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Studies on the Length-Weight Relationship and Condition Factor of *Labeo rohita* and *Labeo fimbriatus* from Pamba River, Kerala, India

Suja Nagampoozhi
Department of Zoology, St Aloysius College, Edathua, Alappuzha, Kerala, India
*Correspondence for materials should be addressed to SN (email: nsuja_r@yahoo.co.uk)

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Abstract
The length-weight relationship and condition factor of *Labeo rohita* and *Labeo fimbriatus* were analyzed to evaluate the significance of allometric growth and the overall well-being of the species. The study was conducted for a period of six months. A total of 160 individuals were examined. For *L. rohita*, total lengths ranged from 13.2 cm to 46.0 cm, with weights between 193.65 g and 1490.05 g. In the case of *L. fimbriatus*, lengths varied from 11.0 cm to 43.8 cm, and weights ranged from 186.3 g to 1216.3 g. The slope value (b) estimated for *L. rohita* and *L. fimbriatus* were 2.73 and 2.81, which shows both the species exhibits negative allometric growth pattern. The regression equation calculated for *L. rohita* was Log W = -1.216 + 2.73 Log L and for *L. fimbriatus* was Log W = 0.032 + 2.81 Log L. The b value differed from the ideal cube law of '3' as is the case of the length-weight relationship studied in this species else-where. The mean values of computed condition factor for all specimen of *L. rohita* were 1.76 and *L. fimbriatus* was 1.95 which indicated that both the species are generally in good condition within their habitat.

Keywords: Condition factor; Correlation coefficient; *Labeo rohita*; *Labeo fimbriatus*; Length-weight relationship

Introduction

Fish make up more than half of all known vertebrate species, with around 32,000 described species to date, exhibiting remarkable diversity in morphology, habitats, physiology, and behavior [Nelson et al., 2016]. During their development, organisms typically grow in both length and weight. In fish, this growth is influenced by several key factors, including the availability of food, competition for food among individuals, water temperature, oxygen levels and overall water quality. Additionally, the size, age and sexual maturity of the fish play important roles in determining growth patterns. In fish, size is generally more biologically relevant than age, mainly because several ecological and physiological factors are more size-dependent than age-dependent. Variability in size has important implications for diverse aspects of fisheries science and population dynamics (Erzini, 1994). Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indices (Ecoutin et al., 2005).

The study on the relationship between length and weight holds both scientific and practical significance. It serves as a fundamental tool in fisheries biology, offering reliable insights into the growth dynamics of fish populations. For proper exploitation and management of the population of fish species, the length-weight relationship is a very important parameter (Alam et al., 2014). Length-weight regressions have been used frequently to estimate weight from length because direct weight measurements can be time-consuming in the field (Sinovcic et al., 2004). It was

observed that in natural habitat, when the length of fish increases, the weight of fish also increases in proportion, thereby showing that the weight of fish is a function of length.

The cube law suggests that the fish weight increases three times as compared to length. This relationship was initially used to obtain information on the growth condition of fish and to find out whether the somatic growth was isometric or allometric (Le Cren, 1951; Ricker, 1975). The actual relationship between length and weight may deviate from the expected cubic value (exponent of 3), often due to environmental conditions or the physiological state of the fish. By establishing a mathematical relationship between these two variables, such as length and weight, scientists can assess deviations from expected weight at given lengths. Relationship between length and weight is required for setting up yield equation and sometimes it may be useful as a character to differentiate "small taxonomic units".

Length and weight measurement can give information on the stock composition, life span, maturity, growth and production (Erkoyuncu, 1995; Moutopoulos and Stergiou, 2000). The length - weight relationship is a mathematical model equation which enables calculation of unknown variable among the two variables (Mir et al., 2012). Length - weight relationship (LWR) of fishes are important in fisheries and fish biology because they allow estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them (Sarkar et al., 2008). The length - weight relationship is an effective technique that affords evidence on the reproductive history, health condition, spatial distribution of different ecologically different species and their historical comparisons among different populations (Egbal et al., 2017). The length and length - weight relation is a fundamental data for fishery biologists to enforce regulations for a sustainable management of fishery (Chaki et al., 2013). The length - weight relationship and condition factor (K) are one of the important aspects of fishery management as well as conservation point of view. How much a particular environment is favorable for optimal growth of a fish is determined by seeing the well being of the fish. This well being of fish is called 'condition of fish' and is determined on the basis of condition factor (K). When condition factor value is higher it means that the fish has attained a better condition. The condition factor of a fish reflects physical and biological circumstances and fluctuations by interactions among feeding condition and physiological factors (Le Cren, 1951).

