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Research Article

Morphometric Characteristics, Length-Weight Relationships, and Condition Factors of Five Indigenous Fish Species from the River Ganga in Bihar, India

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Morphometric characteristics, length-weight relationships (LWRs), and condition factors (K) were studied for five indigenous fish species belonging to five different families (*Barilius barila* Hamilton, *Cirrhinus reba* Hamilton, *Chanda nama* Hamilton, *Mystus bleekeri* Day, and *Clupisoma garua* Hamilton), from the River Ganga in Bihar, India. A total of 557 fish individuals were collected seasonally from September 2021 to August 2022 using a monofilament drift gill net and a conical trap net Khairel jal. In morphometric analysis, the highest degree of correlation was observed between the total length and the standard length for all species (except *C. garua*). The estimated exponent value b varies from 2.920 to 3.214, where the slopes of regression lines among the species have significant differences ($p < 0.0001$). The b value indicated that three species (*B. barila*, *C. nama,* and *C. garua*) follow positive allometric growth, whereas *M. bleekeri* shows isometric growth and *C. reba* exhibits negative allometric growth. The condition factor value for these fishes ranged from 0.67 to 0.98, which indicated that the population of *C. reba* was robust compared to all other species ($p < 0.0001$). A new maximum length (146.8 mm) was obtained for *B. barila* from India. The present study gives baseline biological information on five commercially important indigenous fish species found in the River Ganga, Bihar. As the population of these species has been dwindling in recent times, these data will be important for the conservation and sustainable utilization of these important species in the long run.

1. Introduction

Ganga is the largest river system in India and is home to around 300 freshwater fish species that support 10–13 million riverine fishers' livelihoods and nutritional security [1]. Many freshwater fish species have become critically endangered as a result of human interventions, including the building of multipurpose dams and barrages, overfishing, pollution, invasions of exotic species, climatic changes, and soil erosion [2–4]. Approximately 480 kilometers of the River Ganga flow through Bihar, and fish were caught using traditional fishing gear (monofilament drift gill nets and Khairel jal). Annual fish landings from the Patna stretch of this river were 7.4 tons [5], while Bihar's total fish production was 0.64 metric tons with an annual per capita fish consumptions rate of 8.82 kg [6]. In local fish markets, catfish sell for 300–400 rupees per kilogram (US$ 3.67–4.89), while minor carps sell for 100–150 rupees per kilogram (US$ 1.22–1.83), but this depends on availability and season. The study of the biological parameters of fish species provides valuable information for management and sustainable use. Morphometric characters are frequently used to identify fish species [7] and determine whether a stock is heterogeneous or homogeneous [8]. The length-weight relationship of fish is a useful index for evaluating growth, survival, maturity, reproduction, and general well-being [9]. It explains the change in weight of fish with respect to length and vice versa [10]. It is often used to estimate fish biomass when the

length-frequency distribution is known [11], to determine possible differences between separate unit stocks of the same species [12] and to estimate the mean weight of fish based on known length [13]. It also serves as a tool to assess the life history characteristics of fish populations, such as stock composition, age at sexual maturity, and lifespan and provides important insights into resource conservation [14, 15]. Similarly, the condition factor provides information on the health status of species and the community as a whole [16] and can be used to compare the physiological robustness of fish on a numerical basis [17]. In recent times, increased pollution, reduced water flow, and the use of nonscientific fishing methods have had an impact on the morphological and physiological statuses of fish species. In spite of their commercial and ecological importance, there is still a scarcity of information on morphometric characteristics, length-weight relationship, and condition factors, for numerous fish species from the River Ganga. Therefore, the present study aimed to generate baseline data on these parameters of five indigenous fish species, the *Barilius barila* Hamilton, *Cirrhinus reba* Hamilton, *Chanda nama* Hamilton, *Mystus bleekeri* Day, and *Clupisoma garua* Hamilton, belonging to the families, Danionidae, Cyprinidae, Ambassidae, Bagridae, and Schilbeidae, respectively.

