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Research Article

The Length–Weight Relationships of 17 Freshwater Fishes Inhabiting Bosten Lake, China

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Bosten Lake is an important inland freshwater lake in China, which is rich in fishery resources. However, due to various factors, its fishery resources have declined. The length–weight relationship (LWR) is of great significance for fish research and fishery management. This study was based on the samples of 17 freshwater fish species collected from 10 sampling points in Bosten Lake from March 2023 to November 2024. The LWRs were determined, the regression parameters and the coefficient of determination (R^2) were calculated, and the fish condition factor BW/TL^3 was analyzed. The results showed that the b value of the LWR parameters of the 17 freshwater fish species ranged from 1.262 to 3.665. The b values of most fish species were within the expected range. The LWRs of all fish species were significantly different ($p < 0.05$), and the R^2 values ranged from 0.746 to 0.999. The LWR of *Aristichthys nobilis* was the strongest, and that of *Rhodeus ocellatus* was the weakest. This study reported for the first time the LWRs of *Channa argus* in the lake, and its b value was the highest, and the growth pattern was related to its ecological niche. The research results provide basic data and theoretical basis for fish ecology research, fishery resource management, and lake ecological protection.

Keywords: Bosten Lake; environmental factors; fish ecology; fishery resource management; length–weight relationship (LWR)

1. Introduction

Bosten Lake, situated in Xinjiang, China, within the geographical coordinates of 86°40′-87°25′ east longitude and 41°56′-42°14′ north latitude, stands as one of the prominent inland freshwater lakes in the country. It is not only endowed with abundant fishery resources, a diverse array of fish species, but also assumes a vital and indispensable role in the local ecological milieu [1]. Regrettably, over the past few decades, the decline in Bosten Lake's fishery resources stems from multiple causes: invasive species intrusion, overfishing, intensive human activities, and rapid industrial/agricultural expansion. These factors, combined with resultant water quality degradation, have collectively led to the observed resource depletion.

The length–weight relationship (LWR) conventionally serves as a valuable tool for estimating fish weights predicated on length distributions, precisely delineating the growth patterns of various species, and meticulously dissecting the spatiotemporal fluctuations in fish population status and their adaptive proclivities [2]. Besides, this relationship also occupies a central and non-negotiable position in the realms of fishery management and fish resource conservation [3]. In Bosten Lake, a total of 17 fish species have hitherto been documented [4]. Grounded on the most recent sampling data procured from Bosten Lake, the present study ascertain the LWRs of 17 fish species that populate this aquatic ecosystem. The overarching objective is to furnish fundamental data and a theoretical underpinning for fish ecology research, the formulation of efficacious fishery resource management strategies, sustainable ecological protection, and development of the lake.

2. Materials and Methods

Fish samples of 17 species were collected from 10 sampling sites in Bosten Lake (Figure 1). The sampling period spanned from March 2023 to November 2024, with systematic sampling conducted twice per quarter: once at the beginning (e.g., March 1–5, June 1–5) and once at the end (e.g., May 25–31, August 25–31) of each quarter. This schedule ensured coverage of seasonal environmental variations and fish physiological changes. The fishing gear used for the collection included custom-made multimesh composite gill nets (60 m in length and 2 m in height, with mesh sizes of 5, 10, 15, 25, 33, 48, 55, 70, 88, and 100 mm in total 10 different sizes) and wire mesh traps (15 m in length, with mesh 2a = 5 mm). The total length (TL) in millimeters and the total body weight (BW) in grams of each fish were measured, respectively, using a vernier scale and an electronic balance. The data were recorded with the required precision. The LWRs of the 17 fish species were determined by using the logarithmic transformation equation $\text{Ln (BW)} = \ln a + b \ln \text{(TL)}$, where BW represents body weight (g) and TL represents the total length (mm). The 95% confidence intervals (CIs) and the coefficient of determination (R^2) of the regression parameters a and b were calculated. The fish condition factor BW/TL^3 was introduced to reflect the fatness or leanness of the fish body. A log-log plot was used to remove outlier data. The significance of all regressions in the data set was tested by using the professional statistical software Origin 2022.

3. Results

The b value and R^2 value are critical parameters in the regression analysis of LWRs. The body lengths and weights of 17 freshwater fish species belonging to three orders and seven families in Bosten Lake were estimated and analyzed (Table 1). It was analyzed that the parameter b values of the LWRs of these 17 fish species ranged from 1.262 to 3.665. The b value of *Rhinogobius giurinus* was the smallest (1.262) and that of *Channa argus* was the largest (3.665). The value of parameter b can be used to describe the growth pattern of fish: when $b \neq 3$, it is allometric growth. When $b < 3$, it means that as the body length of the fish increases, its growth increases relatively less; when $b > 3$, it indicates that as the body length increases, the plumpness of the fish will increase; when $b = 3$, it is isometric growth, that is, the body shape of the fish remains unchanged during growth. Most of the fish species were consistent with the expected range of b values between 2.5 and 3.5. All the fish's LWRs showed significant differences ($p < 0.05$).