The estimated values of condition factor are generally used in three cases: (1) comparison of two or more co- specific populations living in similar or different conditions of food, density or climate (2) determination of the period and duration of gonad maturation and (3) observation of the increase or decrease in feeding activity or population changes, possibly due to modification in food resources (Weatherly and Gill, 1987). Condition factor is useful in assessing even age and sex of of some species (Anibeze, 2000). Variation in the values of condition factor can also be useful in the study of seasonal changes occurring in the fishes along with the rate of change of feeding potential and thus can be used to optimise the fishery production (Sarkar et al,. 2008). The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds and other water quality parameters (Khallaf et al., 2003). The present study aimed to find out the length-weight relationship and condition factor of *Labeo rohita and Labeo fimbriatus* inhabiting Pamba river, Kerala. This study provides a baseline data on these two food fishes, which maybe important basic tool for management and conservation practices of these fishes.

Materials and Methods

Length-weight analysis

A total of 160 *Labeo rohita* and *L. fimbriatus* fishes of varying sizes were collected from Pamba river during March 2024 to September 2024 in order to calculate their length-weight relationship and condition factors. Total length (cm) of each fish was taken from the tip of the snout to the extended tip of the caudal fin using a measuring scale to the nearest of 0.1 cm. Total weight was taken in single pan electronic balance to the nearest of 0.01 gm. Total length of all specimens were used in order to calculate the length-weight relationship. For any biological organism the length-weight relationship is generally non-linear and expressed in the form of parabolic equation:

$$W = a L^b$$

Where, weight (W) is proportional to a certain power (b) of the length (L) and 'a' is the intercept. As weight is a power function of length, logarithms were used so that the exponential relationship can be expressed by a linear equation:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Values of the exponent 'b' provide information on fish growth. When 'b'=3, increase in weight is isometric. When the value of 'b' is other than 3, weight increase is allometric (positive if 'b' >3, negative if 'b' <3) (Berhan et al., 2019). In order to confirm whether b values obtained in the linear regressions were significantly different from the isometric value (b=3), t-tests with appropriate degrees of freedom were used (Sümbüloğlu and Sümbüloğlu, 2000). The length-weight data was analysed using ordinary least squares regression (at 95% confidence) using STATISTICA version 5.0.

Condition factor

The Condition factor (K) generally, used for determining the physiological state of a fish, including reproductive capacity. The heavier the fish for a length, the higher its condition factor.
The condition factor is calculated by using the following formula (Fulton, 1904):

$$K = \frac{W \times 100}{L^3}$$

Where, K is the condition factor, W is the body weight of fish in grams and L is the total length in centimetres (Bagenal et al., 1978).

Results and discussion

The smallest size recorded for *L. rohita* was with 132 mm total length and 193.65 gm weight. The largest specimen recorded was 460 mm total length with 1490.05 gm weight. The smallest size of *L. fimbriatus* was recorded with 110 mm total length and 186.34 gm weight and the largest size was recorded with total length 438 mm and weight of 1216.33 gm. The length-weight relationship in fish is affected by a number of factors including sex, feeding, maturity, specimen number, area, seasonal effects, degree of stomach fullness, habitat, health and general fish condition. The linear equation was fitted separately for both the species. The relationship indicated negative allometric growth in both *L. rohita* and *L. fimbriatus.*

The regression equation for *L. rohita* was calculated as follows :

$$\text{Log } W = -1.216 + 2.73 \text{ Log } L$$

Where, -1.216 is the intercept 'a' and 2.73 is the slope 'b'. All the values obtained were highly significant (P< 0.001).

The regression equation for *L. fimbriatus* was calculated as follows :

$$\text{Log } W = 0.032 + 2.81 \text{ Log } L$$

Where, 0.032 is the intercept 'a' and 2.81 is the slope 'b'. All the values obtained were highly significant (P< 0.001) (Table 1).

The result revealed that both *L. rohita* and *L. fimbriatus* did not follow the cube law completely with the value of exponent 'b', 2.73 and 2.81 respectively, thus revealing negative allometric growth (b<3). Similar finding for *L. rohita* had been reported by Ujjania et al. (2012), who stated that negative allometric growth patterns are characterized by fish becoming slimmer with increase in length. Many other workers have reported similar findings in cold water cyprinids where fish is becoming slimmer with increase in weight (Dar et al., 2012). Can et al. (2002) found similar negative allometric value in *L.rohita* with 'b' 2.90 which may be due to various factors like food availability, environmental changes, season, sex and many other physiological factors. Rajanna et al. (2019) reported negative allometric growth in *L. fimbriatus* from Vani Vilasa Sagara Reservoir, Karnataka. Some of the previous studies revealed that the length-weight relationship of *L. rohita* (Jhingran, l952), *L. calbasu* (Pathak, 1975) and *L. fimbriatus* (Rajanna et al., 2019) exhibited positive allometeric growth patterns. Das et al. (2014) reported that the length–weight relationship of the same species may be different in the population because of feeding, reproductive activities and fishing. Bhat (2011) studied the length–weight relationship and condition factor of *L. rohita* (Cyprinidae) and reported an isometric growth. Umesh et al. (2012) observed an almost isometric pattern of growth in *L. rohita* and the condition factor values showed that the condition existing was conducive for the feeding and optimum growth of the fish.

