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RESEARCH ARTICLE

Length-weight relationships and condition factors of three freshwater fish species – *Bangana dero* (Ham.), *Cyprinus carpio* L., and *Sperata seenghala* (Sykes) – from the Sutlej River, India

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Abstract. Waterbodies are polluted by human activities or the increasing intensity of these activities, and this affects fish populations. The quality of the water fish inhabit directly impacts their growth and overall health. Length-weight relationships (LWRs) and relative condition factors (K_n) were estimated for three freshwater fish species from the Sutlej River of India from October 2020 to May 2022. A total of 232 fish specimens were caught with cast and gill nets in Gobindsagar Reservoir, Himachal Pradesh and Ropar Wetland, Punjab. Total length was strongly correlated with all the morphological characters ($p < 0.001$). The growth coefficients calculated (b) for *Bangana dero*, *Cyprinus carpio*, and *Sperata seenghala* were 2.858, 2.506, and 2.555, respectively, and indicated negative allometric growth. The correlation coefficients (r) indicated strong linear relationships between the weights and lengths of all three fish species. The outcomes of this study will help fisheries researchers, environmentalists, and scientists to develop future monitoring and conservation strategies for these fish species.

Keywords: fish population, fish morphometric characters, allometric growth, fish management

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Introduction

Fish morphology has traditionally been the primary data source for taxonomic classification and evolutionary studies. Morphometric variations are used widely to compare and differentiate among species and groups based on overall body type or distinctive anatomical forms (Straüss and Bond 1990). According to the von Bertalanffy (1938) fish growth model, the growth rate of fishes increases at a declining rate with weight. In addition to size, the main factors affecting fish growth include age, sexual maturity, food availability, the number of fish exploiting the same food sources, temperature, oxygen, and other water quality parameters (Kuriakose 2017). In addition to fishing, drastic changes stemming from human interference, such as habitat fragmentation, instream dredging, bank stabilization, and increased hydroelectric power facilities, directly impact fish diversity and changes in fish community composition (Boston et al. 2016). Most previous studies focused on biotic factors (Imsland and Jonassen 2003), such as stocking density (Aijun et al. 2006), and abiotic factors (Imsland et al. 2007) that affect fish growth. Fish morphological features respond strongly to adverse environmental conditions according to species.

Length-weight relationships (LWRs) of fishes are crucial for fisheries and fish biologists since they permit estimating the average weight of a group of fish of a particular length by the mathematical relationship between these two parameters (Bagenal and Tesch 1978). The LWR is the essential biological parameter that provides information on the development and health of individual fish species and whole fish communities (Le Cren 1951). They are crucial for managing and conserving natural populations (Moutopoulos and Stergiou 2002). The relative relationship between fish length and weight is utilized as a proxy for fish condition based on the presumption that heavier fish of a given size are in better condition (Pope and Kruse 2001). It offers more knowledge about the physical attributes, growth patterns, general health, habitat conditions, life history, and fatness and condition of fishes (Froese 2006). Another effective biometric tool is the relative condition factor (K_n) obtained from LWRs (Le Cren 1951). K_n evaluates the deviation of fish from the average weight in a given sample to determine if a specific aquatic environment is suitable for fish growth (Abobi 2015). When K_n levels are equal to or near 1, fish species are considered to be generally fit.

The Sutlej River is the easternmost and the longest of the five Indus River tributaries, with a length of 1,450 km. Many dams, barrages, and wetlands have been created along the Sutlej for irrigation, electricity, and sources of potable water. The Bhakra, the highest gravity dam, was built on the Sutlej to provide irrigation and generate around 20,000 MW of electricity at hydroelectricity facilities in Punjab, Rajasthan, and Haryana. This study focused on assessing the morphometric and length-weight relationship of the indigenous minor carp, *Bangana dero* (Ham.), the exotic *Cyprinus carpio* Linn., and the giant river catfish, *Sperata seenghala* (Sykes). These species were chosen for the present investigation because of their availability, commercial importance, and popularity as food fish in the study area. All three species are potamodromous and benthopelagic in nature. The present study focused on investigating the morphometrics, length-weight relationships (LWR), and relative condition factor (K_n) of *Bangana dero*, *Cyprinus carpio*, and *Sperata seenghala* to determine the waterbody's fitness for these fish species. This data will help in the management and conservation of the species and future comparisons of populations of the same species.

