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METABOLISM OF *Oreochromis niloticus* (PERCIFORMES: CICHLIDAE) IN VARIOUS SALINITIES

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ABSTRACT

Sixty *Oreochromis niloticus* of standard length ranging between 2.5 cm and 15.9 cm and weighing between 0.43 g and 92.35 g were acclimated to experimental salinities of zero (fresh water), 3.5, 9.0 and 24.0 ppt. Oxygen uptake of each fish which was regarded as a measure of metabolism was measured in each of these salinities using closed system respirometers. The range of salinity used had no effect on the metabolism of the fish. This was due to the energy of metabolism expended by the fish in osmoregulation being too negligible to effect a change in the metabolic activities of the fish, as indicated by the oxygen consumption rate. A positive correlation existed between the body weights and oxygen consumption rates as described by the equation; log Y = 0.39 + 0.52 log x; r = 0.73, n = 240. Although the larger specimens consumed more oxygen than smaller ones, the latter had higher weight specific oxygen consumption rate (weight specific metabolic rate) than the larger fishes. This relationship was described by the regression equation: log Y = 2.95 – 0.47 log x, r = 0.78, n = 240. Hence, weight specific metabolic rate increased with decreasing weight of *O. niloticus*.

Keywords: Oxygen consumption, metabolism, Oreochromis niloticus, salinities.

INTRODUCTION

Tilapine fishes are generally the most abundant fishes in most natural fresh water bodies in the tropics (Ibrahim & Babiker 1979). The respiratory demand of *Tilapia* are slight and they are hardy and endowed with the ability to endure high environmental temperatures. These, among other things, make them to be widely cultivated in Africa (Etim *et al*, 1989).

The study of metabolism and energy demand of metabolism in fish is usually done by the measurement of its oxygen consumption (Jobling, 1982).

Different physicochemical and biological parameters have varying effects on the metabolic rate as indicated by measurements of oxygen consumption. Many workers have studied the effects of body weight on the metabolic rate of fish (Newell and Pye, 1971; Dixon and Milton, 1978). The relationship is usually exponential as expressed by the regression equation $Y = ax^b$; where Y is the metabolic rate; X is the weight of the specimen, b is the slope of the line, and a is the intercept on the Y-axis. The equation could be linearized into the form log Y = log a + b log x.

Oxygen requirements of fish per unit body weight are inversely related to the body weight (Brocksen and Cole 1973; Hettler 1976). This implies a decrease in specific metabolic rate with increase in weight of fish. This is due to the difference in body surface between large and small fishes with the result that there is relatively greater calorific need for smaller fishes than for bigger ones (Hoar and Randall, 1969).

Water salinity is of importance to fishes. Brett (1979) notes that in freshwater fishes, decreases in growth with increasing salinity was due to increase in energy for osmoregulation and maintenance of fish. Teleost which are able to successfully move from freshwater to sea water and vice versa are those with efficient ion regulatory mechanism.

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The nile tilapia *Oreochromis niloticus* are robust fishes and individually small in size. A thorough understanding of the biology of its metabolism will serve as a springboard for researches which could eventually enhance its successful culture. Herein lies the reason for this study which seeks to elucidate the effect of body size and salinity on the oxygen consumption and metabolism of the species.

MATERIALS AND METHODS

Sixty specimens of live *O. niloticus* ranging in standard length from 2.5 cm (or 0.43 g) to 15.9 cm (or 92.35 g) were obtained from the fish farm of the Institute of Oceanography, University of Calabar in the morning to minimize the adverse effect of environmental temperature change. In the laboratory, the fishes were acclimatized for 14 days in borehole water of zero part per thousand (ppt) salinity. The dissolved oxygen content of the water in the acclimation tank was kept close to air saturation value through aerating with electrically operated air pumps. The light and dark cycle in the laboratory varied with the normal day and night cycle, the tank temperature was at 28± 1.5 °C. During acclimation, the fishes were fed with prepared fish feed pellets and the acclimation tank was cleaned and water changed daily.

