Research Article

Pressure of Urbanisation on the Fish Community Structure in Küçük Menderes River Basin (Turkey)

Kentleşmenin Küçük Menderes Nehir Havzası (Türkiye) Balık Toplulukları Üzerindeki Baskısı

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Abstract

Urbanization is linked to changes in aquatic flora and fauna, including fishes, and it often leads to a decline in fish diversity, richness, and density. This study aims to determine the fish fauna and their abundance in Küçük Menderes River Basin, which is under the threat of urbanization. The field surveys were carried out in 50 different locations in lotic and lentic biotopes, and fish sampling was performed by using electro-shocker, seine-net, and gillnets in November 2017 and May 2018. A total of 21 taxa belonging to 14 families (Anguillidae, Acheilognathidae, Atherinidae, Blenniidae, Cobitidae, Cyprinidae, Gobiidae, Leuciscidae, Mugilidae, Nemacheilidae, Percidae, Poecilidae, Siluridae and Syngnathidae) was identified. Cyprinidae has the highest species richness with four taxa and the most commonly found fish species were *Squalius kosswigi* and *Cyprinus carpio*. In terms of abundance of species, *Gambusia holbrooki* was the most dominant fish species in Hırsız (the catch per unit effort = 23.28 n/min/m^2) and Kuskudan (the catch per unit effort = 24.00 n/min/m^2) streams. While *Alburnus demiri*, *Barbus pergamonensis*, *Cobitis fahireae*, *Oxynoemacheilus germencicus*, *Petroleuciscus smyrnaeus* and *S. kosswigi* are Anatolian endemics, *Atherina boyeri*, *Carassius auratus*, *C. gibelio* and *Gambusia holbrooki* are the invasive fish species in the basin.

Keywords: *Water pollution, invasive fish, drought, endemic, irrigation*

Öz

Kentleşme, balıkları da kapsayan sucul fauna ve floradaki değişimlerle bağlantılı olup sıklıkla balık çeşitliliği, zenginliği ve yoğunluğunda azalmaya yol açmaktadır. Bu çalışmanın amacı, şehirleşme tehdidi altındaki Küçük Menderes Nehir Havzası'nın balık faunası ile bunların bolluklarını belirlemektir. Saha çalışmaları, durgun ve akışlı biyotoplardaki 50 farklı istasyonda sürdürülmüş ve balık örneklemesi elektroşoker, ığrıp ve galsama ağları kullanılarak Kasım 2017 ve Mayıs 2018

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tarihlerinde gerçekleştirilmiştir. 14 familyaya (Anguillidae, Acheilognathidae, Atherinidae, Blenniidae, Cobitidae, Cyprinidae, Gobiidae, Leuciscidae, Mugilidae, Nemacheilidae, Percidae, Poecilidae, Siluridae ve Syngnathidae) ait toplam 21 takson tanımlanmıştır. Cyprinidae dört takson ile en yüksek tür çeşitliliğine sahiptir ve *Squalius kosswigi* ve *Cyprinus carpio* en yaygın balık türleri olarak tespit edilmiştir. Türler bollukları açısından değerlendirildiğinde, *Gambusia holbrooki* Hırsız (birim çaba başına düşen av miktarı = 23.28 adet/dk/m^2) ve Kuskudan (birim çaba başına düşen av miktarı = 24.00 adet/dk/m^2) derelerindeki en baskın balık türüdür. *Alburnus demiri, Barbus pergamonensis, Cobitis fahireae, Oxynoemacheilus germencicus, Petroleuciscus smyrnaeus* ve *S. kosswigi* havzadaki Anadolu endemikleri iken *Atherina boyeri, Carassius auratus, C. gibelio* ve *Gambusia holbrooki* istilacı balık türleridir.

Anahtar kelimeler: *Su kirliliği, istilacı balıklar, kuraklık, endemik, sulama*

Introduction

River basins have an essential role in the biosphere as a conduit for water and are used by humans for transportation, fisheries, hydropower, and domestic, industrial, and agricultural water supplies (Pompeu & Alves, 2005). Urbanization is a process of the increasing number of people in an area and it leads to a horizontal or vertical growth of urban areas (Hassan Rashid et al., 2018). Both increased human population and growth in urban areas increase the pressure, such as pollution and rising water requirement for domestic use, on water resources. Therefore, urbanization is one of the major threats affecting the river basins (Shukla et al., 2013), and it is linked to changes in aquatic fauna, including fishes and it often leads to declines in fish diversity, richness, and density.

Küçük Menderes River, located in the centre of the west coastline of the Anatolia, flows through the province of İzmir. Today, İzmir is one of the biggest metropolitans of Turkey and it has been an important settlement area of the Western Anatolia since the ancient ages. According to "the level of urbanisation" that means the proportion of the population living in urban areas to the country's total population, İzmir is the third largest city of Turkey. The urbanization level of the city has increased rapidly by immigration with the urbanization models originating from trade, industry, tourism and agriculture. The boundaries of the urban areas have been expanded, especially with the administration of "metropolitan" status in 1984 and the urban population of Izmir, which was 818,251 in 1980, reached 1,489,772 in 1985 and 4,367,251 today (Işık, 2005; Turkey Statistical Institute [TURKSTAT], 2020). Due to the rapidly increasing population and urbanization, many aquatic and terrestrial ecosystems in the region are under threat (Kurucu & Chiristina, 2008; Sökmen Yılmaz & Yılmaz, 2019)

Küçük Menderes River receives its waters from the small streams in Kiraz lowland and it flows into the Aegean Sea in the west of Selçuk. There are three

natural lakes (Belevi, Çatal and Gebekirse) and also some dam lakes built to supply drinking and irrigation water in the river basin. Küçük Menderes River has formed saline wetlands before reaching into the Aegean Sea and these wetlands were entitled as Selçuk Bird Paradise. In 1991 it was announced as 1st and 2nd Degree natural protected area by the Ministry of Culture and Tourism and in 1994 as wildlife protection area by the Ministry of Agriculture and Forestry (Sütgibi, 2009).

