



The Length-Weight, Length-Length Relationship and Condition Factor of Angora Loach, *Oxynoemacheilus angorae* (Steindachner, 1897) Inhabiting Kılıçözü Stream in Kızılırmak River Basin (Central Anatolia-Turkey)

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ABSTRACT

In this study, length-weight relationship (LWR), length-length relationship (LLR) and condition factor (K) of Angora loach, *Oxynoemacheilus angorae* were determined. A total of 103 specimens were sampled from Kılıçözü Stream in 2014. The length and weight of specimens were ranged 3.5-9.8 cm and 0.38-6.58 g, respectively. Length-weight relationships for female, male and all samples were found as $W= 0.01056.TL^{2.896}$ ($r^2= 0.923$), $W= 0.00963.TL^{2.940}$ ($r^2= 0.978$) and $W= 0.00987.TL^{2.929}$ ($r^2= 0.963$), respectively. LWRs indicated an isometric growth in female, male and all samples. The values of Fulton's condition factor (K) ranged from 0.699 to 1.246 for females and from 0.654 to 1.072 for males. All length-length relationships were statistically significant.

Introduction

Angora loach, *Oxynoemacheilus angorae* (Steindachner, 1897) is a teleost fish which inhabiting in the Middle East Asia. Angora loach described as least concern in The IUCN Red List of Threatened Species and declared that this situation will worsen in the future. It inhabits a wide range of habitats from streams and shores of large rivers to muddy lakes with dense vegetation. This species spawns commonly first time at 1 year. Angora loach feeds on benthic invertebrates (Freyhof, 2014).

Relationship between length and weight varies among fish species according to their body shape and condition of fishes (Schneider et al., 2000). It is an important fishery management tool (Bolger and Connoly, 1989). These relationships also permit the calculation of condition indexes and let for comparisons of species growth orbit between sexes, different seasons, and regions (Froese, 2006). Also it is important for conservation of fish species (Kamaruddin et al., 2011). Fulton's condition factor (K) is commonly utilized in fisheries and fish biology researches (Froese, 2006). Condition factor indicate differences according to sexual maturity, availability of food sources, age and sex of some species (Anibeze, 2000). Total length (TL) and fork length (FL) is usually utilized in studies of fish growth, whereas standard length (SL) is mainly used in systematic studies (Arslan et al., 2004). In this situation, there are difficult

for studies to be compared with each other and to interpret the results (Yazıcı et al., 2015). Therefore, length-length transformations in fish are useful for comparative studies using different length measures (Yılmaz et al., 2010; Tsagarakis et al., 2015). There are a few investigations on the length-weight, length-length relationship and condition factor of Angora loach from Kızılırmak River basin (Birecikligil et al., 2016). Also, a research on karyotype of Angora loach was conducted at inland waters in Kırşehir (Gaffaroğlu et al., 2014).

In this paper, we report that length-weight, length-length relationships and condition factor of Angora loach inhabiting Kılıçözü Stream at Kızılırmak River basin.

Materials and methods

Study Area

Kılıçözü Stream is located northern side of Baran mount in Kırşehir (Turkey-Central Anatolia). It is mix to Kızılırmak River and flow North-south direction. Length of this stream is 80 km. İğdeliöz, Kılıçözü, Güzler irrigation regulators and Çoğun dam lake were built on Kılıçözü Stream. The water level of stream reduces in summers. The average flow rate of the stream is 34.3 hm³/year (Anonymus, 2011).

Sample Size and Data Collection

A total of 103 *O. angorae* were obtained from Kılıçözü Stream. Catching of fish samples were conducted by using electrofisher in October 2014. After the collection of the fish samples were transported to the research laboratory. The total length (TL), fork length (FL), and standard length (SL) of each specimen was measured to the nearest 1 mm and their weight was determined using digital balance with precision of 0.01 g. Sex determination was performed by macroscopic examination of gonads. The chi-squared test was carried out on the observed sex ratios to show whether the proportions deviated significantly from the expected 1: 1 ratio (Zar, 1999). The length-weight relationship was calculated via the formula $W = aL^b$, where W is the body weight (g), L is the total length (cm), a is the intercept, and b is the slope (Bagenal and Tesch, 1978). The parameters a and b of length-weight relationship were estimated by linear regression of the transformed equation: $\text{Log } W = \text{Log } a + b \text{ Log } L$. The determination coefficient (r^2) was used as an indicator of the quality of the linear regression. Whether the growth of fish was isometric ($b = 3$) or allometric ($b > 3, b < 3$) was estimated by the student's t-test. Analysis of covariance (ANCOVA) was used to test difference of the b values of length-weight relationship between sexes (Zar, 1999). The Fulton's condition factor was computed using the formula $K = 100 W L^{-3}$, where K is the Fulton's condition factor, W is the body weight (g), and L is the total length (cm) (Ricker, 1975). Differences between K values of females and males were tested using the student's t-test (Zar, 1999). All length-length relationships were established using linear regression analysis. Relationships between TL & FL, FL & SL, and SL & TL were estimated separately according to females, males and all samples. All statistical analyses were considered significant at $P < 0.05$.

