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LENGTH-WEIGHT RELATIONSHIPS OF 18 FISH SPECIES FROM LAKE KUILEI, YANGTZE RIVER BASIN, CHINA

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Abstract: This study is based on monthly sampling (from April 2013 to April 2015) of 18 fish species representing three families. Samples were obtained using benthic fyke-nets, block nets, and multi-mesh gillnets in Lake Kuilei, a shallow lake of the Yangtze River basin, China (N 31º24′ , E 120º51′). Using ordinary least-squares linear regression, length-weight relationships of these fish species were estimated, with equations for 3 species reported for the first time. The maximum total length records of the 15 species exceeded those reported in FishBase. This paper provides new LWR equations for these species to be included in FishBase.

Key words: Growth; Length-weight relationships; Shallow lake; Lake Kuilei

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Length-weight relationships (LWRs) are extremely important aspects of fisheries biology[1, 2]. These relationships are often reported from the parameters from regression equations or mathematical power functions. These equations are used for many miscellaneous purposes including stock assessment, routine monitoring, and as components of fisheries management programs[3]. Equations also provide necessary data for comparing life-history characteristics of fishes from different areas or habitats[4—6].

The Yangtze River is the third largest river in the world. There are many freshwater lakes distributed along the Yangtze River basin, which cumulatively account for about 60% of the total surface area of all of the freshwater lakes in China[7]. Historically, these lakes were connected directly or indirectly with the Yangtze River main stem, forming a series of potamo-lacustrine ecosystems that were highly unique in China[8]. These lakes are typically shallow, do not thermally stratify, have abundant vegetation, and exhibit relatively high biological productivity and fish diversity[9, 10]. Because of the important ecological functions that these potamo-lacustrine ecosystems serve and their high levels of biodiversity, the World-Wide Fund for Nature (WWF) has designated the Yangtze River and its adjacent lakes as one of the Global 200: Priority Ecoregions for Global Conservation[11].

Knowledge about the biological characteristics of fishes resident to these shallow Yangtze River lakes is still very limited[12, 13]. Previous reports on LWR equations have been largely focused on large-body fish species of commercial interest or from reaches in the upper basin[14—17]. On the other hand, LWR information of smaller-bodied fishes is relatively scarce, with little literature available. To address this information gap, intensive fish sampling was conducted in the lower reaches of the Yangtze River basin where by 18 fish species were collected and analyzed to estimate length-weight relationships. These analyses also included 3 species that had not previous published LWR equations.

1 Materials and Methods

The study was conducted at Lake Kuilei (N 31º24′, E 120º51′) in Jiangsu Province of Eastern China. This lake has a surface area of 670 ha and an

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average depth of 2.74 m. This lake is characteristic of shallow lakes in the lower Yangtze River basin, and also is a drinking water source for Kunshan City. The physico-chemical characteristics of the lake were monitored from April 2013 to April 2015 and are presented in Tab. 1.

Tab. 1 The mean, standard deviation (±SD) and range of the physico-chemical parameters monitored in Lake Kuilei

Parameters	Mean±SD	Range
Water temperature (℃)	18.84±7.93	6.78—27.70
Secchi depth (cm)	69.78±13.86	54.00—96.75
pH value	8.25±0.22	7.97—8.73
Conductivity (μS/cm)	492.52±5.54	453.01—549.23
Dissolved oxygen (mg/L)	9.97±2.13	6.02—12.79
Total nitrogen (mg/L)	1.11±0.25	0.70—1.73
Total phosphorus (mg/L)	0.06±0.05	0.02—0.17
Chlorophyll *a* (μg/L)	4.79±1.89	2.85—9.99

