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Research Article

Length-Weight and Length-Length Relations of 14 Freshwater Fish Species from the Qiantang River, China

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The Qiantang River, located in Zhejiang Province, China, is a crucial water resource with significant ecological and economic importance. This study aimed to evaluate fishery resources in the Qiantang River Basin by analyzing the length-weight relationships (LWRs) and length-length relationships (LLRs) of 14 fish species. Fish samples were collected between July 2021 and November 2023 using multipanel nylon gillnets and cage nets. Each specimen was measured for total length (TL) and standard length (SL), as well as weighed. Linear regression models were employed to estimate LWRs and LLRs, with statistical tests revealing significant relationships ($P < 0.05$) and high R^2 values above 0.91. The study contributed new LWRs for two species and LLRs for three, deepening our understanding of their biology. These findings enriched FishBase and offered valuable data for fish stock assessments and management strategies in the Qiantang River Basin. Future research can utilize this foundation to explore population dynamics and promote sustainable management practices.

1. Introduction

The Qiantang River, located in Zhejiang, China (117°30′–121°30′E, 28°00′–30°30′N) [1], is the region's primary watercourse, covering 40.39% of the province's land [2]. Spanning 688 kilometers and with a basin area of 55,558 square kilometers [3], it supports diverse functions, including drinking water supply, hydroelectric power, flood control, irrigation, and tourism [1, 3, 4]. In the 1980s, the river was abundant in fish, with a recorded 202 species [5]. However, over the past few decades, fish populations have suffered a persistent decline due to detrimental factors such as extensive sand dredging, overfishing, invasive species, environmental degradation, and coastal urbanization [1, 3, 4]. Human activities have significantly altered the river's ecological landscape, necessitating assessment since the 1980s when no comprehensive fishery surveys were conducted, resulting in a 30-year data gap. To address this knowledge gap and support effective management and conservation efforts, it is imperative to conduct a survey of the Qiantang River's fishery resources and environmental conditions.

Length-weight relationships (LWRs) and length-length relationships (LLRs) are fundamental in understanding fish biology and play a pivotal role in fisheries management and conservation [6]. This study, grounded on the latest sampling data from the Qiantang River, aims to establish LWRs and LLRs for the 14 fish species that inhabit this aquatic ecosystem.

2. Materials and Methods

Fish samples were systematically collected from the Qiantang River Basin in Zhejiang, China (Figure 1), over a 2021–2023 timeframe, encompassing diverse seasons. Two fishing methodologies were employed: multipanel nylon gillnets (20–40 meters long, 1–3 meters high, mesh size 3–8 cm) and cage nets (0.2 meters height, 0.3 meters width, and 10 meters length, mesh size 5 mm). To maintain standardization, fishing operations occurred primarily during early morning hours, from 02:00 to 06:00. Identification of collected fish species was conducted according to the Fauna of Zhejiang: Freshwater Fishes protocol [7], with scientific

