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RESEARCH ARTICLE

In Memory of Fahire Battalgazi; Bringing Back a Fish Collection to Life

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Abstract
Istanbul University (I.U.) plays an important role in handing down the valuable to the next generations by protecting its scientific and cultural assets with the museums it possesses. Fish collection have inherited from I.U. Hydrobiology Institute to I.U. Faculty of Aquatic Sciences and preserved until today in I.U. Faculty of Aquatic Sciences, Inland Fisheries Production and Research Unit located in Sapanca (Sakarya, Turkey). In course of time, the protective liquid of fish material has begun to evaporate from the jars; or they have somehow lost their efficiency in protection. For this reason, it was aimed to recover this collection, which contains rare samples from Turkish seas and freshwater habitats, to update the jar labels, and to replenish the preservative fluids. During this venture, we came across some fish samples that were collected and examined by Prof. Dr. Fahire Battalgazi, the first Turkish woman ichthyologist, who occupies an important position in the history of science of Turkey. Here, we introduce the fish species (*Alburnus kotschyi, Capoeta barroisi, C. trutta, Carasobarbus luteus, Garra kemali, Gobio microlepidotus, G. insuyanus, Oxynoemacheilus eregliensis, Petroleuciscus borysthenicus, Squalius fellowesii and Vimba vimba*) collected and/or examined by Prof. Dr. Fahire Battalgazi and labeled with her own handwriting.
Keywords: Battalgil, Fish, History of Science, Museum

Introduction

Museums and collections are indispensable elements of scientific research and the education and cultural development of everyone from different ages (Okan, 2015; Mercin, 2017). Natural history museums and biological material-based museums have ensured their importance and reliability by preserving the objects and information from the past to the present. Natural history museums and collections exhibit remains of both present and past organisms and also examples of rare or extinct organisms in their inventories, so that we can understand their origin and value. In addition, they provide scientists the opportunity to compare the biological samples obtained from different times and places belonging to the same species. They also undertake the role of "identification keys" for identifying the species that cannot be determined among the specimens with species diagnosis. In general, biological specimens are immediately pre-treated in the places where they are collected, and the place, date, sampling tool and the person were recorded. Samples are stored under appropriate conditions until they are examined by researchers in the laboratory. In laboratory conditions, while the samples are taken into the final protective liquid, new labels are prepared using the information on the first label, and these labels are placed both inside and outside the jar. It is very important to choose the label material, which is resistant to the preservative in the jar, and to write the information in pencil that will not be affected by the protective liquid. Jars should be numbered, and all information should be recorded in the collection book and electronic media.

Fahire Battalgazi, the first woman ichthyologist of the Republic of Turkey, had lived from 1902 (1905) to 1948. She graduated from Darülfünun (former name of Istanbul University) in 1926 (Battalgazi Uslu, 2019) and started to work at the Istanbul University Zoology Institute in 1927 (Bahadır, 2018). Fahire Battalgazi has changed her surname from Battalgil to Battalgazi at 1944 (Battalgazi Uslu, 2019). She contributed to both the formation of an important fish collection at the Istanbul University and scientific literature. Fahire Battalgazi has been conducted his doctoral research with Ord. Prof. Dr. Curt Kosswig (Bahadır, 2018), who had encouraged her to study freshwater fishes of Turkey. She identified and described a large number of fish species until her death (Battalgil, 1940, 1942, 1944; Battalgazi, 1944).

Fahire Battalgazi is one of the iconic representatives of the young Republic of Turkey, which had given extra importance to science and women. She contributed greatly to the fish biodiversity literature of Turkey. When considering the economic and social conditions of that time, her works can be regarded as extremely difficult and valuable by studying the fish fauna of several water sources of Turkey, naming fish species that are still valid today, and constitution of an inland fish collection in the I.U. Institute of Hydrobiology (Battalgil, 1940, 1942, 1944; Battalgazi 1944). Of the 31 species she described, 15 are still valid and all of them are endemic to Turkey (Table 1). There are also six freshwater fish species named in honor of Fahire Battalgazi (Battalgazi Uslu, 2019) (Table 2, see Battalgazi Uslu, 2019). Two endemic fish species, *Alburnus akili and A. nicaeensis,* which she identified, are now listed as Extinct (EX) in the IUCN red list (Freyhof, 2014a, 2014b; Küçük, 2012). *Alburnus adanensis* identified in 1944 has not been seen again after this date and it is thought that it might be extinct (Freyhof *et al.*, 2018).

