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Short Communication

Length–weight relationship and condition factor of ten cyprinid fish species from the Caspian Sea, Urmia Lake and Persian Gulf basins of Iran

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Abstract
In this study, the length-weight relationships (LWRs) and condition factor (*K*) were estimated for 1334 specimens belonging to ten species including *Acanthobrama marmid*, *A. microlepis*, *A. urmianus*, *Romanogobio persus*, *Leuciscus aspius*, *Luciobarbus capito*, *L. mursa*, *L. caspius*, *Alburnus atropatenae* and *Petroleuciscus ulanus* from the Caspian Sea, Urmia Lake and Persian Gulf basins of Iran. The total length and weight of the individuals varied from 3.4 to 84.5 cm and 0.4 to 6600 g respectively. The values of the slope parameter (*b*) and condition factor ranged from 2.99 – 3.38 and 0.79 – 1.25 respectively. LWRs with high correlation coefficients were calculated for all species (R^2 > 0.95). Based on the results, the allometric growth pattern of the studied species were positive except for *L. aspius*, *L. capito*, *L. mursa* and *P. ulanus*. This study provides useful data regarding the LWRs and condition factor of ten fish species in Iranian inland waters that can be used in fisheries management, stock assessment and future studies.

Keywords: Caspian Sea; correlation coefficients; Iranian inland waters; LWRs; Persian Gulf; Urmia Lake.

1 | INTRODUCTION

Length–weight relationship (LWR) is an important tool in fisheries biology (Sarkar *et al.* 2008) and ecology (Froese 2006) with several applications such as converting length into biomass, calculating the standing crop biomass, stock assessment, investigation of ontogenetic changes, assessment of the population dynamics, understanding the life cycle traits (e.g. condition factor, mortality and growth), comparing the growth rate and its pattern in different populations (Goncovales *et al.* 1997; Fafioye and Oluajo 2005; Froese 2006; Alam *et al.* 2012; Jafari-Patcan *et al.* 2018, Mouludi-Saleh and Keivany 2018; Yadav and Dhanze 2018; Mouludi-Saleh and Eagderi 2019; Abbasi *et al.* 2019). Condition factor (*K*) is used to assess well-being of fishes under different conditions, including physiological, climatic and environmental circumstances hence, it can be affected by many parameters, including nutritional quality, aquatic system (rivers or lakes) and seasonal changes (Nikolski 1969; Mouludi-Saleh and Eagderi 2019). However, study on the biological features of the endemic species is important for their conservation due to their limitation in specific habitats (Almaca 1984).

Based on the above-mentioned importance of LWR and *K* parameters of the endemic fish species, this study was aimed to provide LWR and *K* data of ten fish species, viz. *Acanthobrama marmid* Heckel, 1843, *A. microlepis* (De Filippi, 1863), *A. urmianus* (Günther, 1899), *Romanogobio persus* (Günther, 1899), *Leuciscus aspius* Linnae-

us, 1758, *Luciobarbus capito* (Güldenstaedt, 1773), *L. mursa* (Güldenstaedt, 1773), *L. caspius* (Berg, 1914), *Alburnus atropatenae* Berg, 1925 and *Petroleuciscus ulanus* (Günther, 1899) from the Caspian Sea, Urmia Lake and Persian Gulf basins of Iran.

2 | METHODOLOGY

From May 2010 to August 2017, a total of 1334 specimens of ten fish species were collected from the Caspian Sea, Urmia Lake and Persian Gulf basins (Table 1) by electrofishing, cast net, beach seine and gill net. Specimens were preserved in 10% buffered formalin after anaesthesia, and transferred to the laboratory for further studies. The total length (TL) and total weight were measured using digital callipers to the nearest 0.05 mm and 0.01 g respectively. Using a plotted power function, the growth relationship between total length and weight estimated as $W = a\ TL^b$ (Froese 2006) with 95% confidence limits of the constants ("*a*" and "*b*") and logarithmically transformed into $LogW = Loga + bLogL$ (Froese *et al.* 2011). Where *W* is the total body weight (g), *L* is the total length (cm), *b* is the regression coefficient and *a* is the intercept of the regression. 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. $b = 3$, $p < 0.05$). Condition factor was calculated according to Fulton (1904) and Froese (2006) using $K = W / L^3 \times 100$ formula, where *W* is the weight of fish (g) and *L* is the total length (cm). All statistical analyses were performed in Excel 2016 and PAST (version 2.17b).

3 | RESULTS

The regression coefficient (*b*), intercept (*a*), 95% confidence limits of the constants *a* and *b*, correlation coefficient (R^2) of the LWRs and *K* of these fish species are shown in Table 2. The results showed that *b*-values of the studied species varied from 2.99 (*L. capito*) to 3.38 (*A. atropatenae*), and R^2 values were high (0.95 – 0.992, $p < 0.001$). The *K* of the studied species ranged between 0.79 (*A. marmid* and *P. ulanus*) and 1.25 (*L. caspius*).

4 | DISCUSSION

The LWRs of the fish species were for those species belonging to new localities or basins. In LWRs, *b*-values of falls between 2.5 and 3.5 (Froese 2006) or 2 – 4 (Tesch 1971), showing that they are within these expected ranges. *b*-values higher and lower than 3 indicated positive and negative allometric respectively. Based on the results, allometric growth pattern of the studied species was positive except for *L. aspius*, *L. capito*, *L. mursa* and *P. ulanus* that were isometric.

TABLE 1 Description of the sampling sites in the present study during 2010–2017.

