LENGTH–WEIGHT RELATIONS FOR 16 FRESHWATER FISH SPECIES (ACTINOPTERYGII: CYPRINIFORMES: CYPRINIDAE) IN THE HAN RIVER, SOUTH KOREA

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Abstract. Length–weight relations (LWRs) for 16 freshwater fish collected from June to October 2018 in the Han River, South Korea, were estimated. The following species, representing the family Cyprinidae, were studied: *Abbottina rivularis* (Basilewsky, 1855); *Acanthorhodeus chankaensis* (Dybowski, 1872); *Tanakia lanceolata* (Temminck et Schlegel, 1846); *Acheilognathus rhombeus* (Temminck et Schlegel, 1846); *Acheilognathus yamatsutae* Mori, 1928; *Carassius auratus* (Linnaeus, 1758); *Chanodichthys erythropterus* (Basilewsky, 1855); *Gnathopogon strigatus* (Regan, 1908); *Hemibarbus labeo* (Pallas, 1776); *Pseudogobio esocinus* (Temminck et Schlegel, 1846); *Pseudorasbora parva* (Temminck et Schlegel, 1846); *Pungtungia herzi* Herzenstein, 1892; *Sarcocheilichthys nigripinnis* (Günther, 1873); *Squalidus chankaensis* Dybowski, 1872; *Squalidus japonicus* (Sauvage, 1883); *Opsariichthys uncirostris* (Temminck et Schlegel, 1846). The values of parameter *b* for all species were within the expected 2.5–3.5 range according to Froese (2006). The LWRs data for two species in this study, *Acheilognathus rhombeus* and *Gnathopogon strigatus*, were not previously available in FishBase.

Keywords: LWRs, weight–length relations, WLRs

INTRODUCTION

Length–weight relations (LWRs) are used to estimate weight corresponding to a given length (Le Cren 1951, Froese 2006). LWRs has been used in fisheries research since the beginning of the 20th century (Froese 2006). LWRs studies constitute an important prerequisite in fisheries biological investigations, because, they can be used for various ecological studies, including evaluating fish condition, comparing fish growth among areas where has different habitat condition (Tesch 1968, Petrakis and Stergiou 1995, Koutrakis and Tsikliras 2003).

The Han River is one of the Korean major 4 rivers because of its economic, cultural, and historical importance. Furthermore, the Han River has the highest fish diversity among all Korean flowing waters (Yoon et al. 2018). Despite this importance, there were no LWRs data available for the Han River.

In this study, LWRs for 16 freshwater fish species which are abundant at the study site in the Han River, South Korea, were estimated to be listed in FishBase.

MATERIAL AND METHODS

The following species, representing the family Cyprinidae, were studied: *Abbottina rivularis* (Basilewsky, 1855); *Acanthorhodeus chankaensis* (Dybowski, 1872); *Tanakia lanceolata* (Temminck et Schlegel, 1846); *Acheilognathus rhombeus* (Temminck et Schlegel, 1846); *Acheilognathus yamatsutae* Mori, 1928; *Carassius auratus* (Linnaeus, 1758); *Chanodichthys erythropterus* (Basilewsky, 1855); *Gnathopogon strigatus* (Regan, 1908); *Hemibarbus labeo* (Pallas, 1776); *Pseudogobio esocinus* (Temminck et Schlegel, 1846); *Pseudorasbora parva* (Temminck et Schlegel, 1846); *Pungtungia herzi* Herzenstein, 1892; *Sarcocheilichthys nigripinnis* (Günther, 1873); *Squalidus chankaensis* Dybowski, 1872; *Squalidus japonicus* (Sauvage, 1883); *Opsariichthys uncirostris* (Temminck et Schlegel, 1846). Fishes were collected in the Han River (37°24′20.37″N, 127°32′13.77″E) using a cast net (mesh 7 mm) and fyke nets (mesh 4 mm) from June to October 2018. The total length (L) [cm] and body weight (W) [g] were measured immediately at the site of capture. The fishes were examined after being anesthetized using 0.1 $g \cdot L^{-1}$ ethyl 3aminobenzoate methanesulfonate

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salt (Sigma-Aldrich, Munich, Germany). The length and weight were determined using a digital caliper and a digital balance (MW II-6000N, CAS) to the nearest 0.1 cm and 0.1 g, respectively. After the examination and recovery, the fishes were released from the recovery tank (100 × 100 × 80 cm).

The LWR for each species was estimated by the regression equation

$$W = aL^b$$

where a and b are parameters of the equation (Le Cren 1951, Ricker 1973, Froese 2006). Before regression analysis, obvious outliers were removed by linear regression of the log-transformed equation (Froese 2006). Scientific names for all species and family assignments were based on Eschmeyer's Catalog of Fishes (Fricke et al. 2019).

