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Short Communication

Length-Weight Relationships for Thirty Fish Species in Lake Niushan, a Shallow Macrophytic Yangtze Lake in China

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Abstract

Length-weight relationships are presented for 30 fish species captured from April 2002 to January 2004 in Lake Niushan, China. The values of the exponent b in the length-weight relationships ($W=aL^b$) ranged from 2.845 to 3.435 and the median of b was 3.103, whereas 50% of the values ranged between 3.032 and 3.203. In the eight examined species, sexual dimorphism did not affect the length-weight relationships, except in the cases of *Siniperca chuatsi* and *Cultrichthys erythropterus*. The application of the length-weight relationships presented here should be limited to the observed length ranges.

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Introduction

Length-weight relationships are extensively used in fisheries researches and are useful for (1) calculating the weight of a given individual fish of known length or total weight of fish from length-frequency distribution; (2) estimating age structure, weight growth rate, and several other aspects of fish population dynamics; (3) converting growth-in-length equations to growth-in-weight equations for use in stock assessment models; (4) estimating indices of condition of fish in a given geographical area; and (5) making between-region comparisons of life histories and morphology of certain species (Kohler et al. 1995; Petrakis and Stergiou 1995; Anderson and Neumann 1996; Moutopoulos and Stergiou 2000; Stergiou and Moutopoulos 2001).

In this study we describe length-weight relationships for 30 fish species in Lake Niushan, which is one of the numerous lakes distributed along the middle and lower reaches of the Yangtze River, China. These lakes are typically shallow with dense submerged aquatic macrophytes and are highly productive (Liu 1984; Xie and Chen 1996). Historically, they were interconnected to the main stream or the branches of the Yangtze River, thus forming a potamo-lacustrine complex ecosystem. The frequent exchanges of nutrients and the complement of habitats between lentic and lotic waters provided favorable conditions for the development of unique and complicated biota (Liang and Liu 1995). Fish species are abundant in these lakes -- generally 40~70 species or even more in some lakes (Fang et al. 1995; Huang and Xie 1996; Zhang et al. 1996; Song et al. 1999; Zhu 2004). Studies on fish population biology, including length-weight relationship, have been widely carried out in these lakes since the 1960's. However, most of these studies focused mainly on commercially important fish species, such as common carp *Cyprinus carpio*, bighead carp *Aristichthys nobilis*, silver carp *Hypophthalmichthys molitrix*, crucian carp *Carassius auratus*, mandarin fish *Siniperca chuatsi*, topmouth culter *Culter alburnus* and so on. Very few published data on length-weight relationships are available for small forage fishes which are of low commercial values. Moreover, there is an urgent need to utilize and monitor the excessive forage fish resources in these Yangtze lakes, and this requires basic knowledge of population biology for the forage species (Xie et al. 2000).

The 30 fish species (Table 1) we included in the present study are all common and representative species in the middle and lower reaches of the Yangtze River. Among them, 15 species are targeted by local commer-

Table 1. Descriptive statistics and estimated parameters of the length-weight relationships for the 30 fish species collected in Lake Niushan during the period 2002-2004

Species	Sex	N	Length characteristics				Parameters of the relationship				*P*	Growth
			Mean	SE	Min.	Max.	a	b	SE (b)	r^2		type
Abbottina rivularis *	Both	187	6.07	0.078	3.1	10.4	0.0079	3.032	0.059	0.934		IS
Acheilognathus chankaensis *	Both	68	7.51	0.057	6.3	8.7	0.0091	3.127	0.132	0.895		IS
Aristichthys nobilis	Both	114	45.45	1.027	24.2	73.4	0.0061	3.167	0.032	0.989		PA
Carassius auratus	Both	1126	14.84	0.135	5.5	31.8	0.0120	3.100	0.010	0.989		PA
	Males	150	13.71	0.313	7.7	22.3	0.0110	3.127	0.023	0.992		
	Females	215	15.77	0.309	7.7	22.3	0.0125	3.087	0.021	0.990	0.1814	
Channa argus *	Both	383	35.12	0.465	11.3	70.0	0.0054	3.121	0.023	0.979		PA
	Males	32	37.73	0.895	28.4	51.7	0.0065	3.069	0.078	0.981		
	Females	33	37.44	0.771	30.6	47.0	0.0115	2.915	0.087	0.973	0.1863	
Ctenopharyngodon idellus	Both	243	42.33	0.651	15.2	78.2	0.0108	3.006	0.023	0.986		IS
Culter alburnus *	Both	413	46.42	0.632	23.9	104.4	0.0036	3.121	0.014	0.991		PA
Culter dabryi *	Both	51	31.27	1.266	13.9	45.8	0.0032	3.246	0.057	0.985		PA
Cultrichthys erythropterus	Both	780	17.30	0.132	5.2	33.2	0.0021	3.435	0.015	0.985		PA
	Males	90	16.72	0.256	13.5	25.4	0.0022	3.340	0.061	0.972		
	Females	105	19.32	0.266	13.6	25.5	0.0011	3.642	0.061	0.972	0.0059	
Cyprinus carpio	Both	315	46.05	0.784	12.4	82.3	0.0149	2.966	0.019	0.987		IS
	Males	67	47.27	0.882	38.2	70.3	0.0202	2.876	0.090	0.940		
	Females	59	54.86	1.291	37.9	70.4	0.0192	2.911	0.092	0.947	0.8791	
Hemiculter bleekeri *	Both	54	15.69	0.287	8.9	20.2	0.0060	3.059	0.173	0.857		IS

