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An Investigation on Some Population Parameters of Tigris Trout (*Salmo tigridis* Turan, Kottelat & Bektaş, 2011) for Çatak Stream, Upper Tigris Basin/ Türkiye

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ABSTRACT

The present study examined length-weight relationship and some growth parameters of Tigris Trout (*Salmo tigridis* Turan, Kottelat & Bektaş, 2011) caught in Çatak Stream. By using electroshock and casting nets, 162 Tigris trout were caught between January 2008 and January 2009. The fork lengths and total weights were measured, and sexes of the caught fish were identified. Furthermore, their age was also identified in line with their otoliths. The age range was found out as II–VII age. The mean of fork length was found to be 19.69 ± 3.80 cm for males and 19.89 ± 4.63 cm for females. While the mean of total weight was 97.19 ± 5.98 g for males and 102.18 ± 6.10 g for females. The length weight relationship was found as $W = 0.187\ L^{2.834}$. Length and weight relationship according to von Bertalanffy growth equations, they were estimated as $L_t = 36.467\ \left(1 - e^{-0.188(t+1.180)}\right)$, $W_t = 495.428\ \left(1 - e^{-0.188(t+1.180)}\right)^{2.834}$ respectively. Growth type was found to be negative allometric in males and females individuals. In line with the samples examined, it was revealed that the population was mainly composed of II and III elderly individuals. The male/female ratio was found out as 1:2 among the samples.

Keywords: Çatak Stream, *Salmo tigridis,* Tigris trout, growth parameters

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Yukarı Dicle Havzası, Çatak Çayı Dicle Alabalığı (*Salmo tigridis* Turan, Kottelat & Bektaş, 2011)'nın Bazı Populasyon Parametrelerinin İncelenmesi

Öz: Bu çalışmada Çatak Çayı'ndan yakalanan Dicle alabalıklarının (*Salmo tigridis* Turan, Kottelat & Bektaş, 2011) boy-ağırlık ilişkisi ve büyüme özellikleri incelenmiştir. Ocak 2008-Ocak 2009 tarihleri arasında elektroşok ve serpme ağ kullanılarak toplam 162 adet Dicle Alabalığı yakalanmıştır. Yakalanan balıkların çatal boyları, total ağırlıkları ölçülmüş, cinsiyetleri belirlenerek otolitlerinden yaş tayinleri yapılmıştır. Çalışmada alabalıkların yaş aralığı, II-VII olarak tespit edilmiştir. Ortalama çatal boy, erkeklerde 19,69±3,80 cm, dişilerde 19,89±4,63 cm, ortalama total ağırlık erkeklerde 97,19±5,98 g, dişilerde 102,18±6,10 g olduğu belirlenmiştir. Boy ağırlık ilişki W=0,187 $L^{2,834}$, boyca ve ağırlıkça Von Bertalanffy büyüme eşitlikleri sırasıyla L_t=36,467 $(1\text{-}e^{-0,188*(t+1,180)})$, W_t=495,428 $(1\text{-}e^{-0,188*(t+1,180)})^{2,834}$ olarak hesaplanmıştır. Dişi ve erkek bireylerde büyüme tipi negatif allometri olarak bulunmuştur. İncelenen örneklerde populasyonun ağırlıklı olarak II ve III yaşlı bireylerden oluştuğu belirlenmiştir. Örneklerde erkek/dişi oranı 1:2 olarak belirlenmiştir.

Anahtar kelimeler: Çatak Çayı, *Salmo tigridis,* Dicle alabalığı, büyüme parametreleri

