

## RESPIRATORY METABOLISM IN *OREOCHROMIS MOSSAMBICUS*, PETERS UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

Reema Thampi, Parveen Rattan and Anil Chatterji

Department of Marine Sciences, University of Goa, Goa-403 005 (RT), College of Fisheries, Peth Killa, Ratnagiri-415 612 (PR) and National Institute of Oceanography, Dona Paula, Goa-403 004, India (AC)

**ABSTRACT:** Oxygen consumption in *Oreochromis mossambicus*, Peters (3-60 g in weight) was measured under different stress conditions at a constant temperature of  $20 \pm 1^\circ\text{C}$ . The rate of oxygen consumption was significantly higher ( $0.170 \text{ ml g}^{-1}\text{h}^{-1}$ ) at a salinity of  $30 \times 10^{-3}$  compared with that ( $0.132 \text{ ml g}^{-1}\text{h}^{-1}$ ) in freshwater. The oxygen consumption was also found to be affected by changes in pH. Weight specific rate decreased significantly from  $0.113$  to  $0.045 \text{ ml g}^{-1}\text{h}^{-1}$  with increasing body weight. A positive correlation was recorded between availability of dissolved oxygen and the rate of oxygen consumption by the fish. While copper sulphate and malachite green inhibited the respiratory metabolism, formaldehyde treatment raised it from  $0.088$  to  $0.118 \text{ ml g}^{-1}\text{h}^{-1}$ .

**KEY WORDS:** *Oreochromis mossambicus* - respiratory metabolism - stress conditions.

### INTRODUCTION

Fishes of the tribe Tilapiini (Cichlidae), commonly known as "tilapia", have been receiving much attention in recent years as they have become an important source of protein in tropical and subtropical countries. In India, tilapia is found mostly in lakes, rivers and ponds although they thrive in estuarine waters of salinity up to  $30 \times 10^{-3}$ .

A number of investigations have been carried out on oxygen consumption in fishes under normal conditions (Beamish, 1964; Caulton, 1978; and Barton and Barton, 1987). In present day aquaculture practices, ponds are subjected to various ectoparasitocidal and fungicidal treatments. The respiratory physiology of fish living there is liable to be affected by each treatments. The fish are also more susceptible to different diseases in a confined environment. Various predisposing factors such as deteriorating environmental conditions, increasing incidence of contact due to over crowding and competition play a significant role. Considering this important aspect, an attempt has been made in the present investigation to assess the metabolism of *Oreochromis mossambicus* with special reference to oxygen consumption under different stress conditions. The results of the study are expected to help in assessing environmental suitability, optimum oxygen concentration required for survival of the fish and in estimating oxygen budget when the ponds are subjected to various treatments.

### MATERIALS AND METHODS

*Oreochromis mossambicus* of varying size (6.1 to 21.9 cm) and weighing between 4.6 to 57.3 g were caught from a local pond at Dona Paula, Goa. The fish were acclimated for 15 days in two fibre glass tanks of 1000 litres capacity each. Separate groups of fish were used in individual experiments. The fish were not feed during the hours of study in order to avoid any variation in the respiratory metabolism.

The respiratory chambers used in this study were of a closed type and consisted of 5 litre plastic carboys. The water in the respiratory chambers was aerated prior to the experiments. Four litres of water was poured into each respiratory chamber through a 125 micron sieve to filter out dust particles. Healthy fishes of similar size were selected for the experiments. The fishes were transferred to the respiratory chambers after recording weight of each specimen. The water surface in each chamber was sealed properly with a thick layer of liquid paraffin. All experiments were conducted at a constant temperature of  $27\pm 1^{\circ}\text{C}$ . The dissolved oxygen (DO) was estimated following Winkler's method (Grasshoff *et al.*, 1983) for each chamber at 0, 1, and 3 hour of the experiment. Depletion in dissolved oxygen divided by number of hour was taken as index of the dissolved oxygen consumed by the fish  $\text{h}^{-1}$ . On dividing the value obtained with the weight of the fish, the dissolved oxygen consumed  $\text{g}^{-1}$  of the fish  $\text{h}^{-1}$  was calculated. Three replicates were used for each group of fishes and the data were tested statistically (ANOVA;  $P < 0.05$ ) to assess the effects of various parameters on oxygen consumption.

