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# Length-Weight Relationship and Growth Pattern of Bengal Loach (*B. Dario)* in Bangladesh

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**Abstract:**

The study established length-weight relationships and to determine growth pattern of Bengal Loach **(***BOTIA DARIO)***.** Sampling was carried out once in a month over a calendar year from the Someshwari River in Netrakona. At each sampling, at least 25 individuals were collected. Among 300 individuals, the measurement of standard-length was from3.50 to 25.3 cm and body weight varied from 2.1 to 21.5 g. The parameters 'a' and 'b' of the equation, $W=aL^{b}$varied monthly and it ranged from 0.018 to 0.081, and 2.021 to 3.211, respectively. The highest value of 'a' was calculated in June and the lowest value was in February. The highest value of 'b' was calculated in February and the lowest value was in June. The generalized length-weight relationship was $BW=0.034SL^{2.805}$ pooling all monthly samples data. The highest correlation coefficient was estimated in June and the lowest value was in January. Isometric growth pattern were found for monthly populations in January, February, April, May, July, August, September and October; while, allometric growth pattern was found in March, June, November, and December. The growth pattern of pooled data of all monthly samples was allometric.

**Keywords:** length-weight relationships, isometric growth, allometric growth, Bengal Loach

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## Introduction

Bangladesh is possessed with vast marine, coastal and inland water bodies. It is one of the resourceful countries with its wide range of marine aquatic biodiversities. Inland fisheries are covering an area of 47.60 lakh ha, which has two sub-sectors, i.e. inland capture and inland culture [1]. The climatic condition of the country (moderate temperature, heavy rainfall during monsoon seasons) is also suitable to support the huge and diversified fish. It has a coastal area of 2.30 million ha and a coastline of 710 km along the Bay of Bengal which supports large artisanal and coastal fisheries. There are about 260 species of fish in the freshwater and 486 species of fish available in marine waters in Bangladesh [2]. Fish plays a major role in the Bangladeshi diet because of its easily digestibility and rich source of animal protein. Mainly small indigenous species (SIS) (<25 cm) consumed dominantly. SIS species contains high amount of vitamin-A. Ali [3] listed 143 species of SIS in Bangladesh. A total of 61 small indigenous species of fish was identified from various natural waters. According to Rahman [4], there are 260 species of freshwater indigenous fish in Bangladesh. Among them, which grow to a size of 25 cm or 9 inches in mature or adult stage in their lifecycle are known as "SIS" (Small Indigenous Species) [5]. The parameters of length-weight relationship equation of the form $BW=aSL^{b}$ were estimated by using log-transformed linear regression of body weight on standard length. Growth pattern of fishes can be determined by depending on 'b' value of 95% confidence level. The value of b for isometric growth is '3' and values greater or less than '3' indicate allometric growth. Length-weight relationships of fish, in general, are important because they: (a) allow an estimate of the condition of fish; (b) allow the estimation of biomass from length observations; (c) allow the conversion of growth-in-length equations to growth-in-weight; and (d) are useful for between-region comparisons of life histories of Species [6]. The b value was calculated to find out whether the fish is growing allometrically or isometrically. If the b value is 3.0 the growth is isometric, and it holds good only when the density and form of the fish are constant. If it is allometric, the fish grows with weight increasing at slower ($b < 3.0$) or faster ($> 3.0$) relative to the increase in length. The length-weight relationship is useful for the prediction of weight from length values, condition of fish, stock assessment and estimation of biomass [7]. The specific objectives of this study were to model monthly length-weight relationship, to derive a general length-weight relationship, to extrapolate monthly variations of length-weight relationship and to understand the monthly growth pattern of *B. dario*.

## Material and methods

### Study area

The population for the present study was chosen purposively in Someshwari River at Durgapur Upazila under district of Netrakona (24°52'00" to 24.8667° N Latitude and 90°58'00" to 90.9667° E Longitude) where *B. dario* were collected.

### Collection of fish sample

Monthly sampling of *B. dario*was carried out over a calendar year for a period of one calendar year. 25 individuals of fish were collected randomly (Table 1). The fish specimens in the sample were preserved in a plastic container with 10% buffered formalin.

