

THE FISH FAUNA OF A KARST SPRING; ÖZLEN STREAM (ANTALYA, TURKEY)

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ABSTRACT. Most of the ichthyological research in Turkish freshwaters are focused on large rivers. However, recent evidence indicated that local endemics and/or threatened fish species may be trapped in small springs such as karst-fed streams. In small karst-fed streams the downstream end of the underground flow reaches the surface and drain to the sea in a very short distance. Thus, fish fauna in such water bodies should be investigated for the presence of any threatened fish species. In this study, the fish fauna of a karst-fed small stream, Özlen Stream, where no ichthyological information exist, was investigated on a seasonal basis. A total of 8 fish species (*Anguilla anguilla*, *Carassius gibelio*, *Squalius fellowesi*, *Oncorhynchus mykiss*, *Gambusia holbrooki*, *Mugil cephalus*, *Liza saliens* and *Salaria fluviatilis*) were identified. *C. gibelio*, *O. mykiss* and *G. holbrooki* are exotic and invasive fish species for Turkish freshwaters. Furthermore, *C. gibelio* and *G. holbrooki*, are considered a serious threat to natural fish populations in Turkey. Presence of such invasive fish species even in a small river indicates that they are expanding their distribution area in Turkey.

1. INTRODUCTION

Turkey has a very unique freshwater fish fauna including species originated both from Europe and Asia [1]. According to the latest checklist, the Turkish freshwater fish fauna is composed of 377 species [2].

There has been a growing interest on fisheries and the freshwater fish diversity in Turkey during the last decades [1-6] which significantly contributed to the available knowledge on their distribution, taxonomy and ecology. However, there are still

Keyword and phrases. Karst spring, invasive, Eşen river, mosquito fish

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Communications Faculty of Sciences University of Ankara Series C: Biology

some gaps particularly on the fish fauna of karst-fed rivers or karst-springs where the downstream end of the underground flow reaches the surface and drain to the sea in a very short distance. Such karst-springs are mainly located in the Southern Anatolia, primarily in Mediterranean Region [3]. Their flow regime depends on the precipitation rates or snow-melt. Thus, some of them can be exposed to drought intermittently [7]. Recent research has shown that local endemics and/or threatened fish species may be trapped in such small springs [6]. Thus, fish fauna in such water bodies should be investigated for the presence of any threatened fish to prepare species conservation plans.

The rivers and streams located in Mediterranean regions are unique habitats in an ecological point of view. The streams in the Mediterranean region (also called med-streams) comprising the highest number of threatened freshwater species in Europe [8] are considered as global hotspots for biodiversity and endemism [9]. Unfortunately, they are very sensitive to environmental alterations resulting from human impacts. For example, in Antalya (Turkey), the drainage of municipal sewage directly to the aquifers feeding the groundwater flow is considered to be a serious concern for drinking water supply. It also creates a major threat to biodiversity in both groundwater-fed freshwaters and the Antalya Bay which may play a role as the final sink for surface runoff and groundwater flows [10]. Investigation and monitoring of the flora and fauna in such streams might brought new insight to the biodiversity and distribution of aquatic organisms. Therefore, the present study aims to represent the freshwater fish fauna of a karst-spring, Özlen Stream (Antalya, Turkey), where no ichthyological information exists on the stream.

2. MATERIALS AND METHODS

2.1. The study area

The study area, Özlen Stream, is located on the southern west coasts of Antalya (Fig. 1). Özlen Stream is approximately 4 km long and originates from a spring near Karidere village (Kaş, Antalya) and drains into the Mediterranean Sea from the Patara coasts. There is a fish farm located nearby the headwaters of Özlen Stream.