A collection of inland and freshwater organisms from Turkey was created by the researchers of Baltalimanı Zoology Station, which was established in 1930 under Darulfünun (Kadıoğlu, 2003), and I.U. Institute of Hydrobiology, which was established on June 27, 1951 (Anonymous, 1951). Not all of these collections have survived until today. Fahire Battalgazi's fish collection was kept in the Hydrobiology Institute until it was closed in 1983. Some of the collection samples belonging to this institution were transferred to the I.U. Faculty of Science and the I.U. Faculty of Aquatic Sciences (also known as School of Fisheries at that time).

Fish samples, most of which were from inland waters, collected by Hydrobiology Institute of Istanbul University have been preserved in a warehouse and limnology laboratory in Sapanca Inland Fisheries Research and Application Unit of Faculty of Aquatic Sciences, Istanbul University were kept for a long time in improper conditions. The information on the number of species, their distribution in Turkey's inland waters, and the researcher who caught them were not known exactly before this study. The collection, which has been waiting idle for many years, has been started to work on the collection with the support of the I.U. Scientific Research Projects Unit so that it can be used in scientific and educational studies again. Therefore, the aim of this study to brought together the fish collection and to introduce the fish species which collected, examined and labelled by Prof. Dr. Fahire Battalgazi, who achieved great success in ichthyology in her short life period.

Table 1: Fish species described by Fahire Battalgazi and the latest status of these species. (Valid species are shown as bold).

Species identified by Fahire Battalgazi	Latest status of the species (Fricke *et al.*, 2020)
Acanthorutilus anatolicus caralis	*Pseudophoxinus anatolicus* (Hankó, 1925)
Alburnus akili	***Alburnus akili* Battalgil, 1942**
Alburnus chalcoides carinatus	***Alburnus carinatus* Battalgil, 1941**
Alburnus chalcoides istanbulensis	***Alburnus istanbulensis* Battalgil, 1941**
Alburnus chalcoides nicaeensis	***Alburnus nicaeensis* Battalgil, 1941**
Alburnus chalcoides sapancae	***Alburnus istanbulensis* Battalgil, 1941**
Alburnus heckeli	***Alburnus heckeli* Battalgil, 1944**
Alburnus kosswigi	*Alburnus escherichii* Steindachner, 1897
Alburnus mossulensis delineatus	*Alburnus sellal* Heckel, 1843
Alburnus nasreddini	*Alburnus escherichi* Steindachner, 1897
Alburnus sellal adanensis	***Alburnus adanensis* Battalgazi, 1944**
Barbus tauricus oligolepis	***Barbus oligolepis* Battalgil, 1941**
Barbus tauricus polylepis	*Barbus cyclolepis* Heckel, 1837
Barynotus verhoeffi	*Carasobarbus chantrei* (Sauvage, 1882)
Caspialosa tanaica etemi	*Alosa tanaica* (Grimm, 1901)
Cobitis bilseli	***Cobitis bilseli* Battalgil, 1942**
Cobitis phrygica	***Cobitis phrygica* Battalgazi, 1944**
Gobio gobio intermedius	***Gobio intermedius* Battalgil, 1944**
Gobio gobio microlepidotus	***Gobio microlepidotus* Battalgil, 1942**
Hemigrammocapoeta caudomaculata	***Garra caudomaculata* (Battalgil, 1942)**
Leuciscus heterandrius	*Petroleuciscus borysthenicus* (Kessler, 1859)
Leuciscus cephaloides	***Squalius cephaloides* (Battalgil, 1942)**
Nemachilus frenatus afrenatus	*Oxynoemacheilus frenatus* (Heckel, 1843)
Phoxinellus thracicus	*Leucaspius delineatus* (Heckel, 1843)
Varicorhinus antalyensis	***Capoeta antalyensis* (Battalgil, 1944)**
Vimba vimba tenella abulyontis	*Vimba vimba* (Linnaeus, 1758)
Vimba vimba tenella aphnitis	*Vimba vimba* (Linnaeus, 1758)
Vimba vimba tenella istanbulensis	*Vimba vimba* (Linnaeus, 1758)
Vimba vimba tenella nicaeensis	*Vimba vimba* (Linnaeus, 1758)
Vimba vimba tenella sapancae	*Vimba vimba* (Linnaeus, 1758)

