



Length-Weight (L-W), Length-Length (L-L) Relationships and Condition Factor (K) of *Gobio artvinicus* (Teleostei:Gobionidae) from the Lower Çoruh River Basin, (NE Türkiye)

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Abstract: In this study, some basic biological parameters (sex ratio, condition factor (K), LWRs and LLRs) of *Gobio artvinicus* (Artvin gudgeon) inhabiting Borçka Reservoir and its tributaries from the lower Çoruh River Basin were investigated for the first time. Fish specimens were collected from June 2017 to May 2018 and totally 120 Artvin gudgeon ranging from 8.1 cm to 13.2 cm in TL were sampled. The sex ratio (F:M) was calculated as 1.18:1.00 in favor of females but it did not deviate from the expected ratio of 1:1 ($P>0.05$). The total length-weight relationships were determined as $W=0.008TL^{3.159}$ for females, as $W=0.012TL^{2.971}$ for males and as $W=0.009TL^{3.088}$ for combined sex. While the b-values which reflect the body shape were significantly different from the isometric growth indicating positive allometric growth ($b>3$) for females and combined sex (Pauly's t-test, $P<0.05$), however the b value of males did not differ from the isometric growth ($b=3$) pattern (Pauly's t-test, $P>0.05$). The slopes (b values) were found statistically significant for both sexes (ANCOVA, $P<0.05$). Results of the LLRs indicated that the values of the correlation coefficient were highly correlated ($r^2>0.9$) for each sex and relationship. Mean K values were calculated as 1.128 ± 0.011 for females and 1.102 ± 0.008 for males indicating a good growth condition in this habitat. The present study will provide a baseline on some biological parameters of *G. artvinicus* to provide a guideline for the fisheries management authority and fisheries scientists for further investigations as well as presents the first known reference on the LWRs and LLRs of this species for the FishBase database. Furthermore, the reported results will contribute to the conservation and sustainability of this species in the area.

Keywords: Artvin gudgeon, biological parameters, borçka reservoir, *Gobio artvinicus*, morphometric relationships.

Aşağı Çoruh Nehri Havzası'ndan (KD Türkiye) *Gobio artvinicus* (Teleostei : Gobionidae)'un Boy-Ağırlık (L-W), Boy-Boy (L-L) İlişkileri ve Kondisyon Faktörü (K)

Öz: Bu çalışmada Aşağı Çoruh Nehri Havzası'nda yer alan Borçka Baraj Gölü ve kollarında yaşayan *Gobio artvinicus* (Artvin Derekeyası)'un bazı temel biyolojik parametreleri (cinsiyet oranı, kondisyon faktörü (K), LWR'ler ve LLR'ler) ilk kez incelenmiştir. Haziran 2017'den Mayıs 2018'e kadar balık örnekleri toplanmış ve toplam boyları 8,1 cm ile 13,2 cm arasında değişen toplam 120 Artvin Derekeyası örneklenmiştir. Cinsiyet oranı (D:E) dişiler lehine 1,18:1.00 olarak hesaplanmış, ancak beklenen 1:1 oranından sapma göstermemiştir ($P>0,05$). Toplam boy-ağırlık ilişkileri dişilerde $W=0,008TL^{3,159}$, erkeklerde $W=0,012TL^{2,971}$ ve tüm bireyler için $W=0,009TL^{3,088}$ olarak belirlenmiştir. Vücut şeklini yansıtan b değerleri, dişiler ve tüm bireyler için pozitif allometrik ($b>3$) olarak izometrik büyümeden önemli ölçüde farklı bulunurken (Pauly's t-test; $P<0,05$), erkek bireylerin b değeri izometrik büyümeden ($b=3$) farklılık göstermemiştir (Pauly's t-test; $P>0,05$). Eğimler (b değerleri) her iki cinsiyet için de istatistiksel olarak farklı bulunmuştur (ANCOVA, $P<0,05$). LLR'lerin sonuçları, her bir cinsiyet ve ilişki için korelasyon katsayısı değerlerinin yüksek düzeyde ilişkili olduğunu ($r^2>0,9$) göstermiştir. Ortalama K değerleri, dişilerde $1,128\pm0,011$ ve erkeklerde $1,102\pm0,008$ olarak hesaplanmış ve tür için bu habitatta iyi bir büyüme durumuna işaret etmektedir. Bu çalışma, *G. artvinicus*'un bazı biyolojik parametreleri hakkında, balıkçılık yönetim otoritesi ve balıkçılık bilim adamlarına daha ileri araştırmalar için bir kılavuz sağlamak üzere bir temel oluşturacak ve FishBase veritabanı için bu türün LWR'leri ve LLR'leri hakkında bilinen ilk referansı sunacaktır. Ayrıca, rapor edilen sonuçlar bu türün bölgede korunmasına ve sürdürülebilirliğine katkıda bulunacaktır.

