



Effect of Environmental Acidic pH on Oxygen Consumption of Fish, *Cyprinus carpio* (L.)

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ABSTRACT

The present study was aimed to investigate the total oxygen consumption of freshwater fish *Cyprinus carpio* during exposure and acclimation to sublethal acidic pH (5.0) medium. The oxygen consumption of fish significantly depleted in all the days of exposure to sublethal acidic pH 5.0 starting from first day to fourteen days of exposure. The rate of total oxygen consumption depletion was higher on first day. From the second day onwards a gradual decreasing trend was observed in the depletion up to 14th day of exposure. The unit oxygen consumption of fish on exposure to sub-lethal pH medium exhibited significant depletion when compared to control. The rate of depletion was maximum in the initial days of exposure and was reduced gradually in twelfth and fourteenth day of exposure. But, at day 14th not significant decrease was observed in both the parameters of the experimentation. This observation indicates that the fish was capable of regulating their metabolic modulations and physiological functions through acclimation process to be the possible reason for the successful survival of fish in acidifying water. The reduced oxygen consumption of fish on exposure to sublethal acidic medium confirms the prevalence of hypoxic condition in the surrounding medium.

INTRODUCTION

Environmental stress is of prime importance during the course of exposure of an animal to different acidic media. Acidic medium is known to be the highly influencing to the most organisms and therefore low pH of aquatic medium is an important aspect of environmental pollution. The oxygen consumption in fish has been considered as an index for denoting the intensity of metabolism as metabolic activity of an organism is increased by its oxygen utilization (Bijay Bhushan Prasad et al. 2003).

Respiration is an essential physiological activity of all the living organisms by which they obtain energy for carrying out all metabolic activities of the body (Bhaskar & Govindappa 1985, Krishna Murthy 1991). The rate of oxygen consumption, which is the basic physiological parameter, serves as an indicator of physiological stress (Bhaskar & Govindappa 1985) and changes in the oxygen consumption could be used to evaluate any change that would occur in the metabolism due to alterations in the environment. Such stresses like acidic medium have been studied by Sreenivasa Reddy et al. (2008), pesticides by Roberts et al. (1987), heavy metals by Venkata Reddy et al. (2007), pulp mill effluents by Reeta Kumari et al. (2011), hydrocarbons by Percy (1977), and natural stresses like temperature and salinity by Bashamohideen (1984). Thus, variations in respiratory activity have been used as sensitive indicators of stress in fish exposed to pollutants, in general (Bashamohideen 1984).

The above studies unequivocally suggest that the sensitive indicator of stress like O₂ consumption in fishes exposed to pollutants is considerably increased and decreased; but studies involving the O₂ consumption of the whole animal with reference to sublethal effect of acidic media is very few in fishes which are of great commercial and economical value. Hence, an attempt is made in the present investigation to study the influence of acidic media on certain aspects of O₂ consumption in major carp, *Cyprinus carpio* following exposure to the sublethal concentration of acidic medium at different exposure periods.

MATERIALS AND METHODS

Procurement and maintenance of experimental material:

The common freshwater carp, *Cyprinus carpio* (Linnaeus) is an economically important edible fish having great commercial value. They were collected as for the recommendation of the local Department of Fisheries, Government of Andhra Pradesh, India. The fish was kept in large aquaria with continuously following dechlorinated water to acclimatise them to laboratory conditions (27°C ± 2°C, pH 7.0 ± 0.2 and light period of 12 h per day) for fifteen days before they were used for experimentation. This fish is known for its adaptability to laboratory conditions and suitability to acidic media studies (Bhaskar & Govindappa 1985). Hence, this fish was selected as the experimental model for the present investigation. As the smaller fish are considered to be more sensitive to toxic pollutants rather than larger one

(Anderson & Weber 1975), small sized fish weighing around 200 ± 50 g were selected for the present investigation. After 24hrs of the stipulated period, the fish were immediately used for the estimation of oxygen consumption and unit oxygen consumption in different aquatic pH media.

Determination of Mortality of Fish at Different pH Media

Preparation of different pH media: The acidic media with different pH ranging between 3.0 and 7.0 with a variability of 0.5 were prepared by adding 1 N hydrochloric acid to water. 1 N solution of hydrochloric acid was prepared separately with distilled water (pH 7.0), soft water, chlorides ($110 \text{ mg/L} \pm 10$), carbonates ($16 \text{ mg/L} \pm 2$), bicarbonates ($400 \text{ mg/L} \pm 50$), and hardness (35 mg/L as $\text{CaCO}_3 \pm 4$). The 1 N HCl was added for the purpose of obtaining different acidic media mentioned above and their pH were verified with pH meter (Elico, India). As the chloride ions are least toxic, hydrochloric acid was used widely for the preparation of acid media (Jones 1968).

Determination of percentage mortality of the fish: The water media having different pH range of 3.0 to 7.0 with variability of ± 0.5 pH were taken. For each pH medium in the above range, 10 separate tanks were maintained with fish, each tank containing 10 individuals. The fish were fed daily at 8 am with commercial fish pellets and the medium in the tanks was changed at 9 a.m. The pH of the media was maintained constantly by employing special dropping system during experimentation.

The number of fish that died in each of the above media was recorded at regular intervals of time up to 96 h. The percentage of mortality was calculated on the basis of individuals that died at each time interval. The media, where the mortality of the fish was observed, were taken as lethal media, and the others where there was no mortality, were taken as sublethal media. The oxygen consumption was determined during the temporal sequence of exposure starting from the first day till the maintenance of constant oxygen consumption by the fish, i.e., 10th day to 14th day.

