Some population characteristics of *Oxynoemacheilus angorae* (Steindachner, 1897) from the Perşembe Plateau meandering streams in Ordu, Turkey

Serdar Yedier, Derya Bostanci, Nazmi Polat

Abstract. The aim of the current study was to determine the length-weight relationship (LWR) and length-length relationship (LLR) with condition factor (K) values for *Oxynoemacheilus angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey. A total of 65 fish specimens, which were caught with electrofishing gear, were examined. Fish standard length (SL), fork length (FL), total length (TL), and body weight (W) were determined. There were no statistical differences between the measurements of male and female *O. angorae* specimens; therefore, the female and male specimens were evaluated together in the current study. The LWR equation and determination coefficient of *O. angorae* were W = 0.014 TL$^{2.7359}$ (r^2 = 0.9659). The 95% confidence interval of the *b* value for the *O. angorae* specimens from the Perşembe Plateau meandering streams was 2.7261 to 2.7435. In the present study, it was determined that *O. angorae* specimens showed negative allometric growth. Calculations of *O. angorae* TL-SL, TL-FL, and FL-SL relationship equations and determination coefficients were as follows: TL = 0.2091+1.1646 SL, (r^2 = 0.986); TL = 0.1341+1.0301 FL (r^2 = 0.9914); and FL = 0.0998+1.1261 SL, (r^2 = 0.9868), respectively. A new maximum total length was recorded for *O. angorae* in this study. The average condition factor value of *O. angorae* was 0.9954. This value could have indicated that this species was encountering some problems in this habitat. The *O. angorae* parameters determined were the first data reported for the Perşembe Plateau meandering streams in Ordu, Turkey (Middle Black Sea Region).

Keywords: Length-weight relationship, length-length relationship, growth, condition factor, Middle Black Sea Region

Introduction

Length-length (LLR) and length-weight (LWR) relationships of fish species are important in fisheries and fish biology (Yılmaz and Polat 2011). They permit estimating the body weight of fish from total length and the total length of fish from standard length by establishing mathematical relationships among these variables (Sarkar et al. 2008). Moreover, LWR and LLR relationships are also used to assess fish stocks, and they provide information on the growth status of fish species in different habitats (Yılmaz et al. 2010). The condition factor is one of the most important parameters related to fish body shape, and this parameter can provide information about the development of fish species in different

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habitats (Froese 2006). In this way, researchers can compare fish populations belonging to the same species in different habitats based on condition factors. Thus, data on the impact of habitat differences on the fish can be provided (Yedier et al. 2019).

Angorae loach, *Oxynoemacheilus angorae*, is a member of the family Nemacheilidae. This species is widespread from Jordan to Turkey (Froese and Pauly 2020). *O. angorae* is one of the native freshwater fish species in Turkish ichthyofauna. Moreover, the species is distributed in both lentic and lotic habitats in Turkey. The conservation status of the species on the IUCN Red List is that of least concern (LC) (Freyhof 2014). The problems caused by eutrophication, contamination, and decreases in water levels from dam construction are the most important factors endangering the species (Froese and Pauly 2020). There are few studies in the literature on the length-length and the length-weight relationships with condition factor of this species from different aquatic habitats (Golzarianpour et al. 2011, Hasankhani et al. 2014). The species was also reported in many Turkish inland waters such as Balıklı Stream (Gaygusuz et al. 2013), Söğütözü Creek (Erk'akan et al. 2014), Kılıçözü Stream (Yazıcıoğlu and Yazıcı 2016), Kirmir Stream (Zencir and Korkmaz 2016), the Kızılırmak River Basin (Birecikligil et al. 2016), and Asartepe Dam Lake (Saylar et al. 2020). There are very few studies on this species compared to other native fish species. Additionally, studies focused on the biology and population characteristics of this species are quite limited, and there are no studies on the length-length and length-weight relationships with condition factor of *O. angorae* from Ordu inland waters.

Therefore, the main objective of the current study was to determine the length-length, length-weight relationships with condition factor of *O. angorae* inhabiting the Perşembe Plateau meandering streams in Ordu, Turkey. The current study was the first to be conducted on the length-length and length-weight relationships with condition factor of *O. angorae* from Ordu inland waters.