Results

Sex, Length and Weight Distribution

During the study period, a total of 103 individuals were captured. 63 (61.16%) were females and 40 (38.84%) were males. Overall sex ratio of females to males was 1.0:0.63, which did deviate from 1:1 ($\chi^2 = 5.136, P < 0.05$). The total lengths and body weights of all samples varied as 3.5-9.8 cm (mean= 7.354, SD= 1.185) and 0.38-6.58 g (mean= 3.647, SD= 1.324), respectively (Table 1).

Length-Weight Relationships

Length-weight relationships showed that high compatibility between length and weight of males, females and all individuals ($P < 0.001, r^2 > 0.92$). Totally, parameters b of LWR was computed as 2.940 for males, 2.896 for females and 2.929 for all samples (Table 1). The variations in b values from 3 were not statistically significant and indicated an isometric growth for males ($t = -0.84, P > 0.05$), females ($t = -0.98, P > 0.05$), and the overall population ($t = -1.24, P > 0.05$). No significant difference was observed in slopes of LWR of females and males (ANCOVA, $F = 0.12, P > 0.05$).

Condition Factor

The average value of Fulton's condition factor (K) was calculated as 0.864 for males, 0.863 for females, and 0.863 for all samples (Table 2). There was no significant difference in mean K values between sexes (t-test, $P > 0.05$). The higher K values of females and males were obtained in the 6.5-7.9 cm ($K = 0.87$) and 5.0-6.4 cm ($K = 0.922$) length group, respectively. Mean K values of females increased with length groups, whereas the mean K values decreased with length groups in males (Figure 1).

Length-Length Relationships

All length-length relationship parameters of *O. angorae* were shown in Table 3. The determined r^2 values for all LLRs of females, males and all specimens were greater than 0.972 and highly significant ($P < 0.001$).

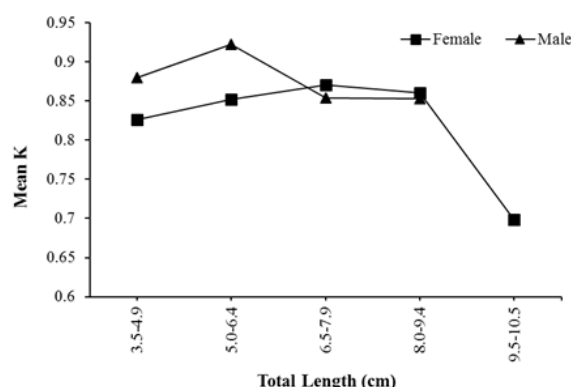


Figure 1 Mean condition factor (K) per total length class for female and male of Angora loach from Kılıçözü Stream, Turkey

Table 1 Descriptive statistics and estimated parameters of length-weight relationship (LWR) of Angora loach from Kılıçözü Stream, Turkey.

Sex	n	Total Length (cm)		Weight (g)		Parameters of LWR			
		Min	Max	Min	Max	a	b	95 % CI of b	r ²
Male	40	3.5	8.9	0.38	6.06	0.0096	2.940	2.795-3.085	0.978
Female	63	3.9	9.8	0.49	6.58	0.0105	2.896	2.681-3.109	0.923
All	103	3.5	9.8	0.38	6.58	0.0098	2.929	2.815-3.042	0.963

n: sample size, a and b: parameters of LWRs, Min: minimum, Max: maximum, r²: coefficient of determination

Table 2 Descriptive statistics of condition factor of Angora loach from Kılıçözü Stream, Turkey.

