

LENGTH-WEIGHT RELATIONS OF 14 ENDEMIC FISH SPECIES FROM THE UPPER YANGTZE RIVER BASIN, CHINA

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Abstract. Length–weight relations were estimated for 14 endemic fish species of the upper Yangtze River, namely *Sinogastromyzon szechuanensis* Fang, 1930; *Jinshaia sinensis* (Sauvage et Dabry de Thiersant, 1874); *Megalobrama pellegrini* (Tchang, 1930); *Coreius guichenoti* (Sauvage et Dabry de Thiersant, 1874); *Rhinogobio cylindricus* Günther, 1888; *Rhinogobio ventralis* (Sauvage et Dabry de Thiersant, 1874); *Procypris rabaudi* (Tchang, 1930); *Ancherythroculter kurematsui* (Kimura, 1934); *Ancherythroculter nigrocauda* Yih et Wu, 1964; *Acrossocheilus monticola* (Günther, 1888); *Leptobotia elongata* (Bleeker, 1870); *Hemiculterella sauvagei* Warpachowski, 1888; *Hemiculter tchangi* Fang, 1942; and *Xenophysogobio boulengeri* (Tchang, 1929). The *a* values obtained ranged from 0.006 to 0.023, and *b* values ranged from 2.955 to 3.377. The *t*-test results indicated the first seven species grew isometrically and the other 7 species grew allometrically.

Keywords: Length–weight relations, LWR, endemic fish, upper Yangtze River

The Yangtze River is the third longest in length- and ninth largest river in the world. The upper Yangtze River flows from Yibin to Yichang with a length of 1040 km and more than 50 tributaries joining the mainstream. Because of its meteorological, hydrological, physiographical, and geological diversity, the basin is characterized by pronounced habitat heterogeneity and considered a biodiversity hot spot for fish conservation (Dong 2003). There are about 286 species and subspecies including 124 endemic species distributing in the upper Yangtze basin (He et al. 2011).

In fish biology, length and weight are two basic morphological traits at the individual- as well as at the population level. The weight of fishes is closely related to their length, and there are three somatic growth types for most fish species: isometric (all fish dimensions increase at the same rate), positive allometric (a fish increases more in weight than predicted by its increase in length) and negative allometric (a fish increases less in weight than predicted by its increase in length) (Froese et al. 2011). Length–weight relation (LWR) has been used widely for fishery management and conservation. It provides information on the condition factor and somatic growth type (isometric or allometric) of fish species (Le Cren 1951, Bagenal and Tesch 1978, Bolger and Connolly 1989). It enables the calculation of individual weight from its

length, estimating age structure, weight growth rate, and stock assessment. This relation has also been used for comparison of species growth between sexes, different seasons and regions (Froese 2006). Up to now, LWRs of 3584 species can be checked in FishBase (Froese and Pauly 2012)

Our current knowledge on the biological traits of Chinese freshwater fishes is still very limited (Fu et al. 2003). In particular, LWRs are only known for some commercially important fishes such as: *Cyprinus carpio* L.; *Carassius auratus* (L.); *Ctenopharyngodon idella* (Valenciennes, 1844); etc. In this study, we estimated the LWR parameters for 14 endemic fish species collected from the upper Yangtze River and its tributaries. Also, to the best of our knowledge, this study presents the first reference on the LWRs worldwide for these species.

The collections were made periodically between October 2011 and July 2012 in the mainstream of the upper Yangtze River and its seven tributaries. Three types of fishing gear were used in the sampling course, gill net (1.5, 4, 5, and 5.5 cm mesh), trap, and longline hooks. Sampled fish were identified to species according to references (Ding 1994, Yue 2000), and then measured to the nearest 0.1 cm standard length (*L*), weighed (*W*) with a digital balance with the accuracy of 0.1 g. Length and weight data were pooled together in each species without

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sexing or discrimination as to sampling sites and time. A log–log plot of data was done for all species; outliers were identified and removed (Froese 2006). The parameters a and b of relations of the form

$$W = aL^b$$

were estimated through a logarithmic transformation (Tesch 1971, Cone 1989), i.e.,

$$\log W = \log a + b \log L$$

Intercept a and slope b were estimated by ordinary least squares regression and 95% confidence limits of a and b were calculated. The b -value was tested by t -test to check whether the growth of each species is isometric ($b = 3$), positive allometric ($b > 3$) or negative allometric ($b < 3$).

A total of 3782 specimens covering 2 families, 10 genera, and 14 species were caught from upper Yangtze River and its tributaries. The species studied were: *Sinogastromyzon szechuanensis* Fang, 1930; *Jinshaia sinensis* (Sauvage et Dabry de Thiersant, 1874); *Megalobrama pellegrini* (Tchang, 1930); *Coreius guichenoti* (Sauvage et Dabry de Thiersant, 1874); *Rhinogobio cylindricus* Günther, 1888; *Rhinogobio ventralis* (Sauvage et Dabry de Thiersant, 1874); *Procypris rabaudi* (Tchang, 1930); *Ancherythroculter kurematsui* (Kimura, 1934); *Ancherythroculter nigrocauda* Yih et Wu, 1964; *Acrossocheilus monticola* (Günther, 1888); *Leptobotia elongata* (Bleeker, 1870); *Hemiculterella sauvagei* Warpachowski, 1888; *Hemiculter tchangi* Fang, 1942; and *Xenophysogobio boulengeri* (Tchang, 1929). Thirty two outlines were excluded according to the log–log plot, and regressions were made for a total of

3750 individual fish specimens. The species name, sample size (n), length and weight ranges, intercept a , slope b , 95% confidence interval of a and b , coefficient of determination (r^2), growth type and t -test value were summarized in Table 1.

