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RESPIRATORY METABOLISM IN *ETROPLUS MACULATUS* (BLOCH) UNDER ESTUARINE CONDITIONS AND PESTICIDE STRESS

S. D. Rita Kumari and K. S. Sreeletha

Department of Aquatic Biology and Fisheries, University of Kerala, Beach P.O., Trivandrum-695 007

ABSTRACT

The impact of environmental changes on the respiratory metabolism of the cichlid fish *Etroplus maculatus* (Bloch) in the Veli Lake, a brackishwater lake on the southwest coast of India has been examined in detail. The routine metabolism of the fish has been checked with regard to temperature, salinity, hydrogen-ion-concentration and biocides on the rate of oxygen consumption.

The rate of oxygen consumption showed increase with increasing temperature and the fish could not tolerate temperatures higher than 41°C. At higher pH concentrations (8.8) there was increase in oxygen consumption while slight variations have no effect on the metabolism. The highest salinity tolerated by the fish was 16.65‰. The oxygen uptake was more in this medium and less at lower and higher salinities. The fish exhibited a maximum tolerance level of 0.04 mg/l in the pesticide Nuvan. At the initial level of 0.005 mg/l the fish exhibited the maximum oxygen uptake (0.5814 ml/l/gm body wt/hr), the rate at 0.01 mg/l showed a slight decrease and the trend continued as the concentration increased. The fish could tolerate a concentration of upto 0.5 ml/l of Dimecron. At 0.1 mg/l the oxygen intake was 0.7647 ml/l/gm body weight/hr. Further increase in concentration of the pesticide resulted in a stress and gradual decrease in oxygen consumption. These indicate that the biocides have a depressive effect on the respiratory metabolism of the fish. The present study thus reveals that oxygen requirement of this fish in its estuarine habitat is quite characteristic and the demands depend on the environmental conditions.

INTRODUCTION

A Large amount of literature has accumulated in the past on measurements of metabolic rates. Of these oxygen consumption is often taken as an index of the energy needs of the organisms (Fry, 1957, 1971 ; Brett, 1962, 1970). An advantage of this technique is that frequently the oxygen available for consumption imposes limits on the distribution and survival of animals. Of the three levels of oxygen consumption namely standard, routine and active (Fry, 1957) the first one has been defined by Krogh (1914) as the nearest attainable approximation to the basal metabolism which would obtain when the organism is at rest. Routine oxygen consumption is oxygen consumed by the fish whose movements are spontaneous and is the most commonly measured rate while active oxygen consumption pertains to oxygen consumed when the fish is stimulated to maximum activity.

Our information is still incomplete regarding metabolic rates in fishes of the cichlid group living in estuarine conditions. The present work pertains to the respiratory metabolism in the Orange chromide *Etroplus maculatus* (Block) under estuarine conditions and pesticide stress. This study was specially undertaken with a view to examine the nature of the above stress to which the fish is subjected to under the conditions prevailing in a very special habitat namely the Veli Lake which is a backwater which is open to the sea only for 5-10 days intermittently during the monsoon season.

MATERIAL AND METHODS

Healthy specimens of *E. maculatus* collected from the Veli Lake were utilized for the experiment. They were acclimated to laboratory conditions in large glass aquaria with a bottom layer of sand containing well water to which 20% filtered sea water was added. The specimens were acclimated for ten to fourteen days at a temperature of 30-32°C, pH of 7.1, salinity around 6‰ and oxygen at near air saturation. The fish were fed with tubifex worms on every alternate days. The specimens were not fed during the actual experimental period to avoid any increase of respiratory metabolism, resulting in products which might influence the findings.

Only healthy specimens without any symptoms of disease were selected for the experiment. The water in the aquaria was renewed once in every week, ensuring that fish were disturbed as little as possible. During the acclimation period no experiments were conducted. There was no mortality and in a fortnight the fishes were completely acclimated. Fish once used for an experiment were never used for subsequent experiments.

The sealed vessel method was adopted during the present study on account of its high reliability. The oxygen consumed by the fish is expressed in millilitres per litre per gram body weight per hour.

A one litre conical flask with provision for continuous water circulation was used as the respirometer. The respirometer was sealed with a three-holed rubber stopper. In addition to the inlet and outlet tubes, a separate tube for taking samples for oxygen estimation was also fitted airtight in the three holes of the stopper. Provision for completely closing and opening the three tubes were also made. The respirometer was immersed in a large trough containing water to minimise disturbances from external stimuli and temperature fluctuations. Groups of fishes were utilized in the investigation rather than individuals, since single fish had too small an influence on the oxygen concentration to make ½ hour/1 hour readings feasible.

