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SHORT PAPER

Length-Weight Relationships of Nine Cyprinid Species from Inland Waters of Turkey

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Abstract

This study reports first estimation of length-weight relationships for nine Cyprinid species; *Barbus niluferensis* Turan, Kottelat and Ekmekçi, 2009, *Capoeta baliki* Turan, Kottelat, Ekmekçi and Imamoglu, 2006, *Capoeta banarescui* Turan, Kottelat, Ekmekçi and Imamoglu, 2006, *Capoeta ekmekciae* Turan, Kottelat, Kirankaya and Engin, 2006, *Capoeta erhani* Turan, Kottelat and Ekmekçi, 2008, *Capoeta turani* Özuluğ and Freyhof, 2008, *Luciobarbus kottelati* Turan, Ekmekçi, Ilhan and Engin, 2008, *Squalius kottelati* Turan, Yilmaz and Kaya, 2009 and *Squalius seyhanensis* Turan, Kottelat and Doğan, 2013 from inland waters of Turkey. Coefficient of determinations (r^2) ranged from 0.9951–0.9767 and *b* values ranged between 2.7895 and 3.1176. Allometric growth pattern was statistically observed for *C. baliki* (Pauly's *t* test: $t = 9.7098$, $P<0.001$) and *S. seyhanensis* (Pauly's *t* test: $t = 6.5348$, $P<0.001$).

Keywords: Cyprinidae, length-weight relationships, new species, inland water, Turkey.

Türkiye İç Sularından Dokuz Cyprinid Türünün Boy-Ağırlık İlişkisi

Özet

Bu çalışmada, Türkiye iç sularından kaydedilen dokuz yeni Cyprinid türü için (*Barbus niluferensis* Turan, Kottelat and Ekmekçi, 2009, *Capoeta baliki* Turan, Kottelat, Ekmekçi and Imamoglu, 2006, *Capoeta banarescui* Turan, Kottelat, Ekmekçi and Imamoglu, 2006, *Capoeta ekmekciae* Turan, Kottelat, Kirankaya and Engin, 2006, *Capoeta erhani* Turan, Kottelat and Ekmekçi, 2008, *Capoeta turani* Özuluğ and Freyhof, 2008, *Luciobarbus kottelati* Turan, Ekmekçi, Ilhan and Engin, 2008, *Squalius kottelati* Turan, Yilmaz and Kaya, 2009 and *Squalius seyhanensis* Turan, Kottelat and Doğan, 2013) boy-ağırlık ilişkileri (LWRs) ilk kez rapor edilmiştir. Determinasyon katsayısı (r^2) 0,9951 ve 0,9767 arasında hesaplanmıştır. Türler için hesaplanan *b* değerleri ise 2.7895 ve 3.1176 arasında değişim göstermiştir. *C. baliki* (Pauly's *t* test: $t = 9.7098$; $P<0.001$) ve *S. seyhanensis* (Pauly's *t* test: $t = 6.5348$; $P<0.001$) türleri için allometrik büyüme özelliği tespit edilmiştir.

Anahtar Kelimeler: Cyprinidae, boy-ağırlık ilişkisi, yeni tür, iç su, Türkiye.

Introduction

Length-weight relationships are important and have many applications in fish stock assessments, biomass estimations, ecological studies and modeling aquatic ecosystems (Froese, 2006). Length-weight relationships are also provides valuable information about the habitats where the fish lives, condition, reproduction history, life cycle and the general health of fish species (Froese *et al*., 2011). Many studies have been reported related to length-weight relationships for a variety of fish species and many are available on the www.fishbase.org (Froese and Pauly, 2014) and catalog of fishes.

Here, we presented for the first time length-weight relationships for 9 Cyprinid species except for *Capoeta erhani*, *Capoeta baliki* and *Luciobarbus kottelati* from inland waters of Turkey (Table 1).