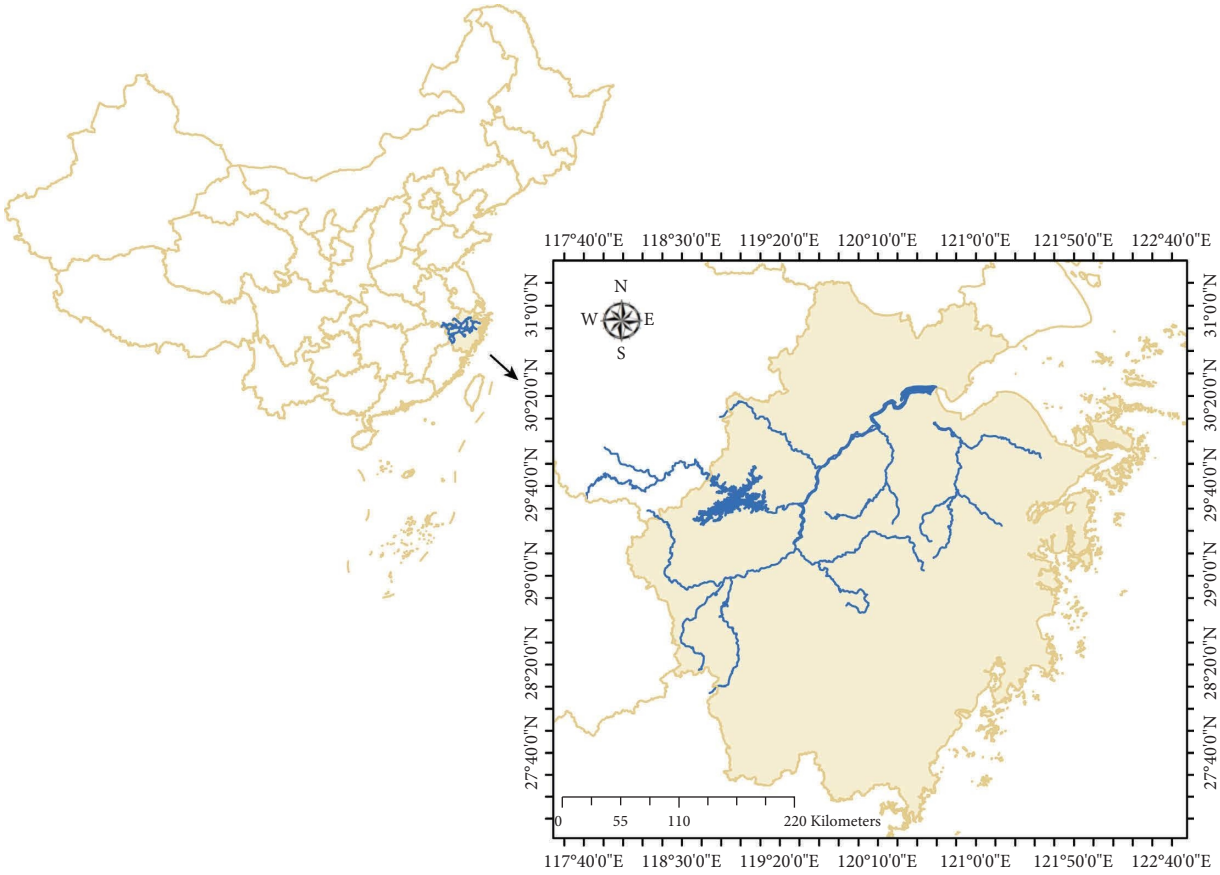

FIGURE 1: Map of the study area: the location of the Qiantang River Basin, Zhejiang, China.

names and authors of each fish species confirmed through FishBase [8]. All procedures were conducted in compliance with the Chinese Laboratory Animal Administration Regulations and received approval from the Ethics Committee of Hangzhou Academy of Agricultural Sciences, with the reference number HZSNKY-20210323.

This study examined 14 freshwater fish species, focusing on their length-weight (LWRs) and length-length (LLRs) relations. The species included *Rhodeus sinensis* Günther, 1868 from Acheilognathidae, *Tachysurus nitidus* (Sauvage and Dabry de Thiersant, 1874) from Bagridae, *Coilia nasus* Temminck & Schlegel, 1846 from Coiliinae, *Trachidermus fasciatus* Heckel, 1837 from Cottidae, *Hemiculter leucisculus* (Basilewsky, 1855) from Cyprinidae, *Rhinogobius giurinus* (Rutter, 1897) from Gobiidae, two species from Gobionidae - *Squalidus argentatus* (Sauvage and Dabry de Thiersant, 1874) and *Pseudogobio vaillanti* (Sauvage, 1879), *Odontobutis obscurus* (Temminck & Schlegel, 1845) from Odontobutidae, and five species from Xenocyprididae, *Pseudolaubuca sinensis* Bleeker, 1864, *Culter alburnus* Basilewsky, 1855, *Pseudobrama simoni* (Bleeker, 1864), *Megalobrama terminalis* (Richardson, 1846), and *Opsariichthys bidens* Günther, 1873.

Each specimen was measured to the nearest 0.1 cm (total length, TL; standard length, SL) and weighed to the nearest 0.1 g (weight, W) simultaneously.

