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Research Article

The Length-Weight Relationships of Twelve Fish Species from the Heishui River, China

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Length-weight relationships are presented for twelve fish species collected at 22 sampling points in the Heishui River, a priority tributary for fish conservation in the mainstream of the Baihetan Reservoir area, China. A combination of gill nets was used for sampling over a period between November 2018 and May 2021. The gill nets consisted of 12 nets per point with dimensions of 20 × 2 m (length and width), mesh size ranging from 20 to 80 mm, and soaking depth ranging from 40 to 160 cm. In addition, fixed gill nets were employed, with 10 nets per point having dimensions of 10 to 30 m in length and 1.5 to 2.5 m in width. The mesh size of these fixed gill nets was 10, 15, or 20 mm. This study presents the length-weight relationships of twelve species for the first time in the Heishui River Basin, including the new maximum body length of *Pseudorasbora parva* (Temminck and Schlegel, 1846). The slope (b) values for the assessed species ranged from 2.5 to 3.5. All the estimated relationships are highly significant ($P < 0.05$) with a high coefficient of determination R^2 ranging from 0.9574 to 0.9997. It is expected that the results obtained from this study will contribute to filling the knowledge gap in this area and also assist fisheries scientists in future assessment studies.

1. Introduction

After the impoundment of the Baihetan hydropower station in 2021, significant environmental changes have occurred in the Heishui River, which is one of the main tributaries to the Baihetan Dam reservoir. These changes include alterations in water temperature, hydrological conditions, and riverbed structure [1, 2]. These environmental shifts have had crucial impacts on fishery resources' growth, reproduction, habitat conditions, and biodiversity. In addition, the interruption of river connectivity has obstructed fish migration [3].

The length-weight relationship (LWR) of fish is of great importance in fishery research. It is commonly used to estimate fish weight based on length distribution, determine the growth pattern of species, and analyze temporal and spatial variations in fish population conditions and adaptability [4]. In the Heishui River, more than 44 fish species have been reported [4]. However, due to the scarcity of data on LWRs, this study aims to fill this knowledge gap by presenting the first reference for LWRs of twelve fish species.

2. Materials and Methods

Specimens of twelve fish species were collected from the main stream of the Heishui River from November 2018 to May 2021. Fish resource surveys were conducted for an

