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**Short Communication**

# Length Weight and Length-Length Relationships of Nine Native Fish Species from the Yichang Reach of the Middle Yangtze River, China

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**SL, WJ and YH conceived and designed the research. SL wrote the manuscript. SL analyzed the data with WL. SL, WS and WL carried out the experiment.**

**Key words**
**The middle Yangtze River, Native fish, Length–weight relationships, Length–length relationships, Relative body weight**

## ABSTRACT

We determined the length-weight relationships (LWRs) and length-length relationships (LLRs) for nine fish species belonging to three families inhabiting the Yichang reach of the middle Yangtze River, China. The samples were collected with gill nets (2×50 m, mesh size: 40 and 60 mm) between November 5th, 2019, and December 31st, 2019. A total of 1252 specimens were used to estimate the related parameters. The LWRs parameters of all nine species were found to be significant ($P < 0.05$). The values of b in LWRs ranged from 2.455 to 3.009. New maximum total length (TL) and standard length (SL) records for two of the nine species were reported, and the first report of LWRs of *Xenocypris davidi* was provided. The results of our study provided Fish Base with new data and basic biological information for research, management, and conservation of the middle Yangtze River ecosystem.

With a total length of 6397 km, the Yangtze River is the longest river in China. As the main breeding sites and habitat of fishes, the middle reaches of Yangtze River have eleven spawning grounds for the four major Chinese carp and account for 42.7% of the total spawning scale of the mainstream of the Yangtze River. Determining the length-weight relationships (LWRs) is an effective approach for assessing fish biomass based on the conveniently obtained length data (Liu *et al*., 2018). A variety of information can be obtained from LWRs, including growth rate, age structure, age at first maturity, and segregation of stocks (Singh *et al*., 2017). Recently, it has been broadly used in the assessment of fish resources, conservation, and management of fish populations in combination with other environmental and population parameters (Fafioye and Oluajo, 2005; Froese, 2006; Pervin and Mortuza, 2008). Some studies reported on the association between the length and weight of fish in the Yangtze River. However, most of the earlier studies were conducted on the upper reaches or its tributaries, such as the research of 77 fish species in the Chishui River (Liu *et al*., 2014), 11 fish species in the Yibin River (Li *et al*., 2015), and two species of *Jinshaia sinensis* and *Zacco platypus* in the upper reaches (Wang *et al*., 2015). However, there is a lack of biological information for most of the freshwater fish species in the middle Yangtze River. The results of our study provided updates and data on nine native fish species for FishBase, as well as basic biological information for research, management, and conservation of the middle Yangtze River ecosystem.

## *Materials and methods*

The fish specimens were collected from the Yichang reach (30°42'-30°24' N; 111°16'-111°26' E) of the middle Yangtze River, using a stationary gill net (2×50 m,

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mesh size: 40 and 60 mm) from November 5th, 2019 to December 31st, 2019. Species were identified in the field; each individual was measured for standard length (SL, mm), total length (TL, mm) to the nearest 1mm, and body weight (W, g) to the nearest 0.1g. FishBase was used to cross-reference all scientific names (Froese and Pauly, 2022). The experiments were approved by the Institutional Review Board on Bioethics and Biosafety of the Chinese Sturgeon Research Institute.

The relationship between length and weight was determined using the expression: $W = a \times L^b$ (Froese, 2006), where W represents the body weight (W, g), L is the standard length (SL, mm), a is the intercept of the regression and b is the slope or regression coefficient. A and B parameters of the weight–length relationship were calculated by linear regression analysis based on natural logarithms: $\ln W = \ln a + b \times \ln L$. The relationship between TL and SL was determined using linear regression analysis of $TL = a + b \times SL$ (Zhang *et al*., 2016). To remove outliers, log-log plots within species were performed using SPSS 17.0. The 95% confidence limits (Cl) of a and b parameters were estimated. The coefficient of determination ($r^2$) was used to estimate the correlation between W and L. All statistical analyses were considered significant at 5% ($P < 0.05$).

Relative body weight (Wr) was estimated using the formula: $Wr = W/(a*L^b) \times 100$ (Froese, 2006), where W is the body weight (W, g), L is the total length (TL, mm), a and b are the parameters of LWRs.

