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Studies on Length-weight and Length-length Relationships, Relative Condition Factor and Fulton's Condition Factor of *Hemiculter leucisculus* (Pisces: Cyprinidae) from the Southwestern Caspian Sea Basin

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Abstract
In this study, length-weight (LWR) and length-length relationships (LLRs), relative condition factor (k_{rel}) and Fulton's condition factor (k) of 235 *Hemiculter leucisculus* Basilewsky were determined between the periods of March 2012 to February 2013 in Sefidroud River, in the Southwestern Caspian Sea basin. The maximum recorded total length for males and females were 16.90 cm and 18.10 cm, respectively. The length-length relationships among the total length (TL), fork length (FL) and standard length (SL) for *H. leucisculus* were found to be highly significant (r^2>0.968, p<0.001). The length-weight relationship shows the obtained *b* values for males, females and male-females were 2.549, 2.680 and 2.465 respectively, which indicated a negative allometric growth trend of this species. Also, relative condition factor (K_{rel}) for males, females and male-females were 0.710, 0.622 and 0.743 respectively and Fulton's condition factor (K) for males, females and male-females were 0.922, 0.842 and 0.843 respectively. These results will be useful for fishery managers to impose adequate regulations for sustainable fishery management.

***Key words*:** Condition factor, Length-weight relationship, Sefidroud River, Iran

Introduction

H. leucisculus Basilewsky is a none-indigenous fish in the Caspian Sea basin. Its original distribution includes the rivers of China, Korea and Vietnam, and the Amur River basin (Holčík and Razavi, 1992). In Iran, *H. leucisculus* is reported from the International Wetlands includes Alma-Gol, Adji-Gol and Ala-Gol (Patimar *et al*., 2008) and from Zarivar Lake (Esmaeili *et al*., 2011). Also Abdoli (2000) recorded this species from the lower Sefidroud River, Anzali wetland and from middle Aras River. *H. leucisculus* found in rivers, lakes, small ponds and swamps but there is a little finding about its habitat requirements (Coad, 2013). *H. leucisculus* is an edible fish and is conserved in China but it is more important because it compete with innate species for food and predation on fish eggs and young (Holčík and Razavi, 1992). The *H. leucisculus* can easily modify their food habit as conditions warrant (Holčík and

Razavi, 1992). For the adequate management length-weight and length-length relationships, condition factor and growth are important tools for any fish species (King, 2007; Ndome *et al*., 2012). Length-weight importance is clear in estimating the average weight at a given length group (Beyer, 1987), and in assessing the relative wellbeing of a fish population (Bolger and Connoly, 1989), and are useful for between region comparisons of like histories of a specific species (Wootton, 1990). For comparison of growth studies, length-length relationship is important factor (Moutopoulos and Stergiou, 2002). The results of condition factor can be used to compares the wellbeing of a fish and is based on the theory that heavier fish of a given length are in better condition (Bagenal and Tesch, 1978), it is used as an index of growth and feeding intensity (Fagade, 1979). Condition factor is decreases with increase in length (Bakare, 1970; Fagade, 1979), and also influences the reproductive cycle in fish (Welcome, 1979). The length-weight relations of some species recently have been studied in Iran and other localities (Barrientos-Medina *et al*., 2013; Mousavi-Sabet *et al*., 2013; Moutopoulos *et al*., 2013; Qiang *et al*., 2013). The available information about fish population biology including length-weight relationship in Iran is restricted to some information on commercially important marine and freshwater fishes (Hosseini, 2002; Shokri *et al*., 2005; Esmaeili, 2006; Raeisi *et al*., 2011; Mousavi-Sabet *et al*., 2013). This study presents information about length-weight and length-length relationships, relative condition factor and Fulton's condition factor for *H. leucisculus* in Sefidroud River, in southwestern of the Caspian Sea basin.

Materials and methods

The sampling was carried out in Sefidroud River (37°15.46´N, 049°5.598´E). The river is located in the north of Iran, in southwestern of the Caspian Sea basin (Fig. 1). Sampling was done from March 2012 to February 2013. The fish were caught with traditional fishing gears. All specimens were fixed and preserved in 8% formaldehyde solution and transferred to the ichthyology laboratory of department of fisheries sciences, faculty of natural resources, the University of Guilan. For each specimen total length (TL), fork length (FL) and standard length (SL) were measured by using measuring board nearest 1 mm, body weight (g) was taken on a digital balance with 0.01 g accuracy. And the sex was assigned by examining the gonads.