Nowadays, Küçük Menderes River is under the pressure of urbanization due to its fertile agricultural lands and high industrial and tourism potential. However, the lack of infrastructure (sewage, treatment plants, etc.) and rapid population growth in the basin cause water pollution/lose and damage water balance (Yıldız et al., 2009). Many of the streams have been turned to reservoirs to provide water for domestic, agriculture and industrial purposes for the metropolitan İzmir.

A limited number of studies were conducted about the distributions of the fishes in the streams and lakes of the river basin in the past (Karaman, 1972; Balık, 1979; Balık et al., 1995; Sarsu, 1981; İlhan et al., 2009). Karaman (1972) has described *Squalius kosswigii* as a new species from the Gümüldür Stream, which was located in the Tahtalı Dam sub-basin before the construction of the dam. In the study on taxonomy and ecological characteristics of freshwater fishes in Western Anatolia, Balık (1979) has reported that eight fish species, *Salaria fluviatilis* (Asso y del Rio, 1801), *Oxynoemacheilus germencicus* (Erk'akan, Nalbant & Özeren, 2007), *Alburnus demiri* Özuluğ & Freyhof, 2008, *Chondrostoma holmwoodii* (Boulenger, 1896), *Rhodeus amarus* (Bloch, 1782), *Alburnoides bipunctatus* (Bloch, 1782) and *S. kosswigii* have been living in Gümüldür, Şaşal and Bulgurca streams. According to Sarsu (1981), freshwater fish species living in Gümüldür Stream and its associated sources have been reported as *Anguilla anguilla* (Linnaeus, 1758), *Barbus pergamonensis* Karaman, 1971, *Cyprinus carpio* Linnaeus, 1758, *Cobitis fahireae* Erk'akan, Atalay-Ekmekçi & Nalbant, 1998, *Mugil cephalus* Linnaeus, 1758, *Chelon aurata* (Risso, 1810), *A. demiri*, *C. holmwoodii*, *R. amarus*, *A. bipunctatus*, *S. kosswigi*, *O. germencicus* and *S. fluviatilis*. As a faunistic study, Balık et al. (1995) have contributed to the fish fauna of the Tahtalı Dam basin with three new species, *Petroleuciscus smyrnaeus* (Boulenger, 1896), *Gambusia holbrooki* Girard, 1859 and *Chelon ramada* (Risso, 1827). After the construction of the Tahtalı Dam, İlhan et al. (2009) have studied some biological characteristics of *Perca fluviatilis* Linnaeus, 1758, which was introduced for stocking purposes to the dam. In the study about the length-weight relationships for freshwater fish species living in Küçük Menderes River Basin, Korkmaz et al. (2015) have reported the presence of *Carassius gibelio* (Bloch, 1782) and *Carassius carassius* (Linnaeus, 1758).

These studies listed above have shown that there was no comprehensive study for the whole basin and only the fish species lists or some biological characteristics of these fishes in some locations of the basin were given and the abundance values of these fish species were not studied. The conservation and sustainability of biological diversity could be ensured by monitoring diversity using scientific methods. Therefore, it is very important to repeat the inventory and monitoring studies of fish fauna in the inland waters with time intervals (Özuluğ & Saç, 2019). However, the presenting of abundance values of the existing fish species would be highly useful to reveal time-dependent changes for future studies. The main objective of this study is to determine the recent fish fauna living in Küçük Menderes River Basin. Additionally, by calculating the abundance values of these fish, it is likely to evaluate the pressures of urbanization.

Method

The field surveys were conducted in a total of 50 sampling sites (42 streams, 1 transitional water, 2 natural lakes and 5 dam lakes) in Küçük Menderes River Basin in November 2017 and May 2018 (Figure 1, Table 1).

Figure 1

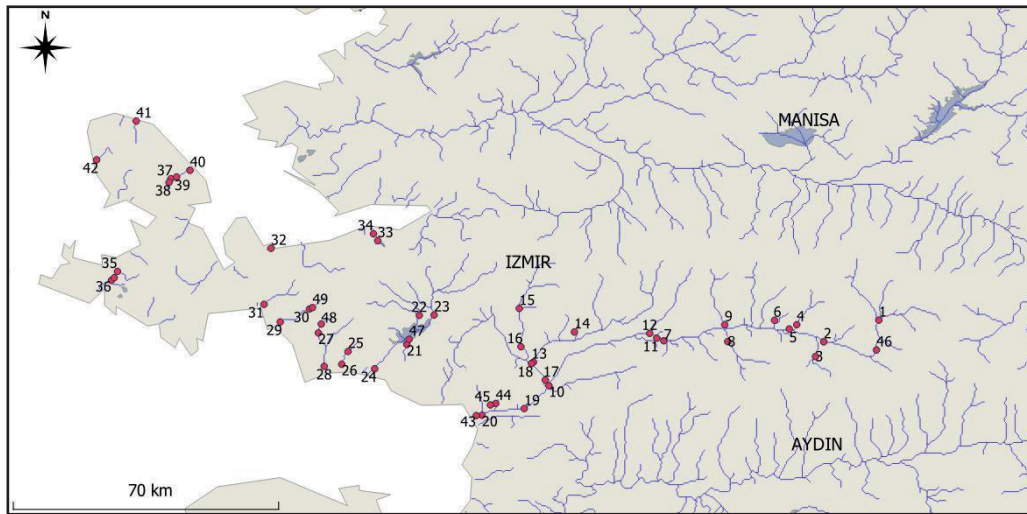*Sampling Sites in Küçük Menderes River Basin*

