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Length-Weight Relationship of 15 Different Freshwater Fish Species in the Gediz River Basin (Turkey) Lentic System

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ABSTRACT

The aim of study is to determine the length-weight relationship of freshwater fish species in the Gediz River basin lentic system. Fish samples were collected between November 2016 and April 2017 using multi mesh gillnets and beach seine nets from six different locations in the Gediz River basin lentic system. Length–weight relationship was estimated for 15 fish species (*Luciobarbus lydianus, Barbus pergamonensis, Cyprinus carpio, Carassius gibelio, Petroleuciscus smyrnaeus, Alburnus battalgilae, Squalius fellowesii, Chondrostoma holmwoodii, Vimba vimba, Rhodeus amarus, Pseudorasbora parva, Atherina boyeri, Cobitis kurui, Gambusia holbrooki* and *Knipowitschia mermere*), belonging to 8 different families (Cyprinidae, Leuciscidae, Acheilognothidae, Gobionidae, Atherinidae, Cobitidae, Poeciliidae, Gobiidae). Computed exponent *b* and R^2 values ranged from 1.9348 to 4.3466 and 0.7072 to 0.9986, respectively. In the study, a longer maximum length value was determined for the two species than reported in the literature. In addition, this study presents the first records of *LWR* parameters for four endemic species in the basin.

Keywords: *LWR* parameters, lake, reservoir, West Anatolia, Gediz River

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Gediz Nehri Havzası Lentik Sistemindeki (Türkiye) 15 Farklı Tatlı Su Balığı Türünün Boy-Ağırlık İlişkileri

Öz: Çalışmanın amacı, Gediz Nehri lentik sisteminde yayılış gösteren tatlısu balık türlerinin boy-ağırlık ilişkilerini belirlemektir. Balık örnekleri Kasım 2016 ve Nisan 2017 tarihlerinde Gediz Nehri lentik sistemindeki (6 farklı lokalite), çokgözlü solungaç ve kıyı sürütme ağları ile toplanmıştır. Boy-ağırlık ilişkileri, 8 farklı aileye (Cyprinidae, Leuciscidae, Acheilognothidae, Gobionidae, Atherinidae, Cobitidae, Poeciliidae, Gobiidae) ait, 15 balık türü (*Luciobarbus lydianus, Barbus pergamonensis, Cyprinus carpio, Carassius gibelio, Petroleuciscus smyrnaeus, Alburnus battalgilae, Squalius fellowesii, Chondrostoma holmwoodii, Vimba vimba, Rhodeus amarus, Pseudorasbora parva, Atherina boyeri, Cobitis kurui, Gambusia holbrooki* and *Knipowitschia mermere*) için tahmin edilmiştir. Hesaplanan *b* ve R^2 değerleri sırasıyla, 1,9348 ile 4,3466 ve 0,7072 ile 0,9986 arasında değişmektedir. Çalışmada, iki tür için mevcut literatürde bildirilenden daha uzun bir maksimum uzunluk değeri tespit edilmiştir. Ayrıca bu çalışma havzadaki dört endemik tür için boy-ağırlık ilişkisi parametrelerinin ilk kayıtlarını sunmaktadır.

Anahtar kelimeler: Boy-ağırlık ilişkisi parametreleri, göl, rezervuar, Batı Anadolu, Gediz Nehri

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Introduction

Length and weight, both in population and individual basis, are two basic morphological characteristics in fish biology. The weight of fish is closely related to their length, thus it determines whether somatic growth is isometric or allometric. Length-weight relationship (*LWR*) is widely used for fisheries management and conservation (LeCren 1951; Pitcher and Hart 1982; Froese 2006; Froese et al. 2011). They are commonly used for weight estimation from the length of individual fish (Tsoumani et al. 2006) and for the calculation of condition factors when comparing observed and expected length–weight values (LeCren 1951; Froese 2006; Gaygusuz et al. 2013).

Turkey is geographically situated between two continents and is one of the few terrestrial parts of world with high biological diversity. Turkey's geography consists of the Anatolian and Thrace regions, but its ichthyofaunal richness originates

from the Anatolian region (Görür et al. 1984; Güçlü and Küçük 2015). Although scientific studies in Anatolia began in the second half of the 18th century, the basic biological information for the majority of freshwater fish species in Turkey is still missing (Güçlü and Küçük 2015).