The LWRs were determined using the following formula:

$$W = a\mathrm{TL}^b, \tag{1}$$

where W is the weight [g], TL is the total length [cm], a is the intercept, and b is the allometric coefficient/slope. The formula was equipped with a simple linear regression model based on log-transformed data. The 95% confidence limits (CL) for parameters a and b and the coefficients of determination (R^2) were also determined [6]. A linear regression was used to determine the LLRs,

$$\mathrm{SL} = a + b\mathrm{TL}, \tag{2}$$

where SL is the standard length [cm] and other measurements are defined as above. For species with $R^2 < 0.95$, outliers were discarded and regression was recalculated. All statistical analysis was performed using SPSS 19.0 (IBM SPSS Statistics, Inc., Chicago, IL, USA).

3. Results

The length-weight relationships (LWRs) and length-length relationships (LLRs) of 14 fish species were rigorously estimated and statistically analyzed. Table 1 summarizes the descriptive statistics and LWR parameters, while Table 2 presents corresponding data for LLRs (TL vs. SL). All LWRs and LLRs exhibited significant correlations ($P < 0.05$), with

Table 1: Descriptive statistics and estimated parameters of LWR ($W = aTL^b$) for 14 freshwater fish species sampled in the Qiantang River, China.

Species	N	Total length (cm)		Total weight (g)		LWR parameters					FishBase
		Min	Max	Min	Max	a	b	R^2	95% CL a	95% CL b	
Rhodeus sinensis Günther, 1868	70	3.0	6.2	0.46	3.20	0.015	2.929	0.919	0.011–0.021	2.719–3.139	
Tachysurus nitidus (Sauvage and Dabry de Thiersant, 1874)	20	11.3	17.3	11.50	37.00	0.008	2.974	0.953	0.004–0.020	2.646–3.302	
Coilia nasus Temminck & Schlegel, 1846	59	14.6	26.3	6.75	40.15	0.001	3.156	0.930	0.001–0.003	2.927–3.385	
Trachidermus fasciatus Heckel, 1837	17	8.8	21.1	6.79	82.10	0.014	2.832	0.973	0.007–0.029	2.573–3.092	*, #
Hemiculter leucisculus (Basilewsky, 1855)	90	9.2	15.3	5.60	23.69	0.009	2.906	0.928	0.006–0.014	2.735–3.077	
Rhinogobius giurinus (Rutter, 1897)	48	4.4	9.1	0.90	7.70	0.008	3.101	0.924	0.005–0.013	2.837–3.365	
Squalidus argentatus (Sauvage and Dabry de Thiersant, 1874)	16	5.0	11.0	1.30	13.80	0.020	2.637	0.967	0.011–0.036	2.357–2.917	
Pseudogobio vaillanti (Sauvage, 1879)	12	8.9	17.4	6.24	37.51	0.016	2.743	0.958	0.006–0.043	2.340–3.146	*
Odontobutis obscurus (Temminck and Schlegel, 1845)	46	3.9	16.9	0.50	55.40	0.012	3.045	0.968	0.009–0.017	2.877–3.213	
Pseudolaubuca sinensis Bleeker, 1864	45	13.5	24.9	11.62	58.06	0.010	2.727	0.940	0.005–0.018	2.516–2.938	#
Culter alburnus Basilewsky, 1855	56	6.5	29.1	1.50	130.60	0.007	2.902	0.991	0.006–0.009	2.826–2.979	
Pseudobrama simoni (Bleeker, 1864)	29	9.6	18.1	8.68	38.58	0.028	2.531	0.932	0.014–0.055	2.261–2.800	
Megalobrama terminalis (Richardson, 1846)	62	33.4	63.5	355.00	3322.85	0.005	3.245	0.946	0.002–0.011	3.045–3.444	#
Opsariichthys bidens Günther, 1873	49	5.6	17.3	1.70	55.60	0.009	2.989	0.989	0.007–0.011	2.896–3.081	

Note. N, sample size; Min and Max, the minimum and maximum of the total length in cm and the total weight in g; a and b, parameters of LWRs; R^2, coefficient of determination; 95% CL, 95% confidence limits.
*new information for the FishBase; #new records of the maximum total length.

Table 2: Length-length relations (SL = $a + b$TL) of 14 fish species sampled in the Qiantang River, China.