In the regression analysis of the LWRs, the R^2 value was used to measure the goodness of fit model. It was found that the R^2 values ranged from 0.746 to 0.999. The LWR of *Aristichthys nobilis* corresponded to a relatively high value, with an R^2 of 0.999. There was a high linear correlation between the body length and weight of *A. nobilis*. The value of the LWR of *Rhodeus ocellatus* was relatively low, with an R^2 around 0.746. The linear relationship between body length and weight was weak, and many variations could not be explained by the LWR model.

4. Discussion

In this study, the LWRs of 17 freshwater fish species in Bosten Lake were successfully determined. Although 16 fish species in Bosten Lake have been reported [4], this study reported for the first time the LWR of *C. argus* in the lake.

The parameter b values of the LWRs ranged from 1.262 to 3.665. The b values of most fish species were within the expected range of 2.5–3.5, indicating that the growth patterns of most fish conformed to the general rule. *A. nobilis* had a relatively high b value (3.133) and the strongest LWR. As the body length increased, the plumpness increased significantly, which might be related to its biological characteristics and ecological niche in the lake ecosystem. *R. giurinus* had the weakest LWR with a b value of 1.262, suggesting that its growth pattern might be affected by various special factors, such as its relatively small body size, high sensitivity to environmental changes, or food resource utilization mode. In the study of marine fish by the authors in [5], it was found that the growth patterns of small fish were more easily disturbed by environmental fluctuations, which were somewhat similar to the situation of *R. giurinus* in this study. At the same time, the authors in [6] also pointed out in relevant studies that the body size of fish was related to the stability of the growth pattern. According to this study, small fish were often more susceptible to external disturbances due to their limited reserves, further corroborating the speculation on the special growth pattern of *R. giurinus*. The study by the authors in [7] revealed that fish in different ecological niches adopt distinct resource allocation strategies during growth; this finding provided a theoretical basis for understanding the specific growth pattern of *A. nobilis*, which is influenced by its unique ecological niche. *C. argus*, as a carnivorous fish in Bosten Lake, had the highest b value (3.665), and the increase in BW was quite significant with the growth of body length. This was closely related to its position as a top predator in the ecosystem. Its strong predation ability enabled it to obtain rich and high-quality food resources, thus supporting the rapid increase in BW during the increase in body length. The authors in [8] pointed out that carnivorous fish at a higher trophic level in the food chain often showed higher characteristics during growth due to sufficient nutrient intake, which was consistent with the situation of *C. argus* in this study, further confirming the important impact of ecological niche on the growth pattern of *C. argus*. Moreover, the authors in [9] also showed in relevant studies that the predation efficiency and food conversion efficiency of carnivorous fish would directly affect their LWRs. *C. argus* could quickly accumulate biomass with its efficient predation strategy, which was more prominent in the b value.

All the fish's LWRs showed significant differences ($p < 0.05$), and the R^2 values ranged from 0.746 to 0.999. The LWR model established in this study had relatively high