Materials and methods

The Perşembe Plateau is one of the tourism centers of Ordu Province, Turkey, with unique meandering streams located at an altitude of 1,500 meters, which are some of the best examples of meanders in the country. Sampling was conducted in six of these meandering streams on the Perşembe Plateau, and *O. angorae* specimens were caught with a Samus-725MS (Fig. 1). The body weight (W) of the fish specimens was recorded to the nearest 0.01 g and standard length (SL), fork length (FL), and total length (TL) were measured to the nearest 0.1 cm (Fig. 2). The length-weight relationship of *O. angorae*
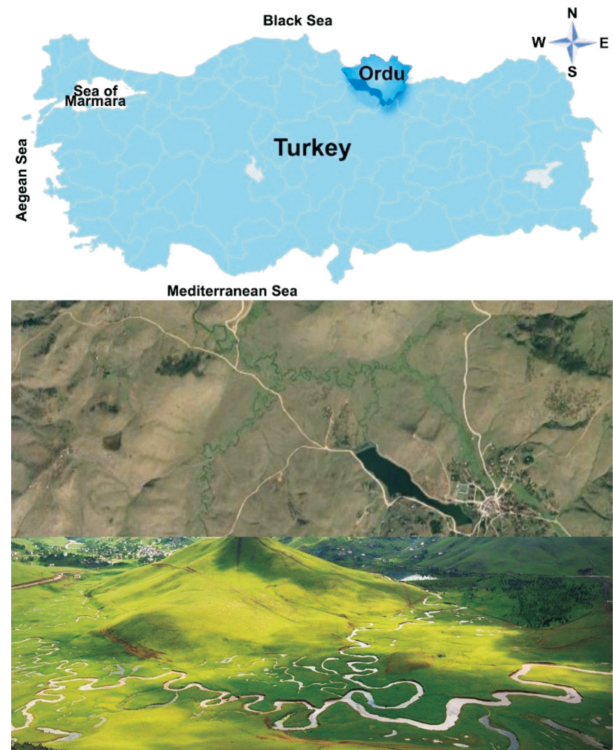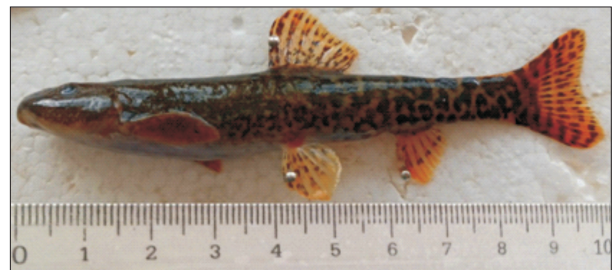

Figure 1. Map of the study area.

Figure 2. *Oxynoemacheilus angorae* specimens caught during sampling.

Table 1

Descriptive statistics of morphometric measurements of *Oxynoemacheilus angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey

Morphometric measurements	n	Mean ± SE	SD	min	max	Coefficient of variation %
Body weight (g)	65	3.41±0.164	1.324	1.20	7.51	38.80
Total length (cm)		7.34±0.123	0.994	5.3	10.0	13.55
Fork length (cm)		6.99±0.119	0.961	5.1	9.6	13.74
Standard length (cm)		6.13±0.105	0.848	4.4	8.4	13.85

n: sample size; SE: standard error; min and max: minimum and maximum values, respectively.

inhabiting these streams was calculated with the equation $W = aL^b$, where W is fish body weight (g), L is fish total length (cm), *b* is the slope, and a is the intercept (Bagenal and Tesch 1978). The *b*-values obtained from the length-weight relationship were tested using the t-test, and these results concerning *b* values were used when determining the growth type of this species. A 95% confidence interval (95% CI) of the *b* value was also calculated for the *O. angorae* specimens caught. The linear regression model y = a ± bx was used to determine the TL-SL, TL-FL, and FL-SL relationships. The quality of the linear regression model was evaluated using the determination coefficient (r^2) for *O. angorae* specimens. Fulton's condition factor (K) was calculated with the following equation: $K = 100*(W/L^3)$, where W is fish body weight (g), and L is fish total length (cm) (Ricker 1975). Minitab 16 was used for all statistical analyses.

