

Original Article

Biological traits of striped dwarf catfish, *Mystus vittatus* (Bloch, 1794) (Bagridae) in the Old Brahmaputra River, Northeastern Bangladesh: Implications for sustainable fisheries management

Imran Bin Younos¹, Tariq-Al Kasif², Nushrat Jahan¹, Md. Muntasir Rashib³, Hridoy Kumer Biswas², Ashak Mahmud¹, Md. Fakhrul Islam^{*2,4,5}

¹Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh.

²Department of Fisheries, Jamalpur Science and Technology University, Jamalpur 2012, Bangladesh.

³Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh.

⁴The State Key Laboratory of Freshwater Ecology and Biotechnology, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, Hubei, China.

⁵University of Chinese Academy of Sciences, Beijing 100049, China.

Abstract: The present study investigates the population dynamics and biological traits of *Mystus vittatus* in the Old Brahmaputra River. A total of 515 specimens were collected between January and December 2024, excluding the breeding season (March to May), using gill nets. Standard biometric methods were applied to analyze length–frequency distributions, length–weight (LWR), and length–length (LLR) relationships. Three condition factors (allometric (KA), Fulton's (KF), and relative (KR)), form factor ($a_{3,0}$), and relative weight (WR) were also assessed. The growth pattern was negatively allometric (b -value = 2.56). $KA = 0.0287 \pm 0.004$, $KF = 1.2286 \pm 0.263$, and $KR = 1.0241 \pm 0.142$ indicated healthy physiological status and adequate food availability. A strong linear relationship was found between total length and standard length. The form factor ($a_{3,0} = 0.0068$) reflected a streamlined body shape suited to flowing waters. WR ranged from 71.25 to 142.15, indicating favorable growth conditions with some seasonal variation. These biometric insights provide valuable baseline data for assessing population health and growth dynamics of *M. vittatus*. Given ongoing habitat pressures and reduced river flow, species-specific management and conservation measures are urgently needed to ensure the sustainability of fisheries in the Old Brahmaputra River.

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Introduction

The Brahmaputra River, widely regarded as one of Asia's greatest rivers, is among the most prominent in Bangladesh. This abundant freshwater habitat hosts over 1,300 species of flora and fauna, with around 600 indigenous to the Brahmaputra River watershed (Bashar et al., 2020). Diverting from the mainstream of the Brahmaputra near Jamalpur district, the Old Brahmaputra, now with lessened water flow, has turned into an isolated river, following a roughly 200-kilometer path to the southeast till it meets the Meghna River, which runs in the Kishoreganj district (Bashar et al., 2020). Bangladesh's freshwater habitats are rich in biodiversity (Shamsuzzaman et al., 2017; Newaz and Rahman, 2019), with at least 265 species of finfish

and 24 species of prawns (DoF, 2018). Among these, freshwater catfish are valued commercially since they are primarily considered a food and recreational resource (Islam et al., 2024).

Fishes in the order of Siluriformes, also referred to as "catfishes", are an important group of ichthyofauna found in freshwater, marine, and coastal environments. There are 35 families of Siluriformes worldwide (Mawa et al., 2022). One such species, *Mystus vittatus*, has a wide distribution across Asian countries (Hossain, 2014) and inhabits diverse freshwater environments, including *beels*, streams, ponds, and flooded rice fields (Hossain et al., 2009; Aditya et al., 2010; Islam et al., 2022). Although *M. vittatus* is classified as a species of "Least

*Correspondence: Md. Fakhrul Islam
E-mail: fakhrul@jstu.ac.bd

Table 1. Available literature of *Mystus vittatus* from worldwide water-bodies.

