EFFECT OF TEMPERATURE ON RESPIRATION OF *LABEO FIMBRIATUS* (BLOCH)

H. MOHAMAD KASIM
Central Marine Fisheries Research Institute Centre, Veraval.

ABSTRACT

Labeo fimbriatus (Bloch) was tested at non-lethal temperatures to measure its oxygen uptake both in oxygen dependant and independant zones. The metabolic rate was almost uniform in oxygen independant zone, in oxygen dependant zone reduced drastically and then oxygen level becomes lethal. This species regulated the oxygen consumption at lower rate at extreme high and low temperatures than at intermediary optimum temperatures. The lethal oxygen level was much higher at low temperatures, whereas it was the lowest at optimum temperature. The highest lethal oxygen level at low temperature is attributed to the inhibition in oxygen uptake. Cold-acclimated fish consumed more oxygen than the warm-acclimated fish. The time to death was the highest at low temperature.

INTRODUCTION

The effect of temperature as controlling factor, regulating metabolism (energy utilization), has been studied extensively on aquatic organisms. These studies are highly essential when the growth of the organisms and their production potentials are considered during their culture process. The reviews by Prosser (1955), Bullock (1955), Prosser and Brown (1961), Fry (1971) and Kinne (1960, 1970) give a vivid account on the different aspects of animal responses to temperature changes.

Various workers have studied on the oxygen consumption in relation to different aspects. Of all these, the limiting effect of oxygen partial pressures (pO_2) upon oxygen consumption is considered as an important aspect (Shepard 1955), which has been generally ignored by many workers in the past. Further, in view of the present stress being given on the culture of aquatic organisms in sewage and waste waters, the present work on the effect of oxygen uptake within the zone of respiratory dependance on the young carp will be of significance for successful culture of this species.

MATERIALS AND METHODS

The material used for the present study was the fringe-lipped carp, *Labeo fimbriatus* (Bloch) young ones, 2.97 $\pm$ 0.64 cm and 369 $\pm$ 117.9 mg, obtained from the induced-spawning centre of Tamil Nadu Fisheries Department, Vaigai

Dam. The fish were acclimated to 25 and 30°C ± 1°C 70 l aquaria and fed daily once with formulated diet. The temperature in the acclimation and test tanks was controlled as explained by Kasim et al (1977).

Uniform-sized fish were selected for one set of experiment. Conical flasks of 110 ml capacity were used as respiration chambers and the experiments were conducted in triplicates. Fifteen fish were used for one set of experiment. Fish were selected and introduced into the respiration chambers which contained air-saturated water at the required temperature maintained over night. The flasks were closed air tight with provision to tap out water sample for analysis and were incubated in 70 l aquaria in which the required test temperature was maintained. At regular intervals of time water samples were drawn from the respiration chambers one after another and the last chamber was left out till the fish died due to anoxia. After water sampling, the flasks were discarded and the fish were weighed and measured serially. The difference in the initial and final reading of the oxygen content gave the oxygen consumed by the fish. The partial pressure of oxygen which was near air-saturation initially gets gradually reduced and monitored by the oxygen uptake by fish in due course of time and this in turn affects the oxygen consumption of the fish. The time interval for water sampling was kept short at high temperatures and was increased towards low temperatures. Modified Winkler's method (Strickland and Parsons 1968) was used to determine the oxygen content in water samples. Though each experiment was conducted with five different fish, it is assumed as having carried out with single fish as the fish were more or less of same weight.