Table 2. Fish species attributed to Fahire Battalgazi (Battalgazi Uslu, 2019).

Species	References
Chondrostoma fahirae (Ladiges, 1960)	Ladiges, 1960
Cobitis battalgilae Băcescu, 1962	Băcescu, 1962
Pseudophoxinus battalgilae Bogutskaya, 1997	Bogutskaya, 1997
Cobitis fahireae Erk'akan, Atalay-Ekmekçi & Nalbant, 1998	Erk'akan, *et al.*, 1998
Gobio battalgilae Naseka, Erk'akan & Küçük, 2006.	Naseka, *et al.*, 2006
Alburnus battalgilae Özuluğ & Freyhof, 2007	Özuluğ & Freyhof, 2007

Material and Methods

All of the samples available in the collection were kept in the jars and preserved in formaldehyde solution. Formaldehyde, used for long-term preservation of various organisms or tissue samples, is highly toxic and carcinogenic substance (Zararsız *et al.*, 2004). For this reason, samples treated with formaldehyde are transferred into preservatives such as ethanol, which have fewer negative effects, in order to protect human and environmental health and to save time and water. After rinsing the material, they were transferred to 30% and 50% ethanol series for different time intervals (1-15 days) depending on the size of the individuals, and then they were finally put into the labelled jars filled with 70% ethanol solution away from daylight (Özuluğ & Saç, 2019). All kinds of scientific information on the labels inside or outside of jars that are free of formaldehyde solution have been recorded in the laboratory notebook and also electronical database. In order to avoid damaging the original labels, they have treated accordingly, and photographed. Standard length (SL) was measured from the tip of the snout to the posterior extremity of the hypural complex. Measurements were made with a millimetric scale board. The current scientific names of the fish species have been checked from Eschmeyer's catalog of fishes (Fricke *et al.*, 2020).

Results

Within the scope of the study, all fish material in the I.U. Faculty of Aquatic Sciences Fish Collections (IUFASFC) (250 jars) were examined. It was noticed that some fish species did not have a proper identification. While some of the jars had labels attached to outside and/or inside of them, some jars did not have any labels.

The oldest specimen in the collection was an individual of the *Monochirus* sp. caught from the Marmara Sea in 1932. It is followed by *Petroleuciscus smyrnaeus* (Boulenger, 1896) caught from Izmir in 1938; *P. borysthenicus* (Kessler, 1859) from Küçükçekmece Lagoon (Istanbul); *Capoeta trutta* (Heckel, 1843) from Şanlıurfa and *Barbus* sp. from Batman in 1939. The material covers an interval between the 1930s and the 1980s.

152 of the jars bear information about time, collector and the locality of the material (stream, lagoon, lake, dam lake, sea, gulf, village, district, province). Whereas, in 98 jars, only the name of the species was found on the labels and there was no further information about the samples. According to the existing information, it has been found that the samples have collected from 37 inland water resources and three different seas in Turkey (Fig. 1). The provinces were in alphabetical order: Adana, Adıyaman, Aksaray, Amasya, Ankara, Antalya, Aydın, Balıkesir, Batman, Burdur, Bursa, Denizli, Diyarbakır, Edirne, Elazığ, Erzincan, Eskişehir, Isparta, İstanbul, İzmir, Kahramanmaraş, Karaman, Kars, Kayseri, Kırklareli, Kırşehir, Konya, Malatya, Manisa, Muğla, Muş, Sakarya, Samsun, Sivas, Şanlıurfa, Trabzon and Van. Additionally, there were a small number of sea fish samples caught in the Marmara Sea, Edremit Bay and Iskenderun Bay in the collection (Fig. 1).

