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Food utilization in the fish *Channa striatus* exposed to sublethal concentrations of DDT and methyl parathion

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Abstract. Sublethal concentrations of DDT and methyl parathion (MP) in the medium significantly affected the rates of feeding, absorption and conversion in *Channa striatus*. Fish exposed to 250 ppb DDT or MP consumed 23 or 50% less food than those exposed to pesticide-free water. Correspondingly, absorption rate also decreased from 120 cal/g live fish/day in the control to 88 and 59 cal/g/day in those exposed to 250 ppb DDT and MP. Efficiency to convert the absorbed food into body substance dropped from 30% in the control to 6 and 12% in the 250 ppb DDT and MP groups. Metabolic rate of the control averaged to 84 cal/g/day; whereas exposure to DDT did not significantly affect the metabolic rate, a concentration of 250 ppb MP depressed the rate to 52 cal/g/day.

Keywords. Sublethal concentration; DDT; *Channa striatus*; food utilization; methyl parathion.

1. Introduction

Channa striatus is an obligate air-breathing fish, the juveniles of which thrive in overlapping zones of paddy fields, irrigation canals and ponds; hence the fish has been recommended for culture in the paddy fields (Iyengar 1962). Consequent to intensive agricultural operations, the fish is continuously exposed to pesticide stress. The shallowness of the habitat and the faster evaporation of water in the tropics concentrate the pesticide in the medium. Sublethal concentration of pesticide is known to alter the habitat, behaviour pattern, growth, reproductive potential and resistance to diseases through a variety of mechanisms in non-target species (Holden 1973). From elaborate static bioassay tests using *C. striatus*, the 96 hr LC_{50} values have been found to be 330 ppb for DDT and 880 ppb for MP (Bhaskaran 1980). Preliminary observations have revealed that *C. striatus* (15 g) survives over 40 days at sublethal concentration of 250 ppb of DDT or MP. Considerable information is available on the influence of exogenous factors such as temperature (Vivekanandan and Pandian 1977), ration (Vivekanandan 1976), PO_2 (Pandian *et al* 1977), and depth and volume of water (Pandian and Vivekanandan 1976) on the pattern of food utilization in some air-breathing fish. The present paper reports the influence of sublethal concentrations of DDT and MP on food utilization in *C. striatus*.

2. Material and methods

Specimens of *C. striatus* (15±2 g) were acclimated separately for 7 days at chosen concentration (250, 125, 62 and 31 ppb) of DDT or MP in glass aquaria containing 5 l of water. The desired concentration of the pesticide in aquarium water was achieved by adding appropriate quantity of stock solution of the pesticide prepared in acetone. Technical grade DDT (Bharat Pulverisers, Bombay) and MP (Bayer, India) were used to prepare the stock solutions. The loach *Lepidocephalichthys thermalis* served as prey during acclimation and experiment.

Healthy acclimated *C. striatus* were weighed and used for the feeding experiment, which lasted for 22 days. Two series (DDT and MP) of experiments, each consisting of 3 to 6 individuals for each test concentration were conducted. A control group was also fed separately exposing the fish to pesticide-free water. All the fish were fed *ad libitum* on weighed quantities of live *L. thermalis* once a day. The residual prey left in the aquarium were collected every day and dried. Faeces egested by the fish was collected by filtering the entire aquarium water once in 4 days and drying the residue. After removing the water for faeces collection, the aquarium was filled with fresh water and the pesticide concentration was maintained by adding appropriate quantity from the stock solution. At the end of the experiment the fish was weighed and dried. Water and caloric contents of a few sample fish were estimated and these were used to determine the values for the test fish (see also Maynard and Loosli 1962). The food, faeces and fish were dried to weight constancy at 90°C and weighed to an accuracy of 0.1 mg. Caloric content was determined in Parr 1411 semi-micro bomb calorimeter following the standard procedure.

The scheme of energy balance followed in the present study was that of IBP formula of Petrusewicz and MacFadyen (1970), usually represented as: $C = F+U+M+P$, where C is the food consumed, F the faeces, U the urine, M the energy lost as heat due to metabolism and P the growth (= conversion). Food energy absorbed (A) was calculated by subtracting F from C, and P was calculated by subtracting the energy content of the fish at the commencement of the experiment from that at the termination. M was estimated by subtracting P from A; the M value thus arrived at includes a constant (see Nirmala 1981) but negligible fraction of U (Winberg 1956). Rates of feeding, absorption and conversion and metabolism were calculated by dividing the respective quantum of energy by the products of fish weight (g) and duration of the experiment (22 days) and expressed in terms of cal/g live fish/day. Efficiency of absorption was calculated by relating A to C and conversion efficiency (K_2) relating P to A.

3. Results

Exposure to sublethal concentration of the pesticides significantly influenced the caloric content of the fish and faeces (table 1). With increasing concentration of the pesticides in the medium, caloric content of the fish decreased; the decrease was from 5389 cal/g dry weight in the control to 4671 or 4725 cal/g in the fish exposed to 250 ppb DDT or MP. Depletion of energy per unit weight of organismic matter is considered to reflect utilization of high energy containing lipids for

Table 1. Caloric content of *C. striatus* and faeces as functions of DDT and MP concentrations.