In order to study effect of salinity on oxygen consumption, four salinity concentrations (0, 10, 20, 30 ppt) were prepared by mixing seawater with freshwater. For each experiment three respiratory chambers were used. One of these served as the control group.

Effect of pH was tested by adjusting the pH of the water at levels of 5, 6, 7, 8 and 9 by using 1N HCl or 1N NaOH. For each experiment two respiratory chambers were used. One of these served as control.

Effect of size on oxygen consumption was checked by selecting fish of four different sizes (weighing between 5-58 g). Two fishes of similar size were used in each experiment.

To study the effect of different levels of dissolved oxygen on fish metabolism, observations were made over a period of seven hours and eight samples were collected at one hour interval.

Three concentrations of  $\text{CuSO}_4$  (0.25, 0.5, 1, and 2 ppm) were prepared from a stock solution of 2 ppt to study oxygen consumption by the fish at different concentrations of  $\text{CuSO}_4$ .

Four concentrations of formaldehyde (15, 20, 25 and 30 ppm) were prepared from full strength formaldehyde (40%) to study its effect on oxygen consumption.

To estimate the oxygen consumption at different concentrations of malachite green, a stock solution of 0.2 ppt of malachite green was prepared. This stock solution was later used to achieve the test concentrations of 0.05, 0.075, 0.10, and 0.20 ppm.

## RESULTS

Oxygen consumption gradually increased with increase in salinity. Maximum oxygen consumption was recorded when the salinity was  $30 \times 10^{-3}$  and lowest in freshwater (Fig. 1A).

The oxygen consumption also increased with increase in pH up to 7 but subsequently started falling with further increase in pH (Fig. 1B).