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Anahtar kelimeler: Artvin derekeyası, biyolojik parametreler, borçka baraj gölü, *Gobio artvinicus*, morfometrik ilişkiler.

INTRODUCTION

Türkiye has a rich freshwater fish diversity and endemism because of having both European and Asian-origin species (Tarkan et al., 2015). The unique position of Türkiye at the crossroads between Europe, Asia and Africa, also bordering the Mediterranean, Aegean, and Black Seas has provided an exciting mixture of fish species in its diverse habitats (Sekercioglu et al. 2011). Turkish inland fish fauna includes 384 species belonging to 20 orders and 34 families with more than half of the ichthyofauna (96.1% of the fish species, 369 species) are native of which 54.2% (208 species) are considered endemic and 3.9% (15 species) are non-native (Çiçek et al., 2020).

Gobio Cuvier, 1816 as a member of the Gobionidae, is a genus of small, mainly riverine Eurasian freshwater fishes distributed from the Iberian Peninsula in the west to China, Mongolia, and eastern Siberia in the east. Currently, the genus comprises 47 valid species (Fricke et al., 2022). The genus, *Gobio* is known to be one of the richest genera because of its adaptations to different habitats (Turan et al., 2016). The members of this genus are widely distributed in freshwater lakes and rivers in Türkiye, a hotspot for freshwater fish diversity and endemism (Aksu & Bektaş, 2019). This genus is widely distributed in freshwater lakes and rivers in Europe and Asia, including Anatolia (except Eastern and Southeastern Anatolia) (Turan et al., 2016). Up to now, 15 species have been recognised from Turkish inland waters, 12 of which are endemic to Türkiye (Turan et al., 2018). However, Turan et al. (2018) stated that *Gobio battalgilae* and *G. microlepidotus* are synonymous due to the high similarity in their morphological and meristic characteristics. Therefore, currently totally 14 valid gudgeon species belonging to the genus *Gobio* distribute in Turkish inland waters.

Gobio artvinicus Turan, Japoshvili, Aksu & Bektaş, 2016, which is commonly known as the Artvin gudgeon, also locally named as Artvin Derekayası (Kaya et al., 2020) is a small freshwater species of gudgeon from the genus *Gobio* in the family of Gobionidae. It inhabits swift and warm flowing water, with cobbled and pebbled bottoms. This species was firstly described from the Aralık and Çiftkopru Streams, tributaries of the lower part of Çoruh River in the Black Sea basin in NE Türkiye and reported to occur only in Çoruh River also has not been recorded in any other place (Turan et al., 2016), except a recent record from an Aras River drainage, (Caspian Sea basin), despite intensive field works (Kaya et al., 2020). However, its occurrence in the Caspian Sea basin was thought to be based on translocation by Kuljanishvili et al. (2020), who reported the *G. artvinicus* from Armenia, Azerbaijan, and Georgia.

