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Pesticide Induced Physiological and Behavioural Changes in an Estuarine Teleost *Therapon jarbua* (Forsk)

T. LINGARAJA and V. K. VENUGOPALAN
Centre of Advanced Study and Research in Marine Biology, Porto Novo-608 502

Static bioassays were conducted with pesticides like PP′-DDT, Dimethoate (Rogor)* and Carbaryl (Sevin) to determine the median lethal concentrations (LC_{50}) on an estuarine teleost *Therapon jarbua* (Forsk). The respiration rates of fishes exposed to pesticides, as well as those of controls were determined. Respiration abnormalities were noticed in treated fishes. The metabolic rates are generally higher in treated fishes than in the controls. The behaviour of fishes exposed to LC_{25} (96h) concentrations of pesticides is discussed. Estuarine fishes appear to be more sensitive and susceptible to pesticides than fresh water fishes. The pesticides affect the locomotory and swimming behaviour of fishes. Loss in weight of fishes exposed to LC_{50} (96 h) concentration of pesticides was also estimated. The present report gives a comprehensive account of the toxic nature of these pesticides to fishes.

During the past two decades there has been a great increase in the manufacture and utilization of pesticides to protect agricultural crops. These pesticides applied in the fields, reach estuarine ecosystem during run off. Pesticide toxicants may induce changes in behaviour and physiology of organisms which may lead to ecological crisis. Hence it was felt to study in detail such induced changes. Studies on bioassays and effect of pesticides on organisms are basically important to find out the toxic nature of the pesticides and changes occurring in treated organisms. Static bioassays with pesticides on estuarine and fresh water fishes were conducted by Sreenivasan & Swaminathan (1967), Mathur (1969), Eisler (1970), Bhatia (1971), Verma *et al.* (1974 a, b) and Rao (1974) assess and compare the toxic nature of different pesticides. The respiration abnormalities induced in fishes due to exposure to lethal concentration of pesticides were studied by Waiwood & Johansen (1974) and Peer Mohamed (1975). The behavioural responses of fishes exposed to lethal concentration of pollutants were studied by Mathur (1969), Bull (1974) and Verma *et al.* (1974 a, b). In the present study representative pesticides from each category, namely, organochlorine-DDT, organophosphorus-Dimethoate, and organocarbamate-Carbaryl, were selected and their effects on *Therapon jarbua* were observed.

*Reference to trade names does not imply endorsement by CASRMB, Porto Novo

Materials and Methods

The fishes were collected from the Vellar estuary (11°29′N—79°49′E) at Porto Novo, adjacent to the Biological Station, using cast net. Fishes were acclimatized in the laboratory for one week and were fed with juvenile prawns collected from the estuary. Feeding was stopped two days before the commencement of the experiments. The length and weight of the fishes varied from 6.9-9.2 cm and 6.5-13.1g respectively (6–9 months old groups). pp′–DDT;1,1,1, trichloro, 2,2, bis (p-chlorophenyl) ethane, dimethoate; 0,0, dimethyl, S (N-methyl-carbomoyl) methyl phosphorodithioate and carbaryl; 1, naphthyl, N-methyl carbamate were supplied by M/s Hindustan Insecticide Ltd., New Delhi; Rallis India Ltd., Thana and Union Carbide India Ltd., Bhopal, respectively. The carrier solvents used were acetone, ethyl alcohol and methyl alcohol for DDT, dimethoate and carbaryl respectively.

When there was little agricultural activity, the estuarine water was pumped and stored in the adjacent aquarium reservoir.

It was assumed that pesticide concentration in this water was negligible in quantity. More over the estuarine water used in these experiments, was filtered with Whatman No. 1 filter paper to remove particulate matter and to avoid absorption of added pesticides. The pH of the water was measured with an Elico pH meter. The oxygen content and salinity were estimated according to the methods given by Strickland and Parsons (1968). In all these experiments the temperature of the water was maintained at 29 ± 1.0°C.