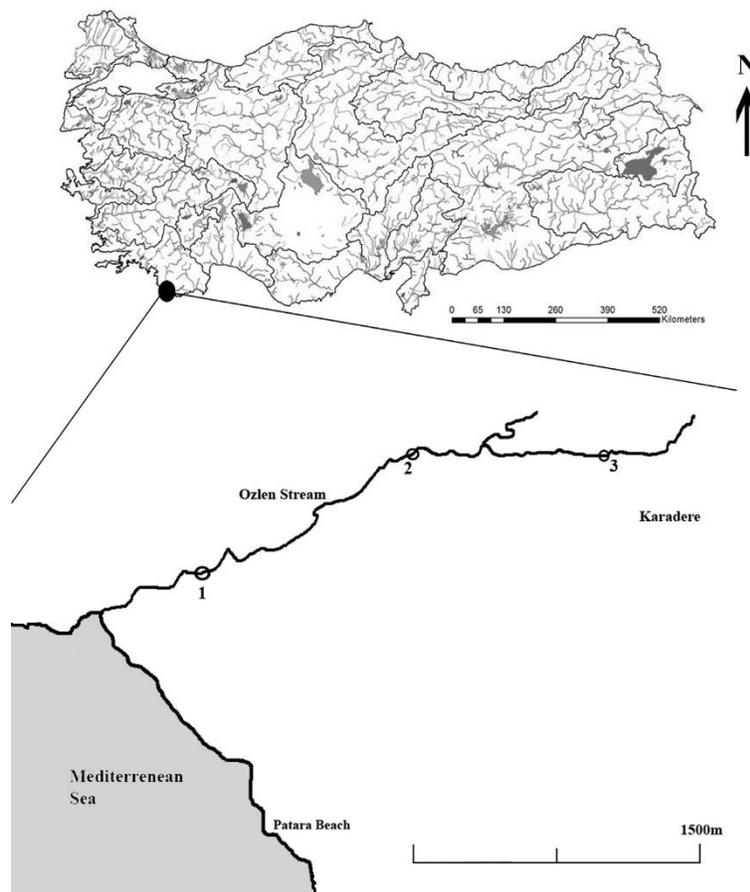


FIGURE 1. Map showing the sampling locations on Özlen Stream. Sampling stations 1: $36^{\circ} 19.901'N$ $29^{\circ} 13.940'E$; 2: $36^{\circ} 20.394'N$ $29^{\circ} 14.674'E$; 3: $36^{\circ} 20.423'N$ $29^{\circ} 15.394'E$

2.2. Fish Sampling and Processing

Fish sampling was carried out by electrofishing with a backpack electrofishing gear (Samus 725-MP) on a seasonal basis from September 2018 to August 2019. Sampling was performed by wading in an upstream direction which included all representative habitats. Fish were caught from 3 different sampling stations on the stream including headwaters and river mouth (Figure 1). Fish specimens were euthanized using an overdose of MS-222 and fixed in formaldehyde solution (10%) and brought to the laboratory for processing. Samples were transferred to 70% ethanol for further processing. The standard length (SL) were measured (nearest to 0.1 mm) with a digital compass. Meristic characteristics including branched and

unbranched rays in dorsal (D), ventral (V), anal (A) and pectoral (P) fins, lateral line scales, the number of gill rakers, pyloric caeca and pharyngeal teeth were also noted with a stereoscopic binocular microscope (Leica EZ4) where needed. Fish were identified according to Geldiay and Balık [11], Banarescu and Bogutskaya [12], Smith and Darwall [13] using metric and meristic characteristics mentioned above.

3. RESULTS

A total of 89 fish specimens which belong to 8 species and 7 families (Anguillidae (1), Cyprinidae (1), Leuciscidae (1), Salmonidae (1) Poeciliidae (1), Mugilidae (2) and Blenniidae (1)) were identified from the Özlen Stream. Morphometric measurements and counts for each fish species are given below. The classification of fishes in the present study is adopted from Eschemeyer's Catalog of Fishes [14].

Family: Anguillidae

Anguilla anguilla (Linnaeus, 1758) (European eel)

Material examined: Özlen Stream (Stations 1, 2, 3) (22.09.2018, 3 specimens; 02.03.2019, 3 specimens, 18.05.2019, 4 specimens; 10.08.2019, 9 specimens; SL: 12.2-27.8 cm).

Diagnostic characteristics: D 243-265, A 178-196, P 17-18, C 9-11.

Family: Cyprinidae

Carassius gibelio (Bloch, 1782) (Prussian carp)

Material examined: Özlen Stream (Station 1) (18.05.2019, 4 specimens; SL: 12.2-15.5 cm).

Diagnostic characteristics: D III-IV 15-17, A III 5, V: II 6, P: I 13, peritoneum black.

Family: Leuciscidae

Squalius fellowesii (Günther, 1868) (Aegean chub)

Material examined: Özlen Stream (Station 3) (10.08.2019, 7 specimens; SL: 8.4-14.2 cm)

Diagnostic characteristics: D III 71/2-91/2, A III 61/2- 91/2, lateral line scales 40-42, gill rakers 7-10, pharyngeal teeth 2.5-5.2.

Family: Salmonidae

Oncorhynchus mykiss (Walbaum, 1792) (Rainbow trout)

Material examined: Özlen Stream (Station 2) (18.05.2019, 1 specimen, SL: 22.4 cm)

Diagnostic characteristics: D: III-IV 10, A: III-IV 9, P: I 12, V: II 9, C: 19, lateral line scales: 139.

Family: Poeciliidae

Gambusia holbrooki Girard, 1859 (Mosquitofish)

Material examined: Özlen Stream (Stations 1, 2) (22.09.2018, 9 specimens; 02.03.2019, 11 specimens, 18.05.2019, 14 specimens; 10.08.2019, 15 specimens; SL: 2.3-5.2 cm)

Diagnostic characteristics: D I-II 6-7, A I-II 7-8, lateral line scales 29-31

Family: Mugilidae

Mugil cephalus Linnaeus, 1758 (Flathead grey mullet)

Material examined: Özlen Stream (Station 1) (22.09.2018, 2 specimens; 10.08.2019, 3 specimens; SL: 15.6-25.6 cm).

Diagnostic characteristics: D1 IV, D2 I 9, A III 8, P 17, V 15, Sq, 42-43, pyloric caeca 2

Liza saliens (Risso, 1810) (Leaping mullet)

Material examined: Özlen Stream (Stations 1) (22.09.2018, 1 specimen; SL: 23.2 cm).