Located in the Aegean Region of Turkey, Gediz River's length is second only to the Büyük Menderes River, which is flow in the south is roughly parallel with a distance of slightly more than a hundred kilometers. Length of the Gediz River is 401 km and has a stream catchment area of 17.500 km². River basin has been contaminated day by day, due to intensive, rapid and excessive industrial, domestic and agricultural expansion. However, the reserve suffers from water shortages due to large volume water demand of irrigation projects connected to the Demirköprü reservoir. High level of urbanization and industrialization throughout the basin also cause Gediz River to be exposed to severe pollution, especıally from sand and gravel quarries and the leather industry. These factors have caused the river's former rich fish reserves to become a thing of the past in today (Güçlü and Küçük 2015).

There is no ecological study (length–weight relationship) conducted with *Luciobarbus lydianus, Chondrostoma holmwoodii, Barbus pergamonensis* and *Cobitis kurui*, which are endemic fish fauna of the basin. Researches on the other endemics of the basin, *Petroleuciscus smyrnaeus, Alburnus battalgilae* and *Knipowitschia mermere* are also limited. In this study, we described the *LWR* parameters for 15 fish species (8 endemic, 3 natural and 4 invasive species) obtained from 6 different locations (including two lake and four reservoirs) in the lentic system of the Gediz River basin (Aegean Region, Turkey). The aim of this study was to produce *LWR* for species in Gediz River basin, which will be helpful for sustainable management of local fishery and developing of conservation programs in the region.

Materials and Methods

The study was carried out in 6 different locations including two lakes and four reservoirs (Küçükler, Afşar, Buldan and Demirköprü reservoirs, the Gölcük and the Marmara Lakes) in the lentic system of the Gediz River basin (Turkey) (Table 1). 1630 individuals were caught from 15 species, belonging to 8 families (Cyprinidae (4), Leuciscidae (5), Achelignothidae (1), Gobionidae (1), Atherinidae (1), Poeciliidae (1), Gobiidae (1) and Cobitidae (1)). Sampling was carried out in November 2016 and April 2017 (one fishing operation was carried out on the specified dates) with multi mesh gillnets (35x1.5 m and 35x6 m in size, 10, 15, 20, 40, 55, 70, 80 and 100 mm mesh size) according to modified TS EN 14757 and beach seine net (5 and 15 mm mesh size) in the study area. Family names were given taxonomically according to Stout et al. (2016) and Van der Laan (2017). Specimens were measured to the nearest 0.1 cm total length and weighted to the nearest 0.01 g total weight. The *LWR* was established using the exponential regression equation $W = aTL^b$, where *W* was the body weight in g, *TL* was the total length in cm, "*a*" is the intercept and "*b*" is the regression coefficient (Ricker 1975). The statistical significance level of the coefficient of determination (R^2) and 95% confidence intervals (95% CI) of *b* was also estimated (Zar 1999).

Table 1. Lentic sampling points in the Gediz River basin

Lokality	Code	Altitude	Coordinates
Küçükler reservoir (Uşak)	KR	1.241 m	38° 52′ 30′′ N- 29° 36′ 39′′ E
Afşar reservoir (Manisa)	AR	249 m	38° 14′ 20′′ N- 28° 36′ 29′′ E
Buldan reservoir (Denizli)	BR	481 m	38° 08′ 40′′ N- 28° 50′ 44′′ E
Demirköprü reservoir (Manisa)	DR	234 m	38° 39′ 40′′ N- 28° 21′ 01′′ E
Gölcük Lake (İzmir)	GL	1.052 m	38° 19′ 01′′ N- 28° 01′ 37′′ E
Marmara Lake (Manisa)	ML	76 m	38° 36′ 59′′ N- 27° 59′ 00′′ E

Results and Discussion

A total of 1630 specimens of 15 species belonging to 8 families were used for calculation of the *LWR*. Table 2 shows range of *TL* and *W*, parameters *a* and *b*, the 95% confidence limits of *b* and the regression coefficient (R^2). Eight of these 15 species were endemic. Computed *LWR* parameters for 4 endemic species (*L. lydianus, C. holmwoodii, B. pergamonensis, C. kurui*) are given for the first time. New maximum length values has been determined for *P. parva* (11.14 cm TL, Afşar reservoir) and *K. mermere* (3.74 cm TL, Marmara Lake) in the basin. The expected range of $2.5<b<3.5$ was confirmed for all species (Froese 2006). Positive or negative allometry indicates a rounder or slimmer body, respectively, whereas isometric

growth shows that the body grows in the same proportion in all dimensions (Jobling 2008). The values of parameter *b* varied from 1.9348 (*A. battalgilae*, Marmara Lake) to 4.3466 (*C. gibelio*, Demirköprü reservoir). The regression coefficient between length and weight (R^2) varied between 0.7072 for *C. kurui* (Marmara Lake) and 0.9986 for *V. vimba* (Marmara Lake).

