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Respiratory Responses Of Indian Major Carp *Catla Catla* (Hamilton) During Thermal-Stress And Thermal-Adaptation

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ABSTRACT
The two vital respiratory parameters namely Oxygen consumption of the whole fish and the Opercular activity in the Indian Major Carp was investigated during thermal-stress and Thermal-adaptation. The Indian major carp *Catla catla* subjected to and Slow temperature change from 22 ºc to 32ºc (heat-adaptation) and 32ºc to 22 ºc (cold -adaptation) at the rate of 1ºc 60 hours showed a gradual stepping-up of oxygen consumption and opercular activity in heat-adaptation and a stepping-down of oxygen consumption and opercular activity in the case of cold-adaptation and in both cases reached the control values within 35 days, where as *Catla catla* exposed abruptly to a temperature change from 22 ºc to 32ºc (heat-stress) and 32ºc to 22 ºc (cold -stress) at the rate of 1ºc hour exhibited neither stepping-up nor stepping-down in oxygen consumption and opercular activity and they could not reach the control values within 35 days. Stress is a physiological load acted upon the fish, where as adaptation is a slow process of compensation without physiological load

Key Words--*Catla catla*, oxygen consumption, opercular activity, Temperature-Stress, Temperature-adaptation

Introduction

Temperature is one of the most important environmental factors with tremendous influence on the Eco-physiology of organism. Fishes are to be found inhabitants of environmental temperatures ranging from below 0°C to 50°C.The rate of metabolic process in the form of activity of animals is influenced by the ambient temperature (T Das et al ,2004 & 2006) This environmental factor exerts a tremendous influence on the eco-physiology of animal, its activity and distribution (Precht et al, 1973). A great deal of work has been done in poikilotherms in relation to temperature compensation (Kinne,1964 a,b; Fry 1964; Pampathirao 1965; Hazel and Prosser 1974; Bashamohideen1984). The adaptation to a new temperature or a change in temperature involves a number of active processes and hence energy expenditure is needed for metabolic re organisation (Hochachka, 1961a,b; 1967, 1969; Hochachka and Somero, 1968, 1973).

The adaptation is a slow process in which the fish adjusts to a slow change in the environment without physiological load on the part of it. Extensive work has been done and voluminous data are available in these areas of thermal-adaptation in poikilotherms, especially in fishes (Kinne, 1964 a,b; Fry, 1964,1970; Prosser, 1965; Pampapathi Rao, 1967; Precht et al, 1973; Hazel and Prosser, 1974; Basha Mohideen, 1979, 1983, 1986; Mushtaq Ahmed, 1988; Abdul Rahim, 1989; Shankar Naik, 1993). Stress" is used to mean the environmental factor itself and a stress factor or "stressor" is an environmental change that is severe enough to require a physiological response on the part of the animal.

In several fishes, it was reported that adaptation to higher temperature proceeds faster than adaptation to lower temperature. Therefore in fishes increases in heat resistant through warm adaptation is faster than the loss of it or gain in cold resistance through cold-adaptation (Spoor, 1955; Brett, 1956). Measurement of oxygen consumption and the Opercular activity have been employed more than any other experimental parameter to monitor changes in metabolism associated with temperature-adaptation. The uptake of oxygen rate is considered as a good index for overall physiological activity and an indicator of environmental-stress of the animal, and such a physiological index is easy to obtain both in the field and in the laboratory with a variety of environmental stresses, including the temperature-stress of the present investigation. With this background an attempt is made in this paper Respiratory responses of Indian Major Carp *Catla catla* (HAMILTON) during thermal-stress and Thermal-adaptation

MATERIAL AND METHOD

The experimental male fish *Catla catla* weighing 20±2 grams were collected from local Government Fisheries Department, Anantapur and stored in large glass aquaria in the laboratory at room temperature (27°C±0.5°C) and exposed to natural photoperiod. Only male members of the fish *Catla catla* is used throughout the experimentation in order to avoid the effect of sex.

The oxygen consumption of the whole fish was measured by the improved Winkler's method as developed by Basha Mohideen and Kunnemann (1978)

The rate of opercular activity (i.e. ventilatory pump) was studied individually by noting down the time (in seconds) for 10 opercular movements in the respective exposure periods. The rate of opercular activity is calculated using the formula 10/t, where 't' is the time taken for 10 opercular movements In each fish the study was made for three times and mean is taken into account.

Oxygen consumption of the whole fish and the Opercular activity in the Indian Major Carp Catla catla adapted to 22°C and 32°C was measured separately and it was continued till the attainment of constant level in Oxygen consumption and Opercular activity These 22°C and 32°C fishes were re-adapted separately in the following pattern.

