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Short Communication

Length-Weight Relationships of 8 Plateau Indigenous Fishes of Xinjiang, China

Liwei Xia, Xinyue Wang, Chengxin Wang, Fangze Zi, Jianmin Ge, Yong Song and Shengao Chen*

College of Life Science and Technology, Tarim University, Tarim Research Center of Rare Fishes, Alar 843300, China

Liwei Xia and Xinyue Wang contributed equally to this study and share first authorship.

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Authors' Contribution
SC and LX presented the concept. SC managed funding acquisition. YS and SC provided resources and supervised the project. CW, XW, LX and SC wrote the manuscript. LX designed experiments, analysed and interpreted data. XW collected samples. CW and XW analysed data analysis. FZ and JG performed data curation and investigation. All authors agreed to the final version of manuscript.

Key words
LWRs, *Schizothorax, Triplophysa*, Plateau indigenous fishes, Ichthyology

ABSTRACT

In this study, the length and weight of eight fish species from Xinjiang, China, were measured, the length-weight relationships (LWRs) were analyzed, and growth status was evaluated. A total of 274 samples were collected by trawl nets (set gill nets) and ground bamboo cages with net diameters of 15-20 mm and 25-30 mm, respectively. In the present study, the LWRs were determined for eight species of plateau fish and the *b*-values for the eight species ranged from 2.672-3.320, which were all within the expected range of 2.5-3.5. The results of the study provided reference values for the *b*-values of *Schizothorax irregularis,* and we measured the maximum length of *Schizothorax biddulphi*. The statistical relationships between the length and weight of these eight fish species were highly significant ($p < 0.01$), with r^2 values > 0.819.

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The seven rivers from where samples are collected are situated in Xinjiang, Northwest China, and serve as major tributaries of the Tarim, Ili, and Kashgar River systems. Xinjiang, located in the interior of Asia, is far from any ocean and shares borders with many countries, including India, Pakistan, Afghanistan, and Russia. The region is characterized by a typical arid climate. The rivers of Xinjiang originate from the Tianshan, Altay, Karakorum, and Kunlun Mountains and the Pamir Plateau. Each river flows in mountainous areas (Guo *et al*., 2012). Therefore, the special geographical location has formed a unique fishery resource and environment, nurturing rare fish species unique to the plateau region. As the population increases and water resource and development and utilization expand in the northwest, the ecological environment of rivers has deteriorated, making it increasingly difficult for an increasing number of fish to survive and reproduce. Although of high conservation value, basic biological data, such as the length-weight relationships (LWRs) of fish, remain scarce. Therefore, there is an urgent need to study the basic biology of fisheries and provide valuable information for the conservation of highland fish resources.

The study of relationship between length and weight (LWRs) provides information about the growth of fish, their general health and the health of their habitats (Jisr *et al*., 2018; Morato *et al*., 2001; Mouludi-Saleh and Keivany, 2018). These studies provide valuable information about the growth pattern, general health status, habitat conditions, life history, obesity degree and quality of fish, as well as their morphological characteristics (Schneider *et al*., 2000; Froese, 2006).

Materials and methods

Data were collected from eight sites using gill nets and ground-based bamboo cages from March 2016 to October 2019 (Table I). Five kinds of *Schizothorax* fishes (16 *Schizothorax biddulphi*, 42 *Gymnodiptychus dybowskii*, 27 *Schizothorax irregularis,* 35 *Diptychus maculatus,* and 35

* Corresponding author: shengao@taru.edu.cn
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Schizothorax pseudaksaiensis), two kinds of *Triplophysa* fishes (25 *Triplophysa zamegacephala* and 60 *Triplophysa microphysa*) and 34 *Perca schrenkii* were collected (Table II). Each sample's standard length (SL) was measured to an accuracy of 0.01 cm, and the precision of body weight (BW) was 0.01 g. The relationships between length and weight are expressed as follows: $W = a \times L^b$, where W is the weight (BW, g), L is the standard length (SL, cm), *a* is the intercept, and *b* is the allometric growth coefficient. Following Froese (2006), before the regression analysis of BW on SL, the ln-ln diagram of length and weight was used to inspect the abnormal values visually, and the extreme values were excluded from the regression analysis. The statistical significance level of r^2 was estimated. All data analysis was carried out using SPSS 18.0 (SPSS Inc.) and Origin 8.0.

Results and discussion

Analysis of 274 samples of eight kinds of fish was performed. Table II gives the sample size, size range (cm, TL, G, and BW), longitudinal relationships parameters a, b, and r^2, and 95% confidence limits of a and b. The statistical relationships between the length and weight of all eight species were highly significant ($p < 0.001$), and the r^2 value was > 0.819. The value of parameter b remained within the expected range of 2.762-3.320 (Froese, 2006). According to the LWRs predictions (Froese *et al*., 2014), the estimated values of the a and b parameters of the eight species of fish in this study were consistent with the prediction results and showed high significance for the body length-weight relationships ($p<0.01$). Length-weight relationships parameters may vary between seasons and are influenced by factors such as maturity, temperature, salinity, acquired food and food utilization (Sui *et al*., 2015; Asadi *et al*., 2017).

The b-value can be used to judge the growth state of fish. The *b*-values ranged from 2.762 (*Triplophysa microphysa*) to 3.320 (*Diptychus maculatus*), with *b*-values remaining within the expected range of 2.5-3.5 (Froese, 2006). *T*-tests of the *b*-values of eight species of

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Table I. Sampling sites of eight fish species in Northwest China.

