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Biometric indices of *Mystus tengara* (Hamilton, 1822) in the Jamuna River from Bangladesh

Most. Afrina Akter Kona[1], Md. Abidul Hasan[2], Mst. Shahinur Khatun[2], Mst. Meherun Nesa[2], Tasnim Akter Akhi[2], Md Golam Sarwar[2], Md. Mizanur Rahman[2], Bhuban Mohan Majhi[3] and Md. Yeamin Hossain[2]*

[1]Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[2]Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh
[3]Aquatic Ecology and Fisheries Laboratory, Department of Zoology, Sidho-Kanho-Birsha University, Purulia, 723104, West Bengal, India

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ABSTRACT

The freshwater catfish, *Mystus tengara* is an economically important, and nutritionally valuable food fish in south Asia. The present study provides the first complete description of Biometric indeces, *i.e.*, population structure, growth pattern, condition factors and form factor ($a_{3.0}$) of *M. tengara* in the Jamuna river (Sirajganj region), northwest Bangladesh. Sampling was done using different traditional fishing gears during March 2023 to February 2024. A total of 200 specimens were measured ranging from 5.00-9.90 cm TL and 1.33 - 7.67 g BW. The estimated b value indicated an allometric negative growth pattern (b=2.07) in *M. Tengara*. The LWRs were highly significant (p<0.001) with r^2 values >0.925. The K_F was best indicated the well-being of *M. tengara* among the four types of condition factors in the Jamuna River. A Wilcoxon sign-ranked test for W_R showed no significant dissimilarity from 100, signifying the balanced habitat for *M. tengara.* The estimated form factor ($a_{3.0}$) was 0.0085, which indicates that the fish is a moderately elongated and compressed-bodied catfish. These results would be used for sustainable management of *M. tengara* species in Bangladesh and neighboring countries.

Introduction

The Asian striped dwarf catfish, *Mystus tengara* (Hamilton 1822), belongs to the family Bagridae is a commercially important small indigenous fish species of Bangladesh (Mitu and Alam 2016). This species occurs widely throughout the Indian subcontinent including Bangladesh, India, Pakistan, Sri Lanka, Nepal and Bhutan (Froese and Pauly 2017). It has been also reported from Myanmar, Malaysia, Laos, Vietnam and Cambodia (Froese and Pauly 2017). *M. tengara* are used to be abundant in the rivers, creeks, canals, reservoirs, lakes, swamplands (*beels*, *haors* and *baors*) and ponds of Bangladesh (IUCN Bangladesh 2015). Nonetheless their populations have seriously declined to the lower risk near threatened due to over exploitation and various ecological changes in its natural habitats (Hossain et al. 2009). It is beneficial for calcium deficiencies and has a very pleasant flavour (Bhuiyan 1964). Fish weight can be used to indicate growth. Fish development patterns can be assessed using length-weight relationships (LWRs) to determine whether they are isometric or allometric.

*Corresponding author
E-mail address: yeamin.fish@ru.ac.bd (Md. Yeamin Hossain)

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The biometric index is an analytical framework used to examine the diversity of life history strategies among organisms across the world, as well as to understand the causes and consequences of variations in their life cycles. The life history traits of *M. tengara* include age- and stage-specific patterns and the timing of key biological events such as birth, growth, sexual maturity, reproduction, and death. These traits such as the age at first reproduction, number of offspring, level of parental care, senescence, and lifespan are influenced by both physical and ecological factors in the species' environment. The biometric index comprises several key parameters, including length frequency distribution (LFD), length-length relationships (LLRs), length-weight relationships (LWRs), condition factor, and form factor ($a_{3.0}$). Among these, length-length relationships (LLRs) are particularly valuable in fisheries management, as they support comparative growth studies and stock assessments (Moutopoulos and Stergiou 2002; Hossain et al. 2006).

Length frequency distribution of any fish is important to know the states of the size structure of that fish population in nature. The evaluation of gear selectivity of catches by different kinds of gear fished in the same water (Bagenal and Tesch 1978) is complemented by the use of length-weight relationships (LWRs), which are an important tool in fishery management (Bagenal and Tesch 1978; González Acosta et al. 2004). They are used in various aspects including estimation of right from length observations. calculation of production and biomass in the assessment of fish population in addition providing information about body condition of specimens in stocks or populations (Lai and Helser 2004).

