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Energetics of resting metabolism in an Indian major carp (*Catla catla* Ham.)

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Abstract

Resting metabolism in Indian major carp, *Catla catla* Ham. fingerlings was investigated. For this purpose a water recirculatory system in the laboratory was used. The metabolic energy losses were determined by the indirect method of oxygen consumption by the fish and was then multiplied by an oxycalorific coefficient (Q_{ox}). Five metabolism chambers in the experimental system were used where there were two same treatment runs in quadruplicate of mean total weight of fish fingerlings of 109.5, 110.4, 112.8 and 111.6g/chamber. The water temperature in the system was 28±0.5°C. The mean metabolic rate in the replicates showed no significant variation ($p>0.05$) and was found to be 151.66, 153.91, 150.25, 152.74 $mgO_2/kg/h$ respectively. This showed an equivalent energy loss 5.40, 5.52, 5.51 and 5.56 KJ/chamber/day (35.60, 35.92, 36.67 and 36.40 KJ/kg/day) respectively.

Key words : Resting metabolism, *Catla catla*

Introduction

A large proportion of the energy budget of a fish is required to maintain metabolic costs needed for maintaining basic bodily functions, activity, digestion, absorption, processing of food etc. It is open to question whether the term "basal metabolism" like in "mammalian species" should be used when referring to measurements of 'minimal' metabolic rates of fish species. In practice, most estimates of the 'minimal metabolism' in studies with fish have been obtained using experimental protocols that are similar to those fasting metabolic rates in domestic animals. However, metabolic rates in fish is usually termed as resting or resting routine metabolic rate where the fish should be post-absorptive with low levels of spontaneous swimming movement in respirometer chamber (Jobling 1994).

Four metabolic rates - standard metabolism, feeding metabolism, routine metabolism and active metabolism can be distinguished in fishes. However, for fish the real standard rate is not often measured, because laboratory fish are rarely motionless. It is better to use resting metabolism for standard rate when the fish is restricted unfed with minimum activity in a minimum confined area with insignificant stress (Chakraborty *et al.* 1992a). Unlike mammals, fishes can not be kept at full rest condition. Thus, it is customary to consider resting metabolism as equivalent to basal metabolism and measured in fishes by keeping them motionless as much as possible. The resting metabolism, results in thermo-neutral environment accompanying the energy cost of maintenance.

Different methods exist in determining the standard or resting metabolism in many fish (Winberg 1956, Holiday and Blaxter 1964, Brett and Zala 1975, Ross and Mckinney 1988, Chakraborty *et al.* 1992a). The energy fish needs comes from the energy stored in the chemical bonds of the food they eat through ingestion or from energy stored in the body. The energy spent for resting metabolism can be estimated by indirect method of calorimetry by measuring oxygen consumption by the fish in water (Brafield 1985). This method is based on the assumption that energy production in fish is an aerobic process and requires oxygen for oxidizing nutrients either from food or the fishes own tissues, although insignificant anaerobic metabolism may also exist in fish (Blazka 1958). Hourly measurement of oxygen consumption of post-absorptive fish over 24 hour periods gives an estimate of total daily energy expenditure.

There have been no report about the study of energetics of resting metabolism on Indian major carp, *Catla catla* which is a delicious and favourite fish throughout the sub-continent. This study as a part of energy budget experiment was designed to determine the pattern and amount of loss of energy in *Catla catla* through resting metabolism in metabolism chamber.

Materials and methods

Experimental fish and acclimatization

Fingerlings of Indian major carp, *Catla catla* Ham. from a single stock of 10 -11g size were collected from Freshwater Station of Bangladesh Fisheries Research Institute, Mymensingh. They were then acclimatized in a plastic pool with adequate water having continuous aeration by an aerator (Daivo, 8200 aerator). The fingerlings were given prophylactic treatment with 3% NaCl dip for 10 minutes and 0.5 mg/l methylene blue. Faecal matters produced by fingerlings were removed by siphoning everyday morning and water of the

pool was partly (about 40%) changed with fresh aerated water in order to avoid any environmental stress on fishes. After first two days in unfed condition in the pool the fingerlings were given pelleted diets having 30% crude protein at the rate of about 1% of body weight as maintenance ration. The acclimation of the experimental fish in the pool continued for three weeks. The experiment was conducted in metabolism chambers in a water recirculatory system in the laboratory of Fisheries Technology department of Bangladesh Agricultural University.