Aspects	Waterbody/Country	References
Length-weight relationships and condition factors	West Bengal, India	Das et al. (2024)
Temperature-optimized	West Bengal, India	Dhara et al. (2023)
Life-history traits	The Mekong Delta, Vietnam	Phan et al. (2023)
Life history traits	The Ganges River, Bangladesh	Mawa et al. (2022)
Bioaccumulation of heavy metals	Yamuna River, India	Tabrez et al. (2021)
Sublethal effects of phenol	Adirampattinam, Tamil Nadu, India	Muthukumaravel et al. (2021)
Seasonal variation of the length-weight relationship	Kangsabati River, India	Chakraborty et al. (2019)
Condition, length-weight and length-length relationships	The Mathabhanga River, Bangladesh	Hossain et al. (2006)

Concern” both in Bangladesh (IUCN Bangladesh, 2015) and globally (IUCN, 2020), such classifications indicate populations that have gradually decreased, prompting the need for management strategies to secure their ongoing existence in natural habitats (Nature Conservation Act, 1992).

In the area of fisheries management, length-weight relationships (LWRs) serve as a valuable tool for estimating weight from length data, assessing fish population production and biomass, and providing insights into the physiological condition of stocks or organisms (Kamal et al., 2009; Zamani Faradonbeh et al., 2015a; Keivany et al., 2015; Abbasi et al., 2019; Eagderi et al., 2020). Furthermore, in comparative growth studies in fisheries management, length-length relationships (LLRs) are of significant importance (Moutopoulos and Stergiou, 2002; Jafari-Patcan et al., 2018; Mouludi-Saleh and Eagderi, 2019; Çiçek et al., 2020). In fisheries biology, the condition factor is a commonly used index that assesses fish condition based on length and weight. The physiological state, general health, and potential yield of fish are commonly assessed using various condition factors (Richter, 2007; Zamani Faradonbeh et al., 2015b; Radkhah and Eagderi, 2018); these numerical parameters offer crucial insights into fish health, revealing its capacity for growth, survival, and reproductive success, which can determine the viability of subsequent generations (Le Cren, 1951). For evaluating fish condition, the relative weight (W_R) serves as a significant index (Rypel and Richter, 2008).

Furthermore, the form factor ($a_{3.0}$) aims to explain the shape, size, and structure of fish species, which is essential for their survival and adaptation to various environments (Froese, 2006). Changes in body shape

enhance energy efficiency and improve movement in water environments. The form factor ($a_{3.0}$) significantly influences the success of fish within their habitats, impacting hydrodynamics and niche occupancy. Physiological status, classified as ideal, lean, or fatty, is crucial for understanding the physiology of a given species (Khatun et al., 2018; Kasif et al., 2025).

Fish biometrics serve as essential biological indicators, enabling the assessment of fish population physical fitness and the status of fish stocks. The breadth of *M. vittatus* in this domain is well-documented, as summarized in Table 1. Several investigations have examined various facets of *M. vittatus*, including LWRs and LLRs derived from biological characteristics observed in the Old Brahmaputra River. To effectively manage these species and execute conservation strategies for the Old Brahmaputra River, comprehensive information on their life history characteristics is essential. This study aims to delineate the key life history characteristics of *M. vittatus* from the Old Brahmaputra River in northeastern Bangladesh, specifically examining its length-frequency distributions (LFDs), length-weight relationships (LWRs), length-length relationships (LLRs), condition factors, form factor, and physiological status. Additionally, our objective is to identify the key factors and risks driving the decline of fish species in the Old Brahmaputra River.

Materials and Methods

Study area: The sampling for this research work took place at multiple landing locations along the Old Brahmaputra River in northeastern Bangladesh (Nandina Gudara, Godara Ghat, and Narundi Bazar Ghat point) (Fig. 1). In this study, *M. vittatus* was