Table 2. *LWR* parameters of fishes in lentic systems in Gediz River basin

Species	Loc.	*n*	*TL* range	*W* range	*a*	*b*	95% CI of *b*	R^2
				Cyprinidae				
L. lydianus	DR	14	9.53-11.03	9.12-14.20	0.0148	2.8459	2.8216-2.8621	0.9506
	AR	27	13.57-25.26	26.05-182.45	0.0134	2.9266	2.8984-2.9412	0.9761
B. pergamonensis	KR	16	12.89.16.89	23.67-50.21	0.0785	2.2511	2.2301-2.2732	0.9257
C. carpio	GL	9	14.89-20.85	47.35-159.13	0.0050	3.4250	3.3976-3.4501	0.9507
	BR	35	12.61-22.64	33.52-191.51	0.0291	2.7721	2.7623-2.7903	0.9751
	AR	12	12.85-25.50	34.84-339.57	0.0123	3.0752	3.0601-3.0934	0.9719
C. gibelio	GL	20	12.44-17.64	38.12-102.00	0.0144	3.1038	3.0812-3.1189	0.9373
	KR	15	19.52-20.61	121.69-145.10	0.0015	3.8076	3.7912-3.8220	0.8644
	BR	21	19.23-20.85	122.35-160.60	0.0025	3.6361	3.6203-3.6424	0.9134
	DR	5	19.72-20.03	124.60-134.50	0.0003	4.3466	4.3109-4.3821	0.9630
	ML	56	7.59-22.85	6.36-216.60	0.0167	3.0320	3.0192-3.0498	0.9849
	AR	15	14.15-21.21	50.78-172.97	0.0115	3.1229	3.1145-3.1387	0.9632
				Leuciscidae				
P. smyrnaeus	GL	85	5.29-8.24	2.36-10.98	0.0011	3.1597	3.1456-3.1721	0.9776
	ML	208	4.91-12.48	1.64-30.65	0.0075	3.3276	3.3040-3.3421	0.9830
	AR	307	5.25-13.42	2.08-35.15	0.0100	3.1655	3.1423-3.1875	0.9831
A. battalgilae	DR	34	12.01-18.56	15.11-76.88	0.0009	3.9075	3.8821-3.9206	0.9470
	ML	10	19.42-19.86	75.14-81.25	0.2353	1.9348	1.9175-1.9542	0.8759
S. fellowesii	KR	47	11.54-17.61	15.80-52.16	0.0312	2.6073	2.5901-2.6231	0.9210
	BR	14	12.84-19.14	18.90-56.34	0.0314	2.5971	2.5701-2.6124	0.9124
C. holmwoodii	AR	27	15.44-23.74	31.23-104.60	0.0041	3.2680	2.2431-2.2789	0.9880
V. vimba	ML	15	12.06-23.41	18.47-189.23	0.0032	3.4884	3.4686-3.5001	0.9986
				Acheilognothidae				
R. amarus	DR	25	3.48-5.81	0.46-2.79	0.0067	3.4511	3.4345-3.4704	0.9245
	ML	142	3.48-5.61	0.46-2.38	0.0081	3.3473	3.3223-3.3635	0.8919
				Gobionidae				
P. parva	DR	73	5.51-9.10	1.46-6.87	0.0094	3.0080	2.9802-3.0121	0.9434
	ML	122	4.63-9.67	0.91-8.04	0.0236	2.5294	2.5058-2.5421	0.8078
	AR	61	4.09-11.14*	0.80-15.47	0.012	2.9863	2.9740-3.0023	0.9880
				Atherinidae				
A. boyeri	DR	101	6.61-10.48	1.84-8.98	0.0029	3.4227	3.4006-3.4442	0.9637
	ML	19	5.93-7.44	1.37-2.66	0.0082	3.9208	3.9002-3.9445	0.7767
				Cobitidae				
C. kurui	BR	14	6.82-8.58	2.58-4.84	0.0206	2.5074	2.4790-2.5132	0.9539
	ML	15	5.22-7.22	1.14-2.30	0.0162	2.4941	2.4601-2.5147	0.7072
	AR	21	7.01-8.00	2.58-3.32	0.0066	3.0271	3.0178-3.0413	0.9258
				Poeciliidae				
G. holbrooki	ML	20	3.09-5.13	0.50-2.64	0.0090	3.4789	3.4640-3.4825	0.9589
				Gobiidae				
K. mermere	ML	25	2.53-3.74*	0.19-0.66	0.0082	3.4064	3.3814-3.4206	0.8723

