Title: Estimation of Some Population Parameters of Squalius cephalus (Linnaeus 1758) in Tabakhane Stream (Ordu-Turkey)

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Estimation of Some Population Parameters of *Squalius cephalus* (Linnaeus 1758) in Tabakhane Stream (Ordu-Turkey)

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Abstract

The purpose of this study is to estimate some population parameters such as length-length and length-weight relationships and condition factor of *Squalius cephalus* living in Tabakhane Stream (Ordu-Turkey). A total of 326 *S. cephalus* individuals were sampled from Tabakhane Stream, located in Ünye district in the Ordu Province, by using an electroshocker. It was determined that the mean total, fork and standard lengths of the fish samples were 7.58±0.143 cm, 7.06±0.133 cm, and 6.30±0.121 cm, respectively, and their average weight was 6.05±0.322 g. The length-weight relationship of the species was calculated as $W=0.0088TL^{3.0648}$ ($R^2=0.993$). As a result of our analyzes, it was determined that the *S. cephalus* population in Tabakhane Stream showed a positive allometric growth. In the present study, it was determined that the 95% confidence interval of the *b* value in the length-weight relationship equation was between 3.0566-3.0678 and there was a strong relationship between body weight and total length. Relationship equations between total, fork and standard lengths were calculated as $TL=1.0724FL+0.0086$ ($r^2=0.998$), $TL=1.1763SL+0.167$ ($r^2=0.997$), and $FL=1.0961SL+0.1529$ ($r^2=0.998$) and it was determined that there are strong relationships between standard, fork and total length measurements of *S. cephalus* living in Tabakhane Stream. It was determined that the condition factor values of *S. cephalus* ranged between 0.740 and 1.276. The average condition factor was 0.998±0.005. There is no previous study on the population of *S. cephalus* living in Tabakhane Stream. In this study, the condition factor, length-weight and length-length relationships of *S. cephalus* in this habitat were reported for the first time.

Keywords: *Squalius cephalus*, length-length relationship, length-weight relationship, Condition factor, Tabakhane Stream, Ordu

1. INTRODUCTION

Genus *Squalius* is a large fish group in the family Leuciscidae, represented by 50 species in the world [1]. *Squalius cephalus* (Linnaeus 1758) is a freshwater fish species and is widely distributed in European inland waters, Black Sea, Caspian Sea and Azov Sea Basins, and most of the inland waters in Caucasus Region and Anatolia [1, 2].

The conservation status of *S. cephalus* is *LC* in the IUCN Red List [3]. *S. cephalus* is an economically important fish species [4, 5] and many studies were carried out on different populations of this species both in Turkey and abroad such as determination of reproductive characteristics [6, 7], growth characteristics [8-11], morphological variation [12], genetics [13, 14], biological characteristics [15]. In nature,

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whether in terrestrial or aquatic habitats, living things inherit growth as an integral part of their life history, and this growth is also very important event for the life cycles of fish species [16, 17]. The growth dynamics, length-weight relationship (LWR), length-length relationship (LLR) and condition factor (K) of any fish species are important biological parameters to evaluate stock variation, determination of growth rate, spawning time and maturity appearance [18, 19].

Length-weight relationship (LWR) refers to the dynamics and growth patterns of fish populations in general. The slope b value calculated in this relationship is used to determine how the growth of fish is affected by changes in habitat, seasons and other factors [20]. Whether the slope b in this equation differ significantly from 3.0 value indicates the type of growth of the fish species in the respective habitat: for instance, negative allometric growth ($b<3$), isometric growth ($b=3$), or positive allometric growth ($b>3$) [21].

Length-length relationships (LLRs) of fish species are important in comparing growth studies of the species in different habitats and also different length measures of fishes are required for certain applications in fish biology and fisheries management [22, 23]. Also, standard length can be useful as a basic measure of length for scientific purposes, as total length is not always available (e.g. bitten or damaged). Furthermore, standard length is more commonly used in fisheries management, such as defining minimum legal lengths for commercial and recreational fishing. Therefore, reliable length-length relationships are required for data length conversions [24].