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Introduction

Natural trout, which show a wide distribution in the waters of our country, are known as mountain trout, Black Sea trout, red spotted, Tigris and Anatolian trout. Natural trout is distributed in streams between 100 and 2300 m in altitude (Kocabas et al. 2013). In these regions, called trout zones, the flow of water is fast, and the amount of oxygen is high. Generally, the body structures of trout are shuttle-shaped, and the sides are flat. On the lateral lines, there are 10–12 large red spots with small red spots (Aras et al. 1986; Geldiay and Balık 1996). Recently, deterioration in physical habitat structures of rivers, deterioration of water quality, a decrease of flow rates due to global climate change, dams and obstacles to prevent passing fish in rivers have negatively

affected the fish stocks in these places. In addition to these negativities, excessive catching pressure, which is economically valuable and believed to cure diseases, has brought natural trout stocks to extinction. More studies are required on trout populations in Turkey; however, the studies are limited because of the geographic location of the habitat and the difficulty of obtaining samples. It can be said that most of the existing literature is based on taxonomic studies (Alp and Kara 2004). A number of studies have examined natural trout stocks in Turkey. Among the studies conducted on natural trout, Aras (1976) and Aras et al. (1986) deal with bio-ecological status. Çetinkaya (1996) and Alp and Kara (2004) tried to figure length-weight relationship and condition factors. Kocaman et al. (2004) and Yüksel et al. (2020a), examined population parameters, while Tanır and Fakıoğlu (2017) conducted biomass and density studies. Yüksel et al. (2020b) determined morphometric features. Duman et al. (2011) investigated the nutritional content of their meat. Çatak Stream natural trout species was named as *Salmo trutta macrostigma* (non Dumeril 1858) until 2011 (Tortonese 1954; Geldiay and Balık 1996). However, Turan et al. (2011), in their study supported by molecular methods, it was determined that natural trout living in Çatak Stream belonged to a different group of family was renamed as *Salmo tigridis* (Tigris trout). There are only two studies related to *S. tigridis* (Çetinkaya 1996; Akkuş and Sarı 2017) at Çatak Stream, which is located in the triangle of Hakkari, Van and Siirt provinces (east-south Turkey). Despite the number of natural trout populations in many regions of Turkey, the information about their growth and reproductive characteristics is insufficient (Yüksel et al. 2020a). The lack of an up-to-date study on the population parameters of the *S. tigridis* causes uncertainty about this species which is rapidly declining due to overfishing in the region. The aim of this study is to find out the population characteristics of the *S. tigridis* as well as shedding light onto the measures to be taken to protect the decreasing species of *S. tigridis*.

Materials and Methods

The study was conducted on the Çatak Stream, one of the main tributaries of the Tigris River. Çatak Stream, which is located in the Upper Tigris Basin, arises from the mountainous parts of the village of Sıcaksu at an altitude of 2338 m in Van-Gürpinar district. Çatak Stream is located in an area which is difficult to reach due to the steep terrain conditions (Figure 1).