Results and Discussion

The rate of oxygen consumption (mg|g|h) was calculated from the raw data. As these data pertain to different varying oxygen partial pressures (pO_2 mm Hg), they were further standardised by plotting on an arithmetic graph to obtain the metabolic rate uniformly at pO_2 25, 50, 75, 100, 125 and 150 mm Hg as shown in Fig. 1 for 30°C acclimation. The respiration curves fitted through the plots in Fig. 1 are typical and exhibit the respiratory response of this species to different pO_2 and temperatures. As seen from Fig. 1 the rate of oxygen consumption was almost uniform at all oxygen partial pressures approximately above 100 mm Hg at respective test temperatures. Subsequently, the metabolic rate tends to decline at a particular partial pressure below 100 mm Hg. The fish is supposed to enter the oxygen dependant zone at this partial pressure where it is subjected to metabolic stress. The oxygen dependant zone can be demarked from the oxygen independant zone at this point where the oxygen uptake becomes entirely dependant on oxygen partial pressure and this place can be called as 'critical tension point.' At this critical tension point the almost uniform rate of oxygen uptake at higher oxygen partial pressures becomes drastically reduced and the function of resipration stops at still lower partial pressures as the oxygen level becomes lethal.

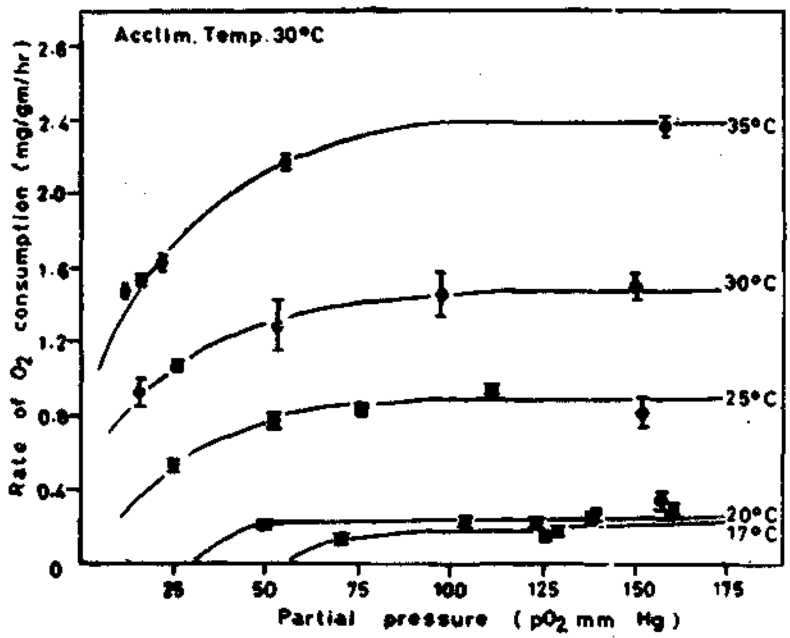

FIG. 1. Rate of oxygen consumption (mg/g/h) as different oxgen partial pressures ($p0^2$ mm Hg) for *L. fimbriatus* acclimated to 30°C and tested at different temperatures as indicated.

The standardised rate of oxygen consumption thus obtained from the above treatment is characteristic and is directly proportional to temperature and pO_2. This can be clearly seen from Fig. 2 where these data are plotted on a semilogarithmic chart and regression lines have been fitted through the plots. The effect of temperature acclimation is very much evident from these lines. The 25°C-acclimated fish maintained higher metabolic rate than the 30°C-acclimated fish at test temperatures 20 and 25°C, and at 30°C the metabolic rate of both the acclimations was almost uniform. At 35°C, the 30°C-acclimated fish maintained much higher metabolic rate than the 25°C-acclimated fish. Further, the metabolic rate of the latter was lower when tested at 35°C than at 30°C (Fig. 2). This can be attributed to the regulation of the oxygen uptake at a lower rate by this species at 35°C as this temperature is sublethal for this species when acclimated to 25°C (Kasim 1979). It is an advantage among the poikilotherms to depress the oxygen uptake at extremes of temperatures which are quite nearer to sublethal levels and increase the same at intermediary optimum temperatures as a means of compensation (Prosser 1958, Precht 1958, Fry 1971).