Table 1 (continued)

Species	Sex	N	Length characteristics				Parameters of the relationship				P	Growth
			Mean	SE	Min.	Max.	a	b	SE (b)	r^2		type
Hemiculter leucisculus *	Both	128	15.19	0.215	8.9	21.4	0.0077	2.948	0.086	0.904		IS
	Males	106	14.62	0.133	11.7	18.1	0.0113	2.827	0.123	0.835		
	Females	152	14.65	0.111	11.7	18.3	0.0104	2.863	0.093	0.864	0.8443	
Hyporhamphus intermedius *	Both	22	12.16	0.232	10.5	14.3	0.0020	2.866	0.197	0.914		IS
Hypophthalmich-thys molitrix	Both	96	39.70	0.791	15.2	64.1	0.0052	3.162	0.026	0.994		PA
Mastocembellus sinensis *	Both	84	16.65	0.301	10.5	24.2	0.0008	3.286	0.104	0.923		PA
Megalobrama amblycephala	Both	428	32.34	0.279	10.0	45.9	0.0066	3.203	0.019	0.986		PA
Micropercops swinhonis *	Both	64	4.54	0.092	2.5	6.1	0.0037	3.364	0.162	0.874		PA
Mylopharyngodon piceus	Both	18	63.38	3.406	43.6	83.6	0.0097	3.063	0.089	0.987		IS
Odontobutis obscura *	Both	412	13.07	0.100	7.8	19.0	0.0063	3.298	0.046	0.926		PA
Parabramis pekinensis	Both	79	29.56	0.861	9.9	41.6	0.0034	3.322	0.039	0.990		PA
Paracheilognathus imberbis *	Both	92	5.23	0.066	4.0	7.3	0.0101	2.982	0.062	0.963		IS
	Males	43	5.32	0.126	4.0	7.3	0.0101	2.994	0.063	0.982		
	Females	49	5.16	0.057	4.3	5.9	0.0119	2.872	0.130	0.912	0.4406	

Table 1 (continued)

Species	Sex	N	Length characteristics				Parameters of the relationship				P	Growth
			Mean	SE	Min.	Max.	a	b	SE (b)	r^2		type
Pelteobagrus fulvidraco *	Both	494	13.64	0.164	7.2	25.5	0.0158	2.845	0.028	0.954		NA
Pseudorasbora parva	Both	107	6.64	0.188	3.0	10.7	0.0074	3.081	0.037	0.985		PA
	Males	54	7.04	0.111	4.2	8.5	0.0068	3.112	0.081	0.966		
	Females	33	6.13	0.152	4.4	8.6	0.0088	3.046	0.092	0.973	0.3780	
Rhinogobius giurinus *	Both	27	4.60	0.163	3.0	6.2	0.0075	2.983	0.252	0.849		IS
Rhodeus ocellatus *	Both	44	4.49	0.070	3.5	5.7	0.0104	3.049	0.166	0.889		IS
Sarcocheilichthys nigripinnis *	Both	167	8.16	0.131	4.0	12.3	0.0066	3.145	0.041	0.973		PA
Silurus asotus *	Both	35	28.38	1.019	17.5	45.2	0.0019	3.325	0.118	0.960		PA
Siniperca chuatsi	Both	1072	26.00	0.219	10.0	66.1	0.0103	3.105	0.013	0.983		PA
	Males	187	24.78	0.410	17.0	43.6	0.0112	3.069	0.030	0.982		
	Females	189	26.16	0.408	16.5	44.0	0.0079	3.185	0.031	0.982	0.0113	
Toxabramis swinhonis *	Both	289	8.92	0.082	5.3	12.1	0.0061	2.845	0.057	0.897		NA
Xenocypris argentea	Both	51	14.17	0.209	10.8	18.0	0.0061	3.089	0.164	0.879		IS