(1) The 22°C adapted fishes were re-adapted to a slow temperature change at the rate of 1°C/60hrs from a temperature range of 22°C to 32°C for a period of 35 days (heat-adaptation)

(2) The 22°C adapted fishes were re-adapted to an abrupt temperature change at the rate of 1°C/hr from a temperature range of 22°C to 32°C for a period of 35 days (heat-stress)

(3) The 32°C adapted fishes were re-adapted to a slow temperature change at the rate of 1°C/60hrs from a temperature range of 32°C to 22°C for a period of 35 days (cold-adaptation

(4) The 32°C adapted fishes were re-adapted to an abrupt temperature change at the rate of 1°C/hr from a temperature range of 32°C to 22°C for a period of 35 days (cold-stress)

RESULT AND DISCUSSION

The basic physiological parameters namely the oxygen consumption of the whole fish and opercular activity are much higher in 32°C temperature adapted fishes than that of the 22°C temperature adapted ones. When the fishes were subjected to a slow temperature change at the rate of l°C/60 hrs , there is a gradual stepping-up in the rate of oxygen consumption and opercular activity, and ultimately, in due course of time (i.e., 35 days) the values reached the original levels of the 32°C temperature adapted control fishes as it is seen in (Figs. 3, 5) shows that the fishes are totally adapting to 32°C in the process of heat-adaptation.

While in cold-adaptation, when the fishes were subjected to a temperature change from 32°C to 22°C at the rate of l°C/60 hours, there is a gradual stepping-down in the same parameters namely the oxygen consumption and opercular activity and approximately reaching to the original levels of 22°C temperature adapted control fishes is observe in (Fig.6,8) However, the per cent recovery in the heat-adaptation is relatively higher than that of the cold-adaptation (Table: 1).

On the other hand, when the fishes were subjected to heat-stress from 22°C to 32°C at the rate of l°C/hr, there is no stepping-up of oxygen consumption and opercular activity, and when the fishes were subjected to cold-stress from 32°C to 22°C at the rate of l°C/hr, there is no stepping-

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down of oxygen consumption and opercular activity, and reaching of the control (values of 32°C temperature adapted fishes for heat-stress and values of 22°C temperature-adapted control fishes for cold-stress) is not to be seen (Figs. 4, 7) even after a period of 35 days. The rate of oxygen consumption and opercular activity of these stressed fishes (heat-stressed and cold-stressed) fluctuate considerably over a longer period of time, some times weeks. when fishes transferred to new temperatures. Such fluctuations may be the result of the operation of stress phenomenon, as also noticed in other cases.

Therefore a linear relationship is established between oxygen consumption and opercular activity, as also revealed in the present investigation. Moreover, the fluctuations in the opercular activity, And very interestingly the vetilatory frequency slowly increased, unlike in stress situation and reached the control levels in Catla catla subjected to (32°C temperature adapted fishes) in the case of heat-adaptation, and the same is slowly decreased reaching he control values (22°C temperature-adapted fishes) in the case of cold-adaptation. In both adaptations heat as well as cold the Catla catla was subjected to a slow temperature change at the rate of l°C/60 hrs (2 1/2 days). Therefore, the heat-adapted fishes exhibited a fairly good amount of per cent recovery in oxygen consumption (93.33%) and opercular activity (95.23%) when compared to the heat-stressed fishes which were recorded only (53.17%) and (77.10%) recovery in the rate of oxygen consumption and opercular activity; and also the cold-adapted fishes showed a fairly good amount of per cent recovery of (89.50%) and (90.94%) with reference to oxygen consumption and opercular activity when compared to cold-stressed fishes which showed (51.60%) and (62.09%) recovery is relatively higher in the case of heat-adaptation than that of the cold-adaptation in this fish Catla catla (Table: 2).

TABLE-1

Comparision between heat-stress and heat-adaptation with reference in per cent change and per cent recovery in physiological parameters in *Catla catla*
at 35th day exposure

Physiological parameters	Per cent change		Per cent recovery	
	Heat-stress	Heat-adaptation	Heat-stress	Heat-adaptation
Oxygen consumption	9.23	91.71	53.17	93.33
Opercular activity	41.27	74.49	77.10	95.23

TABLE-2

Comparision between cold-stress and cold-adaptation with reference in per cent change and per cent recovery in physiological parameters in *Catla catla*
at 35th day exposure

Physiological parameters	Per cent change		Per cent recovery	
	Cold -stress	Cold - adaptation	Cold -stress	Cold - adaptation
Oxygen consumption	-27.75	-51.16	51.60	89.50
Opercular activity	-24.72	-40.47	62.09	90.94

This high degree of recovery is reflected in the corresponding high per cent recovery in the stress condition. Thus, the study of the rate of oxygen consumption and opercular activity clearly reveals the distinction between slow and abrupt transitory changes taking place in the range of ambient temperature from 22°C to 32°C and vice-versa. Hence the time course of oxygen consumption and opercular activity when compared and considered together, could serve as good indicators of thermal-stress and also used as suitable and convenient tools for differentiation of temperature-stress from temperature-adaptation and ultimately are useful for monitoring thermal pollution in aquatic environment.