Materials and methods

Study area and sampling method

The present research was conducted at the upstream and downstream sites of Gobindsagar Reservoir, Himachal Pradesh (31°24'30''N; 76°29'42''E) and the Ropar Wetland, Punjab (31°00'02''N; 76°32'05''E) in the Sutlej River, India from October 2020 to May 2022 (Fig. 1). Collecting fish samples was authorized by the H.P. Fisheries Department and Principal Chief Conservator of Forests (Wildlife), Government of Punjab (see letter nos. FSH-F [5]-41/99-ARC-IV-910 and Misc./8625). A total of 232 fish specimens were collected from Gobindsagar Reservoir, Himachal Pradesh (31°24'30''N; 76°29'42''E) and the Ropar Wetland, Punjab (31°00'02''N; 76°32'05''E) using a set of cast and gill nets with mesh sizes of 40, 60, 80, 100, and 120 mm with the help of local fishermen. The species collected included the exotic *Cyprinus carpio* (N = 76), the giant river catfish, *Sperata seenghala* (N = 38) from Gobindsagar Reservoir, and indigenous minor carp, *Bangana dero* (N = 118), from the Ropar Wetland. The specimens were identified using standard keys by Talwar and Jingran (1991). Morphometric measurements were recorded for 24 characters using traditional methods described in Jayaram (2013), which included total weight (TW), total length (TL), standard length (SL), fork length (FL), predorsal distance (PreDD), length of dorsal fin (LDF), length of anal fin (LAF), depth of anal fin (DAF), preanal distance (PreAD), length of pectoral fin (LPecF), length of pelvic fin (LPelF), minimum body width (MinBW), maximum body width (MaxBW), distance between pectoral and pelvic fins (DPP), distance between pelvic and anal fins (DPA), length of caudal fin (LCF),

