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Research Article
Length-weight Relationships and Condition Factors of *Cirrhinus reba* (Hamilton, 1822) in Padma River, Bangladesh

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Abstract

Background and Objective: The study on length-weight relationship (LWRs) and condition factors has a great potential for effective management of a fish species. So the present study was aimed to explore the length-weight relationship and condition factors of a vulnerable fish species *Cirrhinus reba*. **Materials and Methods:** A total of 600 individuals of *C. reba* was collected from Padma River have been evaluated for the present study from five distinct stations during 1 year (From January to December, 2015). Length and weight of the individual fish were measured using a digital slide calipers and an electronic balance. Length-weight relationship was analyzed using the equation: $W = a \times L^b$. Fulton (K_F) and relative (K_R) condition factors were determined using the equation: $K_F = 100\,W/L^3$ and $K_R = W/a \times L^b$, whereas, relative weight (W_R) was calculated using the equation: $W_R = (W/W_S) \times 100$. **Results:** Total length and weight of the individuals were found to vary from 6.60 -23.80 cm and 2.63-136.00 g, respectively. The LWRs for male, female and combine sex were found highly significant ($p<0.01$) with good linear regression close to 1 ($r<1$). Male fishes were found to show isometric growth, whereas, female showed positive allometric growth pattern. Relative condition factor (K_R) and relative weight (W_R) both were found to show significant ($p<0.01$) correlation with body weight of *C. reba*. **Conclusion:** It was concluded that there was a significant relationship between the growth pattern, length and weight of *C. reba* in different months. The stock of *C. reba* from Padma River were in declining trend. However, proper management of this fish species is recommended.

Key words: Length-weight relationship, fulton's condition factor, relative condition factor, *Cirrihinus reba*, Padma river, immense potential

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Effective management of a fishery population is depended on structure of that fish stock[1,2]. Ecological characterization of a fish population in terms health assessment, stock condition (different unit stocks of the same species), biological traits (recruitment, growth and mortality of fishes) and breeding protocols are solely depended on population structure of fishes in any water body[3-6]. Morphometric relationships including length-weight relationships (LWRs) and different condition factors are important biological parameters for fishes to assess the health of the fish stock population[7,8]. Morphometric relationships can also be used to develop fish stock assessment models that ease to estimate stocks, standing crop biomass and seasonal variations in fish growth and ultimately management of fish population[9-12]. Success of a population in a water body can also be estimated through different condition factors[13]. Both Fulton's condition factor (K_F) and relative condition factor (K_R) provide overall health status in terms of biomass fitness and wellbeing of a fishery population in a water body[12,14]. Understanding the life cycle of fish species and achievement of adequate ecosystem equilibrium can be achieved by better condition factor of fish population[15].

However, based on the importance of morphometric study of fishes, the present study was designed to explore length-frequency distributions, length-weight relationship and condition factors of threatened fish, reba carp (*C. reba*) in the water of Padma river (Northwestern Bangladesh).

MATERIALS AND METHODS

Study site: The present study was conducted in the lower parts of the Ganges River, North-Western (NW) Bangladesh also known as the Padma River. Five distinct stations were selected for collection of experimental fishes during one year (From January, 2015 to December, 2015) of study period. Name of the sampling stations with GPS point are shown in Fig. 1.