Loc: lokality, *n*: number of individuals, *T*L: total length (cm), *W*: weigth (g), *New maximum length

According to Tesch (1971), the values *b* varies between 2 to 4, and mostly remained within the expected range of 2.5-3.5. Length-weight relationship parameters are affected by various factors such as season, number of individuals surveyed, habitat, gonad maturity, gender and stomach content (Bagenal and Tesch 1978). In particular, *b* values are considered to be high for two species (*b*= 4.3466 *C. gibelio* - Demirköprü reservoir, *b*= 1.9348 *A. battalgilae* Marmara Lake). Because the number of samples is small and therefore covers a narrow range of lengths (Froese 2006).

The comparison of the values obtained in the study with limited number of previous studies conducted in the basin is shown in Table 3. Differences with *b* values obtained in the other studies may be due to factors affecting fish growth, such as water quality and nutrient availability (Sparre et al. 1989). Another reason for such differences may be the differences in number of samples, sampling time and sampling methods of the species.

Table 3. Comparison of *LWR* parameters reported by different studies in the Gediz River basin lentic system

Species	Locality	Ref.	*n*	*TL* range	*W* range	*a*	*b*	R^2
A. boyeri	Marmara Lake	1	101	3.70-8.70	0.40-5.40	0.0084	2.908	0.971
	Marmara Lake	2	20	3.80-4.70	0.36-0.64	0.0010	2.580	0.880
	Demirköprü reservoir	2	41	3.90-13.60	0.40-16.50	0.0080	2.949	0.990
	Gediz estuary	3	121	3.20-10.139	0.24-7.29	0.0073	2.985	0.999
C. gibelio	Marmara Lake	1	2213	6.80-27.50	4.90-372.20	0.0173	2.974	0.976
	Buldan reservoir*[1]	4	2325	9.70-25.50	23.80-269.10	0.0310	2.870	0.985
C. carpio	Marmara Lake	1	120	11.30-49.00	24.00-1790.00	0.0310	2.796	0.979
V. vimba	Marmara Lake	1	79	14.20-24.90	36.30-236.90	0.0053	3.283	0.974
R. amarus	Marmara Lake	1	105	2.80-6.50	0.26-4.49	0.0089	3.328	0.972
P. parva	Marmara Lake	1	116	5.20-11.00	1.60-14.60	0.0121	2.929	0.983
G. holbrooki	Marmara Lake*[2]	1	5	2.60-3.90	0.20-0.80	0.0145	2.945	0.818
	Marmara Lake	5	35	-	-	0.0160	2.905	0.975
A. battalgilae	Marmara Lake	1	298	14.60-24.10	31.60-141.60	0.0102	2.997	0.876
P. smyrnaeus	Marmara Lake	1	87	4.40-13.80	1.30-45.70	0.0091	3.284	0.994
K. mermere	Marmara Lake	1	39	2.00-2.70	0.08-0.23	0.0069	3.429	0.849

Ref.: Reference, *[1] Fork length, *[2] *G.affinis*, 1.İlhan and Sarı 2015; 2. İnnal and Engin 2020; 3. Kara et al. 2017; 4. Sarı et al. 2008; 5. Kurtul and Sarı 2020

The results of the study provide useful information for the management and protection of endemic species that are particularly threatened by water pollution, habitat loss, river regulation, water extraction and invasive-alien fish inflows. Besides contributing the *LWR* knowledge of fish found in the inland waters of Turkey, this study will form an important basis for the work will be done in the future.

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