Winkler's method was followed in determining the oxygen content of water..

The influence of different environmental factors were studied by keeping all factors except the one under investigation constant.

Oxygen consumption in five temperature ranges of 21°C, 26°C, 31°C, 36°C and 41°C were measured. The temperature of the ambient water (31°C) was lowered or increased by lowering or increasing the temperature of the water of the trough in which the respirometer was immersed. Transfer of the specimens to the different temperature was always sudden.

The effect of different pH 5.2, 6.1, 7.0, 7.9, 8.8 — on oxygen consumption was examined. Different pH levels were obtained by adding 1 N NaOH or 1 N HCl to the filtered well water.

The oxygen consumption of the fish in five salinity levels — 3.3‰, 6.6‰, 9.9‰, 13.2‰ and 16.5‰ was measured. Filtered well water was utilised for diluting the filtered sea water (S = 36.2‰).

The effects of two pesticides — Nuvan and Dimecron — on the rate of oxygen consumption of the fish were studied. Stock solutions of 0.1% were prepared for both the pesticides. These were suitably diluted to make the required concentrations in mg/l. The toxicity levels and maximum tolerance levels were determined for mature fish. The highest concentrations (0.04 mg/l for Nuvan and 0.5 mg/l for Dimecron) in which the fish survived for 24 hour period of exposure were taken as the maximum tolerance level. Four levels below this were selected and oxygen consumption estimated in each of these five concentrations.

Results and Discussion

Influence of temperature on oxygen consumption

The results of the experiment presented in Table 1 show that the rate of oxygen consumption increases as temperature rises from 21°C to 41°C. The fish could not tolerate temperature higher than 41°C.

Temperature is an important ecological factor among the abiotic entities of the fish's environment. The degree of influence is all the more greater since fishes are obligate poikilotherms. It is well known that the metabolic rate of aquatic poikilotherms is closely dependent on the water temperature. Generally in poikilotherms, standard metabolism increases continuously with temperature. The results of the present investigation are in conformity with the above-mentioned generalisation. There is a near linear relationship between temperature and rate of oxygen consumption evidently pointing to the fact that temperature influences the respiratory metabolism of the fish and that the fish is temperature dependent. Therefore, as suggested by Prosser (1955) the temperature dependence of *E. maculatus* may be achieved through suitable adjustment of the metabolism and not by an adjustment of the milieu.

While considering metabolism at lower temperature, a few workers have found that in perfectly acclimated fish, metabolism in the cold is almost equal to that at high temperatures (Parvatheswara Rao, 1972 a, b). Schlieper's (1950) finding that a decrease in temperature may have a temporary stimulating effect and Sullivan's (1954) statement that the frequency of spontaneous movement is greater at temperatures both above and below the temperature preferendum may be an explanation of such results. Sobhana (1976) and Usha Peethambaran (1981) also have reported a departure from the usual linear relationship. This, however, has not been found to be the case in the present investigation. Hence as stated by Fry (1971), temperature is certainly a complex factor manifesting itself in a multiplicity of ways and few general statements can be made of the relation of standard metabolism to temperature except that different species are adjusted to different temperature ranges in different ways.

Influence of pH on oxygen consumption

The results presented in Table 2 indicate that at lower concentrations, the oxygen consumption is low, but at higher concentration, there was increase in oxygen consumption. But at concentrations 6.1, 7.0, 7.9 the oxygen consumed was remarkably the same indicating thereby that slight variations in the pH of the medium have virtually no effect on the metabolism.

The nature of ionic regulation in fishes has attracted a good deal of attention for almost a century, but the metabolic aspects and ionic stress have been relatively little investigated. The present study is of relevance since the habitat of *E. maculatus* is subjected to considerable pollution by the effluents from the Travancore Titanium Products Ltd. which manufactures Titanium dioxide. The effluents contain among others sulphuric acid, ferrous sulphate and titanium dioxide. This lowers the pH of the medium causing a stress on the organisms. During the present study it was found that the rate of oxygen consumption in the pH range 6.1 to 7.9 was identical. Vijayamohan *et al.* (1984) observed the same number of cirral movements/minute in *Balanus tintinnabulum* in pH 6.0 to 6.5. But in pH 8.1, there was a slight decrease and a considerable decrease in 5.55 and 5.00 pH. Nair *et al.* (1986) while investigating the rate of respiration in *Perna*

TABLE 1. *Influence of temperature on oxygen consumption in* Etroplus maculatus

Temperature (°C)	21°C ±0.5	26.1 ±0.5	31.0 ±0.5	36.0 ±0.5	41.0 ±0.5
Oxygen consumed in ml/l/gm body wt./hr	0.3592	0.3832	0.7185	0.7900	0.7902