Results

In the current study, a total of 65 individuals were captured with electrofishing gear of which 37 (56.92%) were female and 28 (43.08%) were male. The *O. angorae* specimen weights (W) ranged from 1.20 g to 7.51 g, and standard length (SL), fork length (FL), and total length (TL) ranged between 4.4–8.4 cm, 5.1–9.6 cm, and 5.3–10 cm, respectively. The average total length of *O. angorae* individuals was 7.34 ± 0.123 cm (Table 1). The average

weight of the species was 3.41 ± 0.164 g (Table 1). In the present study, the largest total length was 10.0 cm and the smallest total length was 5.3 cm. Among the morphometric measurements identified in the present study, weight had the highest coefficient of variation, while total length had the lowest (Table 1). Female and male individuals were evaluated together because there was no difference between their length or weight measurements (t-test; P > 0.05).

Total length and fish weight frequency distributions were also determined for the *O. angorae* specimens (Fig. 3). The total length-weight relationship was determined as $W = 0.014TL^{2.7359}$ ($r^2 = 0.9659$) in all *O. angorae* specimens, and these results are presented in Figure 4. There was a strong relationship between the length and the weight values of the *O. angorae* specimens with a 95% confidence interval of *b* that ranged from 2.7261 to 2.7435. The length-length relationship showed that standard length, fork length, and total length were highly correlated with one another (Fig. 5). The TL-FL, TL-SL, and FL-SL relationship equations with the determination coefficient for *O. angorae* were TL = 0.1341 + 1.0301 FL; ($r^2 = 0.9914$), TL = 0.2091 + 1.1646 SL; ($r^2 = 0.986$), and FL = 0.0998 + 1.1261 SL;($r^2 = 0.9868$), respectively (Fig. 5). In the present study, the minimum and maximum condition factors of *O. angorae* specimens from the Perşembe Plateau meandering streams were 0.7012 and 1.0272, respectively, and the mean condition factor calculated was 0.8295 ± 0.0079.
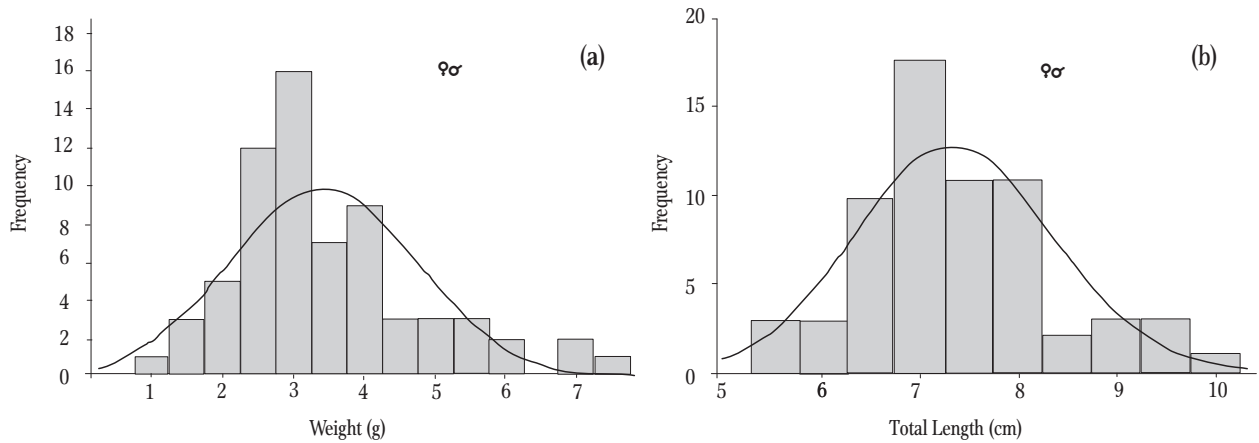
Figure. 3. Weight-frequency (a) and total length-frequency (b) distributions of *Oxynoemacheilus angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey.
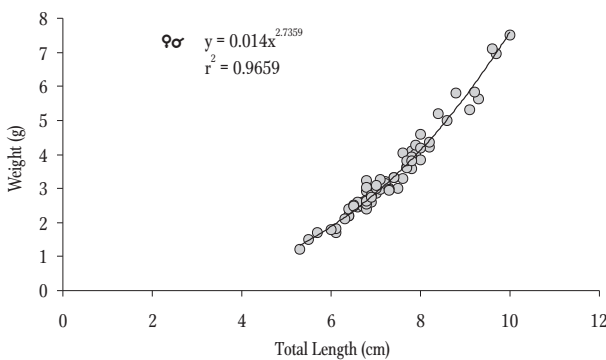

