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COMPENSATORY REGULATION IN *M. armatus* AND *P. sophore* (FRESH WATER FISH) ACCLIMATED TO COLD AND WARM TEMPERATURE

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Over a wide range of temperature, thermal compensation occurs for the maintenance of metabolic regulation in most of the fishes with the environment. Poikilotherms regulate their metabolism and activity in the compensatory direction against thermal stress under natural as well as laboratory conditions. Therefore, there is a compensatory regulation in the oxygen consumption of *P. sophore* and *M. armatus* to seasonal thermal variation. Compensation in the oxygen consumption of brain, liver and muscle of a tropical freshwater teleost, *Puntius sophore* acclimated to cold (20°C) and warm (35°C) temperature, was found varying significantly. The pattern of compensation was size dependent in their tissues. The tissues from the smaller fish were found to compensate to a greater degree than those from the larger ones. Temperature acclimation also leads to compensatory responses which, while species- specific,consistently increase the capacity for sustained swimming at low temperature.

INTRODUCTION

It has been known that poikilotherms compensate in their metabolism and activity during thermal acclimation and that such compensation occurs at different levels of organisation. Only a few of them are aimed at establishing the interaction between the intact fish and it's tissues . Each tissue has its own pattern of temperature compensation which need not necessarily be the same as that of the intact animal. Extensive evidence has been coming forth in substantiation of the concept that poikilotherms regulate their metabolism and activity in the compensatory direction against thermal stress, under natural as well as laboratory conditions (Parvatheswara Rao 1959 and Prosser, 1958).

Fishes are primarily water breathers, where gills take care of the total metabolic gas exchange. However, bimodal gas exchange has been reported in many teleostean fishes where gills are supplemented by skin and buccopharyngeal breathing. The growth studies on O_2 consumption indicate almost similar relationship of oxygen consumption and respiratory area to body weight. The present study is an attempt to provide the possible relationship between O_2 consumption and respiration of a freshwater mud- eel, *Mastacembelus armatus* at two ambient water temperature where bimodal gas exchange mechanism exist, uses both the gills and skin to obtain oxygen from water and air.

Metabolic regulations and studies were directed at different organisational levels of the animals, such as the organismal, cellular and even at the sub cellular level. This type of approach, besides establishing the fact of metabolic compensation to thermal stress elucidates its modus operandi (Bullock, 1955; Prosser, 1958; Parvatheswara Rao, 1971a, 1971b).

M. armatus is found in fresh and brackish water in the plains and hills of India. Colour of the fish is rich brown above paler beneath with a black and dark brown irregular zig zag pattern between lateral lines on dorsal ridge; length up to 61 cm; good for eating.

P. sophore is common all over India,found in shallow ponds and streams,body silvery with a yellowish tinge; size up to 13 cm. long. Fish is reported to have a bitter taste and also considered medicinal.

In the majority of fishes there is a general increase in metabolic rate with increase in temperature. Influence of metabolic rate as expressed in terms of oxygen consumption has been studied in a number of fish species (Pandey, 1978).

MATERIAL AND METHODS

Living specimens of different sizes of *Mastacembelus armatus* (Lac) and *Puntius sophore* (Ham) were transferred to laboratory glass aquarium with continuous flow of water. The fishes were acclimatized to the laboratory conditions for a fortnight. The fishes were fed daily on pieces of earthworm or goat liver.

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1. Thermal stress and compensatory metabolic regulation

Both the winter and summer samples were used. The winter fish samples were collected in November and stocked in laboratory aquaria till their oxygen consumption was measured towards the middle of January. Similarly the summer samples were collected in April and stocked in laboratory aquaria till their oxygen consumption was measured towards the middle of theJune. The oxygen consumption of the fish of different sizes was measured at 25° and 35°C as described by Parvatheswara Rao (1959) using the unmodified Winkler's iodometric method as described by Welsh and Smith (1960). The water temperature was around 24°C (± 1°) during winter and 31°C (±1°) during summer. In the case of the summer fish their oxygen consumption was also measured at the habitat temperature 31°C. In the case of the winter fish no separate measurements were made at their habitat temperature, as 25°C was most appropriate to the winter habitat temperature (24° ±1°C) and the measurements already made at 25°C were taken to represent the oxygen consumption of these winter fish.

