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Oxygen uptake of *Olyra longicaudata* (McClelland, 1842) in relation to body weight

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Abstract
Oxygen uptake is a valid measure of metabolism on which production of aquaculture depends. The weight specific oxygen uptake in *Olyra longicaudata* was still unknown. So, the fishes were collected from Chisang river basin, Letang from February to July, 2019. Oxygen uptake rate of the fishes was carried out in laboratory of Post Graduate Campus, Biratnagar conducted by the cylindrical glass respirometer with the aim of estimating oxygen consumption. Data were analyzed from logarithmic transformations of body weight and oxygen uptake expressed by the allometric equation. The total oxygen uptake increased with increasing body weight by a power of 0.580. There was positive correlation coefficient equal to 0.9586 ($p<0.01$). The weight specific oxygen uptake declined with increasing body weight by power of 0.419 with correlation coefficient equal to 0.9252 ($p<0.01$). The study was concluded that the specific metabolic rate is higher in smaller than in larger fishes.

Keywords: Chisang, respirometer, metabolic rate, correlation coefficient

Introduction

Oxygen is essential for the function, growth and welfare of animals. Metabolism of the fish is necessary in order to estimate the requirement for promoting and sustaining growth. Regulation of metabolism is directly reflected in respiration. The uptake of respiration by the fish is taken as a measure of its metabolism. Increase in metabolic activity increase the rate of oxygen uptake. Oxygen uptake in fish is influenced by various extrinsic and intrinsic factors viz. temperature, photoperiod, pollutants, season and time, pH, salinity, oxygen, carbon dioxide tensions, body weight, state of activity, nutrition, stage in life cycle, sex, gonadal cycle and hormones etc. [1]. The metabolic rate is known to increase with temperature and feeding level [2], swimming speed and stress [3-6], as well as to decrease with increasing size [7]. Killen *et al*. [8] studied the intraspecific scaling of metabolic rate in fishes. Kumari *et al*. [9] determined the relationship between oxygen uptake and body weight in *Notopterus notopterus* at 24.0±1.0 ^{0}C under continuous water flow system. Subba and Ghosh [10] studied the oxygen uptake in relation to body weight in a hill stream fish *Glyptothorax telchitta* from the Saptakoshi river. They found that with a unit increase in body weight, the oxygen uptake per unit time (mlO_2h^{-1}) increases by a power of 0.930 showing significant positive correlation whereas the weight specific oxygen uptake decreases by a power of 0.070 showing significant but negative correlation. Akbulut *et al*. [11] resolved the oxygen consumption rate of Black Sea Trout (*Salmo trutta labrax*). Segovia *et al*. [12] studied the oxygen consumption rate in four groups of *Oplegnathus insignis* under three different water temperature 13 ^{0}C, 18 ^{0}C and 23 ^{0}C. Mohapatra *et al*. [13] determined oxygen consumption of advanced fry and fingerlings of Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*). Hallikhed [14] gave a detail account on oxygen uptake in relation to temperature variation and showed a gradual increase in the oxygen consumption during heat adaptation and a gradual decrease during cold adaptation. Kumar and Ahsan [15] studied the bimodal oxygen uptake in an air breathing fish *Channa marulius* and concluded that with unit increased in body weight, aquatic, aerial and total oxygen uptake increased by an fractional power of 0.8309, 0.7729 and 0.7737 respectively whereas aquatic, aerial and total oxygen uptake per unit body weight decreased by the fractional power of 0.1901, 0.2796 and 0.2302 respectively. Prakoso *et al*. [16] gave the detailed account on oxygen consumption of *Mugil celphalus* at different temperature (15 ^{0}C, 20 ^{0}C and 25 ^{0}C) and found that the rate was high at 25 ^{0}C.

Olyra longicaudata is rare fresh water hill stream cat fish inhabiting under vegetations and stony beds in shallow water.

They prefer shallow and clear cold running water with high level of dissolved oxygen enriched with larval and aquatic insects, crustaceans, annelids, mollusks etc. [17]. The conservation status of the fish is least concern, IUCN 2010. In Nepal, it was reported from Kadya tributary of Trijuga river, Udayapur [18] and also found in Chisang river, Letang [19].

