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Length-length, length-weight relationship and condition factor of fishes in Nevşehir Province, Kızılırmak River Basin (Turkey)

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Abstract: This study described some biological parameters, including length-weight, length-length relationships and Fulton's condition factor (K) of *Aphanius marassantensis*, *Capoeta tinca*, *Carassius auratus*, *Carassius gibelio*, *Cyprinus carpio*, *Oxynoemacheilus angorae* and *Squalius* cf. *cephalus* from the Nevşehir Province (Kızılırmak River Basin), based on 1222 specimens collected from May to September, 2014. The length-weight relationships were estimated as follows $W=0.0193L^{2.987}$, $W=0.165L^{2.839}$, $W=0.0345*L^{2.731}$, $W=0.023*L^{2.856}$, $W=0.0097*L^{3.138}$, $W=0.0078*L^{3.102}$ and $W=0.014*L^{2.962}$, respectively as given above. The mean K values were calculated as 1.96±0.29, 1.67±0.20, 3.48±0.42, 2.23±0.46, 0.99±0.24, 0.79±0.11 and 1.41±0.21, respectively at the same order. Additionally, the relationships among total length, fork length and standard length were also estimated for these species. The length-length relationships were highly correlated ($r^2>0.98$) and significant ($P<0.05$).

Keywords: Kızılırmak River Basin, Nevşehir, Length-length relationship, Length-weight relationship, Fulton's Condition Factor.

Introduction

Length-weight relationships (LWRs) are used for estimating the weight corresponding to a given length, and condition factors are used for comparing the condition, fatness or well-being of fish, based on the assumption that heavier fish of a given length are in better condition (Froese, 2006). von Bertalanffy developed a growth equation in length, and for the equivalent in weight, he used the exponent b=3, assuming isometric growth (Froese, 2006). According to Froese (2006), Hile (1936) presented a first interpretation of the exponent b that the difference from 3.0 indicates the direction and rate of change of form or condition. The larger difference from 3.0 indicates the larger change in condition or form (Froese, 2006).

Different values in condition of a fish indicate the state of sexual maturity, the degree of food sources availability, age and sex of some species. Le Cren (1951) also compared weight-length relationships for perch, *Perca fluviatilis* in Lake Windermere for different life stages, sexes, stages of gonad development, and different seasons. He found significant differences and concluded that no single regression would adequately describe the length-weight relationship for the perch.

Although length-weight conversion factors are of fundamental importance in fisheries science, recent data from Turkish freshwater fishes are generally lacking. Therefore, estimation of LWRs for fishes distributed in freshwaters of Turkey will fill in some of the gaps. These relationships are also an important component of FishBase (Froese and Pauly, 2015). The aim of the present study is to determine the length-weight, length-length relationships and Fulton's condition factor of seven fish species, including *Aphanius marassantensis* Pfleiderer, Geiger & Herder, 2014; *Capoeta tinca* (Heckel, 1843); *Carassius auratus* (Linnaeus, 1758); *Carassius gibelio* (Bloch, 1782); *Cyprinus carpio* Linnaeus, 1758; *Oxynoemacheilus angorae* (Steindachner, 1897) and *Squalius* cf. *cephalus* (Linnaeus, 1758) in Nevsehir Province (Kızılırmak River Basin), Turkey.

Materials and Methods

This study was carried out in the streams and lakes in borders of the Nevşehir Province periodically every

Table 1. Coordinates of the sampling sites in Nevşehir Province.