Length-weight relationships (LWRs) and condition factor (K) are of great importance in fishery assessment studies due to providing information about the growth of the

fish, its general wellbeing, and fitness in the existing habitat (Yesilcicek et al., 2015; Jisr et al., 2018). The biometric studies that give valuable information on fish species for an estimated assessment of their biomass are keystone tools for fisheries research and management (Zargar et al., 2012). In biometric studies, it is essential to determine the growth characteristics related to the length and weight of the fish (Morato et al., 2001), in addition to the condition of wellbeing of the species influenced by different biological and environmental factors. The LWRs in fish also provide significant information about the general health, growth pattern, life history, habitat conditions, fish fatness and condition, as well as morphological characteristics of the fish (Schneider et al., 2000; Froese, 2006).

The length-length relationships (LLRs) are important in fishery management because of different types of fish length measurements are utilized in ichthyological studies. For example, whereas total length (TL) and fork (FL) length are commonly used for estimation of fish growth, standard length (SL) is generally used in systematic studies. Standardizing the length measurements of fish helps to compare of different populations. Therefore, LLRs in different populations should be known (Moutopoulos & Stergiou, 2002; Kirankaya et al., 2014). Hence, comparing of the relationships between different length types in fisheries also plays a significant role in growth studies (Froese & Pauly, 1998).

The present study aims to contribute to the limited knowledge on some biological and morphological aspects (LWRs, LLRs, sex composition and K) of *G. artvinicus* from Borçka reservoir and its tributaries in the lower part of Çoruh River basin. To the best of the author's knowledge this study is the first one on this species and certainly will provide a significant contribution to the current literature and very important in monitoring the populations and ensuring the sustainability of this species in its distribution area. The International Union for Conservation of Nature (IUCN) has not yet assessed the status of this species, so that, the current status of the species is listed as not evaluated (NE). Evaluation of some bio-ecological characteristics of the species with this study will also make an important contribution to the assessment of *G. artvinicus* against to IUCN criteria. The results of the present study will be helpful for researchers and fisheries management authorities to better understand the life history patterns and ecology of this species.

MATERIAL AND METHOD

Study Area: The present study was carried out in Borçka Reservoir and its tributaries, located in the lower Çoruh River Basin in the Northeastern Black Sea region of Türkiye. Borçka Dam is located approximately 300 m downstream of the junction of Çoruh River and Murgul

Stream, 2,5 km upstream of Borçka district and 30 km northwest of Artvin province (Figure 1). The reservoir has 419 hm³ volume at average water level and a surface area of 10.84 km². Çoruh River has a total length of 431 km, within 410 km of the borders of Türkiye and the last 21 km in Batumi (Georgia) where the river falls into the Black Sea (Yesilcicek & Kalayci, 2020).

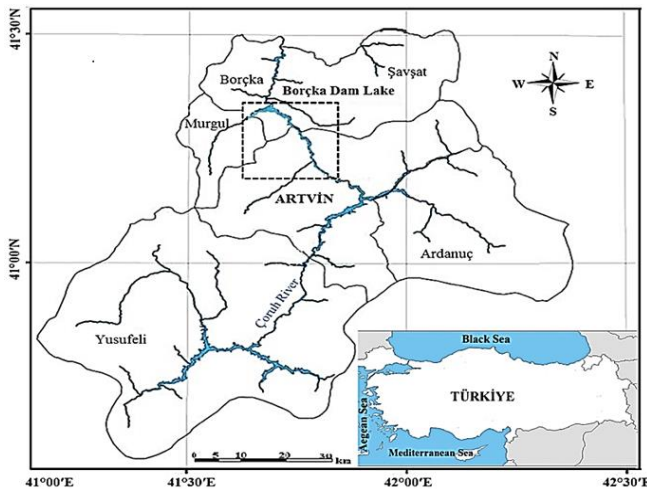


Figure 1. The map of the study area (Dashed lines represent the boundaries of the study area)

Fish Sampling: *G. artvinicus* samples were caught from June 2017 to May 2018 by using trammel nets with various mesh sizes (16, 17, 18, and 20 mm bar length in the inner panels and 50 mm in the outer panels) and by pulsed DC electrofishing device from the reservoir and its tributaries. Each fish specimen was measured in TL, FL and SL with a digital vernier caliper with a precision of 0.01 mm and weighed to the nearest 0.01 g body weight (W). Sex was determined via macroscopic observation of the gonads using the morphological differences such as structure, shape and color.