Negi (2013) has done work on length–weight relationship and condition factor of *L. rohita* from Bhagwanpur fish pond Roorkee, Uttarakhand, India. They reported that the 'b' value was significantly more than 3.0. The morphometric relationship of Indian major carps were established and reported that the negative allometric growth for *Catla catla*, positive allometric growth for *Labeo rohita* and isometric growth for *Cirrhinus mrigala* in Jaisamand Lake, Udaipur (Balai et al., 2017).

The coefficient of correlation was 0.971 for *L. rohita* and 0.924 for *L. fimbriatus,* suggesting that the two variables, weight and length are highly correlated (P< 0.001). The values of correlation coefficient depicted a strong positive correlation between length and weight indicating an increase in length with corresponding increase in weight.

Table 1. Descriptive statistics and estimated parameters of length - weight relationship for *Labeo rohita* and *L. fimbriatus* from Pamba River, Kerala, India

Species	Sample size (n)	Total Length range (cm)		Total Weight range (gm)		Regression parameters		R^2	Condition factor	
		Minimum	Maximum	Minimum	Maximum	a±SE	b±SE		Range	Mean
L. rohita	160	13.2	46	193.65	1490.05	-1.216 ± 0.64	2.73 ± 0.14	0.971	1.16 - 2.97	1.76
L. fimbriatus	160	11	43.8	186.34	1216.33	0. 032± 0.58	2.81± 0.22	0.924	1.17 - 2.86	1.95

a: Intercept, b: Regression coefficient, SE: Standard Error, R^2: Coefficient of determination

Table 2. Condition factor of *L. rohita* for various length groups

Length group (cm)	Condition factor	
	Range	Mean
10-15	2.66 - 2.97	2.81
15-20	2.34 - 2.48	2.41
20-25	1.83 - 2.19	2.01
25-30	1.36 - 1.66	1.5
30-35	1.42 - 1.58	1.5
35-40	1.24 - 1.4	1.32
40-45	1.31 - 1.39	1.35
45-50	1.16 - 1.26	1.2
Average condition factor of the sampled population		1.76

Table 3. Condition factor of *L. fimbriatus* for various length groups

Length group (cm)	Condition factor	
	Range	Mean
10-15	2.58 - 2.86	2.72
15-20	2.63 - 2.75	2.7
20-25	2.29 - 2.43	2.36
25-30	2.05 - 2.56	2.3
30-35	1.32 - 1.64	1.5
35-40	1.41 - 1.76	1.6
40-45	1.17 - 1.3	1.2
Average condition factor of the sampled population		1.95

The earlier report has revealed that the fluctuations in the condition of the fish is related to reproductive cycle (Le Cren, l95l; Qayyum and Qasim, l964), feeding rhythms (Hile, 1948; Qasim, 1957), physicochemical factors of environment, age, physiological state of fish or some other unknown factors (Brown, l957; Kumar et al., 1979). In the present study, condition factor (K) was estimated for different length classes. The mean values of computed condition factor for *L. rohita* ranged from 1.16 to 2.97 with an average of 1.76 for the entire sampled population (Table 2). The condition factor for *L. fimbriatus* ranged from 1.17 to 2.86 with an average of 1.95 for the entire sampled population (Table 3). K values greater than 1 reveal that the environment of the selected habitats were conducive for the growth and survival of the candidate fish species.

The results showed the highest values of 'K' occurs in the lower length classes and after that it showed a constancy at higher lengths and did not change rapidly with increasing length. The falling trends of K value with respect to increase of length are conveyed to be a good sign of length corresponding to sexual maturity [Hart, 1946]. The higher values in the lower length classes may be due to intense feeding in the pre adult stage. The condition factor does not merely reflect the feeding condition of the adult stage, but include the state of gonad development, based on the consumption of fat reserves during the spawning periods. Thus the decrease in condition factor may be due to high metabolic rates at the start of the spawning. Same results were obtained by Thompson (1942).

Conclusion

The present study was undertaken with a focus on key parameters such as length, weight, and condition factor, recognizing their importance in providing vital insights into the growth and overall well-being of the fish. The length-weight relationship for *Labeo rohita* and *Labeo fimbriatus*

exhibited a linear pattern, as indicated by the high correlation coefficient values. Both species demonstrated negative allometric growth, as reflected in their respective exponent values. The condition factor values observed in this study clearly suggest that the environment is favorable for the health and well-being of the fish. This research holds significant value, as it offers essential information on growth patterns and the general condition of the species, serving as a useful tool for fishery managers in stock assessment and in formulating effective management strategies for sustainable resource conservation.

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