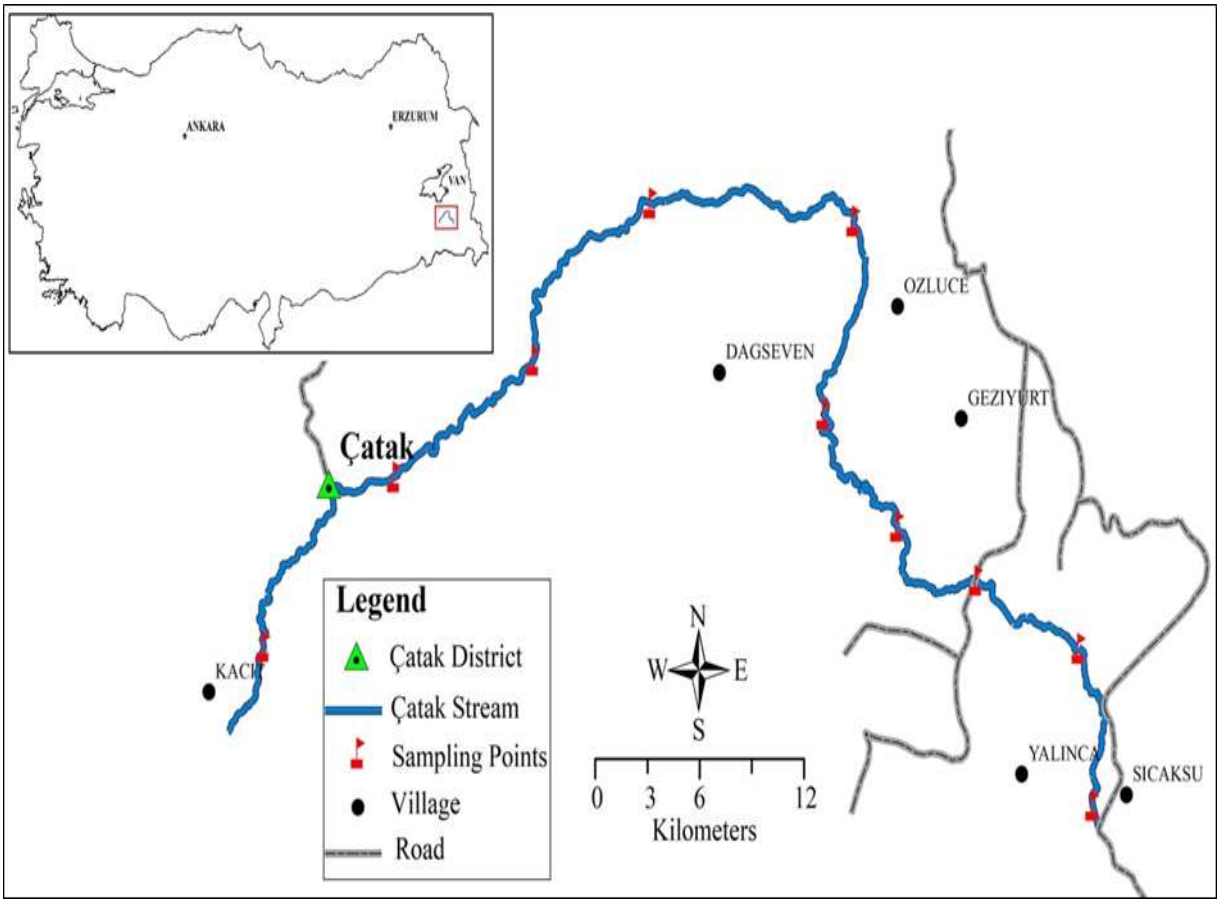

Figure 1. Çatak Stream and sampling points

The sex of the fish was determined by visual or microscopic examination of the gonads. Seasonal fish sampling was carried out with a 12 Volt DC and 7–14 amp battery, portable electroshock device and fish scoop with 2–4 mm mesh sizes. In the deep areas, where the electroshock device is not effective, the scattering net with 5 mm mesh size is used in the sampling. Sampling studies were carried out at 10 different points with a length of 200 meters (Gelwick 1990), chosen by taking the terrain conditions and the habitat structure of the river into account. The total weights of the caught fish were made on a digital scale with ± 0.1 g sensitivity, and fork lengths were determined on a measuring board with a precision of ± 1 mm. The age of the fish was determined by reading the age rings of the otolith from each fish under the light microscope. Furthermore, $W = a\,L^b$ equation was used to calculate the length -weight relationship (Froese 2006). Where, *W* and *L* indicates as total weight (g) and fork length (cm) respectively. The a and b values of LWRs are calculated from the regression analysis. The t-test ($p<0.05$) was applied to determine whether the b value is different from 3.

Von Bertalanffy (1957) growth constants have also been used $L_t = L_\infty\,(1 - e^{-K\,(t - t0)})$, $W_t = W_\infty\,(1 - e^{-K\,(t - t0)})^b$ for equations. L_∞ represents the maximum theoretical length that a Tigris trout can reach, and W_∞ represents the maximum theoretical weight that it can reach. In order to compare the growth parameters calculated in the study with the previous studies in the literature, fi ($\acute{\Phi}$) value developed by Pauly and Munro (1984) was calculated. $\acute{\Phi} = \ln K + 2\ \ln L_\infty$ was used to calculate $\acute{\Phi}$.

Results

In line with the findings of the present study, it was found that examined fork length values of 162 individuals ranged between 10.8 and 31 cm, and their weights ranged between 15 and 308 g. The maximum and minimum fork length values are 13.3–31cm in males and 10.8–29.5cm in females, respectively. Total weight values were between 31.1–308 g in males and 15–234.8 g in females. Average weight and length values of age groups between II and VII are given in Table 1.