The fish was isolated and starved 24 hr prior to the measurement of their oxygen consumption, so as to eliminate the influence of differential feeding on their oxygen consumption. Before actual measurement the fish was allowed an equilibration time of 30 min, during which period a uniformly gentle flow of water was maintained through the respiration chambers. This is to bring the fish down to a state of normalcy from a state of excitement resulting out of handling procedure. Measurements were made on individual fish at the same time each day, so as to eliminate the interference of diurnal rhythms on their oxygen consumption. After measuring the oxygen consumption, the weight of each fish was recorded. Entry of light into the respiration chambers was prevented by giving them a thick coat of black paint because light stimulated the fish to higher levels of oxygen consumption.

2. Initial Adaptive Responses to Thermal Stress

Time course of acclimation of oxygen consumption to warm (35°C) and cold (20°C) was studied in *P. sophore*. In each case a number of individuals of different sizes were experimented upon to assess whether these metabolic responses to thermal stress are size dependent. Oxygen consumption was measured as per the method described earlier (Parvatheswara Rao, 1959) using the Winkler's iodometric method for the estimation of dissolved oxygen content of the water samples (Welsh and Smith, 1960). In each fish the basal rate of the oxygen consumption was measured.

For warm acclimation fishes were kept in thermostatically controlled water baths adjusted to 35°C (±0.5°C) and for cold acclimation in a B.O.D. type incubator adjusted to 20°C (±0.5°C) when *P. sophore* was studied the room temperature was 29°C. Oxygen consumption of the fish was measured at the same time each day to eliminate the possible interference diurnal rhythms.

The difference of significance was calculated by student t-test at the level of 5%. Calculation of Q10 Values : Q10 (Change per 10°C rise in temperature) values were calculated by the formula $\log Q10 = (\log M2 - \log M1)/(T2 - T1) \times 10$ Where M1 and M2 are the mean value of parameters at ambient water temperature T1 and T2.

RESULTS AND DISCUSSION

Compensatory metabolic regulation to thermal stress in *M. armatus* (Lac) and *P. sophore* (Ham) have been studied. There was an initial increase in the oxygen consumption of fish on transfer to high temperature (35°C) but there was a steady decline in the oxygen consumption leading to the attainment of a new stable level on continued exposure to this temperature (35°C).

In the case of *P. sophor*e warm acclimation was complete and proceeded fast, while cold acclimation was only partial and proceeded relatively slowly. Conversely, warm acclimation in *M. armatus* although fast, but partial.

Oxygen consumption of the fish initially dropped on transfer to 20°C but there was a gradual increase in the oxygen consumption on continued exposure to the temperature (20°C), in the course of the following few days leading to the attainment of a few stable level which however, was lower than the original level. Therefore, cold acclimation in *P. sophore* can be best considered partial.

The experimental approach for the metabolic rates of cold and warm acclimated animals have been compared at a few common acute temperatures within or even outside the range without taking into account the normal metabolic rate at the natural habitat temperatures.

It is suggested that in order to make this assessment more reliable, metabolic compensation to the cold and warm acclimation temperatures should be treated as two separate and independent processes and assessed as such relative to the controls. The ecological significance and physiological interest of metabolic temperature compensation in poikilotherms have also been found to play some significant role.

The interrelation between the intact fish and its tissues with the reference to the metabolic temperature compensation was studied. The coincidence between the types of compensation in the intact fish and its brain suggested an important role for the central nervous system in the regulation of the compensatory processes in the fish. The possible physiology behind varying degrees of compensation in the different tissues might play an important role.

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