Likewise, condition factor (K) is an index that reflects the interactions between biotic and abiotic factors in the physiological state of fish in their respective habitats [17]. It shows the well-being of the population at various life cycle stages [25]. In other words, the K is an important tool for assessing environmental effects on fish and reflects the relative health of fish populations [26]. According to the calculated K value, the status of fish species in the relevant habitat can be evaluated and compared with their populations in other regions. For example, when the condition

factor value is $K=1$ and $K>1$, it can be understood that the fish is in a good growth state, and when $K<1$, the organism is in a weaker growth state compared to an average individual of the same length.

There are limited studies on the population of *S. cephalus*, which has a wide distribution in Turkish inland waters and has commercial value, in the Black Sea region. There is no study examining the population characteristics of this species in Tabakhane Stream in Ordu. For this reason, the main aim of this study is to determine the condition factor, length-weight and length-length relationships of *S. cephalus* which sampled from the Tabakhane Stream (Ordu-Turkey) in the Middle Black Sea Region.

2. MATERIALS AND METHODS

Tabakhane Stream is a lotic ecosystem located on the borders of Ünye district of Ordu Province in the central Black Sea region of Turkey (Figure 1). *Squalius cephalus* samples were collected from Tabakhane Stream (Ordu-Turkey) using the SAMUS 725 MP electroshocker (Figure 1).

Figure 1 Sampling area of *S. cephalus* in Tabakhane Stream (Ordu-Turkey).

Fish samples were measured for total length (TL), fork length (FL) and standard length (SL) (0.01 cm.) The weight of each fish (W) was recorded

(0.01 g). Gender of the fish samples was determined by microscopic and macroscopic examinations of the gonads.

All length-length relationships such as TL & SL, TL & FL, and FL & SL were calculated using linear regression model (y=ax+b) and the correlation coefficients of each relationship were determined. Length-weight relations of the fish samples were calculated using the equation W=aL^b, where L is the total length (cm), W is the weight of the fish (g), "*a*" and "*b*" are the parameters of the equation [27]. In this study, the 95% confidence interval (95%CI) of the b value was also calculated. In the current study, the parameters "*a*" and "*b*" were estimated from linear regression applied to the log-transformed variables such as logW=log*a* + *b*logL. Condition factor (*K*) of *S. cephalus* in this habitat was calculated using the equation $K=100(W/L^3)$ where L is the total length (cm), W is the weight of the fish (g) [28].

The t-test was used to test whether the slopes (*b*) were significantly different from 3 and based on these results the growth type of the species in this habitat was determined. In addition, whether there is a statistical difference between the length and weight measurements of female and male individuals was tested using the t-test. All statistical analyzes in the study were performed using the Minitab 17 software.

3. RESULTS AND DISCUSSION

A total of 326 *S. cephalus* individuals were caught in the field studies carried out in the Tabakhane Stream (Ordu-Turkey). As a result of field studies, it was determined that 111 samples (34.05%) were male, 71 samples (21.78%) were female and 144 samples (44.17%) were juveniles.

Average body weight and total length values of the fish samples were determined as 6.05±0.322 g and 7.58±0.143 cm, respectively. The descriptive statistics of the weight, total, fork and standard lengths data of the species of *S. cephalus* evaluated within the scope of the study are presented in Table 1.

Table 1 Descriptive statistics of *S. cephalus* from Tabakhane Stream (Ordu-Turkey).

Measurements		Mean	SE	SD	Min.	Max.
Weight (g)		6.05	0.322	5.814	0.53	32.40
Total Length (cm)		7.58	0.143	2.574	3.50	14.50
Fork Length (cm)	♀+♂	7.06	0.133	2.397	3.30	13.30
Standard Length (cm)		6.30	0.121	2.185	3.00	12.00

SE: Standard error, SD: Standard deviation, Min: Minimum, Max: Maximum.

The length and weight frequencies of *S. cephalus* from the Tabakhane Stream (Ordu-Turkey) were presented in Figure 2.