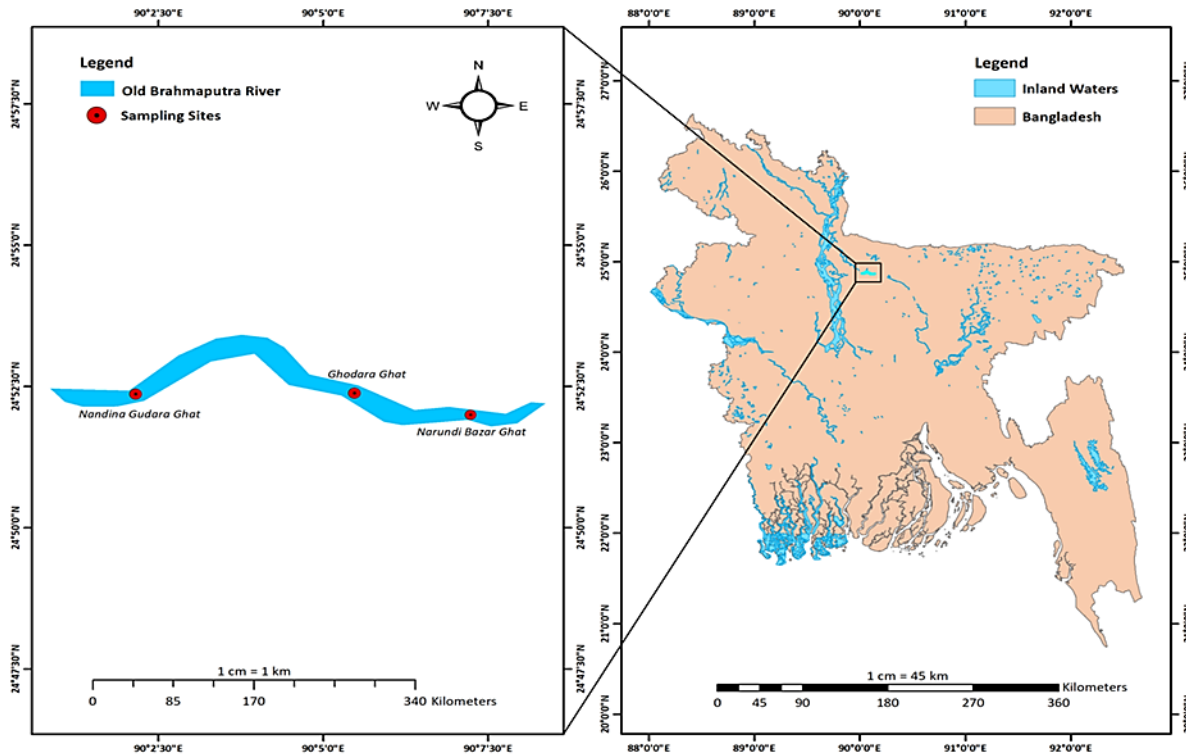


Figure 1. Map of the study site, where the sampling points (Nandina Gudara Ghat, Ghodara Ghat, and Narundi Bazar Ghat) were marked by an oval shape.

captured by commercial fishers from January to December 2024, except during the breeding season (March to May), when sampling was paused. A total of 515 specimens were collected using gill nets (1.5–2.5 cm) with assistance from local fishers and were subsequently preserved in an ice box immediately on site.

Fish size measurement: The collected specimens were brought to the laboratory and positioned on filter paper to facilitate flat drying. The morphometric characteristics of the samples were measured. After that, the body weight (BW) of each fish was measured with an electronic weighing machine (Sartorius, Germany). Total length (TL) and Standard length (SL) were then measured with precision up to 0.1 cm using digital slide calipers (Mitutoyo, Japan).

Length–weight relationships: According to Le Cren (1951), the length-weight relationship (LWR) of fish is typically determined through the formula $W = a \times L^b$, where body weight is represented by W , L denotes the total length, ‘ a ’ and ‘ b ’ are the constants derived from the regression analysis. To facilitate linear regression analysis, this formula was logarithmically

transformed: $\ln[W] = \ln[a] + b \ln[L]$. This method provides a robust framework for examining growth patterns and size-weight dynamics in fish populations, enabling the estimation of weight based on length. Beyond its use in growth assessment, the LWR also provides valuable insights into seasonal variations in fish condition, standing stock biomass, and population structure over time. The coefficients a and b , including their 95% confidence intervals, were estimated to quantify the growth trend.