The knowledge about oxygen uptake in relation to body weight permits the prediction of the oxygen consumption by an animal of given size which may be useful to know the time period for transportation of live fries, fingerlings and adults and also in their storage. So, an attempt was made to know the correlation coefficient between oxygen consumption and body weight of the fish. The study provides information about the fish and might help on its culture and conservation.

Materials and Methods

Study area

The study was carried out in laboratory of Post Graduate Campus, Biratnagar (Alt. 72 MSL, 26º 28’ 60’’ N & 87º 16’ 60’’ E,) located in Morang district of Province 1, Nepal. It is 2nd largest industrial and busiest city with population of 2, 40,000 & area of 103.88 km^2.

Specimen collection

Live twenty five specimens of the *O. longicaudata* of different body weight (0.8g to 5.2g) were collected from Chisang river basin nearby Lamitar, Letang (Alt. 291 MSL, $26^0$45’46.3” N & $87^0$30’0.15”E) with the help of local fisherman using nylon mosquito nets from February to July , 2019.

The collected specimens were acclimatized in a large glass aquarium inside Zoology laboratory of Post Graduate Campus, Biratnagar for a month. The temperature acclimation at each sampling date was similar to that of the natural environment. The experimented fish was undernourished for 12 hours before experimentation. The fishes were weighed before introduced into the experiment. Atmospheric temperature, ambient temperature and operculum frequency were also recorded.

Measurement of oxygen consumption

Among 25 specimens, only 15 specimens were introduced in the experiment. A flow-through cylindrical glass respirometer (24 cm long and 7 cm in diameter) of 722 ml volume, was used in order to measure the inflow and the out flow water. The Winkler´s method [20] was used to measure the oxygen content of the inspired and expired water. The constant flow of water was maintained in experiment at the rate of 600 ml per hour. Metal clops are used to control the constant flow of water. The oxygen uptake per unit time and body weight was determined by the difference of dissolved oxygen of inspired and expired water and body weight of the fishes. The respirometer was connected to a large water tank with constant water level. The tank was connected to chlorine free tap water. At first rate of flow of water was high and then slowed down. The fish was acclimatized in the respirometer for one hour before experimentation. Visual disturbance was refrained by a black cloth cover over the respirometer. Both ends of the respirometer were connected to the conical flasks from where inspired and expired water were collected for measurement of concentration of the dissolved oxygen content using Winkler’s volumetric method [20]. Oxygen consumption per unit time (mlO_2/hr) and per unit body weight (mlO_2/g/hr) was calculated by the differences of dissolved oxygen levels between inspired and expired water and body weight of the fish. At every half an hour interval, three readings were taken and then an average value was calculated out of the three readings.

Regression analysis after logarithmic transformation was done to show regression coefficient between oxygen uptake and body weight and also between specific oxygen consumption and body weight. The correlation coefficient and estimated value were calculated by power equation. The expression of the relationship between oxygen uptake and body weight was made by the following allometric equation:

$$VO_2 = {}_aW^b$$

or

$$\text{Log } VO_2 = \text{lag } a + b \log W.$$

Where, VO_2 = oxygen uptake per unit time
a = intercept
b =regression coefficient W= weight of the fish

Statistical analysis

Coefficient of correlation between body weight and oxygen uptake per unit time with number of fishes collected were performed by using Karl Pearson’s method. The coefficient of correlation was calculated by using excel software.

Results

The oxygen uptake rate was determined in fifteen weight groups of *O. longicaudata*. The body weight was ranged from 0.8 g to 5.2 g, atmospheric temperatures from 26 ^{0}C to 30 ^{0}C, ambient temperature from 25 ^{0}C to 27 ^{0}C,operculum frequency per minute from 101 to 123, oxygen consumption (mlO_2/hr) from 0.7044 to 2.032 and weight specific oxygen uptake (mlO_2/g/hr) from 0.8805 to 0.3907 (Table 1). The dissolved oxygen of the ambient water ranged from 4.032mg/l to 5.360mg/l and pH of water was 7.