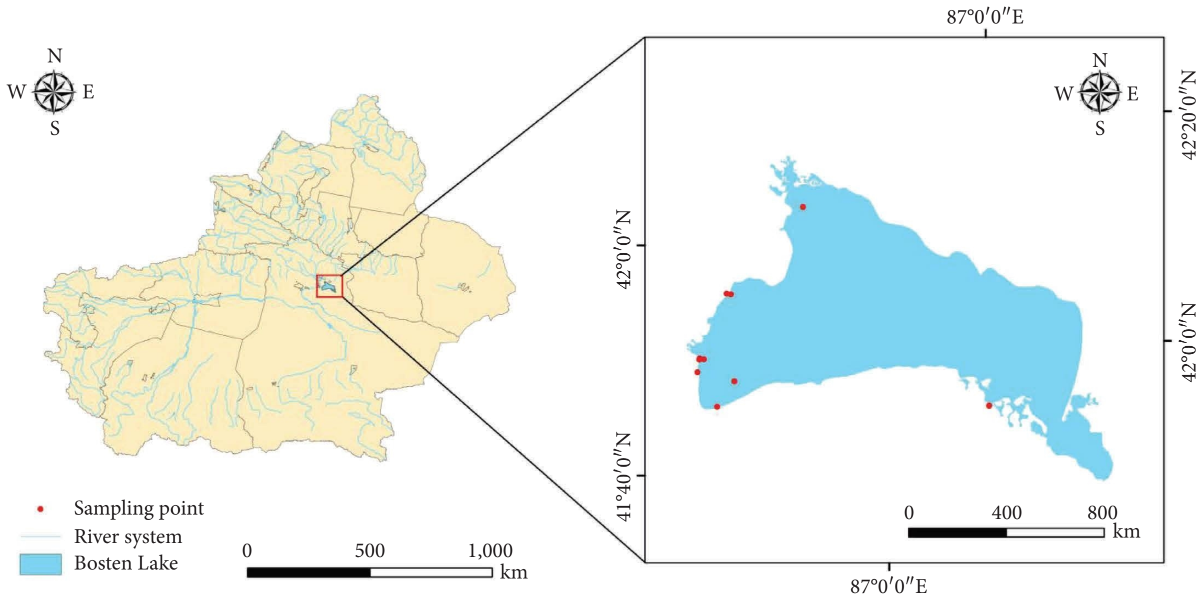

Figure 1: Fish resource survey point map.

reliability and validity. In the process of fishery resource monitoring, if it was difficult to directly obtain the fish weight data, the body length data could be used to estimate the weight through the established LWR model to understand the change in fish resource quantity. The authors in [10] successfully carried out long-term monitoring and assessment of the fish resource quantity in the lake by establishing the LWR model in the fishery resource assessment of the southern continental shelf and upper slope of Sicily. In addition, the authors in [11] also adopted a similar method of constructing the LWR model in the study of *Rutilus rutilus* and *Perca fluviatilis* in the Ob River Basin of Siberia, Russia, and combined with the field monitoring data to verify the accuracy and practicability of the model in resource quantity estimation, further illustrating the feasibility and universality of the research method in this study.

The fish condition factor BW/TL^3 reflects the fatness or leanness of the fish's body [12, 13] which showed that the seasonal variation in food abundance in the environment significantly affected the fish condition factor and the parameters of the LWR. The authors in [14] found that the fish condition factor and the LWR of *Oreochromis niloticus* also changed before and after the breeding period, and the breeding consumption would lead to a decrease in the condition factor and affect the relevant parameters. Furthermore, the authors in [15] pointed out in the study of the growth, energy metabolism, and behavior of piscivorous and insectivorous juvenile rainbow trout at different temperatures that the change in environmental temperature would affect the fish metabolism and then change the nutrient absorption and utilization efficiency, which would finally be reflected in the condition factor and the LWR. In this study, *A. nobilis* had the strongest LWR ($R^2 = 0.999$), indicating that it occupied a relatively stable and dominant ecological niche in the Bosten Lake ecosystem. The growth process of *A. nobilis* was relatively less affected by environmental factors, with relatively stable growth characteristics and resource utilization patterns. *R. ocellatus* had the weakest LWR ($R^2 = 0.746$). Due to its weak competition ability for food resources and the breeding strategy that was easily affected by environmental fluctuations, the uncertainty in its growth process increased, and the relationship between body length and weight was relatively less close.

Compared with relevant studies in other regions, the LWRs in this study had both similarities and differences. In the study of 12 indigenous fish species and three shellfish in the mangrove and floodplain ecosystems in southwestern Bangladesh [16], the growth patterns of the fish had some similarities with those of the fish in Bosten Lake in terms of the b value range and the performance of the relationship with the environment. However, the analysis remains insufficient in comprehensively explaining how distinct ecosystem types specifically influence species composition, ecological pressure mechanisms, and variations in LWR parameters. Different ecosystems impose unique selection pressures: stable lakes' foster benthic species such as *Carassius auratus* with specialized growth patterns [17], while dynamic river systems support rheophilic species such as *Acipenser sinensis* adapted to strong currents [18]. Ecological pressures also vary significantly—eutrophic lakes drive rapid growth strategies in *Hypophthalmichthys molitrix* to avoid hypoxia [19], whereas brackish environments force *Liza haematocheila* to prioritize osmoregulation over growth [20]. These ecological differences directly impact LWR parameters, and piscivorous taxa in nutrient-rich systems exhibit higher b values due to energy-dense diets, while herbivores in flowing waters allocate resources to hydrodynamic body structures [21]. Environmental stability further affects model fitness, with species in consistent ecosystems showing tighter length–weight correlations versus those in variable habitats [22]. Additionally, anthropogenic disturbances disrupt natural growth trajectories through size-selective harvesting and metabolic

Table 1: The length–weight relationships of 17 freshwater fish species collected from Bosten Lake.