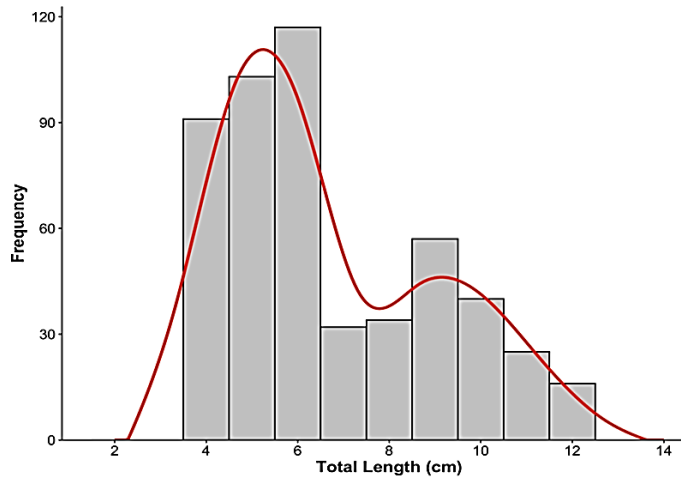
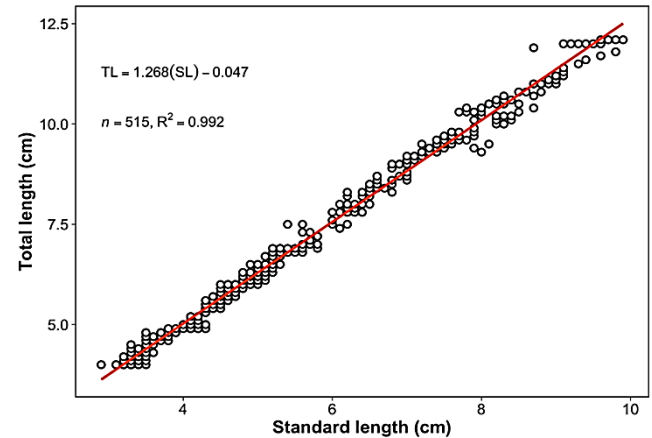
Length-length relationship: We measured TL and SL to the nearest cm to create a linear regression of TL versus SL.

Condition factors: The allometric condition factor (KA), following Tesch (1968), was computed using the formula of $KA = W/L^b$, where W represents body weight (BW) in grams, L denotes total length (TL) in centimeters, and ‘ b ’ is the exponent from the length-weight relationships (LWRs). The condition factor (KF) proposed by Fulton (1904) was calculated as $KF = 100 \times (W/L^3)$, where W is body weight (g), and L is total length (cm). The relative condition factor (KR) was determined by the equation $KR = W / (a \times L^b)$ (Le

Table 2. Morphometric measurements of the *Mystus vittatus* captured from the Old Brahmaputra River, northeastern Bangladesh.

Measurements	<i>n</i>	Min	Max	Mean± SD	95 % CL
Total length (cm)		4	12.1	7.120±2.25	6.925-7.315
Standard length (cm)	515	2.9	9.9	5.652±1.76	5.499-5.805
Body weight (g)		1.16	18.76	5.233±4.47	4.845-5.620

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

Figure 2. Length–frequency distribution of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.Figure 3. Length–length relationships of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.

Cren, 1951). The relative weight (KR) was calculated using the formula $WR = (W/W_s) \times 100$ (Froese, 2006). In addition, W_s refers to $W_s = aL^b$.

Form factor: The form factor ($a_{3,0}$) was determined through the formula $a_{3,0} = 10^{\log a - s(b-3)}$ (Froese, 2006). In this scenario, the regression variables for the LWR between BW and TL are designated as a and b , with s representing the slope of $\ln(a)$ plotted against b .

Physiological status: The equation $\bar{a} = BW/(TL)^b$ was used to assess the physiological condition of *M. vittatus* individuals, determining whether they are in an optimal, lean, or fatty state (King, 2013). When the calculated value of \bar{a} matches the LWR parameter ‘ a ’, the fish is considered to be in optimal health condition. Variations from this value reflect the condition of the fish, which can be categorized as lean ($\bar{a} < a$) or fatty ($\bar{a} > a$) (Rahman et al., 2023).