Table 1: Oxygen uptake in relation to body weight

Body weight (g)	Atmospheric temperature (^{0}C)	Ambient temperature (^{0}C)	Operculum frequency (per minute)	Oxygen uptake			Estimated value
				mlo_2/hr	mlo_2/g/hr	mlo_2/kg/hr	
0.8	26.5	26.0	123	0.7044	0.8805	880.50	0.7395
1.4	26.0	25.0	122	0.8543	0.6102	610.20	0.9108
1.6	27.5	26.0	122	1.0081	0.6300	630.06	0.9842
1.8	28.0	27.0	122	1.0792	0.5995	599.50	1.0539
2.0	26.0	25.0	122	1.0346	0.5173	517.30	1.1203
2.4	28.5	27.0	120	1.1533	0.4805	480.50	1.2455
2.6	26.5	26.0	119	1.5491	0.5958	595.80	1.3047
2.8	28.0	26.0	119	1.1109	0.3967	396.70	1.3620
3.0	27.0	26.0	116	1.4113	0.4704	470.40	1.4177

3.2	27.0	26.0	115	1.5110	0.4721	472.10	1.4716
3.4	30.0	26.0	115	1.6802	0.4941	494.10	1.5244
4.0	27.0	26.0	107	1.6400	0.4100	410.00	1.6750
4.2	27.0	26.0	102	1.7541	0.4176	417.60	1.7234
4.6	28.0	27.0	102	1.7877	0.3886	388.60	1.8167
5.2	27.0	27.0	101	2.0320	0.3907	390.70	1.9511
Avg. =2.87	Avg.=27.33	Avg=26.13	Avg.=107	Avg.=1.3540	Avg.= 0.5169	Avg.= 516.93	Avg. = 1.3533

Body weight of fishes(X), oxygen uptake(Y), logX and logY are presented as the parabolic chart for statistical analysis (Table 2).Value of logX, logY and their square and products are increased as increasing body weight.

Table 2: Parabolic chart

S.N.	X	logX	logX^2	Y	Logy	logY^2	logX.logY
1	0.8	-0.09691	0.009392	0.7044	-0.15218	0.023159	0.014748
2	1.4	0.146128	0.021353	0.8543	-0.06839	0.004677	-0.00999
3	1.6	0.204120	0.041665	1.0081	0.003504	0.000012	0.000715
4	1.8	0.255273	0.065164	1.0792	0.033102	0.001096	0.008450
5	2.0	0.301030	0.090619	1.0346	0.014772	0.000218	0.004447
6	2.4	0.380211	0.144561	1.1533	0.061942	0.003837	0.023551
7	2.6	0.414973	0.172203	1.5491	0.190079	0.036130	0.078878
8	2.8	0.447158	0.199950	1.1109	0.045675	0.002086	0.020424
9	3.0	0.477121	0.227645	1.4113	0.149619	0.022386	0.071387
10	3.2	0.505150	0.255177	1.5110	0.179264	0.032136	0.090555
11	3.4	0.531479	0.282470	1.6802	0.225361	0.050788	0.119775
12	4.0	0.602060	0.362476	1.6400	0.214844	0.046158	0.129349
13	4.2	0.623249	0.388440	1.7541	0.244054	0.059563	0.152107
14	4.6	0.662758	0.439248	1.7877	0.252295	0.063653	0.167210
15	5.2	0.716003	0.512661	2.0320	0.307924	0.094817	0.220474
	Σ=43.8	Σ=6.1698	Σ=3.2130	Σ=20.312	Σ=1.7018	Σ=0.4407	Σ=1.09207

Relationship between body weight and oxygen uptake per unit time (mlO_2/hr) at 26.13±0.16^{o}c

The log/log plot of the oxygen uptake in relation to body weight shows the straight line as shown in fig.1, when different scores were plotted by using least square regression method. The slope of regression line from logarithmic equation was 0.580. The oxygen uptake (mlO_2/hr) increased from 0.7044 to 2.0320 with increasing body weight from 0.8 g to 5.2 g by a power of 0.580. (Figure1). There was positive significance between oxygen consumption and body weight with the correlation coefficient (r) equal to 0.9586 ($p<0.01$).The increased oxygen consumption exhibited an exponential relationship with increasing body weight. The value of regression coefficient and intercept was 0.580 and 0.749 respectively.