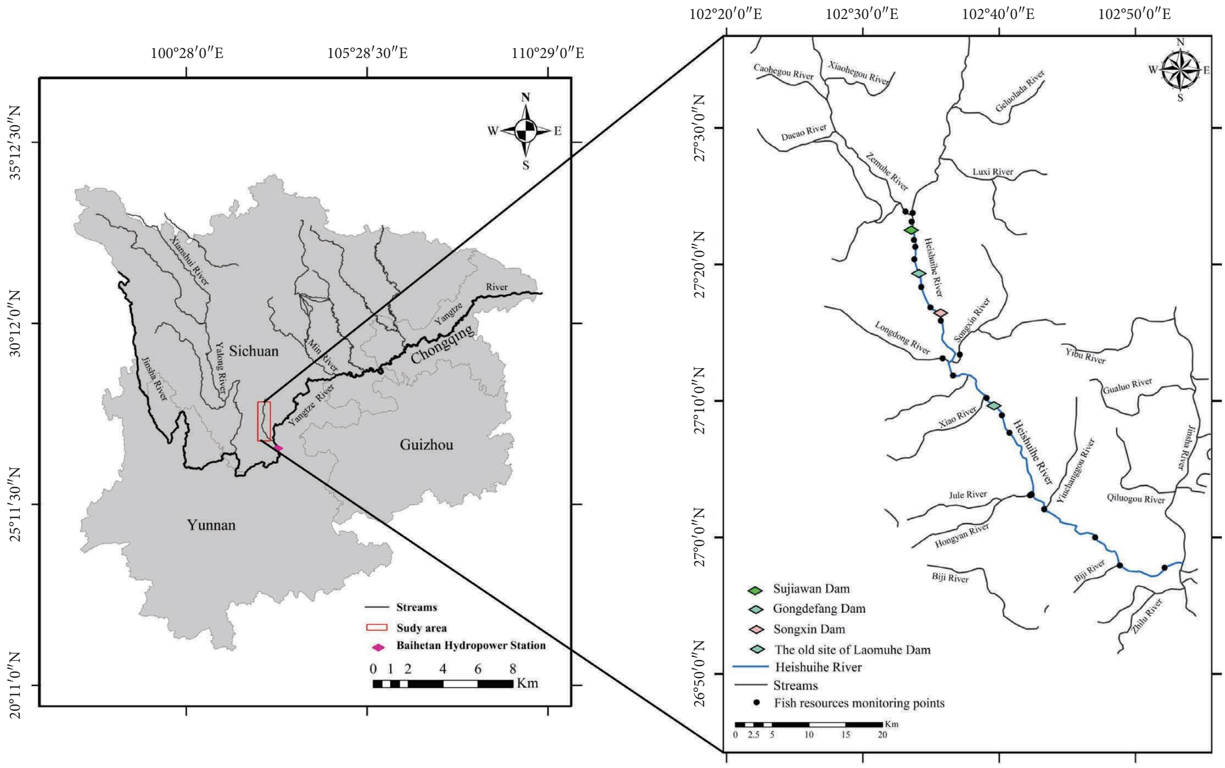

Figure 1: Fish resource survey point map.

average of 30 days per quarter, ensuring an annual average of 120 days. A total of 22 sampling points (see Figure 1 and Table 1) were set up in the main stream of the Heishui River. Fish specimens were collected twice a day using a combination of gill nets (12 nets per point with dimensions of 20×2 m in length and width, mesh size: 20~80 mm, and soaking depth: 40~160 cm) and fixed gill nets (10 nets per point with dimensions of 10~30 m in length and 1.5~2.5 m in width and mesh size: 10, 15, or 20 mm). The trapping time was 10 hours per day. Fish species were identified according to Ding [5] and Chu [6]. The total length (TL) and body weight (BW) were measured on-site with an accuracy of 0.1 cm and 0.1 g, respectively.

The length-weight relationships $BW = aTL^b$ of twelve fish species were determined using a log-transformed equation: $\text{Log}(BW) = \log a + b\log(TL)$, where BW is the wet body weight (g), TL is the total length (cm), a is the intercept, and b is the slope. The 95% confidence intervals (CIs) and coefficient of determination (R^2) were determined for the regression parameters a and b. In addition, this study introduces the fish body fullness BW/TL^3 [7] to reflect the fatness of fish.

In this study, log-log plots were used to remove outlier data, and the significance of all regressions in the datasets was tested by using Origin 9.0. The relationship between the fish body fullness and the regression parameter a was tested by the Pearson correlation test. The significance levels for all analysis are set at $P < 0.05$.

3. Results

This paper analyzes 12 fish species belonging to 2 families and 1 order. The ranges of TL (cm), and BW (g), as well as the LWR parameters (a and b), coefficient of determination (R^2), and 95% confidence intervals (CI) for a and b are shown in Table 2. The values of parameter b range from 2.505 to 3.307 for 12 fish LWRs, consistent with the expected range of 2.5–3.5 in the natural environment, as reported by Ma et al. [16], Wang et al. [17], and Yang et al. [18]. The relationships between TL and BW are highly significant for all fish species ($P < 0.05$), with R^2 values ranging from 0.9574 to 0.9997 for the LWRs.