The experimental system constructed for this purpose was according to the design made by Chakraborty *et al.* (1992b) where five "slope-partitioned" metabolism chambers of rectangular shape connected with faecal column were used. The third chamber was used as reference chamber and contained no fish whereas the other four chambers contained experimental fishes. The water recirculatory system comprised one sumptank, one header tank and two filtration tank connected by one inch diameter PVC pipe. Water from the sumptank was pumped by an immersion pump to the header tank to distribute the water through a half inch pipe into each of metabolism chambers. The flow of water through this pipe to the metabolism chambers was regulated by ball valves. Each metabolism chamber was provided with a hole at the bottom corner of the upper part so that a 5 mm hole could support an outlet. One, 5mm plastic pipe was fitted through this hole from inside of each of the metabolism chamber and made water tight. This served as an outlet of the chambers. The water entering into the faecal column passed directly either in the filtration or via a flow-meter into the oxygen cuvette to lead into the filtration tank. All the water flow was controlled by three-way-valve. The water being filtered entered into the sump tank. Each of the metabolism chambers received a good supply of air saturated water from the header tank through a small diameter PVC pipe. The continuous and constant water supply was controlled by valves. Normal photoperiod of 12h light and 12h dark was maintained during the experimental period.

Experimental procedure

Ten fishes in four replicates (each fish weighing 10 - 11g) in metabolism chambers were randomly selected from the acclimation pool by a scoop net and weighed by a sensitive balance and then released in the metabolism chamber. Two days before the start of the experiment, fishes in chambers were not fed. The metabolism chambers were named as A, B, R, C and D. The chamber 'R' was used as reference to determine the dissolved oxygen content in the system water and had no fish in it. Whereas, the other four chambers A, B, C and D contained fish. A constant water flow rate of 30 L/h through the

flow meter was maintained in all metabolism chambers during direct monitoring of oxygen consumption. After the first day in unfed condition for acclimation in the chambers, fish were subjected to measure the resting metabolic rate for another three unfed days. Twenty four hours hourly measurement of oxygen consumption by the fish in metabolism chambers was done directly by an oxygen probe (Check:Mate, Mettler Toledo Ltd.) set inside the flowing water in cuvette in the system. The oxygen consumption by fish in each chamber was directly measured as mg\l. The values were expressed as $mgO_2/kg/h$ using the following formula :

$$mgO_2/kg/h = \frac{(O_2sat - O_2out) \text{ X water flow rate (l/h) x } 1000}{\text{Weight of fish (g)}}$$

Where, O_2sat = Dissolved oxygen (mg/l) in the reference chamber
O_2out = Dissolved oxygen in the outlet of the metabolism chamber containing fish.

The values were then converted into energy (KJ) by multiplying with suitable oxycalorific equivalent (Brafield 1985). An oxycalorific value of 13.56 J/mgO_2 oxygen (Brett and Groves 1979) was used in determining the resting metabolic rate in this case for starved fish. Hourly mean values over 24h period were calculated in order to obtain the pattern of daily resting metabolic rate and the total amount of energy lost in this respiration.

Results

Table 1 represents the mean oxygen consumption of unfed *Catla catla* in four different replication of the two experimenal runs during normal 12h light and 12h photoperiod. It is seen that the mean oxygen consumption over 24 hours were 151.66 (±4.86), 153.91 (±6.23), 150.26 (±5.69) and 152.74 (±6.06) $mgO_2/kg/h$ for replication A, B, C and D respectively. No significant variation ($p > 0.05$) of resting metabolic rate was found among the four replicate groups during unfed condition. In normal photoperiod of 12 hour light and 12 hour dark regime, *Catla catla* showed a small variation in oxygen consumption. The oxygen consumption over 24 hours period shows a rhythmic respiratory pattern with comparatively higher rate in day light than in the dark (Fig. 1). In the day time the mean values of oxygen consumption were 155.58 (±7.38), 158.75 (±6.71), 163.08 (±9.69) and 159.32 (±8.65) $mgO_2/kg/h$) in the replicates A, B, C and D respectively and were not significantly ($p>0.05$) different, whereas, the mean values of oxygen consumption during night were less than that in day light (Table 1). The maximum oxygen consumption values were 162, 164, 165 and 161 $mgO_2/kg/h$ in contrast to minimum values of 142, 143, 142 and 143 $mgO_2/kg/h$ in four replicates respectively. However, no

significant variation ($p>0.05$) between maximum and minimum values were observed. Considering the oxycalorific (Q_{ox}) value of 13.56J/mgO_2 (Brett and Groves, 1979), the obtained values were converted into energy and found 5.40, 5.52, 5.51 and 5.56 KJ/chamber/day in replication A, B, C and D respectively. This energy when recalculated was found to be 35.60, 35.92, 36.67 and 36.40 KJ/kg/day respectively.