Table 1

Sampling Sites in Küçük Menderes River Basin with Coordinates

St. No	St. Name	Coordinates	Locality
1*	Keleş Creek	38.188261°N, 28.225178°E	Kiraz, İzmir
2*	Taşavra Creek	38.136694°N, 28.094658°E	Beydağ, İzmir
3*	Pirinççi Creek	38.102115°N, 28.074048°E	Ödemiş, İzmir
4**	Gelinbözü Stream	38.177378°N, 28.030595°E	Ödemiş, İzmir
5**	Küçük Menderes River-1	38.165631°N, 28.013342°E	Ödemiş, İzmir
6**	Zeytinlik Creek	38.187889°N, 27.978032°E	Ödemiş, İzmir
7***	Rahmanlar Stream	38.140291°N, 27.715971°E	Tire, İzmir
8	Eğridere Stream	38.137058°N, 27.866841°E	Tire, İzmir
9*	Aktaş Creek	38.177333°N, 27.859872°E	Ödemiş, İzmir
10*	Küçük Menderes River-2	38.032566°N, 27.443286°E	Torbalı, İzmir
11***	Küçük Menderes River-3	38.145197°N, 27.698732°E	Tire, İzmir
12**	Falaka Creek	38.156692°N, 27.682031°E	Bayındır, İzmir
13**	Ilıca Stream	38.088649°N, 27.406979°E	Torbalı, İzmir
14**	Uladı Creek	38.160030°N, 27.503622°E	Bayındır, İzmir
15*	Fetrek Creek-1	38.215895°N, 27.373613°E	Torbalı, İzmir
16***	Fetrek Creek-2	38.124985°N, 27.378049°E	Torbalı, İzmir
17***	Çevlik Creek-1	38.045394°N, 27.435825°E	Torbalı, İzmir
18***	Çevlik Creek-2	38.085461°N, 27.402874°E	Torbalı, İzmir
19***	Küçük Menderes River-4	37.978428°N, 27.384794°E	Selçuk, İzmir
20***	Küçük Menderes River-5	37.963007°N, 27.283960°E	Selçuk, İzmir
21*	Değirmendere Stream	38.130352°N, 27.106610°E	Menderes, İzmir
22	Şaşal Stream	38.199433°N, 27.136033°E	Menderes, İzmir
23	Tahtalı Creek	38.200436°N, 27.171187°E	Menderes, İzmir
24**	Koca Creek	38.072829°N, 27.030365°E	Menderes, İzmir
25*	Ürkmez Stream-1	38.114544°N, 26.966368°E	Seferihisar, İzmir
26**	Ürkmez Stream-2	38.083291°N, 26.952555°E	Seferihisar, İzmir
27**	Karakoç Stream-1	38.157961°N, 26.898151°E	Seferihisar, İzmir
28	Karakoç Stream-2	38.083766°N, 26.909176°E	Seferihisar, İzmir
29**	Yassıdere Stream-1	38.184390°N, 26.806520°E	Seferihisar, İzmir
30**	Yassıdere Stream-2	38.214620°N, 26.875686°E	Seferihisar, İzmir
31	Azmak Stream	38.225769°N, 26.767904°E	Seferihisar, İzmir
32**	Akpınar Stream	38.357671°N, 26.784006°E	Urla, İzmir
33*	Kona Stream-1	38.384826°N, 27.033001°E	Balçova, İzmir
34**	Kona Stream- 2	38.392633°N, 27.028781°E	Balçova, İzmir
35**	İncirli Stream	38.303509°N, 26.420841°E	Çeşme, İzmir
36	Hırsız Stream	38.282206°N, 26.404382°E	Çeşme, İzmir
37**	Kısık Stream	38.523252°N, 26.547126°E	Karaburun, İzmir
38**	Kışla Stream	38.514904°N, 26.542971°E	Karaburun, İzmir
39*	Kuskudan Stream-1	38.528542°N, 26.561015°E	Karaburun, İzmir
40**	Kuskudan Stream-2	38.543320°N, 26.592170°E	Karaburun, İzmir
41**	Uzun Stream	38.660341°N, 26.465133°E	Karaburun, İzmir
42**	Sudeğirmeni Stream	38.568424°N, 26.371368°E	Karaburun, İzmir
43	Transitional water	37.959942°N, 27.264050°E	Selçuk, İzmir
44	Çatal Lake	37.990383°N, 27.317102°E	Selçuk, İzmir
45	Gebekirse Lake	37.986933°N, 27.304530°E	Selçuk, İzmir
46	Beydağ Dam Lake	38.117427°N, 28.219555°E	Beydağ, İzmir
47	Tahtalı Dam Lake	38.142752°N, 27.111891°E	Menderes, İzmir
48	Kavakdere Dam Lake	38.178899°N, 26.903701°E	Seferihisar, İzmir
49	Seferihisar Dam Lake	38.217997°N, 26.882979°E	Seferihisar, İzmir
50	Alaçatı Dam Lake	38.288922°N, 26.413136°E	Çeşme, İzmir

* means the riverbed was dry in autumn 2017; ** means the riverbed was dry in both seasons; *** means fish was not captured due to water pollution.

In streams, fish samples were collected by electro-shocker (SAMUS 725-G portable electro-shockers; frequency 50-55 Hz; 20-60 cm fishing depth) from the stations and sampling was conducted opposite direction of the water flow (European Committee for Standardization [CEN], 2003). In transitional waters, seine nets (5 mm mesh size, 30 m in length and 2 m in width) were used (CEN, 2006).

In lakes, fish samples were captured using benthic and pelagic multi-mesh gillnets. Benthic gillnets (30 m in length and 1.5 m in width) have 12 different mesh sizes from 5 mm to 55 mm. Pelagic gillnets (27.5 m in length and 6.0 m in width) have 11 different mesh sizes from 6.25 mm to 55 mm (CEN, 2015). Additionally, in shorelines of lakes, a scoop-net (2 mm mesh sized) was used to capture small fishes.

Collected specimens were sacrificed with a lethal solution of anaesthesia (clove oil) and then transferred to a 5% formaldehyde solution. In the laboratory, for each individual, standard length (SL) was measured to the nearest 0.1 cm, and total body weight (W) was weighed on a digital balance with a 0.01 g accuracy.

To determine the fish abundance, the catch per unit effort (CPUE) was calculated using the following equation; CPUE = (n/t/a) × 100 (n: specimen numbers, t: time (minute (min) for streams and hour (h) for lakes, a: sampling area) (Jordan & Willis, 2001; Mehner et al., 2005). In streams, the sampling area means the area sampled by electro-shocker and the fish samples were captured from a maximum 200 m length of sampling sections in a maximum of 20 minutes. In lakes, the sampling area means the gillnet area used for the fish catch and the maximum length of time the nets stayed in the lake was limited to 12-16 hours. For the fish species caught with seine-net and scoop-net, CPUE was not estimated.