RESULTS

LWRs of the 16 species were estimated and the results are presented in Table 1. A total of 3155 fish individuals were examined and their total length and body weight ranges are presented. Parameters a and b were estimated with 95% coefficient limits for each. Correlation of determination (r^2) was above 0.900 for all species. The values of parameter b for all species were within the expected 2.5–3.5 range according to Froese (2006). Also, the parameter b for all species except two species, *Acanthorhodeus chankaensis* and *Tanakia lanceolata*, were within the ranges from earlier studies listed in FishBase (Froese and Pauly 2019). The parameter a of *Squalidus japonicus* and *Chanodichthys erythropterus*, which has elongated body shape, were the lowest among 16 species and the a of *Carassius auratus*, which has the shortest and deep body shape in this study, were the highest.

DISCUSSION

Parameter b for all 16 species were above 3.0, which means that large specimens in the sample have increased in height or width more than in length (Froese 2006). However, it is difficult to say that they changed their body shape while growing up (allometric growth) since the sampling period includes their spawning season that the weight of adult individuals increases because of the eggs or gonads development.

In this study, the values of parameter b for two species, *A. chankaensis* and *T. lanceolata*, were not within the ranges from prior studies which are listed in FishBase (Froese and Pauly 2019). Nevertheless, we consider the b for those two species in this study are adequate because the LWRs equations for both species were calculated by using wide range length data which are large enough to include their whole life stage (from juvenile to adult) and also the number of specimens for both species are enough (Froese et al. 2011).

Parameter a is strongly associated with the body shape of fish. Froese (2006) introduced the 'form factor' which can be used to interpret the body shape of fish. However, the form factor needs numerous LWRs estimations of target species for accurate calculation since it needs the slope value of log$a$ vs. b regression analysis. Nevertheless, parameter a can be used to compare the body shape

Table 1

Descriptive statistics and estimated parameters of the length–weight relations for 16 freshwater cyprinid fish species in the Han River, South Korea

Species	N	Total length [cm]	Weight [g]	Regression parameters					
				a	95% CL of a	b	95% CL of b	r^2	b in FishBase
Abbottina rivularis	42	3.8–11.7	0.4–11.8	0.0051	0.0038–0.0068	3.233	3.093–3.373	0.981	2.960–3.590
Acanthorhodeus chankaensis	250	5.3–9.9	1.5–10.9	0.0106	0.0088–0.0129	3.020	2.926–3.114	0.941	3.457–3.500
Tanakia lanceolata	393	2.5–10.8	0.1–14.2	0.0080	0.0071–0.0089	3.165	3.109–3.221	0.969	2.920–3.010
Acheilognathus rhombeus	568	3.8–13.5	0.5–32.2	0.0095	0.0083–0.0108	3.107	3.038–3.175	0.932	—
Acheilognathus yamatsutae	359	4.7–10.3	0.9–12.6	0.0067	0.0058–0.0078	3.238	3.159–3.317	0.948	3.040
Carassius auratus	101	3.7–35.1	0.5–757.2	0.0125	0.0116–0.0136	3.084	3.049–3.120	0.997	2.732–3.336
Chanodichthys erythropterus	72	8.7–55.8	3.2–874.1	0.0044	0.0035–0.0055	3.033	2.967–3.099	0.992	2.723–3.397
Gnathopogon strigatus	36	4.7–10.3	1.0–11.6	0.0081	0.0048–0.0137	3.145	2.877–3.414	0.940	—
Hemibarbus labeo	313	4.5–31.1	0.4–247.6	0.0056	0.0051–0.0063	3.117	3.064–3.170	0.977	2.950–3.170
Pseudogobio esocinus	69	5.4–17.4	1.0–40.2	0.0059	0.0048–0.0071	3.038	2.956–3.121	0.987	2.980–3.160
Pseudorasbora parva	148	4.3–9.4	0.6–8.3	0.0069	0.0052–0.0091	3.149	3.003–3.294	0.925	2.900–3.370
Pungtungia herzi	58	3.7–15.6	0.3–46.3	0.0067	0.0045–0.0099	3.182	2.979–3.386	0.944	3.160–3.380
Sarcocheilichthys nigripinnis	339	4.0–12.8	0.5–24.6	0.0071	0.0063–0.0079	3.158	3.102–3.214	0.973	2.996–3.230
Squalidus chankaensis	49	4.5–10.2	0.7–10.4	0.0048	0.0026–0.0089	3.287	2.990–3.583	0.910	3.430
Squalidus japonicus	186	4.0–9.5	0.4–6.9	0.0044	0.0037–0.0052	3.279	3.190–3.368	0.966	3.160
Opsariichthys uncirostris	172	5.4–25.3	0.8–127.5	0.0063	0.0053–0.0075	3.022	2.945–3.098	0.972	3.020–3.190

between species with similar values of the parameter *b* (Froese 2006). In this study, there was a tendency for higher *a* in short and deep body shaped species. This result is because the values of parameter *b* for all species in this study were similar.

We provide the new LWRs data for two species, *Acheilognathus rhombeus* and *Gnathopogon strigatus*, which have not hitherto been available in FishBase (Froese and Pauly 2019). However, the number of specimens for *G. strigatus* is not high enough to estimate an adequate LWRs equation. Therefore, we recommend to use LWRs of this species from this study as baseline information for future studies.

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