Static bioassays were conducted in aquarium glass tanks of size 90 x 90 x 90 cm. 200 litres of water were taken in a tank and 10 animals were released into each tank. The animals were not fed during the period of experiments. They were always handled with a scoop net to minimise disturbance. Required concentrations of the toxicants were added from the stock solutions, preserved in a refrigerator. The volume of solvent added did not exceed 0.1 ml in the case of acetone and 0.5 ml in the case of ethyl and methyl alcohols. Practically no mortality of fishes occurred at the volume of solvents added. Periodic observations were made to note the behaviour of the fishes. Dead fishes were removed immediately from bioassay tanks. The resultant data were plotted on log-probit charts supplied by Codex Book Co., Norwood, Mass - 02062, U. S. A. and the LC_{50} values were computed as recommended by Litchfield & Wilcoxon (1949).

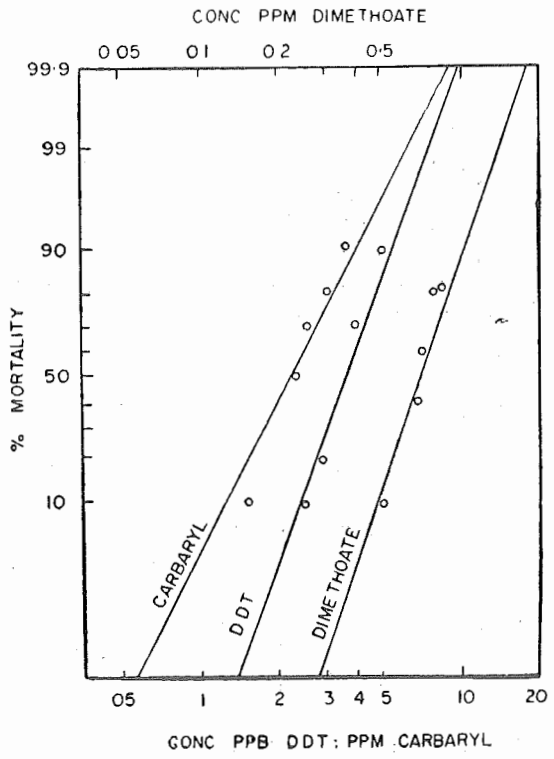

Fig. 1. *Toxicity curves of the pesticides-Log-probit analysis*

The continuous flow method suggested by Welsh & Smith (1949) was followed to estimate the rate of oxygen uptake of fishes. One animal was used in each experiment and a set of four such experiments were conducted. Oxygen consumption was estimated for 8 hours continuously for both control and pesticide treated fishes. Similarly groups of fishes were subjected to 96 hours in LC_{25} (96 h) concentration of the selected pesticides and then transferred to clean medium and oxygen consumption was studied. The volume of carrier solvents added in respiration studies also did not exceed 0.1 ml. It was ascertained that no change in oxygen consumption was induced at the level of solvents added.

Results and Discussion

Immediately on exposure to the pesticides, the fishes started to swim actively. The fishes released to the toxic medium were found to be in a state of excitement and the opercular movements increased rapidly. Freshly collected fishes, if exposed to pesticide medium vomited all the food taken. They excreted more rapidly in contaminated medium than in uncontaminated medium, suggesting that the digestive processes are affected. After a short period of exposure in lethal concentrations of these pesticides the fish lost its active swimming habit. More mucus was secreted in order to reduce the irritating effect of the pesticides. Nearly at LC_{50} concentration on the fourth day the animal lost its sense of touch and locomotion and preferred to lie at the bottom. Prior to death, the animal swam fastly and dashed against the sides of the tank and died.