Materials and Methods

Fish were caught by pulsed DC electric fishing equipment between 22 November 2002 and 18 August 2014 in different regions from Turkish inland waters. Sampling areas, sampling dates and the number of individuals belonging to the 9 Cyprinid species are shown in Table 1. Fish were killed with an overdose of MS 222, fixed in 4% formaldehyde and

Table 1. Sampling areas, sampling date and number of sampling individuals of 9 species belonging to 4 different genus

Species	Sampling Area			Sampling	*n*
	Province	Stream and River	Basin	Date	
Barbus niluferensis	Balıkesir	Kocaçay Stream, Susurluk River	MS	16.10.2004	50
Barbus niluferensis	Bursa	Nilüfer Stream, Susurluk River	MS	14.09.2004	69
				Total	119
Capoeta baliki	Ankara	Ilhanlı Stream, Sakarya River	BS	19.07.2004	26
Capoeta baliki	Ankara	Ilhanlı Stream, Sakarya River	BS	15.06.2005	64
Capoeta baliki	Ankara	Kızılcahamam Stream, Sakarya River	BS	15.04.2004	37
Capoeta baliki	Ankara	Kızılcahamam Stream, Sakarya River	BS	14.07.2004	19
Capoeta baliki	Ankara	Kızılcahamam Stream, Sakarya River	BS	18.06.2005	32
Capoeta baliki	Kırşehir	Delicеırmak Stream, Kızılırmak River	BS	22.11.2002	10
Capoeta baliki	Kırşehir	Delicеırmak Stream, Kızılırmak River	BS	11.09.2004	49
Capoeta baliki	Samsun	Abdal Stream, a coastal Stream	BS	15.08.2004	72
Capoeta baliki	Samsun	Abdal Stream, a coastal Stream	BS	18.09.2004	19
Capoeta baliki	Sivas	Zara Stream, Kızılırmak River	BS	22.11.2004	5
				Total	333
Capoeta banarescui	Artvin	Bulanık Stream, Çoruh River	BS	14.06.2004	19
Capoeta banarescui	Erzurum	Tortum Stream, Çoruh River	BS	19.07.2004	36
Capoeta banarescui	Artvin	Çifteköprü Stream, Çoruh River	BS	07.07.2004	6
Capoeta banarescui	Artvin	Aralık Stream, Çoruh River	BS	16.09.2004	4
Capoeta banarescui	Erzurum	Aksu Stream, Çoruh River	BS	24.12.2004	1
Capoeta banarescui	Erzurum	Büyükköy Stream, Çoruh River	BS	15.10.2005	17
Capoeta banarescui	Artvin	Ardanuç Stream, Çoruh River	BS	18.07.2005	18
				Total	101
Capoeta ekmekciae	Artvin	Bulanık Stream, Çoruh River	BS	14.07.2004	42
Capoeta ekmekciae	Artvin	Çifteköprü Stream, Çoruh River	BS	19.07.2004	5
				Total	47
Capoeta erhani	Kahramanmaraş	Aksu Stream, Ceyhan River	M	08.06.2014	17
Capoeta erhani	Kahramanmaraş	Geçit Stream, Ceyhan River	M	15.06.2005	7
				Total	24
Capoeta turani	Adana	Üçürgene Stream, Seyhan River	M	10.06.2014	17
				Total	17
Luciobarbus kottelati	Aydın	Karasu Stream, Büyük Menderes River	AS	06.04.2005	6
Luciobarbus kottelati	Uşak	Civril Stream, Büyük Menderes River	AS	18.08.2014	5
				Total	11
Squalius kottelati	Kahramanmaraş	Menzelet Dam Lake, Ceyhan River	M	10.02.2006	12
Squalius kottelati	Kahramanmaraş	Aksu Stream, Ceyhan River	M	14.06.2005	6
				Total	18
Squalius seyhanensis	Kayseri	Zamantı Stream, Seyhan River	M	12.06.2005	122
Squalius seyhanensis	Kayseri	Zamantı Stream, Seyhan River	M	17.12.2005	348
Squalius seyhanensis	Kayseri	Zamantı Stream, Seyhan River	M	25.04.2006	51
				Total	521
TOTAL					1191

BS: Black Sea, MS: Marmara Sea, AS: Aegean Sea, M: Mediterranean Sea.

stored in 70% alcohol solution. Total lengths (*TL*) of specimens were measured to the nearest 0.1 mm and the fish were weighed to the nearest 0.01 g.