Statistical analysis: Software applications, including RStudio, GraphPad Prism 8, and Microsoft Excel 2019, were utilized to conduct the statistical analyses. Normality within each group was initially assessed using visual histograms and subsequently validated with the Kolmogorov–Smirnov and Shapiro–Wilk tests. Additionally, the homogeneity of variance was

assessed. The nonparametric Mann–Whitney U test was used to compare total length (TL), body weight (BW), and condition variables when the assumption of normality was violated. The Wilcoxon signed-rank test was used to assess whether the average relative weight (WR) differed significantly from 100 (Anderson, 1996). The Spearman rank test was used to examine the relationships between the TL and BW parameters and the condition variables (KA , KF , KR , and WR). The significance level for all statistical tests was set at 5% ($P < 0.05$).

Results

Length-frequency distribution: The LFDs revealed that the most diminutive and the most substantial individuals measured 4–12.1 cm in TL (Table 2, Fig. 2).

Morphometric relationships: The length-weight relationships (LWRs) of *M. vittatus* are presented in Table 3, which includes the regression coefficients (a and b), their 95% confidence limits, the coefficient of correlation (r^2), and the growth pattern. The ‘ b ’ values obtained from the LWRs were significantly less than 3.0 ($b < 3.00$; $P < 0.001$), indicating negative

Table 3. Descriptive statistics and estimated parameters of the length-weight and length-length relationships of *Mystus vittatus* from the Old Brahmaputra River, northeastern Bangladesh.

Equation	a	b	95% CL of a	95% CL of b	r ²
BW= a × TL ^b	0.0281	2.56	0.0260-0.0303	2.51-2.59	0.984
BW= a × SL ^b	0.0486	2.58	0.0449-0.0526	2.53-2.62	0.973
TL= a + bSL	0.0836	0.7821	0.0372-0.1300	0.7759-0.7883	0.991

TL, total length; BW, body weight; SL, standard length; a, intercept; b, slope; CL, confidence limit for mean values; r², coefficient of determination.

Table 4. Descriptive statistics of condition factors measurements with their 95% CL of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.

Condition factors	n	Min	Max	Mean±SD	95% CL
Allometric condition factor (KA)		0.0200	0.0399	0.0287±0.004	0.0284-0.0291
Fulton's condition factor (KF)	515	0.8692	2.1406	1.2286±0.263	1.2058-1.2514
Relative condition factor (KR)		0.7125	1.4215	1.0241±0.142	1.0118-1.0364
Relative weight (WR)		71.251	142.15	102.41±14.23	101.18-103.64

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

Table 5. Estimation of correlation for condition factors with TL and BW of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.

Correlation	r _s values	95% CL of r _s	P- values	Level of significance
TL vs. KA	0.02111	-0.06798 to 0.1099	0.6327	ns
TL vs. KF	-0.6638	-0.7108 to -0.6109	< 0.0001	****
TL vs. KR	0.02109	-0.06801 to 0.1098	0.6330	ns
TL vs. WR	0.02109	-0.06801 to 0.1098	0.6330	ns
BW vs. KA	0.1577	0.06970 to 0.2432	0.0003	***
BW vs. KF	-0.5598	-0.6180 to -0.4955	< 0.0001	****
BW vs. KR	0.1577	0.06967 to 0.2432	0.0003	***
BW vs. WR	0.1577	0.06967 to 0.2432	0.0003	***

KA, allometric condition factor; KF, Fulton's condition factor; KR, relative condition factor; WR, relative weight; r_s, Spearman rank-correlation values; CL, confidence limits; P, shows the level of significance; ns, not significant; *** significant; ****highly significant.

growth (A-). Furthermore, Table 3 and Figure 3 depict the LLR (TL vs. SL), presenting the estimated parameters 'a' and 'b', their corresponding 95% confidence limits, and the coefficient of determination (r²) values. All established LLRs demonstrated high statistical significance (P<0.001).

Condition Factors: The allometric condition factor (KA), Fulton's condition factor (KF), and relative condition factor (KR) of *M. vittatus* were calculated as 0.0287±0.004, 1.2286±0.263, and 1.0241±0.142, respectively (Table 4). The Spearman rank correlation test revealed no significant relationships with TL for KA and KR, except for KF (rs = -0.6638, P<0.0001), which showed a significant correlation. When correlated against body weight (BW), KA and KR demonstrated significant correlation, and KF was highly significantly correlated with BW (P<0.0001) (Table 5).

