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Original Article

New Localities and Length-Weight Relationship for *Alburnus caeruleus* in the Euphrates and Tigris River Basins (Turkey)

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ABSTRACT

The aim of the present study was to contribute to the geographic distribution and length-weight relationship of *Alburnus caeruleus* Heckel, 1843 living in the Euphrates and Tigris River basins (Turkey). For this purpose, fish specimens were investigated from the collection preserved in the Istanbul University Science Faculty Hydrobiology Museum (IUSHM). The length–weight relationship was calculated using the equation: $W=aL^b$. Through sample examinations, *A. caeruleus* was identified from one new locality (Eğri Stream) in the Euphrates River basin and with this contribution, the distribution range of the fish has extended to the tributaries of the Atatürk Dam Lake in the north. The results also contributed to the literature with two new localities of *A. caeruleus* species in the Savur Stream and River Tigris, both in the Tigris River basin. The *b* values calculated for the Euphrates and Tigris populations were 3.243±0.139 (n=56) and 3.340±0.329 (n=30) respectively, which both indicated positive allometric growth. In addition, the *b* value was calculated for *A. caeruleus* from the Tigris River basin is the first finding. This study also reported a new maximum length (TL) for *A. caeruleus* (13.0 cm).

Keywords: Freshwater fish, biogeography, distribution area, *b* value, allometric growth

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INTRODUCTION

Turkey, lying at the nexus of three biodiversity hotspots (the Caucasus, Irano-Anatolian, and Mediterranean), has a high freshwater fish diversity (Myers, Mittermeier, Mittermeier, Gustavo da Fonseca, & Kent, 2000; Şekercioğlu et al., 2011) and hosts approximately a total of 368 freshwater fish species (Çiçek, Birecikligil, & Fricke, 2015). The genus *Alburnus* (Family: Leuciscidae) is one of the species-rich fish groups, which includes approximately 14% of all freshwater fish species existing in Turkey (Çiçek et al., 2015). Anatolia is the center of biodiversity and endemism of the genus *Alburnus*. However, the genus has long been accepted as complex with a number of subspecies and synonyms, which had very short descriptions and no type materials (Özuluğ & Freyhof, 2007a). Recently, in order to clarify the taxonomy of the genus, certain species have been reviewed and 26 species belonging to the genus *Alburnus* have been recognized as valid from the inland waters of Turkey (Bogutskaya, Küçük, & Ünlü, 2000; Freyhof & Kottelat, 2007a, 2007b; Özuluğ & Freyhof, 2007a, 2007b; Elp, Özuluğ, Şen, & Freyhof, 2013; Elp Şen, & Özuluğ 2015; Özuluğ, Geiger, & Freyhof, 2018; Freyhof & Turan, 2019; Freyhof, Kaya, Bayçelebi, Geiger, & Turan, 2019; Fricke, Eschmeyer, & Van der Laan, 2020).

The Euphrates and Tigris rivers, originating in Turkey, have important main drainage basins in the Southern Anatolia and the Middle East. They flow south-westward through Syria and Iraq and discharge into the Persian Gulf (El-Fadel, El Sayegh, Abou Ibrahim, Jamali, El-Fadl., 2002; Şekercioğlu et al., 2011). In total, six species be-

longing to the genus *Alburnus* (*A. caeruleus, A. heckeli, A. kurui, A. mossulensis, A. selcuklui,* and *A. sellal*) were reported from these two basins (Fricke, Bilecenoğlu, & Sarı, 2007; Elp et al., 2015; Fricke et al., 2020). The black spotted bleak, *Alburnus caeruleus* was originally described from Aleppo-Syria and was listed as Least Concern (LC) in the IUCN Red List because of its widespread occurrence (Turkey-in-Asia, Iraq, Iran, and Syria) and tolerance to many threats (Freyhof, 2014). For Turkish inland waters, Turan, Kaya, Ekmekçi & Doğan (2014) described a new species, *Alburnoides recepi* from the Merzimen Stream, a tributary of the Euphrates River. However, Birecikligil, Eagderi, Jouladeh-Roudbar & Çiçek (2017) examined the morphometric, meristic and molecular characters of the fish samples from the same locality and found a large overlap with those of *A. caeruleus,* hence they reported this species to be treated as synonym of *A. caeruleus*.