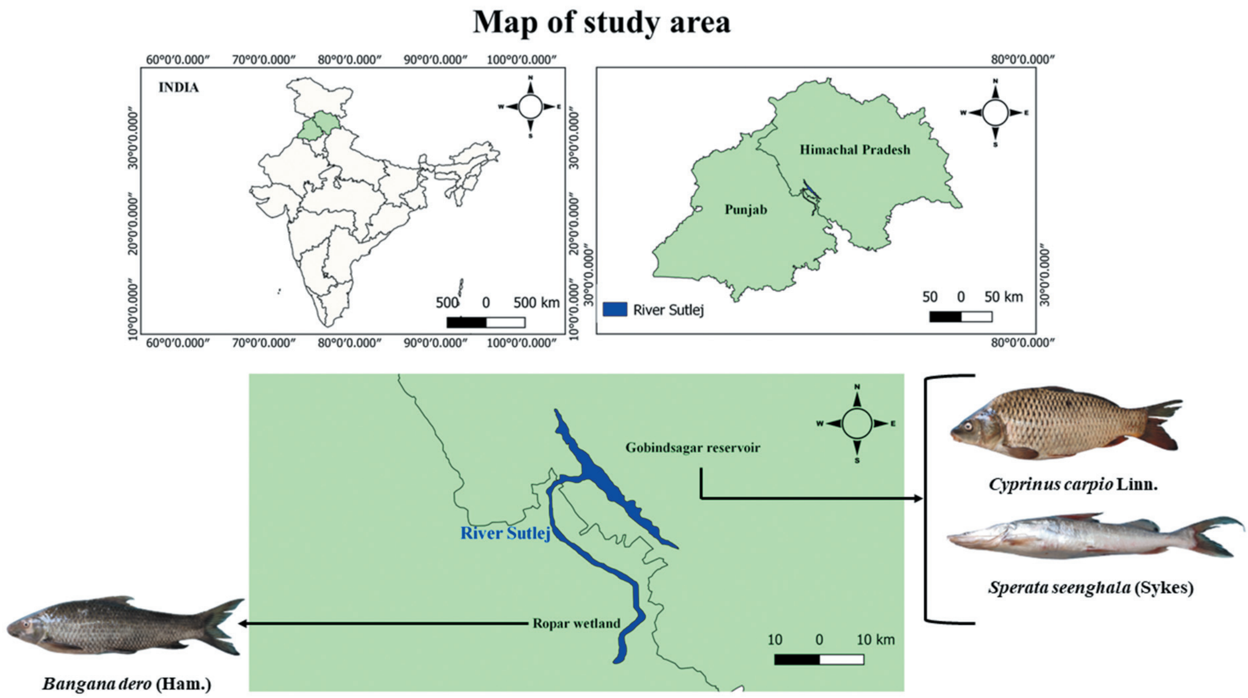

Figure 1. Sampling locations of *Bangana dero* (Ham.), *Cyprinus carpio* Linn., and *Sperata seenghala* (Sykes) collected from the Sutlej River, India.

length of caudal peduncle (LCP), head length (HL), head depth (HD), pre-orbital distance (PreOD), post-orbital distance (PostOD), eye diameter (ED) and, interorbital distance (IOD). All the measurements were taken from the left side of the fish body as standard measurements.

Data analysis

The descriptive statistics taking into consideration mean, standard deviation, and ranges of morphometric parameters were calculated. Correlation coefficients and regression equations between independent and dependent parameters were calculated using SPSS (version 22.0).

For computing the length-weight relationship (LWR), each fish specimen was measured for total length (TL – 0.1 cm precision) with a digital dial vernier caliper, and total weight (TW – 0.01 g precision) with a digital scale. The LWR was calculated using the Cube law formula by Froese (2006) as follows:

$$W = aL^b$$

where W is the weight of the fish in grams (g), L is the total length of the fish (cm), a is the constant (intercept), and b is the slope of the regression lines.

Using the linear regression of the log-transformed equation by LeCren (1951), parameters a represented the intercept and b the slope of the regression coefficient was calculated:

$$Log(W)=b\ log(L)+log\ (a)$$

where b is equal to 3, the growth exhibited by the fish is isometric. The fish show negative allometric growth and become thinner with increasing length when b is less than 3. When b is greater than 3.0, fish become heavier, showing positive allometric growth that reflect optimum conditions for growth.

The relative condition factor (K_n), a measure of the well-being of fish, was calculated using an equation by LeCren (1951):

$$K_n = \frac{W}{W'}$$

where K_n is the relative condition factor of fish, W is the observed weight of fish, and W' is the

Table 1
Mean values (cm), standard deviation (SD), and ranges of different morphometric parameters of *B. dero* (n=118), *C. carpio* (n=76), and *S. seenghala* (n=38)