2. Materials and Methods

2.1. Study Area. Fish were collected at seasonal intervals from Digha Ghat Patipul (25°40′8.4″N; 85°0′18″E), a fish landing site of the River Ganga in Bihar, India (Figure 1). A total of 557 specimens of five indigenous fish species were collected from September 2021 to August 2022. These four-season samples were pooled for statistical analysis. Fish specimens were caught using a monofilament drift gill net (100–200 m length, 1.5-2 m width, 10–30 mm mesh size, and 4–6 hours" of operational time) and a conical trap net/Khairel jal (7-8 m length, 10 m mouth width, 1 m cod end width, and cod end mesh size 5–10 mm). Freshly caught fish specimens were kept in an ice box and brought to the laboratory. Fish specimens were identified to the species level using the standard manuals/taxonomic literature [18, 19]. The total length of specimens was measured from the tip of the snout to the tip of the caudal fin to the nearest 1 mm using a digital Vernier caliper (Insize - 0/150 mm), and wet weight was recorded to the nearest 1 g using a digital balance (WENSAR TM-MAB 220).

2.2. Morphometric Characters. The morphometric characters were recorded in the laboratory in a fresh condition using standard methods [20, 21]. The morphometric traits measured were total length (TL), standard length (SL), predorsal length (PDL), prepectoral length (PPL), prepelvic length (PVL), preanal length (PAL), caudal peduncle depth (CPD), head length (HL), snout length (SNL), eye diameter (ED), postorbital length (POL), interorbital length (IOL), caudal fin length (CFL), and body depth (BD). Linear regressions were performed for the compared traits using the least squares method [22]. For meristic traits, the number of rays in the dorsal (DFR), pectoral (PFR), ventral (PVR), anal (AFR), and caudal fin (CFR) was counted. In addition, the number of gill rakers on the first-gill arch (GR) was analyzed. Descriptive statistics were performed for the meristic counts.

2.3. Length-Weight Relationships (LWRs). The length-weight relationships were established separately for each species using the equation $W = aL^b$ [9], where W = body weight (g) of the fish specimens, L = total length (mm), a = intercept, and b = slope of the regression line. Furthermore, the relationship was expressed in the logarithmic form $\log W = \log a + b \log L$. A T-test was applied to determine whether the regression coefficients differ significantly from the isometric value of 3 ($p < 0.05$). The isometric growth is considered for a fish species when the estimated regression coefficient value is close to 3. In contrast, if it deviates from 3, fish growth becomes either negative allometric ($b < 3$) or positive isometric ($b > 3$).

2.4. Condition Factor. Condition factor (K) of the studied fish species was determined as per Fulton's index $K = W/L^3 * 100$ [23]. Here, "K" is the condition factor, "W" is the total body weight (g) of fish specimens, and "L" is the total length of specimens (mm).

2.5. Data Analysis. A statistical analysis of all the data was performed using Graph Pad Prism software. These fish's length and weight parameters are recorded in millimeters (mm) and grams (g). The data were presented as mean ± SD.

3. Results

3.1. Morphometric Characters. Table 1 shows the regression of total length (TL) on standard length (SL), predorsal length (PDL), prepectoral length (PPL), preventral length (PVL), preanal length (PAL), caudal peduncle depth (CPD), head length (HL), snout length (SNL), eye diameter (ED), postorbital length (POL), interorbital length (IOL), caudal fin length (CFL), and body depth (BD). For *B. barila*, *C. reba*, *C. nama*, and *M. bleekeri*, the correlation coefficient shows the highest degree of correlation between the total length and standard length, while for *C. garua*, it shows the highest correlation between the total length and head length. The correlation coefficient reveals the lowest degree of correlation between the total length and caudal fin length, snout length, and postorbital length for *B. barila*, *C. nama*, and *C. garua*. Descriptive statistics for meristic counts are shown in Table 2. For each species, the gill rakers had the highest coefficient of variation, while the caudal fin ray, ventral fin ray, and pectoral fin rays of *B. barila*, *C. reba*, and *C. nama* had the lowest coefficient of variation. Based on the Kruskal–Wallis multiple comparison tests, the mean values of the gill rakers of *B. barila* were statistically different from those of *C. garua* ($p = 0.0438$). The mean of *C. reba* is significantly different from *C. nama* ($p = 0.0168$) and *C. garua*