Pesticide	Exposure concentration (ppb)	Calorific content (cal/g dry weight)	
		Fish	Faeces
	Control	5389 ± 226	1333 ± 42†*
	31	5189 ± 217	1440 ± 98
DDT	62	4989 ± 347	1548 ± 75
	125	4830 ± 315	1645 ± 69
	250	4671 ± 261	1745 ± 86*
	31	5123 ± 289	1405 ± 192
	62	4857 ± 217	2475 ± 139
MP	125	4791 ± 159	1548 ± 141
	250	4725 ± 165	1612 ± 121†

*$t = 6.088$ $P<0.01$; †$t = 3.080$ $P<0.05$

metabolism (see Pandian 1983); it is likely that *C. striatus* under the pesticide stress mobilize fat reserves to meet the higher metabolic energy demand. On the other hand, energy content of faeces increased from 1333 cal/g in the control to 1745 or 1612 cal/g in those exposed to 250 ppb DDT or MP (table 1), suggesting that a fraction of the prey containing energy-rich lipid is not digested and absorbed.

The feeding rate of the control fish averaged, 125 cal/g/day (table 2). In the fish exposed to 31, 62 and 125 ppb of DDT, the feeding rate was not significantly different from those exposed to the corresponding concentrations of MP. But at 250 ppb of DDT or MP, the rate was only 96 to 63 cal/g/day. At this sublethal concentration, it decreased to about 50% of the control value in the DDT and MP series, respectively; the feeding capacity of *C. striatus* is more severely impaired by MP than DDT.

Trends obtained for absorption rate of the fish in different groups of DDT and MP series were more or less similar to the respective values obtained for feeding rate (figure 1). Fish exposed to 250 ppb DDT or MP absorbed 88 or 59 cal/g/day compared to 120 cal/g/day absorbed by that in the control group (table 2). Absorption efficiency, which was around 94% was not affected by the exposure to the pesticides; however, statistical comparison of the mean efficiency values of the control fish and those exposed to the highest concentrations of DDT or MP showed that efficiency was affected at the highest tested sublethal concentration of the pesticides.

Exposure to the pesticides significantly affected the rate and efficiency of food conversion. The control fish converted at the rate of 36 cal/g/day compared with 6 and 7 cal/g/day in the highest concentration of DDT and MP, respectively. Conversion efficiency also decreased to 6 and 12% in these groups.

With increasing pesticide concentration and stress, *C. striatus* channelled a greater proportion of the absorbed food energy into metabolism. Metabolic rate of the fish in the DDT series oscillated around 85 cal/g/day (table 2). In the MP series, it progressively decreased from 83 cal/g/day in the 31 ppb group to 52 cal/g/day in the fish exposed to the highest concentration.

Table 2. Food utilization in *C. striatus* (15 g) exposed to different concentrations of DDT and MP.

Parameter	Control	Concentration (ppb)							
		31		62		125		250	
		DDT	MP	DDT	MP	DDT	MP	DDT	MP
Feeding rate	125±7.1	117±6.2	116±6.2	109±2.7	103±6.6	90±4.6	84±6.2	96±8.2	63±6.4
Absorption rate	120±6.8	111±5.9	110±5.8	103±2.3	98±6.2	83±4.3	80±4.3	88±7.5	59±6.0
Conversion rate	36±3.2	24±3.1	27±5.9	17±4.4	20±2.9	10±1.6	14±1.7	6±1.6	7±1.0
Metabolic rate	84±4.1	87±2.9	83±6.7	86±2.8	78±5.4	73±3.3	66±7.5	82±6.3	52±6.0
Absorption efficiency	96±0.7	95±1.2	96±1.3	94±1.7	95±2.0	93±2.0	5±1.0	92±1.9	93±1.5
Conversion efficiency	30±1.3	21±1.5	24±5.1	18±1.9	19±2.7	11±1.5	18±3.2	6±1.5	12±1.8

Each value represents the mean (±SD) performance of 3-6 individuals fed *ad libitum* on live *Lepidocephalichthys thermalis* for a period of 22 days at 29°C. The rates are expressed in cal/g/day and the efficiencies in %.

Student's t test: Feeding rate : 31 ppb DDT *vs* 31 ppb M.P. $t = 0.197$; $P > 0.5$
62 ppb DDT *vs* 62 ppb M.P. $t = 1.457$; $P > 0.5$
125 ppb DDT *vs* 125 ppb M.P. $t = 1.346$; $P > 0.5$

Absorption efficiency : 250 ppb DDT *vs* Control $t = 2.79$; $P < 0.05$
250 ppb M.P. *vs* Control $t = 2.60$; $P \leq 0.05$

