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Length-Length, Length-Weight Relationships and Condition Factors of Some Anatolian *Oxynoemacheilus seyhanensis* (Bănărescu, 1968) Populations

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ABSTRACT

This study was conducted to provide length-weight (LWRs), length-length (LLRs) relationships and condition factor of *Oxynoemacheilus seyhanensis* from seven habitats belonging to three inland water basins of Turkey. A total of 166 specimens were collected from Yıldızeli, Taşköprü, Suşehri (Kızılırmak basin), Büyükpotuklu, Pınarbaşı and Örenşehir (Seyhan basin) and Akdağmadeni (Yeşilırmak basin) rivers during 2017-2019. The mean (±SE) of the total, fork lengths and weight were calculated as 6.49±1.59 cm, 6.35±1.60 cm and 3.47±2.41 g, respectively. b constant of LWRs ranged from 2.29 (Suşehri) to 3.52 (Büyükpotuklu), showing growth pattern of positive allometric in all studied populations except Suşehri (negative allometric), Pınarbaşı (ısometric) and Örenşehir (isometric) population. Condition factor was ranged from 0.92 (Pınarbaşı) to 1.15 (Örenşehir). In all length-weight and length-length relationships with r^2 were higher than 0.91. The results of above-mentioned parameters for this deep-bodied stone loach showed that wide range of *b*-value shows morphological flexibility of this species in different habitats.

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Anadolu'nun Bazı *Oxynoemacheilus seyhanensis* (Bănărescu, 1968) Popülasyonlarında Boy-Boy, Boy-Ağırlık İlişkileri ve Kondisyon Faktörü

ÖZET

Bu çalışma, Türkiye'nin üç nehir havzasına ait yedi habitattan *Oxynoemacheilus seyhanensis*'in boy-ağırlık (LWRs), boy-boy (LLRs) ilişkilerini ve kondisyon faktörünü belirlemek amacıyla yapılmıştır. Bu amaçla 2017-2019 yılları arasında Yıldızeli, Taşköprü, Suşehri (Kızılırmak havzası), Büyükpotuklu, Pınarbaşı, Örenşehir (Seyhan havzası) ve Akdağmadeni (Yeşilırmak havzası) akarsularından166 örnek toplanmıştır. Total, çatal boy ve ağırlığın ortalaması (+SH) sırasıyla 6,49 ± 1,59 cm, 6,35 ± 1,60 cm ve 3,47 ± 2,41 g olarak hesaplanmıştır. Sonuç olarak, boy-ağırlık ilişkisindeki *b* değerinin 2,29 (Suşehri) ile 3,52 (Büyükpotuklu) arasında değiştiği görülmüş ve Suşehri (negatif allometrik), Pınarbaşı (isometrik) ve Örenşehir (isometrik) popülasyonları hariç incelenen tüm popülasyonların pozitif allometrik büyüme özelliği görülmüştür. Kondisyon faktörünün ise 0,92 (Pınarbaşı) ile 1,15 (Örenşehir) arasında değişmekte olduğu belirlenmiştir. r^2 değeri tüm ilişki hesaplamalarında 0,91'ün üstünde bulunmuştur. Bu kalın gövdeli çöpçü balıkları *b* değerinin geniş bir değişim aralığına olması farklı habitatlardaki morfolojik esnekliğe işaret etmektedir.

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Anahtar Kelimeler
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Seyhan Havzası
Kızılırmak Havzası
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LWRs

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INTRODUCTION

Understanding of fish growth and condition factors are important in biological and ecological studies of fishes (Froese and Binohlan, 2000). The length-weight (*LWRs*) and length-length relationships (*LLRs*)

parameters of the fish species are important in the fisheries biology, providing information on several aspects of fish population dynamics and to understand the condition of fishes (Bagenal and Tesch, 1978; Gürkan and Taskavak, 2007). The condition factor of fishes indicates the interaction between biological and non-biological factors in the physiological conditions of them (Bagenal and Tesech, 1978). Estimation of this index in fish species is also very useful for comparing two or more populations inhabiting under the same or different conditions, and shows the status of populations during different stages of the life cycle (Bagenal and Tesech, 1978).