Results

Fish were captured in 38% (19 stations) of the 50 stations, however, there were no fish in other stations due to pollution (7 stations) and drought (24 stations). A total of 21 fish species belonging to 14 families were determined in the river basin (Table 2). Cyprinidae has the highest species richness with four taxa and the most commonly found fish species were *Squalius kosswigi* (8 stations) and *Cyprinus carpio* (7 stations).

In terms of abundance of fish species, CPUE $(n/t/m^2)$ values ranged from 0.01 to 24.00 in stream stations and *G. holbrooki* was the most dominant fish species in the Hırsız (CPUE = 23.28 $n/min/m^2$) and Kuskudan (CPUE = 24.00 $n/min/m^2$) streams. In lakes, CPUE $(n/h/m^2)$ values ranged from 0.01 to 62.43 and *P. fluviatilis*

was the most dominant fish species in Beydağ Dam Lake (CPUE = 62.43 n/h/m^2). Fish species with a CPUE (n/min/m^2 and n/h/m^2) value of 1 and above are determined as *R. amarus, C. carpio, A. demiri, P. smyrnaeus, S. kosswigi, Chelon* sp., *O. germencicus, P. fluviatilis* and *G. holbrooki*. While *A. demiri, B. pergamonensis, C. fahireae, O. germencicus, P. smyrnaeus* and *S. kosswigi* are Anatolian endemics, *A. boyeri* (Kavakdere Dam Lake)*, C. auratus, C. gibelio* and *G. holbrooki* are the invasive fish species in the basin (Table 3).

Table 2

Fish Species Captured from Küçük Menderes River Basin and the Distribution of These Fishes by Sites

Fish species	Stations
Familia: Acheilognathidae	
Rhodeus amarus (Bloch, 1782)	22
Familia: Anguillidae	
Anguilla anguilla (Linnaeus, 1758)	44
Familia: Atherinidae	
Atherina boyeri Risso 1810	45, 48
Familia: Blenniidae	
Salaria fluviatilis (Asso, 1801)	21
Familia: Cobitidae	
Cobitis fahireae Erk'akan, Atalay-Ekmekçi & Nalbant 1998	23, 44
Familia: Cyprinidae	
Barbus pergamonensis Karaman 1971	15, 22
Carassius auratus (Linnaeus, 1758)	50
Carassius gibelio (Bloch, 1782)	15, 23, 44, 46, 47, 50
Cyprinus carpio Linnaeus, 1758	44, 45, 46, 47, 48, 49, 50
Familia: Gobiidae	
Knipowitschia caucasica (Berg, 1916)	45, 48
Familia: Leuciscidae	
Alburnus demiri Özuluğ & Freyhof, 2008	22, 23, 45
Petroleuciscus smyrnaeus (Boulenger, 1896)	8, 21, 23, 44, 45, 46
Squalius kosswigi (Karaman, 1972)	15, 22, 23, 25, 28, 31, 33, 48
Familia: Mugilidae	
Chelon aurata (Risso, 1810)	45
Chelon ramada (Risso, 1827)	45, 43
Chelon sp.	28, 31
Familia: Nemacheilidae	
Oxynoemacheilus germencicus (Erk'akan, Nalbant & Özeren, 2007)	15, 22, 23
Familia: Percidae	
Perca fluviatilis Linnaeus, 1758	46, 47, 49
Familia: Poecilidae	
Gambusia holbrooki Girard, 1859	36, 39, 44, 45, 48, 50
Familia: Siluridae	
Silurus glanis Linnaeus, 1758	47
Familia: Syngnathidae	
Syngnathus abaster Risso, 1827	45

Table 3

The Individual Numbers, Body Size and Weight Distributions and Sampling Sites of Fish Species Captured in Küçük Menderes River Basin

Fish species	St. No	n	TL (cm) min – max	W (g) min – max	CPUE (n/min/m²; n/h/m²)
Rhodeus amarus	22[S, 1]	29	2.6 – 5.3	0.17 – 2.49	1.66
Anguilla anguilla	44[A]	2	43.9 – 50.5	148.24 – 191.03	*
Atherina boyeri	45[A, 2]	1	6.4	1.60	0.03
	48[A, 2]	1	7.8	3.08	0.02
Salaria fluviatilis	21[S, 1]	20	3.4 – 6.7	0.40 – 3.50	0.76
Cobitis fahireae	23[A, 1]	1	5.3	0.92	0.03
	23[S, 1]	7	5.1 – 6.8	0.94 – 2.47	0.06
	44[A]	1	5.3	0.84	*
Barbus pergamonensis	15[S, 1]	1	6.3	3.62	0.05
	22[S, 1]	3	6.9 – 9.5	4.36 – 12.26	0.17
Carassius auratus	50[A, 2]	4	8.9 – 14.5	12.07 – 45.56	0.17
Carassius gibelio	15[S, 1]	6	3.1 – 4.8	0.57 – 2.14	0.30
	23[S, 1]	1	31.7	743.49	0.01
	44[A, 2]	19	13.0 – 20.3	39.41 – 144.52	0.32
	44[S, 2]	22	16.7 – 23.7	65.46 – 242.11	0.64
	46[A, 2]	12	15.5 – 19.8	70.72 – 153.05	0.31
	46[S, 2]	6	17.8 – 32.0	86.34 – 561.33	0.10
	47[A, 2]	21	12.2 – 30.4	27.18 – 631.71	0.44
	47[S, 2]	15	20.0 – 33.3	174.4 – 796.43	0.20
	50[A, 2]	4	8.9 – 15.9	9.27 – 47.79	0.17
Cyprinus carpio	44[S, 2]	1	24.5	200.65	0.03
	45[A, 2]	1	33.0	532.15	0.47
	46[A, 2]	8	13.8 – 18.2	39.74 – 87.84	0.21
	47[A, 2]	1	22.6	160.08	0.02
	48[A, 2]	3	23.1 – 24.3	234.29 – 255.38	0.05
	48[S, 2]	1	27.7	386.22	0.02
	49[S, 2]	10	22.5 – 34.1	156.36 – 734.19	0.14
	50[A, 2]	209	7.0 – 21.8	5.17 – 136.83	8.93
	50[S, 2]	22	9.7 – 22.6	13.51 – 169.44	0.72
Knipowitschia caucasica	45[A]	1	2.3	0.1	*
	45[S]	14	1.6 – 3.0	0.04 – 0.26	*
	48[A]	1	3.2	0.35	*
	48[S]	1	2.7	0.20	*
Alburnus demiri	22[A, 1]	1	6.7	4.40	0.04
	22[S, 1]	20	5.9 – 8.5	1.79 – 6.29	1.14
	23[A, 1]	4	3.6 – 5.4	0.32 – 0.95	0.11
	45[A, 2]	4	14.8 – 15.8	29.36 – 36.35	0.12
Petroleuciscus smyrnaeus	8[S, 1]	29	1.8 – 8.5	0.06 – 8.50	0.52
	21[S, 1]	69	2.9 – 8.2	0.25 – 8.18	2.63
	23[A, 1]	1	6.1	3.43	0.03
	23[S, 1]	1	7.4	8.13	0.01
	44[A, 2]	50	9.1 – 12.0	10.14 – 23.10	0.85
	44[S, 2]	9	9.0 – 10.4	9.66 – 15.40	0.26