Diagnostic characteristics: D1 IV, D2 I 9, A III 8, P 16, V I 5, Sq 44, pyloric caeca 8.

Family: Blennidae

Salaria fluviatilis (Asso, 1801) (Freshwater blenny)

Material examined: Özlen Stream (Station 2) (22.09.2018, 2 specimens; 18.05.2019, 1 specimen; 10.08.2019, 3 specimens; SL: 2.1-7.8 cm).

Diagnostic characteristics: D XII-XIII, A 18-19, P 13-14, V 3-4.

4. DISCUSSION

Özlen Stream is located very close to Eşen River (150 km long) which has a very large drainage area (1200 km²). Although, there is a partial data on the fish fauna of Eşen River [4], this is the first study reporting the ichthyofauna of a karst-fed small stream, Özlen Stream (~ 4 km long). We observed a direct connection between Özlen Stream and Eşen River via irrigation channels during the field studies. Thus, it is possible to observe similar species in both rivers. A total of 10 fish species have been reported from the downstream regions of Eşen River [4]. *Carassius carassius* reported by Onaran *et al.* [4] seems to be a misidentification. *A. anguilla*, *S. fluviatilis*, *Leuciscus cephalus*, *M. cephalus* and *L. saliens* were also reported by Onaran *et al.* [4]. *L. cephalus* specimens are treated as a different species described as *Squalius fellowesii* according to the latest study by Özuluğ and Freyhof [5]. *Liza ramada* and *Oedalechilus labeo* which reported by Onaran *et al.* [4] were not caught

in the current study. Furthermore, this is the first study reporting the occurrence of *O. mykiss* and *G. holbrooki* in the sampling area. In another study, 24 fish species have been reported from several streams discharging to Antalya Bay (Mediterranean Sea) [15]. The use of one type of fishing gear to catch fish may have had an effect on the lower abundance of fish in the sampling localities. Combining different fishing methods may decrease the possibility of missing any fish species inhabiting the stream. On the other hand, several physico-chemical and hydromorphological parameters may affect the fish assemblages [6]. Geological characteristics and topographic structures also have a crucial impact on the distribution of fish. However, no such information is available for Özlen Stream.

A total of 8 fish species were identified from the stream. *A. anguilla* was observed throughout the stream course and its abundance was higher in the headwaters of the Özlen stream. This might indicate that the stream continuum is very important for European eel in Özlen Stream. European eel is categorized as Critically endangered (CR) by the International Union of Conservation for Nature (IUCN) [16]. The only report on the fish fauna of Eşen River indicates that European eel also inhabits Eşen river. However, no European eel was caught in the downstream regions of Eşen River during this study (data not given here). Thus, Özlen Stream seems to play a major role in the life cycle of this fish species in the sampling area.

Three non-native and invasive fish species (*O. mykiss*, *C. gibelio* and *G. holbrooki*) were caught during the field studies. There was only 1 specimen of *O. mykiss* which probably escaped from the trout farm located on the headwaters of the stream. There is a debate whether this species naturalized or not in Turkish freshwaters [1, 17]. However, current findings support that rainbow trout cannot sustain its population reproductively in Özlen Stream. *C. gibelio* and *G. holbrooki*, are considered a serious threat to natural fish populations in Turkey. Such invasive fish species, particularly *G. holbrooki*, seems to be expanding its distribution area in Turkey [17-18]. Their intentional or unintentional release into the irrigation channels which are directly connected to the Özlen Stream might be responsible for their occurrence in Özlen Stream. These irrigation channels also create a connection between Özlen Stream and Eşen River. Thus, it is also possible that Eşen River might be the main source of these invasive fish. The presence of such fish species may impact fish populations particularly, fish with complex life cycles such as *A. anguilla*. There were no *G. holbrooki* in the downstream regions of Eşen River (data not given here). Past experience supports that mosquito fish inhabits slow moving and shallow waters. The high flow rate might have limited their occurrence in Eşen River. However, a more comprehensive study including the sampling points in the tributaries of Eşen River is needed to validate their absence or presence in Eşen River.

The lower rates of annual precipitation create a major stress on the med-streams located in Mediterranean region of Turkey [19]. Intermittent drought is very common in such small med-streams [20]. Although, there was a decrease in the flow rates of Özlen Stream during summer months, current findings indicate that Özlen Stream is a perennial running water. Water withdrawal for irrigational purposes and the intensive use of pesticides in the greenhouses located in the sampling area creates a major threat to aquatic life both in Özlen Stream and Eşen River and eventually the recipient Mediterranean Sea. Furthermore, the presence of invasive species in Özlen Stream is another threat to native biota inhabiting the stream. Recent research has shown that local endemics and/or threatened fish species may be trapped in small springs [6]. Thus, such small karst-fed streams may play a crucial role in the fate of local endemic fish species and/or threatened fish species that inhabits the stream. Thus, fish fauna in such water bodies should be investigated before human impacts reach to an irreversible point.

Acknowledgements. The authors are grateful for their assistance to S. Cevher Ozeren (Ph.D) and Ronald Fricke (Ph.D) on the taxonomic confirmation of some fish species.

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