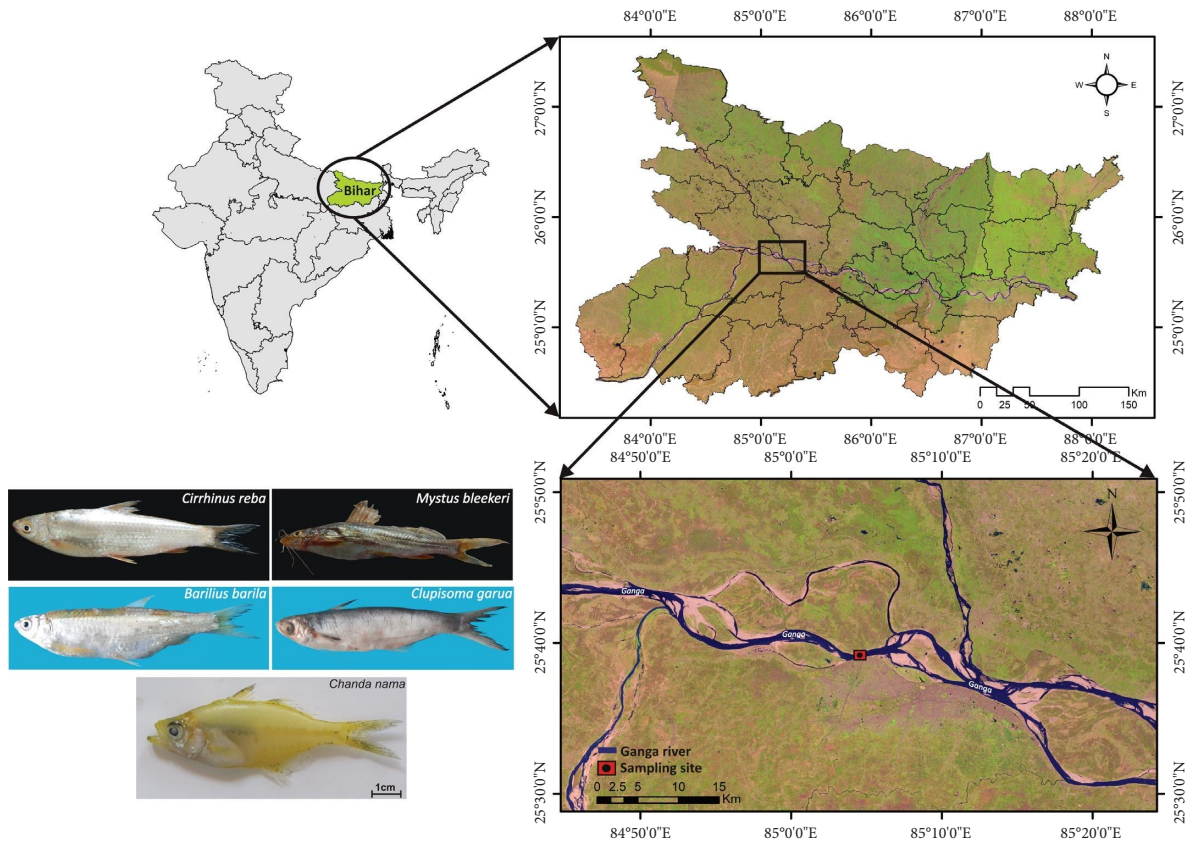

FIGURE 1: The sampling map of the study area.

TABLE 1: The relationship between TL and the SL, PDL, PPL, PVL, PAL, CPD, HL, SNL, ED, POL, IOL, CFL, and BD of five fish species from the River Ganga, Bihar, India.

	B. barila Correlation *r*	*C. reba* Correlation *r*	*C. nama* Correlation *r*	*M. bleekeri* Correlation *r*	*C. garua* Correlation *r*
TL vs. SL	0.983	0.995	0.990	0.984	0.908
TL vs. PVL	0.923	0.968	0.977	0.959	0.916
TL vs. BD	0.916	0.958	0.775	0.832	0.834
TL vs. PPL	0.914	0.942	0.911	0.877	0.848
TL vs. PAL	0.910	0.976	0.961	0.950	0.932
TL vs. HL	0.910	0.965	0.932	0.934	0.936
TL vs. SNL	0.903	0.720	0.829	0.741	0.818
TL vs. POL	0.901	0.906	0.879	0.831	0.736
TL vs. ED	0.895	0.877	0.978	0.886	0.887
TL vs. CPD	0.892	0.948	0.856	0.874	0.865
TL vs. PDL	0.888	0.991	0.976	0.941	0.910
TL vs. IOL	0.873	0.912	0.941	0.826	0.775
TL vs. CFL	0.802	0.937	0.915	0.848	0.776

TL: total length, SL: standard length, PDL: predorsal length, PPL: prepectoral length, PVL: preventral length, PAL: preanal length, CPD: caudal peduncle depth, HL: head length, SNL: snout length, ED: eye diameter, POL: postorbital length, interorbital length, CFL: caudal fin length, and BD: body depth.