[A]: Autumn; [S]: Spring; [1]:Electro-shocker; [2]: Gillnet; [3]: Beach seine-net; *Scoop net; **Seine-net

Table 3

(Continued)

Fish species	St. No	n	TL (cm) min – max	W (g) min – max	CPUE (n/min/m^2; n/h/m^2)
P. smyrnaeus (continued)	45[A, 2]	16	8.5 – 11.3	8.93 – 44.81	0.03
	46[A, 2]	2	9.3 – 10.4	11.65 – 15.81	0.05
Squalius kosswigi	15[S, 1]	4	2.4 – 3.7	0.15 – 0.59	0.20
	22[A, 1]	1	6.6	2.97	0.04
	22[S, 1]	37	3.2 – 11.8	0.22 – 23.05	2.11
	23[A, 1]	6	3.5 – 6.3	0.47 – 2.92	0.17
	23[S, 1]	25	1.8 – 13.8	0.05 – 36.06	0.22
	25[S, 1]	11	2.2 – 14.1	0.07 – 36.57	0.11
	28[S, 1]	4	2.4 – 2.9	0.12 – 0.27	0.04
	31[S, 1]	40	4.2 – 13.8	0.73 – 35.68	5.13
	33[S, 1]	60	4.3 – 15.3	0.84 – 52.52	3.00
	48[A, 2]	94	10.1 – 23.9	11.69 – 183.65	1.65
	48[S, 2]	17	11.6 – 17.5	16.60 – 58.12	0.33
Chelon aurata	45[A, 2]	21	15.5 – 36.0	25.15 – 356.63	0.61
	45[S, 2]	1	20.0	56.98	0.02
Chelon ramada	43[A, 3]	4	9.8 – 12.9	8.5 – 16.12	**
	43[S, 3]	2	13.2 – 24.5	13.60 – 135.11	**
	45[A, 2]	1	35.0	374.22	0.03
Chelon sp.	28[A, 1]	20	2.4 – 3.1	0.12 – 0.33	0.48
	28[S, 1]	1	2.7	0.20	0.01
	31[S, 1]	17	2.3 – 4.8	0.10 – 1.07	2.18
Oxynoemacheilus germencicus	15[S, 1]	58	2.2 – 4.1	0.08 – 0.79	2.90
	22[S, 1]	34	2.6 – 4.2	0.13 – 0.75	1.94
	23[A, 1]	12	4.7 – 6.2	0.89 – 2.31	0.33
	23[S, 1]	1	6.5	2.50	0.01
Perca fluviatilis	46[A, 2]	32	6.2 – 25.0	2.78 – 275.86	0.82
	46[S, 2]	3933	1.1 – 29.8	9.02 – 492.84	62.43
	47[A, 2]	81	13.0 – 29.2	27.22 – 375.65	169.00
	47[S, 2]	115	14.2 – 30.4	33.00 – 443.69	1.52
	49[A, 2]	2	24.2 – 26.7	193.34 – 290.76	0.05
	49[S, 2]	44	15.4 – 36.1	50.78 – 864.80	0.62
Gambusia holbrooki	36[A, 1]	149	1.2 – 3.9	0.03 – 0.48	23.28
	36[S, 1]	60	1.4 – 4.3	0.01 – 0.94	10.00
	39[S, 1]	24	2.5 – 4.8	0.15 – 1.32	24.00
	44[A]	30	1.4 – 2.8	0.03 – 0.19	*
	44[S]	21	1.6 – 3.0	0.05 – 0.29	*
	45[S]	20	1.7 – 4.8	0.04 – 0.63	*
	48[A]	24	1.8 – 3.6	0.06 – 0.48	*
	50[A]	1	1.6	0.04	*
Silurus glanis	47[A, 2]	1	26.8	105.88	0.02
Syngnathus abaster	45[S]	3	6.0 – 7.2	0.10 – 0.19	*

[A]: Autumn; [S]: Spring; [1]:Electro-shocker; [2]: Gillnet; [3]: Beach seine-net; *Scoop net; **Seine-net

Discussion and Conclusion

As a result of the observations made in the field, remarkable four problems are determined: (1) dryness due to atmospheric conditions and/or overuse of water in domestic/industrial sector/agricultural irrigation, (2) water pollution, (3) the presence of invasive-alien or translocated fish and (4) deterioration of river continuity (horizontally and vertically) due to hydraulic structures such as dams, flood protection structures and culverts. Many of these problems affecting Küçük Menderes River basin are thought to be the consequences of the pressures of the increasing urbanization level. We observed that while drought is the main problem for some stations, two or more problems mentioned above are effective together in the others.

In river ecosystems, fish could not be caught in total 31 stations in both sampling periods, and also19 of them were dry in both seasons. Even though 5 of them were wet in one sampling period, no fish were detected. On the other hand, habitat losses as a result of pollution and/or hydraulic structures affected 7 stations negatively (St. 7, 11, 16, 17, 18, 19, and 20) (Table 1). Fish only sampled from 11 stations; six of them were sampled in both seasons (St. 8, 22, 23, 28, 31, and 36) and five stations (St. 15, 21, 25, 33, and 39) were dry in autumn 2017, but there were water and fish in spring 2018. Since the river basin is located in the Mediterranean climate zone, the drought is expected in the riverbed in the summer period with decreasing rainfall. However, the high number of dry stations in the streams throughout the year is remarkable. This situation is not only a result of the meteorological situation but also the dams built for domestic uses or irrigation purposes. It is recommended to release the water to the riverbeds from the dams to keep the ecological processes to continue healthily.