Species	Sampling sites	Sampling time	Fishing gear	Latitude	Longitude
Schizothorax biddulphi (Günther, 1876)	Kizilsu River	2019.05	Set gill nets	39.49′ - 39.50′N	75.31′ - 75.35′E
Gymnodiptychus dybowskii (Kessler, 1874)	Akezi River	2019.05	Ground bamboo cages	42.90′ - 42.91′N	81.11′ - 81.12′E
Schizothorax irregularis (Day, 1876)	Yarkand River	2016.03	Set gill nets	40.44′ - 40.45′N	80.81′ - 80.82′E
Diptychus maculatus (Steindachner, 1866)	Taxkorgan River	2019.05	Set gill nets	37.85′ - 37.86′N	75.40′ - 75.41′E
Schizothorax pseudaksaiensis (Herzenstein,1889)	Tekes river	2019.05	Set gill nets	42.95′ - 43.09′N	81.30′ - 81.64′E
Triplophysa microphysa (Fang, 1935)	Aksu river	2016.09	Set gill nets	40.50′ - 40.51′N	80.77′ - 80.78′E
Triplophysa zamegacephala (Zhao, 1985)	Gaiz river	2017.07	Ground bamboo cages	39.29′ - 39.31′N	75.90′ - 75.92′E
Perca schrenkii (Kessler, 1874)	Tekes river	2018.05	Ground bamboo cages	42.91′ - 42.94′N	80.64′ - 80.90′E

Table II. Descriptive statistics and estimated parameters of LWRs ($W = a \times L^b$) for eight fish species from Northwest China.

Species	n	r^2	SL (cm)	BW (g)	a	b	95% CI of a	95% CI of b
Schizothorax biddulphi (Günther, 1876)	16	0.975	7.90 - 65.80	4.78 - 1352.20	0.008	3.198	0.0066-0.0094	3.1268-3.2351
Gymnodiptychus dybowskii (Kessler, 1874)	42	0.944	4.55 - 23.75	0.97 - 89.55	0.011	3.008	0.0102-0.0125	2.8780-2.9463
Schizothorax irregularis+ (Day, 1876)	27	0.819	15.40 - 50.60	101.00-1658.90	0.014	3.158	0.0125-0.0168	3.0971-3.2000
Diptychus maculatus (Steindachner, 1866)	35	0.965	14.65 - 23.75	23.37 - 85.74	0.002	3.320	0.0020-0.0023	3.3096-3.3605
Schizothorax pseudaksaiensis (Herzenstein,1889)	35	0.970	15.45 - 64.87	90.61-7650.00	0.023	3.097	0.02167-0.0251	3.0703-3.1195
Triplophysa microphysa (Fang, 1935)	60	0.906	6.80 - 13.03	2.26 - 18.74	0.012	2.762	0.0119-0.0127	2.7521-2.7851
Triplophysa zamegacephala (Zhao, 1985)	25	0.907	5.05 - 6.71	1.55 - 3.96	0.011	3.071	0.0108-0.0116	3.0597-3.1011
Perca schrenkii (Kessler, 1874)	34	0.944	4.95 - 20.74	2.0 - 285.5	0.025	3.100	0.0240-0.0278	3.0697-3.1427

n denotes the number of analyzed specimens, SL denotes the standard length, BW denotes the body weight, a is the coefficient of proportionality, b is the allometric coefficient, CI is the confidence limit, r^2 is the coefficient of determination, and + denotes a lack of LWR data in FishBase.

fish with 3 (Pauly, 1984; Froese, 2006) indicated the *b*-values of *Schizothorax biddulphi*, *Diptychus maculates*, *Schizothorax pseudaksaiensis*, *Triplophysa microphysa*, and *Triplophysa zamegacephala* were significantly different from 3 ($p < 0.05$). Among them, the b-value of *Triplophysa microphysa* was < 3, which indicates a negative allometric growth pattern. The *b*-values of *Schizothorax biddulphi*, *Diptychus maculates*, *Schizothorax pseudaksaiensis*, and *Triplophysa zamegacephala* were > 3, which indicates a positive allometric growth pattern. Notably, the b-value differed within *Triplophysa microsa* (Bhat *et al*., 2010). The sampling location and number of samples in this study were similar to those in the study of *Triplophysa microphysa* by Bhat *et al*. (2010) but the sampling time was different. Therefore, it can be speculated that the difference in *b*-values may be due to the different sampling times leading to different sexual maturities of the samples. Studies have shown that there is a large difference in the b-value between young and adult fish and between females and males (Chen *et al*., 2018; Haniffa *et al*., 2006; Hossain *et al*., 2012; Sheikh and Ahmad, 2018). The study found that the species in this study had *b*-values that differed from those in other studies (Huo *et al*., 2012; Zhang *et al*., 2016; Sui *et al*., 2015; Chen *et al*., 2018), and that the same species of fish had different *b*-values in different ecological environments, and this difference could be attributed to a combination of one or more of the following factors: (a) differences in the number of specimens tested, (b) differences in fish habitat environment, (c) sex, (d) seasonal effects, and (e) differences in the observed length range of the specimens (Froese, 2006; Hossain *et al*., 2009; Sani *et al*., 2010; Borah *et al*., 2018). In addition, the b-value of *Schizothorax irregularis* was calculated to enrich the information in the fish database in this study. This study provides basic information on the LWRs of eight plateau indigenous fish species from Xinjiang rivers. These results have important implications for the conservation of biodiversity and sustainable management of endemic fish population resources in Xinjiang.

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Ethics statement

This research was conducted in accordance with ethics committee procedures of animal experiments.

Statement of conflict of interest

The authors have declared no conflict of interest.

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