Oxynoemacheilus seyhanensis belongs to the Nemacheilidae family that small fishes inhabiting freshwaters of Asia, Europe, and northeast Africa (Nelson et al., 2016), With 58 species belongs to the family, they have agreat diversity in Turkish inland waters, which 40 of them are endemics (Çiçek et al., 2018, 2020, 2021; Saygun et al., 2021). *O. seyhanensis* reported from the Mediterranean tributary, Seyhan, Kızılırmak and Yeşilırmak River basin (Çiçek et al., 2018; Sungur, 2020; Seçer et al., 2020). The LWRs of few Turkish nemacheilid species are available (Gaygusuz et al., 2012; Erk'Akan et al., 2013, 2014; İnnal et al., 2015; Yazıcıoğlu and Yazıcı, 2016; Özcan and Altun, 2016; Özcan and Serdar, 2018; Özdemir et al., 2019 Yedier et al. 2021; Seçer et al., 2021); hence, providing such a data for these taxa is crucial for their management and conservation purposes (Tabatabaei et al., 2015).

Based on the above-mentioned information, the present study aimed to determine the length-weight, length-length relationship and condition factor of *O. seyhanensis* inhabiting three basins of Turkey.

MATERIAL and METHOD

A total of 166 specimens of *O. seyhanensis* were collected by single sampling from seven stations, including Yıldızeli, Taşköprü, Suşehri (Kizilirmak basin), Büyükpotuklu, Pınarbaşı and Örenşehir (Seyhan basin) and Akdağmadeni (Yeşilırmak basin) rivers using electrofishing device from 2017 to 2019 (Table 1, Figure 1-2). Fishes were anesthetized with Ethyl 3-aminobenzoate methanesulfonate (MS-222), and fixed into 10% buffered formaldehyde.All samples were transferred to the laboratory and their total and fork lengths, and total weight were measured using digital calipers to the nearest 0.05 mm and digital scale to the nearest 0.01 gr, respectively.

Table 1 Coordinates of sampling stations
Çizelge 1. Örnekleme istasyonlarına ait koordinatlar

Station (*İstasyon*)	River (*Nehir*)	Basin (*Havza*)	Latitute (*Enlem*)	Longitude (*Boylam*)	Sampling Date (*Örnekleme Tarihi*)
Akdağmadeni	Çakraz stream	Yeşilırmak	39°48'15.0"N	36°09'28.5"E	12 July 2018
Büyükpotuklu	Zamantı River	Seyhan	38°43'54.2"N	36°22'46.4"E	15 March 2016
Örenşehir	Zamantı River	Seyhan	38°59'40.5"N	36°34'34.3"E	28 March 2018
Pınarbaşı	Zamantı River	Seyhan	38°47'03.9"N	36°26'54.6"E	30 August 2017
Suşehri	Kizilirmak River at Zara	Kızılırmak	39°58'10.6"N	37°43'22.0"E	12 July 2018
Taşköprü	Gökırmak River	Kızılırmak	41°30'54.7"N	34°13'13.5"E	19 May 2018
Yıldızeli	Yıldız stream	Kızılırmak	39°45'40.2"N	36°45'49.4"E	30 August 2017

The LWRs was determined by the method of least squares using the equation of $W = aL^b$ and logarithmically transformed into $LogW = Log a + b LogL$ (Froese, 2006), where W is the total body weight (g), L is the total length (cm) and "*a*" is the intercept and "*b*" is the slope (Froese et al., 2011). Prior to regression analyses, log-log plots of the length-weight pairs were performed to identify outliers (Froese et al., 2011). The b value was tested by t-test to verify that it was significantly different from the isometric growth (b = 3).All statistical analyses were performed in Excel 2016 and SPSS (IBM SPSS Statistics 22) package program.