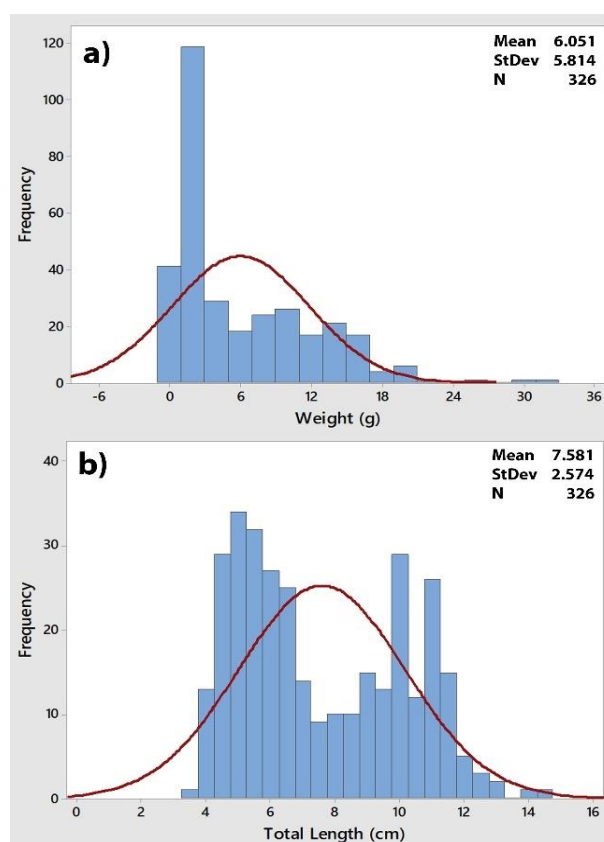Figure 2 The weight-frequency and length-frequency distributions of *S. cephalus* in Tabakhane Stream (Ordu-Turkey).

As a result of the t test, it was determined that the total length and weight values were not statistically different between female and male *S. cephalus* individuals (P>0.05). Therefore, the calculations were carried out to represent the entire population, including all female+male individuals.

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Growth parameters such as length-length, length-weight and condition factor are some of the most important data sources that provide information about the growth status of fish in the relevant habitat [29-31]. These parameters can also be used to compare populations of the same species in different habitats [32, 33].

When the literature is examined, it is seen that different total, fork and standard lengths are used in many growth studies [34-38]. These differences in some growth studies can cause confusion when making regional comparisons. At this point, the use of length-length relations of the relevant species can be beneficial in solving the problem. In addition, these relations allow the estimation of the length of a morphometrically damaged sample using the length-length relations.

Length-length relationships (LLRs) of *S. cephalus* from Tabakhane Stream were calculated by using the linear regression model. It was determined that the coefficients of determination (r^2) of the LLRs ranged from 0.997 to 0.998 and that there were strong relationships between the length values of the *S cephalus* from Tabakhane Stream (Figure 3).

