SHORT COMMUNICATION

Length-weight relationship of ten species of Leuciscinae sub-family (Cyprinidae) from Iranian inland waters

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Abstract In this study, the length-weight relationships (LWRs) were estimated for 697 specimens belonging to ten species of Leuciscinae subfamily, viz. *Squalius berak*, *S. namak*, *S. turcicus, Acanthobrama marmid*, *A. microlepis*, *Chondrostoma esmaeilii*, *Leuciscus latus*, *Alburnus doriae*, *Leucaspius delineates* and *Blicca bjoerkna* from Iranian inland waters, including the Persian Gulf, Caspian Sea, Namak Lake, Dasht-e Kavir, Hari River and Isfahan basins. Total length and total weight of the examined specimens ranged 3.8-27.8 cm and 0.59-247 g, respectively. Fishes were collected using electrofishing device between July 2010 and August 2017. This study represents the first reports of LWRs data for *A. doriae*, *C. esmaeilii*, *L. latus* and *L. delineates*. The length-weight parameter *b* found to be 2.75 (*A. microlepis*) - 3.44 (*B. bjoerkna*) with regression coefficients (r^2) ranging 0.87 to 0.99 for the studied fishes. The student's t-test showed all studied species have a positive allometric growth pattern except *A. doriae* (isometric) and *A. microlepis* (negative allometric).

Introduction

Study of fish species and their populations are important to understand their biological aspects in order to optimal management of their resources (Jalili et al. 2015; Mouludi-Saleh et al. 2017). The length-weight relationship (LWR) of fishes is applied and important tool to estimate the weight of a specimen from its length and vice versa, to estimate the biomass, evaluation of fish stocks, ontogenetic changes and growth studies (Kumolu-Johnson and Ndimele 2010; Mouludi-Saleh and Keivany 2018; Jafari-Patcan et al. 2018; Mouludi-Saleh and Eagderi 2019). Based on the latest checklist of freshwater fishes of Iran, a total of 297 species have been reported from Iranian inland water basins (Esmaeili et al. 2018), with Leuciscinae including 25 species. Since biological data of fishes such as LWR is important for both fishery biology and taxonomic studies for proper management and conservation (Oscoz et al. 2005), hence, this study was conducted to determine LWRs of the ten species of the subfamily Leuciscinae from Iranian inland waters.

Materials and methods

A total of 64 specimens of *Squalius berak*, 86 *S. turcicus*, 49 *S. namak*, 12 *Leuciscus latus*, 11 *Chondrostoma esmaeilii*, 9 *Acanthobrama marmid*, 11 *A. microlepis*, 28 *Alburnus doriae*, 17 *Leucaspius delineatus* and 392 *Blicca bjoerkna* were collected between July 2010 and August 2017 using electrofishing device (SAMUS MP750) (Table 1).

Specimens were preserved in 10% buffered formalin after anesthesia, and transported to the fisheries laboratory of University of Tehran (Iran). The total length (TL) and body weight of each specimen were

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Table 1 Data of sampling stations

Spices	River	Basin	Latitude	Longitude
Squalius berak Heckel, 1843	Khersan	Persian Gulf	31°14'36"N	50°59'27"E
	Choman	Persian Gulf	36°01'41"N	45°57'48"E
	Bane	Persian Gulf	35°54'31"N	45°56'36"E
	Gaveh	Persian Gulf	34°53'45"N	47°23'42"E
Squalius turcicus De Filippi, 1865	Tajan	Caspian Sea	36°12'13"N	53°05'10"E
	Talar	Caspian Sea	36°11'74"N	53°00'92"E
	Balekhlo-Chay	Caspian Sea	38°00'46"N	47°58'24"E
	Kheyr	Caspian Sea	36°36'35"N	51°33'45"E
	Sefid	Caspian Sea	36°53'42"N	49°30'55"E
	Siyah	Caspian Sea	36°26'39"N	52°53'43"E
Squalius namak Khaefi, Esmaeili, Sayyadzadeh, Geiger & Freyhof, 2016	Ghareh-Chai	Namak Lake	34°52'48"N	50°02'16"E
	Mazlaghan-Chay	Namak Lake	35°06'50"N	49°40'39"E
	Nam	Dasht-e Kavir	35°42'41"N	52°40'19"E
Leuciscus latus Keyserling, 1861	Hari	Hari River	35°56'49"N	61°08'59"E
Chondrostoma esmaeilii Eagderi, Jouladeh-Roudbar, Sungur Birecikligil, Çiçek & Coad, 2017	Sarab-e Ravansar	Persian Gulf	32°42'47.60"N	46°39'20"E
Acanthobrama marmid Heckel, 1843	Dinevar	Persian Gulf	36°01'29"N	49°28'07"E
Acanthobrama microlepis (De Filippi, 1863)	Sefid	Caspian Sea	36°01'29"N	49°28'07"E
Alburnus doriae De Filippi, 1865	Toof-Sefid	Isfahan	32°29'03"N	50°10'58"E
Leucaspius delineatus (Heckel, 1843)	Sefid	Caspian Sea	32°29'1.77"N	50°11'0.87"E
Blicca bjoerkna (Linnaeus, 1758)	Aras	Caspian Sea	39°07'19.61"N	46°52'7.54"E

measured using digital calipers and an electronic balance to the nearest 0.01 mm and 0.01 g, respectively. The length-weight relationship was determined by the method of least squares using the equation of $W = aL^b$ and logarithmically transformed into $\log W = \log a + b \log L$ (Froese 2006), where W is the total body weight (g), L is the total length (cm) and "a" is the intercept and "b" is the slope.

