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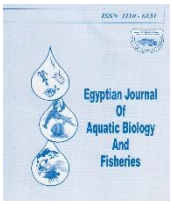

Biometric Studies of 10 Fish Species Inhabiting the Kakodonga River Basin of Golaghat, Assam, India

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ABSTRACT

Biometric studies of 10 fish species from five families (Cyprinidae, Bagridae, Sisoridae, Osphronemidae and Badidae) inhabiting Kakodonga River basin of Golaghat, Assam, India are presented. The length-frequency distributions (LFDs) showed that the minimum total length (TL) was 3.19cm for *Trichogaster fasciata* and maximum TL was 11.53cm for *Mystus vittatus*. Two species (*Puntius chola* and *Gagata cenia*) showed positive allometric growth pattern; four species (*Puntius conchonius*, *Gagata gagata*, *Trichogaster fasciata*, *Badis badis*) showed negative allometric growth pattern; and four species (*Puntius ticto*, *Puntius sophore*, *Mystus vittatus*, *Mystus bleekeri*) showed isometric pattern of growth. However, the K_R values ranged between 0.35 and 1.98 while the K_F value ranged between 0.29-6.89 which is an indicative of good health condition of the fish community. The form factor $a_{3.0}$ ranged between 0.008 and 0.176 across the fish species depicting their body shape. This is the first report of biometrics of fish species from Kakodonga River which will throw light on the sustainability of the river system and take up management strategies in future course of time.

INTRODUCTION

Inland freshwater fisheries play a vital role, having a tremendous impact on local riparian livelihoods, the economy, and ecological balance. Being a rich source of protein, essential nutrients, and vitamins **(Ohen & Abang, 2007)**, fishery resources are in increasing demand, leading to overexploitation and population decline. Fisheries generally make every effort to sustain a healthy aquatic environment that preserves both fish biodiversity and biomass **(Tsikliras *et al*., 2015)**. They fundamentally address cultural, social, and biological aspects in order to protect fish stocks while simultaneously meeting the dietary demands of society **(FAO, 2003)**. Improvement in fishery management and conservation appears to be the need of the hour, and for effective management, biometric studies are highly recommended by various researchers **(Anene, 2005; Atama *et al*., 2013)**. Such studies enhance understanding of fish species through precise assessments of biomass in specific habitats **(Jisr *et al*., 2018; Hasan *et al*., 2020)**.

The length–weight relationship (LWR) is one of the most important aspects of biometric studies. It not only helps in determining fish growth characteristics **(Schneider *et al*., 2000; Froese, 2006)** but also provides a reliable estimate of biomass. LWR enables weight estimation of the stock without requiring individual counts. In LWR, length can be converted to weight, which in turn provides insights into reproductive status, growth, and maturity of the fish **(Beyer, 1987)**. The form factor "a3.0" indicates the general body shape of the fish **(Hossain *et al*., 2012)**. Furthermore, LWR helps determine distribution patterns and assess the condition status of fish populations. The condition status significantly influences growth, reproduction, and survival potential within the fish community **(Hossain *et al*., 2012)**.

Although biometric studies are recognized as an important component of fishery management, no scientific documentation exists on the biometric characteristics of fish from the Kakodonga River, which makes significant contributions to the fisheries of the Golaghat area in Assam, India. Therefore, the present study attempted to assess the length–weight relationships (LWRs), length–frequency distributions (LFDs), form factor (a3.0), and condition factors (KR and KF) of ten fish species belonging to five families (Cyprinidae, Bagridae, Sisoridae, Osphronemidae, and Badidae). These findings aim to provide valuable insights into the sustainable fishery potential of the Kakodonga River in the Golaghat region.