	B. dero		*C. carpio*		*S. seenghala*	
Morphometric parameters	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range
Total length (TL)	34.43±0.39	27–44	31.97±0.33	25–40.8	50.29±1.27	34.5–66
Standard length (SL) cm	27.82±0.33	22–38.5	26.05±0.28	20–32.3	39.13±0.88	30–49
Fork Length (FL)	30.39±0.34	23.7–40	28.84±0.31	22.3–37	41.71±1.01	31–54
Predorsal distance (PreDD)	11.21±0.13	8.6–14.5	12.52±0.16	10–16.8	16.22±0.41	12.3–21.4
Length of dorsal fin (LDF)	5.19±0.07	3.6–7.3	9.77±0.11	7.6–12.5	5.14±0.10	3.8–6.3
Length of anal fin (LAF)	2.38±0.03	1.5–3.4	2.47±0.03	2.0–3.4	3.89±0.16	2.2–7.0
Depth of anal fin (DAF)	4.97±0.07	3.3–6.6	4.41±0.06	3.5–5.9	5.64±0.12	4.2–7.4
Preanal distance (PreAD)	20.21±0.25	10.6–28	19.17±0.19	14.5–24	29.67±0.83	18.9–37.2
Length of pectoral fin (LPecF)	5.12±0.07	3.5–7.3	4.75±0.06	3.5–6.0	6.02±0.14	4.6–7.8
Length of pelvic fin (LPelF)	4.76±0.07	3–6.9	4.42±0.05	3.1–5.9	5.36±0.12	3.8–7.0
Minimum body width (MinBW)	3.81±0.05	2.5–7.5	3.96±0.05	2.8–5.4	2.74±0.07	1.6–3.5
Maximum body width (MaxBW)	7.90±0.12	5.4–12	10.15±0.10	8.3–12.5	7.46±0.19	5.4–10
Distance between pectoral and pelvic fins (DPP)	8.21±0.11	5.8–11.0	6.12±0.07	4.2–7.9	11.87±0.26	7.8–14.5
Distance between pelvic and anal fins (DPA)	7.27±0.09	5.3–9.5	7.02±0.08	5.3–8.9	8.86±0.29	5.5–14.3
Length of caudal fin (LCF)	7.37±0.08	5.3–9	6.59±0.09	4.3–8.8	11.58±0.32	7.5–15
Length of caudal peduncle (LCP)	4.43±0.06	2.9–6	3.85±0.07	2–5.5	5.33±0.14	3.4–7.0
Head length (HL)	5.83±0.07	4.4–7.9	7.45±0.09	6.2–10.1	10.45±0.24	6.3–12.9
Head depth (HD)	4.49±0.05	3–6	5.55±0.07	4–7	4.39±0.16	3–7
Pre–orbital distance (PreOD)	2.47±0.04	1.5–4.5	2.68±0.04	2–3.6	2.97±0.07	2–3.8
Post–orbital distance (PostOD)	2.92±0.03	2.2–4	3.93±0.04	3.2–5.2	6.67±0.13	5.2–8.2
Eye diameter (ED)	0.83±0.01	0.5–1.2	1.23±0.02	0.8–1.9	1.16±0.03	0.7–1.6
Interorbital distance (IOD)	2.58±0.04	1.8–4.2	2.96±0.04	2–3.9	2.62±0.06	1.9–3.2

calculated weight of fish. When $K_n \geq 1$, the fish is assumed to be in good growth condition; however, when $K_n \leq 1$, the fish is considered to be in poor growth condition compared to average individuals of the same length.

Results

Morphometric parameters

The morphometric parameters were recorded, and their mean values and ranges are presented in Table 1. The correlation coefficient (r) was applied for the total length and head length of the fish. The parameters with the highest correlation to total length (TL) were fork length (FL) and standard length (SL) in all three species (Table 2). With respect to head length, the highest correlation was observed for head depth in *B. dero* at a value 0.878; with post-orbital distance in *C. carpio* and *S. seenghala* at correlations of 0.898 and 0.933, respectively (Table 3). The outcomes of the correlation study made it clear that all morphometric parameters varied proportionately as total length increased. The HD, PreOD, PostOD, ED, and IOD characters also changed with increases in head length.

Table 2
Relationship between total length (TL) and standard length (SL), fork length (FL), pre dorsal distance (PreDD), post dorsal distance (PostDD), length of dorsal fin (LDF), length of anal fin (LAF), depth of anal fin (DAF), pre-anal distance (PreAD), length of pectoral fin (LPecF), length of pelvic fin (LPelF), minimum body width (MinBW), maximum body width (MaxBW), distance between pectoral and pelvic fins (DPP), distance between pelvic and anal fins (DPA), length of caudal fin (LCF) and length of caudal peduncle (LCP) of three fish species from the Sutlej River, India

	B. dero	*C. carpio*	*S. seenghala*
TL vs SL	0.975	0.972	0.957
TL vs FL	0.982	0.990	0.945
TL vs PreDD	0.919	0.868	0.943
TL vs LDF	0.876	0.856	0.799
TL vs LAF	0.722	0.735	0.830
TL vs DAF	0.890	0.718	0.591
TL vs PreAD	0.950	0.965	0.876
TL vs LPecF	0.902	0.685	0.859
TL vs LPelF	0.884	0.755	0.715
TL vs MinBW	0.606	0.707	0.905
TL vs MaxBW	0.859	0.583	0.696
TL vs DPP	0.845	0.661	0.870
TL vs DPA	0.846	0.766	0.826
TL vs LCF	0.873	0.680	0.802
TL vs LCP	0.840	0.550	0.786
TL vs HL	0.902	0.822	0.907
TL vs HD	0.860	0.638	0.749
TL vs PreOD	0.663	0.610	0.799
TL vs PostOD	0.855	0.812	0.941
TL vs ED	0.591	0.574	0.768
TL vs IOD	0.721	0.592	0.816

Length-weight relationship and relative condition factor (K_n)

The total length (TL) and total weight (TW) of the three different freshwater fish species were in the ranges of 27–44 cm and 190–920 g for *B. dero*, 25–41 cm and 212–910 g for *C. carpio*, and 35–66 cm and 190–1170 g for *S. seenghala*, respectively.

