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Original Research Paper

Effect of Pesticides on Aquatic and Aerial Oxygen Consumption in an Air Breathing Murrel Fish, *Channa gachua*

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ABSTRACT

The present paper deals with the effect of three pesticides namely Metacid-50 (Organophosphate), Dithane M-45 (Carbamate) and Kelthane (Organochlorine) on changes in dual mode of oxygen consumption of an air breathing murrel fish, *Channa gachua*. The mean values of aquatic, aerial and total oxygen uptake of control group of fish (40.0 ± 1.5g) were recorded as 52.44, 61.56 and 114.0 mL/kg/h respectively. This group of fish obtained 46% and 54% oxygen respectively from aquatic and aerial route. Exposure of fish to the pesticides brought significant decrease in aquatic as well as total oxygen uptake, while it increases in oxygen consumption through aerial route as compared to control. It is due to action of pesticides on acetylcholinesterase enzyme, respiratory muscles paralysis and respiratory failure causing finally death.

INTRODUCTION

Respiration is one of the most important physiological parameters on which many of the vital functions like growth and reproduction of fishes depend (Holden 1973), which in turn has a direct bearing on the productivity of freshwater ecosystems in terms of fish production. The freshwater air breathing fishes of tropical countries inhabit waters of low O_2 content and experience hypoxic water in summer and normoxic water during winter and rainy season. In accordance with the fluctuations in the physico-chemical characteristics of the ambient waters, the air breathing fishes are equipped with dual mode gas exchange machinery, employing respiration using highly vascularised air breathing organs and branchial integument exchange of gases with water.

These days pesticides are used indiscriminately, which affect aquatic environment including fishes. One of the early symptoms of acute pesticide poisoning is the alteration or failure of respiratory metabolism (Holden 1973). Changes in oxygen uptake of fishes in response to pesticide exposure are varying in different fishes exposed to a variety of pesticides (Karuppiah 1996). The effect of pesticides on oxygen consumption has been extensively studied in a number of water breathing fishes (Mount 1962, Waiwood & Johansen 1974, Vasanthi 1985). However, these investigators estimated only the changes in aquatic respiration even though the air breathing fishes like, *Mystus vittatus* (Gopalakrishna Reddy & Gomathy 1977) and *Channa punctatus* (Sambasiva Rao et al. 1984) were used in their investigations. A review of literature indicates that the effects of pesticides on the proportion of oxygen uptake from water and air by air breathing fishes were studied by only a few workers (Bakthavathasalam 1980, Natarajan 1981, Ganapathyraman 1987 and Karuppiah 1996), therefore, the present work has been undertaken in an air breathing fish, *Channa gachua* to advance our information in this regard.

MATERIALS AND METHODS

Channa gachua is an air breathing murrel fish belonging to the family Channidae of the order Channiformes. It is found in estuaries and freshwaters of India. It has a very good flavour and is popular as food. This fish has dual mode of gas exchange as it extracts O_2 from water through gills and from air by accessory respiratory organs. The accessory respiratory organs comprise one pair of suprabranchial chambers.

Live specimens of *Channa gachua* were procured from local fish dealers at Hazaribag and maintained in large glass aquaria of size 90 × 60 × 60cm with continuous flow of water. The fish were fed with chopped goat liver daily during a minimum acclimation period of 15 days in the laboratory. Routine oxygen consumption from air and still water was measured in a closed glass respirometer containing 3 litres of water (initial O_2 content = 6.5 mg/L; pH = 7.2) and 0.51 mL of air (Fig. 1). The fish had free access to air through a small semi circular hole (10 cm diameter) in a disc float. Carbosorb (B.D.H) or KOH in a Petri dish was placed on the float to absorb CO_2, thus, the fish could exchange gases with water by way of its gills as well as with air using the suprabranchial chamber. The air phase of respirometer was connected to a differential manometer. Movement of the manometer fluid follow uptake of oxygen when the CO_2 is absorbed by Carbosorb (KOH). The fish were acclimatized to the respirometers at least 12 hours before the readings were taken. The concentration of dissolved oxygen in the water was estimated by Winkler's volumetric method (Welch 1948). The oxygen uptake through gills was calculated from the difference between the O_2 levels of the ambient water in the respirometer before and after the experiment and the reading of volume of water in the respirometer. Oxygen uptake from air was measured and calculated by volume change in the manometer and by use of the combined gas law equations and vapour pressure (Dejours 1975). Mean values of CO_2 of a series of observations on each fish at STPD and standard errors were calculated. The experiments were conducted at 29.0 ± 1.5°C. The pH of the ambient water was measured by an electronic pH meter. The respiratory chambers were thermostated by immersion in a temperature controlled water bath.