Acclimation of fish to sublethal acidic medium: The sublethal acidic media (pH 5.0) was employed as an ambient medium for acclimatization of the fish. The fish were fed daily at 8 a.m. with commercial fish food pellets and the medium in the tanks was changed at 9 a.m. The fish were taken into the respiratory chamber containing the same pH medium at 2.00 p.m. on alternate days and the oxygen consumption was determined within a period of 1h. After this the fish were transferred into their respective tanks. The oxygen consumption was determined during the temporal sequence of exposure starting from the first day till the maintenance of constant oxygen consumption by the fish, i.e., 10th day to 14th day. Similarly control fish in the neutral pH

7.0 were maintained and their oxygen consumption was also studied individually over the temporal sequence of time as done in the case of fish maintained under sublethal acidic media.

Estimation of oxygen consumption: The oxygen consumption of fish was determined by the static method described by Saroja (1959). The unit oxygen consumption was calculated by dividing the oxygen consumption by weight of the fish and represent as $\text{mg O}_2/\text{g/h}$.

Statistical treatment of data: All the values of 't' below 5 percent levels are considered as not significant and the value above 5 percent level are considered as significant.

RESULTS AND DISCUSSION

The pH of water plays an important role in regulation of growth and development of aquatic animals. The present study was aimed to find out the relationship between environmental acidification on the growth and development of *Cyprinus carpio* (L).

The measurement of oxygen consumption becomes a marker to understand the overall changes that takes place in the whole body on exposure to any stress condition. Several investigators (Sailaja et al. 2009, Chavan et al. 2011, Sathick et al. 2011, Sindhe et al. 2011) reported that the level of whole oxygen consumption was an index for metabolic modulations that take place in the body on exposure to acidic stress.

The data presented in Tables 1 and 2 show changes in the total oxygen consumption and unit oxygen consumption of the freshwater fish during exposure to sublethal acidic (pH 5.0) media. The total oxygen consumption was significantly decreased on first day of exposure to sublethal acidic pH 5.0 medium and exhibited a non significant change over control on 14th day of exposure. This observation indicates that the fish was capable of regulating their metabolic modulations and physiological functions through acclimation process to compensate the acidic stress imposed by the external media, which might be the possible reason for the successful survival of fish in acidified water. Decrease in total oxygen consumption might be due to hypoxic condition prevailed in external media. Another reason might be due to reduced gaseous exchange through gill surface because of excessive formation of mucous (Suchismita Das & Abhik Gupta 2012). The other alternative could be the reduced oxygen carrying capacity of the blood due to altered blood pH on exposure to acidic media. Several investigators also reported earlier in supporting to the present study that decreased ability of fish to extract oxygen from low pH waters (Packer & Dunson 1972, Sailaja et al. 2009).

The reduced oxygen consumption of fish on exposure to sublethal acidic media confirms that prevalence of hypoxic

Table 1: Changes in total oxygen consumption (mg of O₂/h/g wet wt of kg Bw) during different days of exposure to sub-lethal acidic medium in comparison to control.

S.No	Time in days	Control (pH 7.0)	Sub-lethal (pH 5.0)
1	1	0.2780±0.051	0.1675±0.0104; -39.74; p<0.001
2	2	0.2730±0.0160	0.1528±0.0115; -44.02; p<0.001
3	4	0.2784±0.0144	0.1722±0.0092; -38.14; p<0.001
4	6	0.2752±0.0181	0.1912±0.0128; -30.52; p<0.001
5	8	0.2719±0.0161	0.2081±0.0156; -23.46; p<0.001
6	10	0.2792±0.0169	0.2145±0.0144; -23.17; p<0.001
7	12	0.2821±0.0150	0.2391±0.0154; -15.24 N.S
8	14	0.2791±0.0122	0.2694±0.0156; -3.47 N.S

Mean ± SD, + and - indicates percentage increase and decrease, 'p' denotes statistical significance and 'NS' indicates non-significant.

Table 2: Changes in unit oxygen consumption (mg of O₂/h/g wet wt) of fish during different days of exposure to sub-lethal acidic medium in comparison to control.

S.No	Time in days	Control (pH 7.0)	Sub lethal (pH 5.0)
1	1	3.7252±0.0221	2.8420±0.1310; -23.70; p<0.001
2	2	3.8224±0.0425	2.6051±0.1202; -31.84; p<0.001
3	4	3.7235±0.0421	2.9752±0.1081; -20.09; p<0.001
4	6	3.7210±0.0521	3.0244±0.0951; -18.72; p<0.001
5	8	3.8314±0.0512	3.1652±0.0951; -17.38; p<0.001
6	10	3.7935±0.0131	3.2826±0.0710; -13.46; p<0.001
7	12	3.7624±0.0831	3.3789±0.1710; -10.19; p<0.001
8	14	3.7416±0.0626	3.5914±0.1430; -4.01 N.S

Mean ± SD, + and - indicates percentage increase and decrease, 'p' denotes statistical significance and 'NS' indicates non-significant.

condition in the surrounding media. Since the unit oxygen consumption also exhibited similar depletion trend, it suggests the possibility of existence of hypoxic condition. The unit oxygen consumption of fish also exhibited nonsignificant change on 14th day of exposure. This observation supports and forms a basic evidence for the perfect type of acclimation by adults. Since the total oxygen consumption in animals forms a marker for the general metabolism, the stabilization of total oxygen consumption on 14 days exposed fish reflects the maintenance of normal oxygen consumption on par with the control fish. Hence, two weeks period of exposure to fish to acidic media made successful in survival through acclimation process, failure of such a regulatory mechanism, might be responsible for the mortality of fish in lethal pH media.

In view of acclimation of fish to acidic media provided better metabolic adjustments at whole animal level reveal the better survival value. Thus, the changes in oxygen consumption could reflect the effect of acidic media on the aquatic fauna especially in fishes.

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