Condition factor is a quantitative parameter of the state well-being of that fish that will determine present and future population success by its influence on growth, reproduction and survival (Hossain et al. 2006). Body condition is very usually used in fisheries biology because it is an expensive, non-lethal alternative to proximate analysis of tissues (Sutton et al. 2000), although there are assumptions that may be passed away, limitations to its application and non-critical use can lead to erroneous interpretation of data and incorrect conclusion (Sutton et al. 2000). Le Cren (1951) defined condition as length-weight analyses of the variation form the expected weight for length of individual fish on relevant groups of individuals as indicators of fish, general well-being, gonad development etc.

A number of investigations on the diet and feeding habits (Pantulu 1961; Pandian 1966; Bhatt 1971; Kaliyamurthy and Rao 1972; Azadi et al. 1987; Khan et al. 1988; Rahman et al. 2004; Krishna Rao 2007), reproductive biology (Gupta and Banarjee 2013; Mitu 2017), bioaccumulation of heavy Metals and their toxicity (Tabrez 2021) of various *Mystus* species have previously been conducted in Bangladesh and India. In spite of earlier research on heavy metal bioaccumulation, food, and reproductive biology in *Mystus* species, thorough studies concentrating on *M. tengara* specific population dynamics, ecological interactions, and the consequences of environmental changes are still lacking. Furthermore, there is a lack of empirical research on the biological index of this species.

This research aims to provide a comprehensive analysis of its growth patterns, length-frequency distributions, length-weight relationships, length-length relationship, condition factors, and form factor ($a_{3.0}$), addressing significant gaps in the understanding of this commercially important species. By integrating biometric indices and evaluating the effects of environmental changes, this study aims to support effective management and conservation strategies to ensure the sustainability of *M. tengara* populations in Bangladesh.

Materials and methods

Fish Sampling and Measurement

The study was conducted in the Jamuna River (Latitude 24º 27′ N; Longitude 89º 42′ E), located in the Sirajganj region of Bangladesh, which is one of the largest river ecosystems in the country. Samples of *M. tengara* were collected from the fishers' catch at various points along the Jamuna River in Bangladesh from March 2023 to February 2024. The fish were caught using traditional fishing gear, including dip nets (dharma jal), push nets (thela jal), and bamboo traps (wucha) (Bhuiyan 1964). To prevent decomposition, the samples were immediately preserved with ice and then fixed in a small plastic container with a 5% formalin solution as soon as possible. Before measuring, the fish were washed with running tap water to remove any residual formalin. For each individual, total length (TL) was measured from the tip of the snout to the most posterior point of the caudal fin, while standard length (SL) was measured from the tip of the snout to the posterior end of the caudal peduncle. Length measurements were typically taken using slide calipers, and whole body weight (BW) was recorded on a digital balance with an accuracy of 0.01 g. This study was based on the sampling of fish, where primary data were collected from the samples and subsequently analyzed, while secondary information was gathered from various published documents and websites to support the research findings.

Population structure

The relationship between weight and length was calculated using the expression: $W = aL^b$, where the W is the body weight (g), L the standard length (cm), *a* intercept of the regression and *b* is the regression coefficient (slope) Parameters *a* and *b* of the weight-length relationship will be estimated by linear regression analysis based on natural logarithms: In (W) = ln (a) + b In (Hossain et al. 2017). Additionally, 95% confidence limits of the parameters *a* and *b* and the statistical significance level of r^2 also estimated. In order to confirm whether *b* values obtained in the linear regressions are significantly different from the isometric value of ±95% the equation according to Sokal and Rohlf (1987): t_s = (b-3)/sb will be applied, where *t*, is the t-test value, *b* the slope and so the standard deviation of the slope (*b*). The comparison between obtained values of t-test and the respective tabled critical values is allowed for the determination of the *b* values statistically significant, and their inclusion in the isometric range (b=3) or allometric range (negative allometric, b<3 or positive allometric; b>3). The extreme outliers attributed to data error will be omitted from this analysis. Only total length (TL) will be used to make the relationships with other length of the study specimen. Measurements of the length-length relationship using total length (TL) *vs*. standard length (SL). The equation is, TL=*a*+*b**SL.