Here, $VO_2 = {}_aW^b$

Or, $\log. VO_2 = \log.a + b \log.W = \log 0.749 + 0.580 \log W = -0.1255 + 0.580 \log W$

The estimated value for 1 g, 10 g, 100 g and 1000 g the fishes were 0.749, 2.847, 10.826 and 41.160 respectively using power equation $y = 0.749x^{0.580}$.

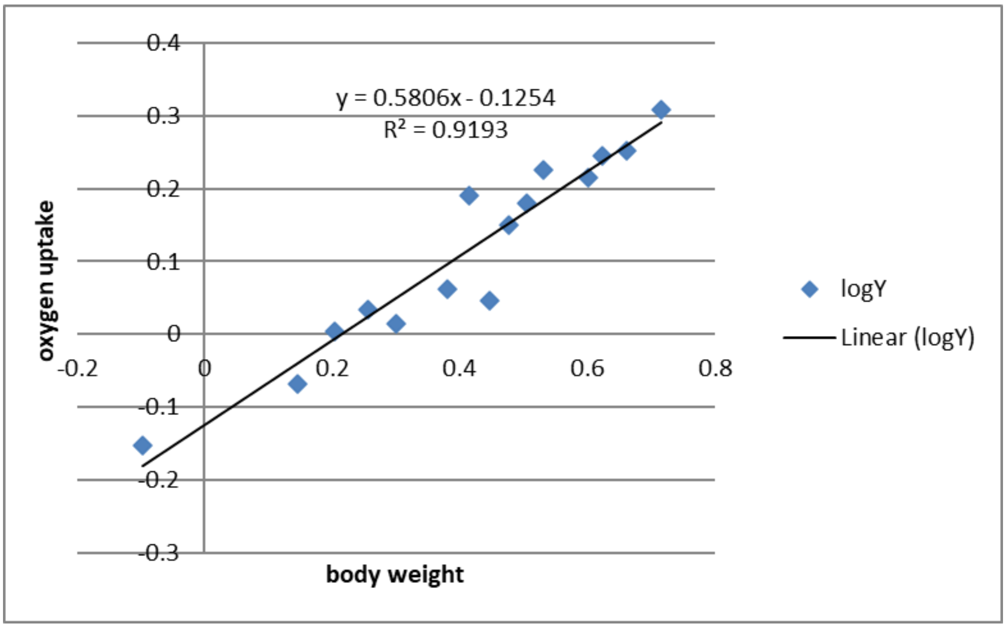

Fig 1: Log/log plots showing the relationship between oxygen uptake and body weight in *O. lognicaudata*.

Relationship between body weight and oxygen uptake per unit body weight ($mlO_2/g/hr$) at 26.13±0.16 ºc

Body weight of fishes (X), weight specific oxygen uptake(Y), logX and logY are presented as the parabolic chart for statistical analysis (Table 3).

Table 3: Parabolic chart

S.N.	X	logX	$logX^2$	Y	logy	$logY^2$	logX.logY
1	0.8	-0.09691	0.009392	0.8805	-0.055270	0.003054	0.0053562
2	1.4	0.146128	0.021353	0.6102	-0.214527	0.046021	-0.031348
3	1.6	0.204120	0.041665	0.6300	-0.200659	0.040264	-0.040958
4	1.8	0.255273	0.065164	0.5995	-0.222210	0.049377	-0.056724
5	2.0	0.301030	0.090619	0.5173	-0.286257	0.081943	-0.861719
6	2.4	0.380211	0.144561	0.4805	-0.318306	0.101318	-0.121023
7	2.6	0.414973	0.172203	0.5958	-0.224899	0.050579	-0.093327
8	2.8	0.447158	0.199950	0.3967	-0.401537	0.161231	-0.179550
9	3.0	0.477121	0.227645	0.4704	-0.327532	0.107277	-0.156272
10	3.2	0.505150	0.255177	0.4721	-0.325966	0.106253	-0.164661
11	3.4	0.531479	0.282470	0.4941	-0.306185	0.093749	-0.162730
12	4.0	0.602060.	0.362476	0.4100	-0.387216	0.149936	-0.233127
13	4.2	0.623249	0.388440	0.4176	-0.379239	0.143822	-0.236360
14	4.6	0.662758	0.439248	0.3886	-0.410497	0.168507	-0.272060
15	5.2	0.716003	0.512661	0.3907	-0.408156	0.166591	-0.292240
	Σ=43.8	Σ=6.1698	Σ=3.2130	Σ=7.754	Σ=-4.4684	Σ=1.4699	Σ=-2.8967