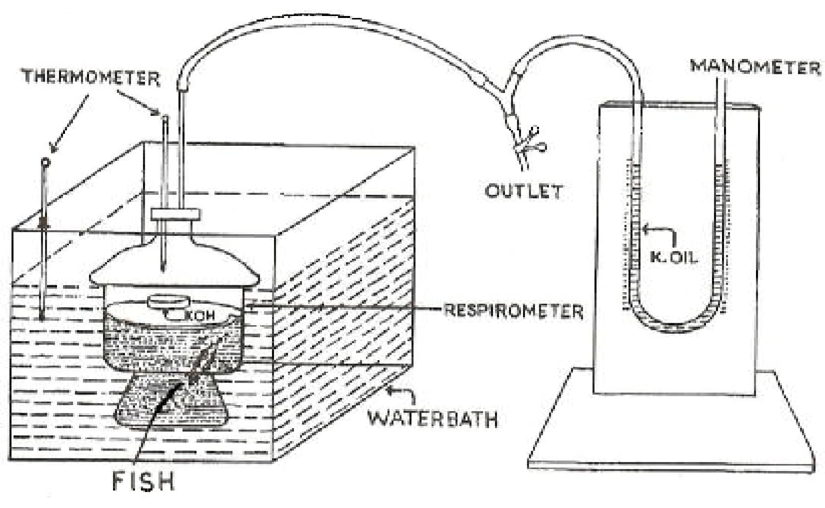

Fig. 1 : Experimental set-up for the measurement of dual mode of O_2 uptake in *Channa gachua.*

Acute toxicity tests were performed with one pesticide of each group (i.e., one each from organophosphate, organochlorine and carbamate). The pesticide's technical or trade name, active ingredients, etc. are as follows:

1. Metacid-50 (organophosphate): 50%, methyl parathion = O-O dimethyl O-P-nitrophenyle phosphorothionate; Bayers India Ltd., Mumbai.
2. Dithane M-45 (carbamate): 75% manozeb as zinc ion and manganese ethylene bis dithiocarbamate. Indofil Chemical Ltd., Mumbai.
3. Kelthane E.C. (organochlorine): 18.15%, 1,1 bi-chlorophenyl 2,2,2 trichloroethanol (DICOFOL): Indofil Chemical Ltd., Mumbai

Metacid and Kelthane were in liquid form, and Dithane M-45 was soluble in water. The desired degree of concentrations were prepared by adopting the dilution techniques of APHA (1971). The 96 hr bioassay tests were performed employing the technique of static bioassay tests (Doudoroff et al. 1951). The TLm (median tolerance limit) or LC_{50} (96h) values were 11.0 mg/L for Metacid, 14.0 mg/L for Kelthane, and 20.0 mg/L for Dithane M-45. The determination of aquatic, aerial and total oxygen consumption in the fishes were made at sublethal concentration of pesticides (Table 1). Values of O_2 uptake were expressed as mL O_2/kg/hr. Five fish were used for each set of the experiment. The mean values of oxygen uptake of all the fish of each set of experiment were taken and compared.

The difference of significance, if any, between the control and experimental groups of fish, was calculated by Student's 't'-test at the level of 5%.

OBSERVATIONS

The data showing the effect of sublethal concentrations of Metacid-50, Dithane M-45 and Kelthane on aquatic, aerial and total oxygen uptake (mL O_2/kg/hr), percent aerial and aquatic O_2 uptake, and aquatic/aerial O_2 uptake ratio are summarized in Table 1.

The mean values of aquatic, aerial and total O_2 uptake of control group of fish was recorded as 52.44 ± 0.93, 61.56 ± 1.08 and 114.0 ± 1.93 respectively. This group of fish obtained 46% and 54% oxygen respectively from aquatic and aerial route. The aquatic/aerial O_2 uptake ratio was calculated to be 0.852 in this group of fish.

Exposure of fish to different sublethal concentrations of all the three pesticides brought significant decrease in aquatic and total oxygen uptake. The experimental fish obtained 30.0-38% O_2 through aquatic route as compared to 46% in control group, while the O_2 uptake through aerial route ranged from 62-70% as compared to 56% in the fish of control group. The ratio of aquatic/aerial O_2 ranged from 0.428-0.613 in experimental fish as compared to 0.852 in the control group. Thus, a shift in the dependency towards air-breathing was clearly marked out in fish exposed to different concentrations of all the three pesticides. The effect of these pesticides were dose dependent and the Kelthane was found to be more effective as compared to Dithane M-45 and Metacid 50.

DISCUSSION

Different water bodies with varied physico-chemical qualities are present in tropical India. Various piscine organizations, including gills are modified to suit these water bodies. The dual breathers can survive in hypoxic and hypercarbic swampy waters or even pesticides polluted water due to the presence of air breathing organs supplementary to gills. However, such water bodies are unsuitable

Table 1: Effects of pesticides on dual mode oxygen uptake (mLO_2/kg/hr). Percent decrease in total oxygen uptake, percent increase in aerial oxygen uptake and aquatic/aerial oxygen uptake ratio in a air breathing fish *Channa gachua*. N = 5; Body wt.= 40.0 ± 1.5g; Water temp. = 29.0 ± 1.5°C ± SEM; * = Significant