Table 1. Fork length and weight values (min-max)

Age	Number		Male		Female	
	Male	Female	Fork L. (cm) (min-max)	Weight (g) (min-max)	Fork L. (cm) (min-max)	Weight (g) (min-max)
2	35	13	19.9-13.8	91.8-31.1	19.8-10.8	91.8-15
3	45	22	20.1-15	102.9-41.2	18.3-14.9	73.5-36
4	14	7	24.1-21	148-97	24-20.5	146.4-108.6
5	6	4	25.5-24.5	181.1-158.1	24.5-24	160-126.1
6	4	6	29-25.9	312.2-224.8	27.2-26	226.8-189.7
7	4	2	31-26.5	318.2-203.2	29.5-27	234.8-234.1

During the process of reading ages, it was found out that the rate of VII-old fish was the lowest among the examined individuals, and it was 3.70%. The proportion of the other age groups was 6.17% among the elderly individuals in VI, 6.17% among the in V age group, 12.96%, among the elderly in IV, 41.35%; among the elderly in III, 29.62% among the elderly in II. Individuals belonging to age group III are the most dominant age group with a rate of 41.35%. The population was predominantly composed of II and III (70.98%) elderly individuals (Figure 2).

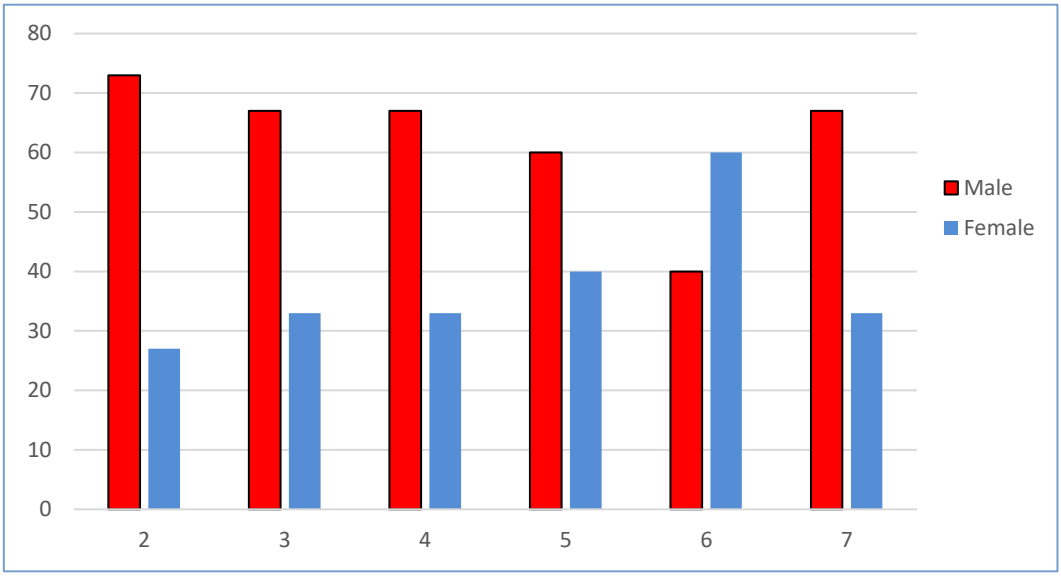

Figure 2. Proportional (%) distribution of male and female individuals in age groups

Length -weight relationships of the individuals sampled in the study were calculated for male and female individuals (Figure 3).