($p < 0.0001$), while *M. bleekeri* is also significantly different from *C. nama* ($p = 0.0101$) and *C. garua* ($p < 0.0001$). The mean value of gill rakers in *C. reba* and *M. bleekeri* is not statistically significant ($p > 0.99$). The results indicate that there are no significant differences in morphological characters and meristic counts of these species within their populations, indicating that the stocks of these fish that occur along the Ganga River are homogeneous. Therefore, the fin formula based on meristic counts can be written as follows: D08–10 P11–15 V08–10 A10–13 C18–24 GR19–26 for *B. barila*; D09–11 P13–16 V09-10 A07–09 C21–24 GR24–39 for *C. reba*;

Table 2: Descriptive statistics of DFR, PFR, VFR, AFR, CFR, and GR of five fish species from the River Ganga, Bihar, India.

	B. barila ($n = 20$)				*C. reba* ($n = 16$)				*C. nama* ($n = 14$)				*M. bleekeri* ($n = 39$)				*C. garua* ($n = 27$)			
	Min.	Max.	Mean	CV%	Min.	Max.	Mean	CV%	Min.	Max.	Mean	CV%	Min.	Max.	Mean	CV%	Min.	Max.	Mean	CV%
DFR	8	10	8.70 ± 0.57	6.57	9	11	10.19 ± 0.54	5.33	VII, 15	17	16.25 ± 0.96	5.89	I, 6	8	7.01 ± 0.24	3.44	I, 6	8	6.94 ± 0.29	4.26
PFR	11	15	13.57 ± 0.87	6.41	13	16	14.25 ± 1.06	7.47	11	12	11.75 ± 0.50	4.26	I, 6	8	6.82 ± 0.57	8.36	I, 10	12	10.9 ± 0.35	3.25
VFR	8	10	8.33 ± 0.58	6.93	9	10	09.06 ± 0.25	2.76	I, 05	06	05.25 ± 0.51	9.52	6	7	6.03 ± 0.17	2.79	06	7	6.05 ± 0.21	3.45
AFR	10	13	11.33 ± 0.97	8.52	7	09	07.81 ± 0.54	6.97	III, 14	16	15.50 ± 0.98	6.45	7	11	9.81 ± 0.68	6.92	29	36	30.13 ± 2.50	4.51
CFR	18	24	21.24 ± 1.34	6.30	21	24	22.56 ± 0.89	3.95	22	24	22.50 ± 1.09	4.44	18	22	19.49 ± 1.36	6.99	19	24	21.48 ± 2.16	10.07
GR	19	26	21.82 ± 2.09	9.57	24	39	33.83 ± 5.46	16.13	16	20	17.75 ± 1.71	9.62	20	38	29.31 ± 4.2	14.00	13	20	16.36 ± −0.71	10.46

Min: minimum, Max: maximum, DFR: dorsal fin ray, PFR: pectoral fin ray, VFR: ventral fin ray, AFR: anal fin ray, CFR: caudal fin ray, GR: gill rakers, and CV: coefficient of variations. Meristic counts were calculated using the mean lengths of 111.52 ± 6.97 for *B. barila*, 122.82 ± 16.65 for *C. reba*, 78.98 ± 4.43 for *C. nama*, 92.69 ± 9.32 for *M. bleekeri,* and 162.10 ± 16.08 for *C. garua*. The data are expressed as mean ± SD (standard deviation).

Table 3: Descriptive statistics and estimated LWRs parameters of five fish species from the River Ganga, Bihar, India.

Species	*N*	TL				TW			Regression parameters					
		Min (mm)	Max (mm)	Mean (mm)	Maximum length reported from FB (mm)	Min (gm)	Max (gm)	Mean (gm)	95% CL *b*	95% CI *r*	*a*	*b*	*r*	Allometric growth pattern
B. barila	106	67.90	146.8*	97.06 ± 16.44	100.0	2.43	21.84	8.51 ± 4.61	3.12–3.36	0.965–0.984	0.00000279	3.241	0.976	+Allometric
C. reba	95	65.00	201.0	119.66 ± 20.21	300.0	4.00	81.41	16.57 ± 10.42	2.79–3.05	0.902–0.956	0.00001290	2.920	0.939	−Allometric
C. nama	54	45.10	86.10	65.47 ± 10.04	110.0	0.81	06.85	2.85 ± 1.46	3.01–3.38	0.929–0.976	0.00000148	3.192	0.958	+Allometric
M. bleekeri	159	58.75	119.40	88.29 ± 8.94	177.0	1.36	18.00	6.05 ± 2.56	2.85–3.18	0.843–0.913	0.00600000	3.013	0.883	Isometric
C. garua	143	92.91	216.08	146.89 ± 21.47	609.0	5.54	65.09	21.69 ± 10.70	2.99–3.29	0.926–0.961	0.00400000	3.145	0.946	+Allometric