In Turkey, *A. caeruleus* is found in the Euphrates and Tigris River basins and the information on the distribution of the species has only been presented in a few studies. It was reported in the Tigris River basin along with the Eğil Dam Lake (Diyarbakır), Dicle University Pond (Diyarbakır), Stream Bitlis (Siirt), Ambar Stream (Diyarbakır) and Başur, Zarova and Bağlıca streams (Siirt) (Kaya, Turan, & Ünlü, 2016; Freyhof & Turan, 2019). In addition, the distribution areas of the species in the Euphrates River basin were listed as Balıklıgöl Lake (Şanlıurfa), Erikliyayla Spring (Kilis), Stream Çakal (Adıyaman) and Merzimen, Karasu and Nizip streams (Gaziantep) (Bekleyen & İpek, 2010; Birecikligil & Çiçek; 2010; Freyhof & Turan, 2019). The species was also reported in the Sinnep Stream (Kilis), which is one of the small headwater streams of the Qweik River that flows to northern Syria (Birecikligil et al., 2017). In Iran, *A. caeruleus* has a narrow distribution range (Mohammadian-kalat et al., 2015) and is known from a few localities in the Tigris River basin; Gamasiab and Doab rivers (Esmaeili, Gholamhosseini, Mohammadian-Kalat, & Aliabadian, 2018), Maroon River (Zareian, Esmaeili, Zamanian Nejad, & Vatandoust, 2015), and Chardaval River (Zareian, Esmaeili, Zamanian Nejad, & Vatandoust, 2015; Mousavi-Sabet et al., 2015).

Both freshwater habitats and freshwater fishes are now notably sensitive to several major threats such as habitat modification, fragmentation, destruction, overfishing, invasive species, pollution, and climate change (Reid, Contreras MacBeath, & Csatádi, 2013). Recently, there has been increasing concern for the conservation status of native fish, therefore, it is quite important to update and increase the knowledge of the geographic distribution of freshwater fishes (Baigun & Ferriz, 2003). The goals of this study were i) to report additional localities to the geographic distribution of *A. caueruleus* in the Euphrates and Tigris River basins, ii) to estimate the length-weight relationship of the species living in these two river basins.

Studies for the conservation of fish cannot be separated from a detailed examination of their bio-ecological characteristics and an estimation of the length-weight relationship of fish is one such useful biological parameter (Hossain, Rahman, Ahamed, Ahmed, & Ohtomi, 2013; Giannetto et al., 2015). The length-weight relationship data is needed by fishery biologists, managers, or conservationists to compare the life histories of fishes among different geographic locations (Hossein et al., 2011; Akhtar & Khan, 2018). Also, the length-weight relationship is helpful for converting fish lengths into biomass in field surveys. The measurement of a fish length is more easy and rapid compared with its weight; therefore it is considered to be more practical to estimate weight where only the length is known (Harrison, 2001; Froese, Tsikliras, & Stergiou, 2011). The information on the length-weight relationship of *A. caeruleus* was available only in three previous studies. In Turkey, Birecikligil & Çiçek, (2011) reported the length-weight relationship of this species, inhabiting a river in the Euphrates River basin. In the other two studies, Mousavi-Sabet, Khataminejad, & Vatandoust (2014) and Valikhani et al. (2020) presented the findings of this equation obtained from the different populations inhabiting the inland waters of Iran.

MATERIALS AND METHODS

Fish specimens were inspected from the samples preserved in the Istanbul University Science Faculty Hydrobiology Museum (IUSHM). Fish were collected by electro-fishing in June 2008 and September 2009. The fish samples were measured to the nearest 0.1 cm for total length (TL) using a digital calliper and weighed to the nearest 0.01 g for body weight (W) on an electronic balance. The length–weight relationship was calculated using the equation: $W=aL^b$, where W is the total weight (g), L is the total length (cm), *a* and *b* are regression parameters (Le Cren, 1951; Froese, 2006). The 95% confidence interval (CI) of parameter *b* was calculated to exhibit significant deviation from the isometric condition (*b*=3) (King, 2007). The map (Figure 1) was created using the QGIS v. 3.4 software available from http://qgis.org.

