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Note

Mass specific oxygen uptake in the freshwater catfish *Wallago attu* (Bloch & Schneider, 1801)

SURESH CHANDRA[1], S. K. SINGH[2], S. DAS GUPTA[3] AND S. K. SAHOO[4]

[1]*Chirrapani Experimental Field Centre, Directorate of Coldwater Fisheries, Champawat, Uttarakhand - 262 523, India*

[2]*Central Soil Salinity Research Institute, Karnal - 132 001, Haryana, India*

[3]*Central Institute of Fisheries Education, Yari Road Campus, Andheri (W), Mumbai - 400 061, Maharashtra, India*

[4]*Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar - 751 002, Odisha, India*

e-mail: schandra@dcfr.res.in

ABSTRACT

Mass specific oxygen uptake in juveniles of *Wallago attu* under three concentrations of dissolved oxygen *viz.,* saturated, 100% (SW) DO 7.5-7.0 mg l^{-1}, normoxic, 60% (NW) DO 4.5-4.0 mg l^{-1} and hypoxic, 30% (HW) DO 2.5-2.0 mg l^{-1} at water temperature of 28±1^{0}C was measured in the laboratory. Two size groups of juveniles, with body weight 152.5±10 g and 187.5±5 g, were exposed to three concentrations of dissolved oxygen in closed respirometer system. The volume of oxygen uptake decreased with increase in body weight of fish. Breathing frequency (BF) increased with lowering of DO level in both the weight groups. Under different retention periods and number, mean oxygen uptake was 506.5±4.1, 285.1±4.6 and 120.1±5.1 mg kg^{-1} h^{-1} respectively in the smaller size group, with BF of 53-96 min^{-1}, while in the bigger size group (187.5±5 g), oxygen consumption was 473.2±22.4, 272.7±9.7 and 78.1±1.2 mg kg^{-1} h^{-1} respectively with a breathing rate (BR) of 49.6 - 78.1 min^{-1}. With an increase of 35±7.5 g body weight, mean reduction of 12.4-42.0 mg kg^{-1} h^{-1} DO was recorded. An abrupt behavioural change was observed below DO concentration of 4.0-3.5 mg l^{-1}. Oxygen uptake value showed declining trend with lowering of DO concentration. Based on these results, oxygen uptake has been estimated at 27.8 mg 100 g $juvenile^{-1}$ h^{-1} at DO saturation level of 60% in water.

Keywords: Hypoxic, Normoxic, Oxygen uptake, Saturated, *Wallago attu*

Among cultivable fish species, catfish finds a special place, contributing substantially in world aquaculture production and acting as a prize regulator of other fish species in the market. Non-air breathing large catfish *Wallago attu,* also known as freshwater shark in India, offers culture possibilities owing to its good growth rate in culture systems. This species is commonly found in perennial rural ponds as well as in wild water bodies and has good market demand, especially in north-western states of India, where less spiny fishes are preferred. Information on culture aspects of this species, including oxygen consumption rate are insufficient and large scale mortality is encountered during transport of this species for culture or for live marketing. Oxygen consumption of major carps, catfishes and other cultivable species under various conditions have been studied and reviewed by several authors (Basu,1952; 1959; Motwani and Bose, 1957; Fry, 1971; Singh, 1977; Kramer, 1987; Kunwar *et al.,*1989; Battacharya and Subba, 2006). Dissolved oxygen demand of fishes under culture conditions depends on many extrinsic and intrinsic factors like feeding status, weight of fish and water temperature (Andrews and Matsuda, 1975). Not much information is available on physiologically worked out dissolved oxygen requirement for the juveniles of *W. attu* under different oxygen concentrations. With a view to generate information on the desired amount of dissolved oxygen for live transportation, the present study on oxygen requirement in *W. attu* under three different dissolved oxygen regimes under laboratory condition was undertaken. Simple method of oxygen measurement was employed which may be beneficial where specialised facilities are not available.