**Table 1**: Collection report of Bengal loach*B.dario*

| Sampling month | No. of fish | Size range | |
|---|---|---|---|
| | | Standard length (cm) | Body weight (g) |
| January | 25 | 4.3-6.8 | 2.1-6.7 |
| February | 25 | 4.2-8.9 | 2.0-21.5 |
| March | 25 | 4.6-6.6 | 2.28-6.01 |
| April | 25 | 4.8-6.1 | 2.1-4.75 |
| May | 25 | 4.8-6.9 | 2.26-7.52 |
| June | 25 | 4.5-6.7 | 2.59-5.67 |
| July | 25 | 4.9-9.2 | 2.54-15.62 |
| August | 25 | 4.6-7.7 | 2.47-10.44 |
| September | 25 | 6.3-8.9 | 6.64-16.50 |
| October | 25 | 5.9-8.0 | 4.4-11.55 |
| November | 25 | 5.6-8.1 | 5.14-17.24 |
| December | 25 | 4.1-8.0 | 2.21-11.55 |

### Length-weight relationship

#### Sample relationship

The relationship between standard length (SL) and body weight (BW) was calculated using the power curve expression:

$$BW = aSL^b$$

Where,

BW = Body weight in g,

SL = Standard Length in cm, and

‘a’ and ‘b’ are constants.

Parameters ‘a’ and ‘b’ of the length-weight relationship were estimated by linear regression analysis based on natural logarithms:

$$\ln BW = \ln a + b\,(\ln SL)$$

Where,

$lnBW$ = dependent variable

$lnSL$ = independent variable

lna and b are intercept and slope of the log-log linear relationship respectively.

The slope of the linear equation was estimated using the following formula:

slope, $b = [n\ \Sigma XY - \Sigma X\ \Sigma Y] / [n\ \Sigma X^2 - (\Sigma X)^2]$

Where, $X = lnSL$, $Y = lnBW$, n = number of observations in the sample.

The intercept of the linear equation was estimated by the formula given below:

Intercept, $lna = Y - bX$

The 'a' value in the equation of length-weight relationship ($BW = aSL^b$) was estimated as, a = exp (lna).

To measure the correlation between length and weight, the most commonly used correlation coefficient which in other name is known as the Pearson product moment correlation coefficient was employed in this study. The correlation coefficient is a descriptive measure of the strength of the linear relationship between two variables. The correlation coefficient, r was estimated by:

$r = [n\ \Sigma XY - \Sigma X\ \Sigma Y] / \sqrt{([n\ \Sigma X^2 - (\Sigma X)^2]\ [n\ \Sigma Y2 - (\Sigma Y)^2])}$

The coefficient of determination ($r^2$) is the proportion of the variation of dependent variable which can be explained by the variation of the independent variable. It was used to measure the utility of the regression equation for making predictions. The coefficient of determination is the square of the correlation coefficient, and its value lies between 0 and 1.

**Population relationship**

For population length-weight relationship, 95% confidence limits of the parameters 'a' and 'b' in the equation of $BW = aSL^b$ were estimated.

The variance of independent variable of log-log linear equation,

$Sx^2 = [n\ \Sigma X^2 - (\Sigma X)^2] / [n\ (n-1)]$

The variance of dependent variable of log-log linear equation,

$Sy^2 = [n\ \Sigma Y^2 - (\Sigma Y)^2] / [n\ (n-1)]$

The variance of the slope (Sb2) was estimated by using following formula:

$Sb^2 = [1/ (n-2)]\ [(S_y^2/Sx^2)-b^2]$

The standard deviation of the slope, $S_b = \sqrt{[1/ (n-2)]\ [(S_y^2/S_x^2)-b^2]}$

The standard error of the slope, $Se_b = S_b/\sqrt{n}$

The 95% confidence limit of the slope, $b \pm Se_b{*}t$, where t is the value from t tablewith (n-2) degree of freedom

The variance of intercept ($S_{lna}^2$) was estimated by using following formula:

$S_{lna}^2 = S_b^2\ [(n-1)\ S_x^2/n + X^2]$

The standard deviation of the intercept, $S_{lna} = \sqrt{[S_b^2\ \{(n-1)\ S_x^2/ n + X^2\}]}$

The standard error of the intercept, $Se_{lna} = S_{lna}/\sqrt{n}$

The 95%confidence limit of the intercept, $lna \pm Se_{lna}{*}t$

The lower and upper limits of 95% confidence interval of 'a' value in lengthweightrelationship were calculated taking exponential values of both limits oflna.

**Growth pattern designation**

Growth pattern of individuals belong to a monthly sample was judged based on'b' value in the cubic equation $BW = aSL^b$; if the 'b' is equal to 3, the sample growth was isometric; if not equal to 3, the growth pattern was allometric. The growth pattern of the individuals in the population of a particular month was designated appraising limits the confidence of ‘b’ value at 95% level. If ‘b’ value of confidence limits incorporated 3, the population growth in that month was isometric, otherwise the growth was concluded to be allometric.