There is a water pollution problem throughout Küçük Menderes River Basin, from the headwater to the Pamucak coast where it flows into the sea. According to field observations, the problem becomes more distinct especially in the settlement areas along the main river branch. The most prominent example of water pollution was observed in two stations located on Fetrek Creek. The first station located before the settlement area (St. 15) was dry, however, the second station was wet with domestic or industrial wastewater flow along the riverbed after the settlement area (St. 16). In order to protect the whole ecosystem, it is necessary to prevent domestic and industrial wastewater discharged to the environment without suitable treatment.

As a result of the fishing done in Küçük Menderes River Basin, 21 fish species were detected (Table 2) and three of them, *G. holbrooki*, *C. gibelio* and *C.*

auratus are invasive-alien fish for the freshwater fish fauna of Turkey (İnnal & Erk'akan, 2006; Tarkan et al., 2015). *Gambusia holbrooki* was captured from six stations (Table 2), one of them is the Hırsız Stream, which is the outlet water of the Alaçatı Dam Lake, with high catch efficiency and the other is Kuskudan Stream-1 station, which is the outlet water of Mordoğan Pond (Table 3). In these two stations, the streams are very shallow and have a very weak flow, which is almost stagnant. Although *G. holbrooki* has a wide habitat tolerance, it prefers to be in stagnant or slow-flowing waters compared to fast-flowing waters (García-Berthou, 1999; Pyke, 2005). Since there is no other fish to compete, *G. holbrooki*, an opportunistic species, is considered to have high catch efficiency at these two stations. The other four stations, where this invasive fish was determined, are the shores of the lentic water bodies (Table 2). They were obtained by using a scoop-net. The catch efficiency at these stations could not be evaluated as no specimen was caught with the standard fishing nets used in the lakes. The other two invasive-alien fish, *C. gibelio* and *C. auratus*, have entered into Turkish inland waters in the early 1980s and their first records were given from the Gala Lake in Evros River Basin (Baran & Ongan, 1988). Over time, they were introduced to other water basins in Turkey by stocking purposes. *C. auratus* was detected only from Alaçatı Dam Lake and *C. gibelio* was detected from one stream station (St. 15, Fetrek Creek) and four lentic water bodies (Table 2). It is quite important to control these three invasive species in the basin and to determine their interactions with native species which many of them are endemic fish species.

Four species, *A. boyeri*, *S. glanis*, *P. fluviatilis*, and *C. carpio,* which are native members of the freshwater fish fauna of Turkey, are translocated fish for the basin. The most important factor in their voluntary/accidental translocation is fish stocking. They can easily become dominant fish with the absence of natural predators in the inland water environment. They enter or/with their biological features such as reproduction and feeding. These translocated species, which are mostly preferred for economic reasons, may threat to biodiversity (McKinney, 2001; De Silva et al., 2009). It should be preferred to give priority to native fish species while stocking fish in river basins. Also, maximum attention should be shown not to move the unwanted species to the new environment together with the species preferred in fisheries. When an alien fish species enters a new environment, it will be both very difficult and quite expensive to remove it from there.

There are some hydraulic structures such as dams, culverts, flood protection structures, weirs and bridges in Küçük Menderes River Basin that destroy the stability of the river both horizontally and vertically. Besides, the other threats such as to take the natural riverbed in a channel, the destruction of the meanders or riparian

areas, the fortification of the river banks with concrete or rocks are also remarkable for the basin. All these interventions affect the biodiversity of both the river and the terrestrial area where it interacts. Excluding the five dam lakes, one or more of the hydraulic structures listed above are present in almost all stations. Evaluating the native fish species of Küçük Menderes River basin, different fish species may show different habitat preferences from upstream to downstream; some (*A. demiri, B. pergamonensis*) prefer fast-flowing regions, while others (*R. amarus, P. smyrnaeus*) prefer slow-flowing regions with abundant vegetation; some species (*C. fahireae*) prefer sandy-muddy ground while others (*O. germencicus, R. amarus*) prefer stony sediment. However, structures in the habitat of these fish are very important threat to the survival of them. *Barbus pergamonensis, O. germencicus, P. smyrnaeus* and *S. kosswigi* are the endemic fishes living in these streams and further intervention in the riverbed may threaten the existence of these fishes in the future. Especially, in the upstream direction of the Fetrek Creek, there are deep oxbow lakes formed by the closure of the meanders and these small oxbow lakes are thought to have been used as shelters for these endemic fishes as well as other aquatic organisms during arid periods. Therefore, these deep oxbow lakes should be protected, intervention to their natural structure should be avoided and its water should not be used for irrigation. To ensure the stability of the river basin, the coordinates, types and features of all hydraulic structures should be documented and the unnecessary structures should be demolished and environmentally friendly solutions such as fish passages should be developed.

As a result of urbanization, Tahtalı, Beydağ, Kavakdere, Seferihisar, and Alaçatı dams were built for both domestic use and irrigation purposes to meet the needs of the growing population. Although these dams have already pressure on the habitat use of the native fish fauna, the introduced/translocated fishes are also important threats in the dams and the streams of the sub-basins. The Tahtalı Dam, built on the Gümüldür Stream in the 1990s, is the most important drinking water body in Izmir city and the streams and their environments in the dam sub-basin are protected by the local authorities. Despite, this sub-basin is rich in endemic species (*A. demiri, B. pergamonensis, C. fahireae, O. germencicus, P. smyrnaeus* and *S. kosswigi*), it is also under threat of invasive (*C. gibelio*) and translocated (*C. carpio* and *P. fluviatilis*) fish species. In the Şaşal and Tahtalı creeks, the main sources of the Tahtalı Dam, all the fish species are Anatolian endemics except *C. gibelio* (in the Şaşal Creek) and the abundance of these endemics is higher than invasive one, since *C. gibelio* mostly prefers lentic systems to lotics ones (Table 3). Although it has the potential to become one of the dominant fish of the Tahtalı Dam with its reproductive success, it has to share the same biotope with the predators *P. fluviatilis* and *S. glanis*,

which were introduced to the dam for stocking purposes. These predator fishes may also control the overgrowth of *C. gibelio* population.

