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TECHNICAL CONTRIBUTION

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Length–weight relationship of 12 fish species from the Lhasa River and surrounding area in Tibet, China

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Summary

Presented are the relationship between standard length (SL) and weight (W) for 12 fish species in Tibet, China, representing three families and six genera from the Lhasa River. All fish samples were collected by either electro-shocker (12 V, 200 Hz), fish cages (mouth opening: 40 × 40 cm^2, 5 m), or drift gillnets (3 × 1.5 m; mesh-size: 3 cm to 8 cm) from different areas in the Lhasa River Basin, August and September 2015. Parameter *b* ranged from 2.88 to 3.29, and all correlation coefficient (r^2) values were higher than 0.95. Length–weight relationships (LWRs) for three of the species as well as one maximum length are first reports for FishBase.

1 | INTRODUCTION

Lhasa River (90°05′–91°09′E; 28°20′–30°15′N) drains an area of 32,471 km^2, and is the biggest tributary of the Yarlung Zangbo River. Located north of Lhasa City, the Lhasa River is approximately 551 km in length, with an average basin altitude of about 4,500 m (Chen & Chen, 2010). In previous studies (Chen & Chen, 2010), the fish specimens collected in the Lhasa River mainly belonged to the Schizothoracinae, Nemacheilinae, and Sisoridae families (Bureau of Aquatic Products, Tibet, China, 1995). These indigenous fishes grow slowly, and their relatively late sexual maturity is due to the special geographic and environmental characteristics of the area, such as low water temperatures, low dissolved oxygen, and diet shortages (Sun, Yao, Cheng, & Chen, 2016; Zhou, Li, Pan, Zhaxilamu, & Li, 2013). Native fishery resources declined sharply because of increasing anthropogenic disturbances, including exotic fish invasions, overfishing, habitat degradation, and water pollution (Tang et al., 2013). Some exotic fish species successfully established populations in Tibet, resulting in sharply-rising populations and thus affecting aquatic biodiversity (Chen & Chen, 2010). Because of their low numbers and/or narrow body size range, six exotic species were not considered in this study. However, two dominant exotic fish species (*Hypseleotris swinhonis* and *Pseudorasbora parva*) were given special attention.

Length–weight relationships (LWR) are used extensively in fishery research and management (Lei, Chen, Tao, Xiong, & Chen, 2015). Mainly used to estimate the condition of the fish, standing stock biomass, and conversion of growth-in-length equations to growth-in-weight, the LWRs are useful for between-region comparisons of the life histories of species (Froese, Tsikliras, & Stergiou, 2011; Goncalves et al., 1997; Moutopoulos & Stergiou, 2002; Torres, Ramos, & Sobrino, 2012). This paper describes the LWRs of 12 species sampled in the Lhasa River, Tibet, China.

2 | MATERIALS AND METHODS

Fish samples were collected using either a fish electro-shocker (12 V, 200 Hz), fish cages (mouth opening: 40 × 40 cm^2, 5 m), or drift gill-nets (3 × 1.5 m; mesh-size: 3 cm to 8 cm) from different areas (pools, wetlands, rivulets and shallow branches) in the Lhasa River Basin from August to September 2015. The standard length (SL) was measured to the nearest 0.01 cm with a digital caliper, and the body weight was determined using a digital balance with an accuracy of 0.01 g. The collected fishes were then placed in 15% formalin for further identification in the laboratory. The specimens were identified and verified according to Fauna Sinica (Chen, 1998; Chu, Zheng, & Dai, 1999; Wu & Zhong, 2008; Yue, 2000), FishBase (Froese & Pauly, 2016), and the fishes of the Qinghai–Xizang Plateau (Wu & Wu, 1992).