Fishes were sampled monthly from April 2013 to April 2015 using benthic fyke-nets (long 15 m, stretched mesh size 0.4 cm), multi-mesh gillnets (long 30 m, high 1.5 m, stretched mesh size ranging from 1.0—12.5 cm), and block nets (stretched mesh size 4 cm). The benthic fyke-nets and block nets were deployed between AM 8:30 and 10:30 hours, and the catches from the end pockets were collected after 24 hours; The multi-mesh gillnets were deployed at PM 18:00, and were collected at AM 6:00 next day. All the fishes collected were placed into plastic bags, labeled, refrigerated, and later identified and analyzed. In the laboratory, sampled fish specimens were identified to species level following Chen (1998) and Ni (2005) and enumerated[18, 19]. Total length to the nearest 0.1 cm somatic weight to the nearest 0.01 g were measured. All scientific names of fishes were checked against FishBase[6]. The relationship between body weight and total length was calculated using the equation: $W=aL^b$, where W is the body weight (g), L is the total length (cm), a is the regression intercept parameter and b is the regression slope parameter. Outliers were identified and excluded according to the method of Froese (2006), with 95% confidence limits of a and b estimated using a bootstrapping procedure based on 1000 iterations.

2 Results

The length and weight measures of 15864 specimens representing 18 species were used to estimate length-weight relationships. All statistical descriptions of LWR parameters for each species are provided in Tab. 2. Records in FishBase[6] indicates this study provides new LWR records for 3 species denoted with * in Tab. 2. Sample sizes ranged from 33 (*Taenioides cirratus*) to 1821 (*Toxabramis swinhonis*). Coefficients of determination r^2 were all high, ranging from 0.910 (*Hemiculter leucisclus*) to 0.995 (*Sarcocheilichthys sinensis*). Estimates of b ranged from 1.6678 (*T. cirratus*) to 3.3780 (*T. swinhonis*), and averaged 3.0183 (Tab. 2). Maximum lengths of 15 species exceeded the FishBase records and are shown in bold type in Tab. 2.

3 Discussion

Compared to estimates contained in FishBase[6], no LWR information was available for *Microphysogobio microstomus*, *S. sinensis* and *T. cirratus*. In addition, revised (i.e., greater) maximum total lengths are presented for 15 species, including *Paracheilognathus imberbis*, *Acheilognathus macropterus*, *Sarcocheilichthys nigripinnis*, *Hemibarbus maculates*, *Odontobutis obscura*, *Culter mongolicus*, *Pseudorasbora parva*, *Pseudobrama simoni*, *T. swinhonis*, *Paracanthobrama guichenoti*, *Acheilognathus chankaensis*, *Hemiculter leucisclus*, *Cultrichthys erythropterus*, *Rhinogobius giurinus* and *Micropercops swinhonis*. The present study indicated that b estimates for all species except *T. cirratus* fell within the range of 2.5—3.5[3], which is normal for the vast majority of freshwater fishes. Although *T. cirratus* had an estimated b of 1.6678, the aberrant value was probably due its small, elongated shape. Additionally, there are some differences in b estimates calculated from the present study compared to other authors[12, 16, 17, 20—23] for 10 other fishes. These species included *P. imberbis*, *H. swinhonis*, *H. leucisclus*, *P. simoni*, *S. nigripinnis*, *T. swinhonis*, *P. Parva*, *P. guichenoti*, *C. erythropterus* and *A. chankaensis*. However, these b estimates for these 10 species are in general agreement with other studies, which suggest that the b parameter may be affected by factors such as habitat, length ranges used, sex, stomach fullness, sample size, diet, preservation techniques, and annual differences in environmental conditions[3, 16, 24, 25]. In the present study, we were not able to account for these factors in our estimations.

In conclusion, this study successfully provided new and revised information on LWRs for 18 fish species from the Yangtze River basin, which should be useful for sustainable utilization, management, and protection of fishery resources in lower Yangtze River lakes of China.