For the LLRs, the linear regression of the fork length (FL) versus total length (TL) was determined by using L=a+bL. Condition factor also was calculated according to Fulton (1904) and Froese (2006) using $CF=W/TL^3\times100$ formula, where, W is the weight (gr) and TL is the total length (cm).

RESULTS and DISCUSSION

Descriptive statistics, including the number of samples, total lengths and weight ranges, confidence limits and regression parameters of α, *b*, r^2 and condition factor of the seven studied populations of *O. seyhanensis* are presented in Table 2 and data of the LLRs in Tables 3.

The mean±SE of the total and fork lengths, and weight of the studied populations were 6.49±1.59, 6.35±1.60 and 3.47±2.41cm, respectively. All length–weight relationships were highly significant ($P<0.05$), with r^2 values being greater than 0.91. The *b* values ranged from 2.29 (Suşehri) to 3.52 (Büyükpotuklu), the condition factor from 0.92 (Pınarbaşı) to 1.15

(Örenşehir) and coefficient of both LWRs and LLRs (r^2) ranged 0.91-0.99. In addition, the growth pattern was estimated isometric or positive allometric for all studied population except that of Suşehri that was negative.

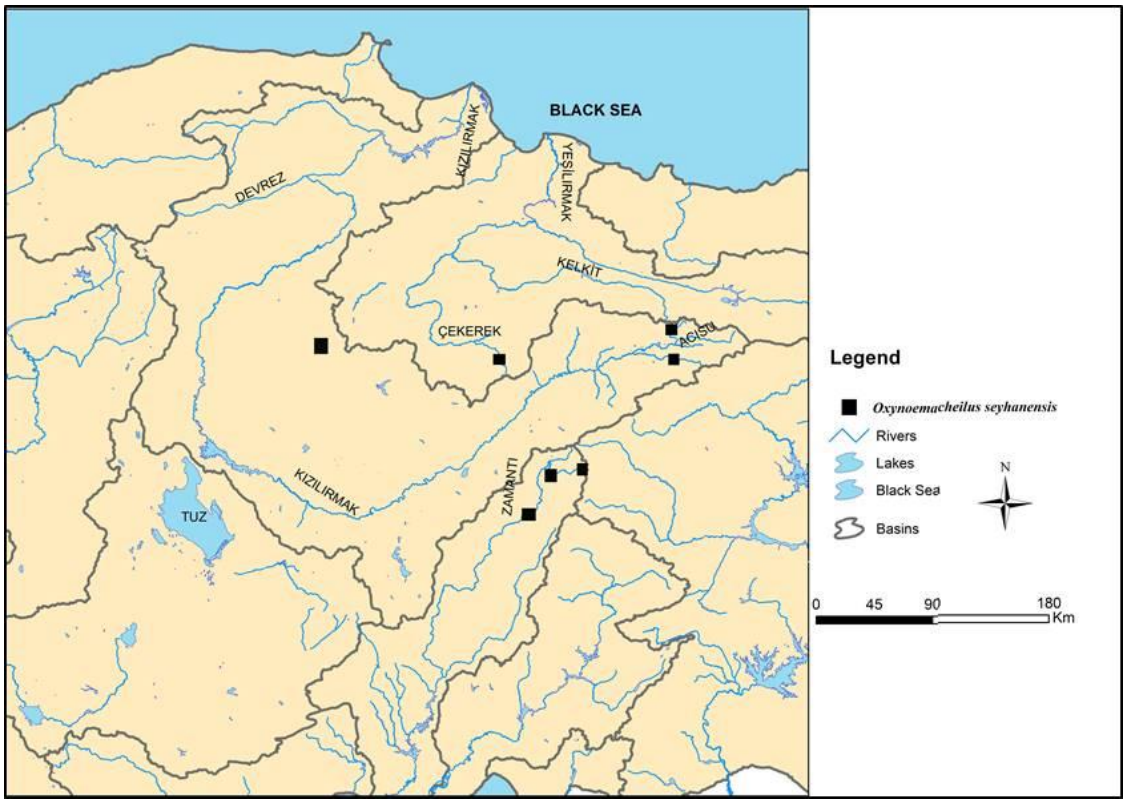

Figure 1. Distribution map for *Oxynoemacheilus seyhanensis* in Kızılırmak, Yesilırmak and Seyhan
Şekil 1. Oxynoemacheilus seyhanensis'in Kızılırmak, Yeşilırmak ve Seyhan'da dağılım haritası