The LWRs for all specimens were calculated using the formula $W = aL^b$, where W is the body weight (g), L is the standard length (cm), coefficient a is the intercept, and coefficient b is the slope (Ricker, 1973). The statistical significance level of the correlation coefficient (r^2) was estimated, and the fitted parameters a and b were estimated via the linear regression of the log-transformed equation as $\log W = \log a + b \log L$. Outliers were identified by the log-log plot and omitted from analyses (Froese, 2006; Zar, 1984). To determine whether the hypothetical value of isometry (3) fell within these limits, the 95% confidence limit (CL 95%) of a and b was calculated (Froese, 2006). All statistical analyses were performed using the Originpro 9.1 software and Excel (Microsoft Office 2007).

3 | RESULTS

The twelve fish samples belonged to three families and six genera. The species, sample size, minimum, maximum, and LWR parameters,

TABLE 1 Descriptive statistics and estimated parameters of standard LWRs ($W = aL^b$) for 12 species caught in Lhasa River and surrounding areas, August–September 2015

			Standard length (cm)		Weight (g)		Length–weight relationship parameters				
Family	Species	*n*	Min	Max	Min	Max	*a*	95% CI of *a*	*b*	95%CI of *b*	r^2
Cyprinidae	*Pseudorasbora parva* (Temminck & Schlegel, 1846)[e]	26	3.11	6.53	0.47	4.03	0.0078	0.0066–0.0090	3.29	3.14–3.44	0.972
	Oxygymnocypris stewartii (Lloyd, 1908)	17	13.61	29.90	55.47	394.45	0.0112	0.0056–0.0168	3.09	2.93–3.25	0.968
	Schizopygopsis younghusbandi Regan, 1905	50	4.00	27.32	0.13	250.20	0.0123	0.0108–0.0138	3.01	2.97–3.04	0.993
	Schizothorax macropogon Regan, 1905	29	11.50	35.07	24.93	825.03	0.0128	0.0078–0.0178	3.12	3.00–3.22	0.975
	Schizothorax oconnori Lloyd, 1908	35	7.90	35.30	6.65	593.04	0.0206	0.0184–0.0228	2.88	2.85–2.91	0.996
	Schizothorax waltoni Regan, 1905	21	8.32	19.72	9.01	112.57	0.0142	0.0103–0.0181	3.01	2.91–3.11	0.988
Cobitidae	*Triplophysa microps* (Steindachner, 1866)[a]	28	5.54	**10.73**	1.10	6.95	0.0045	0.0031–0.0059	3.09	2.94–3.24	0.956
	Triplophysa orientalis (Herzenstein, 1888)	27	3.70	7.92	0.53	4.13	0.0061	0.0047–0.0075	3.18	3.06–3.30	0.975
	Triplophysa stenura (Herzenstein, 1888)	27	3.92	10.03	0.38	9.38	0.0060	0.0041–0.0079	3.17	3.02–3.32	0.954
	Triplophysa stewarti (Hora, 1922)[a]	25	3.28	5.23	0.45	1.54	0.0089	0.0069–0.0109	3.08	2.93–3.23	0.956
	Triplophysa tibetana (Regan, 1905)[a]	50	3.48	13.92	0.43	30.13	0.0085	0.0071–0.0099	3.11	3.04–3.18	0.986
Eleotridae	*Hypseleotris cinctus* (Dabry de Thiersant, 1872)[e]	25	2.53	4.00	0.28	1.21	0.0141	0.0131–0.0171	3.11	2.94–3.28	0.963

n, sample size; min, minimum length or minimum weight; max, maximum length or maximum weight; *a* and *b*, parameters of the equation; CL 95%, 95% confidence limits; r^2, coefficient of determination.
[a]No references on length–weight relationships in FishBase database.

CL 95% of parameters *a* and *b*, and r^2 values are presented in Table 1. The *b* value of the LWRs ranged from 2.88 (*Schizothorax oconnori*) to 3.29 (*Pseudorasbora parva*). The r^2 ranged from 0.954 (*Triplophysa orientalis*) to 0.996 (*Schizothorax oconnori*). The first reports on length–weight relationships in FishBase for three species (*Triplophysa microps*, *Triplophysa tibetana*, *Triplophysa stewarti*) are marked with an asterisk (*) in Table 1. New maximum lengths for one species (*Triplophysa microps*) are marked in bold in Table 1. LWRs for two exotic species are denoted with an [e] in Table 1.