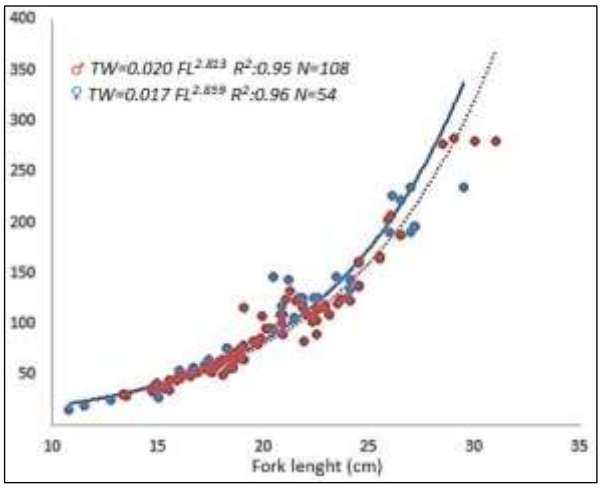

Figure 3. Relationship for male and female fish

As a result of the regression analysis, the regression coefficient value (b) was calculated as 2.834 (negative allometric growth; t-test $p<0.05$) in all individuals, 2.813 (negative allometric growth; $p<0.05$) in male subjects, and 2.859 (negative allometric growth¸; t-test $p<0.05$) in female subjects (t-test, $p<0.05$). R^2 value calculated as a result of regression analysis, and it was calculated as $R^2 = 0.961$ in all individuals. Furthermore, $R^2 = 0.966$ was in females, and $R^2 = 0.957$ was in males (Table 3). In the study, the (b) value, which is calculated for females, males and all individuals, was calculated as (2.89) among males as the lowest level. Von Bertalanffy growth parameters of Çatak Stream *Salmo tigridis* population were calculated for all individuals (Table 3). Von Bertalanffy growth parameters for male individuals**,** the maximum theoretical length was $L_\infty = 37.235$, and maximum theoretical weight was $W_\infty = 524.982$. Brody growth coefficient was revealed as $K = 0.175$, theoretical age was $t_0 = -2.201$, and $Ø$ value was calculated as 5.49. In female individuals**,** the maximum theoretical length was $L_\infty = 35.297$, and maximum theoretical weight was $W_\infty = 454.989$. Brody growth coefficient was revealed as $K = 0.248$, theoretical age was $t_0 = -1.330$, and $Ø$ value was calculated as 5.73.

Table 2. Regression analysis parameters

Sex	Number of individuals (n)	Regression parameters		r^2	t- test	Growht type
		a	b			
All indv.	162	0.018	2.834	p<0.05	0.961	Negative allometric
Male	108	0.017	2.813	p<0.05	0.966	Negative allometric
Female	54	0.020	2.859	p<0.05	0.957	Negative allometric

Table 3. Von Bertalanffy growth parameters calculated for all individuals

Von Bertalanffy growth parameters (male)					Von Bertalanffy growth equation (male)
L_∞ *(cm)*	W_∞ *(g)*	*K*	t_0	*Ø*	$L_t = 37.235 \cdot (1 - e^{-0.175 \cdot (t+2.201)})$
37.235	524.982	0.175	-2.201	5.49	$W_t = 524.982 \cdot (1 - e^{-0.175 \cdot (t+2.201)})^{2.813}$
Von Bertalanffy growth parameters (female)					Von Bertalanffy growth equation (female)
L_∞ (cm)	W_∞ (g)	K	t_0	*Ø*	$L_t = 36.467 \cdot (1 - e^{-0.248 \cdot (t+1.33)})$
35.297	454.989	0.248	-1.330	5.73	$W_t = 454.989 \cdot (1 - e^{-0.248 \cdot (t+1.133)})^{2.859}$