MATERIALS & METHODS

1. Collection of fish

Monthly fish samples were collected randomly from three sites (S1 26°72'50"N 94°04'69"E), (S2 26°54'43"N 94°11'70"E) and (S3 26°68'69"N 93°82'27"E) from Jan 2022 to Dec 2023 using cast net (1- 3cm mesh size), lift net (1- 3cm mesh size), drum shaped trap boxes (sepa), and seine net (1- 2cm mesh size). The fish were identified following **Talwar and Jhingran (1991)**, **Jayaram (1999)** and **Vishwanath (2021)**. Length-weight data were recorded from the collected samples. The total length (TL) of the fish was measured in centimetres (cm) using digital slide callipers, while the weight was measured in grams (g) using digital top pan balance.

2. Length-frequency distributions

The fish were grouped into length classes of 1cm interval. Monthly length frequency distribution of each species was plotted in chart to get an overview of the population structure.

3. Length weight relationships (LWRs) and growth type (GT)

The LWR was calculated using the allometric model: $W = aL^b$, where W is the body weight (g); L is the total length (cm); a is the intercept; and b is the slope of the regression line. This equation was log-transformed into a linear regression model: $\ln(W) = \ln(a) + b \ln(L)$, with a 95% confidence limit **(Froese, 2006)**. The value of b was used to determine growth type: if $b = 3$, it indicates an isometric growth pattern, where weight increases proportionally with length. If $b \neq 3$, it indicates an allometric growth pattern, where weight and length do not increase proportionally. If $b > 3$, it shows positive allometric growth, meaning weight increases faster than length, and if $b < 3$, it shows negative allometric growth, meaning weight increases more slowly compared to length **(Ricker & Carter, 1958)**.

4. Form factor

The form factor (a3.0) for each species was calculated using the formula: a3.0 = 10^(log a – s(b – 3)), where a and b are regression parameters, and s is the slope with an average value of –1.358 **(Froese, 2006)**.

5. Condition factors

The relative condition factor (KR) was calculated using the formula: KR = W / (aL^b), where W = body weight, L = total length, and a and b = regression parameters **(Le Cren, 1951)**. The Fulton's condition factor (KF) was calculated using the formula: KF = 100 × (W / L^3), where W = body weight and L = total length **(Fulton, 1904)**.

6. Statistical analysis

All statistical analyses were carried out using Microsoft Excel (Version 2007), with significance considered at $P< 0.01$.

RESULTS

1. Length frequency distribution

The length–frequency distribution (LFD) of the *Puntius* species studied generally exhibited a skewed pattern, except for *P. chola*, which showed a normal distribution. *P. conchonius* displayed a positively skewed distribution; *P. sophore* showed a slightly negatively skewed distribution; and *P. ticto* exhibited a negatively skewed distribution, as illustrated in Fig. (1).

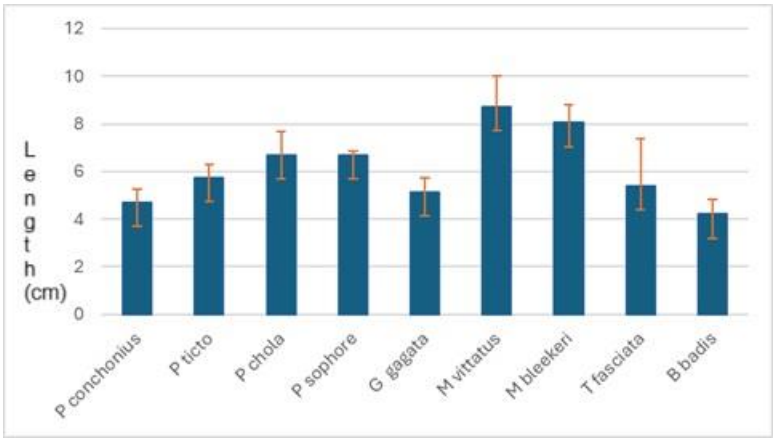


Fig. 1. Average length (with SD) frequency distribution of ten fish species of Kakodonga River

The LFDs of *P. chola*, *P. conchonius*, *P. ticto*, and *P. sophore* varied as follows: 3.96– 6.73cm, 5.42– 9.65cm, 4.25– 6.43cm, and 4.82– 8.70cm, respectively. Most *Puntius* species were concentrated in the 6– 7cm length group, except for *P. conchonius*, in which the dominant length group was 4– 5cm (Fig. 2).

