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Effect of temperature on oxygen consumption and metabolic rate in *Puntius sophore* (Hamilton-Buchanan, 1822)

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ABSTRACT

Experiments were conducted to evaluate the oxygen demand of *Puntius sophore* under various conditions, with reference to temperature variations and oxygen concentrations. The oxygen requirements at different age groups have also been studied in the laboratory. The oxygen consumption and metabolic rates were studied at every 5°C, varying temperatures from 15-40°C. The fishes were inactive and the metabolic rate was minimal at 15°C, with an increasing temperature the activity of the fish changed and resulted more oxygen consumption. The fishes were found to be active at 25-30°C range of temperature. At the temperature above 35°C was not comfortable, since the fishes were erratic and behavior was not normal. At the ranges 15-40°C the difference in consumed dissolved oxygen of small size and large size fishes are very significant, The percentage increases at every 10°C in metabolic rate at the range of 15-25°C, 25-35°C, 20-30°C and 30-40°C is not uniformly double with increase in temperature. It was observed that the metabolic rate in small size fishes (0.74- 0.92 g) fishes are not coincide with the Vant Hoff's hypothesis, where as 1.63g, 2.20g and 4.14 g. weight fishes, the metabolic rates were observed nearly doubled.

Key words: Oxygen consumption, Metabolic rate, Temperature, percentage, Vant Hoff's hypothesis

INTRODUCTION

The dissolved oxygen levels of the freshwater tanks are dependent upon the season, length of the day, climatic conditions and biotic and abiotic factors. The phenomenon of oxygen consumption in relation to the growth and metabolic activity has been studied and reported in different fish species. The oxygen consumption and metabolic rate is a function of the body size, oxygen concentration and activity of the fish.

Puntius sophore is a diurnal in habitat and there is much variation in the general activity of the organism during different times of the day and night. Hence the oxygen consumption also changes accordingly. It is very difficult to study the activity dependent oxygen consumption in a population of *Puntius spp*. but this can be studied in isolated conditions. Generally the quantity of oxygen consumption increases with an increase in body size. This particular phenomenon has also been studied in other fish species of *Puntius sophore*.

It is well known fact that temperature has a tremendous influence on the oxygen consumption and metabolic rate; with an increase in temperature, the rate of oxygen consumption and metabolic rate increases and this is mostly dependent upon animal's habitat. The increase the oxygen consumption with increase in temperature varies quit markedly depending upon the habitat and the size and age of the organism. The oxygen consumption and basal metabolic rate falls to a minimum at a particular temperature for a particular size group of the animal and further reduction in temperature leads to mortality. There are some very good studies pertaining to the oxygen consumption in relation to variations in temperature (Edward and Irving 1943; Edward 1946). Bhattacharya and Subba (2006) reported on oxygen uptake in relation to body weight was measured in *Esomus dandricus* at two different seasonal temperatures, winter and summer. Oxygen uptake per unit time (mlO2/hr) increased from 0.5335 to 0.7839 with gradual increase in body weight from 0.5 to 1.5 g during winter season. During summer, it increased from 0.5539 to 1.4853 with an increase in body weight from 0.6 to 3.3 g. Paul Miklos et al., 2003 studied Leopard shark oxygen consumption rate increased with increasing temperature, over a range of 12–24°C, with a typical temperature sensitivity (Q_{10} = 2.51). Hanna et al., (2008) reported to higher concentrations of cortisol in association with greater osmoregulatory disturbance in animals acclimated at the lower temperature indicate that the lower water temperature acted as an environmental stressor. Lack of significant differences in U_{crit} between temperature treatments, however, suggests that Pacific cod have robust physiological resilience with respect to swimming performance within temperature changes from 4 to 11° C. The aim of the present studies is on evaluate the oxygen requirements at different temperatures at different size and age groups were not studied earlier and limited knowledge in the field of freshwater fishes.

MATERIAL AND METHODS

Puntius sophore selected for the present study and it was collected from local freshwater tanks. For laboratory experiments fishes were collected by hand netting and transferred them into cement tank containing oxygenated freshwater. Usually the fishes were maintained at room temperature (26-28°C) and fed with artificial diet. The fishes were acclimatized for about 4 days before starting experiments. For laboratory experiments on oxygen requirements, the fishes from the cement tank were transferred to respiratory chamber according to experimental temperatures. The fishes were kept for one hour at each temperature within the respiratory chamber and oxygen consumption by each animal was measured. By using B.O.D. incubator constant temperature was maintained. Initially the respiratory chamber was kept in the B.O.D. incubator when the water temperatures equalized to the ambient temperature then fishes were introduced into the chambers. Care was taken to prevent any air bubbles in between the lid and water column of the respiratory chamber. The fishes were allowed to in the respiratory chamber for one hour and the oxygen consumed by the fish was measured.