Compression in the lateral muscles of the treated fishes was noticed, which probably lead to vertebral deformities. Gill inflammation was noticed after a short period of treatment. In lethal concentra-

tions, the animals did not feed even if food was available. The animal lost balance before death and avoided coming to surface as a deposition of the pesticide remained there. It was observed that animals exposed for 96 h at LC_{50} concentration died even if they were transferred to uncontaminated water, showing that the effect of pesticides was irreversible. Fishes exposed upto 1.8 p.p.b. DDT, 0.2 p. p. m. Dimethoate and 0.4 p. p. m. Carbaryl for 96 h when transferred to clean water, survived and started feeding. Inflammation of the buccal mucosa was observed in treated fishes.

Fresh water fishes in contaminated medium displayed feeble swimming, as observed by Verma *et al.* (1974). At higher concentration a kink at the tail was noticed. Fishes exhibited jerky movements when exposed to DDT. However no such movements were observed in fishes exposed to Dimethoate and Carbaryl. At the end, loss of equilibrium followed by slow movements and quiescence were observed. After two days of exposure to LC_{50} concentration the response to touch decreased progressively.

The LC_{50} values (96 h) of DDT, Dimethoate and Carbaryl to the tested fish were 3.6 p. p. b., 0.70 p. p. m. and 2.2 p. p. m. respectively. Eisler (1970) conducted static bioassays on estuarine teleosts. When the results of the present work are compared with the findings of Eisler it appears that tropical fishes are more resistant than temperate species.

For estuarine teleosts the toxic nature of Dimethoate and Carbaryl is in between DDVP and methyl parathion. It seems that pp[1]–DDT is more harmful to estuarine teleosts of temperate and tropical waters. For example, the 96 h LC_{50} values for DDT ranged from 0.4 to 5 p.p.b.for seven species of estuarine fishes (Eisler, 1970). In the present investigation the 96 h LC_{50} value for *Therapon jarbua* is 3.6 p. p. b., which closely agrees with the above values. The 96 h LC_{50} values of DDT to *Mugil cephalus* and *Anguilla rostrata* are 3 and 4 p. p. b. (Eisler, 1970). These values are close to the LC_{50} values of the fish investigated. Verma *et al.* (1974) have reported that 96h LC_{50} values for the fresh water fishes *Colisa fasciatus* and *Notopterus notopterus* are 126 p. p. b. and 43 p.p.b. respectively. This shows that the estuarine fishes are more sensitive than the fresh water fishes. The 96 h LC_{50} with confidence limits, LC_{90}, LC_{25} and LC_{10} values of the investigated pesticides are given in Table 1.

Fishes exposed to (96 h) LC_{50} concentration and control fishes allowed to starve for 96 h were weighed. The mean percentage weight losses were 17.1 % in DDT, 10.02 % in Carbaryl, 5.40 % in Dimethoate and 3.5 % in control. The weight loss in control is mainly due to starvation. This further confirms the energy loss in treated fish, which is due to higher metabolic rates.

Respiration abnormalities in pesticide treated fishes were studied by Peer Mohamed (1975) and Srivastava *et al.* (1977) on *Colisa fasciatus*. In the present investigation the

Table 1. *Results of acute toxic bioassays (96 h) with estuarine teleost T. jarbua in water of salinity* 19.21 ‰, *oxygen content* 4.8 *ml*/1 *and pH* 7.9 *at* 29 ± 1 °C

Pesticide	LC_{50}	0.05 confidence limits Lower limit	Upper limit	LC_{10}	LC_{90}	LC_{25}	Safe concentration	Bioassay application factor
DDT (p.p.b.)	3.60	2.66	4.86	2.40	5.40	1.65	0.720	0.360
Dimethoate (p.p.m.)	0.70	0.61	0.79	0.48	1.10	0.58	0.014	0.007
Carbaryl (p.p.m.)	2.20	1.66	2.90	1.25	3.90	1.20	0.440	0.022

respiration abnormalities in *T. jarbua,* subjected to LC_{25} (96 h) concentration of selected pesticides were studied. The oxygen uptake rates for controls (96 h starved) fishes varied from 0.30 to 0.45 ml/g/h. It was observed that oxygen consumption varied during the first hour of exposure of the animals. This may be due to excitement and disturbance caused during transfer. There was a two fold increase in oxygen consumption rate of fishes kept in 3 p.p.b., DDT for 96 h. The pattern of oxygen consumption was significantly different from that of controls (Fig. 2). Such an increase was noticed by Waiwood