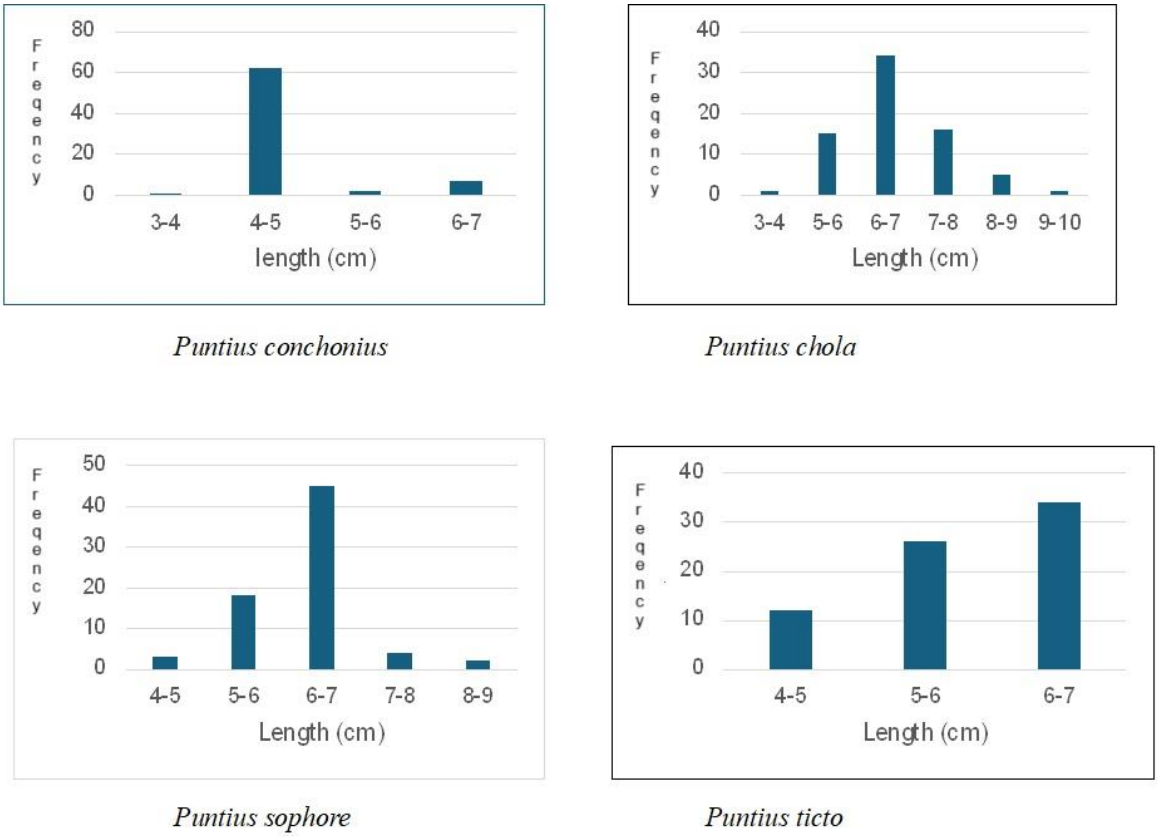


Fig. 2. Length frequency distribution of *Puntius* species

Among the *Gagata* species, *G. cenia* exhibited larger sizes, with total lengths ranging from 6.29–8.21 cm, while *G. gagata* were comparatively smaller, ranging from 3.60–5.71 cm. The numerically dominant length group in *G. cenia* was 6–7 cm, whereas in *G. gagata* it was 5–6 cm (Fig. 3).