Prior to regression analyses, log-log plots of the length-weight pairs were performed to identify outliers (Froese et al. 2011). Outliers perceive in the log–log plots of all species were removed from the regression. The degree of correlation between the variables was computed by the determination coefficient "r^2". The significance level of r^2 was estimated by ANOVA. The student's t-test (ts) was used to determine whether the parameter b is significantly different from the expected or theoretical value of 3 (i.e. b = 3, P<0.05). All statistical analyses were performed in Excel 2016.

Results and discussion

The length-weight relationship data of fish species is an important parameter in estimating the length and age structure of its dynamic population, playing a key role in fisheries assessments. In addition, it can provide information regarding the storage population, age at maturity, life cycle, mortality, and type and rate of the growth (Sorosh Hadad et al. 2018). In the current study, LWRs of 697 fishes of Leuciscinae belonging to ten species were calculated with the first reports of LWR data for *A. doriae*, *C. esmaeilii*, *L. latus* and *L. delineates*.

The results showed b-values of the studied species ranging 2.75-3.44 and regression coefficients (r^2) of 0.87 to 0.99 (Table 2). The b parameter was 3.14 for *S. berak*, 3.09 for *S. namak*, 3.17 for *S. turcicus* 3.11 for *L. latus*, 3.37 for *C. esmaeilii*, 3.29 for *A. marmid*, 2.75 for *A. microlepis*, 3.04 for *A. doriae*, 3.35 for *L. delineates* and 3.44 for *B. bjoerkna*. The values of b parameter in LWRs falls between 2.5 and 3.5 (Froese 2006) or 2-4 (Tesch 1971). In this study, b-values of the studied fish species were within these expected ranges.

In length-weight relationships (LWRs), a b-values which higher and lower than 3 indicated positive

Table 2 Descriptive statistics and length-weight relationship parameters for ten species of Leuciscinae from different basins of Iran during 2010–2017.

Species	N	Total length (cm) Min	Max	Weight (g) Min	Max	a	b	r^2	95% CL of b	95% CL of a	Growth pattern
S. berak	64	5.42	19.02	1.74	99.13	0.009	3.14	0.99	3.06-3.21	0.008-0.011	A$^+$
S. namak	49	8.21	16.62	6.38	66.56	0.010	3.09	0.96	2.93-3.25	0.007-0.015	A$^+$
S. turcicus	86	3.8	15.62	0.59	53.43	0.007	3.17	0.99	3.12-3.23	0.006-0.008	A$^+$
L. latus	12	7.45	16.25	9.12	50.01	0.0072	3.11	0.97	2.97-3.12	0.0031-0.0154	A$^+$
C. esmaeilii	11	9.7	13.65	12.05	43.82	0.0059	3.37	0.94	2.9-3.37	0.0004-0.018	A$^+$
A. marmid	9	4.85	15.49	0.98	58.9	0.007	3.29	0.99	2.55-3.83	0.002-0.053	A$^+$
A. microlepis	11	9.19	12.59	9.81	21.39	0.019	2.75	0.87	2.44-2.77	0.006-0.06	A$^-$
A. doriae	28	7.7	14.15	4.45	26.3	0.009	3.04	0.96	2.76-3.23	0.005-0.016	I
L. delineatus	17	6.03	8.75	1.69	6.47	0.0042	3.35	0.96	3.12-3.78	0.0019-0.006	A$^+$
B. bjoerkna	392	13.7	27.8	26	247	0.013	3.44	0.96	3.22-3.48	0.004-0.09	A$^+$

N = number of individuals; Min = minimum; Max = maximum; a = intercept; b = slope; CL = confidence limits; r^2 = correlation coefficient; I = isometric, A$^+$ = positive and A$^-$ = negative allometric growth pattern.

and negative allometric, respectively. Based on the results, allometric growth pattern was positive for *S. berak*, *S. namak*, *S. turcicus*, *C. esmaeilii*, *A. marmid*, *L. latus*, *L. delineates* and *B. bjoerkna*, isometric for *A. doriae* and negative for *A. microlepis*. The parameter *b*-value of the previously studied *Squalius* species of Iran reported to be 3.14 to 3.37 (3.14 for *S. berak*, 3.25, *S. namak* and 3.37 for *S. turcicus*) (Mouludi-Saleh and Keivany 2018). In Totkabon River (Caspian Sea basin, Iran), *b*-value for *A. microlepis* has been reported to be 2.429 (Zamani-Faradonbe et al. 2015). Asadi et al. (2017) reported a *b*-value of 3.001 for *A. microlepis* from the Shahrbijar River, Southern Caspian Sea basin, Iran. The length-weight relationship parameters may be changed between different seasons and are affected by factors such as size, temperature, maturity, salinity and availability of food. Furthermore, the degree of the sexual maturity, diet, fullness or emptying gut and sampling techniques, number and duration of sampling can affect its value (Yildrim et al. 1998; Wootton 2003; Abbasi et al. 2019). In conclusion, this study provides the first report of LWR data for *A. doriae*, *C. esmaeilii*, *L. latus* and *L. delineates*, and added further data to those previously reported species and can be used as baseline for future studies.

Conflict of interest The authors declare that they have no conflict of interest.

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