N: number of the sample, TL: total length, TW: total weight, Min: minimum, Max: maximum, FB: fish base, CL: confidence of limit, CI: confidence of interval, *r*: coefficient of determinant, ∗new maximum total length, +positive allometric growth, and −negative allometric growth. The data are expressed as mean ± SD (standard deviation).

DVII, 15–17 P11-12 VI, 05-06 AIII, 14–16 C22–24 GR16–20 for *C. nama*; DI, 6–8 PI, 6–8 V06-07 A07–11 C18–22 GR20–38 for *M. bleekeri*; and DI, 6–8 PI, 10–12 V06-07 A29–36 C19–24 GR13–20, for *C. garua*.

3.2. Length-Weight Relationships (LWRs). Table 3 shows the descriptive statistics about the length-weight relationship for five indigenous fish species. The LWRs were determined to be $W = 0.00000279$ L3.241 for *B. barila*, $W = 0.0000129$ L2.920 for *C. reba*, $W = 0.00000148$ L3.192 for *C. nama*, $W = 0.006$ L3.013 for *M. bleekeri*, and $W = 0.004$ L3.145 for *C. garua*. Furthermore, the corresponding logarithmic form was noted as follows: log $W = -12.79 + 3.241$ log L for *B. barila*; log $W = -11.26 + 2.920$ log L for *C. reba*; log $W = -12.39 + 3.192$ log L for *C. nama*; log $W = -5.11 + 3.013$ log L for *M. bleekeri*; and log $W = -5.51 + 3.145$ log L for *C. garua*. The exponent b value ranged from 2.920 to 3.214, and the slopes of the regression lines among the species differed significantly ($p < 0.0001$). An exponent b value reveals that the three species (*B. barila*, *C. nama,* and *C. garua*) show positive allometric growth ($b > 3$), whereas *M. bleekeri* shows isometric growth ($b = 3.013$) and *C. reba* exhibits negative allometric growth. The observation confirms that the exponent value b is species-specific, and each fish species has a specific growth rate.

3.3. Condition Factor. In all specimens of *B. barila*, *C. reba*, *C. nama*, *M. bleekeri*, and *C. garua*, condition factor values ranged from 0.69 to 0.93, 0.81 to 1.46, 0.88 to 1.03, 0.81 to 1.02, and 0.57 to 0.82, with a mean (mean ± SD) of 0.81 ± 0.07, 0.98 ± 0.18, 0.94 ± 0.06, 0.91 ± 0.03, and 0.67 ± 0.05, respectively (Figure 2). Based on the Kruskal–Wallis multiple comparison tests, the mean values of *C. garua* were significantly different from the mean values of *M. bleekeri* ($p < 0.0165$), *C. nama* ($p < 0.0005$), and *C. reba* ($p < 0.0001$), respectively.

4. Discussion

The morphometric data revealed that the regression coefficient has a varying strength relationship between the total length and other characters for each species. These variations are species-specific and depend on the ontogenetic development of the species. In meristic counts, the number of rays in the dorsal, pectoral, ventral, caudal, and anal fins varies within the size range of *B. barila* (97–123), *C. reba* (102–152), *C. nama* (74–83), *M. bleekeri* (77–119), and *C. garua* (138–216), confirming that meristic counts depend on body size and vary with fish growth. Gill rakers are significantly more numerous in planktivorous fish (*C. reba*) compared to carnivorous fish (*C. garua* and *C. nama*), confirming that gill rakers depend on the feeding habits and food preferences of the species. Morphometric plasticity tends to respond to local environmental vitiations related to niche patterns of resource use [24] and physical characteristics of habitats that determine biological, evolutionary, and ecological changes in morphological traits of fish populations [25].