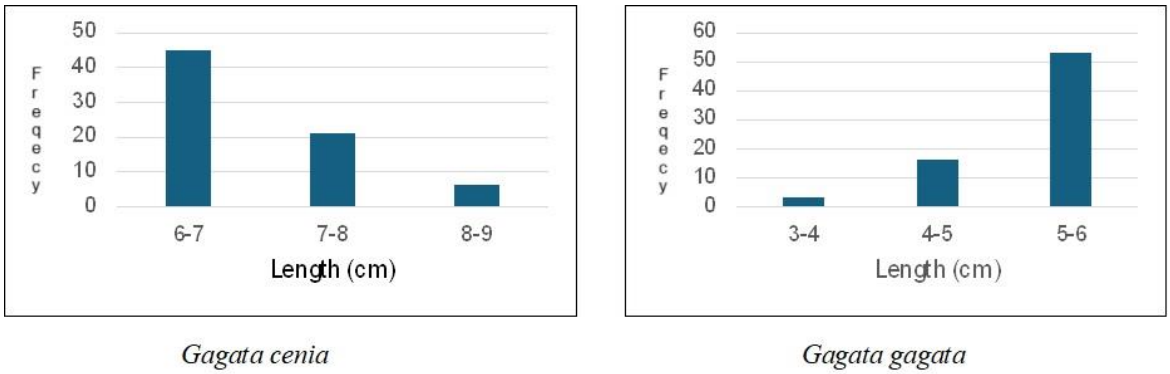
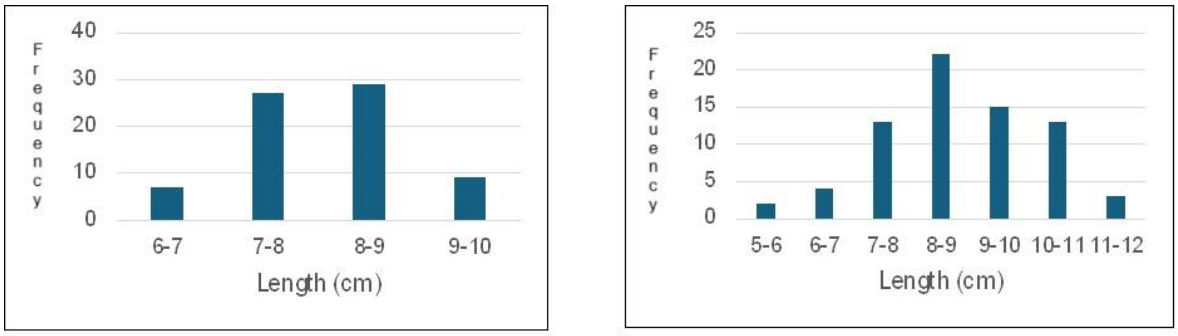


Fig. 3. Length frequency distribution of *Gagata* species

Mystus bleekeri and Mystus vittatus exhibited comparable total length ranges, with *M. bleekeri* measuring 6.55– 9.57cm and *M. vittatus* measuring 5.10– 11.44cm. The dominant length group for *M. bleekeri* was 7– 9cm, whereas for *M. vittatus* it was 7– 10cm (Fig. 4).



Mystus bleekeri *Mystus vittatus*

Fig. 4. Length frequency distribution of *Mystus* species

Trichogaster fasciata showed a total length range of 3.21– 9.28cm, while *Badis badis* ranged from 3.63– 5.00cm. The dominant length group for both species was 4– 5cm (Figs. 5, 6).