As a result of systematic identification of fishes in 250 jars, it was determined that fish belonging to 38 families and 64 genera. In the collection, Leuciscidae (13 genera), Cyprinidae (7 genera), and Gobiidae (5 genera) are the families that have the greatest numbers of genera, respectively (Table 3).

Labels of fish collected from the field and/or examined in the laboratory by Prof. Dr. Fahire Battalgazi have been examined and demostrated in Table 4, Figs. 2–11.

Figure 1. Locations of the fish samples listed in the museum collection (yellow points indicate the inland water recourses and red points for sea stations).

Table 3: Families and Genera of the fish species in the collection.

Family	Genera
Acipenseridae	*Acipenser*
Acheilognathidae	*Rhodeus*
Anguillidae	*Anguilla*
Aphaniidae	*Anatolichthys*
Atherinidae	*Atherina*
Blenniidae	*Salaria*
Bothidae	*Arnoglossus, Bothus*
Centarchidae	*Lepomis*
Cepolidae	*Cepola*
Citharidae	*Citharus*
Clariidae	*Clarias*
Clupeidae	*Alosa, Clupeonella*
Cobitidae	*Cobitis*
Cyprinidae	*Barbus, Capoeta, Carassius, Cyprinion, Cyprinus, Garra, Luciobarbus*
Danionidae	*Barilius*
Esocidae	*Esox*
Gasterosteidae	*Gasterosteus*
Gobiidae	*Babka, Gobius, Mesogobius, Neogobius, Proterorhinus*
Gobionidae	*Gobio*
Leuciscidae	*Abramis, Acanthobrama, Alburnoides, Alburnus, Blicca, Chondrostoma, Leuciscus, Petroleuciscus, Pseudophoxinus, Rutilus, Scardinius, Squalius, Vimba*
Mastacembeliade	*Mastacembelus*
Moronidae	*Dicentrarchus*
Mugilidae	*Chelon*
Mullidae	*Mullus*
Muraenidae	*Murena*
Nemacheilidae	*Oxynoemacheilus*
Percidae	*Perca, Sander*
Phycidae	*Phycis*
Pleuronectidae	*Platichthys*
Salmonidae	*Oncorhynchus, Salmo*
Scorpaenidae	*Scorpaena*
Serranidae	*Serranus*
Siluridae	*Silurus*
Sisoridae	*Glyptothorax*
Soleidae	*Monochirus*
Syngnathidae	*Syngnathus*
Tincidae	*Tinca*
Trachinidae	*Trachinus*

Table 4: Labels of fish collected from the field and/or examined in the laboratory by Prof. Dr. Fahire Battalgazi.

Figure Number	Label Information	Valid Name
Figure 2	*Alburnus orontis* Büyükkaya pınarı Elbistan Seyhan sistemi 1944 Det. Fahire Leg. Feti	*Alburnus kotschyi*
Figure 3	*Gobio gobio microlepidotus* nov. subsp. Det. Fahire Battalgil Beyşehir Gölü 1942	*Gobio microlepidotus*
Figure 4	*Hemigrammocapoeta kemali* Det. Fahire Battalgil Isparta 1942.	*Garra kemali*
Figure 5	23) *Leuciscus fellowesi* …… Köyceğiz gölü X. 1946 *Leuciscus fellowesi* Köyceğiz gölü X 946	*Squalius fellowesii*
Figure 6	*Gobio gobio insuyanus* Cihanbeyli 7.1945	*Gobio insuyanus*
Figure 7	*Varicorhinus barroisi* Büyük Kaya pınarı Elbistan 1944	*Capoeta barroisi*
Figure 8	*Systomus luteus*, Heckel Batman suyu VII 939 leg: Kosswig	*Carasobarbus luteus*
Figure 9	K. çekmece 2/XII/938	*Petroleuciscus borysthenicus*
Figure 10	*Varicorhinus Trutta* Heckel Urfa 1939	*Capoeta trutta*
Figure 11	*Vimba vimba* (Linne) Det. Fahire Battalgazi Yeşilirmak 1945	*Vimba vimba*