**Results and discussion**

**Length weight relationships**

The standard length and body weight of all samples varied monthly and ranged from 3.50 to 25.3 cm and 2.1 to 21.5 g respectively. Table 2 shows detailed monthly parameters of length-weight relationships. The exponent of the power equation, ‘b’ varied monthly and it ranged from 2.021 to 3.211, the lowest ‘b’ value was obtained in June and the highest in February. The value of the parameter, ‘a’ varied monthly as well and it ranged from 0.018 to 0.081. The lowest value of ‘a’ was on February and the highest value of ‘a’ was on June. The values of correlation coefficient (r) ranged from 0.849 to 0.979 and all these values exhibited a degree of positive correlation between length and weight. The highest correlation coefficient was estimated in June and the lowest value was in January. The values of coefficient of determination ($r^2$) vary from month to month and it ranged from 0.721 to 0.960.The highest coefficient of determination ($r^2$) was estimated in June and the lowest value was in January.

**Table 2:** Length-weight relationship parameters of monthly samples for *B.dario*

| Sampling month | a | b | df | r | CI of ‘a’ at 95% CL | CI of ‘b’ at 95% CL |
|---|---|---|---|---|---|---|
| January | 0.082 | 2.360 | 23 | 0.849 | 0.028-0.235 | 1.733-3.001 |
| February | 0.018 | 3.211 | 23 | 0.977 | 0.011- 0.032 | 2.913-3.510 |
| March | 0.043 | 2.634 | 23 | 0.939 | 0.021-0.087 | 2.220-3.048 |
| April | 0.020 | 3.073 | 23 | 0.886 | 0.006-0.065 | 2.383-3.764 |
| May | 0.059 | 2.475 | 23 | 0.960 | 0.033-0.103 | 2.164-2.786 |
| June | 0.120 | 2.021 | 23 | 0.979 | 0.088-0.162 | 1.843-2.199 |
| July | 0.018 | 3.073 | 23 | 0.972 | 0.010-0.032 | 2.753-3.393 |
| August | 0.025 | 2.895 | 23 | 0.912 | 0.009-0.070 | 2.337-3.454 |
| September | 0.061 | 2.538 | 23 | 0.934 | 0.024-0.155 | 2.085-2.991 |
| October | 0.048 | 2.613 | 23 | 0.931 | 0.021-0.111 | 2.173-3.053 |
| November | 0.030 | 3.003 | 23 | 0.950 | 0.013-0.065 | 2.582-3.425 |
| December | 0.059 | 2.548 | 23 | 0.953 | 0.107-0.033 | 2.200-2.896 |
| General | 0.034 | 2.805 | 298 | 0.937 | 0.027-0.043 | 2.686-2.925 |

**Growth pattern**

The general growth pattern for entire sample was negative allometric since the ‘b’ value of the equation $BW=0.034SL^{2.803}$ is less than 3. The limits of ‘b’ with 298 degrees of freedom at 95% confidence level were from 2.686 to 2.924 which did not include 3 (Table 3). The growth pattern, therefore, of *B. Dario* population was allometric.

**Table 3:** Monthly growth pattern of *B. dario*

| Sampling month | b | Growth inference of sample | CI of ‘b’ at 95% CL | Growth inference of population |
|---|---|---|---|---|
| January | 2.367 | allometric | 1.733-3.001 | isometric |
| February | 3.211 | allometric | 2.913-3.510 | isometric |
| March | 2.634 | allometric | 2.220-3.048 | isometric |
| April | 3.073 | allometric | 2.383-3.764 | isometric |
| May | 2.475 | allometric | 2.164-2.786 | allometric |

| | | | | |
|---|---|---|---|---|
| June | 2.021 | allometric | 1.843-2.199 | allometric |
| July | 3.073 | allometric | 2.753-3.393 | isometric |
| August | 2.895 | allometric | 2.337-3.454 | isometric |
| September | 2.538 | allometric | 2.085-2.991 | allometric |
| October | 2.613 | allometric | 2.173-3.053 | isometric |
| November | 3.003 | allometric | 2.582-3.425 | isometric |
| December | 2.548 | allometric | 2.200-2.896 | allometric |
| General | 2.805 | allometric | 2.686 -2.925 | allometric |