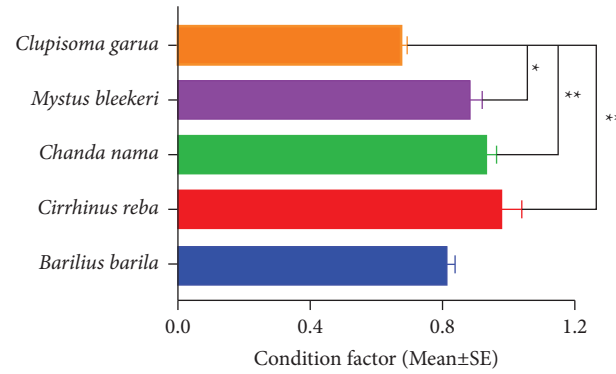

Figure 2: The condition factor variation in five fish species from the River Ganga, Bihar, India. *Significant at 5% level and **Significant at 1% level.

The length-weight relationship is important for understanding fish's growth rate and the pattern. The estimated b values for these indigenous fishes (2.92–3.24) were consistent with the expected range of 2.5–3.5 [10]. *C. reba* has a relatively slow growth rate and tends to be thinner (almost all specimens are in the juvenile stage), whereas estimates for *B. barila* are significantly better. 24.53% of individuals in the entire population of *B. barila* are sexually mature, and these mature specimens range in length from 73 to 123 with a mean length of 108.35 ± 10.55 mm (mean ± SD). In mature specimens, two-thirds of the entire body cavity are occupied by mature ovaries. Furthermore, recorded mean values for the length and weight of these ovaries are 45.90 ± 3.64 and 1.74 ± 0.69, respectively (mean ± SD). Fish fecundity and egg diameter (mm) were calculated to be 3150 ± 1452.62 and 0.77 ± 0.05, respectively. The maximum length observed for *B. barila* (146.8 mm) was higher than previously recorded for this fish (139.5 mm) from the Manas River in Assam, India [26]. The condition factor K is an important factor to explain the relative robustness of fish. The largest variation in K was found in *C. reba*, whereas the least variation was found in *C. garua*. Despite their dissimilar food preferences and different physical forms in the juvenile and adult life stages, the species showed variation in K. In addition, size composition, seasonal sampling, and a limited number of specimens affect the K value of fish. Furthermore, it is also influenced by reproductive status, seasonality of natural diet, and age of fish [10, 27]. In conclusion, the present study on these parameters is perhaps the first detailed report on these five indigenous fish species from River Ganga, Bihar, India. These findings will provide valuable information to the fisheries biologists of the region to study their population parameters and formulate appropriate management measures for the sustainable exploitation of these resources.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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References

[1] A. Pandit, A. Ekka, B. K. Das, S. Samanta, L. Chakraborty, and R. K. Raman, "Fishers' livelihood diversification in Bhagirathi-Hooghly stretch of Ganga River in India," *Current Science*, vol. 116, no. 10, pp. 1748–1752, 2019.

[2] W. S. Lakra, U. K. Sarkar, V. K. Dubey, R. Sani, and A. Pandey, "River interlinking in India: status, issues, prospects and implications on aquatic ecosystems and freshwater fish diversity," *Reviews in Fish Biology and Fisheries*, vol. 21, no. 3, pp. 463–479, 2011.

[3] U. K. Sarkar, A. K. Pathak, R. K. Sinha et al., "Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives," *Reviews in Fish Biology and Fisheries*, vol. 22, no. 1, pp. 251–272, 2012.

[4] M. Sinha and M. A. Khan, "Impact of environmental aberrations on fisheries of the Ganga (Ganges) river," *Aquatic Ecosystem Health and Management*, vol. 4, no. 4, pp. 493–504, 2001.

[5] CIFRI (Central Inland Fisheries Research Institute), *Annual Report*, CIFRI, Kolkata, India, 2021.

[6] DOF (Department of Fisheries), *Handbook on Fisheries Statistics*, DOF, New Delhi, India, 2020.

[7] W. H. Nayman, "Growth and Ecology of fish population," *Journal of Animal Ecology*, vol. 20, no. 1, pp. 201–219, 1965.

[8] S. K. Ahirwal, A. K. Jaiswar, and S. K. Chakraborty, "Biometric analysis of oil sardine, Sardinella longiceps (Valenciennes, 1847) from Mumbai coast of Maharashtra, India," *Indian Journal of Geo-Marine Science*, vol. 46, no. 9, pp. 1810–1817, 2017.