Juveniles of *Wallago attu* (80 nos.) in the weight range of 145-194 g were collected from a rural perennial pond near ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Kausalyaganga, Bhubaneswar and segregated into two weight groups *i.e.,* 152.5 ±10 g and 187.5±5 g and maintained in two separate 100 l rectangular FRP tanks for conditioning. To measure the mass specific oxygen uptake, closed respirometry (or constant volume respirometer) method was followed. Nine closed respirometer glass cylinders each having 10 l capacity, filled with ground tap water containing 1.5-2.0 ppm oxygen were used for the experiment. With the help of an air compressor, three different concentrations of dissolved oxygen *viz*., 100% saturated DO (7.5-7.0 mg l^{-1}), 60% DO normoxic (6.5- 6.0 mg l^{-1}) and 30% DO hypoxic (2.5-2.0 mg l^{-1}) were maintained in three sets at a water temperature of 28+1^{0}C. For each concentration of oxygen, two respirometer cylinders were used in which juveniles were placed, while one cylinder was kept as control with same oxygen concentration without juveniles to measure the oxygen difference during the period. One to three numbers of conditioned juveniles of known body weight and length, starved for three days were transferred to the respirometer cylinders. After transferring the juveniles, the glass jars were sealed and made fully airtight. Retention period in respirometer cylinders varied from 30-80 min. For each concentration, three trials were taken. Opening of the operculum was considered as breathing movement and observed at every 10 min intervals. Behaviour of the juveniles was closely observed and recorded. Initial oxygen content (t_0) of the respirormeter was measured in mg l^{-1}. At the end of the experiment, changed oxygen concentration (t_1) was measured again using Centaury kit ck 710 (Indian make) and verified following standard methods of oxygen determination (APHA, 1998). For each weight group, a total of 36 specimens were used. Respirometer volume minus volume of experimental juveniles (in liter) was taken into account while calculating the total volume of the respirometer cylinder. Mass specific oxygen uptake rate was calculated as follows:

VO_2 = $([O_2]\, t_0 – [O_2]\, t_1) \times V/t \times BW$
VO_2 = Oxygen consumption rate (mg O_2 kg^{-1} h^{-1})
$[O_2]\, t_0$ = Oxygen concentration at time t_0 (mg O_2 l^{-1})
$[O_2]\, t_1$ = Oxygen concentration at time t_1 (mg O_2 l^{-1})
V = respirometer volume minus volume of experimental juveniles (liter)
t = $t_1 – t_0$ (hour)
BW = body weight of experimental *Wallago attu* Juveniles (kg)

On the basis of the above, oxygen requirement for transportation of juveniles was estimated. After completion of experiment, the fishes were given dip treatment in salt as well as $KMnO_4$ solution and were released back in the culture tanks.

The respiration pattern was different in all the three oxygen regimes. Breathing frequency rate (BF) ranged between 52-55 min^{-1} in fishes having an average body weight of 152.5±10 g in saturated water (SW) with normal breathing depth (Table 1). At the beginning of the experiment, high breathing frequency rate was observed in first few minutes, that may probably be due to handling stress, and apparently showed normal behaviour thereafter. However, gradual increase of BF with prolongation of the experiment and decrease of oxygen level was observed. In nearly normoxic water (NW), BF in the range of 80-83 min^{-1} was recorded with increase in depth of breathing. High breathing frequency of 95-110 min^{-1} with very high breathing depth was observed in hypoxic water (HW). Fishes also exhibited abnormal behaviour of coming to the surface and turning upside down. Although juveniles in the second group with higher average body weight of 187.5±5 g showed different breathing rate, the trend was more or less same. In SW, breathing frequency was 49-50 min^{-1} with normal breathing depth while in NW it was 65-70 min^{-1} with slight increase in breathing depth. In HW, high breathing rate between 86-89 min^{-1} with deep breathing depth was observed.

In majority of non-air breathing catfish, oxygen requirement is met through active breathing process and absorbed from the water. The breathing frequency and depth determine the amount of oxygen uptake to maintain normal metabolic activities. Availability of DO in the water medium as well as interaction between physical and biological processes greatly affect the acquisition and

Table 1. Oxygen uptake under different concentrations of dissolved oxygen

Water temp. (^{0}C)	Length (mm)	Weight (g)	No. of fish	*SW DO		*NW DO		*HW DO	
				Breathing rate (min^{-1})	VO_2 (mg kg^{-1} h^{-1})	Breathing rate (min^{-1})	VO_2 (mg kg^{-1} h^{-1})	Breathing rate (min^{-1})	VO_2 (mg kg^{-1} h^{-1})
28^{o}C±1	290-305	160.0	6	55	502.4	83	288.2	95	125.2
		160.0	12	51	510.6	82	286.7	95	120.2
		145.0	18	53	506.6	80	280.5	98	115.0
Mean±SD	297.5±7.5	152.5±10	36	53±2	506.5±4.1	81.6±1.6	285.1±4.6	96±2	120.1±5.1
28^{o}C±1	320-350	194	6	52	492.5	69	268.6	92	78.6
		188	12	49	476.3	66	268.6	85	76.9
		185	18	48	450.8	65	263.0	86	78.8
Mean±SD	335±15	187.5±5	36	49.6±5.4	473.2±22.4	66.6±2.4	272.7±9.7	87.6±4.4	78.1±1.2