Discussion

In a nutshell, in the present study conducted with *Salmo tigridis* individuals in Çatak Stream, the maximum fork length was 31 cm, and the oldest individuals were in VII age group. In the study conducted by Çetinkaya (1996) related to *S. tigridis* individuals in Çatak Stream, the maximum fork length value was 38 cm, and the oldest individual was reported as VIII. In the study we conducted on the same population, it was obvious that there were no VIII elderly individuals in the area, and the fork length value decreased to 31 cm. This situation is thought to have been caused by the catching large individuals aged VIII along with overfishing, habitat destruction and pollution in the past 14 years. It was reported by Alp and Kara (2004) that the populations other than *Salmo platycephalus* in the Zamantı Stream were exploited at a high degree, and those individuals belonging to the high age group were extinct. With the withdrawal of older individuals from VIII, the length value decreased from 38 cm to 31 cm. The decrease in the size of the fish in fish populations is an indicator of overfishing (Avşar 2005). When the studies conducted by other researchers in different regions are examined, it can be claimed that the maximum fork length in the *Salmo trutta macrostigma* population of the Fırnız Stream in Seyhan Basin is 48.5 cm, and the largest age detected is X (Alp and Kara 2004). It was observed that the length and age values obtained from these studies are larger than those obtained from our study. As it is widely known, the growth in fish varies depending on many parameters such as water temperature, nutrient abundance and habitat structure (Çelikkale 1994; Avşar 2005). Therefore, it is expected that these values will come out differently in the studies carried out in streams with different ecological characteristics. In addition, the conservation activities carried out in different regions, which are not of the same sensitivity, are considered as other reasons for the emergence of this situation. When the ratio of age groups in the population is examined, it is seen that the population is composed of mainly II and III age groups with a rate of 70.98%. The proportion of individuals between the ages of IV–VII in the population is 29.02%. This is thought to be due to the intense catching pressure of individuals aged IV–VII, who are larger in length and weight than those of the younger II and III. Korkmaz (2005), in the study on mountain trout in Kadıncık Creek in Tarsus, asserted that 10.94% of the age composition of individuals were older than 3 years due to an intense catching pressure on adult fish. By Alp and Kara (2004), it is stated that there is an illegal and excessive prey pressure on the *S. trutta* population which is one of the most economical fishes among inland water fishes. Female / male ratio was calculated as 1:2 Çetinkaya (1996), in the study of Çatak Stream *S. tigridis* population, reported this ratio as 1:2. This value is consistent with the value calculated in our study. When other studies were examined in terms of female/male ratio, Alp et al. (2005) found 1:0.66 in the Fırnız Stream. In the study of Kocabas et al. (2012) the ratio was 1:1.08 in Uzungöl Stream. On the other hand, Yüksel et al. (2020a) reported the ratio of Munzur Stream as 1:0.96. By the time the other studies are taken into consideration, it is seen that the ratio of male individuals is higher than female individuals similar to the rate in our study. The number of male individuals in populations performing migration movements from trout species is expected to rise more than female individuals (Maitland and Campbell 1992). In general, males come to the reproductive area before females and leave the area later than females (Nikolsky 1963). In freshwater fish populations, males are expected to be more common in the first age groups (Alp et al. 2005). The value of (b) obtained from the regression analysis to determine the length-weight relationship reveals the type of growth in fish (Erkoyuncu 1995). The b values obtained in our study ranged between 2.89 and 2.81, and negative allometric growth was observed for all individuals, female and male individuals. Other studies on natural trout in Turkey (b) value varied a lot. Çetinkaya (1996) found out Çatak Stream *S. tigridis* individuals as 3.07. Yüksel (1997) claimed for Erzurum Teke Stream *S. t.*

