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Length–weight and length–length relationships of 26 fish species from the Yiluo River, a tributary of the Yellow River, China

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Summary

From February to October 2016, a total of 9,754 fish specimens were collected from the Yiluo River, a tributary of the Yellow River, China's second longest river. Based on these samples, length–weight relationships (LWRs) and length–length relationships (LLRs) were estimated for 26 species. Among these data, LWRs for 1 species, LLRs for 11 species, and maximum total lengths for six species were not previously recorded in FishBase. The *a* values of the LWRs varied between 0.0019 and 0.0116, and *b* values from 2.805 to 3.883. All regressions for LWRs and LLRs were highly significant ($p < .001$). These results will be useful for sustainable management and conservation of the fish resources in the Yiluo River and the Yellow River ecosystem.

1 | INTRODUCTION

With a length of 426.3 km and a watershed area of 18,881 km^2, the Yiluo River is the largest tributary in the middle and lower reaches of the Yellow River below the Sanmenxia dam. This river is one of the most important spawning and nursery grounds for many fish species such as the Yellow River carp (*Cyprinus carpio* Linnaeus, 1758), one of the most famous fish species in China (Anonymous, 1976). However, little data have been published regarding the fish biology in the Yiluo River. Thus, facing very rapid economic development, there is an urgent need to conduct studies on fish biology and provide data useful for sustainable utilization and conservation of the fish resources in the river.

Length–weight relationships (LWRs) and length–length relationships (LLRs) are used extensively in fishery research and management (Froese, 2006; Mendes, Fonseca, & Campos, 2004). LWRs have several important implications for the biology, ecology and assessment of the fishery, and LLRs are important for comparative growth studies (Froese & Pauly, 1998; Moutopoulos & Stergiou, 2002). The parameters of maximum length are able to indirectly reflect fishing pressures and habitat suitability in the certain river (Shin, Rochet, Jennings, Field, & Gislason, 2005). The present study provides LWRs and LLRs for 26 fish species sampled in the Yiluo River, including new LWRs for 1 species, new LLRs for 11 species, and new records of maximum total length for 6 species.

2 | MATERIALS AND METHODS

This study was conducted in the lower reaches of the Yiluo River (112°12′–113°04′E; 34°14′–34°50′N) from February to October 2016. Fish specimens were collected bi-monthly by gill nets (mesh size: 2–4 cm), benthic fyke nets (mesh size: 1 cm), and electrofishing. Fish were identified to species level based on morphology (Li, 2015) and checked according to FishBase (Froese & Pauly, 2016). For all specimens, the total length (TL), standard length (SL) and wet body weight (*W*) were measured to the nearest 0.1 cm and 0.1 g, respectively.

LWRs were calculated using the linear equation: log (W) = log (a) + b log (TL), where W represents the wet body weight (g), TL the total length (cm), and a and b are the model parameters (Le Cren, 1951). Prior to regression analyses, log-log plots of the length–weight pairs were performed to exclude extreme outliers (Froese, 2006). TL and SL relationships were established using linear regression analysis

TABLE 1 Descriptive statistics and estimated parameters of length–weight and length–length relationships for 26 fish species in the Yiluo River