Sex	n	Mean K	SE	SD	Min	Max
Male	40	0.864	0.0158	0.0998	0.654	1.072
Female	63	0.863	0.0122	0.0969	0.699	1.246
All	103	0.863	0.0096	0.0975	0.654	1.246

n: sample size, SE: standard errors, SD: standard deviation, Min: minimum, Max: Maximum

Table 3 Length-length relation parameters between total, fork and standard length of Angora loach from Kılıçözü Stream, Turkey.

Sex	n	Equation	a	b	r ²
Male	40	TL= a + bFL	0.092	1.01	0.999
		FL= a + bSL	0.150	1.13	0.992
		SL= a + bTL	-0.165	0.867	0.993
Female	63	TL= a + bFL	-0.139	1.05	0.992
		FL= a + bSL	0.325	1.11	0.975
		SL= a + bTL	0.022	0.837	0.972
All	103	TL= a + bFL	0.022	1.02	0.997
		FL= a + bSL	0.203	1.12	0.987
		SL= a + bTL	-0.102	0.855	0.986

n: sample size, a and b: parameters of LLRs

Table 4 The total lengths and weights for Angora loach populations in different localities.

Locality	Sex	TL (Min-Max)	W (Min-Max)	Reference
Jajroud River	All	3.8-7.6 cm	0.53-4.21 g	Golzarianpour et al., 2011
Balıklı Stream	All	4.7-7.3 cm	0.86-3.56 g	Gaygusuz et al., 2013
Karabogaz Creek	All	4.4-8.3 cm	0.80-6.60 g	Erk'akan et al., 2014
Sirwan River ⁺	All	4.3-8.2 cm	-	Hasankhani et al., 2014
Kızılırmak River Basin	All	2.8-8.6 cm	0.22-6.18 g	Birecikligil et al., 2016
Kılıçözü Stream	All	3.5-9.8 cm	0.38-6.58 g	In this study

Table 5 The parameters of length-weight relation for Angora loach from different habitats.

Locality	Sex	a	b	r ²	Reference
Jajroud River	All	0.008	3.01	0.98	Golzarianpour et al., 2011
Balıklı Stream	All	0.006	3.237	0.88	Gaygusuz et al., 2013
Karabogaz Creek	All	0.0062	3.228	0.92	Erk'akan et al., 2014
Sirwan River ⁺	All	0.011	2.81	0.96	Hasankhani et al., 2014
Kızılırmak River Basin	All	0.008	3.102	0.94	Birecikligil et al., 2016
Kılıçözü Stream	Male	0.0096	2.940	0.98	This study
	Female	0.0106	2.896	0.92	
	All	0.0099	2.929	0.96	

Discussion

The sex ratio of Angora loach in the Kılıçözü Stream was 1.0: 0.63. In other words, females dominated in this population. This result concurs with different researches, which including information about other fish species (Kostrzewa et al., 2003; Yazıcıoğlu et al., 2013; Saylar and Yılmaz, 2014; Jamali et al., 2016).

Total lengths and weights values were similar to different habitats (Table 4). However, there are some differences. The number of samples, sampling time and ecological conditions of habitats may have led to these differences.

The strong relationships between total length and weight were observed ($P < 0.001$, $r^2 > 0.96$). The slope (b) of length-weight relationships range from 2 to 4 in fish (Bagenal and Tesch, 1978). Calculated b parameters of length-weight relationship for females, males, and all fish were close to 3, which is isometric growth indicator.

Calculated b parameter for all samples was lower than conclusions of studies at other habitats. However, it was consistent with data from the Sirwan River (Table 5). Inconsistencies in comparing other habitats may be resulted from number of samples, length and weight distributions, used fishing methods, feeding capacity, food abundance and ecological conditions of habitats. Also, Bagenal and Tesch (1978) reported that length-weight relationship in fish is not stable and it changes depending on feeding ratio, gonad development, food availability and reproduction period.

Mean K value of this species was calculated as 0.863 for females, 0.864 for males, and 0.863 for all samples. Birecikligil et al. (2016) reported that average K value of *O. angorae* in Kızılırmak river basin was 0.94. This result is very close to our finding.

Consequently, this study indicates structural data of population of Angora loach. This species showed good development in Kılıçözü Stream when compared to other habitats. The data of this study are very important. Because *O. angorae* describe as least concern in The IUCN Red List of Threatened Species. Results obtained from this study may be useful in the future to obtain information about population dynamic of *O. angorae*.

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