Figure 4. Length–weight relationship of *Oxynoemacheilus angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey.

Discussion

The family Nemacheilidae is a large one with more than 600 known fish species. *Oxynoemacheilus,* which is a genus of this family, is represented by sixty species globally and more than half of these species occur in Turkish waters (Freyhof et al. 2021). However, a review of the literature indicated that there are a limited number of studies on the relationship of the *Oxynoemacheilus* species of this genus with length-weight, length-length and condition factors. In the present study, the maximum total length of *O. angorae* was 10 cm, which is the largest reported *O. angorae* specimen in the literature. The total length and weight values of the species reported from different localities are presented in Table 2.
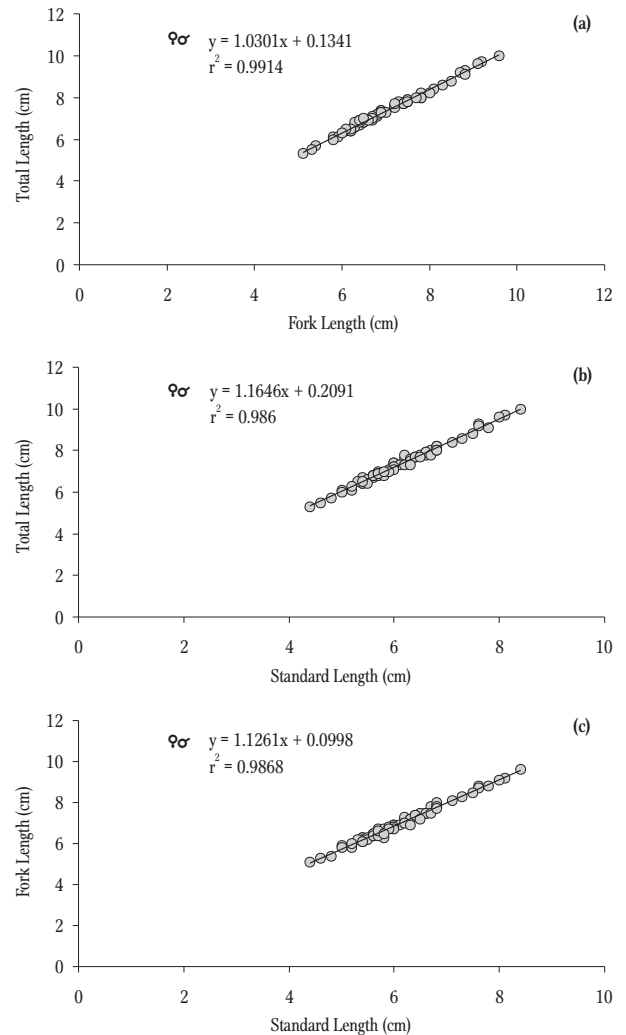

Figure 5. Total length-fork length (a), total length-standard length (b), and fork length-standard length (c) relationships for *Oxynoemacheilus angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey.

