female fish as compared to male of the same species had relatively lower G.S.I. values. As observed by Pastor et al (1988) the uptake of trichlorophenol (T.C.P.) by female guppies was greater than that of the males. However, males eliminated TCP more effectively than that of the females (Pastor et al. 1988).

A one-way analysis of variance for controlling normal fish against pesticide fish gave significant F.Pr values of less than 0.05. Body weight, gonad weight and G.S.I values of pesticide-affected fish were in all cases lower than those of the control (or normal) fish. The standard deviations of the result gave lindane to be 5.00 and (F.Pr) 0.001, PCP was 0.80 and (F.Pr) 0.50, respectively, while that for propoxur was 0.67 and (F.Pr) 0.63, respectively. This is shown in Table 2.

Fish in the lindane-treated ponds were smaller in size as compared to those in the P.C.P. and propoxur treated ponds. Fish in propoxur-treated ponds were least affected in body weight. In terms of gonad weight, the trends were predictive. Fish in lindane ponds had the least weight while fish in propoxur ponds had the largest weight. In all cases, they were lower than comparative varieties for normal control fish. The G.S.I. values followed the same trend. Analysis of variance for female fish and male fish only showed that pesticide males and females in pesticide ponds developed poorly as compared to fish in control ponds. The F.Pr values were less than 0.10, in some case <0.001.

Analysis of the G.S.I results of male and female fish exposed to the pesticides were very significant for the females as compared to the males (F.Pr 0.001).

Table 2 Mean body weight, mean gonad weight and mean G.S.I obtained in the study

Variate	Normal fish (control)	Lindane fish	P.C.P. fish	Propoxur fish
Mean body weight	27.46	18.45	22.64	28.00
Mean gonad weight	0.80	0.32	0.43	0.45
Mean G.S.I.	2.70	1.61	1.71	1.58

Table 3 Data on LC_{50} values obtained for the specified pesticides and fish sample

Pesticide	Fish sample and sex	Procedure employed	LC_{50} (mg/L)
Lindane	Clarias – M	CD	1.10
	Clarias – F	CD	1.30
	Clarias – M	SD	0.92
	Clarias – F	SD	0.93
	Tilapia – M	CD	0.42
	Tilapia – F	CD	0.43
	Tilapia – M	SD	0.34
	Tilapia – F	SD	0.34
	Chrysicthys – M	CD	0.38
	Chrysicthys – F	CD	0.39
	Chrysicthys – M	SD	0.27
	Chrysicthys – F	SD	0.28
PCP	Clarias – M	CD	0.64
	Clarias – F	CD	0.64
	Clarias – M	SD	0.68
	Clarias – F	SD	0.70
	Tilapia – M	CD	0.32
	Tilapia – F	CD	0.33
	Tilapia – M	SD	0.28
	Tilapia – F	SD	0.29
	Chrysicthys – M	CD	0.40
	Chrysicthys – F	CD	0.43
	Chrysicthys – M	SD	0.35
	Chrysicthys – F	SD	0.36
Propoxur	Clarias – M	CD	45.45
	Clarias – F	CD	45.55
	Clarias – M	SD	40.00
	Clarias – F	SD	42.85
	Tilapia – M	CD	29.00
	Tilapia – F	CD	29.12
	Tilapia – M	SD	28.15
	Tilapia – F	SD	28.36
	Chrysicthys – M	CD	22.11
	Chrysicthys – F	CD	22.70
	Chrysicthys – M	SD	21.05
	Chrysicthys – F	SD	21.32

SD single dose experiment, *CD* cumulative dose experiment, *M* male fish, *F* female fish

A comparative analysis of LC_{50} values, which indicate the amount of pesticides taken in by the different fish species is shown in Table 3.

These results confirm the observation made by Pastor et al. (1988) in their study of uptake and elimination of TCP by guppies' (Pastor et al. 1988). The result yet indicates another finding. It indicates that, sudden and heavy flushes of pesticide could cause fish kills in water bodies as was observed in cases of single large dose treatments. Though fish in the SD experiment stayed for between a few hours and a few days, they could not tolerate the high concentrations of the pesticides administered, unlike the fish in the CD experiment that learned to tolerate the pesticides even beyond such time that a full dose was administered. The results also proved that PCP was the most potent pesticide among the three pesticides even when administered at comparatively low concentrations as high mortalities were recorded for all fish samples analysed (Weinbach 1957).

The toxic action of PCP is believed to be the result of its ability to uncouple the oxidative phosphorylation enzyme system. The risk of a toxic effect due to PCP exposure is more pronounced at high ambient temperatures (American Conference of Government Industrial Hygienists 1980).

The results from this study suggest that lindane, PCP and propoxur be declared persistent, bio accumulative and toxic chemicals in the tropics, especially, Ghana. These pesticides were found in fish even 1 month after the administration of pesticides had ceased as indicated in the cumulative studies data. According to Nellor (1999) lindane has already been banned in eight countries in the developed countries, including Sweden and New Zealand. It would be wise to ban it in Ghana and other parts of the world due to its high persistent effect. Its ban would go a long way to ensure a healthier and safer environment for man and other living things, especially aquatic organism.

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