Similar to present study, these strong relationships observed in total length, fork length, and standard length values were reported among *S. cephalus* living in the Abdal Stream (TL-FL, r^2=0.999, TL-SL, r^2=0.999, FL-SL, r^2=0.999), Akçay Stream (TL-FL, r^2=0.998, TL-SL, r^2=0.916, FL-SL, r^2=0.922), Terme Stream (TL-FL, r^2=0.981, TL-SL, r^2=0.984, FL-SL, r^2=0.985) and Yedikır Dam Lake (TL-FL, r^2=0.991, TL-SL, r^2=0.989, FL-SL, r^2=0.996) [39]. Similar results were also reported for *S cephalus* in the Karasu River (TL-FL, r^2=0.96, TL-SL, r^2=0.97, FL-SL, r^2=0.99) [40].
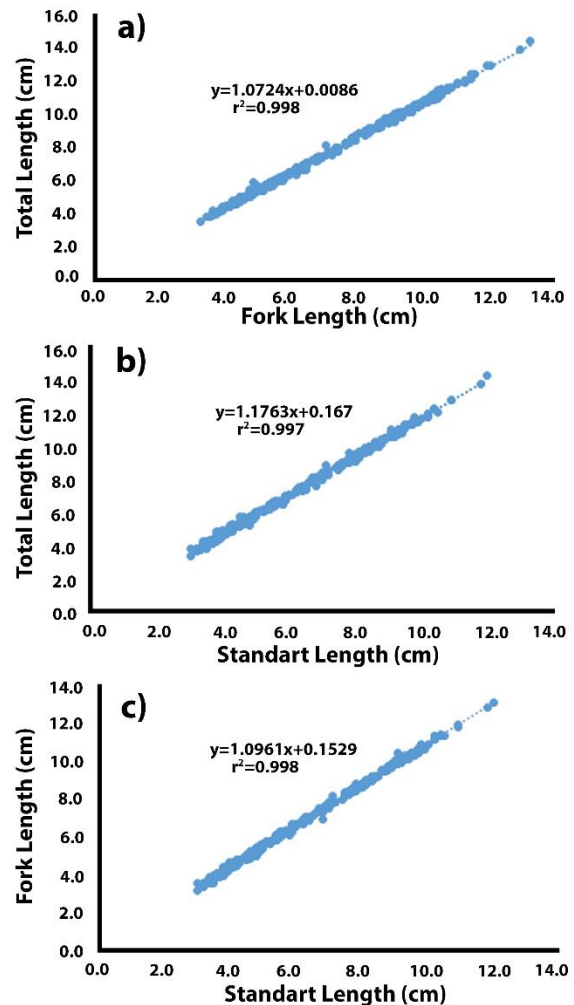

Figure 3 The length-length relationships for *S. cephalus* in Tabakhane Stream (Ordu-Turkey).

Length-weight relationship (LWR) was calculated as W=0.0088TL$^{3.0648}$ (R^2=0.993) for *S cephalus* from Tabakhane Stream (Figure 4). It was determined that there is a strong relationship between the total length and weight values of *S cephalus* in this aquatic habitat (R^2=0.993, Figure 4). In the present study, the *b* value in the total length-weight relationship equation was calculated as 3.0648 and the 95% confidence interval of the *b* value was calculated as 3.0566-3.0678. The *b* value calculated in present study was found to be within this confidence interval. Moreover, the *b* value of LWR was found to differ significantly from 3.0 in the *S cephalus* in this habitat. It was determined that the species showed a positive allometric growth in Tabakhane Stream.
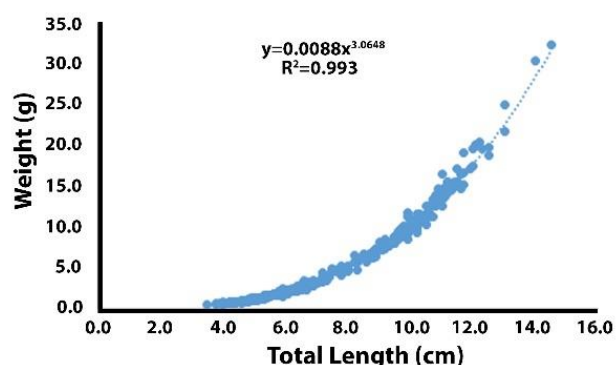
Figure 4 The length-weight relationship for *S. cephalus* in Tabakhane Stream (Ordu-Turkey).

Length-weight parameters are important data sources, especially in fisheries management and fish biology [41]. The *b* value is generally between 2.5 and 3.5 in many studies in which

different marine and freshwater fish are studied [26, 27, 29]. The *b* values in fish can also vary according to gender, age, seasons, physiological conditions, growth rate and nutritional status of the fish [21, 27]. As the fish grows in the fish's life cycle, changes in weight are relatively larger than changes in length because of the cubic relationships between fish length and weight. When the literature was examined, many studies were found on the LWR and growth type of *S. cephalus* in different aquatic habitats (Table 2). As a result of a detailed literature review, although it was reported in many studies that *S cephalus* showed positive allometric growth [30, 39, 42, 43], similar to our study, in some studies it was reported that it showed isometric [9, 44, 45, 46] and even negative allometric growth [47, 48] (Table 2).