Tab. 2 Length-weight relationships for 18 fish species collected Lake Kuilei, China during 2013—2015

Family/Species	N	Total Length (cm)		Body Weight (g)		Regression parameters				
		Min.	Max.	Min.	Max.	*a*	95% CL*a*	*b*	95% CL*b*	r^2
Cyprinidae										
*Microphysogobio microstomus**	1213	2.1	9.0	0.08	9.43	0.0088	0.0088—0.0089	2.9376	2.9289—2.9416	0.915
Paracheilognathus imberbis	545	2.4	**7.8**	0.12	5.01	0.0070	0.0070—0.0071	3.1649	3.1590—3.1723	0.953
Acheilognathus macropterus	1642	5.1	**14.4**	1.44	38.73	0.0076	0.0076—0.077	3.2101	3.2043—3.2145	0.967
Sarcocheilichthys nigripinnis	174	2.5	**13.3**	0.12	22.64	0.0096	0.0108—0.0114	2.9760	2.8924—2.9186	0.982
Hemibarbus maculates	553	11.3	**38.1**	11.51	546.90	0.0064	0.0064—0.0065	3.0851	3.0834—3.0881	0.979
*Sarcocheilichthys sinensis**	64	2.3	20.0	0.10	108.70	0.0068	0.0067—0.0072	3.2169	3.1943—3.2478	0.995
Culter mongolicus	1309	8.9	**65.3**	4.24	2127.0	0.0062	0.0062—0.0064	2.9912	2.9879—2.9940	0.949
Pseudorasbora parva	713	2.6	**13.4**	0.09	31.15	0.0103	0.0103—0.0105	2.8713	2.8649—2.8784	0.965
P. simoni	186	10.8	**21.3**	11.46	112.97	0.0027	0.0027—0.0028	3.3488	2.7859—2.8774	0.949
Toxabramis swinhonis	1821	5.5	**17.8**	0.76	36.68	0.0021	0.0020—0.0021	3.3780	3.3729—3.3780	0.918
Paracanthobrama guichenoti	470	3.89	**38.5**	0.37	704.83	0.0039	0.0038—0.0039	3.2992	3.2938—3.3001	0.992
A. chankaensis	1323	2.2	**10.0**	0.10	11.20	0.0095	0.0095—0.0097	3.0780	3.0688—3.0824	0.974
Hemiculter leucisclus	808	9.76	**27.3**	0.59	153.62	0.0076	0.0076—0.0079	2.9432	2.9391—2.9495	0.910
Cultrichthys erythropterus	1491	4.2	**30.3**	0.45 0.45	231.87	0.0033	0.0033—0.0034	3.2425	3.2459—3.2491	0.991
Gobiidae										
*Taenioides cirratus**	33	3.7	20.4	0.41	9.34	0.0641	0.0635—0.0696	1.6678	1.6091—1.6811	0.976
Rhinogobius giurinus	1558	1.1	**7.4**	0.10	4.13	0.0093	0.0094—0.0096	2.9761	2.9960—3.0368	0.946
Eleotridae										
Odontobutis obscura	715	2.4	**29.0**	0.17	186.8	0.0092	0.0092—0.0094	3.1241	3.1202—3.1296	0.990
Micropercops swinhonis	1246	2.3	**6.6**	0.11	2.63	0.0129	0.0129—0.0131	2.8186	2.8151—2.8166	0.927

Note: *N* = number of individuals; Min. = minimum value; Max. = maximum value; *a* = estimated intercept; *b* estimated slope; CL = 95% confidence limits estimated from bootstrapping procedure; r^2 = coefficients of determination; *No reference in FishBase; New maximum total length (values marked in bold)

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傀儡湖18种鱼类全长与体重关系研究

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摘要: 为了了解中国长江中下游湖泊——傀儡湖(N 31º24′, E 120º51′)鱼类生长的特性, 于2013年4月至2015年4月利用地笼、多网目复合刺网和网簖等工具对该水域鱼类进行了月度调查。共捕获鱼类18种, 隶属于3科, 主要以鲤科鱼类为主。运用最小二乘法对这18种鱼类的全长和体重的回归关系进行拟合, 其中3种鱼类全长与体重的回归方程为首次拟合。此外, 15种鱼类的最大全长超过世界鱼类数据库(FishBase)中记录的最大全长。研究提供的鱼类全长与体重回归方程及其参数填补了世界鱼类数据库的空白。

关键词: 生长; 长度-质量关系; 浅水湖泊; 傀儡湖