Length-weight relationships, condition factor and morphometric characteristics of ten Spirlin (*Alburnoides* Jeitteles, 1861) species from Iranian inland waters

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Abstract

The length-weight relationships, condition factor and morphometrics of 10 species of the genus *Alburnoides* are provided from Iranian inland water. The *a* values ranged from 0.0037 (*Alburnoides damghani*) to 0.0128 (*Alburnoides namaki*), the *b* values ranged from 2.87 (*A. namaki*) to 3.50 (*A. damghani*) and the coefficient of variation (*r2*) ranged from 0.90 (*Alburnoides samii*) to 0.99 (*A. namaki*). Of these, *Alburnoides coadi*, *A. damghani* and *Alburnoides eichwaldii* show positive allometric growth while all the others are isometric growth. Mean condition factors (K) varied from 0.84 (*Alburnoides holciki*) to 1.37 (*Alburnoides idignensis*).

Keywords: Spirlin, Morphological variation, Growth coefficient, Iran

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Introduction

The genus *Alburnoides*, a member of the family Cyprinidae, possesses 13 reported species from Iranian Inland waters that 10 of them are endemic (Jouladeh Roudbar *et al*., 2016; Esmaeili *et al*., 2018; Eagderi *et al*., 2019). The length-weight relationships (LWRs) of fishes are used to estimate the weight of a specimen from its length and vice versa, understanding the life cycle, evaluation of fish stocks, ontogenetic changes and growth studies (Froese, 2006; Cherif *et al*., 2008; Kumolu-Johnson and Ndimele, 2010). Fulton's condition factor (K) is often used to quantify an animal's physical well-being based on the assumption that heavier fish of a given length is in a better condition, and is considered to be a useful complement for growth estimate (Tesch, 1968). In addition, it is a measure of various ecological and biological factors, such as the degree of fitness, gonad development and suitability of the habitat (Mac Gregoer, 1959). Morphological studies on fishes are important from various point of views, including taxonomy, evolution, ecology, behavior, conservation, water resource management, and stock assessment (Park *et al*., 2015; Vatandoust *et al*., 2015). The present study aimed to reports LWRs parameters, condition factor and morphometrics data of 10 species of the genus *Alburnoides* inhabiting Iranian inland waters.

Materials and methods

A total of 484 specimens of the genus *Alburnoides* were collected from the Caspian Sea, Hari River, Namak Lake, Dasht-e Kavir, Kor River and Persian Gulf basins of Iran (Table 1) between July 2013 and August 2014 using electrofishing device. After anesthesia, the specimens were fixed into 10% buffered formalin and transported to the laboratory for further study. Morphometric measurements were performed using digital calipers to the nearest 0.1 mm based on Kottelat and Freyhof (2007). The specimens were weighed to the nearest 0.01 g, and then photographed.

Table 1: Details of the examined specimens for LWR analysis in the present study.

no.	species	basin	latitude	longitude
1	*A. coadi*	Dasht-e Kavir	35°43'	52°39'
2	*A. damghani*	Dasht-e Kavir	36°16'	54°05'
3	*A. eichwaldii*	Caspian Sea	39°21'	45°05'
4	*A. holciki*	Hari River	35°05'	61°08'
5	*A. idignensis*	Persian Gulf	34°23'	47°52'
6	*A. namaki*	Namak Lake	34°53'	50°02'
7	*A. parhami*	Caspian Sea	37°29'	57°26'
8	*A. qanati*	Kor River	30°32'	52°02'
9	*A. samiii*	Caspian Sea	38°17'	48°52'
10	*A. tabarestanensis*	Caspian Sea	36°16'	53°12'

The length-weight relationship (LWR) was estimated by the method of least squares using the equation $W = \alpha L^b$ (Le Cren, 1951; Wang *et al*., 2012; Tabatabaei *et al*. 2015) with 95% confidence intervals of the *a* and *b* constants, and logarithmically transformed into $\text{Log}W = \text{Log}a + b\text{Log}L$, where *W* is the total body weight (g), *L* the total length (cm), *b* the regression coefficient and α the intercept of the regression. The Fulton condition coefficient was calculated according to Froese (2006) using $K = WL^{-3}\times100$, where *K* is the condition factor, *W* = weight (g), and *L* = length (cm). All statistical analyses were performed in PAST v 2.1 and Excel 2016.

Results and discussion

Descriptive statistics, including sample size, length and weight ranges, and regression parameters of α, *b* and r^2 of 10 studied species are presented in Table 2 and the condition factor of these species in Tables 3 and 4. Based on the results, The *a* values ranged from 0.0037 (*A. damghani*) to 0.0128 (*A. namaki*), the *b* values ranged from 2.87 (*A. namaki*) to 3.50 (*A. damghani*) and the coefficient of variation (r^2) ranged from 0.90 (*A. samii*) to 0.99 (*A. namaki*). The values of all examined species were within the expected range of 2.5-3.5 (Froese, 2006). These results revealed positive allometric growth pattern for all species except *A. tabarestanensis* and *A. namaki*. In the previous studies Sabet *et al*. (2016).