*Results*

The present study reports LWRs and LLRs of nine species. LWR parameters, along with the descriptive statistics are given in Table I. LLR parameters along with TL (SL shown in Table I) and Wr are shown in Table II. All regressions were significant ($P < 0.05$), with $r^2$ ranging from 0.886 in *Saurogobio dabryi* to 0.982 in *Xenocypris davidi* for LWRs and from 0.956 in *S. dabryi* to 0.992 in *Parabramis pekinensis* for LLRs, respectively. For LWRs, the values of parame*ter b o*f the regression model varied from 2.455 in *Culter alburnus* to 3.009 in *Pelteobagrus fulvidraco*. For LLRs, it ranged from 1.087 to 1.183. The new maximum TL of *S. dabryi* is 35.9 cm, and new maximum SL is 30.5 cm. The new maximum TL of *Rhinogobio typus* is 47.0 cm, and new maximum SL is 41.2 cm. The relative Wr of nine species ranged from 59.02 to 67.18.

*Discussion*

A total of 1252 fish specimens were collected, representing nine species and three families (Tables I and II). The sample size ranged from 22 individuals of *Culter alburnus* to 473 individuals of *Coreius heterodon*. LWRs are one of the most commonly used formulas in Fishery Ecology Research (Anderson and Neuman, 1996). The parameter b of LWRs reflects the heterogeneity of growth and development (Froese, 2006). The b value is close to 3 indicated that the growth for length and body weight of fish was expressed as isauxesis (Huang and Chang, 1999; Froese, 2006). When b exceeds 3, it indicates positive allometric growth and stands for high productivity conditions, whereas low productivity areas such as deep water tended to stimulate negative allometric growth ($b < 3$) (Philip and Mathew, 1996). In this study, except for

**Table I. Descriptive statistics and estimated parameters of LWRs ($W = a \times L^b$) for nine fish species, Yichang reach in the middle reaches of the Yangtze River, China.**

| Family/ Species | SL (mm) | | TW (g) | Regression parameters | | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Range | Range | a | aCI95% | b | bCI95% | $r^2$ |
| **Family: Cyprinidae** | | | | | | | | |
| *Coreius heterodon* | 473 | 145.2-385.0 | 44-657.5 | 4.64E-05 | 2.92E-05~7.38E-05 | 2.761 | 2.678~2.843 | 0.902 |
| *Parabramis pekinensis* | 76 | 140.4-438.2 | 47.9-1365 | 0.0001 | 4.43E-05~0.000286 | 2.644 | 2.475~2.814 | 0.929 |
| *Xenocypris davidi1* | 43 | 132.2-285.1 | 45.5-441.1 | 3.54E-05 | 1.82E-05~6.89E-05 | 2.869 | 2.746~2.992 | 0.982 |
| *Saurogobio dabryi2* | 136 | 155.0-305.6 | 47.1-283.2 | 4.12E-05 | 1.70E-05~0.000102 | 2.741 | 2.573~2.909 | 0.886 |
| *Rhinogobio typus2* | 100 | 152.4-412.1 | 41.1-577 | 3.96E-05 | 2.07E-05~7.59E-05 | 2.753 | 2.634~2.872 | 0.956 |
| *Culter alburnus* | 22 | 220.0-560.3 | 122.7-1145.5 | 0.000241 | 8.47E-05~0.000687 | 2.455 | 2.273~2.638 | 0.975 |
| **Family: Bagridae** | | | | | | | | |
| *Pelteobagrus fulvidraco* | 37 | 140.3-340.2 | 37.8-406.5 | 1.18E-05 | 3.29E-05~4.21E-05 | 3.009 | 2.769~3.249 | 0.949 |
| *Mystus macropterus* | 32 | 173.4-415.0 | 45.4-562 | 2.89E-05 | 4.89E-05~0.000171 | 2.824 | 2.505~3.143 | 0.916 |
| **Family: Serranidae** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Siniperca chuatsi* | 333 | 90.0-410.0 | 26.6-1879 | 2.05E-05 | 1.33E-05~3.16E-05 | 2.997 | 2.914~3.081 | 0.938 |