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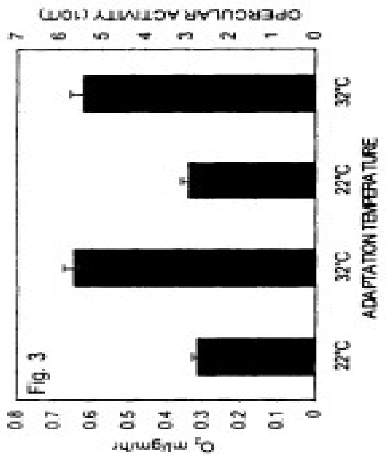
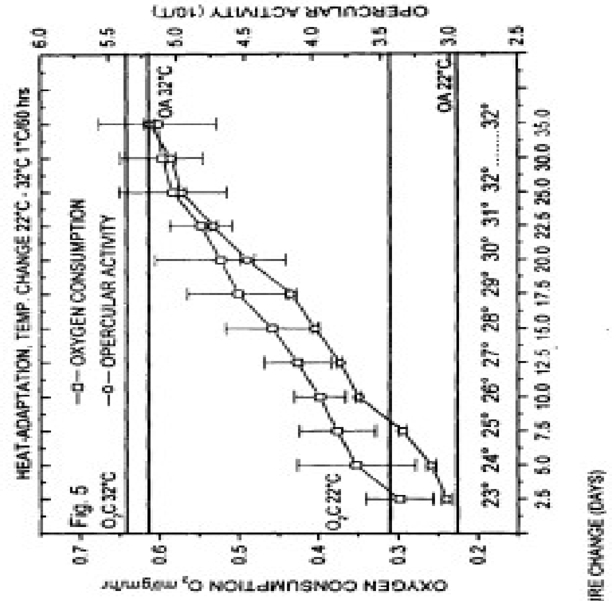
Figures





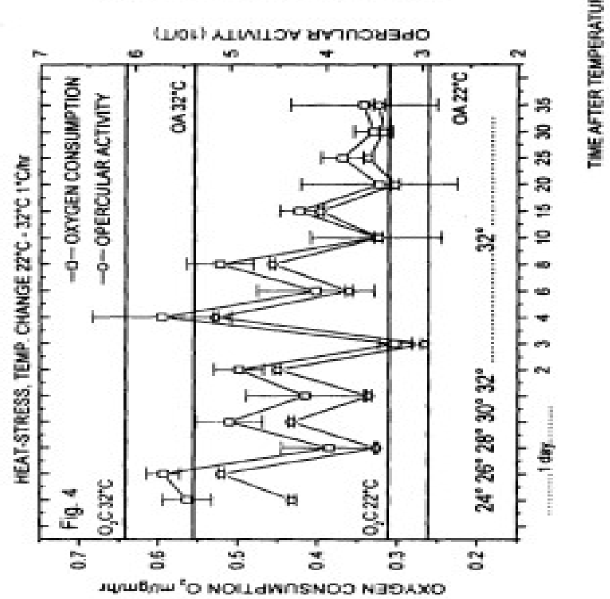


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FIGURE - 3

Histograms showing the levels of the rate of oxygen consumption (O_2 ml/gm/hr) and opercular activity (10/time in seconds for ten opercular movements) in *Catla catla* adapted to 22°C and 32°C temperatures. Each histogram is a mean of six individual measurements.

FIGURE - 4

Rate of oxygen consumption (O_2 ml/gm/hr) (□) and opercular activity (10/time in seconds for 10 opercular movements) (O) in *Catla catla* subjected to an abrupt temperature change from 22°C to 32°C (heat-stress) at the rate of 1°C/hr. Each point is a mean of six individual measurements. Vertical bars represent standard deviation.

FIGURE - 5

Rate of oxygen consumption (O_2 ml/gm/hr) (□) and opercular activity (10/time in seconds for 10 opercular movements) (O) in *Catla catla* subjected to slow temperature change from 22°C to 32°C (heat-adaptation) at the rate of 1°C/60 hrs. Each point is a mean of six individual measurements. Vertical bars represent standard deviation.