The experimental salinities of 3.5, 9.0 and 14.0 ppt were obtained by diluting brackish water (21 ppt) with borehole water (zero ppt). All fishes were acclimated to the required experimental salinities for 8 days before oxygen consumption rate measurements were made. Prior to the test the fish were starved for 12 hours, a period of time short enough to allow for evacuation of the gut content of the fish without necessarily leading to a decline in the respiratory rate due to starvation (Dixon and Milton 1978). Each fish was weighed in water and its length taken for the measurement of the oxygen consumption in a 2-litre capacity respirometer filled to capacity with water of required salinity. Each fish was netted and placed in each respirometer and a control experiment was set up without any fish. The respirometers were aerated for 1.5 hours and fish allowed to adapt to their surroundings. The oxygen content of the water was taken with an oxygen meter before and one hour after the vessel was hermetically sealed. The decrease in oxygen content after one hour was regarded as the quantity consumed by the fish and the microbes. The decrease in oxygen content of the control was attributed to microbial activity and was subtracted from those of the experimental respirometers to determine the actual amount of oxygen consumed by fish. The respirometers were always covered with dark cloths to attenuate visual disturbance. One way analysis of variance ANOVA was used to test for the difference between mean oxygen consumption of fish at various salinities. Regression analysis was used to quantify the relationship between oxygen consumption and weight at different salinities.

RESULTS

In the four salinities tested, oxygen consumption (metabolic rate) varied with the body weight of the organism. The larger the specimen, the greater the amount of oxygen consumed (Fig.1) and the lower the weight-specific oxygen consumption (weight specific

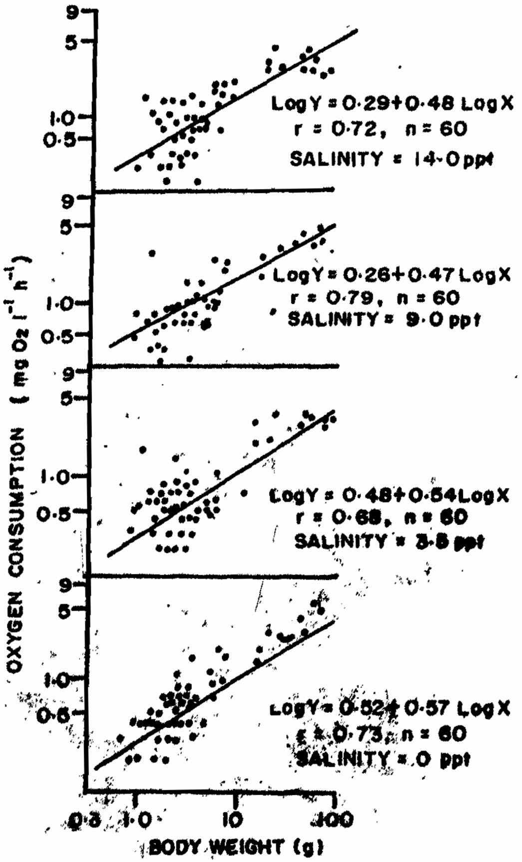

Fig. 1. Relationship between oxygen consumption and body weight of O. niloticus in various salinities

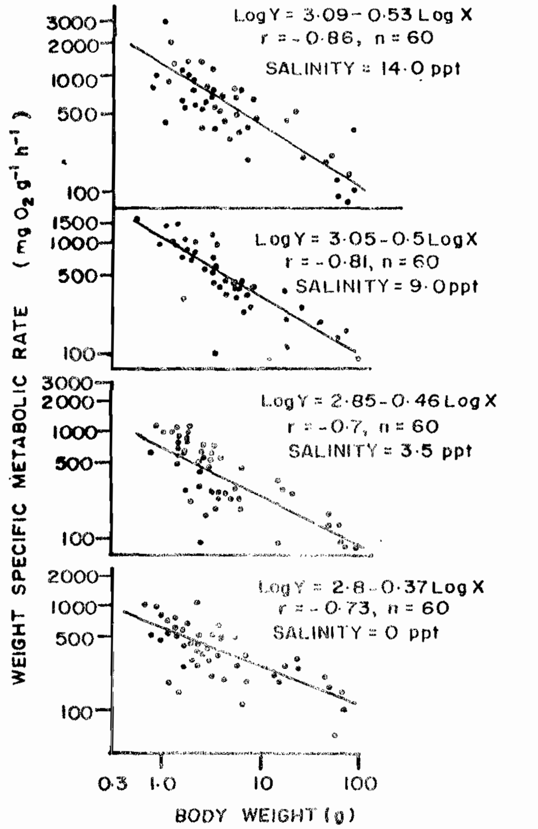

Fig. 2 Relationship between weight specific metabolic rate and body weight of O. niloticus in various salinities