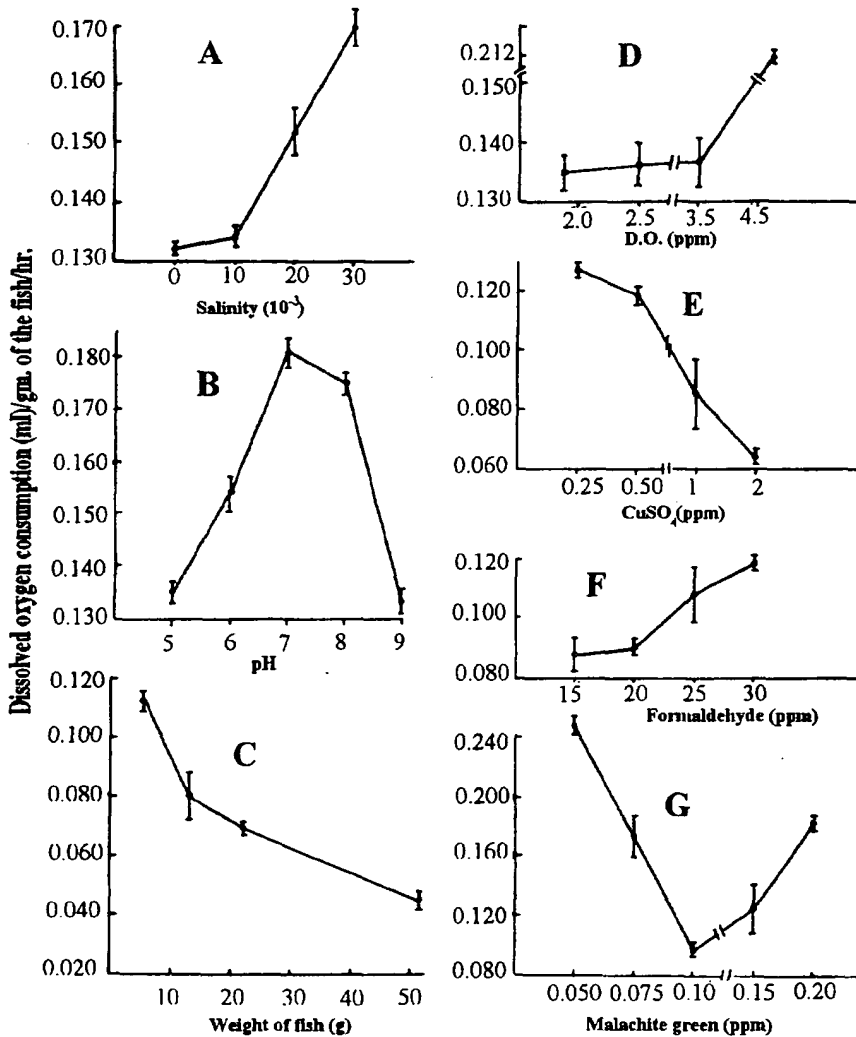


Fig. 1. Oxygen consumption of *O. mossambicus* in response to; (A) salinity, (B) pH, (C) weight, (D) dissolved oxygen, (E)  $\text{CuSO}_4$ , (F) formaldehyde and (G) malachite green. Vertical bars represent standard deviation.

The rate of oxygen consumption was significantly higher ( $P < 0.05$ ) in smaller fishes. It decreased with increase in weight of the fish. The value was minimum in fishes weighing 57.37 g or less (Fig.1C).  $\log_{10}$  of mean specific rate of oxygen consumption was inversely proportional to  $\log_{10}$  of mean size of the fish. The regression coefficients were highly significant ( $P < 0.05$ ).

Highest values of oxygen consumption were recorded when the oxygen in the environment was maximum ( $4.5 \text{ ml l}^{-1}$ ) (Fig.1D). It decreased with decrease in the available oxygen.

A gradual fall in consumption of oxygen was observed at higher concentrations of copper sulphate (Fig.1E). The higher the formaldehyde concentration in the medium, the greater was the rate of consumption (Fig.1F). A decrease in oxygen consumption was observed with increase in malachite green concentration up to 0.10 ppm (Fig.1G).

### DISCUSSION

It is generally known that the assessment of effects of salinity on oxygen uptake is complicated by the fact that the oxygen saturation of water depends on salinity. The two bear an inverse relationship. Variations in salinity are usually accompanied by osmoregulatory adjustments. It is thus likely that the observed increase in oxygen consumption in *O. mossambicus* at higher salinities is due to energy demands imposed by such adjustment. Increase in the respiratory rate with increase in salinity has been observed in young Atlantic menhaden (Hettler, 1976). However, Farmer and Beamish (1969) have reported low oxygen consumption in *Tilapia nilotica* at higher salinities of up to 30 ppt, although the lowest consumption occurred at 11.2 ppt. These observations provide an indirect support for a relationship between oxygen consumption and osmoregulation.

Maximum oxygen absorption by *O. mossambicus* occurred at pH 7. The gradient in the oxygen consumption rate was less between pH 7 and 8. A decrease in pH below 7 has been shown to cause a decrease in the oxygen binding capacity of haemoglobin in *S. niloticus* (Verhenylen *et al.* 1985). This could be a reason in the present study where a net decrease in the oxygen consumption by *O. mossambicus* was observed at low pH. Increase in pH above 8 is known to reduce oxygen consumption (Verhenylen *et al.* 1985). In the present study, increase in oxygen consumption up to pH 7 might be due to increase in swimming activity of the fish.

A decrease in oxygen consumption with increase in weight was observed in *O. mossambicus*. Beamish (1964) has demonstrated that the standard metabolic rate of brook trout, *Salvelinus fontinalis* varies in proportion to weight. Brett (1965) and Rao (1968) have found that in salmonids the active metabolism is weight proportional.