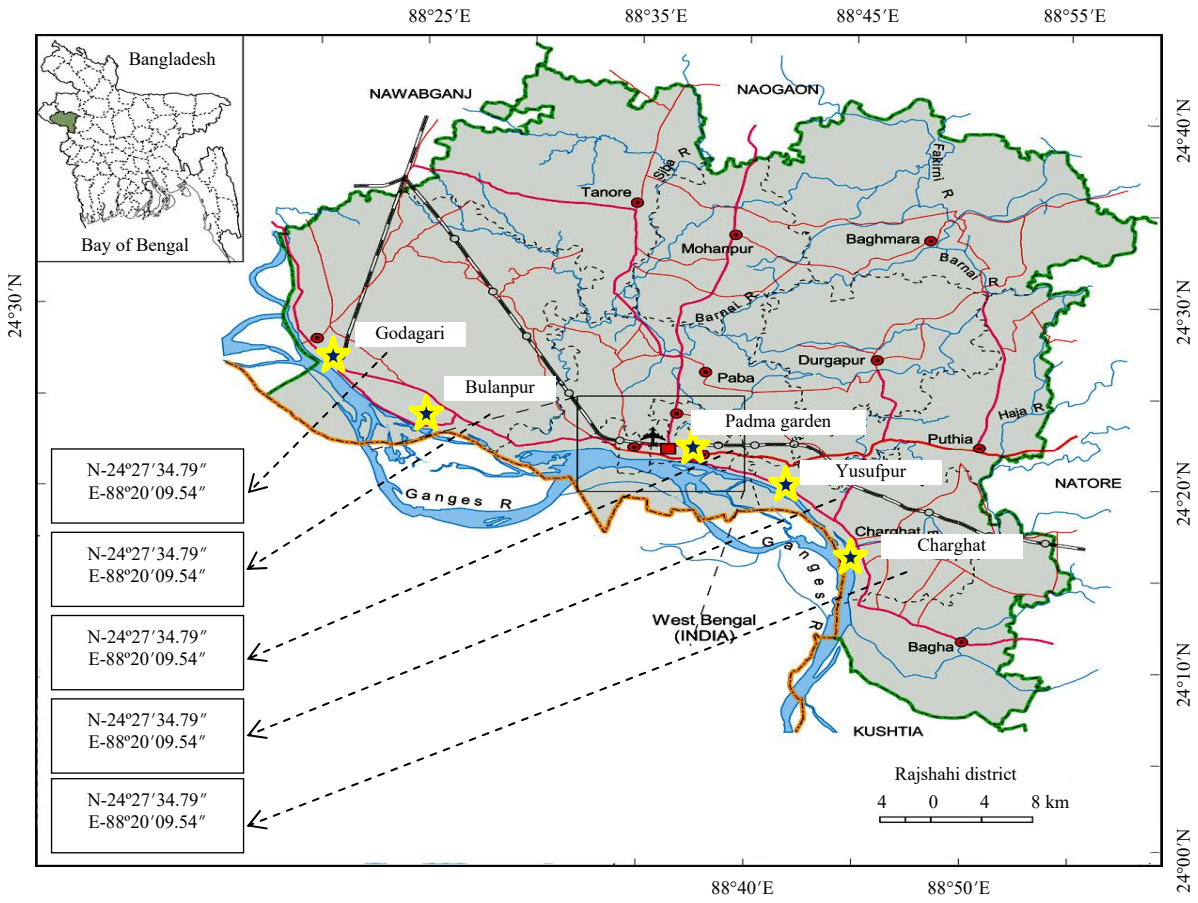

Fig. 1: Location of sampling stations (indicated by yellow stars)
Source: Google map

Sampling: Samples 600 of *C. reba* were collected during daytime (8:00-17:00) on a monthly basis (from January to December, 2016) from the local fish market of each study sites located at Godagari to Charghat Upazila of Rajshahi district. Traditional fishing gears (cast net, square lift net, conical trap and monofilament fixed gill net) were found to use by fisherman to catch the fish. The fish samples were transported to the laboratory and preserved in 10% formalin until the measurement was taken. In the laboratory, Total length (TL) and body weight (BW) of each specimen were measured to 0.1 cm and 0.1 g accuracy with a digital slide calipers and an electronic balance, respectively.

Length-weight relationships: The length-weight relationship (LWR) was estimated using the equations: $W=a\times L^b$ and its logarithmic form:

$$\ln(W) = \ln(a)+b\ \ln(L)$$

Where:

W = Weight (g)
L = Length (cm)
'a' and 'b' = Regression co-efficient

Condition factors: The Fulton's Condition factor (K_F) was calculated employing the equation[16]:

$$K_F = 100\ W/L^3$$

Where:

K_F = Fulton's condition factor
W = Weight of fish (g)
L = Length of fish (cm)

The relative condition factor (K_R) for each individual was calculated by using the following equation[17]:

$$K_R = W/a\times L^b$$

Where:

K_R = Relative condition factors
W = Weight of fish (g)
L = Length of fish (cm)
'a' and 'b' = Regression co-efficient

Furthermore, relative weight was calculated by the equation of Froese[18]:

$$W_R = (W/W_S)\times 100$$

Where:

W_R = Relative weight
W = Weight of fish (g)
W_s = $a\times L^b$ (a and b values were obtained from the relationships between TL and BW)

Statistical analysis: Statistical analysis were performed using Microsoft® Excel-2010 and SPSS, ver. 20.0. (IBM Corporation, Armonk, NY, USA). Non-parametric Wilcoxon rank test was used to compare the mean relative weight of a population[19] with 100 in case to non-normally distributed data. Pearson correlation were analyzed at $p<0.05$% level of the significant. In addition, non-parametric correlation like Kendall's tau-b and Spearman's rho test was used to support statistically between length and weight. Correlation of total length and body weight with Fulton's condition factor (K_F), relative condition factor (K_R) and relative weight (W_R) were tested using Spearman rank correlation test. Regression analysis and line parameters, a (intercept) and b (slope) was made with log-transformed measurement. All statistical analysis were considered significant at 5% ($p<0.05$).