Previous studies reported 19 fish species living in Küçük Menderes River Basin (Karaman, 1972; Balık, 1979; Balık et al., 1995; Sarsu, 1981; İlhan et al., 2009; Korkmaz et al., 2015). Four fish species *C. holmwoodii*, *A. bipunctatus*, *C. carassius* and *M. cephalus*, which are reported from Gümüldür Stream, were not found in the present study. During the sampling period, the lower part of Gümüldür Stream, located at the downstream of the Tahtalı Dam embankment, was dry and seawater had entered to some part of the stream. On the other hand, the fish may have become stuck in a narrow area under changing habitat conditions after the dam construction in the upstream.

Atherina boyeri, C. auratus, S. glanis, S. abaster and *K. caucasica* were reported from the basin for the first time. It is thought that *A. boyeri* (only in Kavakdere Dam Lake)*, C. auratus* and *S. glanis* entered into the basin through fish stocking as mentioned above. *Syngnathus abaster* are originally marine fish, and the only area which is expected to catch of this fish was Gebekirse Lake because of its connection to the sea. Additionally, *K. caucasica*, a small-bodied fish that is very difficult to catch with gillnets, captured from two lakes, Kavakdere Dam Lake and Gebekirse Lake, using a small scoop-net indicating the importance of using different fishing gear to reveal the fish fauna in the ecosystems.

In conclusion, the fish fauna of Küçük Menderes River Basin (İzmir) and their abundances have been studied in detail for the first time. Total 21 fish species have been obtained, however, the number of fish species is likely to be higher. The reasons of the low number of fish species could be as follows; only two sampling periods (spring and autumn), pollution and drought in several stations, the limited (1 or 2) number of the stations in the river tributaries and the gillnet/seine net selectivity in lakes, dams and transitional waters. Six fish species (*A. boyeri*, *S. abaster*, *C. aurata*, *C. ramada*, *Chelon* sp. and *S. fluviatilis*) in the basin are of marine origin with high salinity tolerance and can live in inland waters. *Silurus glanis* and *P. fluviatilis* are native members of the freshwater fish fauna of Turkey and they were introduced into Küçük Menderes River basin for stocking purposes and these two species may threaten the existence of native fishes by their predation pressures. Therefore, it is very critical to monitor and also determine the consequent effects of these invasive and introduced species on the fish fauna, especially native species, of the basin. In addition, all stakeholders should use water with an ecosystem-based approach and prefer nature-friendly methods to eliminate the threats mentioned above in detail.

Acknowledgement

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Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)

Kentleşmenin Küçük Menderes Nehir Havzası (Türkiye) Balık Toplulukları Üzerindeki Baskısı

Nehir havzaları, suyolları olmaları nedeniyle biyosferde önemli bir role sahiptirler ve insanlar tarafından ulaşımda, balıkçılıkta, hidroelektrik üretimi ile evsel, endüstriyel ve tarımsal su temini amaçlarıyla kullanılmaktadırlar. Batı Anadolu'nun önemli akarsularından biri olan Küçük Menderes Nehri, Türkiye'nin metropollerinden biri olan İzmir ili boyunca devam ederek Ege Denizi'ne akmaktadır. Kentleşme, balıkları da kapsayan sucul fauna ve florada meydana gelen değişimlerle bağlantılı olup sıklıkla balık çeşitliliği, zenginliği ve yoğunluğunda azalmaya yol açmaktadır. Günümüzde Küçük Menderes Nehri, verimli tarım arazileri ve yüksek sanayi ve turizm potansiyeli nedeniyle yapılaşmanın baskısı altındadır. Bununla birlikte, havzadaki altyapı eksikliği (kanalizasyon, arıtma tesisleri, vb.) ve hızlı nüfus artışı su kirliliğine/kaybına ve su dengesinin bozulmasına neden olmaktadır. Bu çalışmanın amacı, kentleşme baskısı altındaki Küçük Menderes Nehir Havzası'nın balık faunası ile bunların bolluklarını belirlemektir.

Saha çalışmaları, Küçük Menderes Nehir Havzası'ndaki toplam 50 örnekleme istasyonunda (42 akarsu, 1 geçiş suyu, 2 doğal göl ve 5 baraj gölü) Kasım (2017) ve Mayıs (2018) aylarında gerçekleştirilmiştir. Balık örnekleri akarsularda elektroşoker kullanılarak, geçiş sularında ise kıyı sürütme ağıyla toplanmıştır. Göllerdeki balık örneklemeleri çoklu göz açıklıklarına sahip standart bentik ve pelajik galsama ağları ile yapılmıştır. Toplanan örnekler anestezik çözelti ile bayıltıldıktan sonra %5'lik formaldehit çözeltisine aktarılmıştır. Laboratuvar çalışmasında, her balık için standart boy (SL, cm) ve toplam vücut ağırlığı (W, g) ölçümleri yapılmıştır. Her istasyon için balık bolluğu, birim çaba başına düşen av miktarı (CPUE) hesaplanmıştır.

Çalışılan 50 istasyonun %38'inde (19 istasyon) balık bulunmasına rağmen diğer istasyonlarda kirlilik (7 istasyon) ve kuruma (24 istasyon) nedeniyle balık yakalanamamıştır. Çalışma sonucunda 14 familyaya ait toplam 21 balık türü elde edilmiştir: *Alburnus demiri, Anguilla anguilla, Atherina boyeri, Barbus pergamonensis, Carassius auratus, Carassius gibelio, Chelon ramada, Cobitis fahireae, Cyprinus carpio, Gambusia holbrooki, Knipowitschia caucasica, Chelon aurata, Chelon* sp*., Oxynoemacheilus germencicus, Perca fluviatilis, Petroleuciscus smyrnaeus, Rhodeus amarus, Salaria fluviatilis, Silurus glanis, Squalius kosswigi* ve *Syngnathus abaster*. Cyprinidae, dört taksonla en yüksek tür zenginliğine sahiptir ve en yaygın olarak bulunan balık türleri *S. kosswigi* (8 istasyon) ve *C. carpio* (7 istasyon)'dur.