4 | DISCUSSION

The absence of LWRs for the Triplophysa and Schizothoracinae species from this area was noted based on the information from FishBase (Froese & Pauly, 2016). In this report, the values of parameter *b* all remained within the expected values of 2.5 and 3.5 (Froese, 2006; Huo et al., 2012). Moreover, all regressions were highly significant ($p < .005$), and the r^2 for all LWRs was higher than .95. Thus, we considered our results to be adequate estimations of LWRs. By comparing our results to the Bayesian LWR predictions in FishBase, most LWR parameter estimates came within the expected range for fishes with this body shape and within the respective Genus (Froese & Pauly, 2016; Froese, Thorson, & Reyes, 2014). However, the b value for *P. parva* did not fall within the predicted range, but was near the confidence intervals found by the Bayesian method, meaning that this was still not significantly different.

According to the Red List of China's Vertebrates (2016), two endemic species (*S. waltoni*, *S. macropogon*) are categorized as vulnerable and one (*Oxygymnocypris stewartii*) is listed as endangered (Jiang et al., 2016). The estimated *b* values for *Schizothoracinae* species were slightly higher or lower than the predicted *b* value as compared to the Bayesian LWR approach in FishBase. Additionally, the results of an LWR study of *Schizothoracinae* species in Niyang River (Liu, Ye, & Li, 2016), Yarlung Zangbo River (Huo et al., 2015), or even in the same place (Fan, Zhang, & Pan, 2015) likewise differed from those of the present study. Differences in *b* values can result from several factors, including the number and length range of specimens, habitat, seasonality, gonad maturation, health, stomach fullness, and growth phase (Freitas-Souza, Nobile, Lima, Britto, & Nogueira, 2016; Froese, 2006; Sharma et al., 2016; Tesch, 1971), which were not considered in the present study. LWRs for three *Triplophysa* species are reported for the first time according to FishBase (Froese & Pauly, 2016). The maximum length of *T. microps* in our study (standard length: 10.73 cm) is more than the maximum length recorded (total length: 6.8 cm) in FishBase (Froese & Pauly, 2016). No previous LWR parameter estimates for *T. tibetana* and *T. stewarti* were available in Fish Base (Froese & Pauly, 2016).

Pseudorasbora parva (Temminck and Schlegel, 1846) and *Hypseleotris swinhonis* (Dabry de Thiersant, 1872) are small, freshwater fishes and both highly invasive species. Moreover, the high phenotypic plasticity of *P. parva* in terms of biological traits, such as growth, early maturity, fecundity, and reproductive behavior (Gozlan et al., 2010), leads to their easy invasion of new environments, a phenomenon that has aroused extensive attention all over the world, whereby *P. parva* have dispersed throughout the water courses of China. We therefore compared their *b*-value and body length range in different regions. The *b* value of *P. parva* ($b = 3.29$) is higher than other specimens in our study and is also higher than in the same species from the Lhasa River Basin, Tibet ($b = 3.09$) (Fan et al., 2015), the Ergis River in Xingjiang ($b = 3.09$) (Huo et al., 2012), and the Tian-e-zhou oxbow of the Yangtze River ($b = 3.12$) (Wang, Wang, Sun, Huang, & Shen, 2012). Maximum values of the *P. parva* body length in Tibet, relative to their counterparts in the eastern region, are smaller (Yang & Li, 1989; Han & Li, 1995; Wang et al., 2012; Chen & Zhu, 2013; Li, Xu, & Huang, 2014; Huang et al., 2014), which might be affected by numerous factors such as season, length range, geography, or environmental conditions. The causes of the difference in values of *b* require further studies.

In conclusion, our study provides supplementary data and basic information on the fish population in Lhasa River. Such information will be helpful for subsequent fishery research and management, especially the conservation and restoration of indigenous fishes and for the control of exotic fishes in Tibet.

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