*SW - Saturated water (DO range 7.5-7.0 mg l^{-1}), *NW-Normoxic water (DO range 4.5-4.0 mg l^{-1}), *HW-Hypoxic water (DO range 2.5-2.0 mg l^{-1})

consumption of dissolved oxygen in fishes. Dissolved oxygen is a limiting factor for fish and therefore its availability greatly influences the normal metabolic activities (Fry, 1971). In the present study, for the two weight groups of fishes (152.5±10 g and 187.5±5 g), the oxygen consumption was: 506.5±4.1 & 473.2±22.4; 285.1±4.6 & 272.7±9.7; 120.1±5.1 & 78.1±1.2 mg kg^{-1} h^{-1} under SW, NW and HW respectively at 28±1^{0}C. The results clearly indicate the availability of DO concentration in water as a limiting factor for its acquisition with lowering of concentration. Zeuthen (1947) reviewed data on respiratory metabolism in different organisms and observed that the rate of oxygen consumption declined with increase in body weight. This is in corroboration with the present findings, where with an increase of 35.00±7.5 g body weight, in the second group of juveniles, led to mean reduction of 12.4–42.0 mg kg^{-1} h^{-1} oxygen uptake. Sluggish movement of bigger sized fishes, as observed in respirometer, may be one of the important factors. Stevens and Randall (1967 a, b) opined that due to the change in oxygen level, the increase of opercular ventilation leading to increase in cardiac output during hypoxia condition, oxygen consumption varies between fish and even among the same fish under different conditions.

The increase in oxygen uptake with temperature is associated with an increase in cardiac output and ventricular volume. Rate of oxygen utilisation of fish depends on temperature of the water medium (Andrews and Matsuda, 1975; Battacharya and Subba, 2006). Active swimming fishes have high dissolved oxygen uptake. However, in the present experiment, temperature was maintained as a constant factor in both the weight groups. Oxygen utilisation rate greatly depends on the feeding status of fish and starved fish consume less oxygen than well fed fish (Andrews and Matsuda, 1975). This fact was considered while measuring the DO demand in the present experiment. Andrews *et al*. (1973), demonstrated decline in feed consumption rate with decreasing dissolved oxygen in channel catfish, reared in laboratory tanks. In the present study, oxygen uptake was found to reduce gradually as dissolved oxygen concentration decreased. An abrupt change in swimming behaviour in respirometer was observed below dissolved oxygen concentration of 4.0-3.5 mg l^{-1}. This may probably be the limiting DO level under present conditions for *W. attu* juveniles, where further reduction of oxygen in water begins to restrict metabolic activities/oxygen uptake and put stress on juveniles, as is evident in the behaviour of juveniles. However, detailed study is imperative to confirm the limiting level in terms of other hematological and physiological parameters. Basu (1959) reported that incipient limiting level was above 7 mg l^{-1} for channel catfish. Similar to the present study, where high breathing frequency was observed with lowering of oxygen, Kramr (1987), reported that opercular ventilation frequency is the best documented activity change in response to reduced levels of dissolved oxygen. In both groups of fishes the frequency of opercular movement in saturated water (SF) was between 48-55 min^{-1}, however, it increased to 65-83 min^{-1} in nearly normoxic water (NF) and 85-9 8min^{-1} in hypoxic water (HF) where DO content was below 2.5 ppm. In both the groups of fishes, with lowering of oxygen levels, movement of juveniles towards the surface of the respirometer was noticed with high respiratory frequency. Such behavioural changes may be indication of stress and at the same time to meet desired oxygen level during the experiment.

On the basis of the results of the present study, volume of oxygen required for safe transport of juveniles of *W. attu* was calculated (Table 2). Considering 60% DO saturation (4.5-4.0 ppm), mean VO_2 required for juveniles starved for 3 days was 27.8 mg 100 g $juvenile^{-1}$ h^{-1}. Small sized fingerlings of *W. attu* available in wild water bodies and rural perennial ponds could be collected and transported for culture in well managed ponds. Transportation of smaller fishes is always preferred as more number could be transported safely.

Table 2. Estimate of the amount of oxygen required for transport of *Wallago attu* juveniles for a period of 6-48 h in 60% saturation (It is assumed that 1 mg of oxygen is equivalent to about 0.7 ml O_2)

Temp. (^{0}C)	Mean length (mm)	Mean VO_2 [mg l^{-1} 100 g (01 nos.)$juvenile^{-1}$ h^{-1}]	VO_2 [1 kg (10 nos.) $juveniles^{-1}$ 6 h^{-1}		VO_2 [1 kg (10 nos.) $juvenile^{-1}$ 12 h^{-1}]		VO_2 [1 kg (10 nos.) $juvenile^{-1}$ 24 h^{-1}]		VO_2 [1 kg (10 nos.) $juvenile^{-1}$ 48 h^{-1}]	
			mg l^{-1}	O_2 in ml	mg l^{-1}	O_2 in ml	mg l^{-1}	O_2 in ml	mg l^{-1}	O_2 in ml
28±2	316.25±11.25	27.80	1668.00	1167.60	3336.00	2335.20	6672.00	4670.40	13344.00	9340.80

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