Table 1. Different features of resting metabolism in Indian major carp, *Catla catla* during the experimental peiod

Sl No.	Mean total weight of fish (g) in metabolism chamber	Mean oxygen consumption over 24 hrs (mgO_2/kg/h)	Mean oxygen consumption in light (mgO_2/kg/h)	Mean oxygen consumption in dark (mgO_2/kg/h)	Expended energy in resting metabolism (KJ/chamber/day)	Max. value (mgO_2/kg/h)	Min. Value (mgO_2/kg/h)	Difference (mgO_2/kg/h)
1	109.50 (±2.8)	151.66 (±4.86)	155.58 (±7.38)	148.75 (±4.41)	5.40	162.00	142.00	20.00
2	110.40 (±2.8)	153.91 (±6.23)	158.75 (±6.71)	149.08 (±3.84)	5.52	164.00	143.00	21.00
3	112.80 (±3.0)	150.26 (±5.69)	163.08 (±9.69)	148.74 (±3.46)	5.51	165.00	142.00	23.00
4	111.60 (±2.6)	152.74 (±6.06)	159.32 (±8.65)	144.54 (±4.54)	5.56	161.00	143.00	18.00

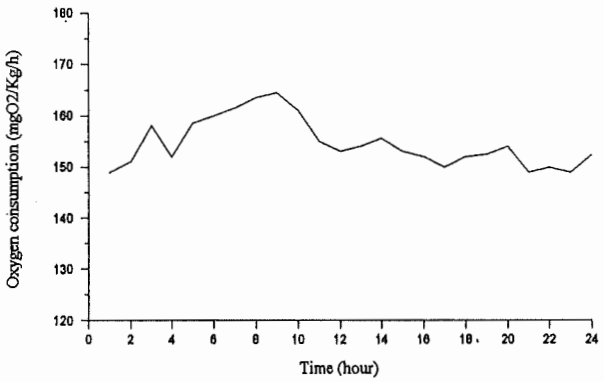

Fig. 1. Mean resting metabolic rate of *Catla catla* over 24 hour period in normal 12h light and 12h dark photoperiod. Time starts at 6.00 am as light period starts (n = 8).

Discussion

The variation in mean metabolic rate in unfed condition during the 24 hours cycle is evident in this study under normal day and light length. The expenditure for resting metabolic rate was found comparatively higher with much larger values during 10 a.m. to 12 am. Many authors have described a single daily peak in the resting metabolic rate (Swift 1962 in *Salmo trutta*, Hirata 1973 in *Salmo salar*, Hamada and Maeda 1983 in *Cyprinus carpio*, Ross

and Mckinney 1988 in *Oreochromis niloticus*). Some authors however, have shown crepuscular with two respiratory peaks at dawn and dusk rhythm (Nagarajon and Gopal 1983 in *Sarotherodon mossambicus*, Kumari and Nair 1979 in *Neomocheilous triangularis*). This work has shown a single daily respiratory peak under normal photoperiod.

Water quality in the experimental system has a large influence on metabolic rate of fish (Winberg 1956). In this study the temperature did not vary beyond 28±0.5°C and oxygen concentration was kept about 7.5 mg/L (Values obtained from reference chamber). Moreover ammonia accumulated in the system water was far below the toxic level because a part of water was changed every day in the sump tank and there were two biological filters in the filtration tanks with the main recirculatory system.

It can be seen from the Table 1 that the mean metabolic rate in the light was not much different from that recorded during the dark period. Similar observations were reported by other authors (Winberg 1956 and Chakraborty *et al.* 1992a). There have been reports about the values for oxygen consumption for resting metabolism in different fish species and a large variation is evident (Hamada and Maeda 1983 and Chakraborty *et al.* 1992a). There have been some correlation between the unfed respiratory rates and fish weight used at different environmental condition. Beamish (1964) recorded 48, 104 and 117.3 $mgO_2/kg/h$ of 146, 100 and 134g size respectively in largemouth bass, *Micropterus salmoides*. In other experiment conducted by Kausch (1969) it was found that 10±5g size carp, *Cyprinus carpio* had resting metabolic rate of 80, 136 and 214 $mgO_2/kg/h$ at 10, 15 and 20°C respectively. Huisman (1976) in another experiment with 31 - 47 and 2 - 16g size common carp obtained a resting metabolic rate of 48 and 83 $mgO_2/kg/h$ respectively. Comparatively higher value of 173 $mgO_2/kg/h$ for resting metabolic rate of 318g size common carp were obtained by Hamada and Maeda (1983) whereas Chakraborty *et al.* (1992a) obtained mean resting metabolic rate for unfed common carp of 70±10g size as 152 $mgO_2/kg/h$. This experiment for mean resting metabolic rate of *Catla catla* was found to be 151 $mgO_2/kg/h$ which shows a quite reasonable value among the reported values.

The mean difference between maximum and minimum oxygen consumption during day light and night in this experiment was 20 $mgO_2/kg/h$, whereas, a variation of 35 $mgO_2/kg/h$ in *Cyprinus carpio* (70 ±10g) was recorded by Chakraborty *et al.* (1992a). This difference of oxygen consumption may be due to the size and species difference used in the experiment.

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