The fish in Fig. 2 is *Alburnus kotschyi Steindachner*, 1863, which is accepted as a valid species today, and on the label "*Alburnus orontis* Büyükkaya pınarı Elbistan Seyhan sistemi 1944 Det. Fahire Leg. Feti" (2 specimen; SL: 80-100 mm). Elbistan mentioned on the label is a district of Kahramanmaraş and the Büyükkaya spring is one of the headwaters of Ceyhan River. It is likely that Seyhan was written incorrectly on the label. According to label, the material was collected by Fethi Akşıray and identified by Fahire Battalgazi. Handwriting on the label belongs to Fahire Battalgazi.

The label in Fig. 3 is typewritten and "*Gobio gobio microlepidotus* nov. subsp. Det. Fahire Battalgil Beyşehir Gölü 1942" (2 specimens; SL: 36-72 mm). *Gobio microlepidotus* Battalgil, 1942 was identified by Fahire Battalgazi from Beyşehir Lake no holotype designated. Lectotype (ZHM H1127) and paralectotypes (ZHM H1127 (1)) selected from ZMH materials by Naseka *et al.* 2006. It is thought that the two fish samples in Fig. 3 syntypes. *Gobio microlepidotus* Battalgil, 1942 is currently a valid endemic species.

Figure 2. *Alburnus orontis* caught from Elbistan in 1944 (uncatalogued).

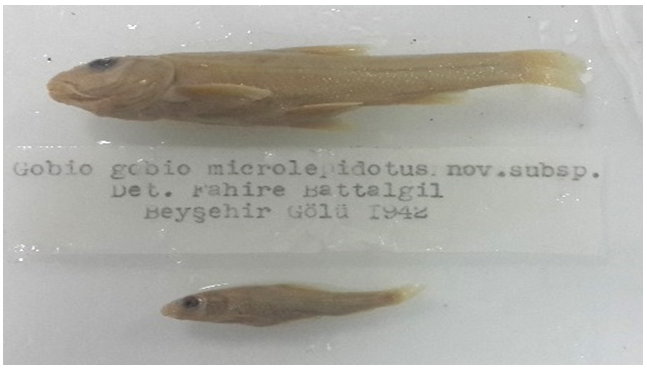

Figure 3. *Gobio microlepidotus* caught from Lake Beyşehir in 1942 (uncatalogued).

In Fig. 4, "*Hemigrammocapoeta kemali* Det. Fahire Battalgil Isparta 1942." is written on the label (1 specimen; SL: 41 mm). The valid name of the species is *Garra kemali* (Hankó, 1925). The protective liquid was partially lost and the fish had shrunk, got dark and lost its pattern.

Figure 4. *Garra kemali* caught from Isparta in 1942 (uncatalogued).

According to the labels in Fig. 5, the jar containing the fish samples had both handwritten and typed information such as the name of the species and the sampling locality. The current name of the species named in the labels is *Squalius fellowesii* (Günther, 1868) a valid species (1 specimen; SL: 194 mm). The information on the different labels is consistent with each other and there is no information about who caught or identified the sample in the jar. It is thought that the species was studied by Fahire Battalgazi since it was obtained in 1946. The articles in the labels are numbered on the figure and are as follows;
1 "23) *Leuciscus fellowesi* …… Köyceğiz gölü X. 1946"
2 "*Leuciscus fellowesi*" (other characters could not be read)
3 and 4 "Köyceğiz gölü X 946" (Fig. 5).

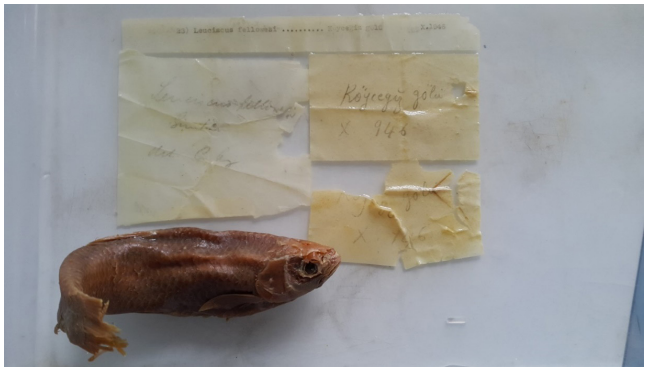

Figure 5. *Squalius fellowesii* caught from1946 from Lake Köyceğiz (uncatalogued).