Growth parameter

The growth parameter, asymptotic length (L_∞), was determined by the maximum length using a specific formula: L_∞ =0.044+0.9841$*log(L_{max})$ (Froese and Binohlan 2000) and asymptotic weight was estimated by $W_\infty=aL^b_\infty$. Furthermore, the age at zero length (t_0) was estimated using the equation $log(-\ t_0)$= - 0.3922 - 0.2752$log(L_\infty)$ - 1.038 $log(K)$ (Pauly 1980). The growth performance index $(Ø')$ was examined through the equation $Ø' =log$ 10(K)+2log 10(L_∞) (Pauly 1984). Additionally, the growth coefficient (K) was calculated utilizing the formula K = ln(1+$L_m/L_\infty)t_m$ (Beverton 1992).

Condition factors

The allometric condition factor (K_A) was calculated using the equation of Tesch (1968): $K_A = W/L^b$, where W is the BW in g, L is the TL in cm and *b* is the LWRs parameter. The Fulton's condition factor (K_F) was calculated using the equation: K_F=100(W/L^3), where W is the BW in g, and L is the TL in cm. The scaling factor of 100 was used to bring the K_F close to unit and the relative condition factor (K_R) for each individual was calculated via the equation of Le Cren (1951): $K_R=W/(a\times L^b)$ where W is the BW in g, L is the TL in cm, *a* and *b* are the LWRs parameter.

Prey-predator status

The W_R was calculated by the equation given by Froese (2006), as: W_R = (× 100, where W is the weight of a particular individual and W the predicted standard weight for the same individual as calculated by $W_S=a\times L^b$ where *a* and *b* values were obtained from the relationships between TL vs. BW.

Form factor

The form factor ($a_{3.0}$) for each species was calculated using the equation given by Froese (2006) as: $a_{3.0}$ = $10^{log\ \ a\text{-}s(b\text{-}3),}$ where *a* and *b* are regression parameters of LWRs and *s* is the regression slope of log *a vs. b*. During this study, *a* mean slope S=-1.358 (Froese 2006) was used for estimating the form factor because information on LWRs is not available for these species for estimation of the regression (S) of in *a vs. b*.

Statistical analyses

Where test for normality assumption was not met, then the non-parametric Wilcoxon rank test was used to compare the mean W_R of a population with 100 (Anderson and Neumann 1996). In addition, the Spearman rank test was used to correlate body measurements (e.g. TL, SL, and BW) with condition factors (K_A, K_F, K_R). Furthermore, the LWRs between waters were compared by the ANCOVA. All statistical analyses were considered significant at 5% (p<0.05).

Results

Population structure

A total of 200 *M. tengara* were collected from fishermen throughout the Jamuna River, Bangladesh

Table-1. Length (cm) and weight (g) measurements with 95% confidence limit of combined Length-weight Relationships of the *Mystus tengara* in the Jamuna River Northwest Bangladesh

Measurement	*n*	Minimum	Maximum	Mean±SD	95%CL
TL (cm)		5.00	9.90	6.60±1.29	6.42-6.78
SL (cm)	200	4.00	8.02	5.32±0.98	5.18-5.46
BW (g)		1.33	7.67	3.32±1.45	3.03-3.44

Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values.

during the study period (March 2023 to February 2024). Table 1 shows the descriptive statistics of maximum and minimum length and weight measurement, and 95% confidence limits (CLs) of *M. tengara*. the range of TLs was 5.00 to 9.90 cm (Figure 1), and that body weight ranged from 1.33 to 7.67 g there. The 6.42-6.78 cm TL size groups were numerically dominant and constituted together 57.70 % of the total population (Fig. 1).

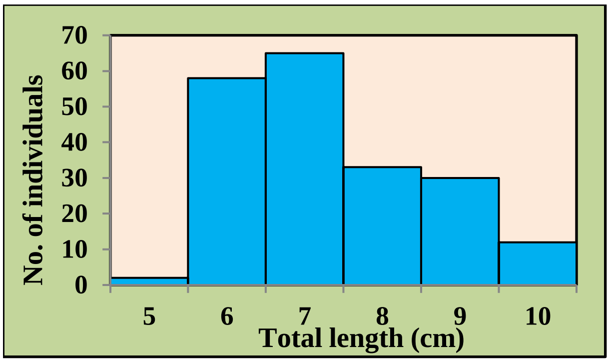

Fig. 1. Length frequency distribution of *M. tengara* from the Jamuna River, north-western Bangladesh.