The LWRs parameters of fish species are important in estimating the length and age structure, evaluation of fish stocks, ontogentic and growth studies (Mouludi-Saleh et al., 2020) especially regarding endemic species due to their limited habitat has a special priority in conservation management (Almaça, 1984). The results of the present study showed that the b value of *O. seyhanensis* populations was between 2.29 and 3.52. According to Froese (2006) and Tesch (1971), this value can be between 2 and 4. Some factors, including nutritional conditions, sexual, time and season of sampling, and physiological factors such as maturity, spawning, and fish health can affect b value (Pauly, 1984; Froese, 2006). In addition, based on the estimated b value, the growth patterns were isometric for Örenşehir and positive allometric (A+) for Akdağmadeni, Büyükpotuklu, Örenşehir, Pınarbaşı, Taşköprü and Yıldızeli but was negative allometric (A-) for Suşehri. These results revealed that in the most of the studied population of this deep-bodied species, the weight increases more that the increase of the length, however in some specie as seen in the that of the Suşehri, this has happened vice versa. This results i.e. wide range of b value shows morphological flexibility of this species in different habitats (Tah et al., 2012; Koffi et al., 2014).

Condition factor is used to compare fish quality in terms of obesity status or fish fitness. Fish that have a high condition factor are heavier than their length; conversely, fish with a low condition factor weight less than their length. Condition factor values for the *O. seyhanensis* studied populations were calculated to be >1 except in the Pınarbaşı population. The low value of K in Pınarbaşı population probably due to unfavorable environmental or biological conditions (Blackwell et al., 2000).

CONCLUSION

The findings of this study provided useful information about the LWRs and LLRs parameters and the condition factor of the *O. seyhanensis* populations which can be effective for further studies related to fisheries management and population dynamics.

Author's Contributions

The contribution of the authors is equal.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