N, sample size; Min. and Max., minimum and maximum total lengths in cm; a and b, the parameters of the length-weight relationship; SE, standard error; r^2, the coefficient of determination; *P*, the *P*-value for Student's *t*-test comparing the slopes of the regressions between males and females; IS, isometric; PA, positive allometric; NA, negative allometric; * , no L–W relationship information was found in FishBase (Froese and Pauly 2006).

cial fisheries, namely *A. nobilis, C. auratus, Channa argus, Ctenopharyngodon idellus, C. alburnus, Culter dabryi, Cultrichthys erythropterus, C. carpio, H. molitrix, Megalobrama amblycephala, Mylopharyngodon piceus, Parabramis pekinensis, Pelteobagrus fulvidraco, Silurus asotus,* and *S. chuatsi*; the other 15 species belong to small forage fishes. To our knowledge, no published data currently exists on the length-weight relationships of *Abbottina rivularis, Acheilognathus chankaensis, Hemiculter bleekeri, Hemiculter leucisculus, Hyporhamphus intermedius, Mastocembellus sinensis, Sarcocheilichtys nigripinnis* and *Toxabramis swinhonis* in the Yangtze region. In addition, no L–W relationship information was found for 18 species (marked with asterisk in table 1) in FishBase (Froese and Pauly 2006).

Materials and Methods

Lake Niushan (30°16-22′ N, 114°27-38′ E) is a shallow lake located on the south bank of the middle reach of the Yangtze River, in the Hubei Province, China. This lake, with a total area of 38 km^2 and a depth of 2.4-5.0 m, is heavily covered with submerged aquatic macrophytes. In the spring of 2003, the macrophyte coverage was 78% of the sediment surface and the macrophyte biomass was 1225 $g \cdot m^{-2}$ (Ye 2007).

Sampling took place in Lake Niushan from April 2002 to January 2004. Fish were captured using gill nets, weir nets, cormorants and electrofishing. Particular effort was exerted to collect small forage fishes and juveniles of some commercial fishes, by sampling seasonally (September 2002 to August 2003) with block nets (15-mm stretched mesh size).

Total length was measured to the nearest 0.1 cm. Individual weight was recorded to the nearest gram or with a precision balance to the nearest 0.1 gram whenever possible. The relationship between total length and weight ($W = aL^b$) was converted into its logarithmic expression: $\ln W = \ln a + b \ln L$. The parameters a and b were calculated by least-squares regression. Student's *t*-test at the 0.05 significant level was applied to verify if the b value for each species was significantly different from the isometric value 3. Student's *t*-test was also used to test for possible significant differences of slopes (b) between the males and females of eight species (Table 1), with the data collected during the breeding season (April to June 2003). The parameters a and b obtained from other geographical areas for some

species are available in FishBase (Froese and Pauly 2006), and are presented for comparison with the values from this study.

Results and Discussion

A total of 9007 individuals of the 30 fish species representing nine families were captured. Cyprinidae (21 species, 70% of the total number of species) was the predominant family. Sample descriptive statistics and estimated parameters of the length-weight relationship for the 30 species are summarized in table 1. The sample size ranged from 18 for *M. piceus* to 1126 for *C. auratus*. All regressions were highly significant ($P < 0.001$) and the r^2 values ranged from 0.849 to 0.994. The estimates of parameter b ranged from 2.845 for *P. fulvidraco* and *T. swinhonis* to 3.435 for *C. erythropterus*, with a mean value of 3.111 (SE = 0.026). The median of b was 3.103, whereas 50% of the values ranged between 3.032 and 3.203 (Figure 1).