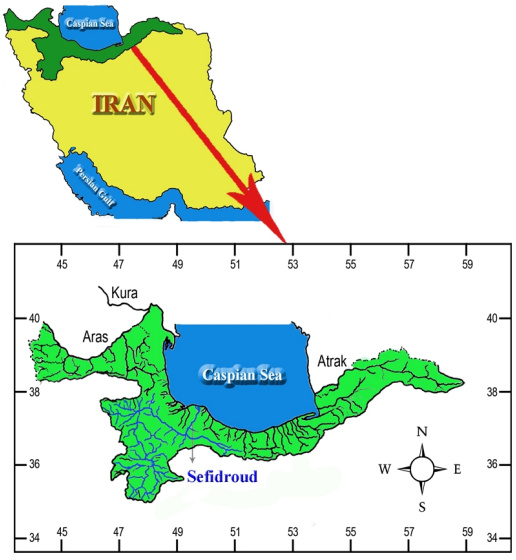

Figure 1. Map of Iranian part of the southern Caspian Sea basin showing some of the most important river system: Aras, Kura, Atrak and Sefidrud (the study area) rivers.

The length-weight relationship was estimated by using the equation, $W = aL^b$

(Froese, 2006). Where W is the whole body weight (g), L is the total length (cm), a is the intercept of the regression and b is the regression coefficient (slope). Values of the exponent b provide information on fish growth. When b = 3, increase in weight is isometric. When the value of b is other than 3, weight increase is allometric (positive if b>3, negative if b<3). This parameters (a, b) are important in stock assessment studies (Can *et al*., 2002; Moutopoulos and Stergiou, 2002). The parameters a and b of the length-weight relationships were estimated by the least-squares method based on logarithms: Log (W) = log (a) + b log (TL).

Moreover relationships among the, TL-FL, FL-SL, and SL-TL were calculated by linear regressions. Also the relative condition factor (K_{rel}) and Fulton's condition factors (K) were calculated for each individual fish according to the equation (Le cren, 1951; Froese, 2006): $K_{rel} = w/al^b$, $K=100\ w/l^3$. Where W is the whole body weight (g), L is the total length (cm), and a and b are the parameters of length-weight relationship.

Results and discussion

A total of 235 specimens of *H. leucisculus* were collected from Sefidroud River (SW of the Caspian Sea basin). The sample size (n), length range, parameters a and b of the length weight relationship, and the determined coefficient (r^2) are given monthly, also length weight relationships were presented for males, females and male-females in table 1. The highest mean of total length (15.61 cm) value of the samples was in August whereas the lowest mean of total length (12.95 cm) value was in April. The mean of total length values for males, females and male-females were 14.04, 14.20 and 14.30 respectively and shown in table 1. Determined coefficient (r^2) values for males, females and male-females were 0.925, 0.872 and 0.868, respectively.

In the present study, the obtained 'b' values for length-weight relationship were lower than 3, i.e., 2.549, 2.680 and 2.465 for males, females and male-females respectively which indicated that the growth is negative allometric in *H. leucisculus*. This is agreed with obtained data for *Gudusia godanahiae* from Nepal (Subba *et al.*, 2009). The results of the present study are not in agreement with reports by Gavrenkov and Ivankov (1976), Subba and Adhikaree (2011) and Moradinasab *et al*. (2012). But Ye *et al*. (2007) showed also negative allometric growth for this species. The variation of b values is determined by primarily on the shape and fatness of the species, various factors may be responsible for the differences in parameters of the length-weight relationships among seasons, sex and time of year and stages of maturity (Sparre, 1992).

Length-length relationships and the coefficient of determination (r^2) are given in table 2. All LLRs (Tab. 2) were highly significant (P<0.001), with all coe□cient of determination values being > 0.968. The values of a, b and r^2 were 0.409, 0.927 and 0.93 respectively for length-length relationship of *H. leucisculus* from the Anzali wetland (Moradinasab *et al*., 2012).

The monthly Fulton's condition factor (K) was ranged from 0.745 to 0.996 and also in males, females and male-females Fulton's condition factor (k) were 0.842, 0.922 and 0.843 respectively that shown in table 3. The lowest and highest mean of K were found in August (K 0.745) and June (K 0.996) respectively. Monthly relative condition factor (K_{rel}) was ranged from

Table 1. Descriptive statistics and length-weight parameters for *H. leucisculus* in Sefidroud River, SW of the Caspian Sea basin.