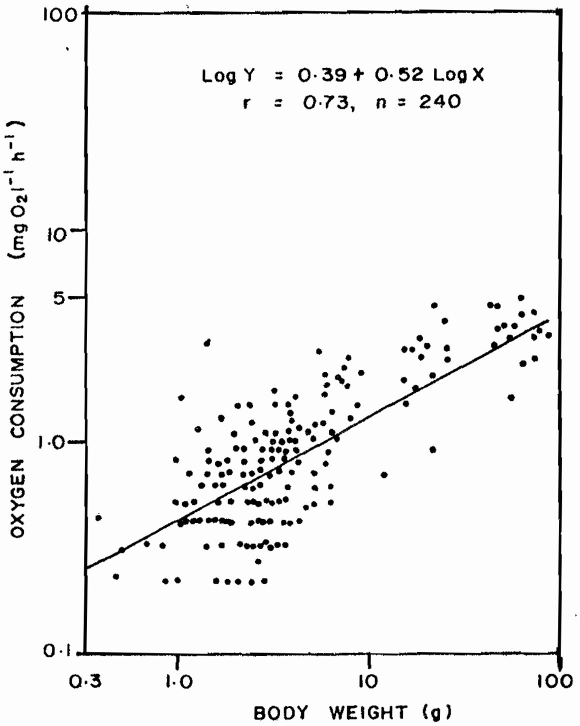

Fig. 3 Relationship between oxygen consumption and body weight of O. niloticus, pooled data from all test salinities

metabolic rate) (Fig.2). Analysis of variance did not show any significant difference ($P > 0.05$) in oxygen consumption rates and weight specific metabolic rates over the range of salinities tested. Since oxygen uptake did not vary with salinity, data were pooled for joint regression equation (Fig.3 and 4). The log-transformed relationship between weight of fish and the corresponding quantity of oxygen consumed at different salinities is given in Fig.1. A positive linear regression equation was obtained between the weight of the fish and their rate of oxygen consumption at the test salinities. The relationship between the length and weight of the fish was described by the equation $\log Y = -1.52 + 3.0 \log x$, $r = 0.92$, $n = 60$, were x = length and Y = weight.

DISCUSSION

The oxygen consumption and specific metabolic rates were similar over the range of salinities tested, and a general trend of increase in oxygen consumption with

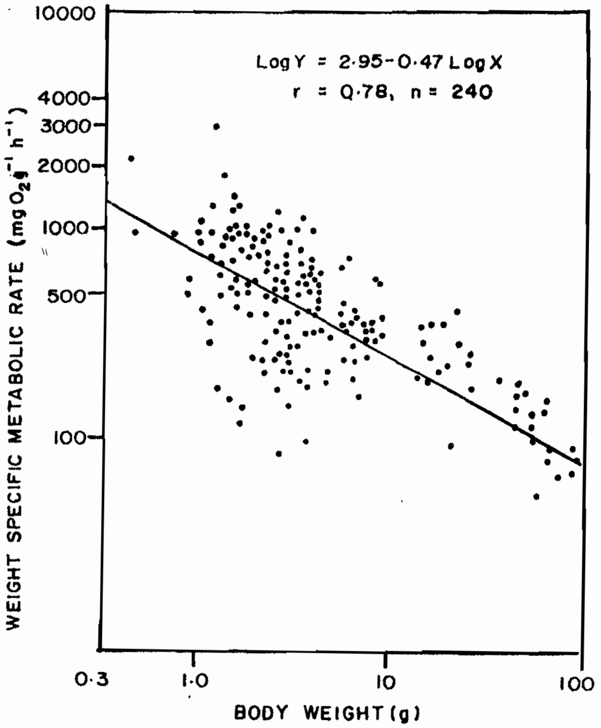

Fig. 4 Relationship between weight specific metabolic rate and body weight of O. niloticus, pooled data from all test salinities

increasing weight of fish was observed. This implies that oxygen consumption is generally proportional to a power function of weight. By the same token, as the fish grows, its weight specific metabolic rate decreases. The implication of this is that the amount of oxygen utilized by *O. niloticus* at a unit time (metabolic rate) increased with increasing body weight while the weight specific metabolic rate increased with decreasing body weight. These results are in conformity with those of many other workers (Newell and Pye, 1971; Aldrich, 1975; Dixon and Milton, 1978; Brill, 1979; Jobling; 1982)