RESULTS

Descriptive statistics of length and weight measurements: A total of 600 (male = 317 and female = 283) specimens of *C. reba* were analyzed for this study. Sample size, minimum and maximum length and body weight and 95% confidence limit (CL) are shown in Table 1. The female fishes were found larger than the males in both total length and weight. In case of combined sex, the total length ranged between 6.60-23.80 cm and total weight from 2.63-136.00 g.

Length-weight relationships (LWR): Logarithmic transformation of LWR parameters, a-intercept, b-slope, correlation co-efficient 'r' (Pearson correlation), nonparametric correlation co-efficient (Kendall's tau-b and Spearman's rho), regression co-efficient 'r^2' and growth pattern are also shown in Table 2. According to the slop (b) value, *C. reba* showed positive allometric growth during the month of June to September, whereas isometric growth in the month of May. However, rest of the month of the year *C. reba* showed negative allometric growth. During the study period, the regression co-efficient 'r^2' indicating good linear regression close to 1 ($r<1$) and suggested good adjustment between length and weight among different months (Table 2). Male fishes were found to show isometric growth and the female fishes were positive allometric growth. However, the LWRs for male, female and combine sex were found highly significant ($p<0.01$) and indicated good linear regression with good adjustment between length and weight (Table 3).

Table 1: Descriptive statistics of length and weight measurements of *Cirrhinus reba*

Measurements	n	Minimum	Maximum	Mean±SD	$CL_{95\%}$
Male	317				
TL		6.70	19.70	12.02±2.72	13.08-13.81
BW		2.63	106.25	19.01±13.72	25.82-32.09
Female	283				
TL		6.60	23.80	13.44±3.08	11.71-12.32
BW		4.10	136.00	28.23±16.08	17.49-20.52
Combined sex	600				
TL		6.60	23.80	12.69±2.98	12.45-12.93
BW		2.63	136.00	23.69±21.49	21.97-25.42

TL: Total length, BW: Body weight, n: Sample size, SD: Standard deviation, CL: Confidence limit for mean values

Table 2: Month-wise length-weight and growth type of *Cirrhinus reba* during January to December, 2015

				Correlation co-efficient 'r'	Non-parametric correlation 'r'			
Months	Logarithmic transformation	Intercept 'a'	Slope 'b'	PC	KC	SC	Regression co-efficient 'r^2'	Growth type
January	ln (BW) = 2.366 ln (TL)-3.255	-3.255	2.366	0.922**	0.741**	0.910**	0.8508	A-
February	ln (BW) = 2.784 ln (TL)-4.029	-4.029	2.784	0.952**	0.817**	0.922**	0.9055	A-
March	ln (BW) = 2.711ln (TL)-3.818	-3.818	2.711	0.980**	0.907**	0.982**	0.9606	A-
April	ln (BW) = 2.810 ln (TL)-4.260	-4.260	2.810	0.992**	0.922**	0.986**	0.9842	A-
May	ln (BW) = 3.008 ln (TL)-4.674	-4.674	3.008	0.986**	0.937**	0.987**	0.9715	I
June	ln (BW) = 3.168 ln (TL)-5.098	-5.098	3.168	0.978**	0.902**	0.974**	0.9562	A+
July	ln (BW) = 3.797 ln (TL)-6.747	-6.747	3.797	0.944**	0.697**	0.821**	0.8921	A+
August	ln (BW) = 3.499 ln (TL)-5.904	-5.904	3.499	0.981**	0.896**	0.977**	0.9621	A+
September	ln (BW) = 3.391 ln (TL)-5.644	-5.644	3.391	0.983**	0.939**	0.992**	0.9654	A+
October	ln (BW) = 2.879 ln (TL)-4.444	-4.444	2.879	0.983**	0.887**	0.976**	0.9655	A-
November	ln (BW) = 2.149 ln (TL)-2.839	-2.839	2.149	0.963**	0.806**	0.918**	0.9267	A-
December	ln (BW) = 2.748 ln (TL)-4.210	-4.210	2.748	0.969**	0.768**	0.895**	0.9389	A-

PC: Pearson correlation, KC: Kendall's tau-b, SC: Spearman's rho, A-: Negative allometric, A+: Positive allometric, I: Isometric, **p<0.005

Table 3: Sex wise length-weight and growth type of *Cirrhinus reba* during January to December, 2015