**Table II. TL, Wr and estimated total length-standard length relationships (TL = a + b×SL) parameters for nine fish species, Yichang reach in the middle reaches of the Yangtze River, China.**

| Family/ Species | Wr (g) | | TL (mm) | Regression parameters | | | | $r^2$ |
|---|---|---|---|---|---|---|---|---|
| | Mean | Range | Range | a | aCI95% | b | bCI95% | |
| **Family: Cyprinidae** | | | | | | | | |
| *Coreius heterodon 1* | 65.88 | 43.4 -- 104.1 | 172.4-445.3 | 18.006 | 13.02~22.992 | 1.098 | 1.080~1.116 | 0.968 |
| *Parabramis pekinensis 1* | 64.01 | 35.7 -- 87.5 | 173.0-514.2 | 12.893 | 7.039~18.747 | 1.135 | 1.112~1.158 | 0.992 |
| *Xenocypris davidi 1* | 59.02 | 31.6 -- 72.2 | 160.3-357.5 | 4.858 | -4.265~13.982 | 1.181 | 1.141~1.22 | 0.989 |
| *Saurogobio dabryi 1, 2* | 64.21 | 33.9 -- 81.4 | 195.5-358.9 | 5.72 | -3.044~14.485 | 1.150 | 1.108~1.193 | 0.956 |
| *Rhinogobio typus 2* | 64.97 | 32.9 -- 88.6 | 175.2-470.0 | 11.784 | 5.845~17.723 | 1.122 | 1.098~1.146 | 0.989 |
| *Culter alburnus 1* | 66.00 | 52.3 -- 92.7 | 256.8-622.4 | 16.031 | -4.737~36.799 | 1.116 | 1.053~1.179 | 0.985 |
| **Family: Bagridae** | | | | | | | | |
| *Pelteobagrus fulvidraco 1* | 62.48 | 30.1 -- 94.6 | 170.4-391.6 | 17.735 | 1.202~34.268 | 1.087 | 1.009~1.166 | 0.958 |
| *Mystus macropterus 1* | 67.18 | 43.2 --90.1 | 200.2-474.5 | -6.358 | -20.034~7.318 | 1.183 | 1.132~1.233 | 0.987 |
| **Family: Serranidae** | | | | | | | | |
| *Siniperca chuatsi 1* | 64.66 | 26.0--103.1 | 116.7-462.1 | 7.191 | 4.559~9.823 | 1.121 | 1.107~1.135 | 0.987 |

Wr, relative body weight; TL, total Length; *a* and b, the parameters for LLR; $r^2$, coefficient of determination; CL, confidence limits. [1] First LLR information. [2] New TL max.

*Culter alburnus* (b = 2.455), all b values fell within Froese's (2006) predicted range. In contrast, only *Pelteobagrus fulvidraco* (b= 3.009) was calculated as isauxesis; the other eight fish species showed negative allometric growth. Hence, the large specimens changed their body shape to become more elongated, or the small specimens were in a better nutritional state when they were sampled (Froese, 2006). Comparing this study to other studies (Ni *et al*., 2022; Dong *et al*., 2022), some deviations from parameter b for some species were identified. For example, the b values of *Saurogobio dabryi* were 3.017 and 2.96 stated by Ni *et al*. (2022) and Liu *et al*. (2013), respectively, whereas in this study, the b value is 2.741. This deviation may be because the samples we used to estimate LWRs were only collected in winter when fishes have low feeding activity and low energy. In other words, the fishes are in a basic metabolic condition. Although the collected specimens used to estimate LWRs should theoretically represent entire size classes of the population (Froese, 2006), due to the size-selective properties of nets types, very small individuals of any species rarely occurred in this study. For instance, the minimum SL and W of *Saurogobio dabryi*, reported by Ni *et al*. (2022), was 4.5 cm and 0.8 g, respectively, whereas, in this study the minimum SL and W were 15.5 cm and 47.1 g, respectively. The sampling methodology, sampling time, sampling location, and sampling size can all affect the estimation of LWRs values (Froese, 2006; Chen *et al*., 2017), thus, the LWRs presented in this paper should be limited to the observed length ranges. We need to expand the sampling season and strengthen the sample size collection in future studies.

The Wr of the nine species was significantly less than 100 in this study. In some studies, it was found that when the Wr of an individual or group of fish is less than 100, it might indicate problems like low food availability or high predation pressure (Rypel and Richte, 2008). In order to protect the fishery resources of the Yangtze River, the Chinese government imposed a ten-year ban on fishing in 2020. During our research in 2019, we found new maximum TL and SL records for two of the nine species and provided the first report of LWRs of *Xenocypris davidi*, which can be used as the background value for assessing the effect of the fishing ban. The findings provided new data for FishBase, and are valuable for further fisheries research, as well as helping to establish conservation and management measures of fish resources in the middle Yangtze River.

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*Data availability statement*

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

*Ethics statement*

The experiments were performed in accordance with the guidelines and regulations of the National Institute of Health Guide for the Care and Use of Laboratory Animals.

*Statement of conflict of interest*

The authors have declared no conflict of interest.

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