Table 2: Descriptive statistics and estimated length–weight relationship parameters of the examined 10 species of the genus *Alburnoides* from Iran.

Species	n	TL (cm)		W (g)		Regression parameters			95% CL of *b*	95% CL of α	Type of growth
		min	max	min	max	*a*	*b*	r^2			
A. coadi	16	6.62	9.67	2.99	11.62	0.0047	3.45	0.97	3.21-3.96	0.0015-0.0077	A+
A. damghani	45	7.13	11.07	3.82	16.04	0.0037	3.50	0.92	3-30.860	0.0016-0.0112	A+
A. eichwaldii	60	3.98	10.98	0.59	10.87	0.0075	3.19	0.97	3.07-3.33	0.0055-0.0094	A+
A. holciki	27	6.54	9.43	2.37	7.82	0.0045	3.29	0.95	2.14-3.79	0.0016-0.0575	I
A. idignensis	37	4.19	10.21	0.82	18.73	0.0103	3.13	0.95	2.97-3.36	0.0060-0.0087	I
A. namaki	30	5.23	9.86	1.30	9.50	0.0128	2.87	0.99	2.65-3.12	0.0075-0.0199	I
A. parhami	43	3.4	7.70	0.34	4.51	0.0082	3.07	0.98	2.97-3.21	0.0063-.00950	I
A. qanati	35	5.81	10.40	1.74	10.25	0.0074	3.11	0.97	2.86-3.26	0.0052-0.0124	I
A. samii	41	6.43	10.83	2.49	16.57	0.0057	3.27	0.90	2.90-3.05	0.0089-0.0122	I
A. tabarestanensis	93	3.54	11.98	0.41	17.56	0.0105	2.98	0.98	2.77-3.41	0.0035-0.0150	I

TL= total length; W=weight; n= number of individuals; min= minimum; max= maximum; *a*= intercept; *b*= slope; CL= confidence limits; r^2= correlation coefficient; I= isometric growth A+= positive allometric growth

Table 3: Range, Mean and Standard deviation of Condition factor of *Alburnoides* species from Iran.

No.	Species	Range	Mean±SD
1	*A. coadi*	1.02-1.36	1.21±0.09
2	*A. samiii*	0.80-1.39	1.02±0.15
3	*A. tabarestanensis*	0.81-1.30	1.0±0.09
4	*A. idignensis*	1.11-1.78	1.37±0.21
5	*A. holciki*	0.72-0.93	0.84±0.08
6	*A. eiachwaldii*	0.82-1.44	1.11±0.14
7	*A. damghani*	0.77-1.37	1.11±0.15
8	*A. namaki*	0.87-1.09	0.98±0.08
9	*A. parhami*	0.75-1.09	0.93±0.01
10	*A. qanati*	0.74-1.09	0.93±0.09

Table 4: Morphometric data of *Alburnoides* from Iran.