RESULTS AND DISCUSSION

An examination of the fish samples in the IUSHM collection, revealed *A. caeruleus* samples collected from ten different sites, both in the Euphrates and Tigris River basins (Figure 1 and Table 1). The fish was a new record for one site (Eğri Stream) in the Euphrates and two sites (Savur Stream and River Tigris (5 km west of Hasankeyf)) in the Tigris drainages (Figure 1, Table 1). With these new contributions, the distribution area of *A. caeruleus* in the Euphrates River basin has extended to the Eğri Stream, which is one of the tributaries of Atatürk Reservoir in the northeast. It is

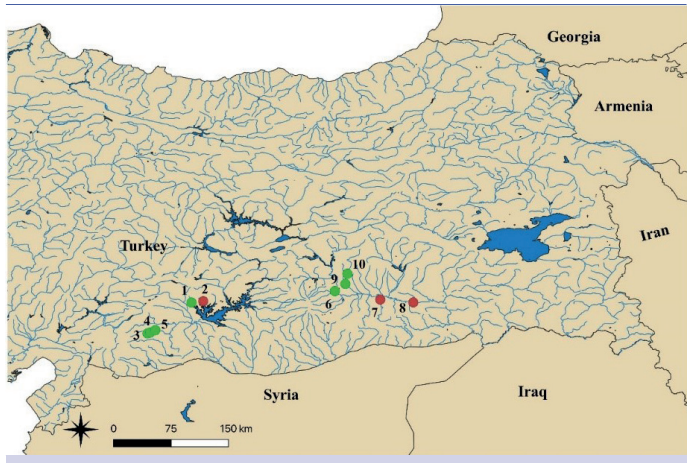

Figure 1. Distribution of *A. caeruleus* in the Euphrates and Tigris River basins in Turkey. Numbers refer to site numbers and red points mean new localities.

Table 1. The data of the sites, sampling dates, individual numbers (n), total lengths, body weights (W) and IUSHM collection codes of *A. caeruleus* in the Euphrates and Tigris River basins in Turkey.

Site No	Site	Coordinate	Province	Basin	Sampling date	n	TL (cm, min-max)	W (g, min-max)	IUSHM collection code
1	Stream Çakal (13 km west of Adıyaman, tributary to Atatürk Dam Lake)	37°43'19.9"N, 38°09'55.0"E	Adıyaman	Euphrates	20 June 2008	56	3.4-6.2	0.31-2.22	IUSHM 37800-351
2*	Stream Eğri (6 km southeast of Adıyaman, tributary to Atatürk Dam Lake)	37°44'30.0"N, 38°20'06.0"E	Adıyaman	Euphrates	20 June 2008	5	5.2-6.4	1.20-2.59	IUSHM 37800-349
3	Merziman Stream-1 (a tributary of the stream south of Yavuzeli)	37°16'36.0"N, 37°31'55.9"E	Gaziantep	Euphrates	27 Sept. 2009	2	5.2-5.7	1.00-1.10	IUSHM 2017-1290
4	Merziman Stream-2 (south of Yavuzeli)	37°17'31.9"N, 37°34'19.9E"	Gaziantep	Euphrates	27 Sept. 2009	10	5.1-11.2	0.90-12.71	IUSHM 2017-1291
5	Merziman Stream-3 (at Bağtepe)	37°19'28.9"N, 37°38'39.9"E	Gaziantep	Euphrates	28 Sept. 2009	5	4.1-13.0	0.42-15.57	IUSHM 2017-1292
6	River Tigris-1 (south of Diyarbakır at ten-eye-bridge)	37°53'12.9"N, 40°13'46.9"E	Diyarbakır	Tigris	19 June 2008	13	4.9-6.5	0.83-2.75	IUSHM 37800-341
7*	Savur Stream (between Bayındır and Ahmetli east of Tepe)	37°45'49.0"N, 40°53'02.0"E	Diyarbakır	Tigris	26 Sept. 2009	4	3.5-6.0	0.26-1.15	IUSHM 2017-1293
8	River Tigris-2 (5 km west of Hasankeyf)	37°43'25.0"N, 41°21'37.0"E	Batman	Tigris	25 Sept. 2009	17	4.3-6.8	0.52-2.03	IUSHM 2017-1294
9	Ambar Stream (at road to Silvan, 25 km east of Diyarbakır)	37°59'24.0"N, 40°22'55.9"E	Diyarbakır	Tigris	26 Sept. 2009	4	5.7-8.8	1.14-4.22	IUSHM 2017-1295
10	Ambar Stream (west of road from Diyarbakır to Bingöl about north of junction 15 km)	38°08'13.9"N, 40°24'46.0"E	Diyarbakır	Tigris	26 Sept. 2009	5	6.4-8.2	2.09-4.65	IUSHM 2017-1296

* indicates new distribution sites for the species.

assumed that *A. caeruleus* may have a wider distribution area, hence it is suggested that the Euphrates and Tigris River basins should be extensively studied in detail to determine the recent status of this species and other fishes inhabiting the region.