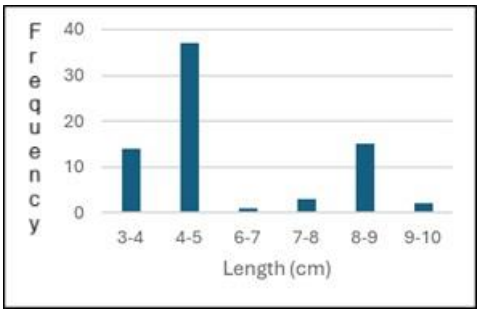


Fig. 5. Length frequency distribution of *Trichogaster fasciata*

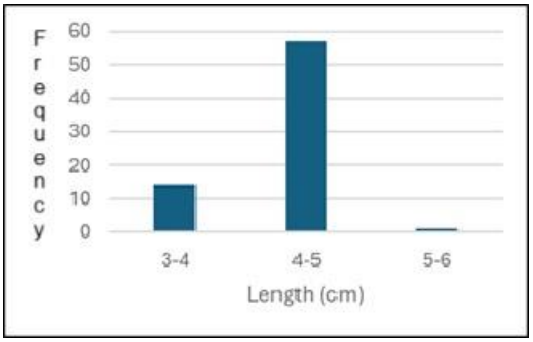


Fig. 6. Length frequency distribution of *Badis badis*

2. Length-weight relationship

Table (1) shows that the highest TL was 11.53cm for *Mystus vittatus* and the lowest TL was 3.19cm for *Trichogaster fasciata*. *Puntius chola* showed the maximum body weight (27.81g) while *Gagata gagata* showed the minimum body weight (0.36g).

Table 1. Length (cm) and weight (g) evaluation of ten fish species from Kakodonga River

Species	Family	Measurement	Min.	Max.	Mean ± SD	$CL_{95\%}$

Puntius chola (n=72)	Cyprinidae	TL	5.68	9.65	6.72±0.84	0.19
		BW	2.10	27.81	6.40±5.55	1.30
Puntius conchonius (n=72)	Cyprinidae	TL	3.96	6.73	4.72±0.56	0.13
		BW	1.05	4.68	2.82±0.96	0.23
Puntius ticto (n=72)	Cyprinidae	TL	4.25	6.43	5.73±0.56	0.13
		BW	1.26	5.01	3.21±1.01	0.24
Puntius sophore (n=72)	Cyprinidae	TL	4.82	8.70	6.33±0.69	0.16
		BW	2.06	14.12	4.48±1.99	0.47
Gagata youssoufi (n=72)	Cyprinidae	TL	3.59	5.71	5.14±0.58	0.14
		BW	0.36	2.45	1.49±0.57	0.13
Mystus vittatus (n=72)	Bagridae	TL	5.09	11.53	8.72±1.30	0.31
		BW	1.42	18.82	8.39±4.39	1.03
Mystus bleekeri (n=72)	Bagridae	TL	6.55	9.57	8.04±0.75	0.18
		BW	2.26	10.40	5.15±1.89	0.44
Gagata caenia (n=72)	Sisoridae	TL	6.29	8.26	6.93±0.48	0.11
		BW	1.02	4.51	2.81±0.84	0.19
Trichogaster fasciata (n = 72)	Osphronemidae	TL	3.19	9.28	5.40±1.97	0.46
		BW	0.67	12.78	3.85±1.97	0.75
Badis badis (n=72)	Badidae	TL	3.63	5.00	4.62±0.44	0.10
		BW	0.75	3.01	1.53±0.52	0.12

n = sample size, Min. = minimum, Max. = maximum, SD = standard deviation, $CL_{95\%}$ = confidence limit, TL = total length, BW = body weight.

A linear relationship between length and weight was established for all species studied, and the regression equations are represented as follows:

Puntius chola: Y = 0.004 + 3.76X;
Puntius conchonius: Y = 0.071 + 2.36X;
Puntius ticto: Y = 0.009 + 3.28X;
Puntius sophore: Y = 0.087 + 3.23X;
Gagata gagata: Y = 0.034 + 2.66X;
Gagata cenia: Y = 0.003 + 3.49X;
Mystus bleekeri: Y = 0.013 + 2.83X;
Mystus vittatus: Y = 0.006 + 3.33X;
Trichogaster fasciata: Y = 0.086 + 2.16X;
Badis badis: Y = 0.046 + 2.25X.

Growth type

The coefficient of determination (r^2) ranged from 0.41 to 0.87 at $P < 0.001$. Four species (*Puntius ticto, Puntius sophore, Mystus vittatus,* and *Mystus bleekeri*) showed an isometric growth pattern (I), with *b* values close to 3 ($b \approx 3$; $P < 0.001$). Two species (*Puntius chola* and

Gagata cenia) exhibited a positive allometric growth pattern (P) (*b*> 3). The remaining four species (*Puntius conchonius, Trichogaster fasciata, Badis badis,* and *Gagata gagata*) displayed a negative allometric growth type (N), with *b* values less than 3, as shown in Table (2).