Species	LLR parameters			FishBase
	a	b	R^2	
Rhodeus sinensis	−0.0243	0.7894	0.9588	
Tachysurus nitidus	0.2751	0.814	0.9892	
Coilia nasus	0.1953	0.8993	0.9810	
Trachidermus fasciatus	0.041	0.8291	0.9987	
Hemiculter leucisculus	−0.0811	0.8308	0.9622	
Rhinogobius giurinus	−0.075	0.8153	0.9697	
Squalidus argentatus	−0.4285	0.8599	0.9952	
Pseudogobio vaillanti	−0.272	0.8537	0.9955	#
Odontobutis obscurus	−0.1312	0.8299	0.9939	
Pseudolaubuca sinensis	0.1125	0.8048	0.9878	#
Culter alburnus	−0.2697	0.8277	0.9922	
Pseudobrama simoni	−0.1218	0.8422	0.9931	
Megalobrama terminalis	−2.0561	0.888	0.9822	#
Opsariichthys bidens	−0.5273	0.8795	0.9963	

Note. a, intercept; b, slope; R^2, coefficient of determination. #, first record of LLR for the species.

R^2 values exceeding 0.91, indicating strong associations. This study contributed new insights by establishing two previously undocumented LWRs for *Trachidermus fasciatus* and *Pseudogobio vaillanti*, as well as three novel LLRs for *Pseudogobio vaillanti*, *Pseudolaubuca sinensis*, and *Megalobrama terminalis*. Additionally, three novel total lengths for *Trachidermus fasciatus*, *Pseudolaubuca sinensis*, and *Megalobrama terminalis* were recorded, surpassing the data available in FishBase [8].

4. Discussion

The coefficient of determination (R^2) ranged from 0.919 (*R. sinensis*) to 0.991 (*C. alburnus*), reflecting a high degree of variability in the fish length data. Several factors, such as size of the sample, length of the specimens, gonad maturity, and diet, significantly impact this relationship, as previously reported [9]. Variations in the relationship between length and weight across species stem from differences in body shape, while intraspecific variations can be influenced by the condition of individual fish, which fluctuates seasonally and annually [10, 11].

The LWR parameter b, estimated in this study, varied from 2.531 to 3.245, falling within the predicted range of 2.5 to 3.5 [6, 12]. Compared with values reported in FishBase [8] revealed deviations in the parameter b for certain species in this study. According to the previous studies, the parameter b of *M. terminalis* was 2.727, and the 95% CL ranged from 2.629 to 2.825 [13]. However, it was 3.245 (95% CL: 3.045–3.444) in our study. Similar results were also seen in other fish species, the b value of *M. terminalis, T. nitidus*, and *C. alburnus* were lower, and in contrast, *P. vaillanti*, *T. fasciatus*, *H. leucisculus*, *S. argentatus*, *P. simoni*, and *O. bidens* were greater than in the previously reported [13–17]. It is important to acknowledge that various factors such as growth patterns, gender, fishing practices, and environmental variables including season, temperature, and food availability can influence LWRs [10, 11, 18]. Given that the specimens in our study were collected using multipanel nylon gillnets (3–8 cm mesh) and cage nets (5 mm mesh), it is reasonable to assume potential size bias in the data. This study employed long-term survey data to estimate LWRs and LLRs for 14 fish species in the Qiantang River Basin, with the derived parameters reflecting mean annual values [3]. The significance of our findings emerges when comparing them with previously reported data.

This study not only enriches FishBase (Froese and Pauly 2023) with novel data but also offers valuable perspectives for fish stock assessment, serving as a solid foundation for future research on population dynamics, ultimately supporting improved management strategies within the Qiantang River Basin.

5. Conclusions

This study contributes essential LWRs and LLRs data for 14 fish species, with novel LWRs for two species and LLRs for three, as well as new maximum total lengths for three. These findings underscore the limited biological knowledge on these species. These LWRs and LLRs allow for the conversion of TL - W and TL - SL in fish stock assessment and are useful for further studies of population parameters to improve management decisions in the Qiantang River Basin. Future studies can build upon these baseline data to further investigate population dynamics and inform sustainable management practices in the region.

Data Availability

The data used in this study are available upon reasonable request to the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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