		TL (cm)		W (g)		LWR parameters					LLR parameters		
Family/species	*N*	Min	Max	Min	Max	*a*	95% CL of *a*	*b*	95% CL of *b*	r^2	*p*	*q*	r^2
Cyprinidae													
Opsariichthys bidens Günther, 1873[b,c]	46	8.1	20.4	3.8	96.4	0.0049	0.0030–0.0078	3.243	3.063–3.423	.971	−0.147	0.853	.994
Hemiculter leucisculus (Basilewsky, 1855)	2,092	4.2	21.4	0.3	83.3	0.0039	0.0032–0.0049	3.248	3.159–3.337	.955	−0.014	0.838	.985
Hemiculter bleekeri Warpachowski, 1888[b]	37	5.2	16.8	1.0	37.4	0.0052	0.0037–0.0073	3.164	3.020–3.308	.987	−0.156	0.853	.987
Chanodichthys erythropterus (Basilewsky, 1855)	32	10.0	29.5	7.4	202.1	0.0059	0.0039–0.0089	3.082	2.931–3.232	.984	−0.242	0.853	.998
Pseudobrama simoni (Bleeker, 1864)[b,c]	970	4.7	17.3	0.6	57.4	0.0043	0.0034–0.0054	3.332	3.238–3.427	.963	−0.159	0.837	.989
Hemibarbus maculatus Bleeker, 1871[b]	35	12.1	26.2	12.4	187.8	0.0055	0.0036–0.0082	3.171	3.026–3.317	.984	−0.334	0.855	.994
Pseudorasbora parva (Temminck & Schlegel, 1846)	1,037	2.9	11.6	0.1	19.8	0.0055	0.0048–0.0063	3.309	3.239–3.382	.968	−0.144	0.845	.996
Sarcocheilichthys nigripinnis (Günther, 1873)	106	3.9	10.9	0.6	17.3	0.0076	0.0061–0.0094	3.221	3.100–3.343	.966	−0.158	0.852	.994
Squalidus argentatus (Sauvage & Dabry de Thiersant, 1874)[b]	72	3.5	8.9	0.3	6.9	0.0081	0.0051–0.0128	3.097	2.858–3.337	.962	−0.203	0.845	.987
Abbottina rivularis (Basilewsky, 1855)	494	4.1	11.4	0.3	18.0	0.0037	0.0031–0.0046	3.464	3.363–3.565	.967	−0.087	0.839	.997
Saurogobio dabryi Bleeker, 1871[b]	99	4.3	17.4	0.7	38.2	0.0116	0.0086–0.0155	2.805	2.682–2.928	.980	0.004	0.847	.994
Rhodeus sinensis Günther, 1868[b]	946	2.5	5.5	0.1	2.2	0.0086	0.0043–0.0172	3.282	2.791–3.772	.857	−0.015	0.799	.981
Rhodeus ocellatus (Kner, 1866)[c]	630	3.1	8.1	0.1	7.3	0.0031	0.0021–0.0045	3.883	3.640–4.126	.907	−0.147	0.828	.976
Acheilognathus chankaensis (Dybowski, 1872)[c]	2,184	3.2	13.5	0.1	44.8	0.0098	0.0079–0.0120	3.176	3.079–3.273	.920	−0.350	0.854	.977
Acheilognathus barbatulus Günther, 1873[a,b]	13	5.5	7.8	1.9	6.3	0.0056	0.0021–0.0148	3.384	2.876–3.891	.951	0.135	0.789	.933
Cobitidae													
Cobitis sinensis Sauvage & Dabry de Thiersant, 1874	12	5.8	10.7	1.1	7.6	0.0047	0.0010–0.0230	3.137	2.347–3.927	.940	−0.494	0.932	.997
Misgurnus anguillicaudatus (Cantor, 1842)	87	4.7	21.9	0.5	122.0	0.0028	0.0019–0.0040	3.299	3.141–3.458	.955	−0.025	0.874	.992

(Continues)

TABLE 1 (Continued)