A winkler's bottle was taken and was filled with water that was to be used for the experiment. One ml of winkler's 'A' (manganous reagent) and one ml of winkler's 'B' (KI and K OH) were added to it. Then it was shaken well so that a precipitate of white divalent manganous hydroxide was produced.

$$Mn^{++} + 2(OH) = Mn(OH)_2$$

The manganous hydroxide reacts with the dissolved oxygen in the sample to produce a dark brown higher divalent manganese hydroxide.

$$2\ Mn(OH)_2 + \frac{1}{2} O_2 = 2\ Mn(OH)_3$$

The winkler's bottle was kept in a dark chamber for about 15 minutes, until the precipitate settle down to the bottom. Then 1 ml of winkler's C (conc, H_2SO_4) was added and was shaken well till all the precipitate is dissolved. The sample was then acidified, thereby dissolving the hydroxide precipitate and initiating the reaction between the manganese or iodine, with in the presence of excess iodide formed the soluble triiodide complex.

$$2MnO(OH)_3 + 6H^+ 3I^- = Mn^{++} + I_3^- + 6H_2O$$

At the point the iodine should be chemically equivalent to the oxygen. 100 ml of this solution was taken into the conical flask. The amount of iodine was now determined by titration with a standardized sodium thyosulphate (0.01N) solution using starch indicator for endpoint detection.

$$S_4O_6^- + 2e^- = 2S_2O_3^-$$

While titrating with the sodium thiosulphate the liberated iodide is ebullient oxygen. The difference between the initial and final oxygen levels gave the amount of oxygen consumed by the organism. The weight specific oxygen consumption or metabolic rate was calculated by dividing the amount of oxygen the taken by the animal by animal's weight per unit time of one hour Montgomery et al. (1964).

RESULTS AND DISCUSSION

Experiments were conducted to evaluate the oxygen demand of *Puntius sophore* under various conditions, with reference to temperature to variations in oxygen concentrations. The oxygen requirements at different age groups have also been studied in the laboratory i.e. (2.4cm, 3.2 cm, 4.1 cm, 5.4 cm and 7.6cm) and weight of the fishes are 0.74gm, 0.92gr, 1.63gm, 2.20gm and 4.14gms. The same size and same weight fishes were maintained throughout the experiment. The oxygen consumption and metabolic rates were studied at ever 5°C, varying temperatures from 15-40°C. The fishes were inactive and the metabolic rate was minimal at 15°C, with an increasing temperature the activity of the fish changed and resulted more oxygen consumption. The fishes were active in temperatures ranging from 25-30°C. Temperature about 35°C was not comfortable, since the fishes were erratic and behavior was not normal. The oxygen consumption and metabolic rate again was depended upon the size of the fish. At higher temperature usually, the small size fishes have higher metabolic rate than the larger ones. But at lower temperature the differences in metabolic rate between the large and small size fishes is minimal and not significant. Large size fishes were found to be very inactive and used to consume lesser amount of oxygen, when compared to small size fishes. Small size fishes have higher metabolic rate when comparison of larger fishes. At 15-40°C the difference in consumed dissolved oxygen of small size and large size fishes are very significant but increasing temperature have resulted in increased consumption of oxygen and sensitivity to ambient temperature (Table 1; Fig 1&2).

In the present investigation the oxygen consumption and metabolic rates were studied at ever 5°C, varying temperatures from 15-40°C. The metabolic rate range was observed from 0.08 to 0.30 in lesser weight of *Puntius sophore* and the metabolic rate range from 0.3 to 0.25 were observed in higher body weight. The similar observations were reported in few numbers of fishes, Bhattacharya (2006) reported the oxygen uptake in relation to body weight was measured in *Esomus dandricus* at two different seasonal temperatures, winter and summer. Oxygen uptake per unit time (mlO2/hr) increased from 0.5335 to 0.7839 with gradual increase in body weight from 0.5 to 1.5 g during winter season. Oxygen uptake per unit time (mlO2/hr) increased by a power of 0.2594 while the oxygen uptake per unit weight (mlO2/g/hr) decreased by a power of -0.7409 at 16 ± 1 ° it can be suggested that the oxygen uptake will decrease with increase in body weight of the fish.