Order	Family	Species	*N*	Total length (cm)			Weight (g)			Fish body fullness (100 g/cm³)	Regression parameters				
				Min	Max	Average value	Min	Max	Average value		*a*	95% CL of *a*	*b*	95% CL of *b*	R^2 (LWR)
Cypriniformes	Cyprinidae	*Carassius auratus*	251	0.58	19.36	8.27	0.57	233.3	25.94	4.586	−2.988	−3.255~−2.722	2.708	2.579–2.836	0.873
		Cyprinus carpio	9	10.22	23.58	15.69	26.40	413.00	128.70	3.332	−3.873	−4.777~−2.970	3.063	2.732–3.395	0.986
		Ctenopharyngodon idellus	3	20.6	31.5	24.23	152.5	568.7	300.53	2.113	−3.666	−17.480–10.147	2.901	−1.452–7.255	0.986
		Aristichthys nobilis	6	6.04	24.7	12.06	3.4	262.9	81.42	4.642	−4.400	−4.654~−4.416	3.133	3.026–3.240	0.999
		Leuciscus baicalensis	4	15.4	17.52	16	82.66	104.69	90.53	2.210	−0.125	−4.533–4.282	1.669	0.079–3.260	0.911
		Hypophthalmichthys molitrix	8	7.46	32.2	14.60	38.52	524.8	140.01	4.499	−0.152	−0.766–0.462	1.805	1.568–2.042	0.983
		Pseudorasbora parva	119	2.67	5.97	4.51	0.32	3.63	1.53	1.668	−4.388	−4.580~−4.196	3.133	3.005–3.260	0.853
		Rhodeus ocellatus	42	1.81	5.04	4.01	0.3	3.7	1.79	2.776	−2.295	−2.821~−1.769	2.037	1.657–2.416	0.746
		Hemibarbus maculatus	10	7.76	17.96	9.84	6.1	81.9	16.83	1.766	−3.690	−6.537~−0.843	2.715	1.459–3.970	0.757
		Hemiculter leucisculus	34	3.77	19.43	10.88	0.79	147.15	33.07	2.568	−4.841	−5.110~−4.573	3.350	3.234–3.446	0.991
		Abbottina rivularis	38	4.64	7.66	5.91	1.40	6.51	3.12	1.511	−4.179	−4.636~−3.721	2.967	2.709–3.225	0.938
Salmoniformes	Osmeridae	*Hypomesus olidus*	122	4.27	11.23	7.5	0.7	12.7	4.55	1.079	−3.978	−4.216~−3.740	2.644	2.525–2.763	0.942
	Esocidae	*Esox lucius*	9	9.64	50.9	21.36	13.07	4685.36	625.31	6.416	−5.294	−6.166~−4.423	3.439	3.147–3.731	0.991
Perciformes	Percidae	*Perca fluviatilis*	42	7.9	20.9	16.66	7	206.4	104.56	2.261	−4.695	−5.148~−4.243	3.293	3.131–3.454	0.977
	Channidae	*Channa argus*	5	32.5	43.2	37.32	415.5	1118.6	690.64	1.329	−6.778	−10.614~−2.942	3.665	2.604–4.726	0.976
	Gobiidae	*Rhinogobius giurinus*	90	1.09	5.90	4.80	0.46	5.08	3.02	2.731	−0.883	−0.995~−0.771	1.262	1.191–1.334	0.933
	Eleotridae	*Micropercops swinhonis*	5	3.35	4.01	3.60	0.91	1.25	1.02	1.993	−1.991	−3.862~−0.120	1.566	0.103–3.028	0.795

Note: a, intercept of LWR; *b*, slope of LWR; lnBW = lna + bln (TL). CL, limits; *N*, number of individuals; R^2, determination.
Abbreviations: BW, body weight; TL, total length.

stressors. To address these gaps, future research should adopt integrative approaches combining ecological niche theory and life history strategies to fully elucidate the complex relationships between ecosystem characteristics and fish growth dynamics.

5. Conclusions

This study has successfully ascertained the LWRs of 17 freshwater fish species in Bosten Lake. Particularly, the LWR of *C. argus* was reported for the very first time, thereby enriching the crucial information pool for fish research in this lake and accentuating the erstwhile inadequacies in the comprehension of the growth patterns and other biological traits of certain fish species. These LWR data are amenable to being employed for the conversion between total length (TL) and body weight (BW) within the ambit of fish stock assessment, which is conducive to conduct in-depth investigations into population parameters and proffers robust support for the amelioration of fishery resource management decisions in Bosten Lake. Precisely, when direct access to fish weight data is arduous, the body weight can be estimated by dint of the total length data through the established model, thus effectuating the efficacious monitoring of the fluctuations in fish resource quantity. Future research can build on these results to explore population dynamics of fish in Bosten Lake, furnishing more copious scientific substantiation for the sustainable management practices of fishery resources in this region, galvanizing the sustainable evolution of the fishery ecosystem in Bosten Lake, and concomitantly proffering significant references for lake ecological conservation.

Data Availability Statement

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

Conflicts of Interest

The authors declare no conflicts of interest.

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