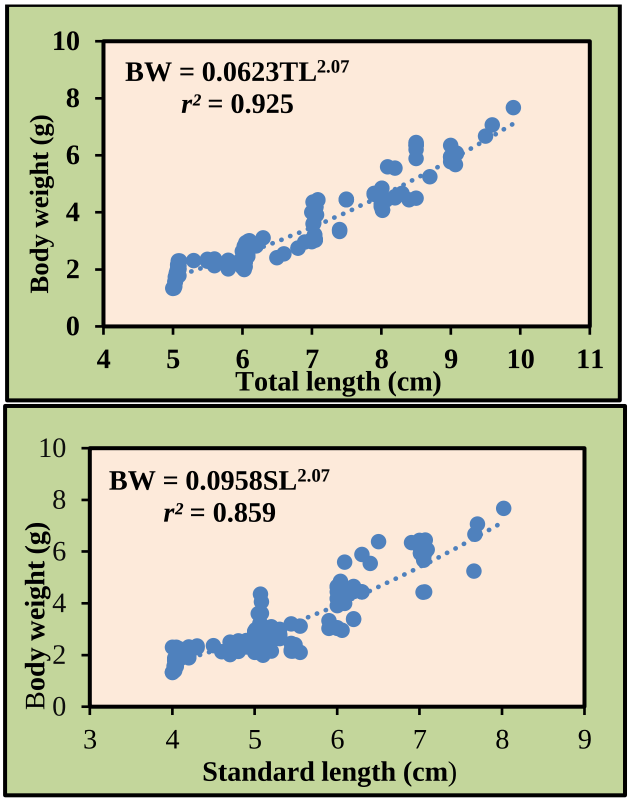

Fig 2. Relationships between total length (TL), standard length (SL) and body weight (BW) of the *Mystus tengara* in the Jamuna River, north-western Bangladesh.

The relationship between TL, SL and BW of *M. tengara* long with the estimated parameters of the LWRs and the coefficient of determination (r^2), are shown in Table 2 and Fig. 2. During this study, the

Table 2. Descriptive statistics and estimated parameters of the length-weight relationships of *Mystus tengara*

Equation	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
	a	*b*			
$BW=a*TL^b$	0.0623	2.07	0.0523-0.0741	1.97-2.16	0.925
$BW=a*SL^b$	0.0958	2.07	0.0767-0.1196	1.94-2.21	0.859

n, sample number; C, combined sex; BW, body weight; TL, total length; SL, Standard length; a and b, regression parameters.

calculated *b* value of the LWR indicates an negative allometric growth pattern. The LWRs was highly significant ($p<0.001$) with a coefficient of determination values of 0.925.

Growth parameter

The growth parameters identified for *M. tengara* encompass L_∞ = 10.56 cm, W_∞ = 8.19 g, K = 0.95 year^{-1}, and t_0 = 0.022 year. The value of t_m was calculated to be 0.89 year, and the growth performance index (φ) was determined to be 2.03.

Condition Factors

The estimated K_A of *M. tengara* ranged from 0.04-0.07 (Mean ±SD, 0.06 ±0.00) (Table 3). According to Spearman rank-correlation tests, there was a significant relationship between BW *vs.* K_A (r_s=

0.1780, p= 0.0058), but not between TL *vs.* K_A (r_s = -0.0194, p = 0.7660) (Table 4).

Prey-predator status

Realtive weight (W_R) of *M. tengara* ranged from 76.23-127.67 (Mean ± SD, 100.13±12.60) during this study (Table 4). According to Spearman rank-correlation tests, there was a significant relationship between BW *vs.* W_R (r_s=0.2282, p =0.0012), but not between TL *vs.* W_R (r_s=0.03893, p =0.5842) (Table 4). According to a Wilcoxon sign-ranked test, W_R showed no significant variation from 98.37-101.89 for *M. tengara* (p = 0.5842). The relationship between TL *vs.* W_R is shown in Fig. 3.

Table 3. Condition factors of *Mystus tengara* (n= 200) in the Jamuna River Northwest Bangladesh.

Condition factors	*n*	Minimum	Maximum	Mean±SD	95% CL
K_A		0.04	0.07	0.06 ±0.00	0.06-0.06
K_F		0.73	1.75	1.11 ±0.25	1.07-1.15
K_R	200	0.76	1.17	1.77±0.12	0.98-1.01
W_R		76.23	127.67	100.13±12.60	98.37-101.89

Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean values.