Table 2 Comparison of length-weight relationships of *S. cephalus* with previous studies.

Habitats	n	*b*	Growth Types	References
Karakaya Dam Lake (Turkey)	527	2.820	A(-)	[47]
Apa Dam Lake (Turkey)	474	2.43	A(-)	[48]
Işıklı Lake (Turkey)	528	3.04	I	[44]
Gelingülü Dam Lake (Turkey)	267	2.870	I	[9]
Hafik Lake (Turkey)	242	2.828	I	[45]
Tödürge Lake (Turkey)	466	3.088	I	[46]
Topçam Dam Lake (Turkey)	332	3.12	A(+)	[49]
Northern Aegean Eustuarine (Greece)	627	3.856	A(+)	[42]
Çamkoru Pond (Turkey)	374	3.012	A(+)	[11]
Almus Dam Lake (Turkey)	305	3.359	A(+)	[50]
Gamasiab River (Iran)	60	3.97	A(+)	[51]
Sakarya River (Turkey)	32	3.188	A(+)	[52]
Yeniağa Lake (Turkey)	729	3.109	A(+)	[53]
Uzunçayır Dam Lake (Turkey)	334	3.136	A(+)	[54]
Karasu Stream (Turkey)	254	3.24	A(+)	[40]
Yalıköy Stream (Turkey)	118	3.0444	A(+)	[30]
Akçay Stream (Turkey)	57	3.285	A(+)	
Abdal Stream (Turkey)	44	3.224	A(+)	[39]
Yedikır Dam Lake (Turkey)	62	3.210	A(+)	
Terme Stream (Turkey)	55	3.298	A(+)	
Karasu River (Turkey)	196	3.27	A(+)	[43]
Tabakhane Stream (Turkey)	326	3.0648	A(+)	Present Study

Condition factor (*K*) is one of the commonly used population parameters to understand the survival, reproduction, maturity and health of fish [20]. In addition, *K* can be used as a good indicator of the water quality or general health of fish populations living in a particular habitat or ecosystem [20, 26, 55]. In addition, the condition factor is an

important biological parameter for the conservation and management of natural populations by providing information about the status of fish species [56, 57]. Maximum and minimum condition factors of *S. cephalus* distributed in Tabakhane Stream (Ünye-Ordu) were calculated as 1.276 and 0.740, respectively.

The mean condition factor was determined as 0.998±0.005. The condition factor value above 1 indicates that the fish are in good condition in this habitat. In this study, the average condition factor was determined close to 1 value. In the literature, it was determined that the average condition factor of *S. cephalus* showed some differences between habitats. For instance, it was reported that the average condition factor of *S. cephalus* is 1.2915 in Çamligöze dam lake [58], 1.43 in Karakaya Dam Lake [43], 1.48 in Lake Yeniçağa [49], and 1.5759 in Lake Akşehir [59]. Differences in the *K* value of a fish species could be a reason for variations in sexual maturity, availability of food sources, age, and sex in the relevant habitat [20, 60].

4. CONCLUSION

The present study provides the first information about the condition factor, length-length, length-weight and relationships of *S. cephalus* from Tabakhane Stream (Ünye-Ordu). This study will help biologists to know the status of this fish and develop culture technology in natural waters and will be useful for the fishery biologists and conservation biologist, for successful development, management, production and ultimate conservation of the most preferred food fishes of the states. Since population parameters are important in fisheries management and fish biology, the determination of these parameters can provide important baseline data, especially by supporting future population monitoring and research studies. Genetic diversity and various factors such as temperature, eutrophication levels, diet and diseases may cause intraspecific differences in the growth parameters of fish species [10]; therefore, future studies in this field can be further improved by supporting these data.

Conflict of interest

There is no conflict of interest to be declared.

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The Declaration of Ethics Committee Approval

This study does not require ethics committee approval or any special permission.

The Declaration of Research and Publication Ethics

The author of the paper declares that he complies with the scientific, ethical and quotation rules of SAUJS in all processes of the article and that he does not make any falsification on the data collected. In addition, he declares that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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