The sample size ranged from 57 individuals for *Acrossocheilus monticola* to 670 for *Coreius guichenoti*. *Procypris rabaudi* recorded the highest maximum length of 49.0 cm followed by *Megalobrama pellegrini* (40.5 cm), *Leptobotia elongata* (34.7 cm) and *C. guichenoti* (34.5 cm). Overall, the values for the intercept (a) remained within the range of 0.007–0.023. The values of b rose from 2.955 in *Xenophysogobio boulengeri* to 3.377 in *Rhinogobio ventralis*. The majority of LWRs were highly significant with the coefficient of determination greater than 0.93. But the r^2 value for *A. monticola* was a bit low (0.863); part of the reason may be the small sample size. Seven of fourteen species showed positive allometric growth ($b > 3$, $P < 0.05$), namely *Sinogastromyzon szechuanensis*, *Megalobrama pellegrini*, *Coreius guichenoti*, *Rhinogobio ventralis*, *Ancherythroculter nigrocauda*, *Hemiculterella sauvagei*, and *Hemiculter tchangi*. The other seven species (*Jinshaia sinensis*, *Rhinogobio cylindricus*, *Procypris rabaudi*, *Ancherythroculter kurematsui*, *Acrossocheilus monticola*, *Leptobotia elongata*, and *Xenophysogobio boulengeri*) grew isometrically.

The somatic growth of fishes is influenced by a number of factors such as sex, gonad maturity, growth phase, season, and stomach fullness (Tesch 1971). These factors were not accounted for in the presently reported study. In

Table 1

Length–weight relations of fishes captured in the upper Yangtze River

Species	n	Length [cm]		Weight [g]		Parameters of LWR					Growth type	t -test ($H_0: b = 3$)	
		Range	Mean	Range	Mean	a	95% CI of a	b	95% CI of b	r^2		t -value	P -value
<i>S. sze</i>	173	3.0–9.8	5.2	0.6–20.1	3.9	0.016	0.014–0.018	3.189	3.104–3.274	0.970	p-AL	4.407	<0.001
<i>J. sin</i>	80	4.3–14.3	8.9	0.9–40.9	12.1	0.011	0.008–0.016	3.099	2.933–3.265	0.946	IS	1.181	>0.1
<i>M. pel</i>	117	4.0–40.5	12.8	0.9–435.4	73.6	0.013	0.011–0.014	3.181	3.127–3.235	0.992	p-AL	8.452	<0.001
<i>C. gui</i>	670	3.6–34.5	14.4	0.8–865.6	91.5	0.015	0.014–0.015	3.030	3.018–3.042	0.997	p-AL	4.665	<0.01
<i>R. cyl</i>	564	5.2–28.2	15.3	1.5–250.0	53.8	0.013	0.012–0.014	3.010	2.972–3.049	0.976	IS	0.502	>0.5
<i>R. ven</i>	282	3.0–23.4	16.1	0.2–253.9	91.7	0.007	0.006–0.007	3.377	3.328–3.425	0.985	p-AL	15.141	<0.001
<i>P. rab</i>	151	3.8–49.0	17.3	1.9–2550.0	238.4	0.023	0.017–0.032	3.014	2.895–3.133	0.943	IS	0.230	>0.5
<i>A. kur</i>	436	5.2–20.3	13.5	2.2–143.1	36.7	0.014	0.012–0.016	2.990	2.937–3.044	0.965	IS	0.360	>0.5
<i>A. nig</i>	109	4.3–22.6	13.5	0.9–178.8	43.1	0.006	0.008–0.011	3.141	3.081–3.201	0.990	p-AL	4.620	<0.001
<i>A. mon</i>	57	8.0–15.5	11.7	13.6–100.3	42.8	0.018	0.009–0.040	3.137	2.803–3.471	0.863	IS	0.810	>0.1
<i>L. elo</i>	133	3.5–34.7	17.9	0.3–518.1	87.2	0.011	0.009–0.013	3.015	2.951–3.078	0.985	IS	0.462	>0.5
<i>H. sau</i>	217	5.8–13.6	10.7	2.0–42.2	17.9	0.006	0.005–0.008	3.308	3.187–3.428	0.931	p-AL	5.017	<0.001
<i>H. tch</i>	555	6.1–23.5	12.5	2.6–201.6	30.1	0.011	0.010–0.012	3.051	3.008–3.094	0.972	p-AL	2.320	<0.05
<i>X. bou</i>	206	2.6–13.4	7.2	0.3–50.0	8.1	0.019	0.017–0.021	2.955	2.897–3.013	0.980	IS	1.520	>0.1

Length = standard length; *S. sze* = *Sinogastromyzon szechuanensis*; *J. sin* = *Jinshaia sinensis*; *M. pel* = *Megalobrama pellegrini*; *C. gui* = *Coreius guichenoti*; *R. cyl* = *Rhinogobio cylindricus*; *R. ven* = *Rhinogobio ventralis*; *P. rab* = *Procypris rabaudi*; *A. kur* = *Ancherythroculter kurematsui*; *A. nig* = *Ancherythroculter nigrocauda*; *A. mon* = *Acrossocheilus monticola*; *L. elo* = *Leptobotia elongata*; *H. sau* = *Hemiculterella sauvagei*; *H. tch* = *Hemiculter tchangi*; *X. bou* = *Xenophysogobio boulengeri*; p-AL = positive allometric; IS = isometric.

addition, selective gear, small sampling size, and narrow length range could have biased and significantly influenced the parameter values of LWRs (Froese et al. 2011). In this study, sample size of most specie (except *Jinshaia sinensis* and *Acrossocheilus monticola*) were above 100, and measured individuals covered juveniles to adults, thus, the LWRs results of these 14 endemic fishes were credible and served as baseline data for endemic fishes management and conservation.

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