The power function of the weight b has been estimated for several organisms. Using data from various authors, a mean value of 0.8 ± 0.072 has been calculated for marine teleosts (Windberg, 1960). The b value for cichlids are generally in the region of 0.5. From our joint regression analysis, the value for *O. niloticus* in this study was 0.52.

The variation in the reported values of b for different fishes could, among other things, be attributed to differences in the surface area of their gills (Jobling, 1982). For instance, plaice with relatively smaller gill surface area exhibits lower metabolic rate than round bodied fishes with larger gill surface area (da Jeager *et al* 1977).

Within the range of test salinities used in ~~this~~ study, the oxygen uptake by *O. niloticus* was found to be independent of salinity. The implication of this is that *O. niloticus* does not expend extra energy in oxygen consumption in a more saline environment than in freshwater milieu.

The changes in oxygen consumption of many fishes in various salinity regimes are different. According to Brett (1981) the metabolic cost of osmoregulation in salinities up to 20 ppt was not sufficient to cause a significant effect on the growth metabolism of chinook salmon. For *Tinca vulgaris* and *T. tinca*, an elevated salinity above 15 ppt would cause a depression in oxygen uptake, and subsequent death at higher salinities. On the other hand, for *Carassius carassius* there is an initial increase in oxygen consumption with increase in salinity up to isotonic level, and a subsequent decrease in oxygen consumption as the medium becomes hypertonic (Watanebe *et al.*, 1988).

What happens to fresh water fish when exposed to a higher salinity milieu has been explained by Maceina *et al.*, (1980). There is a reduction in volume and an increase in concentration of urine; blood flow to the renal glomeruli is attenuated and iron filtration and reabsorption is prevented leading to the inhibition of the passing out of dilute urine. The resultant effect of this is that body water is conserved when fresh water fish is transferred to a higher salinity. Another strategy is that the amount of blood passing through the gills are regulated with attendant effect of reducing the effective area of the gill epithelium. A fresh water fish which finds itself in a high salinity environment will generally lower its activity and blood circulation rate resulting in a concomitant reduction in its oxygen consumption . In this study, a 21 g fish, for example, had its oxygen consumption reduced from 0.69, to 0.63, to 0.4, to 0.43 mg/l in salinities of 0, 3.5, 9.0 and 14.0 ppt, respectively. However, the fact that these oxygen consumption values were not, statistically, significantly different from each other, indicates that the metabolic energy used by *O. niloticus*_ for osomoregulation was not sufficient to effect a significant change in the oxygen demands of the fish in different salinities up to 14.0 ppt.

Salinity has also been shown to exert some profound effect on other physiological parameters (e.g survival/tolerance, growth, food intake and condition) of tilapiine fishes. Salinity tolerance (survival) in tilapiine fishes is a function of ontogenicity. For example, in Florida Red Tilapia, there is a tendency towards increased tolerance with age (Watanabe *et al*.;_1990). For *O. niloticus*, Watanabe *et al.* (1985) found that salinity tolerance remained low until 45 days post-hatching, after which there is an increase in tolerance till a maximum value is obtained at 150 days post-hatching. Salinity of 5 ppt seems to be the best in terms of hatching success of eggs of *O. niliticus,* although fecundity (egg production) was found to be lower with increased salinity (Watanabe *et al.*, 1985).

Food consumption and consequently growth of tilapia is also influenced by salinity. Florida Red Tiliapia (Watanabe *et al.*,1984) grow better with increasing salinities. For Florida Red Tilapia salinity did not just affect growth but also the degree of fatness (condition) and the increase in growth was attributed to increased food consumption.

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