Length-Weight Relationships (LWRs): The relationships between fish length and weight is generally expressed by $W = aTL^b$, which was converted to logarithmic form as $\log W = \log a + b \log TL$, where W is total body weight (g), TL is the total length (cm), a: intercept and b: slope are the regression coefficients. Then LWR parameters for each sex were estimated by linear regression analysis using the log-transformed values of this equation (Ricker, 1973; King, 2007).

Length- Length Relationships (LLRs): The relationships among TL-FL, TL-SL, and FL-SL were determined by applying linear regression analysis. The general linear equation: $y = a + bx$ was used to estimate the length- length relationship parameters needed. Regression equations for the LLRs were established separately for each sex as follows: $FL = a + bTL$, $SL = a + bTL$, $SL = a + bFL$ (Moutopoulos & Stergiou, 2002).

Fulton's Condition Factor (K): Fulton's condition factor (K) was calculated using the following formula; $K = (W/TL^3) \times 100$, where, W is total body weight (g) and TL is total length (cm) (Le Cren, 1951).

Statistical Analysis: The differences in mean values of TL, W and K values between the sexes were checked by Student's t-test. Chi-square (χ^2) test was performed to test whether the observed sex ratio between females to males is deviated from the expected ratio of 1:1. ANCOVA was used to determine if there was significant difference in slopes (b values) between the sexes (Zar, 1999). ANOVA was used to evaluate the statistical significance of the regression using the log-transformed values of length and weight. To compare the slopes to confirm whether the b value was different from the isometric growth ($b=3$) for both sexes and all individuals, Pauly's t-test (Pauly, 1984) was performed using the formula:

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

where, $Sd_{\log TL}$ is the standard deviation of the $\log TL$ values, $Sd_{\log W}$ is the standard deviation of the $\log W$ values, r^2 is the correlation coefficient, and n is the number of specimens used in the calculation. If the calculated t value is greater than the table t values for n-2 degrees of freedom the value of b is different from isometric growth ($b=3$) (Pauly, 1984; Bilgin et al., 2020). All tests applied in the study were performed at the 0.05 level of significance. Statistical analyses were performed using the SPSS and MS Excel software.

RESULTS

Sex Composition: Of the totally sampled 120 Artvin gudgeon individuals in the study, 54.2 % (N= 65) were females and 45.8% (N=55) were males. Accordingly, the ratio of female to male (F:M) was calculated as 1.18:1.00 in favor of females. However, it did not deviate from the expected ratio of 1:1 ($\chi^2 = 0.834, P>0.05$).

Length and Weight Distribution: Of all samples, the TL distributed between 8.1 cm and 13.2 cm (mean 10.3 ± 0.117 cm) and the W ranged from 6.00 to 25.92 g (mean 12.71 ± 0.448). There was not a statistically significant difference in mean TL (Student's t-test; $P=0.318, P>0.05$) and mean W (Student's t-test; $P=0.513, P>0.05$) values between females and males. TL and W characteristics of the Artvin gudgeon by sexes were presented in Table 1.

Table 1. TL and W characteristics of Artvin gudgeon by sexes.

Sex	N	Total Length (cm)		Weight (g)	
		Min-Max	Mean±S.E	Min-Max	Mean±S.E
Female	65	8.2-13.2	10.4±0.160	6.04-25.92	13.22±0.642
Male	55	8.1-12.6	10.2±0.155	6.00-20.75	12.08±0.546
All	120	8.1-13.2	10.3±0.117	6.00-25.92	12.71±0.448