Table 2

Total length (TL) and body weight (BW) ranges for *Oxynoemacheilus angorae* populations in different habitats

Locations	Sex	TL (min-max)	BW (min-max)	References
Balıklı Stream	♀+♂	3.8-7.6 cm	0.53-4.21 g	Gaygusuz et al. 2013
Jajroud River	♀+♂	4.7-7.3 cm	0.86-3.56 g	Golzarianpour et al. 2011
Sirwan River	♀+♂	4.3-8.2 cm	-	Hasankhani et al. 2014
Söğütözü Creek	♀+♂	4.4-8.3 cm	0.80-6.60 g	Erk'akan et al. 2014
Kirmir Stream	♀+♂	4.4-9.6 cm	0.61-6.67 g	Zencir and Korkmaz 2016
Kılıçözü Stream	♀+♂	3.5-9.8 cm	0.38-6.58 g	Yazıcıoğlu and Yazıcı 2016
Kızılırmak River Basin	♀+♂	2.8-8.6 cm	0.22-6.18 g	Birecikligil et al. 2016
Perşembe Plateau Meandering Streams	♀+♂	5.3-10 cm	1.20-7.51 g	This study

In fisheries studies, characteristics of the length-weight in fish species are that growth is isometric when the *b* exponent is 3, growth is negative allometric when *b*<3, and growth is positive allometric when *b*>3. The values of *b* were within the limits of 2.5–3.5 that are reported commonly for many fish species by Froese (2006). The LWRs of *Oxynoemacheilus* species were reported from various aquatic habitats by many authors. For instance, *O. eregliensis* (b=3.196) from Melendiz Creek, *O. evreni* (b=2.788) from Çayır Creek, *O. mesudae* (b=2.628) from Küfe Creek, *O. samanticus* (b=2.919) from Karaboğaz Creek, *O. simavicus* (b=3.261) from Karaçaltı Creek (Erk'akan et al. 2014), *O. hamwii* (b=3.52) from Gölbaşı Lake (Özcan and Altun 2016), and *O. veyseli* (b=2.821) from Bozkuş Creek (Özdemir et al. 2019). Moreover, there are many data on *O. theophilii* that were reported from different freshwater habitats such as Bozcay Creek (b=2.898), Dalaman Stream (b=2.989), Cüneyt Creek (b=3.07), Duger Spring (b=3.188), and Yiğitler Creek (b=3.293) (Innal et al. 2015). The variations in *b* values from 3 were statistically significant for the *O. angorae* specimens from the current study and indicated negative allometric growth for the overall population (P < 0.001). However, growth type varies for the same species occurring in different habitats. For instance, several studies reported that *O. angorae* had different growth types in different habitats (Table 3). There are many factors, such as nutrition, health status, stomach fullness, sex, gonad maturity, changes in water parameters, and even sample size that could have caused individuals of the same species to show different types of growth.

A linear relationship was obtained between the length measurements (TL-SL, TL-FL, and FL-SL) of *O. angorae* from the Perşembe Plateau meandering streams. The regression equation of length-length relationships was determined for *O. angorae* to assess symmetrical growth. The review of the literature indicated that the results obtained by other researchers were similar to those in the present study (Table 4). According to Fishbase (Froese and Pauly 2020), the maximum total length of *O. angorae* is 8.5 cm, while in the current study, a new maximum total length of 10 cm for *O. angorae* was recorded.

The condition factor is one of the most important parameters representing the condition or well-being of fish. The condition factors of fish species of the same species occurring in different habitats can vary. A condition factor value of more than 1 indicates that the health condition of the fish individuals is good (Nash et al. 2006). In the present study, the average condition factor of *O. angorae* was calculated as 0.8295 ± 0.0079, and similar results were reported in several studies such as 0.86±0.009 for the Kılıçözü Stream population (Yazıcıoğlu and Yazıcı 2016), 0.94 ± 0.130 for the Kızılırmak River Basin population (Birecikligil et al. 2016), and 0.9562 ± 0.0349 for the Asartepe Dam Lake population (Saylar et al. 2020). Differences among the condition

Table 3
Length-weight relationship parameters for *Oxynoemacheilus angorae* from different habitats