Table 7. *Puntius sophore* oxygen consumption (mlO_2/hr) and metabolic rate from 15-40°C

S. No	Length cm	Weight gr	Average consumed oxygen values / metabolic rate at every 5°C					
			15°C	20°C	25°C	30°C	35°C	40°C
1	2.4	0.74	±0.06/ 0.08	±0.08/ 0.10	±0.11/ 0.15	±0.15/ 0.20	±0.18/ 0.24	±0.22/ 0.30
2	3.2	0.92	±0.07/ 0.08	±0.09/ 0.09	±0.13/ 0.14	±0.17/ 0.18	±0.21/ 0.22	±0.27/ 0.29
3	4.1	1.63	±0.08/ 0.05	±0.12/ 0.07	±0.16/ 0.10	±0.21/ 0.13	±0.33/ 0.20	±0.41/ 0.25
4	5.4	2.20	±0.10/ 0.04	±0.15/ 0.06	±0.19/ 0.08	±0.28/ 0.12	±0.35/ 0.15	±0.48/ 0.22
5	7.6	4.14	±0.11/ 0.03	±0.18/ 0.04	±0.21/ 0.05	±0.32/ 0.08	±0.52/ 0.13	±0.81/ 0.18

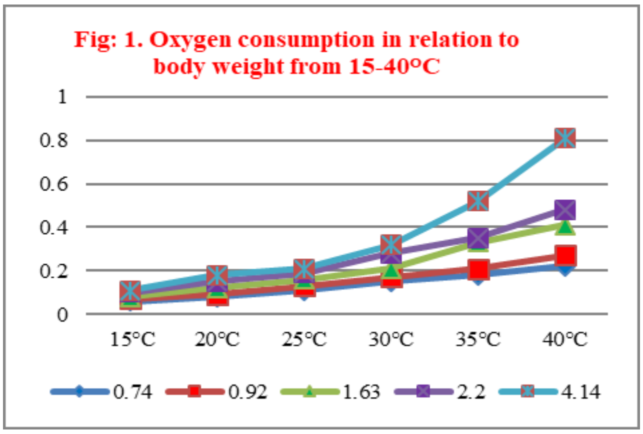

Fig: 1. Oxygen consumption in relation to body weight from 15-40°C

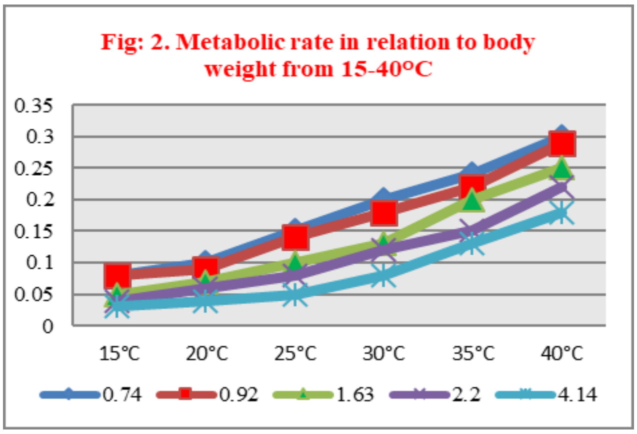

Fig: 2. Metabolic rate in relation to body weight from 15-40°C

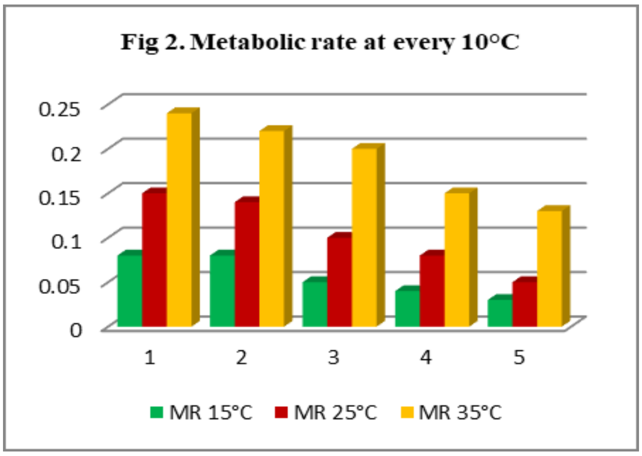

Fig 2. Metabolic rate at every 10°C

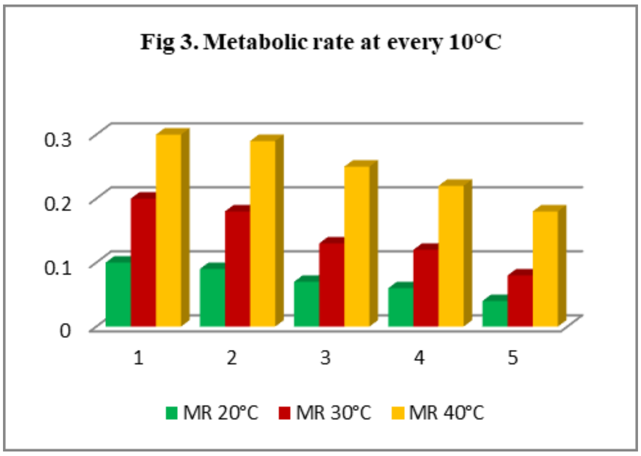

Fig 3. Metabolic rate at every 10°C

Hopkins & Cech (1994) studted the effect of temperature on oxygen consumption in the bat ray *Myliobatis californica.* Cech et al (1994) reported O_2 consumption rate and respiration model effects on temperature and body size in Northern squawfish, *Ptychocheilus oregonenis*. Paul Miklos et al (2003) reported in the leopard shark *Triakis semifasciata*, which is characterized by thermally different regions ranging from 10° C to 26° C during the summer. Past studies have shown that leopard sharks feed on benthic invertebrate prey similar to that of the sympatric bat ray *Myliobatis californica*. Fish metabolic rates typically increase with temperature increases and measured. Beamish (1964) observed the proportionate change in standard oxygen consumption for a given change in temperature appears to be independent of size within each species. The mean slope values of the regressions found for brown trout, brook trout, common white sucker, brown bullhead, and carp are 0.877, 1.052, 0.864, 0.925, and 0.894, respectively. Valentina et al (2011) flow-through respirometry was used to test the effect of acute temperature change on resting routine metabolic rates of two benthic elasmobranchs, Atlantic stingrays *Dasyatis Sabina.*