The total length and body weight of *A. caeruleus* in the present study varied between 3.4-13.0 cm and 0.31-15.57 g for the Euphrates population and 3.5-8.8 cm and 0.26-4.65 g for the Tigris population. Birecikligil and Çiçek (2011) reported that the total length and body weight distribution of this species inhabiting the Euphrates River basin were 3.8-7.1 cm and 0.25-2.85 g. Mousavi-Sabet et al. (2015) found the total length distribution of the species as 6.7-8.2 cm for the Chardaval River and 5.0-9.2 cm for the Gamasiab River in the Tigris River basin. Although the same fishing method (electro-fishing) was used in these three studies, the total length range in the present study was wider. However, the total length distribution presented in this study is similar to the data reported from the Tigris River drainages by Mousavi-Sabet et al (2015). The different habitat characteristics of the sampling sites (e.g. water depth, temperature, and flow rate) are considered to affect the size distribution of the fish. In addition, for *A. caeruleus*, a new maximum total length was found in the present study; the specimen of 13.0 cm examined from the Merziman Stream in the Euphrates River basin was longer than the previously reported as 9.2 cm TL in FishBase (Froese & Pauly, 2019).

The length-weight relationship of *A. caeruleus* living in two different river basins was calculated: i) Stream Çakal (Site-1) in the Euphrates River basin, ii) River Tigris (Site-6 and Site-8 in the main branch of the river). The sample size (n), length and weight distribution, parameters of the length-weight relationship (*a* and *b*) with 95% confidence intervals and correlation coefficients (r) values are summarized in Table 2. The values of *b* (3.243 and 3.340) estimated for two different *A. caeruleus* populations were within the expected range of 2.5 and 3.5 (Froese, 2006), therefore the results can be used as valid. In addition, the slopes of the

Table 2. Descriptive statistics and estimated parameters of length–weight relationships of *A. caeruleus* collected in Stream Çakal and River Tigris.

Species	n	a	b	95% CI of b	r	TL (cm, min–max)	W (g, min–max)
A. caeruleus (from Stream Çakal)	56	0.005	3.243	3.104-3.383	0.988	3.4-6.2	0.31-2.22
A. caeruleus (from River Tigris)	30	0.004	3.340	3.041-3.699	0.968	4.3-6.8	0.52-2.28

length-weight relationship of *A. caeruleus* indicated that two populations living in both the Euphrates and Tigris River basins had positive allometric growth (3.243±0.139 for Stream Çakal and 3.340±0.329 for River Tigris). The values of the correlation coefficient (r>0.95) for both populations indicated a strong positive relationship between length and weight (Table 2).

For the Euphrates population, Birecikligil & Çiçek (2011) calculated the length-weight relationship from 16 specimens with a narrow size range (3.8-7.1 cm) and reported positive allometric growth in the species (*b*=3.515; ±95% CI of *b*=3.099–3.930). This *b* value is in agreement with the one obtained from the present study. Whereas, for the Tigris population, Mousavi-Sabet et al. (2014) calculated this equation from 13 specimens with a very narrow size range (6.6-8.2 cm) and found an isometric growth (*b*=3.072; ±95% CI of *b*=2.417-3.908). Although the growth of a fish is species-specific, it can vary depending on factors such as size range (more small or large specimens) and environment in which they live (Bagenal & Tesch, 1978; Froese, 2006; Kachari, Abujam, & Das, 2017).

Valikhani et al. (2020) studied the length-weight relationship of *A. caeruleus* living in the shallow littoral waters of the Shadegan Wetland (Iran) and reported a negative allometric growth (*b*=2.84±0.15). Their fishing method is different from the studies above. They used a seine-net with 5 mm mesh size. In addition, they calculated the equation from 55 specimens with a narrow size range (3.2-8.5 cm). Compared to the present study in which positive allometric growth was calculated, this difference between the two populations is expected. Apart from size distribution, both the sampling method (electro-fishing vs. seine-net) and habitat differences (river vs. wetland) are considered as factors influencing the length-weight relationship in these two populations. Furthermore, for all populations compared, fish growth is affected by a number of other factors including sex, gonad maturity, season, degree of stomach fullness, and health (Bagenal & Tesch, 1978).

CONCLUSION

The results of the present study will contribute to the distribution range of *A. caeruleus* in the two river basins (Euphrates and Tigris) with new data. This study also provided the first data on the length-weight relationship of *A. caeruleus* population living in the Tigris River basin. The data presented in this study might constitute important background information for establishing further studies on this species.

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