Locations	Sex	a	b	r²	GT	References
Balıklı Stream	♀+♂	0.008	3.01	0.98	-	Gaygusuz et al. 2013
Jajroud River	♀+♂	0.006	3.237	0.88	A+	Golzarianpour et al. 2011
Sirwan River	♀+♂	0.011	2.81	0.96	-	Hasankhani et al. 2014
Söğütözü Creek	♀+♂	0.0062	3.228	0.99	-	Erk'akan et al. 2014
Kirmir Stream	♀+♂	0.015	2.73	0.88	A-	Zencir and Korkmaz 2016
Kılıçözü Stream	♀+♂	0.0099	2.929	0.96	I	Yazıcıoğlu and Yazıcı 2016
Kızılırmak River Basin	♀+♂	0.008	3.102	0.94	I	Birecikligil et al. 2016
Asartepe Dam Lake	♀+♂	0.0171	2.651	0.80	A-	Saylar et al. 2020
Perşembe Plateau Meandering Streams	♀+♂	0.0140	2.74	0.97	A-	This study

a and b: the intercept and slope of the regression line respectively; r^2: correlation coefficient; GT: growth type; I: isometric; A-: negative allometric; A+: positive allometric.

Table 4
Length-length relationship parameters for *Oxynoemacheilus angorae* from different habitats

Locations	n	Sex	Equations	a	b	r²	References
Sirwan River	44	♀+♂	SL=a + bTL	0.000	0.855	0.980	Hasankhani et al. 2014
		♀+♂	FL=a + bTL	0.000	0.948	0.990	
Kirmir Stream	197	♀+♂	SL=a + bTL	0.957	0.957	0.807	Zencir and Korkmaz 2016
		♀+♂	FL=a + bSL	0.073	0.073	0.819	
		♀+♂	TL=a + bFL	0.139	0.139	0.978	
Kılıçözü Stream	103	♀+♂	SL=a + bTL	-0.102	0.855	0.986	Yazıcıoğlu and Yazıcı 2016
		♀+♂	FL=a + bSL	0.203	1.12	0.987	
		♀+♂	TL=a + bFL	0.022	1.02	0.997	
Asartepe Dam Lake	50	♀+♂	FL=a + bSL	0.426	1.0503	0.890	Saylar et al. 2020
		♀+♂	TL=a + bSL	0.404	1.1137	0.870	
		♀+♂	TL=a + bFL	-0.004	1.0525	0.960	
Perşembe Plateau Meandering Streams	65	♀+♂	FL=a + bSL	0.0998	1.1261	0.987	This study
		♀+♂	TL=a + bSL	0.2091	1.1646	0.986	
		♀+♂	TL=a + bFL	0.1341	1.0301	0.991	

TL: total length; FL: fork length; SL: standard length; r^2: coefficient of determination; n: sample size; a and b: the intercept and slope of the regression line respectively.

factors of fish specimens of the same species could result from the effects on the condition factor of habitat differences, sample size, or sampling time. Additionally, it also provides information to researchers on different topics such as condition factors, population density, nutritional status, and the impact of climate change on growth (Froese 2006). However, in the current study, the average condition factor of *O. angorae* specimens (0.8295 ± 0.0079) was determined to be less than 1. This value was the lowest value reported for this species to date in the literature. There could be many reasons for this, including changes in habitat, food availability, season, fish age, and shape (Ricker 1979).

The current study indicates some population characteristics of *O. angorae* from the Perşembe Plateau meandering streams in Ordu, Turkey. The fact that the condition factor value was below the welfare level showed that this species was encountering some problems in the habitat and that these

adversely affected the development of the fish. The fact that this species is listed in the category of least concern on the IUCN list, and that it might have encountered some problems in the Perşembe Plateau meandering streams shows that the results of the present study are very important. The Perşembe Plateau is a popular tourist attraction where tourism continues throughout all seasons of the year, and it is a protected habitat and a potential candidate for designation as a UNESCO World Cultural Heritage site (Bahtiyar Karadeniz and Sarı 2018). It is recommended to investigate and monitor whether factors such as tourism activities, animal husbandry, and water pollution of the Perşembe Plateau meandering streams are some of the causes of these problems in *O. angorae*.

Author Contributions: S.Y., D.B. and N.P. conducted the field study collection and analysis, S.Y. designed the study and the concept, S.Y. and D.B. drafted and revised the manuscript.

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