The weight specific oxygen uptake ($mlO_2/g/hr$) declined from 0.8805 to 0.3907 with increasing body weight from 0.8 g to 5.2 g (Table 1). The slope of regression coefficient by log-log plot of the relationship between body weight and weight specific oxygen uptake was negative i.e. -0.419. Weight specific oxygen uptake ($mlO_2/g/hr$) was decreased with increasing body weight by power of 0.419 (Figure 2). The correlation coefficient obtained by power equation was negative. It is equal to 0.9252 ($p<0.01$) which showed significance.

Here,

$VO_2 = {}_aW^b = 0.749x^{-0.41}$

The estimated value for 1g, 10g, 100g and 1000g fishes were 0.749, 0.2913, 0.1133 and 0.0441 respectively.

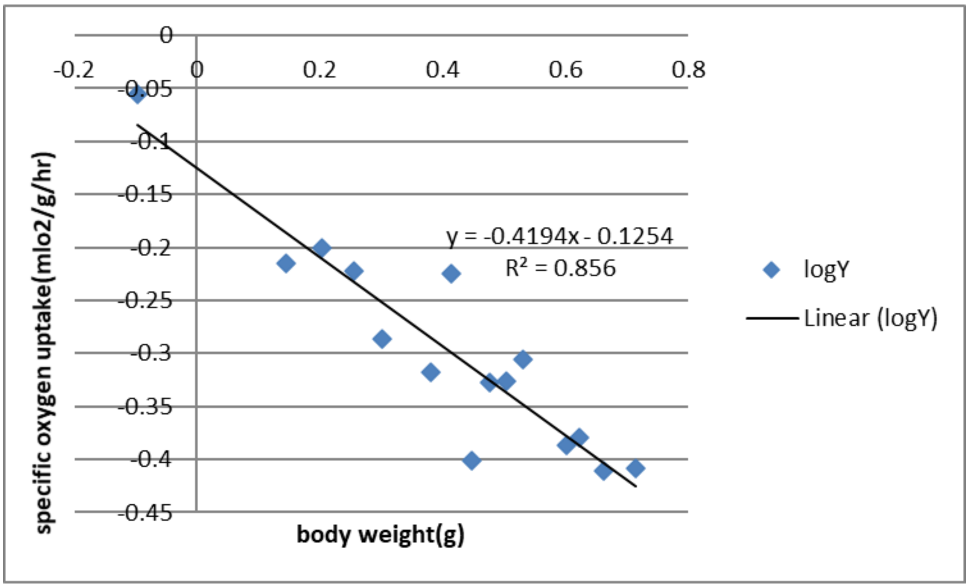

Fig 2: log/log plot showing the relationship between body weight and weight specific oxygen consumption at 26.13±0.16 ºc

The oxygen uptake with intercept, slope and correlation coefficient is summarized in table 4.

Table 4: Oxygen uptake showing intercept, slope and correlation coefficient in *O. longicaudata.*

Body weight Vs oxygen consumption	Intercept (a)	Slope (b)	Correlation coefficient (r)
VO_2 (mlO_2/hr)	0.749	0.580	0.9586
VO_2($mlO_2/g/hr$)	0.749	-0.419	0.9252

Discussion

The oxygen uptake rate was determined in fifteen weight groups of *O. longicaudata*. The ambient temperature of water was ranged from 25 ^{0}C to 27 ^{0}C, operculum frequency per minute from 101 to 123 and the dissolved oxygen of water ranged from 4.032mg/l to 5.360 mg/l and pH of water was 7. These characters of water were suitable for the fishes.