The formulae pertaining to the regression lines shown in Fig. 2 are given in Table 1. The slope of these regression lines indicates the declining trend of

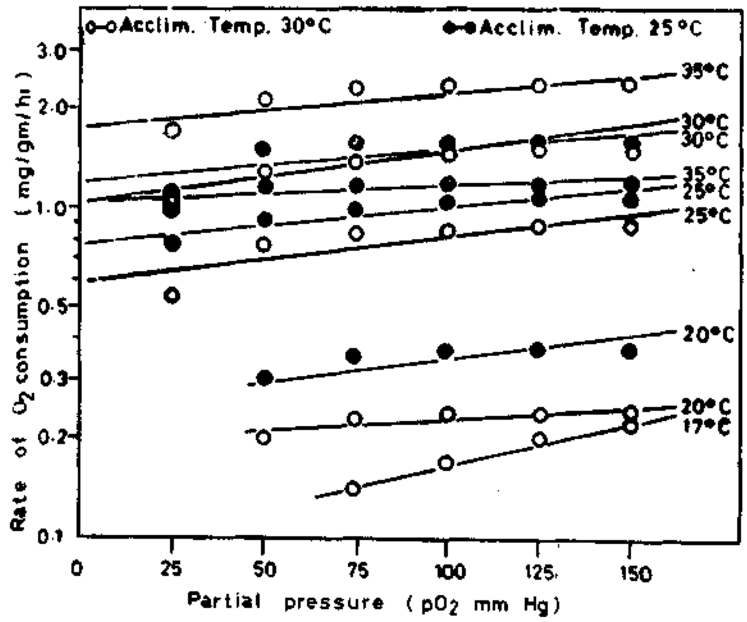

FIG. 2. The rate of oxygen consumption (mg/g/h) at oxygen partial pressures 25, 50, 75, 100, 125, and 150 mm Hg for *L. fimbriatus* acclimated to 25 and 30°C and tested at different temperatures. Plotted on semilogarithmic graph.

the metabolic rate as the oxygen partial pressures decrease. In general, the proportionate reduction in oxygen uptake at various partial pressures appears to be almost uniform at all temperatures. This observation is in consonance with the report of Job (1955) in speckled trout and by Wycliff (1972) in freshwater prawn. The regression lines pertaining to 17 and 20°C of 30°C acclimation are treminated at pO_2 75 and 50 mm Hg, respectively, and also the line of 20°C of 25°-acclimation is cut off at pO^2, 50 mm Hg, as they are supposed to enter the lethal oxygen level (Fig. 2). Further, the lethal oxygen partial pressure at which the fish succumbs due to its inability to absorb any more oxygen increase as the temperature decreases. This is due to the inhibitition in oxygen uptake among poikilotherms at lower extreme temperatures.

TABLE 1. *Formulae for the regression lines fitted in Fig.* 2 *for* Labeo fimbriatus *(Bloch) acclimated to* 25 *and* 30°C *and tested at different temperatures.*

35	Y = 1.0242 + 0.0014 X	Y = 1.7459 + 0.0052 X
30	Y = 1.1740 + 0.0035 X	Y = 1.0710 + 0.0034 X
25	Y = 0.7580 + 0.0025 X	Y = 0.5801 + 0.0026 X
20	Y= 0.2276 + 0.0012 X	Y = 0.1940 + 0.0004 X
17	—— ——	Y = 0.0610 + 0.0011 X

The lethal oxygen level for 25°C-acclimated *L. fimbriatus* was 0.49, 0.37, 0.92 and 0.62 mg|l at 20, 25, 30 and 35°C, respectively, and for 30°C-acclimated fish was 1.02, 0.44, 0.53, 0.67 and 0.53 mg|l at 17, 20, 25, 30 and 35°C, respectively. The lethal oxygen levels are higher at low temperatures than at high temperatures. This corroborates the above observation, that this species could not utilize the available oxygen at low temperatures due to inhibition in oxygen uptake. This inhibition in oxygen uptake appears to be very low at higher extreme temperatures and there seems to be no such inhibition exists at intermediary temperatures as the oxygen has been used up as low as 0.37 mg|l at 25°C by fish acclimated to the same test temperature. This phenomenon is similar to that reported by Ananthakrishnan and Kutty (1974) in murrel and by Kutty and Peer Mohamed (1975) in freshwater mullet.