Length-Weight Relationships

A plot of log *a* versus *b* for all known length weight relationships of fish species results in a linear relationship, and that this relationship can be used to identify outlier data (Stergiou and Moutopoulos, 2001). Therefore, outliers in length weight relationships were visually analyzed on log W and log L graphs and outlier data were removed.

Least squares regression analysis with MS Excel software (2003) was used to calculate the length weight relationship parameters. The length weight relationship was estimated as:

$$W = aTL^b$$

where W is the body weight (g), TL is the total length (cm), a is the intercept, and b is the slope of the regression line.

Comparison of the difference of slope value from $b = 3$ (isometric growth) for all species, Pauly's *t*-test was performed (Pauly, 1984). Pauly's *t*-test was calculated as:

$$t = \frac{Sd_{\log TL}}{Sd_{\log W}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2},$$

where Sd_{logTL} is the standard deviation of the log *TL* values, Sd_{logW} is the standard deviation of the log *W* values, n is the number of Cyprinid fish species used in the computation. The value of *b* is different from 3 if *t* value is greater than the tabled *t* values for n-2 degrees of freedom (Pauly 1984).

Results

Length-weight relationships were calculated for a total of 1191 specimens representing 9 species belonging to 4 genus. The parameters of the length-weight relationships for each species are given in Table 2, together with the regression coefficient (r^2), the number of specimens measured (*n*), the smallest (min), largest (max), mean ± standard error of the total length and 95% confidence inretval *b* and and statistical results.

The exponent (*b*) of the length-weight relationships were estimated between 2.7985 and 3.1176. Isometric or cubic growth (*b*=3) was statistically observed for *B. niluferensis*, *C. banarescui*, *C. ekmekciae*, *C. erhani*, *C. turani*, *L. kottelati*, and *S. kottelati*, while allometric growth pattern was statistically observed for *C. baliki* (Pauly's *t* test: *t*=9.7098, P<0.001) and *S. seyhanensis* (Pauly's *t* test: *t* = 6.5348, P<0.001).

Discussion

This study provides first information on length weight relationships of recently discovered nine cyprinid fish species except for *C. erhani*, *C. baliki* and *L. kottelati* belonging to the genus of *Barbus*, *Capoeta*, *Luciobarbus* and *Squalius* from inland waters of Turkey. Our results about length weight relationships of three cyprinid species are not new, but provide detailed information with other six species.

In this study, *L. kotellati* showed isometric growth (*n* = 11, *b* = 2.8825) which was consisted with previous studies (Gaygusuz *et al*., 2013). Only one study reported allometric growth (*b* = 3.138) for this species in Turkish inland waters (Başıaçık *et al*., 2012) (Table 3).

A recent study, allometric growth (*b* = 3.017) was reported for *C. baliki* from Sakarya River (Gaygusuz *et al*., 2013). Ayyildiz *et al*. (2014), studied age and growth of *C. erhani* in Menzelet Reservoir, Ceyhan River drainage and it was reported that growth of *C. erhani* is positive allometric for males (*b* = 3.2011), isometric for females (*b* = 3.0015) and allometric (*b* = 3.0892) for combined sex (Table 3). However, we observed isometric growth (*b* = 3.0996, *n* = 24) for combined sex of *C. erhani*.