Month	Sex	Length	N	Length characteristics (cm)			Parameters of relationship		
				Min.	Max.	Mean ± SD	A	B	R^2
January	unsexed	TL	13	10.40	16.40	14.63± 1.60	0.183	1.767	0.882
February	unsexed	TL	20	12.90	17.80	15.12± 1.56	0.068	2.556	0.922
March	unsexed	TL	23	12.10	15.90	14.20± 1.05	0.142	1.955	0.736
April	unsexed	TL	26	9.30	15.20	12.95± 1.53	0.060	2.691	0.950
May	unsexed	TL	23	9.60	16.60	13.34± 2.30	0.077	2.530	0.947
June	unsexed	TL	11	12.30	18.10	14.90± 1.62	0.113	2.205	0.992
July	unsexed	TL	25	13.33	18.05	15.69 ± 1.39	0.109	2.306	0.985
August	unsexed	TL	21	13.30	18.00	15.61± 1.36	0.105	2.224	0.809
September	unsexed	TL	33	9.10	14.80	12.62± 1.81	0.083	2.386	0.750
October	unsexed	TL	17	9.30	17.60	14.74± 2.02	0.079	2.452	0.982
November	unsexed	TL	27	12.60	17.30	14.93± 1.11	0.240	1.546	0.515
December	unsexed	TL	8	12.30	14.90	13.75± 0.83	0.092	2.340	0.835
Total	unsexed	TL	235	9.10	18.10	14.30 ± 1.71	0.079	2.465	0.868
	Male	TL	99	9.30	16.90	14.04 ± 0.382	0.074	2.549	0.925
	Female	TL	136	9.10	18.10	14.20 ± 0.274	0.061	2.680	0.872

(N = Number of specimens, A and B = Parameters of the L-W relation, R^2 = Coefficient of determination)

Table 2. Length-length relationships among total length (TL), fork length (FL) and standard length (SL) of *H. leucisculus* in Sefidroud River, SW of the Caspian Sea basin.

Sex	N	Equation	Regression Parameters		
			A	B	R^2
Male	99	TL = a + bFL	0.405	0.873	0.983
		FL = a + bSL	0.335	1.08	0.982
		SL = a + bTL	0.451	0.866	0.980
Female	136	TL = a + bFL	0.389	0.907	0.983
		FL = a + bSL	0.371	0.958	0.985
		SL = a + bTL	0.437	0.895	0.968
Total	235	FL = a + bTL	0.394	0.896	0.971
		FL = a + bSL	0.357	0.993	0.981
		SL = a + bTL	0.443	0.883	0.973

(N = Number of specimens, A and B = Parameters of the L–L relations, R^2 = Coefficient of determination)

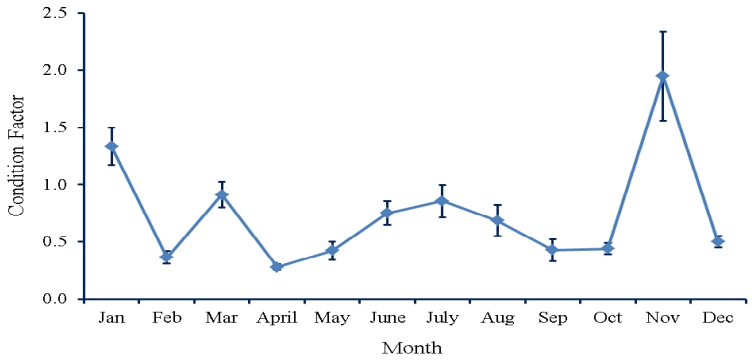

Figure 2. Variation of condition factors (mean ± SE) of *H. leucisculus* in Sefidroud River, SW of the Caspian Sea basin.

0.281 to 1.947 which were 0.710, 0.622 and 0.743 for male, female and male-females respectively (Fig. 2). The lowest (K_{rel} 0.281) and highest (K_{rel} 1.947) mean of K_{rel} were found in April and November, respectively. Moradinasab *et al*. (2012) examined K (0.80 ± 0.05) and K_{rall} (1.00 ± 0.07) values for male-females of *H. leucisculus* in the Anzali wetland. In studies of population dynamics high condition factor values indicates favorable environmental conditions and low values indicate less favorable environmental conditions (Blackwell *et al*., 2000). A number of factors such as sex, seasons, environmental conditions, stress, preservation, maturity, availability of food also affect the condition of fish.

In conclusion, this paper has provided basic data on the LWR, LLR, K and K_{rel} that would be beneficial for fishery biologist's managers to impose suitable regulations for sustainable fishery management in the Sefidroud River.

Table 3. Relative condition factor (K_{rel}) and Fulton's condition factor (K) for *H. leucisculus* in Sefidroud River, SW of the Caspian Sea basin.

Month	Sex	Fulton's condition factor (K)
January	Unsexed	0.901
February	Unsexed	0.750
March	Unsexed	0.811
April	Unsexed	0.775
May	Unsexed	0.975
June	Unsexed	0.996
July	Unsexed	0.686
August	Unsexed	0.745
September	Unsexed	0.763
October	Unsexed	0.806
November	Unsexed	0.921
December	Unsexed	0.816
Total	Unsexed	0.843
	Male	0.922
	Female	0.842

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