N: Sample Size, S.E: Standard Error, Min.:Minimum, Max.: Maximum

Length-Weight Relationships (LWRs): The LWRs were determined as $W=0.008TL^{3.159}$ ($r^2=0.971$, $N=65$) for females, as $W=0.012TL^{2.971}$ ($r^2=0.980$, $N=55$) for males and as $W=0.009TL^{3.088}$ ($r^2=0.970$, $N=120$) for all individuals (Figure 2). The b-values which reflect the body shape were significantly different from the isometric growth ($b>3$) indicating positive allometric growth of Artvin gudgeon for females and combined sex (Pauly's t-test; $t_{female}=2.308$, $t_{combined\ sex}=1.691$, $P<0.05$). However, the b value of males did not differ from the isometric growth ($b=3$) pattern (Pauly's t-test; $t_{male}=0.502$, $P>0.05$). The slopes (b values) of LWRs were found statistically significant for both sexes (ANCOVA, $P<0.05$).

The LWRs for *G. artvinicus* by sexes were presented in Figure 2. The correlation coefficient (r^2) for regression analysis indicated that the Artvin gudgeon has a high correlation ($r^2>0.9$) between the total length and weight variables for both sexes and all individuals. Descriptive statistics and estimated parameters of the LWRs of Artvin gudgeon by sexes were presented in Table 2.

Results of the LLRs indicated that the values of correlation coefficient (r^2) were highly correlated ($r^2>0.9$) for each sex and relationship. Descriptive statistics and estimated parameters of regression and equations of LLRs for Artvin gudgeon by sexes were presented in Table 3.

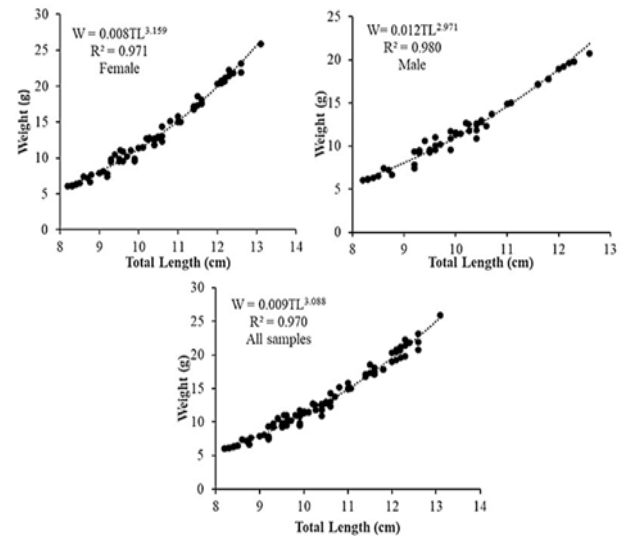


Figure 2. The length-weight relationships (LWR) for the Artvin gudgeon by sexes.

Fulton's Condition Factor (K): The K values of the Artvin gudgeon ranged from 0.791 to 1.459 in females and from 0.955 to 1.276 in males (Table 4). The difference was statistically significant in mean K values between females and males (Student's t-test; $P=0.012$, $P<0.05$).

Table 2. Descriptive statistics and estimated parameters of LWRs of Artvin gudgeon by sexes in Borçka Reservoir.

Sex	N	a	b	S.E. (b)	95% CI of b	R ²	Growth Type	t-value	Pauly's t-test
Female	65	0.008	3.159	0.077	3.004-3.313	0.971	+Allometric	2.308	$p<0.05$
Male	55	0.012	2.971	0.068	2.834-3.108	0.980	Isometric	0.502	$p>0.05$
All	120	0.009	3.088	0.054	2.982-3.194	0.970	+Allometric	1.691	$p<0.05$

N: number of individuals; S.E: Standard Error, Min: minimum; Max: maximum; a: intercept; b: slope; CI: confidence interval limits; R²: correlation coefficient.

Table 3. LLR parameters of Artvin gudgeon by sexes in Borçka Reservoir.