Table 4. Relationships of condition factor with total length (TL) and body weight (BW) of the *Mystus tengara* (n=200) in the Jamuna River Northwest Bangladesh.

Relationships	r_s values	95% CL of r_s	p values	Significance
TL vs K_A	0.03893	-0.1044 to 0.1807	0.5842	ns
TL vs K_F	-0.7563	-0.8115 to -0.6878	< 0.0001	****
TL vs K_R	0.03893	-0.1044 to 0.1807	0.5842	ns
TL vs W_R	0.03893	-0.1044 to 0.1807	0.5842	ns
BW vs K_A	0.2282	0.08824 to 0.3592	0.0012	**
BW vs K_F	-0.6180	-0.6991 to -0.5212	< 0.0001	****
BW vs K_R	0.2282	0.08824 to 0.3592	0.0012	**
BW vs W_R	0.2282	0.08824 to 0.3592	0.0012	**

*TL, total length; BW, body weight; K_A, allometric condition factor; K_F ; Fulton's condition factor; K^R , relative condition factor; W_R , relative weight; r_s , Spearman rank-correlation values; CL, confidence limit; p, shows the level of significance; ns, not significant; * significant; ** highly significant; ***very highly significant.*

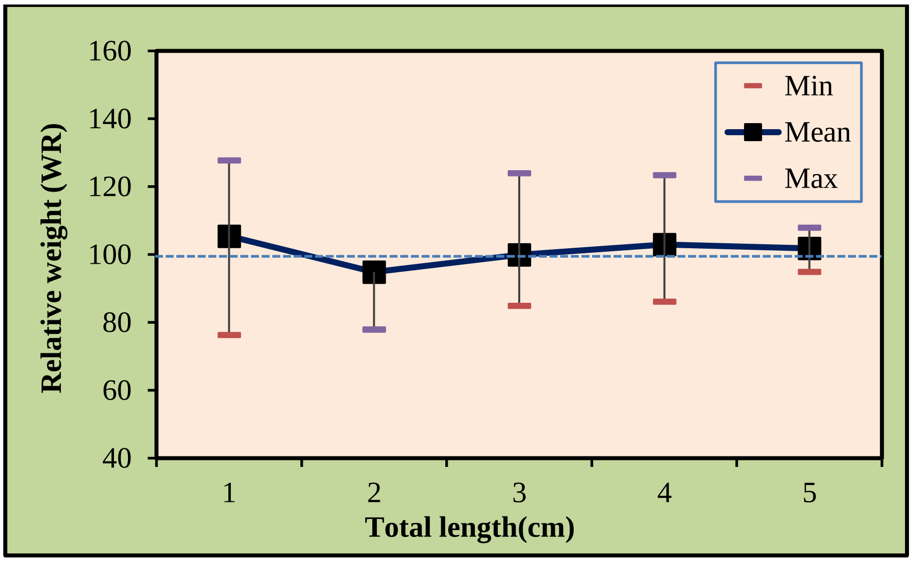

Fig 3. The relationship between total length and relative weight of the *Mystus tengara* in the Jamuna River, north-western Bangladesh

Form factor ($a_{3.0}$)

The calculated form factor ($a_{3.0}$) was found 0.0085 (Table 5) where the minimum and maximum length (5.00cm and 9.90 cm) in the Jamuna River.

Table-5: The calculated form factor ($a_{3.0}$) of *Mystus tengara* for combined sex from the Jamuna River

n	Total length (cm)		*a*	*b*	r^2	Form Factor ($a_{3.0}$)
	Min	Max				
200	5.00	9.90	0.0623	2.07	0.925	0.0034

n, sample; Min, Minimum; Max, maximum; a, intercept; b, slope; r^2, co-efficient of determination.

Discussion

Despite numerous studies on other species, there is currently limited information regarding the biometric indices of *M. tengara* from Bangladesh (Hossain et al. 2013; Hossain et al. 2016a, b, c). Hossain et al. (2016) examined the length-length and length-weight relationships of *M. tengara* in the Mathabhanga River, while Pathak et al. (2013) conducted a study on the same river, focusing on both Bangladesh and India. However, using a large number of specimens with small to large body sizes from the Jamuna River in northwestern Bangladesh, this study presents the length frequency distributions, length-length relationships, length-weight relationships, best condition factors, by weight, form factor, and of *M. tengara*.