macrostigma individuals as 2.59, while Arslan et al. (2004) pointed out 2.89 for *Salmo trutta labrax* individuals living in Çoruh Basin. On the other hand, Alp and Kara (2004) found out Seyhan, Ceyhan and Euphrates in the *S. t. macrostigma* individuals in the range of 3.027–2.878. The same range was 2.89–3.04 for Çoruh Basin Blood Brook Salmo trutta individuals (Arslan et al. 2004). Yüksel et al (2020a) conducted a similar study in Munzur River *S. t. macrostigma* and found the range as 2.9854–2.7251. In a similar vein, Tanır and Fakıoğlu (2017), who studied Çoruh Basin *S. trutta* individuals, reported the range of 3.0672–3.3158. It was observed that the value of (b) obtained in our study was lower than the values obtained from other studies except for the value of 2.59 reported by Yüksel (1997). This situation is thought to be due to the severe winter conditions prevailing for eight months in the Eastern Anatolia Region where the Çatak Stream, which rises at an altitude of 2338 m, is located. During the long winter months, the water temperature in Çatak Stream is nearly zero degrees. Trout stops the feed intake when the water temperature falls below 2 ºC (Çelikkale 1994). In fish, malnutrition that occurs in cold seasons causes a decrease in the length-weight relationship (b) (Arslan et al. 2004). Çetinkaya (1996), (b) value was reported as 3.07 for the Çatak Stream *S. tigridis* individuals. It is seen that this value is higher than the value we calculated (2.89–2.81). This difference is due to the deterioration of the river habitat in the last 14 years due to environmental conditions, the decrease in the amount of food and over-catching due to the withdrawal of large individuals from the population. In addition, as shown in the above mentioned literature (Arslan et al. 2004; Tanır and Fakıoğlu 2017), it is seen that there are differences between the values of (b) in studies conducted at different times in the same habitats. Depending on water temperature, nutrient abundance and reproductive activities, temporal and spatial differences occur in the length-weight relationship of fish populations (Wootton 1991). Populations of the same fish species in different streams may vary in length and weight values depending on environmental factors such as nutrient abundance, water temperature and habitat characteristics (Nikolsky 1963). Considering this situation, it is expected that there will be a difference between (b) value calculated by Çetinkaya (1996) in the same habitat and (b) value calculated in our study in 2019. The value (b) obtained in the study shows that the growth type of all individuals and sexes examined was negative allometry. Aras et al. (1986) claimed that *S. t. macrostigma* growth is usually isometric (b = 3) although (b) values vary between 2.3 and 4.0, he said. The negative allometric growth type detected in this study is consistent with this study. The value of (a) calculated in the regression analysis is used as an indicator to determine the degree of fattening (Condition Factor, K) of the fish (Avşar 2005). In our study, (a) value was calculated as 0.0187. When (a) values obtained from other studies are examined, it can be said that Kara et al. (2011) found 0.016 in the *S. platycephalus* population in the Zamantı Stream of the Seyhan River. For the same value, Yüksel et al (2020a) found 0.0187 in Munzur Stream among *S. t. macrostigma* individuals. Gülle et al. (2007) also reported that the trout in the Western Mediterranean basin is in the range of 0.011–0.015. These values are similar to the values obtained in our study. Since not all qualitative testable growth constants can be evaluated together, there is a high probability of error. In order to solve this problem, Φ 'value which reflects the total growth performance is calculated. In the study, Φ' value was calculated as 5.52 for *S. tigridis*. Considering the values obtained from other studies on natural trout are taken into consideration, the values were 5.81 in the Zamantı Stream (Kara et al. 2011), it was as 5.62 in the Munzur Stream (Yüksel et al. 2020a). It is thought that the differences between Φ 'values reported in other studies with the value of 5.52 in our study are caused by ecological differences that have direct effects on growth performance. *S. tidridis* (Tigris trout), which lives in Çatak Stream, is one of the important biodiversity richness of Turkey. In this study, it was observed that there were no VIII elderly individuals seen in the past years in the population. Of the 162 individuals examined, only 6 VII elderly individuals were found, and II–III elderly individuals were dominant in the whole sample, indicating excessive and illegal fishing on the population. In the Statement No: 5/1 on Regulation of Commercial Fisheries, natural trout fishing in rivers and tributaries of Van province is completely prohibited. In the Statement on the Regulation of Amateur Fisheries Hunting No. 5/2, Çatak Stream (80% of it), including Elmacı Stream starting from Taşliyazı Stream of Gürpınar district, is closed to fishing throughout the year. Although the whole of the stream is closed to commercial fishing and amateur fishing throughout the year, illegal fishing in the region continues extensively on the Tigris trout which shows that the measures are not applied. The continued illegal fishing in the region in the near future may cause the Tigris trout to disappear completely in the Çatak Stream. For this reason, the area declared as fishing prohibition should be expanded to cover the whole Çatak Stream, and the measures should be implemented strictly. In some studies, it has been observed that stream rehabilitation and road construction works have greatly changed the natural flow regime and habitat

structure of the river. Rivers are living ecosystems with flow regimes, basements and coastal structures. It is evident that the natural trout species that adapt to this structure will affect the natural trout species living in the high parts of the stream, such as trout negatively. Preventing interferences that disrupt the natural structures of The Tigris living in the Çatak Stream is of high importance for the continuity of the trout.

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