Station	Date	Location	Coordinate
		Streams	
S-1	17.06.2014	Sulusaray	38º42’44’’N/34º50’48’’E
S-2	17.06.2014	Sulusaray	38º43’47’’N/34º43’57’’E
S-3	17.06.2014	Sulusaray	38º37’18’’N/34º38’04’’E
S-4	18.06.2014	Avanos	38º43’23’’N/34º48’94’’E
S-5	18.06.2014	Avanos-Sarıhıdır	38º38’78’’N/34º48’87’’E
S-6	18.06.2014	Göynük	38º48’34’’N/34º55’73’’E
S-7	18.06.2014	Göynük	38º48’24’’N/34º56’54’’E
S-8	18.06.2014	Göynük	38º51’69’’N/34º57’63’’E
S-9	18.06.2014	Sarılar	38º57’37’’N/34º48’28’’E
S-10	18.06.2014	Çağsak	39º04’57’’N/34º45’28’’E
S-11	18.06.2014	Pazarcık Kuş Cenneti	39º03’08’’N/34º45’28’’E
S-12	19.06.2014	Çağsak	39º05’19’’N/34º44’67’’E
S-13	19.06.2014	Doyduk	39º11’34’’N/34º45’16’’E
S-14	19.06.2014	Doyduk	39º12’22’’N/34º44’19’’E
S-15	19.06.2014	Çayiçi	39º12’21’’N/34º41’11’’E
S-16	19.06.2014	Yassıca	39º13’56’’N/34º39’43’’E
S-17	19.06.2014	Küllüce	39º13’75’’N/34º41’47’’E
S-18	19.06.2014	Karasenir	39º17’44’’N/34º50’91’’E
S-19	19.06.2014	Karasenir-Kanlıca	39º17’13’’N/34º53’21’’E
S-20	20.06.2014	Karasenir-Kanlıca	38º35’82’’N/34º30’36’’E
S-21	20.06.2014	Gökçetoprak	38º39’15’’N/34º18’68’’E
S-22	20.06.2014	Ovaören	38º36’09’’N/34º18’50’’E
S-23	20.06.2014	Ovaören	38º36’40’’N/34º17’73’’E
S-24	20.06.2014	Yalıntaş Lake	38º40’97’’N/34º20’45’’E
S-25	20.06.2014	Hacıbektaş-Ayhan	38º54’32’’N/34º38’10’’E
S-26	20.06.2014	Cemil	38º32’15’’N/34º55’56’’E
S-27	20.06.2014	Ürgüp-Mustafapaşa	38º36’00’’N/34º54’42’’E
		Reservoirs/Lakes	
R-1	18.09.2014	Tatlarin	38º36’52’’N/34º30’15’’E
R-2	18.09.2014	Yalıntaş	38º40’46’’N/34º20’11’’E
R-3	19.09.2014	Ayhanlar	38º49’29’’N/34º43’08’’E
R-4	19.09.2014	Kumtepe	38º55’41’’N/34º37’39’’E
R-5	20.09.2014	Doyduk	39º11’54’’N/34º45’14’’E
R-6	21.09.2014	Damsa	38º32’35’’N/34º55’28’’E
R-7	22.09.2014	Taşlıhöyük	39º08’03’’N/34º55’08’’E
L-8	22.09.2014	Özkonak Lake	38º51’14’’N/34º51’04’’E

month from May 2014 to September 2014. Coordinates of the sampling stations are given in Table 1. A total of 1222 specimens was collected using electrofishing device (SAMUS 725MP) and gillnets of various mesh sizes (5, 6.25, 8, 12.5, 15, 19.5, 24, 29, 35, 43, and 55 mm, knot to knot). Specimens were photographed alive to obtain records of natural coloration. The ichthyological materials obtained in the samples that were fixed in the field into 10% formalin solution and transported to the Ichthyology Laboratory (Department of Biology, Nevşehir Hacı Bektaş Veli University), where they were identified followed by Geldiay and Balık (2007) and Pfleiderer et al. (2014). Total, fork and standard lengths were measured with a digital caliper (with ±0.1 mm precision), and weighed with an electronic scale to the nearest ± 0.01. The samples were deposited at the fish collection of the Nevşehir Hacı Bektaş Veli University.

The length-length (L-L) relationships were calculated by the simple linear regression a: $x = b\,y+\alpha$ where x and y are variables, α and b are regression constants. Weight-length relationship expressed as $W=\alpha*L^{b}$, where W whole body wet weight in grams and L= total length in cm, α and b are regression constants. Logarithmic form of the LWR expressed by $\log W=\log\alpha+b\log L$. Fulton’s condition

Table 2. Length-length relationships among total, fork, and standard lengths of seven fish species from Nevşehir Province, Kızılırmak Basin.