The oxygen uptake (mlO_2/hr) increased from 0.7044 to 2.0320 with increasing body weight from 0.8 g to 5.2 g by a power of 0.580.There was positive significance between oxygen consumption and body weight with the correlation coefficient (r) equal to 0.9586 ($p<0.01$).The increased oxygen consumption exhibited an exponential relationship with increasing body weight. The value of intercept was 0.749.

The weight specific oxygen uptake ($mlO_2/g/hr$) declined from 0.8805 to 0.3907 with increasing body weight from 0.8 g to

5.2 g. The slope of regression coefficient between body weight and weight specific oxygen uptake was negative i.e. -0.419. The correlation coefficient obtained by power equation was negative. It is equal to 0.9252 ($p<0.01$) which showed significance. Weight specific oxygen uptake ($mlO_2/g/hr$) in the present study was decreased with increasing body weight by power of 0.419. The low exponent value i.e. 0.580 (rate of oxygen uptake) and 0.419 (Weight specific oxygen uptake) indicates that rate of dissolved oxygen consumption by the fish is very slow as it is a catfish.

Several researchers have reported that rate of oxygen consumption increases as the body weight increases [21, 22]. The exponent value relating to the oxygen uptake per unit time was always less than 1 as found in most of the fishes by several researchers. The exponent value in the present study was 0.580 which is near to finding of Ruhland [23] and Munshi and Dube [24]. They reported the exponent value as 0.5. Similarly the value for juveniles of *Catla catla* and *Labeo rohita* was recorded as 0.561 and 0.538 respectively [25]. Bhattacharya and Subba [26] reported the slope value in *Esomus dandricus* as 0.5722. In *Notopterus notopterus* the slope value was 0.421 [9] which was lower than the present study. The present value is lower than most of purely water breathing fishes viz 0.64 in mosquito fish *Gambusia affinis* [27], 0.662 in *Mystus cavasius* [28], 0.747 in *Catla catla* [29] and 0.796 in *Cirrhinus mrigala* [30]. Hakim *et al.* [31] in *Channa punctatus* estimated a slope value of 0.629. In *Heteropneustes fossilis* the oxygen consumption through gills increased by a power function of 0.799 [32]. The relationship between oxygen consumption rate and body size was increased by a power function with an exponent of 0.82 [33]. Oxygen uptake in *Channa marulius* was increased with unit increased in body weight by a fractional power of 0.8309 [15].

As compared to other hill stream fishes, the exponent value in the present fish was lower than others. Subba and Ghosh [10] estimated exponent value 0.93 in hill stream fish *Glyptothorax telchitta*. Similarly the estimated slope value in two hill stream fishes *Noemacheilus supicola* and *Garra lamta* was 1.201 and 0.875 respectively [34]. Scholander *et al.* [21] suggested (0.83) as the general role for the fishes. Prosser [35] suggested the exponent value could range from 0.67 to 1.0. These all differences in slope value of different fish species seemed to be due to different growth pattern, stages of their life cycle, physiological condition of the fish and changes in feeding behavior etc. [36, 37, 22]. The weight specific oxygen uptake ($mlO_2/g/hr$) in present study declined with increasing body weight. The reason may due to the sum of enzymes, metabolites and perhaps inhibitors which govern various metabolic activities of organism, is lower in adult in comparison to growing tissue.

The estimated value of oxygen uptake for 1 g of *O. longicaudata* in the present study was 0.7493 which was higher than most of the air breathing fishes and purely aquatic breathing fishes, *Clarias batrachus* (0.134) [38], *Channa marulius* (0.1225) [15] and *Notopterus notopterus* (0.508) [9]. As compared with other hill stream fishes, the estimated value for 1 g in *Garra lamta* was 0.86 and in *Noemachelius supicola* was 0.532 [34] and in *Glyptothorax telchitta* was 0.3202 [10]. The value 0.86 is higher and 0.532 & 0.3202 are lower than 0.7493 found in present study (*O. longicaudata*).

Conclusion
The rate of oxygen uptake was increased with increasing body mass but the rate of metabolism declined with increasing body mass of the fishes. The specific metabolic rate is higher in smaller than in larger fishes.

Breathing frequency, rate of oxygen uptake, mass and size of the fish, temperature, dissolve oxygen and volume of water can predict the time period during transportation of live fishes. Smaller fishes are more preferable in live transportation.

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