The time to death is interdependant on lethal oxygen level and average rate of oxygen consumption. Among 25°C-acclimated fish, the time to death was 564, 321, 315 and 186 minutes at 20, 25, 30 and 35°C, respectively, and among 30°C-acclimated fish it was 1080, 562, 230, 146 and 161 minutes at 17, 20, 25, 30 and 35°C, respectively. The relationship between the time to death and lethal oxygen level is depicted in Fig. 3, where the time to death decreases for every increase in temperature. As seen from this figure, the lethal oxygen level and the time to death are higher at low temperature. Subsequently, both decreases at intermediary temperature, i.e., 25°C and then the lethal oxygen level shoots up again at high temperatures due to the inhibition in oxygen uptake as mentioned earlier. On the other hand, the time to death continues to decline as the temperature advances and this decline is due to the higher rate of oxygen consumption at these temperatures.

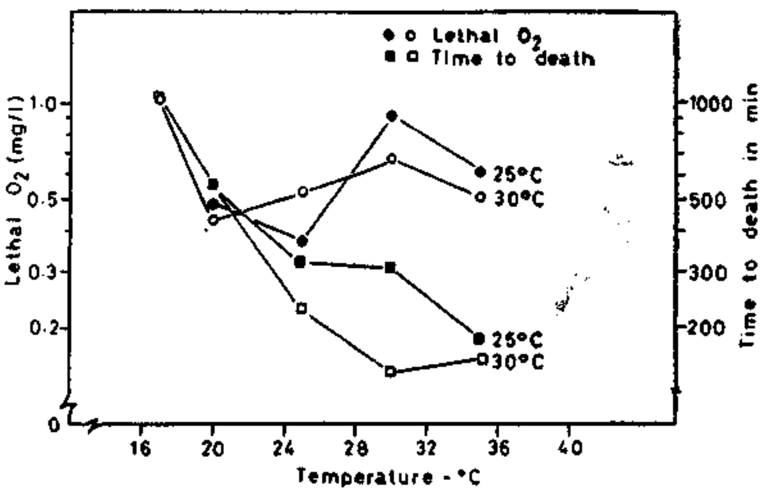

FIG. 3. Lethal oxygen level (mg/l)and time to death (minutes) at different temperatures for *L. fimbriatus* acclimated to 25 and 30°C.

The average rate of oxygen consumption for 25°C-acclimated fish was 0.4, 0.89, 1.34 and 1.11 mg|g|h at 20, 25, 30, and 35°C, respectively, and for 30°C-acclimated fish it was 0.22, 0.25, 0.79, 1.26 and 1.84 mg|g|h at 17, 20, 25, 30 and 35°C, respectively. The average rate of oxygen uptake, time to death and temperature are correlated in Fig. 4. As the temperature increases the oxygen