Information of length frequency distribution of the *M. tengara* in Bangladesh is quite insufficient. No earlier records of length frequency distribution traced from the related literature, inhibiting the comparison with previous result. A number of factors, including historical factors, ecological dynamism (inter and intra-species relations), behavioural insulation, physical insulation (habitat fragmentation), human impact, and historical factors, contribute to the non-homogeneous distribution of genetic variation that causes the differentiation of morphometric and meristic characteristics between populations, particularly in freshwater fishes (Salgueiro et al. 2003).

Additionally, the length-length relationship (LLR) of *M. tengara* in the Jamuna River was determined to be TL = 0.7251x + 0.5405, with a coefficient of determination (r^2) of 0.925. Hossain et al. (2006) reported a similar relationship (SL = 9.60) with a coefficient of determination (r^2) of 0.953 in the Mathabhanga River, Bangladesh. However, differences in LLRs may be due to variations in ecological conditions or physiological differences among the species, as suggested by Le Cren (1951).

Several condition factors, including Fulton's condition factor (Fulton 1904), relative condition factor (Le Cren 1951), allometric condition factor (Tesch 1968), and relative weight (Froese 2006), were utilized to assess the overall health and productivity of *M. tengara*. The condition factor based on length-weight relationships (LWRs) serves as an indicator of changes in food reserves and the general condition of the fish (Offem et al. 2007). Moreover, the condition factor reflects interactions between biotic and abiotic factors affecting the physiological state of the fish, indicating the well-being of the population throughout various life cycle stages (Angelescu et al. 1958).

In this study, the correlation coefficient (*r*) was -0.6180 with a significance level of $p < 0.0001$ for the combined sexes. However, there are no previous studies on the Fulton's condition factor of *M. tengara*, making it impossible to compare these findings with others.

The relative condition factor (K_R) for *M. tengara* in the Jamuna River ranged from 0.76 to 1.17, with a mean value of 1.77 ± 0.12. Pearson's test indicated no significant relationship between TL and K_R (Pearson's $r = 0.03893$, $p = 0.5842$), while a highly significant relationship was observed between BW and K_R (Pearson's $r = 0.2282$, $p = 0.0012$) for the combined sexes. As there are no prior records on the relative condition factor K_R of *M. tengara*, comparisons with the current study are not possible.

Data on *M. tengara* were collected over an extended period, not reflecting a specific season; therefore, these should be regarded as mean yearly averages. A strong correlation was noted between the combined sexes of *M. tengara* and the LLRs for both males and females.

In this work, we examined condition factors (K_A, K_F, K_R) and W_R. The Spearman rank correlation test revealed a significant link between K_F and TL, while K_A, K_F, K_R, and W_R showed significant correlations with female populations. These findings can be utilized to assess the health of *M. tengara* in the Jamuna River and its surrounding ecosystem. Furthermore, a one-sample t-test indicated no significant variation in relative weight W_R from 100 ($p = 0.5842$), suggesting that the ecosystem in the Jamuna River is adequate for *M. tengara*, with balanced prey-predator relationships and sufficient food availability.

The form factor ($a_{3.0}$) can be employed to determine whether the body shape of individuals within a given population or species significantly differs from others

(Froese 2006). The calculated $a_{3.0}$ for *M. tengara* in the Jamuna River was 0.0034. There is currently no reference in the literature regarding the form factor of this species, making this the first study to provide foundational data on *M. tengara* in the Jamuna River for future research.

Conclusion

This study provides important baseline information on the LWRs, condition- and form-factors, and size at sexual maturity of the threatened *M. tengara* from the Jamuna River of Bangladesh. These results of this study would be an effective tool for fishery biologists, managers and conservationists to initiate prompt management strategies and regulations for the sustainable conservation of the remaining stocks of this species in the wetland (Jamuna River) ecosystem. In addition, information on LWRs, condition factors and form factor for *M. tengara* are evidently lacking from literature and data bases including FishBase. Therefore, the results of this study will provide vital information for the online FishBase database, as well as providing an important baseline for future studies within the wetland ecosystems of northwestern Bangladesh.

Conflict of Interest

There is no competing interest that might influence the research work.

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