Table 2. Regression parameters of length-weight relationships, coefficient of determination and growth type of ten fish species from Kakodonga River

Species	Regression Parameters		$CL_{95\%}$ of a	$CL_{95\%}$ of b	r^2	Growth Type	Form factor
	a	b				GT	$a_{3.0}$
Puntius chola (n=72)	0.004	3.76	0.007-0.220	2.86-4.65	0.501	P	0.042
Puntius conchonius (n=72)	0.071	2.36	0.023-0.195	1.69-3.02	0.409	N	0.009
Puntius ticto (n=72)	0.009	3.28	0.005-0.017	2.97-3.59	0.861	I	0.021
Puntius sophore (n=72)	0.087	3.23	0.006-0.018	2.93-3.52	0.873	I	0.176
Gagata youssoufi (n=72)	0.034	2.66	0.006-0.055	1.97-3.36	0.455	N	0.012
Mystus vittatus (n=72)	0.006	3.33	0.002-0.012	2.86-3.74	0.820	I	0.017
Mystus bleekeri (n=72)	0.013	2.83	0.003-0.049	2.20-3.47	0.533	I	0.008
Gagata cenia (n=72)	0.003	3.49	0.005-0.017	2.60-4.39	0.463	P	0.014
Trichogaster fasciata (n=72)	0.086	2.16	0.057-0.124	1.92-2.39	0.828	N	0.006
Badis badis (n=72)	0.046	2.25	0.017-0.121	1.624-2.874	0.423	N	0.004

n = sample size, a and b = regression parameters, $CL_{95\%}$ = 95% confidence limit, GT = growth type, I = isometric, P = positive allometric, N = negative allometric.

- **Form factor ($a_{3.0}$)**

The form factor provides insight into the body shape of fish. The calculated values were as follows: *P. chola* (0.042), *P. conchonius* (0.009), *P. ticto* (0.021), *P. sophore* (0.176), *G. gagata*

(0.012), *M. vittatus* (0.017), *M. bleekeri* (0.008), *G. cenia* (0.014), *T. fasciata* (0.006), and *B. badis* (0.004).

- **Condition factors**

The relative condition factor (K^R) of the ten fish species ranged from 0.35 to 1.99, with a mean ± SD of 1.05 ± 0.31. For Fulton's condition factor (K^f), the values ranged from 0.29 to 6.89, with a mean ± SD of 1.93 ± 1.26 (Table 3).

Table 3. Relative condition factor (K_R) and Fulton's condition factor (K_F) of ten fish species from Kakodonga River

Species (n)	Condition factor	Min.	Max.	Mean ± SD	$CL_{95\%}$
Puntius chola (72)	K_R	0.45	1.97	1.33 ± 0.41	0.09
	K_F	0.64	6.89	1.93 ± 1.26	0.29
Puntius conchonius (72)	K_R	0.48	1.68	1.05 ± 0.29	0.07
	K_F	1.29	4.33	2.68 ± 0.79	0.18
Puntius ticto (72)	K_R	0.63	1.53	1.12 ± 0.14	0.03
	K_F	0.91	2.16	1.65 ± 0.21	0.05
Puntius sophore (72)	K_R	0.66	1.90	1.08 ± 0.21	0.05
	K_F	1.10	2.31	1.68± 0.23	0.05
Gagata youssoufi (72)	K_R	0.35	1.99	1.05± 0.31	0.08
	K_F	0.34	2.26	1.08 ± 0.35	0.08
Mystus vittatus (72)	K_R	0.53	1.68	1.02 ± 0.24	0.06
	K_F	0.59	1.90	1.17± 0.28	0.07
Mystus bleekeri (72)	K_R	0.44	1.97	1.08± 0.27	0.06
	K_F	0.38	1.79	0.97 ± 0.24	0.06
Gagata caenia (72)	K_R	0.37	1.41	1.06 ± 0.23	0.05
	K_F	0.29	1.13	0.83 ± 0.18	0.04
Trichogaster fasciata (72)	K_R	0.57	1.89	1.05 ± 0.34	0.08
	K_F	0.89	4.76	2.34± 0.98	0.23
Badis badis (72)	K_R	0.48	1.98	1.05 ± 0.28	0.07
	K_F	0.68	3.19	1.54± 0.43	0.10

n = sample size, Min. = minimum, Max.= maximum, $CL_{95\%}$ = confidence limit, K_R = Relative condition factor, K_F = Fulton's condition factor.