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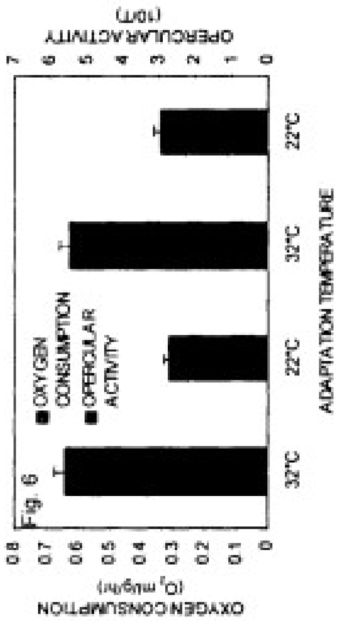

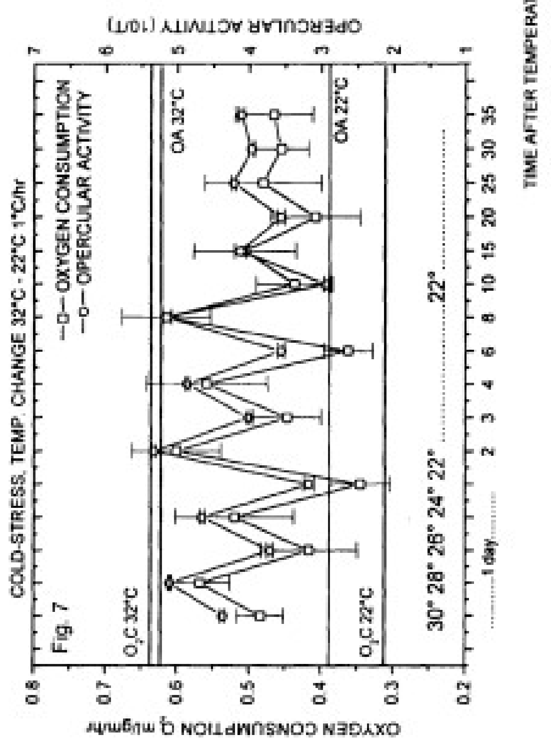

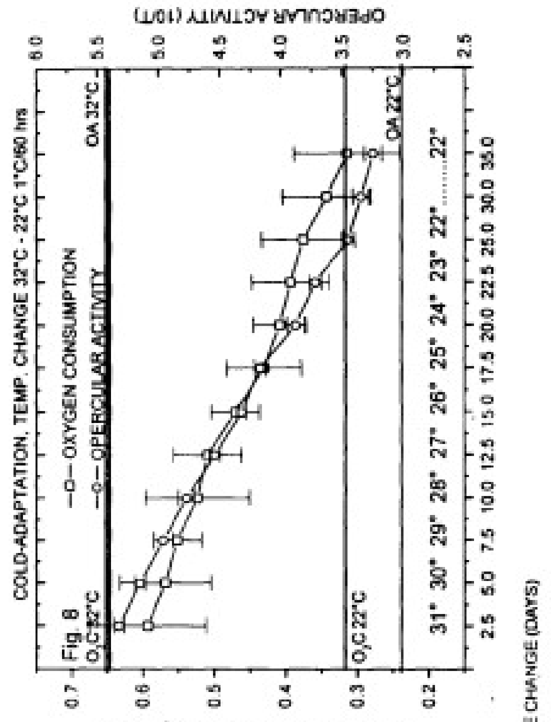

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FIGURE - 6

Histograms showing the levels of the rate of oxygen consumption (O_2 ml/gm/hr) and opercular activity (10/time in seconds for ten opercular movements) in *Catla catla* adapted to 32°C and 22°C temperatures. Each histogram is a mean of six individual measurements.

FIGURE - 7

Rate of oxygen consumption (O_2 ml/gm/hr) (□) and opercular activity (10/time in seconds for 10 opercular movements) (O) in *Catla catla* subjected to an abrupt temperature change from 32°C to 22°C (cold-stress) at the rate of 1°C/hr. Each point is a mean of six individual measurements. Vertical bars represent standard deviation.

FIGURE - 8

Rate of oxygen consumption (O_2 ml/gm/hr) (□) and opercular activity (10/time in seconds for 10 opercular movements) (O) in *Catla catla* subjected to slow temperature change from 32°C to 22°C (cold-adaptation) at the rate of 1°C/60 hrs. Each point is a mean of six individual measurements. Vertical bars represent standard deviation.

CONCLUSION

Thus the study on The two vital respiratory parameters namely Oxygen consumption of the whole fish and the Opercular activity in the Indian Major Carp reveals the distinction between slow and abrupt transitory changes taking place in the range of ambient temperature from 22°C to 32°C and vice-versa. Thus studies of this nature are highly useful in the evaluation of rates of temperature which acts as stressors and induce stress situation, and on the other in the

evaluation of "safe" and ideal rates of temperature which do not act as stressor but, result in the slow and easy compensation of adaptation without physiological load on the part of the animal and evaluation techniques concerned with economical rearing and conservation of useful fauna of the aquatic habitat.

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