[9] E. D. L. Cren, "The length-weight relationship and seasonal cycle in gonad weight and condition in the perch, *Perca fluviatilis*," *Journal of Animal Ecology*, vol. 20, no. 2, pp. 201–219, 1951.

[10] R. Froese, "Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations," *Journal of Applied Ichthyology*, vol. 22, no. 4, pp. 241–253, 2006.

[11] R. O. Anderson and S. J. Gutreuter, "Length, weight, and associated structural indices," in *Fisheries Techniques*, L. Nielsen and D. Johnson, Eds., American Fisheries Society, Bethesda, Maryland, 1983.

[12] M. King, *Fisheries Management, in Fisheries Biology, Assessment and Management*, Blackwell Publishing, Oxford, NY, USA, 2nd edition, 2007.

[13] J. E. Beyer, "On length-weight relationships computing the mean weight of the fish of a given length class," *Fishbyte*, vol. 5, pp. 11–13, 1987.

[14] N. Kolher, J. Casey, and P. Turner, "Length weight relationships for 13 species of sharks from the western North Atlantic," *Fisheries Bulletin*, vol. 93, pp. 412–418, 1995.

[15] Z. A. Muchlisin, M. Musman, and M. N. Siti Azizah, "Length-weight relationships and condition factors of two threatened fishes, Rasbora tawarensis and Poropuntius tawarensis, endemic to Lake Laut Tawar, Aceh Province, Indonesia," *Journal of Applied Ichthyology*, vol. 26, no. 6, pp. 949–953, 2010.

[16] U. K. Sarkar, P. K. Deepak, and R. S. Negi, "Length–weight relationship of clown knife fish *Chitala chitala* (Hamilton 1822) from the River Ganga basin, India," *Journal of Applied Ichthyology*, vol. 25, no. 2, pp. 232-233, 2009.

[17] S. K. Oni, J. Y. Olayemi, and J. D. Adegboye, "Comparative physiology of three ecologically distinct freshwater fishes, Alestes nurse Ruppell, *Synodontis schall* Broch & Schneider and *Tilapia zillii* Gervais," *Journal of Fish Biology*, vol. 22, no. 1, pp. 105–109, 1983.

[18] K. C. Jayaram, *The Freshwater Fishes of the Indian Region*, Narendra Publishing House, North Delhi DL, India, 2nd ed edition, 2010.

[19] P. K. Talwar and A. G. Jhingran, *Inland Fishes of India and Adjacent Countries*, Oxford and IBH Publishing Company, East Delhi, DL, India, 1991.

[20] T. Laevastu, "Manual of methods in fisheries biology," *Technical Manuals in Fisheries Science*, Food and Agriculture Organization of the United Nations, Rome, Italy, 1965.

[21] K. F. Lagler, J. E. Bardach, and R. R. Miller, *Ichthyology*, John Wiley & Sons, Hoboken, NJ, USA, 1962.

[22] G. W. Snedecor and W. G. Cochran, *Statistical Methods*, Oxford and IBH Publishing Ltd, East Delhi, DL, India, 1967.

[23] T. W. Fulton, "The rate of growth of fishes," *Annual Reports Fisheries Board Scotland*, vol. 3, pp. 141–241, 1904.

[24] A. J. Gatz, "Community organization in fishes as indicated by morphological features," *Ecology*, vol. 60, no. 4, pp. 711–718, 1979.

[25] P. S. Prajapat, B. K. Sharma, B. B. Nayak et al., "Delineation of the stock structure of white sardine escualosa thoracata (valenciennes, 1847), along the Indian waters based on biometric analysis," *Indian Journal of Animal Research*, vol. 56, no. 3, pp. 362–368, 2022.

[26] F. Jabeen and A. H. Barbhuiya, "Length-weight relationships of Barilius barila (Hamilton, 1822), Opsarius tileo (Hamilton, 1822) and Cyprinion semiplotum (McClelland, 1839) collected from Manas River in Assam, India," *Journal of Applied Ichthyology*, vol. 34, no. 5, pp. 1210-1211, 2018.

[27] S. K. Ahirwal, A. K. Jaiswar, S. K. Chakraborty et al., "Age, growth and mortality parameters of Indian oil sardine Sardinella longiceps (Valenciennes, 1847) from Mumbai waters, off Maharashtra, India," *Indian Journal of Fisheries*, vol. 69, no. 1, pp. 22–26, 2022.