Species	n	Regression equations		
		Total Length-Fork Length	Total Length-Standard Length	Standard Length -Fork Length
Aphanius marassantensis	45	-	*SL*=(0.987**TL*)-0.5660	-
Capoeta tinca	111	*FL*=(0.9296**TL*)-0.1534	*SL*=(0.856**TL*)-0.4336	*SL*=(0.913**FL*)-0.0569
Carassius auratus	20	*FL*=(0.6159**TL*)-4.8643	*SL*=(0.515**TL*)-4.2090	*SL*=(0.8885**FL*)-0.6962
Carassius gibelio	26	*FL*=(0.6929**TL*)-4.3603	*SL*=(0.586**TL*)-4.0556	*SL*=(0.8461**FL*)-0.3643
Cyprinus carpio	26	*FL*=(0.9024**TL*)-0.598	*SL*=(0.817**TL*)-0.5260	*SL*=(0.8991**FL*)-0.1474
Oxynoemacheilus angorae	54	*FL*=(0.9722**TL*)-0.0504	*SL*=(0.832**TL*)-0.0347	*SL*=(0.8493**FL*)-0.0408
Squalius cf. *cephalus*	62	*FL*=(0.9385**TL*)-0.0698	*SL*=(0.868**TL*)-0.2593	*SL*=(0.9244**FL*)-0.3165

n: number of fishes collected, TL: total length, FL: fork length and SL: standard length

Table 3. Descriptive statistics for length and weight, Fulton's Condition Factor (K) and estimated parameters of length-weight relations for seven species from Nevşehir Province (Kızılırmak River Basin).

Species	n	Mean *TL+SD* (Range)	Mean *TW+SD* (Range)	*a*	*b*	R^2	*%95 CI of b*	*GT*	Mean *K* (Range)
Aphanius marassantensis	140	2.54±0.63 (1.7-4.6)	0.38±0.33 (0.09-2.76)	0.019	2.987	0.96	2.887-3.087	I	1.92±0.29 (1.18-3.26)
Capoeta tinca	136	31.91±5.03 (12.7-39.9)	328.44±128.73 (23.21-624.90)	0.017	2.839	0.95	2.731-2.946	-A	0.96±0.12 (0.61-1.45)
Carassius auratus	58	18.07±1.61 (13.2-20.8)	95.82±22.17 (33.00-125.11)	0.035	2.731	0.81	2.378-3.083	I	1.60±0.19 (1.08-2.08)
Carassius gibelio	144	18.65±3.20 (12.2-39.5)	99.96±60.05 (26.31-445.49)	0.023	2.856	0.85	2.660-3.052	I	1.46±0.31 (0.64-2.14)
Cyprinus carpio	301	22.42±5.82 (12.2-42.4)	216.16±192.80 (34.95-1177.04)	0.001	3.138	0.93	3.043-3.234	+A	1.52±0.37 (0.74-3.89)
Oxynoemacheilus angorae	127	5.64±1.046 (2.8-8.6)	1.88±1.00 (0.22-6.18)	0.008	3.102	0.94	2.967-3.236	I	0.94±0.13 (0.57-1.35)
Squalius cf. *cephalus*	316	20.099±6.29 (4.9-32.7)	130.13±97.99 (1.38-451-37)	0.014	2.962	0.98	2.916-3.007	I	1.56±0.23 (0.69-2.67)

n: number of fishes collected, *TL*: Total Length, *TW*: Total body weight, *SD*: Standard deviation, *a* and *b* regression constants, *CI*: Confidence intervals, *GT*: Type of growth, I: Isometric, -A: Negative allometry, +A: Positive allometry

factor was estimated using following equation: $K=100(W/L^3)$.

Graphics were powered by Microsoft Excel and all analysis were performed using SPSS (IBM SPSS Statistics 22) package program.