As can been seen from Table 2, the values of parameter b for the 12 fish species in this study range from 2.505 to 3.307. According to Ngot [19], Masoumi [20], and Falsone [21], the value of b can be used to describe the growth pattern of a fish: allometric growth ($b \neq 3$) represents a fish that has less girth as length increases ($b < 3$) or has an increase in plumpness as length increases ($b > 3$), and isometric growth ($b = 3$) describes a fish that grows with an unchanging body form. In the present study, only the value b of *Homatula potanini (Günther, 1896)* and *Zacco platypus* [12] is greater than 3. Furthermore, the relationship between fish body fullness and the values of parameters a was analyzed by linear fitting (see Figure 2). The results show that the fish body fullness of Cobitidae and Cyprinidae has a significant positive correlation with the value of a. For Cobitidae, $y = 0.029x - 0.017$ ($R^2 = 0.80$, $P < 0.05$), and for Cyprinidae, $y = 0.032x - 0.039$ ($R^2 = 0.84$, $P < 0.05$). In addition, the value of a in this study is 0.0490, which is higher than 0.0189 reported by Wang et al. [17], indicating that the fullness of *Triplophysa anterodorsalis* [9] has been improved since the restoration of the fish habitat in the Heishui River.

Table 1: Fish resource survey point information.

Order	Survey site information of fish resources in Heishui River				Other descriptions	
	River	Point	Longitude and latitude	Altitude (m)	River width (m)	River movement pattern
1	Zemu River (tributary)	Zemu River	102.552241, 27.398501	1139	15	C (curved)
2	Xiluo River (tributaries)	Xiluo River	102.560900, 27.396916	1145	5–30	C
3	Heishui River	Sujiawan hydropower station upstream	102.559663, 27.386226	1134	80	C
4	Heishui River	Sujiawan hydropower station downstream	102.562491, 27.363806	1099	15	C
5	Heishui River	Gondefang hydropower station upstream	102.564138, 27.355562	1089	10–15	S (straight)
6	Heishui River	Gondefang hydropower station downstream	102.562887, 27.340257	1064	20	C
7	Heishui River	Gondefang hydropower station house downstream	102.571407, 27.306474	1050	50	S
8	Heishui River	Songxin hydropower station downstream	102.582640, 27.281450	1030	10	C
9	Heishui River	Pig farm	102.5953, 27.2653	995	20	S
10	Longdong River (tributary)	Longdong River	102.597531, 27.219240	962	5	C
11	Sancha River (tributary)	Sancha River	102.618554, 27.223879	1000	5	C
12	Heishui River	Songxin hydropower station house downstream	102.610300, 27.198265	914	27	C
13	Heishui River	Laomuhe hydropower station downstream	102.651356, 27.170778	880	40	C
14	Heishui River	Laomuhe hydropower station tail water	102.670034, 27.149692	852	30	S
15	Heishui River	Laomu river hydropower station house downstream	102.679245, 27.128290	827	10~15	C
16	Heishui River	"825" backwater	102.706520, 27.052940	784	35	C
17	Jule River (tributary)	Jule River	102.704414, 27.051918	779	5~10	C
18	Heishui River	Hydrologic stations downstream	102.721691, 27.034945	765	30	C
19	Heishui River	"765" backwater	102.784082, 27.000496	687	18	C
20	Heishui River	Yebi River mouth	102.814372, 26.966321	660	18	C
21	Yebi River (tributary)	Yebi River	102.814262, 26.966212	663	5	C
22	Heishui River	Heishui River mouth	102.868969, 26.963477	617	20	C

Table 2: Descriptive statistics and estimated parameters of length-weight relationships for twelve fish species sampled in the main stream of Heishui River from November 2018 to May 2021.