Characters	*A. coadi*		*A. namaki*		*A. samiii*		*A. tabarestanensis*		*A. damghani*	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Standard length(mm)	55.0-		43.5-		53.9-		59.5-		57.9-	
In percent of standard length										
Body depth maximal	28.2-	30.7±1	26.0-	28.1±2	25.3-	26.9±1	26.5-	27.5±0	27.3-	30.6±1.8
Caudal peduncle depth	10.8-	12.1±0	10.9-	11.6±0	10.1-	11.2±0	10.5-	11.5±0	11.0-	12.1±0.7
Pre-dorsal length	52.6-	54.8±1	50.0-	51.1±0	49.1-	50.8±1	49.9-	51.9±1	52.3-	54.5±1.0
Post-dorsal length	46.7-	49.1±1	50.1-	51.7±1	48.8-	51.4±1	48.7-	50.6±1	48.5-	51.4±1.3
Pre-pelvic length	48.1-	50.0±1	47.4-	49.0±1	45.4-	47.9±1	44.4-	47.2±1	44.7-	47.6±1.7
Pre-anal length	63.5-	67.5±2	62.4-	66.0±2	60.8-	64.3±1	62.7-	64.7±1	62.1-	64.6±1.6
Caudal peduncle	18.4-	21.3±1	20.7–	22.3±1	21.1-	23.9±1	19.8-	22.7±1	20.5-	23.7±1.4
Dorsal-fin base length	13.2-	14.9±0	12.7-	15.1±1	10.6-	13.9±1	12.1-	13.8±1	12.8-	14.7±1.6
Dorsal-fin depth	19.7-	21.5±1	21.2-	22.6±1	20.0-	22.4±1	20.0-	21.8±0	15.0-	20.5±2.1
Anal-fin base length	13.0-	15.9±1	12.4-	16.0±2	13.3-	16.0±2	14.3-	16.8±1	12.1-	14.8±1.7
Anal-fin depth	13.6-	15.6±1	13.5-	15.2±1	13.1-	15.4±1	13.7-	15.2±0	11.1-	14.9±1.6
Pectoral fin length	17.7-	19.7±1	17.9-	19.7±1	16.3-	20.4±1	16.6-	19.0±1	14.7-	18.6±1.8
Pelvic fin length	12.5-	15±1.5	15.1-	15.6±0	13.1-	15.0±0	13.3-	14.7±0	12.1-	15.2±1.6
Pectoral-pelvic-fin	22.1-	24.2±2	20.3-	23.6±1	20.3-	23.4±2	20.6-	22.9±1	20.5-	24.9±1.6
Pelvic-anal-fin origin	17.2-	18.8±1	15.3-	17.9±1	15.6-	17.9±1	15.6-	17.7±1	15.5-	17.9±1.1
Body width	12.7-	13.6±0	13.5-	18.4±4	11.5-	12.7±0	13.1-	14.5±1	8.8-19.6	14.3±3.5
Caudal peduncle width	2.3-3.1	2.7±0.	2.9-5.9	4.2±1.	2.2-2.9	2.5±0.	2.8-4.4	3.4±0.	1.9-4.6	3.2±0.8
Head length (HL)	23.7-	26.3±1	22-	24.7±1	20.4-	23.7±1	22.8-	24.5±1	22.6-	24.9±1.5
In percent of head length										
Snout length	18.2-	21.8±2	21.2-	24.5±2	19.3-	23.3±2	20.0-	22.8±2	17.9-	21.2±2.1
Eye horizontal	23.3-	25.7±1	27.9-	30.1±2	25.6-	27.6±1	23.4-	25.6±2	21.8-	25.9±2.3
Postorbital distance	49.5-	54.6±2	48.6-	51.4±2	37.5-	50.3±6	46.8-	53.2±2	50.6-	54.8±2.7
Head depth at nape	72.3-	81.1±5	76.5-	83.8±4	72.5 –	81.7±5	73.0-	84.6±5	74.1-	84.8±5.8
Head depth at eye	44.9-	56.7±5	55.5-	58.4±3	49.3-	56.2±3	49.8-	55.3±3	52.0-	57.8±4.1
Head length at nape	69.7-	73.8±3	82.1-	87.1±5	62.5-	80.5±7	72.2-	79.7±4	71.7-	78.2±4.9
Head width	43.5-	50.1±4	48.6-	67.3±1	43.9-	51.3±4	46.3-	53.1±5	33.6-	50.6±11.
Inter orbital	30.8-	34.1±2	34.2-	45.9±9	32.6-	37.4±2	29.7-	36.2±4	21.9-	34.9±7.9
Inter nasal	16.7-	18.9±1	18.8–	25.8±5	20.2-	23.9±2	17.1-	20.5±2	13.2-	19.1±3.7
Mouth width	21.9-	26±1.8	27.2-	33.5±5	22.8-	27.3±2	20.3-	25.7±3	17.4-	26.4±6.6
Condition factors	1.02-	1.21±0	0.87-	0.98±0	0.80-	1.02±0	0.81-	1.0±0.	0.77-	1.11±0.1

Table 4 (Continued)