Yakalanan balık türleri bollukları açısından değerlendirildiğinde, akarsu istasyonlarında CPUE (adet/dk/m^2) değerleri 0,01 ile 24,00 arasında değişmiş olup *G. holbrooki* Hırsız (CPUE=23,28 adet/dk/m^2) ve Kuşkudan (CPUE=24.00 adet/dk/m^2) derelerindeki en baskın balık türüdür. Göl istasyonlarındaki balıklara ait CPUE (adet/s/m^2) değerleri 0,01 ile 62,43 arasında değişmiş olup *P. fluviatilis* Beydağ Baraj Gölü'nde en baskın balık türüdür (CPUE = 62,43 adet/s/m^2). *Alburnus demiri, O. germencicus, P. smyrnaeus* ve *S. kosswigi* havzadaki Anadolu endemikleri iken *A. boyeri* Kavakdere Baraj Gölü için yabancı, *G. holbrooki* ise Küçük Menderes Nehir Havzası için yabancı / istilacı balık türüdür.

Bu çalışmada, sahada yapılan gözlemler sonucunda, temel dört sorun tespit edilmiştir; (1) meteorolojik koşullar ve/veya evsel/endüstriyel kullanımlar ile /tarımsal sulama gibi nedenlerden

kaynaklı kuruma, (2) su kirliliği, (3) istilacı, yabancı veya taşınmış balıkların varlığı ve (4) barajlar, taşkın koruma yapıları ve menfezler gibi hidrolik yapılardan dolayı nehir sürekliliğinin bozulması. Bazı istasyonlar için ana sorun kuruma olsa da, bazılarında iki veya daha fazla sorunun birlikte etkili olduğu gözlemlenmiştir.

Nehir ekosistemlerinde her iki örnekleme döneminde toplam 31 istasyonda balık yakalanamamıştır. Bunlardan 19'u her iki mevsimde de kuruyken, 5'inde bir örnekleme döneminde su olmasına rağmen balık tespit edilememiştir. Diğer yandan, kirlilik ve/veya hidrolik yapıların etkisi sonucu olarak yaşanan habitat kayıpları 7 istasyonu (7, 11, 16, 17, 18, 19 ve 20) olumsuz etkilemiştir. Balık sadece 11 istasyondan yakalanabilmiştir ve bunların altısında (8, 22, 23, 28, 31 ve 36) her iki mevsimde su bulunurken beşinde (15, 21, 25, 33 ve 39) sadece ilkbahar örneklemesinde su bulunmaktaydı. Akarsulardaki bu kurumanın sadece meteorolojik nedenlerden kaynaklanmadığı, aynı zamanda evsel veya sulama amaçlı inşa edilen barajların etkisiyle de oluştuğu öngörülmüştür.

Küçük Menderes Nehir Havzası boyunca, nehrin membasından denize aktığı Pamucak sahiline kadar su kirliliği sorunu bulunmaktadır. Saha gözlemlerine göre sorun, özellikle ana nehir boyunca uzanan yerleşim alanlarında daha belirgin hale gelmektedir. Su kirliliğinin en belirgin örneği Fetrek Çayı'nda bulunan iki istasyonda gözlenmiştir. Yerleşim alanı öncesinde bulunan ilk istasyon (15. istasyon) kuru iken, yerleşim alanından sonra gelen ikinci istasyondaki akış halindeki suyun tamamen (16. istasyon) evsel veya endüstriyel kökenli olduğu görülmüştür.

Küçük Menderes Nehir Havzası'nda tespit edilen üç balık türü *G. holbrooki, C. gibelio* ve *C. auratus*, Türkiye içsu balık faunası için yabancı ve istilacı özellikteki balıklardır. Bunlara ek olarak tespit edilen diğer dört tür *A. boyeri, S. glanis, P. fluviatilis* ve *C. carpio* havzaya taşınmış balıklar olarak dikkat çekmektedir. Balık stoklaması çalışmalarında istemli veya istem dışı taşınmalar en önemli faktörlerdir ve bu yabancı balıklar girdikleri iç su ortamında doğal yırtıcıların bulunmaması ya da üreme ve beslenme gibi biyolojik özellikleri ile kolayca baskın balık haline gelebilirler. Çoğunlukla ekonomik nedenlerle tercih edilen bu türler biyolojik çeşitlilik için bir tehdit oluşturabilir.

Küçük Menderes Nehir Havzasında baraj, menfez, taşkın kontrol yapıları, savaklar ve köprüler gibi nehrin hem yatay hem de dikey yöndeki devamlılığını bozan bazı hidrolik yapılar bulunmaktadır. Buna ek olarak, doğal nehir yatağını beton kanala almak, kıyı bölgelerinin tahrip edilmesi, nehir kıyılarının beton veya kayalarla güçlendirilmesi gibi diğer tehditler de havza için dikkat çekicidir. Beş baraj gölü hariç, yukarıda listelenen hidrolik yapıların biri veya daha fazlası hemen hemen tüm istasyonlarda tespit edilmiştir. *Barbus pergamonensis, O. germencicus, P. smyrnaeus* ve *S. kosswigi* bu akarsularda yaşayan endemik balıklardır ve nehir yatağına yapılacak daha fazla müdahalenin gelecekte bu balıkların varlığını tehdit edebileceği düşünülmektedir.

Sonuç olarak, Küçük Menderes Havzası'nın (İzmir) balık faunası ve bollukları bu çalışma ile ilk kez ayrıntılı olarak incelenmiştir. Toplam 21 balık türü elde edilmiştir, ancak tür sayısının daha yüksek olması mümkündür. İstilacı ve taşınmış türlerin havzadaki balık faunası ve özellikle de doğal türler üzerindeki etkilerinin izlenmesi ve belirlenmesi oldukça önemlidir. Ayrıca, tüm paydaşlar ekosistem temelli bir yaklaşımla suyu kullanmalı ve yukarıda belirtilen tehditleri ayrıntılı olarak ortadan kaldırmak için doğa dostu yöntemleri tercih etmelidirler.