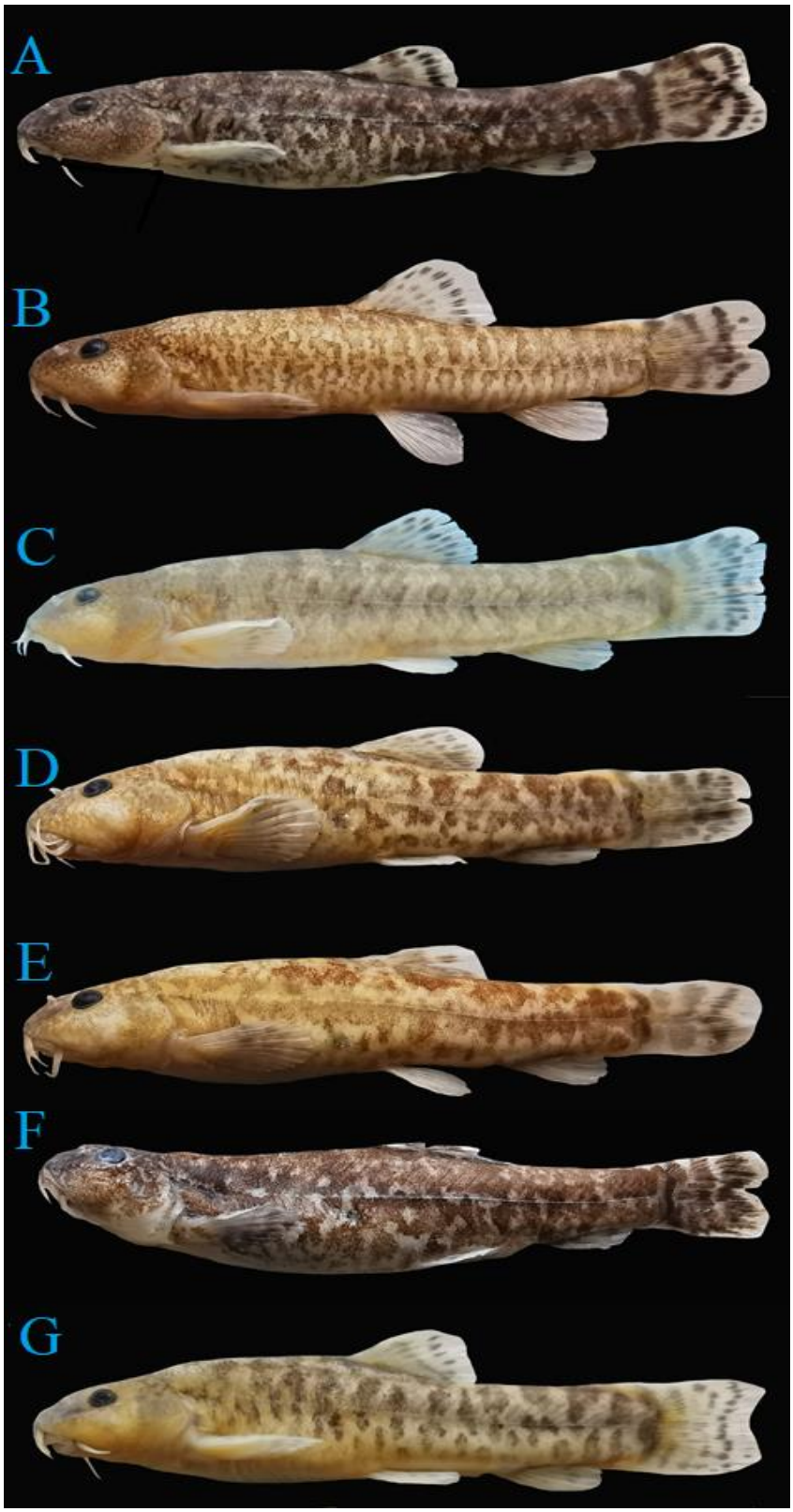

Figure 2. *Oxynoemacheilus seyhanensis*; **A,** Suşehri, 69.8 mm SL, **B**, Yıldızeli, 65.8 mm SL **C,** Taşköprü, 66.9 mm SL **D**, Pınarbaşı, 71.5 mm SL, **E**, Örenşehir, 49.2 mm SL, **F**, Büyükpotuklu, 62.6 mm SL, **G,** Akdağmadeni, 78.5 mm SL

*Şekil 2. Oxynoemacheilus seyhanensis; **A,** Suşehri, 69.8 mm SB, **B**, Yıldızeli, 65.8 mm SB **C,** Taşköprü, 66.9 mm SB **D**, Pınarbaşı, 71.5 mm SB, **E**, Örenşehir, 49.2 mm SB, **F**, Büyükpotuklu, 62.6 mm SB, **G,** Akdağmadeni, 78.5 mm SB*

Table 2. Descriptive statistics and estimated parameters of length-weight relationships for *Oxynoemacheilus seyhanensis* species from different basins of Turkey during 2017-2019.

Çizelge 2. 2017-2019 yılları arasında Türkiye'nin farklı havzalarından Oxynoemacheilus seyhanensis türleri için tanımlayıcı istatistikler ve boy-ağırlık ilişkilerinin tahmini parametreleri.