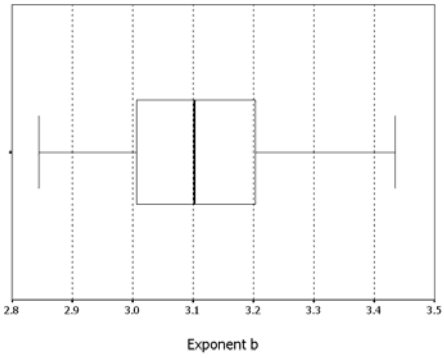

Fig. 1. Box-Whiskers plots of the exponent b of the length-weight relationships ($W=aL^b$) for the 30 fish species in Lake Niushan. The central box covers 50% of data values, the vertical line indicates the median, and the horizontal line represents the range of the values.

The exponent b often has a value close to 3, but varies between 2 and 4 (Tesch 1971). The value b=3 indicates that the fish grows symmetrically or isometrically; values other than 3 indicate allometric growth (Tesch 1971). The kind of growth was determined by Student's *t*-test. The results revealed that 12 species (40.0%) showed isometric growth, 16 species (53.3%) positive allometric growth, and two species (6.7%) negative allometric growth (Table 1).

During the breeding season, pronounced sexual dimorphism in length-weight relationship was observed for *S. chuatsi* and *C. erythropterus* with significant differences in the slopes (b) of length-weight relationships between males and females. No significant differences existed in

the slopes (b) between males and females in the other six examined species (Table 1).

For the 30 species, the data on length and weight are not representative of a particular season or time of year and were obtained throughout the year. Therefore, the length-weight relationships may be assumed to approximate an annual average. However, as a result of the size-selective characteristics of fishing gears the samples may not have included all available lengths. For more precise weight estimations through length-weight relationships, it is important to limit their application to the observed length ranges (Petrakis and Stergiou 1995).

The a and b values for *C. auratus*, *C. idellus*, *C. carpio*, *H. molitrix* and *P. parva* obtained from different geographical areas are presented in table 2. The observed differences in the values can be attributed to the combination of one or more of the following factors: (1) differences in environmental or habitat factors; (2) differences in the utilized length types and length ranges; and (3) differences in the number of specimen examined.

Table 2. Parameters a and b obtained from different geographical areas for five fish species. The utilized length types and length ranges are also given

Species	Geographical area	Length type	Length range (cm)	a	b
Carassius auratus	Alabama, USA[2]	TL	1.5 ~ 40.6	0.0295	2.900
	Lake Niushan, China[1]	TL	5.5 ~ 31.8	0.0120	3.100
	Enisey River, Russian Fed[2]	TL	9.0 ~ 28.0	0.0046	3.563
Ctenopharyngodon idellus	Zhujiang River, China[2]	SL	NA	0.0345	2.862
	Florida, USA[2]	TL	2.9 ~ 25.2	0.0121	3.002
	Lake Niushan, China [1]	TL	15.2 ~ 78.2	0.0108	3.006
	Heilongjiang River, China [2]	SL	NA	0.0178	3.047
	Culture ponds, Hong Kong, China [2]	TL	27.0 ~ 66.0	0.0057	3.108
Cyprinus carpio	Oliver Lake, Indiana, USA [2]	FL	29.3 ~ 76.5	0.0158	2.624
	Lake Volvi, Greece [2]	TL	7.8 ~ 18.1	0.0383	2.670
	Atrek River, Russian Fed [2]	FL	12.0 ~ 59.0	0.0250	2.937
	Lake Niushan, China [1]	TL	12.4 ~ 82.3	0.0149	2.966
	Mekong River, Laos [2]	FL	8.4 ~ 47.0	0.0214	3.012
	Nagano, Japan [2]	TL	31.5 ~ 57.0	0.0037	3.210
Hypophthalmichthys molitrix	Zhujiang River, China[2]	SL	NA	0.0215	2.970
	Heilongjiang River, China [2]	SL	NA	0.0137	3.093
	Lake Niushan, China [1]	TL	15.2 ~ 64.1	0.0052	3.162
Pseudorasbora parva	Lake Niushan, China [1]	TL	3.0 ~ 10.7	0.0074	3.081
	Lake Mikri Prespa, Greece [2]	FL	6.1 ~ 9.5	0.0078	3.270

TL, total length; SL, standard length; FL, fork length; NA, not available; a and b, the parameters of the length-weight relationship; [1]from this study; [2]from FishBase (Froese and Pauly 2006).

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