Relative weight: The relative weight (WR) of

M. vittatus was 102.41±14.23 (Table 4; Fig. 4). According to the results, the Spearman rank correlation analysis indicated a lack of statistically significant connections between TL and WR (rs = 0.0210; P = 0.6330). However, BW and WR showed a strong connection (rs = 0.1577; P = 0.0003).

Form factor: The form factor (a_{3.0}) was found to be 0.0068, which suggests a body elongate and slightly compressed (Table 6).

Physiological status: The greatest proportion of fatty fish was observed within the 11-11.9 cm TL, making up 80% of the population of *M. vittatus*. On the other hand, the ideal fish, which had the most acceptable physiological condition, could be identified by its specific size range of 9-9.9 cm TL, accounting for 68.42% of the observed individuals. In addition, *M. vittatus* individuals with a lean physiological state comprise 62.13% of the population within the 5-5.9 cm TL range (Fig. 5).

Table 6. Calculated form factor of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh, and worldwide.

Water body/ Country	n	Length range (cm)		Regression parameters		References	Calculated $a_{3.0}$	
		Type	min	max	a			b
The Old Brahmaputra River, northeastern Bangladesh	515	TL	4.0	12.1	0.0282	2.56	Present study	0.0068
West Bengal, India	313	TL	4.1	16	0.0086	3.02	Das et al. 2024	0.0091

n, sample size; min, minimum length; max, maximum length; a, intercept; b, slope; $a_{3.0}$, form factor

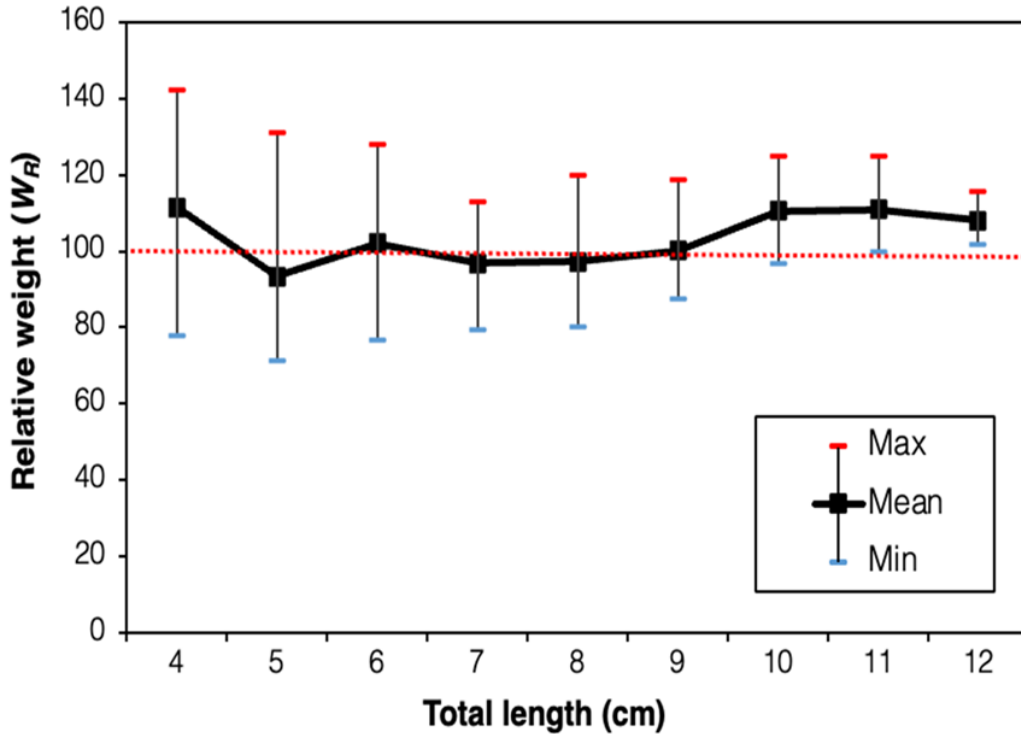


Figure 4. Relative weight (W_R) of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.