Sex	N	Equation	SE (a)	CI of a (95%)	SE (b)	CI of b (95%)	R ²
Female	65	FL= 0.0964 + 0.9160TL	0.1645	-0.2322-0.4251	0.0157	0.8845-0.9475	0.9817
		SL= 0.4429 + 0.7760TL	0.2764	-0.1095-0.9953	0.0265	0.7231-0.8289	0.9317
		SL= 0.3544+0.8479FL	0.2353	-0.1157-0.8246	0.0243	0.7992-0.8965	0.9507
Male	55	FL= -0.0892+ 0.9364TL	0.1670	-0.4243-0.2460	0.0163	0.9037-0.9691	0.9845
		SL= -0.1001+0.8309TL	0.1809	-0.4632-0.2630	0.0176	0.7955-0.8663	0.9771
		SL= 0.0149+ 0.8835FL	0.1487	-0.2835-0.3133	0.0156	0.8522-0.9149	0.9840
All	120	FL= 0.0304+ 0.9234TL	0.1173	-0.2020-0.2628	0.0113	0.9010-0.9458	0.9827
		SL= 0.2320+ 0.7972TL	0.1756	-0.1159-0.5798	0.0170	0.7637-0.8308	0.9497
		SL= 0.2147+ 0.8624FL	0.1471	-0.0766-0.5061	0.0153	0.8321-0.8928	0.9644

N: number of individuals, S.E: Standard Error, a: intercept; b: slope; CI: confidence interval limits; R²: correlation coefficient

Table 4. The Fulton's condition factor (K) values of Artvin gudgeon, *G. artvinicus* by sexes

Sex	N	Mean	Min.	Max.	S.E.
Female	65	1.128	0.791	1.459	0.011
Male	55	1.102	0.955	1.276	0.008
All	120	1.162	0.791	1.459	0.007

DISCUSSION

In the current study, the sex ratio, LWRs LLRs, and K values for the Artvin gudgeon, *G. artvinicus* were reported for the first time. There is no any reference previously reported with which the results of this study can

be compared. Therefore, all comparisons were made with the other species among the genus *Gobio* reported in the available literature. In addition to the present study, a comparison of length-weight relationship parameters of some *Gobio* species previously reported from different areas in Türkiye is given in Table 5.

The values of the coefficient b of the LWRs for *G. artvinicus* were determined as 3.159 for females, 2.971 for males and 3.088 for all individuals within the expected range of 2.5-3.5 (Pauly, 1984; Froese, 2006), however the b value of LWR may generally vary between 2 and 4

(Bagenal & Tesch, 1978). The growth pattern was positive allometric for females and for combined sex, whereas males showed an isometric growth pattern. The growth pattern in fishes can be either isometric ($b=3$), negative allometric ($b < 3$) or positive allometric ($b > 3$) (Pauly, 1984). Isometric growth ($b=3$) is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes slenderer as it increases in weight while positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Riedel et al., 2007). There are several important factors affecting the value of b throughout the life of fish. such as gonad development and the availability of food in their natural habitats may greatly affect the b value (Rosli & Isa, 2012).

The b values in Table 4 that were previously reported from different areas in Türkiye demonstrate that the growth pattern of different *Gobio* species is species-specific and also depends on habitat characteristics where they live. The parameters a and b of the LWRs can be affected by several factors such as sex, gonad maturity, health status, season, habitat, nutrition, environmental conditions including temperature and salinity, stomach fullness, general condition of fish, differences in length range of fish specimens, and fishing gear (Tesch, 1971; Froese, 2006).

The K values calculated for *G. artvinicus* varied from 0.791 to 1.1459 in females (mean 1.128 ± 0.011) and from 0.955 to 1.276 in males (mean 1.102 ± 0.008). The results indicate that the habitat conditions are in favor of the fish growth, hereby, this species is in a good growth condition in the Borçka Reservoir and its tributaries. The condition factor is an index reflecting the interaction between biotic and abiotic components in the physiological conditions of fishes. Therefore, this factor may vary among fish species in different localities (Blackwell et al., 2000) and the fluctuating in this index is also based on the seasonal variations of the gonads and feeding intensity (Biswas, 1993). Higher K values ($K \geq 1$) indicate suitability of a specific water body for growth as well as a good level of feeding and appropriate environmental conditions in favor of fish whereas the K value lower than 1 ($K \leq 1$) is an indicator of the reverse conditions (Le Cren, 1951; Ujjania et al., 2012; Abbasi et al., 2019). For a species or population throughout their life span in different periods the condition factor is not constant and may be influenced by both biotic and abiotic factors. The differences in mean K values between the sexes in the present study may be due to the variations in weight and age/size of individuals sampled, number of specimens, feeding ratios and gonadal developments.