		Total length (cm) (*Total boy (cm)*)			**Total weight (g) (*Total ağırlık (cm)*)**				**Regression parameters (*Regresyon parametreleri*)**		
Station (*İstasyon*)	River (*Nehir*)	N	Min-Max (*Min-Mak*) Mean±SE (*Ortalama±SH*)	Min-Max (Min-Mak) Mean±SE (*Ortalama±SH*)	Condition factor (*Kondisyon faktörü*) Mean±SE (*Ortalama±SH*)	*a*	95% CL of a	*b*	95% CL of b	r^2	Growth Type (*Büyüme Tipi*)
Akdağmadeni	Çakraz stream	29	4.6-9.8 7.03±1.34	0.85-11.9 4.18±2.49	1.06±0.18	0.006	0.003-0.010	3.24	3.03-3.6	0.951	A+
Büyükpotuklu	Zamantı River	18	3.8-6.3 4.94±0.57	0.51-3.24 1.00±0.59	1.01±0.1	0.004	0.002-0.006	3.52	3.3-3.94	0.968	A+
Örenşehir	Zamantı River	15	6.2-9.1 7.6±0.99	2.5-8.6 5.37±2.15	1.15±0.9	0.007	0.004-0.012	3.21	2.94-3.5	0.975	I
Pınarbaşı	Zamantı River	21	3.5-6.6 4.66±0.94	0.38-2.56 1.00±0.73	0.92±0.10	0.006	0.004-0.011	3.22	2.87-3.44	0.971	I
Suşehri	Kizilirmak River at Zara	29	4.8-9.6 8.06±0.97	2.02-7.62 5.58±1.38	1.05±0.08	0.045	0.03-0.075	2.29	2.05-2.49	0.919	A-
Taşköprü	Gökırmak River	27	4.6-8.9 6.58±1.25	0.73-9.19 3.40±2.27	1.03±0.11	0.005	0.003-0.007	3.37	3.16-3.59	0.981	A+
Yıldızeli	Yıldız stream	27	4.5-8.9 6.63±1.10	0.98-8.47 3.44±1.99	1.05±0.09	0.005	0.003-0.008	3.33	3.12-3.54	0.982	A+
Total	-	166	3.5-9.8 6.49±1.59	0.38-11.9 3.47±2.41	1.03±0.16	0.006	0.005-0.008	3.22	3.14-3.3	0.981	A+

TL= total length; W=weight; n= number of individuals; a= intercept; *b*= slope; CL= confidence limits; r^2= correlation coefficient

Table 3. Descriptive statistics and length-length relationship parameters for *Oxynoemacheilus seyhanensis* species from different basins of Turkey during 2017-2019.

Çizelge 3. 2017-2019 döneminde Türkiye'nin farklı havzalarından Oxynoemacheilus seyhanensis türleri için tanımlayıcı istatistikler ve boy-boy ilişki parametreleri.

Station (*İstaston*)	Rivers (*Nehirler*)	Total length (cm) Total boy (cm) Min-Max (*Min-Mak*) Mean±SE (*Ortalama±SH*)	Fork length (cm) Çatal boy (cm) Min-Max (*Min-Mak*) Mean±SE (*Ortalama±SH*)	FL=a+bTL	r^2
Akdağmadeni	Çakraz stream	4.6-9.8 (7.03±1.34)	4.5-9.6 (6.93±1.37)	FL=-0.2332+1.0189TL	0.987
Büyükpotuklu	Zamantı River	3.8-6.3 (4.94±0.57)	3.6-6.2 (4.35±0.57)	FL=-0.158+ 1.0043TL	0.99
Örenşehir	Zamantı River	6.2-9.1(7.6±0.99)	6.0-8.9 (7.42±0.98)	FL=-0.1035+0.9906TL	0.996
Pınarbaşı	Zamantı River	3.5-6.6(4.66±0.94)	3.0-6.5 (4.5±0.97)	F =-0.2962+1.0298TL	0.981
Suşehri	Kizilirmak River at Zara	4.8-9.6(8.06±0.97)	4.6-9.5 (7.86±0.96)	FL=-0.4324+1.0348TL	0.974
Taşköprü	Gökırmak River	4.6-8.9(6.58±1.25)	4.5-8.7 (6.43±1.22)	FL=0.0049+0.9768TL	0.998
Yıldızeli	Yıldız stream	4.5-8.9(6.63±1.10)	4.4-8.6 (6.48±1.07)	FL=0.0116+0.9759TL	0.997
Total		3.5-9.8(6.49±1.59)	3.0-9.6 (6.35±1.60)	FL=-0.1148+0.9947TL	0.993

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