Discussions

Inland fisheries management is effective only when informed by up-to-date, well-documented life-history traits of the wild fish populations involved (Islam et al., 2024). The present study offers one of the first in-depth analyses of key life-history characteristics of *M. vittatus* inhabiting the Old Brahmaputra River in northeastern Bangladesh. A comprehensive dataset comprising 515 individual samples was utilized in this study. Comprehensive data, gathered using traditional fishing gear and encompassing a variety of *M. vittatus* body sizes, enhance our understanding of the species.

The LFD is a key biometric statistic used in dynamic mathematical models to analyze changing patterns by evaluating recruitment, growth rates, mortality, yields, and the total biomass within a specific ecosystem (Sabbir et al., 2021). According to

the current research, the LFD indicates that most individuals fall within the range of 6.00-6.99 cm. Additionally, *M. vittatus* measured 12.1 cm in total length in the current study, which slightly exceeds the previously reported maximum of 12 cm TL from West Bengal, India (Das et al., 2024). This result is reliable based on the outcomes of the present investigation. Length variation in fish is influenced by several factors, including environmental pollution, population structure, sampling season, methodological differences, food availability, feeding intensity, individual size, age, sex, maturity stage, and geographical distribution (Famoofo and Abdul, 2020).

Regardless of the diverse body shapes among fish species, an allometric constant (b -value) close to 3.0 typically indicates isometric growth, meaning the fish's body proportions remain consistent as it

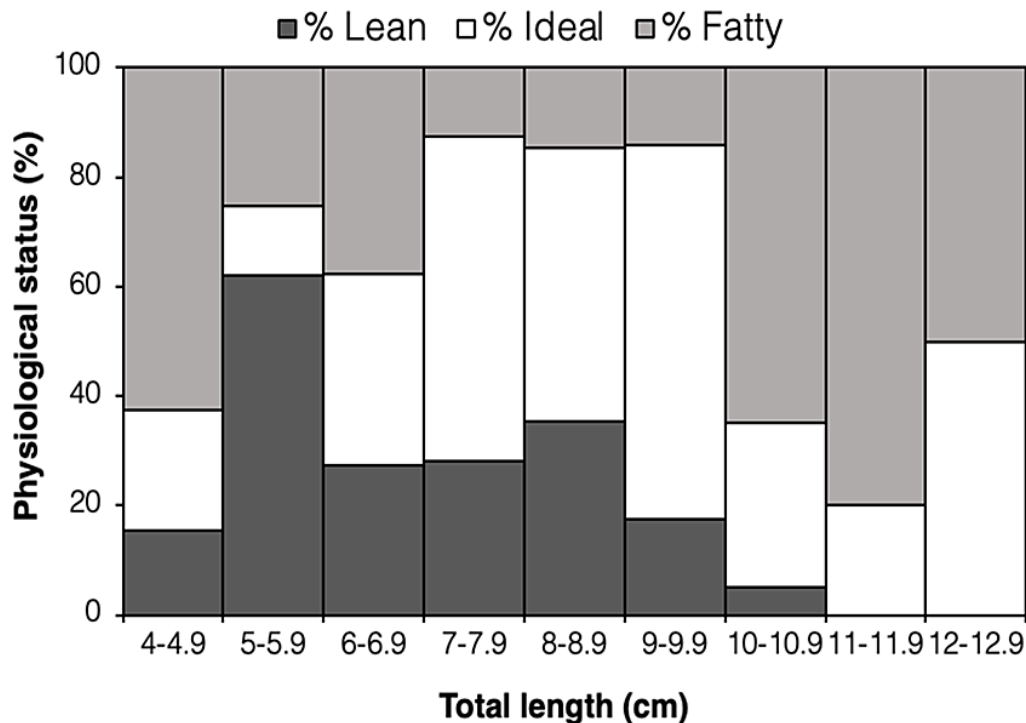


Figure 5. Physiological condition (i.e., lean, ideal, and fatty) of *Mystus vittatus* in the Old Brahmaputra River, northeastern Bangladesh.