DISCUSSION

This study showed that the maximum TL was 11.53cm for *M. vittatus*, while the minimum value was 3.19cm for *T. fasciata*. The maximum TLs recorded were: *M. vittatus* (11.53cm), *P. sophore* (8.70cm), *M. bleekeri* (9.57cm), *P. ticto* (6.43cm), *P. conchonius* (6.73cm), *P. chola* (9.65cm), *T. fasciata* (9.28cm), *G. cenia* (8.26cm), and *B. badis* (5.00cm). The *b* value ranged from 2.16 to 3.76 for all species, which falls within the acceptable range reported in previous studies **(Hossain *et al*., 2009; Hossain *et al*., 2012; Naeem *et al*., 2012; Hossain *et al*., 2014, 2015; Kaushik & Bordoloi, 2015; Borah *et al*., 2017; Nadia *et al*., 2023; Rahman *et al*., 2023)**. These findings are consistent with the present study. However, variations in fish size and growth may be influenced by food availability, with water temperature playing a crucial role **(Yigin & Ismen, 2009)**. In addition, fish size and abundance can also be affected by the type of fishing gear used **(Hossain *et al*., 2012)**.

In this study, two species exhibited a positive growth pattern ($b > 3$), suggesting a plumper body with increasing length. Four species with $b < 3$ displayed a negative allometric growth pattern, indicating a slimmer body with increasing length. The remaining species showed an isometric growth pattern ($b \approx 3$), reflecting optimum body growth **(Jobling, 2008)**. Thus, the *b* value is an important parameter for assessing fish condition across temporal and spatial scales **(Froese, 2006)**.

In the present study, *G. gagata* exhibited a negative growth pattern with a maximum TL of 5.71cm. However, no reference values for this species were found in the literature. In contrast, earlier studies reported *M. bleekeri* as showing a negative growth pattern and *B. badis* as exhibiting isometric growth **(Naeem, 2012; Kaushik *et al*., 2015)**. These differences may be attributed to geographical or environmental factors, disease, age, sex, food availability, or adaptability **(Schneider *et al*., 2000; De Giosa *et al*., 2014)**. Nevertheless, the present study aligns with findings of **Hossain *et al*. (2006)** (for *M. vittatus*), **Chaki *et al*. (2013)** (for *G. cenia*), **Pal *et al*. (2013)** (for *P. sophore*), **Shafi *et al*. (2013)** (for *P. conchonius*), **Maurya *et al*. (2018)** and **Ahriwal *et al*. (2023)** (for *M. bleekeri*), and **Parvin *et al*. (2021)** (for *T. fasciata*), with slight variations.

The form factor (*a3.0*), which is used to assess body shape **(Hossain *et al*., 2013)**, ranged from 0.004 to 0.176. The relative condition factor **(Le Cren, 1951)** and Fulton's condition factor **(Fulton, 1904)** ranged from 0.35 to 1.99 and 0.29 to 6.89, respectively. These two indices are important indicators of the health and habitat conditions of fish species. The present findings suggest an overall good health status, with the relative condition factor obtained from the LWR indicating sufficient food availability **(Offem *et al*., 2007)**.

Overall, these results provide important insights into the health of fish populations in their natural habitats and can guide fishery managers in developing sustainable management strategies for the Kakodonga River and other tributaries of the Brahmaputra drainage in Assam.

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Conflict of interest

The authors declare that they have no conflicts of interest relevant to this study.

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