According to the present observations on *O. mossambicus* the oxygen consumption decreased with decline in the dissolved oxygen content. In rainbow trout, a reduction in oxygen level has been reported to cause an increase in breathing rate of fish (Holeton and Randal, 1967). Fry (1947) has clearly indicated that the active metabolic rate is severely restricted by progressively reducing the level of partial pressure of oxygen.

In the present investigation, the concentrations of copper sulphate tested, were not found to be lethal for *O. mossambicus* (see also Palmer, 1956). The observed decrease

in oxygen consumption by the fish might be associated with the reduced activity of the fish in response to increase in concentration of copper sulphate acting as an environmental stress. The experimental fish were, however, found healthy even after 12 hours of the experiment. With increase in the concentration of formaldehyde the oxygen consumption also increased. Formaldehyde is known to cause irritation of the mucous membrane of the fish and leads to restlessness. This might have increased the metabolic rate resulting in an increase in oxygen consumption by the fish. Similarly, the rate of oxygen consumption has been found to be decreased at higher concentrations of malachite green. It might be due to the decreased activity of the fish which is considered to be the consequence of the decreased energy derivation in metabolism.

### ACKNOWLEDGEMENTS

The authors are thankful to Dr. B.N.Desai, Director NIO, Dr. A.H. Parulekar, Head, BOD for facilities and to Prof. U.M.X. Sangodkar, Head, Department of Marine Science, Goa University for kind help. One of the authors (PR) is grateful to ICAR, New Delhi for the award of a Teacher Research fellowship.

### REFERENCES

- Barton, M. and A.C. Barton, 1987. Effects of salinity on oxygen consumption of *Cyprinodon variegatus*. *Copeia* 1: 230-232.
- Beamish, F.W.H. 1964. Respiration of fishes with special emphasis on standard oxygen consumption. *Canadian Journal of Zoology* 42: 175-188.
- Brett, J.R. 1965. The relation of size to rate of oxygen consumption and sustained swimming speed of sokeye salmon (*Oncorhynchus nerka*). *Journal of the Fisheries Research Board of Canada* 22: 1491-1501.
- Caulton, M.S. 1978. The effect of temperature and mass on the routine metabolism in *Sarotherodon* (*Tilapia*) *mossambicus* (Peters). *Journal of Fisheries Biology* 13: 195-201.
- Farmer, C.J. and F.W.H.Beamish, 1969. Oxygen consumption in *Tilapia nilotica* in relation with swimming speed and salinity. *Journal of the Fisheries Research Board of Canada* 26: 2807.
- Fry, F.W.J. 1947. Effects of the environment on animal activity. *University of Toronto, Biological Series* 55: 1-62.
- Grasshoff, K., M. Ehrhart and K. Kremming. (Eds). 1983. *Methods of Seawater Analysis*, 2nd edition. *Weiheim. Verlag. Chemie*. Pp.1-318.
- Hettler, W.F. 1976. Influence of temperature and salinity on routine metabolic rate and growth of Young Atlantic menhaden. *Journal of Fisheries Biology* 8: 55-65.
- Holeton, G.F. and D.J. Randle 1967. The effect of hypoxia upon the partial pressure of gases in the blood and water afferent and efferent to the gills of rainbow trout. *Journal of Experimental Biology* 64: 317-327.
- Palmer, C.N. 1956. *Algae in Water Supplies*. U.S. Public Health Services Publication, No.657. Pp.1-88.
- Rao, G.M.M. 1968. Oxygen consumption in rainbow trout (*Salmo gairdneri*) in relation to activity and salinity. *Canadian Journal of Zoology* 46: 781-786.
- Verheny, E., R. Blust and C. Doumen. 1985. The oxygen uptake of *Sarotherodon niloticus* L and the oxygen binding properties of its blood and haemolysate (Pisces: Cichlidae). *Comparative Biochemistry and Physiology* 81: 423-426.

(Received: 30 November 1992)