				Correlation co-efficient 'r'	Non-parametric correlation 'r'			
Sexes	Logarithmic transformation	Intercept 'a'	Slope 'b'	PC	KC	SC	Regression co-efficient 'r^2'	Growth type
Male	ln (BW) = 3.020 ln (TL)-4.728	-4.728	3.020	0.897**	0.857**	0.963**	0.9532	I
Female	ln (BW) = 3.215 ln (TL)-5.206	-5.206	3.215	0.894**	0.867**	0.969**	0.9564	A+
Combined sex	ln (BW) = 3.116 ln (TL)-4.958	-4.968	3.116	0.873**	0.865**	0.969**	0.9564	A+

PC: Pearson correlation, KC: Kendall's tau-b, SC: Spearman's, rho, I: Isometric, A+: Positive allometric, **p<0.01

Table 4: Condition factors of the *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

Condition factors	Minimum	Maximum	Mean±SD	$CL_{95\%}$	t-test sig
K_F					
Male	0.39	1.65	0.94±0.14	0.92-0.96	0.033
Female	0.48	1.83	0.97±0.17	0.95-0.99	
Combined sex	0.39	1.83	0.95±0.15	0.94-0.97	
K_R					
Male	0.42	1.76	1.01±0.15	1.00-1.03	0.994
Female	0.49	1.81	1.01±0.16	0.99-1.03	
Combined sex	0.40	1.87	1.01±0.15	1.00-1.03	
W_R					
Male	41.91	176.91	101.70±15.09	100.03-103.37	0.046
Female	49.27	180.66	101.28±16.17	99.39-103.18	0.183
Combined sex	40.08	187.17	101.26±15.80	100.00-102.53	0.019

SD: Standard deviation, CL: Confidence limit for mean values, K_F: Fulton's condition factor, K_R: Relative condition factor, W_R: Relative weight, t-test sig: T-test significant

Condition factors: The sample size (n), minimum and maximum values, Mean±SD, 95% confidence levels of each of the condition factors (K_F and K_R) and relative weight (W_R) of *C. reba* are shown in Table 4. The investigation of condition factors of *C. reba* revealed that, K_F ranged between 0.39-1.65 with a mean value of 0.94±0.14 for male; 0.48-1.83 with a mean value of 0.97±0.17 for female and 0.39-1.83 with a mean value of 0.95±0.15 for combined sex fishes. The mean values of K_R were 1.01±0.15, 1.01±0.16 and 1.01±0.15 for male, female and combined sex fishes, respectively. Unpaired

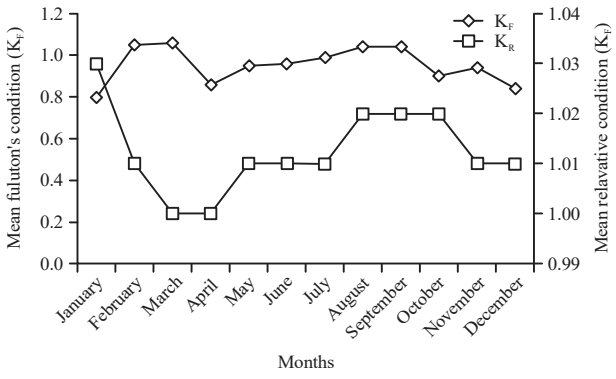

Fig. 2: Monthly mean fulton's condition factor and relative condition factor of *C. reba* (Hamilton 1822) in the Padma River, during the study period

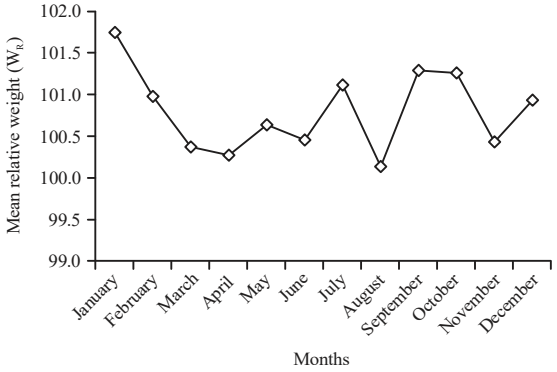

Fig. 3: Monthly mean relative weight of *C. reba* (Hamilton 1822) in the Padma River, during the study period

Table 5: Spearman rank correlation coefficient for total length (TL), body weight (BW), Fulton's condition factor (K_F), Relative condition factor (K_R) and Relative weight (W_R) of *Cirrhinus reba* (Hamilton 1822) in the Padma River, during the study period

Parameters	BW	K_F	K_R	W_R
TL	0.969**	0.125**	-0.057	-0.056
BW		0.324**	0.142**	0.143**
K_F			0.976**	0.976**
K_R				1.000**