Family	Species	N	Total length (cm)			Weight (g)			Fish body fullness ($100\,g/cm^3$)	Regression parameters				
			Min	Max	Average value	Min	Max	Average value		a	95% CL of a	b	95% CL of b	R^2 (LWR)
Cobitidae	*Triplophysa bleekeri* [8][ab]	150	4.3	7.1	5.6	1.60	5.9	3.3	1.819	0.03583	0.03407~0.03767	2.600	2.571~2.629	0.9997
	Homatula potanini (Günther, 1896)	257	4.1	8.5	6.7	1.2	11.5	5.2	1.312	0.01250	0.01131~0.01383	3.128	3.075~3.181	0.9816
	Triplophysa daqiaoensis [5]	295	4.1	9.5	6.9	1.1	11.2	5.2	1.447	0.02343	0.02202~0.02491	2.745	2.7149~2.779	0.9898
	Homatula variegata [8]	150	4.2	13.5	9.1	1.10	27.0	10.2	1.206	0.01742	0.01562~0.01942	2.830	2.780~2.879	0.9884
	Triplophysa anterodorsalis [9]	270	4.6	8	6.9	2.60	11.5	7.6	2.285	0.04896	0.04731~0.07346	2.505	2.390~2.619	0.9932
	Triplophysa xichangensis [9][ab]	41	4.2	14.2	6.4	1.20	4.2	4.2	1.373	0.03139	0.02571~0.03831	2.540	2.432~2.648	0.9830
	Schistura fasciolata [10]	57	4	9.6	6.7	1.10	4	4.5	1.435	0.02976	0.02444~0.03624	2.611	2.507~2.715	0.9790
Cyprinidae	*Discogobio yunnanensis* [11]	57	4	9.6	6.7	1.78	23.8	8.7	2.661	0.04244	0.04155~0.04334	2.750	2.738~2.761	0.9996
	Pseudorasbora parva [12][b]	544	3.5	12.7	6.3	1.20	19.1	6.1	2.138	0.03505	0.02942~0.04175	2.722	2.626~2.817	0.9574
	Zacco platypus [12]	559	4.1	13.1	7.0	1.50	36.3	9.5	1.750	0.00964	0.00838~0.01107	3.307	3.235~3.379	0.9811
	Abbottina rivularis [13]	1262	4.4	10.2	6.6	1.70	13.3	6.3	1.995	0.02406	0.02262~0.02558	2.898	2.865~2.931	0.9692
	Schizothorax wangchiachii [14]	191	3.5	20.9	6.30	1.1	141.9	9.98	1.779	0.02078	0.01893~0.02280	2.901	2.851~2.951	0.9855

Note: a, intercept of LWR; b, slope of LWR; $\log BW = \log a + b \log (TL)$. BW, body weight; CL, confidence limits; N, number of individuals; R^2, coefficient of determination; TL, total length. [a]LWR estimates are available in FishBase [15]; [b]new records of maximum total length in FishBase [15].

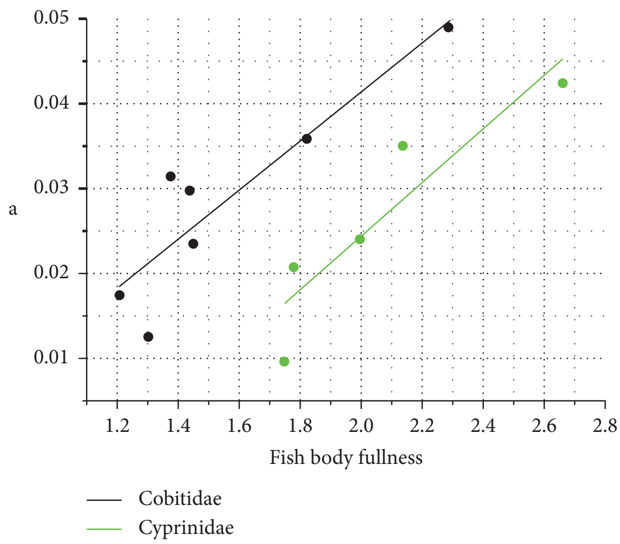

Figure 2: Correlation between fish body fullness and value of LWRs.

4. Discussion

The LWRs of 12 fish species in the Heishui River Basin are first reported in this study. According to FishBase [15] and other published literature, the LWRs of *Triplophysa bleekeri* [8] and *Triplophysa xichangensis* [9] in the Heishui River Basin have not been recorded (Table 2). This study provides the maximum body length of *Pseudorasbora parva* [12] for the first time.