Characters	*A. idignensis*		*A. holciki*		*A. eiachwaldii*		*A. parhami*		*A. qanati*	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Standard length (mm)	70.1-		54.6-		51.8-		24.2-		47.8-	
In percent of standard length										
Body depth maximal	28.6-	31.5±2	27.4-	29.4±1	27.0-	29.2±1	24.9-	26.9±1	25.1-	28±1.9
Caudal peduncle depth	11.4-	12.3±0.	9.7-	10.2±0	11.6-	12.3±0	10.4-	11.6±0	10.1-	11.7±0
Pre-dorsal length	50.3-	51.6±0.	48.5-	50.5±1	49.8-	52.2±1	49.5-	51.7±1	48.8-53	51.1±1
Post-dorsal length	49.9-	52.0±1.	49.2-	51.8±2	49.4-	50.8±1	49.4-	50.8±0	49.9-	51.9±1
Pre-pelvic length	46.2-	47.9±0.	44.0-	47.1±1	46.1-	48.4±1	47-	49.1±1	46.8-	48.6±1
Pre-anal length	60.7-	63.7±1.	60.6-	62.8±1	62.7-	64.8±1	60.8-	64.5±1	63.8-	65.1±1
Caudal peduncle	22.4-	23.6±1.	18.5-	22.0±2	21.3-	23.6±1	20.3-	22.9±1	20.2-	24.2±1
Dorsal-fin base length	12.5-	14.4±1.	13.8-	15.7±1	12.8-	14.5±0	14.5-	16.2±1	11-18.6	15.1±1
Dorsal-fin depth	16.4-	18.2±1.	21.3-	22.7±1	19.3-	21.5±1	20.5-	24.8±1	19-25.1	22±1.7
Anal-fin base length	14.1-	16.9±1.	16.6-	18.8±1	13.5-	15.8±1	14-	16.2±1	11.8-	14.3±1
Anal-fin depth	12.1-	13.8±1.	13.3-	15.5±1	12.8-	14.6±1	14.3-	16.1±1	12.9-	15.9±1
Pectoral fin length	15.7-	17.7±1.	16.8-	18.8±1	15.3-	17.8±1	17.8-	21.3±1	16.8-	19.2±1
Pelvic fin length	13.1-	14.1±1.	14.6-	15.7±0	11.3-	14.0±1	13.6-	15.9±1	12.3-	15.3±1
Pectoral – pelvic-fin	22.9-	24.6±1.	19.6-	22.5±1	21.2-	23.4±1	20.5-	22.2±1	21-26.2	23.5±1
Pelvic – anal-fin origin	16.4-	17.8±0.	16.8-	17.7±0	15.7-	17.9±1	15.2-	17.2±1	15.8-	18.2±1
Body width	12.9-	15.8±1.	11.1-	12.7±0	13.8-	14.8±0	10.1-	12.8±2	11.5-	13.1±0
Caudal peduncle width	2.7-3.8	3.3±0.3	2.4-2.8	2.7±0.	2.2-3.7	3.0±0.	2.2-4.6	2.8±0.	2.3-3.5	3±0.3
Head length (HL)	20.3-	23.6±1.	23.0-	23.9±0	23.2-	24.6±0	25-	26±0.7	22.6-	24.6±1
In percent of head length										
Snout length	21.4-	23.7±1.	21.7-	24.5±2	21.1-	25.7±2	16.2-	20.2±1	17.6-	21±2.1
Eye horizontal	22.2 –	25.5±1.	26.2-	28.9±2	24.0-	27.3±1	29.2-	31.7±2	21-32.3	27.2±3
Postorbital distance	53.2-	55.3±1.	45.5-	52.4±5	46.7-	53.2±3	44.6-	48.4±1	47.6-62	53.4±3
Head depth at nape	82.8-	92.5±4.	76.8-	81.6±3	73.9-	83.6±4	76.5-	81±2.5	75-99.1	87±5.9
Head depth at eye	58.1-	62.4±4.	51.3-	56.7±3	53.7-	59.1±3	52.4-	55.7±2	53.6-	60.2±2
Head length at nape	73.3-	78.5±3.	71.7-	77.4±3	73.2-	81.0±4	74.4-	79.4±2	77.8-	83.7±5
Head Width	53.3-	58.0±4.	48.0-	50.8±2	48.4-	55.1±4	42.9-	52.8±1	44.7-	51.4±3
Inter Orbital	32.8-	37.1±2.	31.8-	33.8±1	30.3-	35.9±2	32.2-	36.6±4	30.3-	34.5±2
Inter nasal	17.7-	19.4±1	18.9-	20.1±0	17.7-	20.4±1	17.1-	22.1±5	15.9-	19.2±2
Mouth width	18.5-	26.6±3.	21.3-	24.5±3	27.2-	31.1±2	22.1-	28.4±6	23.9-	27.5±2
Condition factors	1.11-	1.37±0.	0.72-	0.84±0	0.82-	1.11±0	0.75-	0.93±0	0.74-	0.93±0

Length-weight relationships of 7 species of genus *Alburnoides* were not yet available in Fishbase (Froese and Pauly, 2019), however all of the species of LWRs reported from different localities in Iran and Turkey. In these studies, general growth pattern represented as isometric or positive allometric growth (Çiçek *et al.*, 2016; Mousavi-Sabet *et al.*, 2016; Froese and Pauly, 2019).

The results of this study can serve as baseline data on LWRs for the species to be used and comparison for further biological studies. Since, these type of data in various habitats will be useful for comparisons of life history and morphological aspects of populations inhabiting different localities (Cherif *et al.*, 2008).

Mean condition factors (K) varied from 0.84 (*A. holciki*) to 1.37 (*A. idignensis*). Higher than 1 (*A. coadi, A. samiii, A. tabarestanensis, A. idignensis, A. eiachwaldii* and *A. damghani*) can show a better environmental condition (Eagderi and Radkhah, 2015) for these species.

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