At 15-40°C the difference in metabolic rate of small size and large size fishes are very significant but increasing temperature have resulted in increased metabolic rate. Increased metabolic rate was noticed with an increase in temperature, but the increase in metabolic rate is not uniform at different temperatures studied. The percentage increases at every 10°C in metabolic rate from 15-25°C, 25-35°C, 20-30°C and 30-40°C is not uniformly double with increase in temperature (Fig 3 and 4). The metabolic rate observed in small size (0.74-0.92 gr) fishes are not coincide of Vant Hoff's hypothesis. But in 1.63, 2.20 and 4.14 gr. fish metabolic rates were observed nearly doubled.

Temperature about 35°C was not comfortable, since the fishes were erratic and behavior was not normal was observed present study in *Puntius sophore*. The similar observations were reported by Hanna S. K et al., (2008) observed in Pacific cod *Gadus macrocephalus* was the temperature effects on metabolic rate, swimming performance and condition. Beamish (1964), Brett et al (2006) described the lowest applicable values that could be found in the literature. Spontaneous activity, expressed in terms of average oxygen consumption over the standard rate, varied with temperature. Maximum spontaneous activity for a given species coincided roughly with its preferendum temperature. Hélène Oligny-Hébert et al (2015) assessed the metabolic response of juvenile Atlantic salmon (*Salmo salar*; JAS) originating from two rivers with different natural thermal regimes to different acclimation temperature (15 or 20 °C) and diel temperature fluctuation (constant: ±0.5 °C; fluctuating: ±2.5 °C). Diel temperature fluctuation (15 ± 2.5 °C) near the thermal optimum (16 °C) for the species did not influence standard metabolic rate (SMR) compared with JAS acclimated to a constant temperature of 15 °C. Diel temperature fluctuation at 20 ± 2.5 °C increased.

CONCLUSION

The present observations have revealed interesting results on the variations in oxygen consumption dependent upon temperature, small size fishes are more comfortable at 25-30°C. The temperatures above 30°C were not comfortable an increase in their oxygen consumption. Hence the Vant Hoff's hypothesis indicating the doubling of oxygen consumption for every 10°C increases is not uniformly applied to *Puntius sophore* due to the very fact at the age group.

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