Sl. No.	Condition	Dose g/L	Oxygen uptake (mL O_2/kg/h)			Percent O_2 uptake		Aquatic: Aerial ratio	% Decrease in O_2 uptake	
			Aquatic	Aerial	Total	Aquatic	Aerial		Aquatic	Total
1	Control	-	52.44±0.93*	61.56±1.08	114.0±1.93	46.0	54	0.852	-	-
2	Metacid-50	2.0	24.98±1.64*	46.37±1.24*	71.35±1.08*	35.0	65	0.538	52.36	37.41
3	Metacid-50	4.0	26.65±1.04*	43.47±1.33*	70.12±1.04*	38.0	62	0.613	49.17	38.49
4	Dithane M-45	4.0	26.20±1.23*	56.65±1.28*	82.85±1.12*	31.6	68.4	0.462	50.04	27.32
5	Dithane M-45	8.0	30.9±1.12*	50.42±1.12*	81.32±1.48*	38.0	62	0.613	40.50	28.67
6	Kelthane	5.0	25.0±2.68*	58.32±0.61*	83.32±1.93*	30.0	70	0.428	52.33	26.91
7	Kelthane	8.0	29.06±1.36*	52.09±0.28*	80.15±1.04*	35.0	65	0.538	44.58	29.69

for purely water breathing fishes for the lack of air-breathing organs.

Commonly used pesticides such as organochlorine, organophosphate and carbamate are used to control different kinds of pests. It is very interesting to note that all the different groups of pesticides or even the different pesticides of the same group do not have the same effect on fishes. The mode and site of action of different pesticides also differ and, therefore, it is very difficult to generalize the effect of different pesticides in fishes unless a detailed investigation is carried out.

One of the early symptoms of acute pesticide poisoning is the alteration of respiratory metabolism in fishes. A perusal of literature on the effect of pesticides on oxygen uptake of purely water breathing fishes and of air breathing fishes indicate that the effects of pesticides on oxygen uptake are varied. Waiwood & Johanson (1974) in white sucker, *Catastomus commersoni* after the treatment of methoxychlor, Hunner et al. (1967) in *Lepomis macrochirus* after the exposure of endrin, Bakthvathsalam (1980) in *Anabas testudineus*, Peer Mohammed & Gupta (1984) in *Cirrhinus mrigala* after the treatment of ethyl parathion, Jabde & Ansari (1993) in *Nemechillus aureus* after the exposure of cypermethrin, and Karuppiah (1996) in *Channa striatus* after the treatment of sevin have reported elevated oxygen uptake following exposure to 10 different insecticides. On the other hand Uthaman (1977) in *Colisa lalia* following exposure of γ-BHC, Gopalakrishna Reddy & Gomathy (1977) in thiodon exposed *Mystus vittatus,* Pandey et al. (1979) in DDT, metacid and unizeb exposed *Channa punctatus,* Vasanthi & Ramaswamy (1987) in thiodon exposed *Sarotheroden mossambicus,* Velavan (1992) in Cuman L-exposed *Oreochromis mossambicus*, Kumar (1998) in metacid exposed *Heteropneustes fossilis,* and Pandey et al. (1999) in sevin exposed *Clarias batrachus* have reported 21% to more than 50% decrease in oxygen uptake following exposure to different pesticides. These investigators are of the opinion that the dual mode breathers predominantly rely more on aerial gas exchange as compared to aquatic gas exchange following exposure to different pesticides, which may be assumed as an adaptation towards hypoxic water conditions. These investigators also stated that the dependency on aquatic and aerial respiration is different in different concentration of pesticides indicating a survival value for the fish.

The results obtained in the present study on the dual mode of oxygen uptake of control fish indicates that the *Channa gachua* predominantly relies on aerial gas exchange obtaining 54% of its total oxygen uptake, whereas only 46% was contributed by gills. Similar trends have been reported by Karuappiah (1996) in *Channa striatus* and Munshi et al. (1979) in *Channa marufius* (84.5%)

Channa striatus (67.7%), *Channa gachua* (53.4%) and *Channa punctatus* (86.8%). In the present study on *Channa gachua*, the contribution of gas exchange through aerial route increased between 62-70% following exposure of different concentrations of Metacid-50, Dithane M-45 and Kelthane, which is in conformity with the findings of Karuppiah (1996) and Pandey et al. (1999). The study also shows a significant decrease in both aquatic and total oxygen uptake following exposure to different concentrations of the three pesticides (Table 1), which is consistent with the findings of Pandey et al. (1999, 2005). Though the exact reason for the decrease in O_2 uptake in the fish *Channa gachua* could not be understood, but Chambers (1976) has stated that the mode of action of organophosphate pesticides is the irreversible inhibition of acetylcholinesterase with death in vertebrates usually attributed to respiratory failure from paralysis of respiratory muscles. Similar explanation may be followed here. The increased dependency on aerial respiration in *Channa gachua* following exposure to the three pesticides probably indicates that the fish tries to avoid the aquatic medium containing sublethal concentration of pesticides.

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