The relationship between total length and weight was obtained with the logarithmic equations LogW=2.858logTL-1.805 for *B. dero*, LogW=2.506logTL-1.114 for *C. carpio*, and LogW=2.555logTL-1.552 for *S. seenghala*. Their corresponding power equations were expressed as $W= 0.01566L^{2.858}$ (R^2=0.931) for *B. dero*, $W= 0.07680L^{2.506}$ (R^2=0.823) for *C. carpio*, and $W= 0.02803L^{2.555}$ (R^2=0.873) for *S. seenghala* (Table 4).

After data analysis, a strong correlation was identified between length and weight parameters, with values of 0.965 for *B.dero*, followed by 0.934 for *S. seenghala*, and 0.907 for *C. carpio*. The value of regression coefficient b with the total length of the three species was 2.858 for *B. dero*, 2.555 for *S. seenghala*, and 2.506 for *C. carpio,* which indicated that growth was negative allometric. All of the data obtained are shown on a graph with length on the X-axis and weight on the Y-axis, which indicated linear relationships. These data were transformed into logarithmic values to compute the length-weight relationship and produce a straight line. As a result, log values were used for all computations instead of original values.

The relative condition factor (K_n) varied from 0.79 to 1.27 for *B. dero*, from 0.77 to 1.35 for *C. carpio*, and from 0.64 to 1.76 for *S. seenghala.* The

Table 3
Relationship between head length (HL) and head depth (HD), pre-orbital distance (PreOD), post-orbital distance (PostOD), eye diameter (ED), inter-orbital distance (IOD) of three fish species from the Sutlej River, India

	B. dero	*C. carpio*	*S. seenghala*
HL vs HD	0.878	0.701	0.772
HL vs PreOD	0.852	0.785	0.864
HL vs PostOD	0.776	0.898	0.933
HL vs ED	0.613	0.573	0.711
HL vs IOD	0.798	0.693	0.840

Table 4
Result of the length-weight relationship comprising the total number of samples (N), intercept (a), regression slope (b), coefficient of correlation (r), coefficient of determination (R^2), 95% confidence limit (CL) of b, p-values, and condition factor (K) of three fresh water fish species inhabiting the Sutlej River, India

		Regression parameters						
Species	No.	a	b	r	R^2	95% CL of b	p-value	K±SD
Bangana dero	118	0.01566	2.858	0.965	0.931	2.715-3.001	0.000	1.004±0.09
Cyprinus carpio	76	0.07680	2.506	0.907	0.823	2.238-2.776	0.000	1.005±0.10
Sperata seenghala	38	0.02803	2.555	0.934	0.873	2.225-2.885	0.000	1.012±0.02

mean K_n value of the three freshwater fish species was 1.004±0.00 for *B. dero*, 1.005±0.01 for *C. carpio*, and 1.012±0.02 for *S. seenghala*, which indicated that growth conditions were optimal for all three freshwater fish species from the Sutlej River.