**Correlation is significant at the 0.01 level (2-tailed)

t-test showed significant difference in K_F and insignificant difference in K_R between male and female fishes during the study period. Mean values of W_R were recorded as 101.70±15.09, 101.28±16.17 and 101.26±15.80 for male, female and combined sex fishes, respectively. The W_R value of male and combined sex fishes showed significant difference from the reference value 100. Monthly mean Fulton's condition factor and relative condition factor of fishes are shown in Fig. 2. Low K_F value was observed during January and the highest during March. The K_R value was the highest in the month of January and the lowest in the month of March and April. Monthly variation of relative weight of *C. reba* is shown in Fig. 3. The highest value of W_R was found in the month of January and the lowest in the month of August. Spearman rank correlation showed significant correlation between K_F with TL and BW. However, K_R and W_R both were found significantly correlated with BW (Table 5).

DISCUSSION

A total of 600 specimens of *C. reba* were measured for the present study. These fishes were collected using different types of fishing gears. Therefore, variations in size class might be a common phenomenon. Variations in the total length and weight of *C. reba*, collected from Padma river, were observed when compared to other studies[20-25]. The present regional differences in total length might be attributed to the ecological conditions of the study areas in terms of food availability[26]. However, the present study showed maximum weight of female fishes compared to male fishes, which are in agreement with the findings of previous studies[24,27]. Variations in the fishing gear to catch fish and effect of formalin during preservation might be due the variation in fish size[28]. The month-wise LWR study in the present study depicted different growth types in different months. The calculated values of 'b' for length and weight were lower than 3 in the month of January to April and October to December. In these months the growth type was observed negative allometric. While positive allometric growth was observed in the months of June to September. However, in the month of May the growth type was isometric, where the 'b' value was 3.008. The 'b' value for male, female and combined sex was 3.020, 3.215 and 3.116, respectively, that indicates isometric growth type in male and positive allometric growth type in female and combined sexes. The findings of the growth type at different month and sex-wise showed some dissimilarity with the findings of Hossain *et al.*[24] and Mathialagan *et al.*[25]. That might be due to the environmental effects on growth pattern of fishes. Similar statement was also made by Froese[18], who stated that, the reasons for this month and sex-wise variation in growth types are said to be due to seasonal fluctuations of the environmental parameters, physiological conditions of the fish at the time of collection, sex, gonad development and nutritive conditions. Tesch[29] also added some other causes including habitat, degree of stomach fullness, preservation techniques and differences in the observed length ranges of the specimen caught might also affect the length-weight relationship in fishes. Behavior (active or passive swimmer) and water flow might also be other causes of differences in length-weight relationships[30].

Three types of condition factors were used to assess the overall health and productivity of *C. reba* of Padma river during the study period. The condition factor is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes[31]. The minimum and maximum value of K_F during the study period was slightly lower than the findings of Hossain *et al.*[24]. Seasonal differences in K_F were also observed during the study period with lowest values were observed during the month of January and highest value during the month of March. The fluctuation in K_F might be attributed to seasonal changes in feeding intensity and gonadal development, which was early mentioned by Mathialagan *et al.*[25] for the same species from lower Anicut, Tamil Nadu, India. Relative condition factor (K_R) also did not follow any rule of thumb and fluctuated with different season and size groups. It might also influenced by feeding intensity and the highest value was observed in the months coincided with higher availability of food during the study period. In the present study, the mean value of W_R of combined sexes of *C. reba* showed significant difference from the reference value100 ($p = 0.019$). But Hossain *et al.*[24] have found no significant difference in relative weight from the reference value100 for male and female in their study and indicated that the habitat was still in good condition for *C. reba*. Therefore, based on the findings of the present study it was clear that the habitat of *C. reba* in the Padma river becomes degraded day by day that was reported by Flura *et al.*[32]. Month-wise fluctuation in W_R might also due to the seasonal fluctuation of food content of nature, which are also in agreement with the findings of Offem *et al.*[33], who reported that the seasonal variation in food supply may change condition factor of fishes.

CONCLUSION

In conclusion, the growth pattern of *C. reba* in Padma river was found changed with the change of length and weight of fish in different months. Differences in growth pattern were also observed based on gender of fish species. Male, female and combined sex fishes showed the growth pattern of isometric and positive allometric, respectively. Condition factors were also found varied with the month and gender variation.

SIGNIFICANT STATEMENT

The present study will be an effective tool for fishery biologists, managers and conservationists towards providing management strategies of this species in aquaculture system and for initiate better regulation option for the sustainable conservation of the remaining stocks of this species in the Padma river ecosystem.

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