In this study, the value of *b* for *Homatula variegata* [8] is slightly higher than 2.510 reported in Ma et al. [16], and this value of *b* for *Discogobio yunnanensis* [11] is 2.750, which is similar to 2.640 reported in Tang et al. [22], but lower than 3.22 indicated by Yang et al. [18]. For *Schizothorax wangchiachii* [14], there are also differences in the value of *b* compared with other studies from Ma et al. [16]. These difference might be related to environmental factors (i.e., habitat and breeding season), artificial factors (i.e., accuracy of length and weight measurements, number of captured specimens, and measurement time), and physiological factors (i.e., feeding rate, gonadal maturity, and spawning period) [23–25]; Yang et al. [26]. Furthermore, the value of *b* for *Triplophysa anterodorsalis* [9] in this study is 2.505, which is different from 2.777 reported by Wang et al. [17] in the same basin before the impoundment of the Baihetan hydropower station.

Prior to the ecological restoration of the Heishui River Basin, several researchers surveyed fish resources in the basin at different times. For example, Yang [26] surveyed about 28 species of fish in 2014, Gao [27] surveyed about 39 species of fish in 2016, and Qiu [28] surveyed about 11 species in November 2017. After the ecological restoration of the basin, the research group investigated about 44 species of fish from 2018 to 2021 (12 species of fish in this paper are only part of them). Although the time of the fish resource survey is different, it may bring errors to the number of fish species investigated. Overall, restoration has greatly improved the dominant species and the number of fish in the basin, indicating a more suitable environment for fish and emphasizing the significant effect of tributary alternative habitats on fish protection. In conclusion, the results of this study have achieved a good agreement with previous studies and can be used to predict the LWRs of these 12 fish species.

Data Availability

The data used to support the findings of this study are included within the article.

Disclosure

The funder had no role in the study design; collection, analysis, and interpretation of data; or in the decision to submit the article for publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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References

[1] L. Tang, K. Mo, J. Zhang et al., "Removing tributary low-head dams can compensate for fish habitat losses in dammed rivers," *Journal of Hydrology*, vol. 598, Article ID 126204, 2021.

[2] F. Yan, N. Li, Z. Yang, and B. Qian, "Ecological risk evaluation of baihetan Dam based on fuzzy hazard quotient model," *Water*, vol. 14, no. 17, p. 2694, 2022.

[3] Q. Liu, P. Zhang, B. Cheng et al., "Incorporating the life stages of fish into habitat assessment frameworks: a case study in the Baihetan Reservoir," *Journal of Environmental Management*, vol. 299, Article ID 113663, 2021.

[4] H. Teng, H. Tian, H. Liu et al., "Current status of fish resources in Heishui River, a tributary of the lower reaches of the Jinsha River," *Chinese Journal of Ecology*, vol. 40, no. 5, p. 1499, 2021.

[5] R. H. Ding, *The Fishes of Sichuan*, Sichuan Publishing House of Science and Technology, Sichuan, China, 1994.

[6] X. L. Chu, *The Fishes of Yunnan*, Publishing House of Science and Technology, Sichuan, China, 1990.

[7] X. Q. Li, J. Zheng, Z. K. Wan et al., "Population structure and growth characteristics of Gymnodiptychus pachycheilus in the upper reach of Yalong River," *Chinese Acta Ecologica Sinica*, vol. 43, no. 16, pp. 6833–6850, 2023.

[8] H. E. Sauvage and P. D. De Thiersant, "Notes sur les Poissons des eaux douces de la Chine," *Annales des sciences naturelles*, vol. 1, pp. 1–18, 1874.

[9] S. Zhu, *The Loaches of the Subfamily Nemacheilinae in China (Cypriniformes: Cobitidae)*, Jiangsu Science and Technology Publishing House, Beijing, China, 1989.