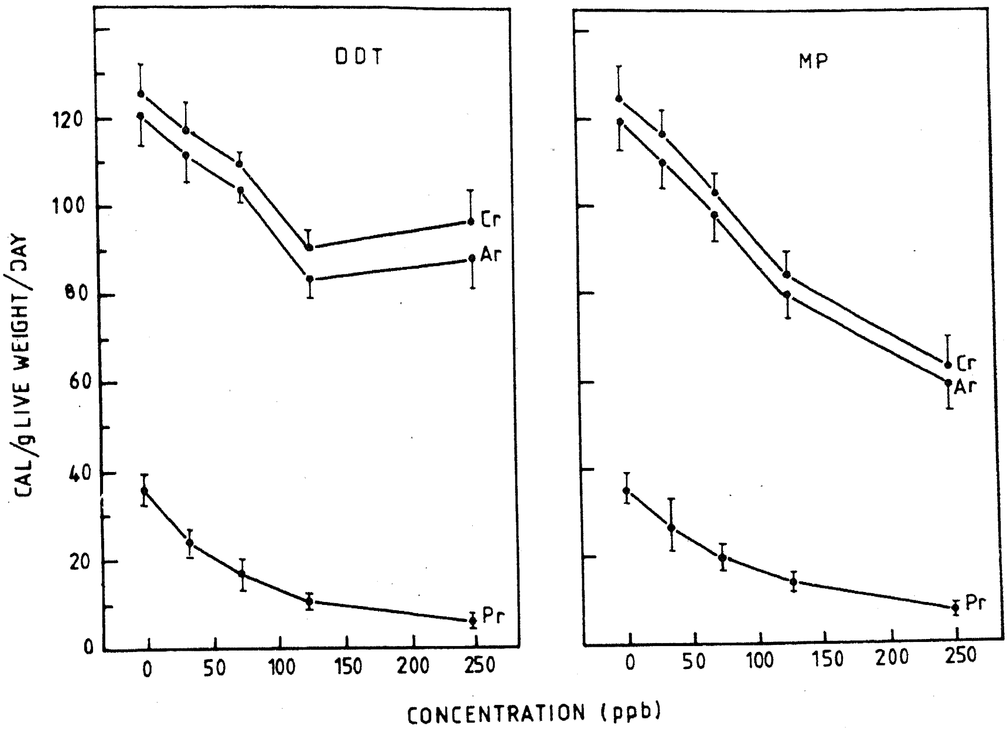

Figure 1. Effect of sublethal concentrations of DDT (left panel) and MP (right panel) on consumption (Cr), absorption rate (Ar) and conversion rate (Pr) in the fish *Channa striatus*. Each value represents the mean (vertical line = SD) performance of 3 to 6 individuals fed for 22 days.

4. Discussion

Despite *ad libitum* supply of live prey, sublethal concentrations of DDT and MP significantly affected feeding and metabolism, and hence growth of *C. striatus*. Exposure to sublethal concentrations of MP depressed feeding rate to 50% and metabolism to 60% of the respective control values, whereas that of DDT reduced feeding (to 80%) but not metabolism. The observed decrease in conversion efficiency of the fish may be attributed mainly to the depressing effect of MP on feeding, and to increased metabolism in that exposed to DDT. Webb and Brett (1973) observed significant decreases in rate and efficiency of conversion in *Oncorhynchus nerka* exposed to sublethal concentration of the organochlorine pesticide, sodium pentachlorophenate. They attributed the depressing effect of the pesticide on feeding as solely responsible for the decreased rate and efficiency of food conversion. The present study indicates that (i) reduction in feeding (as is the case with MP) and/or (ii) the need for allocation of a greater proportion of the absorbed food energy for metabolism (as is the case with DDT) are responsible for the negative effects of the pesticides on food conversion.

Decrease in feeding rate of the fish exposed to MP appears to be due to the impairment of impulse transmission (O'Brien 1976) and physical deformation (Bengtsson 1975) leading to depressed swimming activity, predatory ability and feeding capacity. The report of Bhaskaran (1980) that among *C. striatus* exposed to 96 hr LC_{50} of MP, about 11% suffered from physical deformations (see also McCann and Jasper 1972 for vertebral deformations in *Lepomis macrochirus* exposed to MP) supports the above conclusion. In natural habitat, sublethal concentrations of MP may let *C. striatus* survive, but with poor predatory efficiency.

Metabolic rate of fish depends to a considerable extent on feeding rate (*e.g.* Pandian and Vivekanandan 1976; Vivekanandan and Pandian 1977). Metabolic rate of *C. striatus* exposed to MP decreased with feeding rate, while those exposed to DDT maintained the rate at a level more or less on par with that of the control fish, despite the decrease in feeding rate. Bhaskaran (1980) observed that by uncoupling oxidative phosphorylation from the respiratory chain, DDT decreases the respiratory control (RC) ratio and increases O_2 uptake overrides the depression in metabolic rate owing to the decrease in the feeding rate and as a result, the metabolic rate of the fish under DDT stress is more or less equal to that of the control.

Decrease in the absorption efficiency of *C. striatus* in the 250 ppb DDT or MP series is understandably due to the increase in the calorific content of faeces over that of the control (table 1). The suggestion of Miller and Kinter (1977) that by altering protein conformation in cell membranes, DDT affects activity of enzymes such as ATPase which aid in the absorption of nutrients is worth considering in this content (see also Bhaskaran 1980).

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