Species	Locality	*N*	Basins	Geographical coordinates
Acanthobrama marmid	Gamasiab River	88	Persian Gulf	48°02′01″N 34°20′14″E
Acanthobrama microlepis	Aras River	8	Caspian Sea	44°56′10″N 39°28′56″E
	Ghezel-Ozan River	27	Caspian Sea	49°28′57″N 37°28′56″E
	Sefid River	63	Caspian Sea	49°33′16″N 36°58′51″E
Acanthobrama urmianus	Mahabad-Chai River	168	Lake Urmia	49°43′01″N 36°46′04″E
Romanogobio persus	Mahabad-Chai River	205	Lake Urmia	49°43′01″N 36°46′04″E
Leuciscus aspius	Aras River	79	Caspian Sea	45°19′41″N 39°08′25″E
	Guilan Coast	52	Caspian Sea	49°29′32″N 37°28′32″E
	Mazandaran Coast	2	Caspian Sea	50°54′02″N 36°49′07″E
Luciobarbus capito	Sefid River	127	Caspian Sea	49°48′42″N 37°14′52″E
	Guilan Coast	80	Caspian Sea	49°57′17″N 37°27′09″E
Luciobarbus mursa	Sefid River	58	Caspian Sea	49°30′43″N 36°37′41″E
Luciobarbus caspius	Guilan Coast	41	Caspian Sea	49°57′17″N 37°27′09″E
Alburnus atropatenae	Mahabad-Chai River	145	Lake Urmia	45°43′01″N 36°46′04″E
	Ghale-Chai River	30	Lake Urmia	37°50′24″N 46°04′32″E
	Godar-Chai River	5	Lake Urmia	45°18′59″N 37°00′07″E
Petroleuciscus ulanus	Mahabad-Chai River	94	Lake Urmia	45°45′02″N 36°52′03″E
	Godar-Chai River	62	Lake Urmia	45°18′59″N 37°00′07″E

In general, the *b*-value depends on the species, sexuality, age, sexual maturity, season, nutrition, geographical location of the area, environmental conditions and time of samples in terms of gut fullness or parasitic contamination (Yildrim *et al.* 1998; King 2013). The LWR is also related to fish body shape. In the present study, minimum mean *b*-value belongs to *L. capito* (2.99) with fusiform body shape and maximum value (3.38) belongs to *A. atropatenae* with deep and almost laterally compressed body form, revealing relationship between *b*-value and

body shape.

Some studies proposed that the low number of individuals and limited size range could affect R^2 value (Jellyman *et al.* 1997; Purrafee Dizaj *et al.* 2020) which was not observed in this study. The lowest *K* was calculated for *R. persus*, *L. aspius*, *L. mursa* and *L. caspius* showing their poor conditions of habitats which may be due to unavailability of proper food and lower habitat's environmental conditions (Blackwell *et al.* 2000). A $K > 1$ indicates suitability of a specific water body and environmental condition for growth of fish (Ujjania *et al.* 2012; Mouludi-Saleh and Eagderi 2019). Provided data of the current study can be useful for fishery biologists and manager as well as later population dynamic studies.

TABLE 2 Total length and weight data, regression parameters, 95% confidence limit and condition factor for ten fish species in different basins of Iran during 2010–2017.

Species	Total length (cm)		Total weight (g)		Regression parameters			Condition factor (Mean ± SD)	Growth pattern	*p*-values	*t*-values
	Min	Max	Min	Max	*a* 95% CL	*b* 95% CL	R^2				
Acanthobrama marmid	3.6	13.7	0.47	41	0.0094 0.007–0.011	3.13 3.05–0.23	0.983	1.25 ± 0.19	A^+	<0.05	10.86
Acanthobrama microlepis	6.3	16.6	2.3	53.4	0.005 0.003–0.007	3.28 3.15–3.41	0.971	0.99 ± 0.097	A^+	<0.05	37.22
Acanthobrama urmianus	5.9	20.8	2.23	116	0.007 0.006–0.009	3.15 3.06–3.24	0.963	1.09 ± 0.2	A^+	<0.05	21.53
Romanogobio persus	3.4	11.4	0.4	12.4	0.004 0.004–0.006	3.27 3.16–3.36	0.978	0.86 ± 0.09	A^+	<0.05	37.41
Leuciscus aspius	17.2	68.5	35.4	2550	0.006 0.004–0.009	3.07 2.98–3.13	0.989	0.91 ± 0.11	I	>0.05	38.4
Luciobarbus capito	7.5	84.5	5.2	6600	0.0101 0.008–0.011	2.99 2.95–3.03	0.992	1.01 ± 0.15	I	>0.05	24.58
Luciobarbus mursa	5.4	24.3	1.34	110.5	0.006 0.004–0.008	3.09 2.69–3.23	0.982	0.82 ± 0.09	I	>0.05	10.28
Luciobarbus caspius	30.2	56.5	196	1650	0.004 0.003–0.0102	3.17 2.96–3.15	0.95	0.79 ± 0.08	A^+	<0.05	58.87
Alburnus atropatenae	3.92	19.6	0.5	31.2	0.003 0.002–0.005	3.38 3.21–3.5	0.951	0.95 ± 0.19	A^+	<0.05	78.92
Petroleuciscus ulanus	3.8	9.7	0.56	11.3	0.011 0.009–0.013	3.04 2.96–3.13	0.959	1.25 ± 0.14	I	>0.05	8.5

R^2, correlation coefficient; *a*, an intercept; *b*, regression coefficient (slope); *I*, Isometric; A+, positive allometric

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

SE and AMS research design, data analysis and manuscript preparation. KA and SMS sampling and morphological study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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