In this study, isometric growth was observed in majority of species (*B. nilüferensis*, *C. banarescui*, *C. ekmekciae*, *C. erhani*, *C. turani*, *L. kottelati*, *S. kottelati*) whereas allometric growth were only observed in two species (negative allometric for *C. baliki*, positive allometric for *S. seyhanensis*) (Table 2). The numerical value of *b* ranges between 2.5 and 3.5, and is often close to 3 (Pauly, 1984). Our results showed that *b* values ranged between *b* = 2.7895 for *C. baliki* and *b* = 3.1176 for *S. seyhanensis*. The variation in the exponent (*b*) of the length weight

Table 2. The parameters of the length-weight relationships of 9 species belonging to 4 different genus together with the regression coefficient (r^2), the number of specimens (*n*), minimum (*min*), maximum (*max*), mean ± standard error of the total length and 95% Confidence Interval *b*(±SE) of specimens measured and statistical results

Species	Total Length (cm)					95%Confidence		*Pauly's t-*	
	n	min-max	Mean±SE	*a*	*b*	Interval *b*(±SE)	r^2	*test*	P
Barbus niluferensis	119	6.4-16.4	9.86±0.177	0.0126	2.9776	2.8934-3.0618 (±0.0425)	0.9767	0.5268	ns
Capoeta baliki	333	5.9-31.4	13.52±0.216	0.0191	2.7895	2.7468-2.8322 (±0.0217)	0.9804	9.7098	<0.001
Capoeta banarescui	101	6.9-28.6	15.66±0.451	0.0107	3.0353	2.9689-3.1016 (±0.0334)	0.9881	1.0545	ns
Capoeta ekmekciae	47	6.5-41.4	15.14±1.069	0.0130	2.9639	2.8741-3.0537 (±0.0446)	0.9899	0.8089	ns
Capoeta erhani	24	11.2-21.3	16.38±0.599	0.0084	3.0996	2.9421-3.2572 (±0.0759)	0.9870	1.3132	ns
Capoeta turani	17	4.9-20.9	13.07±1.194	0.0147	2.8942	2.7816-3.0069 (±0.0529)	0.9950	1.9973	ns
Luciobarbus kottelati	11	9.6-25.7	17.30±1.662	0.0176	2.8825	2.6334-3.1316 (±0.1101)	0.9870	1.0656	ns
Squalius kottelati	18	18.0-28.5	21.46±1.444	0.0104	3.0551	2.9412-3.1689 (±0.0537)	0.9951	1.0281	ns
Squalius seyhanensis	521	5.6-41.0	17.07±0.215	0.0095	3.1176	3.0822-3.1529 (±0.0179)	0.9830	6.5348	<0.001

ns: non-significant

Table 3. Comparison of length-weight relationships of recently discovered cyprinid species from inland waters of Turkey

Species		min - max	n	*a*	*b*	r^2	Area	References
Capoeta balikii	TL	9.7-25.4	55	0.009	3.017	0.981	Porsuk Stream, Sakarya River	Gaygusuz *et al.* (2013)
Capoeta erhani	TL	15.2-33.8	135	0.0075	3.0892	0.979	Menzelet Reservoir, Ceyhan River Drainage	Ayyıldız *et al. (*2014)
Luciobarbus kottelati	FL	13.2-32.3	144	0.009922	3.1382	0.975	Adıgüzel Reservoir, Büyük Menderes River Drainage	Başıaçık *et al. (*2012)
Luciobarbus kottelati	TL	5.7-28.0	96	0.017	2.796	0.989	Kamış Stream	Gaygusuz *et al.* (2013)

FL: fork length (cm), TL: total length (cm)

relationships of fish species could be affected by geographic locations, sampling area, seasons, sex, spawning time, sexual maturity, stomach fullness, size range and ecological factors such as temperature (Yılmaz and Polat, 2009; Erguden and Goksu, 2009; Ayyildiz *et al*., 2014). Different species belonging to the same genus can possibly affect the *b* value (Ayyildiz *et al*., 2014).

In further investigations, determination of new species, population parameters such as age, growth, mortality and reproduction biology (spawning time, fecundity and size at sexual maturity etc.) in different areas are necessary to understand stock size and to develop ecosystem based fisheries management.

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