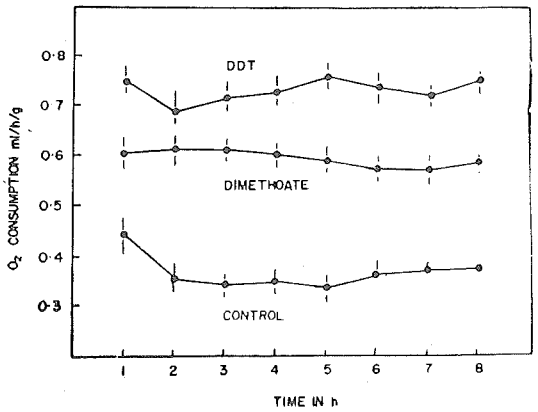

Fig. 2. *Respiration pattern in control and fishes subjected to DDT and dimethoate pesticides*
I Range of respiratory rate
Mean respiratory rate.

(1974) for the sucker fish *Catostomus commersoni* at 0.1 p. p. m. methoxychlor. The variation in oxygen consumption rates may be due to the toxic effect on the gills of the fishes. Histological examination of the gills of the treated fishes is under study. A comparative study of the toxicity of different group of pesticides could be accounted in terms of toxic effects on respiration.

The effect of 0.62 p. p. m. concentration of dimethoate was less from that of 3 p. p. b. DDT. Dimethoate and carbaryl of 0.62 p. p. m. and 1.75 p. p. m. (LC_{25}–96 h) produced almost similar responses. The metabolic rates in fishes treated with dimethoate and carbaryl varied from 0.39 to 0.45 and 0.53 to 0.61 oxygen ml/g/h respectively. The response was less in these pesticides when compared to that observed in DDT. It would be evident from Fig. 3 that dimethoate is slightly toxic and effective than carbaryl

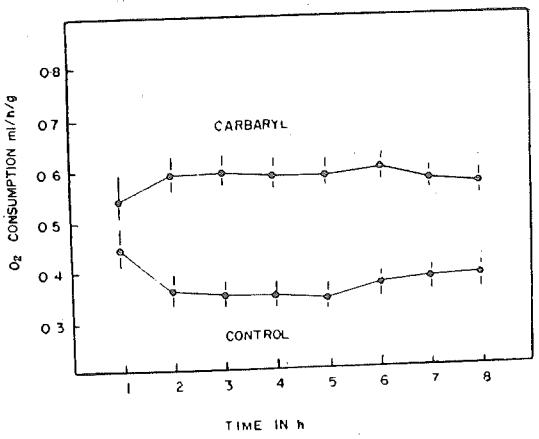

Fig. 3. *Respiration pattern in control and fishes subjected to carbaryl pesticide*
I Range of respiratory rate
Mean respiratory rate

and it initiated more respiration abnormalities. Srivastava *et al.* (1977) have observed similar abnormalities for the fish *Colisa fasciatus* with the pesticide ethyl parathion. The carbamate pesticide carbaryl seemed to be somewhat safe among the pesticides tested.

Dimethoate had been established as a stomach poison. DDT primarily acts upon nervous and respiratory systems. The present investigation confirms this view. There is every likelihood that the estuarine fishes may be exposed to these pollutants during their extensive application in agricultural practices. Consequently these pollutants may induce abnormality in the functional systems of estuarine fishes. The effects of sub-lethal concentration of these pollutants may be further studied. Fishes exposed to clean water after termination of the experiments, do not recover normal metabolic rates which proves that the stimulus caused is irreversible.

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