increases in size. In contrast, a significant deviation from the value of 3.0 indicates allometric growth—values greater than 3.0 reflect positive allometric patterns, where the fish becomes relatively heavier as it grows, while values below 3.0 indicate negative allometry, suggesting the fish becomes more elongated or slender with increasing size. The current study observed a negative allometric growth pattern ($b < 3.0$), indicating that the fish exhibited slower growth in weight relative to length, resulting in a comparatively leaner body form. The b -value for *M. vittatus* across various natural habitats in West Bengal, India, was reported as 2.93 (Das et al., 2024), consistent with the growth pattern observed in the current study. Furthermore, *M. vittatus* from the Mathabhanga River, located in southwestern Bangladesh, exhibited a b -value of 3.05, indicating a more robust growth pattern than observed in the present findings (Hossain et al., 2016). Variations in growth patterns across populations of the same species may result from factors such as seasonal fluctuations during sample collection, differences in maturity stages, and the size distribution of the individuals studied (Tesch, 1968).

The condition factor is a vital indicator that

encapsulates the combined effects of abiotic and biotic factors on the physiological well-being of fish. As such, it serves as a reliable metric for evaluating the overall health and quality of the aquatic environment in which the fish reside (Anene, 2005). The present study evaluated four condition factors (KA , KF , KR , and WR) to determine the physiological condition of *M. vittatus* in the Old Brahmaputra River. The values of KA , KF , and KR ranged from 0.0200 to 0.0399, 0.8692 to 2.1406, and 0.7125 to 1.4215, respectively. A Spearman rank correlation analysis revealed a significant correlation ($P < 0.0001$) between KF and both total length (TL) and body weight (BW), indicating that KF is the most reliable indicator of the species' health in this habitat. Comparative data from Das et al. (2024) reported KF values ranging from 0.699 to 1.50 for *M. vittatus* across various water bodies in West Bengal, India, which are consistently lower than those observed in the current study.

The relative weight (WR) values ranged from 71.25 to 142.15, with a mean value of 102.41 ± 14.23 . A mean WR exceeding 100 indicates that the sampled population is in good to excellent condition, implying that the fish are well-nourished and have access to ample food resources. Despite moderate variability, as

indicated by the standard deviation, most individuals maintain WR values near or above the optimal benchmark. This suggests a favorable ecological scenario characterized by prey abundance, thereby supporting a healthy and thriving fish population in the Old Brahmaputra River.

Moreover, the form factor ($a_{3,0}$) serves as a critical metric for assessing the morphological structure of individual fish within a population (Saha et al., 2023). This study estimated the form factor for *M. vittatus* as 0.0068. In contrast, a higher value of 0.0091 was reported from various water bodies in West Bengal, India. This lower form factor observed in the current population suggests a body shape that may be less suited to rapid, sustained swimming but more adaptive for precise maneuverability, such as navigating complex habitats or facilitating specific foraging behaviors. The observed variation in $a_{3,0}$ values is likely attributable to regional differences in environmental conditions and food availability (Mawa et al., 2022).

Based on the physiological condition of the fish examined in this study, it is advisable to target individuals within the total length (TL) range of 11.0-11.99 cm for harvest. Fish within this size class exhibited optimal condition factors and are likely to yield a satisfactory amount of flesh. However, due to the lack of available literature on the breeding season of *M. vittatus*, no comparative analysis could be conducted in this regard.

Conclusion

The present study assessed the growth pattern of *M. vittatus* in the Old Brahmaputra River in northeastern Bangladesh and found a negative allometric growth pattern, with a b -value of 2.56. This indicates that the fish grows in length faster than in weight, suggesting environmental stress, limited food availability, or habitat degradation in the study area. Such growth patterns can reflect the river's ecological conditions and have implications for the sustainable management of *M. vittatus* populations. Therefore, continuous monitoring of growth dynamics, along with habitat restoration and conservation measures, is

essential to support the health and productivity of this economically and ecologically important species in the Old Brahmaputra River.

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