In case of length-weight relationship, if the confidence limit of ‘b’ value in 95% confidence level is 3, then the growth is isometric and if it is less than or larger than 3, the growth is allometric. Monthly growth in *B. Dario* population in Bangladesh in different months was found isometric in July, August, September, October, January, February, April, and May. The growth of *B. Dario* population was found allometric in November, December, March, June. According to Martin [8], the value of ‘b’ usually remains constant at 3.0 for an ideal fish. In present, study the adult fish showed little deviation from the ideal values. Bal and Rao [9]. Indicated that the values of ‘a’ and ‘b’ differ not only between different species but also within the same species dependingon sex, stage of maturity and food habits. Beverton and Holt [10] reported that cubic relationship between length and weight had the b value near to 3.0. Hile [11] proposed that the b value for an ideal fish might range between 2.5 to 4.0. When comparing length-weight relationships available in the literature, one might find wide variability in parameter estimates for a single species. This is due to the fact that length-weight relationships are greatly affected by many factors related to population variability and to sample and estimation methods. Sampling related factors include sample size, length distribution in the sample and type of length measure, while nutritional conditions account for intrinsic biological variability [12]. The length-weight relationship in fishes can be affected by a number of factors including season, habitat, gonad maturity, sex, diet and stomach fullness, health and preservation techniques and differences in the length ranges of the specimen caught which were not accounted for in the present study. Thus, differences in length-weight relationships between this and other studies could potentially be attributed to the combination of one or more of the factors given above. The widest possible range of length must be included in efficient sampling which is generally obtained with large samples and non-selective fishing techniques. Different mathematical models are used for the calculations which may also significantly affect length-weight relationship parameter estimates. Systematic works on monthly length-weight relationship round a calendar year on any fish population doesn’t exist in this region, let alone Bangladesh. A detail comparison of the length-weight relationships of *B. Dario* of monthly samples, their monthly variations, condition factors and their monthly variations over an entire period of one year was not possible as the published information this species is rare. The study of length-weight relationship could give an idea of the changes of body form as the fish was growing. It could serve also as a measure to predict the weight of fish when only the length is known [13]. Fish base contained 8,049 records for length-weight relationships for 3,164species of fishes as an important component of it [14]. Froese [15] established that the values of the slope b generally range between 2and 4, with 90% of the values ranging from 2.7 to 3.4 based on the analysis of a large number of length-weight relationships from Fish base. The monthly ‘b’ values of *B. Dario* assumed similar trend of those species recorded in Fish base. Both the parameters of length-weight relationship equations varied monthly in particular in the present study. The parameters ‘a’ and ‘b’ of length weight relationship vary with the size range of the sample, sex, season and area [16]. In an extensive work onthe length-length, length-weight relationships and condition factor of same species collected from Someshwari River. Ahmed *et al.* [17] found similar results in their study. The growth pattern that was assigned to the monthly populations for this species varied, a phenomenon that was also apparent in the study of Ahmed *et al.* [17]. on neon hatchet fish *C. cachius*. Length-weight relationships are also originally used to provide information on the condition of fish and may help determine whether somatic growth is isometric ($b=3$) or allometric (negative allometric: $b<3$ or positive allometric: $b>3$) [18].

**Conclusion**

The present study provided that relationship of body weight to standard length of monthly samples revealed different 'a' and 'b' values in this study for fishes. The parameter of equations (a) and the slope of equations (b) varied from month to month. The exponent of the power equation, 'b' varied monthly and it ranged from 2.021 to 3.211, the lowest 'b' value was obtained in June and the highest in February. The value of the parameter, 'a' varied monthly as well and it ranged from 0.018 to 0.081. The lowest value of 'a' was on February and the highest value of 'a' was on June. The values of correlation coefficient (r) ranged from 0.849 to 0.979 and all these values exhibited a degree of positive correlation between length and weight. The highest correlation coefficient was estimated in June and the lowest value was in January. The values of coefficient of determination ($r^2$) vary from month to month and it ranged from 0.721 to 0.960.The highest coefficient of determination ($r^2$) was estimated in June and the lowest value was in January. Growth pattern of fish depends on the value of 'b' of the equation, $W=aL^b$. Different growth inferences were found in different months in case of *B. dario.* Growth pattern of both monthly samples and population was investigated for *B. Dario* in Bangladesh. Analysis revealed that growth pattern of each monthly sample was allometric. Isometric growth pattern were found for monthly populations in January, February, April, May, August, September and October, whereas, allometric growth pattern was found in November, December, March and June. The growth pattern of pooled data of all monthly samples was allometric. This study provides basic information on the length-weight relationship and growth pattern of *B. dario*which may be useful for a sustainable management of this fishery in the marine water environment. Length-weight relationships of fishes which are crucial in the fisheries biology and assessments, estimate the fish's average weight with a given length category by using the mathematical relation. The values are important for estimation of number of fish landed at a particular time and comparison of fish species populations caught from various places at similar or different times.

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