Discussion

The quality of water, which is a crucial component for maintaining diverse ecosystem functions, determines whether it is suitable for industrial and human purposes (Hong et al. 2020). In fisheries assessment studies, length-weight relationships (LWRs) and relative condition factor (K_n) are vital because they reveal information on fish growth, overall health, and fitness in aquatic environments (Jisr et al. 2018). Fish growth can be defined as isometric ($b = 3$), positive allometric ($b \geq 3$), or negative allometric ($b \leq 3$), depending on the value of b in the LWR (Ricker 1975). This study provides knowledge of the LWR parameters of *B. dero* from the Ropar Wetland in Punjab and of *C. carpio* and *S. seenghala* from the Gobindsagar Reservoir (H.P.), which will serve as tools for developing new insights into the growth strategies of these valuable species. The value of the correlation coefficient (r) was found to be very significant, indicating a strong correlation between length and weight ($p < 0.001$) in all three fish species. Regression coefficients a and b were also highly significant ($p < 0.001$). The b value of all three fish species was less than 3, which indicated that fish growth was negative allometric. The highest b value was 2.858 for *B. dero*, followed by 2.555 for *S. seenghala*, while the lowest b value of 2.506 was recorded *for C. carpio*. This indicated that fish weight increased proportionately less than the cube of length, which could have been connected to environmental factors or the physical attributes specific to the fish species. This could have been because of temperature, diet, harvesting techniques, competition for the same food sources, or other abiotic factors (Kuriakose 2017).

Increased water temperature plays a pivotal role as it affects biological processes, including metabolism, growth, reproduction, etc., which can reduce fish populations and even lead to the extinction of some species (Portner and Peck 2010, Fu et al. 2018). A negative allometric growth pattern was observed in *Labeo dero* (now *Bangana dero*) from the Ganga River system with a b value of 2.69 (Malhotra and Chauhan 1984). While the b value of *B. dero* from the Ganga River (Sharma et al. 2016) and the Bramhaputra River and Irrawaddy River system (Yadav and Dhanze 2018) indicated positive allometric growth. Interestingly, a negative allometric growth pattern with a b value of 2.56 was observed in *S. seenghala* from the Sutlej River, Punjab (Kaur et al. 2022). The b value for *C. carpio* was similar to that in a study conducted by Rashid et al. (2018), in which this species exhibited a negative allometric growth pattern identical to that in the present study. In the present study, the value of K was equal to one, which indicated the optimum well-being of the fishes inhabiting the Sutlej River, India. Fish growth condition is influenced by various factors, including food availability, reproductive cycles, habitat, and environmental conditions (Morato *et al.,* 2001). The value of K illustrated fish resilience and good health under existing environmental conditions.

Conclusion

The study's findings showed that length-weight relationships were strongly correlated in all three species. The value of the relative condition factor (K_n) was found to be more than 1 ($K_n \geq 1$), which indicated that the Gobindsagar Reservoir and the Ropar Wetland provided good conditions for fish growth. However, the growth of these three freshwater fish species was found to be negative allometric, which suggested that fish weight decreased with increasing length, possibly due to the influence of abiotic and biotic factors. The outcomes of the present study can be compared with empirical evidence of these species collected in the future in other natural waterbodies, lakes, rivers, and reservoirs. It will also provide valuable information for fishery researchers, scientists, management, and strategists when formulating conservation strategies.

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Author contributions. A.R.: Conceptualization, methodology, investigation, formal analysis, data curation, editing, and writing original draft; R.K: Investigation, formal analysis, reviewing, and editing and supervision.

Declaration of competing interests. The authors declare no competing interests.

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References

Abobi, S. M. (2015). Weight-length models and relative condition factors of nine freshwater fish species from the Yapei Stretch of the White Volta, Ghana. Elixir Applied Zoology, 79(1), 30427-30431.

Aijun, M., Chao, C., Jilin, L., Siqing, C., Zhimeng, Z., Yingeng, W. (2006). Turbot *Scophthalmus maximus*: stocking density on growth, pigmentation and feed conversion. Chinese Journal of Oceanology and Limnology, 24(3): 307-312.

Bagenal, T. B., Tesch, F. W. (1978). Age and growth. Length-weight Relationship and Condition Factor of Fish Populations in Temengor Reservoir: Indication of Environmental Health. In: Methods for Assessment of Fish Production in Fresh Waters. 3rd Edition. Blackwell Scientific Publications, 101-136.

Boston, C. M., Randall, R. G., Hoyle, J. A., Mossman, J. L., Bowlby, J. N. (2016). The fish community of Hamilton Harbour, Lake Ontario: Status, stressors, and remediation over 25 years. Aquatic Ecosystem Health & Management, 19(2), 206-218.

Froese, R. (2006). Cube Law, Condition Factor and Weight-Length Relationships: History, Meta-Analysis and Recommendations. Journal of Applied Ichthyology, 22: 241-253.