Results and Discussion

The length-length relationships among total TL, FL, and SL were presented in the Table 2.

The relationships were estimated for *C. carpio* (TL=0.2635+1.1937*SL; TL=0.1512+1.1037*FL; FL= 0.1224+1.10805*SL) and *C. gibelio* (TL=0.3279+1.2281 *SL; TL=0.0512+1.10963*FL; FL=0.3617+1.1190*SL) as per Gaygusuz et al. (2006). The present study provides L-L relationship parameters for the first time for *A. marassantensis*, *C. tinca*, *C. auratus*, *O. angorae*, *S.* cf. *cephalus* (Froese and Pauly, 2015).

The range of TL and TW parameters of the LWRs and values of K are shown in Table 3. The slope "*b*" values of the LWRs were ranged from 2.731 to 3.138 for *C. auratus* and *C. carpio*, respectively. The LWRs were found highly significant with all "r" values being > 0.900 except species belonging to the genus *Carassius*. This implies that cube law can be applied to most of the species distributed in the Nevşehir Province (Froese, 2006). Indeed in terms of growth type, an isometric growth was observed for five species, *C. tinca* showed negative allometric growth (*b*<3) and *C. carpio* showed positive allometric growth (*b*>3).

There have been some studies on condition factors and LWRs of studied species in the Kızılırmak River Basin or adjacent areas (Table 4). For the studied species in the present study, the *b* values were in agreement with some previous studies. However, some differences were also observed among them.

Growth type of *C. tinca* demonstrates negative allometry in this study. Similar findings were also reported from Islavloz and Delice streams (Gül and

Table 4. Comparison of the LWRs and Fulton's condition factor (K) of studied species in the present study with some other previously published data in Turkey.

Species	*a*	*b*	*GT*	*K*	Habitat	Source
Aphanius marassantensis	0.0111	3.400			Hirfanlı Dam	Yoğurtçuoğlu and Ekmekçi (2015)
Capoeta tinca	0.00004	2.811		1.43	Delice Stream	Gül and Yılmaz (2002)
Capoeta tinca	0.0091	3.119	+A		Çakmak Dam	Yılmaz and Polat (2009)
Capoeta tinca	0.0043	3.352	+A		Derbent Dam	Yılmaz and Polat (2009)
Capoeta tinca	0.0212	2.849	-A		Islavloz Stream	Yılmaz and Polat (2009)
Capoeta tinca	0.0075	3.207	+A		Kızılırmak River	Yılmaz and Polat (2009)
Carassius auratus	0.0210	3.060	I	2.52	Eğirdir Lake	İzci (2004)
Carassius auratus	0.078	3.649	+A		Eğirdir Lake	Kuşat et al. (2006)
Carassius gibelio	0.0084	3.250			Iznik Lake	Tarkan et al. (2006)
Carassius gibelio	0.0265	2.978	I	2.49	Bafra Balık Lake	Bostancı et al. (2007)
Carassius gibelio	0.031	2.87	-A		Buldan Dam	Sarı et al. (2008)
Carassius gibelio	0.0138	3.114			Aksu River	Innal (2012)
Carassius gibelio	0.0274	2.938			Seyitler Reservoir	Bulut et al. (2013)
Carassius gibelio	0.0168	3.149	+A	2.68	Ladik Lake	Yazıcıoğlu et al. (2013)
Carassius gibelio	0.0673	2.571	-A		Seyhan Dam	Ergüden (2015)
Carassius gibelio	0.0173	2.974			Marmara Lake	İlhan and Sarı (2015)
Carassius gibelio	0.015	3.125			Iznik Lake	Uysal et al. (2015)
Cyprinus carpio	0.0250	2.830			Iznik Lake	Tarkan et al. (2006)
Cyprinus carpio	0.0283	2.872	-A	1.87	Liman Lake	Demirkalp (2007a)
Cyprinus carpio	0.0547	2.665	-A	1.77	Çernek Lake	Demirkalp (2007b)
Cyprinus carpio	0.0049	3.191	+A	1.34	Almus Dam	Karataş et al. (2007)
Cyprinus carpio	0.0260	2.90			Seyhan Dam	Ergüden and Göksu (2009)
Cyprinus carpio	0.026	2.825	-A		Altınkaya Dam	Yılmaz et al. (2010a)
Cyprinus carpio	0.0298	2.802	-A		Bafra Balık Lake	Yılmaz et al. (2010a)
Cyprinus carpio	0.021	2.894	I		Derbent Dam	Yılmaz et al. (2010a)
Cyprinus carpio	0.0197	2.895	I		Karaboğaz Lake	Yılmaz et al. (2010a)
Cyprinus carpio	0.0218	2.967	I	1.97	Hirfanlı Dam	Yılmaz et al. (2010b)
Cyprinus carpio	0.0310	2.796			Marmara Lake	İlhan and Sarı (2015)
Oxynoemacheilus angorae	0.006	3.237	+A		Balıklı Stream	Gaygusuz et al. (2013)
Squalius cf. *cephalus*	0.0399	2.683		1.70	Gelingülü Dam	Kırankaya and Ekmekçi (2007)
Squalius cf. *cephalus*	0.0138	3.028			Çamlıdere Dam	Bostancı and Polat (2009)
Squalius cf. *cephalus*	0.0060	3.19			Seyhan Dam	Ergüden and Göksu (2009)
Squalius cf. *cephalus*	0.00005	2.828	I	1.40	Hafik Lake	Ünver and Kekilli (2010)
Squalius cf. *cephalus*	0.0248	2.875		1.52	Hafik Lake	Ünver and Kekilli (2010)
Squalius cf. *cephalus*	0.0106	3.088		1.30	Tödürge Lake	Ünver and Erk'akan (2012)
Squalius cf. *cephalus*	0.0084	3.148		1.37	Keban Dam	Aydın et al. (2015)