Table 5. LWR parameters of some *Gobio* species previously reported from different areas in Türkiye (L.T.: Length Type).

Species Name	N	L.T.	a	b	R ²	Locality	Reference
<i>G. bulgaricus</i>	875	SL	0.017	3.118	0.988	Istranca Stream	Saç & Özuluğ, 2020
<i>G. bulgaricus</i>	52	SL	0.012	3.230	0.979	Turkish Thrace	Saç et al., 2019
<i>G. gymnothethus</i>	20	TL	0.014	2.894	0.959	Melendiz Stream	Erk'akan et al., 2013
<i>G. hettitorum</i>	20	TL	0.004	3.446	0.947	İncesu Stream	Erk'akan et al., 2013
<i>G. insuayanus</i>	53	FL	0.017	2.920	0.941	Insuyu Creek	Ergönül et al., 2019
<i>G. kovatschevi</i>	97	TL	0.007	3.240	0.980	Biga Peninsula	Ilhan et al., 2012
<i>G. microlepidotus</i>	91	FL	0.016	2.906	0.964	Üstünler Stream	Ergönül et al., 2019
<i>G. sakaryaensis</i>	40	TL	0.008	3.217	0.970	Çamkoru Pond	Innal & Erk'akan, 2015
<i>G. sakaryaensis</i>	62	TL	0.003	3.583	0.971	Sakarya River	Aksu et al., 2019
<i>G. artvinicus</i>	120	TL	0.009	3.088	0.970	Borçka Reservoir	Present study

The sex ratio for *G. artvinicus* of female to male (F:M) was calculated as 1.18:1.00, which did not deviate from the expected ratio of 1:1. The knowledge of the sex distribution in fish populations is most important for the reproduction of the population. The sex composition (F:M ratio) in many species is usually as 1:1. However, there may be deviations from this ratio in some species or some age groups (Erkoyuncu, 1995). The sex ratio in fishes may generally vary from species to species, between different populations of the same species and from year to year in the same population as well (Nikolsky, 1963).

CONCLUSION

Continuous monitoring of natural stocks is necessary for sustainable fisheries management. Especially, the determination of the length-weight

relationship is crucial in fisheries biology and management (Garcia et al., 1989; Haimovici & Velasco, 2000; Yeşilçicek et al., 2015). Knowledge of some biological parameters such as length values (minimum, maximum and mean), length relationships (length-weight and length-length) and condition factor of fish species provide very important contributions to the sustainability and rational management of fishery resources. However, when the FishBase database is checked, LWRs, LLRs and growth parameters of *G. artvinicus* are not yet available; therefore, the present study is the first attempt to report this basic knowledge, also to close this gap.

The status of this species is not yet been assessed by the IUCN, so that, the current status of the species is listed as not evaluated (NE). The category of 'not evaluated' doesn't indicate that a species is not at risk from extinction, but simply that the species has not yet been studied for any

risk to be quantified and published. The most important reason for this is the lack of sufficient data. It may be appropriate to give them the same degree of attention as threatened taxa, at least until their status can be assessed (IUCN, 2019). Evaluation of some bio-ecological characteristics of the species with this study will also make an important contribution to the assesment of *G. arvinicus* against to IUCN criteria.

In conclusion, the present study provides the first data on the sex ratio, LWRs LLRs, and also K of *G. artvinicus* which would be helpful for fisheries management authorities and fish biologists in Türkiye. Potential conservation plans need much more data on the biology of the species. The results of the present study will provide a primary dataset to fisheries management authorities and fisheries scientists for further investigations to fully understand the bio-ecological characteristics of this species in addition to taking conservation measures and ensuring the sustainability of its populations in the area.

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