Fu, K. K., Fu, C., Qin, Y. L., Bai, Y., Fu, S.J. (2018). The thermal acclimation rate varied among physiological functions and temperature regimes in a common cyprinid fish. Aquaculture, 495, 393-401.

Hong, Z., Zhao, Q., Chang, J., Peng, L., Wang, S., Hong, Y., Liu, G., Ding, S. (2020). Evaluation of water quality and heavy metals in wetlands along the Yellow River in Henan Province. Sustainability, 12(4):1300.

Imsland, A. K., Jonassen, T. M. (2003). Growth and age at first maturity in turbot and halibut reared under different photoperiods. Aquaculture International, 11(5):463-475.

Imsland, A. K., Schram, E., Roth, B., Schelvis-Smit, R., Kloet, K. (2007). Improving growth in juvenile turbot (*Scophthalmus maximus* Rafinesque) by rearing fish in switched temperature regimes. Aquaculture International, 15(5): 403-407.

Jayaram, K. C. (2013). The Fresh Water Fishes of Indian Region. Narendra Publishing House, New-Delhi, India.

Jisr, N., Younes, G., Sukhn, C., El-Dakdouki, M. H. (2018). Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. The Egyptian Journal of Aquatic Research, 44(4):299-305.

Kaur, S., Tewari, G., Singh, P., Datta, S. N. (2022). Morphometric characterization of giant river catfish, *Sperata seenghala* from river Sutlej, Punjab (India). Indian Journal of Ecology, 49(3), 864-868.

Kuriakose, S. (2017). Estimation of length weight relationship in fishes. In: Course Manual Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management. Lecture Note Series No. 2/2017. CMFRI; Kochi, Kochi, 215-220.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20(2):201-219.

Malhotra, S.K., Chauhan, R. S. (1984). Bionomics of hill-stream cyprinids. IV. Length-weight relationship of Labeo dero (Ham.) from India. Proceedings: Animal Sciences, 93, 411-417.

Moutopoulos, D. K., Stergiou, K. I. (2002). Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). Journal of Applied Ichthyology, 18(3), 200-203.

Pope, K. L., Kruse, C. G. (2001). Assessment of fish condition data. In: Statistical analyses of freshwater fisheries data (Ed.) C. Guy, M. Brown, American Fisheries Society Publication, North Bethesda, 51-56.

Pörtner, H. O., Peck, M. A. (2010). Climate change effects on fishes and fisheries: towards a cause-and-effect understanding. Journal of Fish Biology, 77(8), 1745-1779.

Rashid, R. F., Çalta, M., Basuta, A. (2018). Length-Weight Relationship of Common Carp (*Cyprinus carpio* L., 1758) from Taqtaq Region of Little Zab River, Northern Iraq. Turkish Journal of Science and Technology, 13(2), 69-72.

Ricker, W. E. (1975). Computation and interpretation of biological statistics of fish population. Bulletin Fishery Research Board of Canada, 191: 1-382.

Sharma, N. K., Singh, R., Gupta, M., Pandey, N. N., Tiwari, V. K., Singh, R., Akhtar, M. S. (2016). Length–weight relationships of four freshwater cyprinid species from a tributary of Ganga River Basin in North India. Journal of Applied Ichthyology, 32(3):497-498.

Straüss, R. E., Bond, C. E. (1990). Taxonomic methods: morphology. In: Methods for Fish Biology (Ed.) C.B. Schreck, P.B. Moyle, American Fisheries Society, Maryland, U.S.A: Bethesda, 125-130.

Talwar, P. K., Jhingran, A. G. (1991). Inland fishes of India and adjacent countries, Vol. 2. CRC Press.

Von Bertalanffy, L. (1938). A quantitative theory of organic growth (inquiries on growth laws. II). Human Biology, 10(2), 181-213.

Yadav, K. K., Dhanze, R. (2018). Length-weight relationship and condition factor of *Bangana dero* (Hamilton, 1822) (Actinopterygii: Cypriniformes: Cyprinidae) from northeastern region of India. Journal of Threatened Taxa, 10(7):11863-11868.