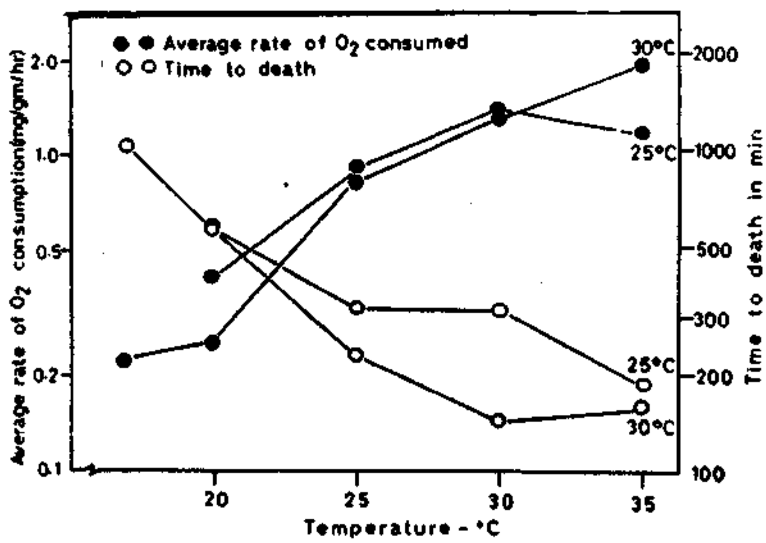

FIG. 4. Average rate of oxygen consumption (mg/g/h) and time to death (minutes) at different test temperatures for *L. fimbriatus* acclimated to 25 and 30°C.

uptake also increases and consequently the time to death dcreases. In many instances the cold-acclimated animals consume more oxygen or exhibit greater activity than the warm-acclimated animals at all temperatures (Gibbson and Fry 1954, Job 1955, 1959 and 1969, Ananthakrishnan and Kutty, 1974, Davis 1968 and Kutty 1972). This is true in the present study also. As seen from Fig. 4, the rate of oxygen consumption of 25°C-acclimated fish are comparatively higher than the 30°C-acclimated group in all test temperatures except at 35°C which, as pointed out earlier, is sublethal level for this species (Kasim 1979). Naturally, as the rate of oxygen uptake is high among the 25°C-acclimated fish the time to death also appears to be higher than the 30°C-acclimated fish. This is mainly because the oxygen consumed was more than the 30°C-acclimated group.

The data on the rate of oxygen consumption were subjected to further analysis of variance (Snedecor and Cochran 1967) and the results are summarised in Table 2. These results are conclusive and clearly indicate that the above described responses of this species with repect to respiratory metabolism are highly significant at both the comparisions 'between temperatures' and 'between partial pressures.' The adaptive response of this species to temperature

TABLE 2. *Results from analysis of variance of rate of oxygen consumption* (mg| mg|h) *at different temperatures for* Labeo fimbriatus (*Bloch*) *acclimated to 25 and 30°C and tested at different temperatures.*

Acclim. temp.	Comparisions	Sum of square	Degree of Freedom	Variance	Value of F ratio	Value for F = 0.05	Value for F = 0.01
25°C	Between temperatures (25, 30 and 35°C)	0.7867	2	0.3934	85.14**	4.10	7.56
	Between partial pressures (25, 50, 75, 100, 125 and 150 mm Hg)	0.2601	5	0.0520	11.26**	3.33	5.64
	Temperature X partial pressures (error)	0.0462	10	0.0046			
	Total	1.0930	17				
30°C	Between temperatures (25, 30 and 35°C)	6.1069	2	3.0535	642.84**	4.10	7.56
	Between partial pressures (25, 50, 75, 100, 125 and 150 mm Hg)	0.5586	5	0.1117	11.26**	3.33	5.64
	Temperature X partial pressures (error)	0.0475	10	0.0048			
	Total	6.7130	17				

** Highly Significant

acclimation is obvious from its metabolic rate. Further, the change in response to the changes in ambient test temperatures is also clear as this species exhibits compensation by increasing the metabolic rate at optimum temperatures and reducing the same at extremes. The routine metabolic rate of this species is much higher than *Poecilia reticulata* (Shanthini 1976) and lower than the freshwater mullet, *Rhinomugil corsula* (Kutty and Peer Mohamed 1975). The above findings will be of immense use for the successful culture of this species under captivity in view of the present importance being given for sewage and waste water culture.

ACKNOWLEDGEMENTS

Grateful thanks are due to Prof. M. N. Kutty, Aquaculturist, FAO, Nigeria, for his guidance and to Prof. S. V. Job for critically going through the manuscript.

References

Ananthakrishan, K. R. and M.N. Kutty. 1974. Mortality and breathing rate at high ambient temperatures in the cichlid fish. *Tilapia mossambica* (Peters). *Indian J. Exp. Biol.*, 12: 55-59.