Family/species	N	TL (cm) Min	TL (cm) Max	W (g) Min	W (g) Max	LWR parameters a	95% CL of a	b	95% CL of b	r^2	LLR parameters p	q	r^2
Paramisgurnus dabryanus Dabry de Thiersant, 1872[c]	10	7.5	21.5	2.7	58.0	0.0066	0.0041–0.0109	2.963	2.760–3.165	.993	−0.356	0.905	.999
Bagridae													
Tachysurus fulvidraco (Richardson, 1846)[b]	227	3.5	21.7	0.4	114.0	0.0088	0.0073–0.0106	3.105	3.029–3.180	.985	−0.348	0.876	.996
Pseudobagrus vachellii (Richardson, 1846)[b]	7	13.5	19.2	19.2	42.8	0.0088	0.0036–0.0214	3.015	2.694–3.336	.967	−0.354	0.853	.998
Tachysurus nitidus (Sauvage & Dabry de Thiersant, 1874)[c]	103	5.1	40.8	0.9	226.2	0.0088	0.0058–0.0132	2.926	2.769–3.083	.959	0.129	0.827	.995
Pelteobagrus ussuriensis (Dybowski, 1872)	44	14.3	31.3	24.3	154.5	0.0083	0.0034–0.0201	3.040	2.732–3.348	.955	−0.227	0.886	.968
Siluridae													
Silurus asotus Linnaeus, 1758[b]	53	8.0	52.0	3.5	1,001.4	0.0084	0.0065–0.0107	2.908	2.822–2.994	.991	−0.389	0.926	.998
Eleotridae													
Micropercops cinctus (Dabry de Thiersant, 1872)	196	2.9	5.7	0.1	2.2	0.0079	0.0045–0.0140	3.246	2.871–3.622	.904	−0.118	0.866	.977
Gobiidae													
Rhinogobius giurinus (Rutter, 1897)	211	2.2	9.0	0.1	9.6	0.0072	0.0054–0.0097	3.261	3.078–3.444	.932	0.057	0.817	.988
Mastacembelidae													
Mastacembelus aculeatus (Bloch, 1786)	11	9.2	14.3	1.4	6.3	0.0019	0.0002–0.0150	3.097	2.232–3.962	.879	−0.170	0.970	.997

N, sample size; TL, total length; *W*, weight; Min and Max, minimum and maximum total length and weight; LWR, length–weight relationship; LWR, length–length relationship; *a*, intercept of the LWR; *b*, slope of the LWR; *p*, intercept of the LLR; *q*, slope of the LLR; r^2, coefficient of determination; CL, confidence limits.
[a]Species with no length–weight information in FishBase up to October 2016 (Froese & Pauly, 2016).
[b]Species with no length–length information in FishBase up to October 2016 (Froese & Pauly, 2016).
[c]New maximum length record in FishBase up to October 2016 (Froese & Pauly, 2016).

of SL = $p + q$TL (Hossain et al., 2006). Coefficients of determination (r^2) and the 95% confidence limits (CL) were also estimated. The parameters and statistical analyses were performed using SPSS 22.0 software.

3 | RESULTS

Overall, a total of 9,754 individuals from 26 species belonging to 7 families were collected and analyzed. Sample size (N), total length and body weight range, parameters of LWRs and LLRs, and the correlation coefficient (r^2) are shown in Table 1. All LWRs and LLRs were statistically significant ($p < .001$). The b value of LWRs ranged from 2.805 for *Saurogobio dabryi* Bleeker, 1871 to 3.883 for *Rhodeus ocellatus* (Kner, 1866). Coefficients of determination (r^2) of LWRs ranged from 0.857 for *Rhodeus sinensis* Günther, 1868 to 0.993 for *Paramisgurnus dabryanus* Dabry de Thiersant, 1872. The q value of LLRs ranged from 0.789 for *Acheilognathus barbatulus* Günther, 1873 to 0.970 for *Mastacembelus aculeatus* (Bloch, 1786); all coefficients of determination (r^2) of LLRs were greater than 0.930. Compared with the information in FishBase (Froese & Pauly, 2016), LWR references for 1 species and LLRs for 11 species are reported here for the first time, and new maximum total lengths are also presented for six species.

4 | DISCUSSION

The biological characteristics for many Yellow River fish species have seldom been reported, especially for fish species in the tributaries. To the best of our knowledge, this is the first report of the LWRs and LLRs for these fish species from the Yiluo River. In the present study, b values of 25 species remained within the expected range of 2.5–3.5 (Froese, 2006), except *Rhodeus ocellatus* (3.883). It has been suggested that the narrow length-range might have had an influence on the LWR parameter values (Froese, Tsikliras, & Stergiou, 2011). In *Rhodeus ocellatus*, the special b value could probably be due to the narrow length-range (3.1–8.1 cm). In conclusion, our study provides significant baseline information on the LWRs and LLRs of 26 fish species from the Yiluo River, results which will be useful for fishery management and conservation in the Yiluo River and the Yellow River ecosystems, as well as providing valuable information for the online FishBase database.

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