(*a* and *b* regression constants, GT: type of growth, *K*: Fulton's Condition Factor)

Yılmaz, 2002; Yılmaz and Polat, 2009). The *b* values of *C. carpio* estimated in this study were generally higher than those in the previous studies (Demirkalp, 2007a, b; Yılmaz et al., 2010a, b) except for Almus Reservoir population (Karataş et al., 2007). The values of *b* for *S.* cf. *cephalus* obtained in this study are in agreement with studies by Bostancı and Polat (2009), Ünver and Erk'akan (2012) and Aydın et al. (2015) that reported *b* value ranged from 3.028 to 3.188. The *b* values for both *C. auratus* and *C. gibelio* are estimated lower than that of previous studies (Table 4).

Difference in *b* values can be attributed to the combination of one or more factors such as number of specimens examined, area/seasonal effect, habitat, degree of stomach fullness, gonadal maturity, sex, health and general fish condition, preservation technique, and differences in the observed length ranges of the specimens caught (Wooten, 1998).

Fulton's condition factor varied between 0.94 for *O. angorae* and 1.92 for *A. marassantensis* (Table 3). The condition factors of *C. auratus* and *C. gibelio* were strikingly lower than the values documented in the previous studies (İzci, 2004; Bostancı et al., 2007; Yazıcıoğlu et al., 2013). The present lower K values might be attributed to low habitat properties. Indeed, both *C. auratus* and *C. gibelio* are invasive species that became overpopulated and stressed their food sources. Additionally in dams where they were caught, direct and indirect negative effects of pollution were observed on conditions. Similarly Radkhah and Eagderi (2015) reported that low condition values indicate less favorable environmental conditions.

Froese (2006) and Heincke (1908) concluded that condition of fish varies with sex, size, season and degree of gonad development. Mean condition of specimens as well as the difference in condition between small and large specimens vary between seasons, localities and years, resulting in different weight-length relationships.

The findings and information on LWRs would be beneficial for fishery biologists and conservationists to impose adequate regulations for sustainable fishery management and conservation of biodiversity for these ecosystems.

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