Bullock, T. H. 1955. Compensation for temperature in the metabolism and activity of poikilotherms. *Biol Rev.*, 30(30): 311-342.

Davis, J. C. 1968. The influence of temperature and activity on certain cardivascular and respiratory parameters in adult sockeye salmon. *M.Sc. thesis*, Univ. of Britsh Columbia.

Fry, F. E. J. 1971. The effect of environmental factors on the physiology of fish. In *Fish physiology* Vol. VI (Eds) W.S. Hoar ana J.D. Randal, Academic Press Inc. (London) Ltd., pp 1-98.

Gibbson, E. S. and F. E. J. Fry The performance of the lake trout, *Salvelinus namaycush* at various levels of temperature ana oxygen pressures. *Canad. J. Zool.* 32: 252-360.

Job, S. V. 1955. The oxygen consumption of *Salvelinus fontinalis*. *Univ. Toronto. Biol.* Ser., 61, *Pub. Ont. Fish Res. Lab* 73: 39pp.

Job, S. V. 1959.. The metabolism of *Plotosus angularis* (Bloch) in varions concentrations of sPlt and oxygen in the medium *Proc. Ind. Acad. Sci.* Vol. Vol. L, Section B, No. 5: 267-288.

Job, S.V. 1969. The respiratory metabolism of *Tilapia mossambica* (Teleostei). I. The effect of size, temperature and salinity. *Mar, biol*, 2: 121-126.

Kasim, H.M. 1979. Ecophysiological stuaies on fry and fingerlings of some freshwater fishes with special reference to temperature tolerance. *PhD., thesis* Madurai Kamaraj University, India.

Kasim, H. M., M. N. Kutty, and J. A. Basil. 1977. A constant low temperature recirculating water bath *J. Madurai* Univ., Vol VI (1): 54.

Kinne, O. 1960. Growth, food intake and food conversion in euryplastic fish exposea to different temperature and salinity. *Physiol. Zool.* 33: 288-317.

Kinne, O. 1970. *Marine Ecology* Vol I: Environmental factors, Part I (Ed) O. Kinne, Wiley Interscience, London.

Kutty, M. N. 1972. Respiratory quotient and ammonia excretion in *Tilapia mossambica Mar. biol.* (Springe-r-Verlag), 16 (2): 126-133.

Kutty, M. N. and M. Peer Mohamed. 1975. Metabolic adaptation of mullet, *Rhinomugil corsula* (Hamilton) with special reference to energy utilization. *Aquaculture*, 5: 253-270.

Precht, H. 1958. In: *Physiclogical Adaptation* Prosser, C.L. Ed.. Amer. Physiol. Soc. Washington. D.C.

Prosser, C. L. 1955. Physiological variation in animals. *Bioi. Rev.*, 30: 229-262.

Prosser, C. L. 1958. *Physiological adaptation*. (Ed). Washington Amer. Physiol. soc.,

Prosser, C. L. and F. A. Brown. 1961. *Comparative Animal Physiology* (2nd edn) Saunders, Philadelphia.

SHANTHINI, S. 1976. The effect of tempeiature, partial pressure of oxygen and iono-osmotic changes upon oxygen consumption in *Poecilia reticulata*. M.Sc., Proiect work submitted to Madurai Univ.

SHEPARD, M. P. 1955. Resistance and tolerance of young speckled trout *Salvelinus fontinali*. to oxygen lack with special iefeience to low oxygen acclimation. *J. Fish. Res. Bd Canda*, 12: 3.

SNEDECOR G. W. AND W. G. COCHRAN. 1967. *Statistical methods*, 6th edn. Oxford and IBH publishing co., New Delhi.

STICKLAND, J. D. H. AND T. R. PARSONS. 1968. *A practical handbook of seawater analysis*. *Fish. Res. Bd. Canada:* 11-16.

WYCLIFF, M. J. 1972 The oxygen consumption of two fresh-water prawns. *PhD., thesis*, Madurai Univ., India.