[10] J. T. Nichols and C. H. Pope, "The fishes of Hainan," *Bulletin of the American Museum of Natural History*, vol. 54, no. 2, pp. 321–394, 1927.
[11] C. T. V. Regan, "Descriptions of three new fishes from Yunnan, collected by Mr. J. Graham," *Annals and Magazine of Natural History*, vol. 19, no. 109, pp. 63-64, 1907.
[12] C. J. Temminck and H. Schlegel, *Pisces in Siebold's Fauna Japonica*, Lugduni Batavorum, Leiden, Netherlands, 1846.
[13] Basilewsky, "Ichthyographia chinae borealis," *Nouveaux mémoires de la Société impériale des naturalistes de Moscou*, vol. 10, pp. 215–263, 1855.
[14] P. W. Fang, "On some Schizothoracid fishes from western China preserved in the national research institute of biology, Academy Sinica," *Sinensia*, vol. 7, no. 4, pp. 421–458, 1936.
[15] R. Froese and D. Pauly, *FishBase*, World Wide Web Electronic Publication, Budapest, Hungary, 2023, http://www.fishbase.org.
[16] B. S. Ma, B. Xu, K. J. Wei et al., "Length–weight and length–length relationships of four native fish species from the Yalong River, China," *Journal of Applied Ichthyology*, vol. 33, no. 4, pp. 839–841, 2017.
[17] C. Wang, Y. Q. Liang, D. M. Huang, and M. Li, "Length–weight relationships of four small fish species caught in the Heishui River, China," *Journal of Applied Ichthyology*, vol. 32, no. 2, pp. 397-398, 2016.
[18] Z. Yang, H. Y. Tang, Y. F. Que et al., "Length–weight relationships and basic biological information on 64 fish species from lower sections of the Wujiang River, China," *Journal of Applied Ichthyology*, vol. 32, no. 2, pp. 386–390, 2016.
[19] H. F. P. Ngot, V. Mamonekene, A. I. Zamba et al., "Length-weight relationships and condition factors of 15 fish species from the loémé River Basin (mayombe, republic of Congo)," *Open Journal of Ecology*, vol. 13, no. 12, pp. 883–893, 2023.
[20] A. H. Masoumi, S. M. Al Jufaili, F. Pourhosseini, and H. R. Esmaeili, "Length-weight relationships of three endemic fish species of the Arabian Peninsula," *International Journal of Aquatic Biology*, vol. 11, no. 1, pp. 30–33, 2023.
[21] F. Falsone, M. L. Geraci, D. Scannella et al., "Length-weight relationships of 52 species from the south of sicily (central mediterranean sea)," *Fishes*, vol. 7, no. 2, p. 92, 2022.
[22] W. Tang, C. Y. Sha, J. Q. Zhang, Q. Wang, W. Xiong, and W. H. You, "Length–weight relationships for three fish species from the Yalong River, southwestern China," *Journal of Applied Ichthyology*, vol. 32, no. 6, pp. 1290-1291, 2016.
[23] S. Chen, Z. Zhang, Y. Cai et al., "Length–weight relationships of five fish species from the Angqu River, China," *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use*, vol. 27, no. 3, Article ID e12409, 2022.
[24] S. Czudaj, C. Möllmann, and H. O. Fock, "Length–weight relationships of 55 mesopelagic fishes from the eastern tropical North Atlantic: across-and within-species variation (body shape, growth stanza, condition factor)," *Journal of Fish Biology*, vol. 101, no. 1, pp. 26–41, 2022.
[25] P. Freon, "Relations tailles-poids, facteurs de condition, et indice de maturité sexuelle: rappels bibliographiques, interprétations, remarques et applications," 1977, https://horizon.documentation.ird.fr/exl-doc/pleins_textes/doc34-07/02665.pdf.
[26] Y. Zhi, T. Huiyuan, G. Yun, Z. Di, and Z. Na, "Effect of spawning migration on the variations of fish assemblage structures in the lower reaches of the Heishui River, Jinsha River," *Journal of Lake Sciences*, vol. 30, no. 3, pp. 753–762, 2018.
[27] X. C. Gao, Q. Zhang, W. Su et al., "Environmental quality assessment based on fish biotic integrity index and eco-restoration mode discussion for the Heishui River Jinsha River," *Resources and Environment in the Yangtze Basin*, vol. 31, no. 01, pp. 104–112, 2022.
[28] Y. L. Qiu, *Ecological Geomorphology Simulation and Fish Substitution Habitat Evaluation in the Heishui River*, Chongqing Jiaotong University, Chongqing, China, 2018.