TABLE 2. *Influence of pH on oxygen consumption in* Etroplus maculatus

Hydrogen-ion-concentration	5.2	6.1	7.0	7.9	8.8
Oxygen consumed in ml/l/gm wt./hr	0.1198	0.2394	0.2394	0.2395	0.2874

TABLE 3. *Influence of salinity on oxygen consumption in* Etroplus maculatus

Salinities (‰)	3.3	6.6	9.9	13.2	16.65
Oxygen consumed in ml/l/gm wt./hr	0.4200	0.5095	0.5364	0.5542	0.5582

indica could not find any significant variation in the oxygen uptake in the pH range — 5.2 to 6.75. Nevertheless at higher pH (7.4 and 8.1) a much higher rate of oxygen utilisation was discernible. The above-mentioned two experimental results agree with the present study. A change in pH value following the discharge of an acid effluent would even change the toxicity of other poisons already present particularly those which dissociate into an ionized and unionized fraction of which one was markedly toxic (Alabaster and Llyod, 1980).

Influence of salinity on oxygen consumption

The highest salinity tolerated by the fish was 16.65‰. The oxygen uptake was more in this medium and less at lower salinities, but there was not much difference when the salinity was increased (Table 3).

A perusal of the literature on the effect of salinity changes on the oxygen consumption in fishes and certain invertebrates shows contradictory results. Dehnel (1960) postulated that a reduction in salinity causes increased oxygen uptake because of increased osmotic load. Gordon *et al.* (1965) states that salinity has no effect on oxygen consumption in certain marine fishes. Parvatheswara Rao (1965), Rao (1968), Holliday (1971) found increased oxygen consumption with increased salinity probably owing to the increased metabolic cost of regulation. Farmer and Beamish (1969) studied *Tilapia mossambica* and observed the lowest oxygen utilisation in isosmotic salinities. Fry (1971), while reviewing the more recent literature on teleost fishes came to the conclusion that the most consistent pattern shows minimum metabolic rates at salinities which are closest to the osmotic content of the body fluids.

From the above discussion, it would appear that, as Chanchal *et al.* (1977) postulated, that the effect of salinity on metabolic rate is both stimulation and depression and it varies from species to species and it has not been possible to generalise the conclusion.

Influence of pesticide on the rate of oxygen consumption

The results presented in Table 4 suggest that in both the pesticides, the rate of oxygen uptake

TABLE 4. *Influence of pesticides on oxygen consumption in* Etroplus maculatus

Concentration (mg/l) ..	0.005	0.01	0.02	0.03	0.04
Nuvan Oxygen consumed in ml/l/gm body wt./hr ..	0.5814	0.5529	0.5155	0.5155	0.4924
Concentration (mg/l) ..	0.1	0.2	0.3	0.4	0.5
Dimecron Oxygen consumed in ml/l/gm body wt./hr ..	0.7647	0.6357	0.5805	0.5665	0.4573

decreased gradually from the control test to higher concentrations of the pesticides. The results prove that the biocides have a depressive effect upon the respiratory rate of the fish under investigation and closer to the lethal concentrations the rate of oxygen consumption was lowered. The fish showed darting movements and excitation at low concentrations, but as the concentration increased, these activities diminished and close to the lethal concentration, the fish remained sluggish and inactive.

Steed and Copeland (1967) examined the effects of exposure to industrial effluents on the respiratory rates of some fishes and shrimps and concluded that their effects on the respiratory rate of fishes were seem to be highly variable. Studies on this aspect with *Labeo rohita* by Hingorani *et al.* (1979) showed that the rate of oxygen consumption of the fish decreased with an increase in the concentration of the effluents. In *Puntius vittatus*, Usha Peethambaran (1981) noted a state of depression in respiratory rate in low concentrations of the pesticides and a state of stimulation in high concentrations. Sambasiva Rao *et al.* (1981) observed that oxygen consumption rate showed initially a slight, but insignificant elevation at 12 hr exposure period to Elsan followed by a drop at all other time intervals. Similar initial response was noticed with other aquatic species exposed to malathion (Kabeer *et al.*, 1981). This has been explained as due to hypoxia induced by the presence of effluents and also because of high concentrations of heavy metals. Leena's (1983) observations on *Garra mullya* are similar to the present investigation which is considered as the general conclusion that increasing concentrations of pollutants result in reduced respiratory rate in fish.

The present study reveals that the oxygen requirements of different animals are characteristic of animal species and oxygen demands of animal depend to a great deal on environmental conditions as Hoar (1976) has postulated.

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