Fig. 6 contains information about *Gobio insuyanus* Ladiges, 1960, a species that endemic to Turkey, and the label says "*Gobio gobio insuyanus* Cihanbeyli 7.1945" (5 specimens; SL: 62-96 mm). The jar also contains pharyngeal teeth in a glass tube. On the tube label, "*Gobio g*. Cihanbeyli Farinks: D. Ph. 5, 2 - 2, 5" statement is included.

Remarks: It is thought that Fahire Battalgazi could not complete or publish her studies on the genre due to her untimely death. After Battalgazi's death, some fish samples and incomplete manuscripts belonging to her were given to Ladiges by Curt Kosswig (Ladiges, 1960). *Gobio insuyanus* was published by Ladiges in 1960. According to Naseka *et al.* (2006), the holotype (ZHM 1133) of *G. insuyanus* is missing. These 5 samples in our collection are paratypes of *G. insuyanus*. There is also *Oxynoemacheilus eregliensis* (Bănărescu & Nalbant, 1978) in the same jar (1 specimen; SL: 52 mm).

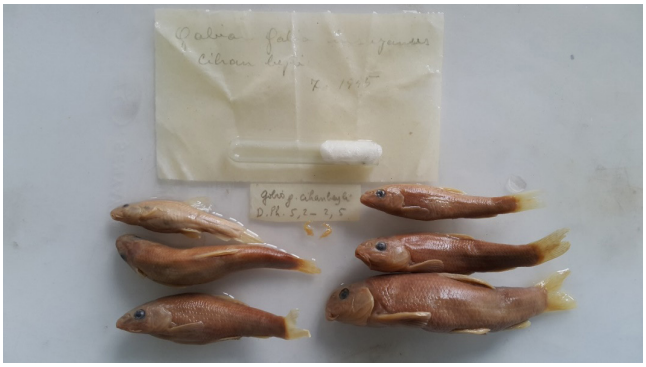

Figure 6. *Gobio insuyanus* and *Oxynoemacheilus eregliensis* caught from Cihanbeyli in 1945 (uncatalogued).

The current name of the species mentioned in Fig. 7 is *Capoeta barroisi* Lortet, 1894 and is a valid species. The label reads "*Varicorhinus barroisi* Büyük Kaya pınarı Elbistan 1944" (2 specimens; SL: 73-85 mm). It is thought that the species was studied by Fahire Battalgazi in 1944, when it was caught.

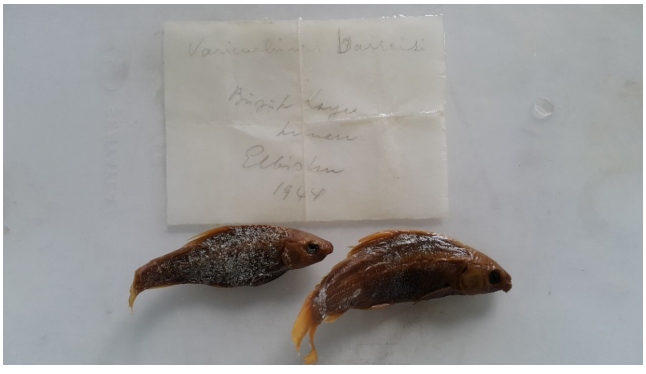

Figure 7. *Capoeta barroisi* caught from Elbistan in 1944 (uncatalogued).

The current name of the species whose name is written in Fig. 8 is *Carasobarbus luteus* (Heckel, 1843). Two labels came out of the jar. The big label says "*Systomus luteus*, Heckel Batman suyu VII 939 leg: Kosswig". The smaller label says, "Batman deresi" (1 specimen; SL: 132 mm). It is thought that the species was studied by Fahire Battalgazi in 1939 when it was obtained.

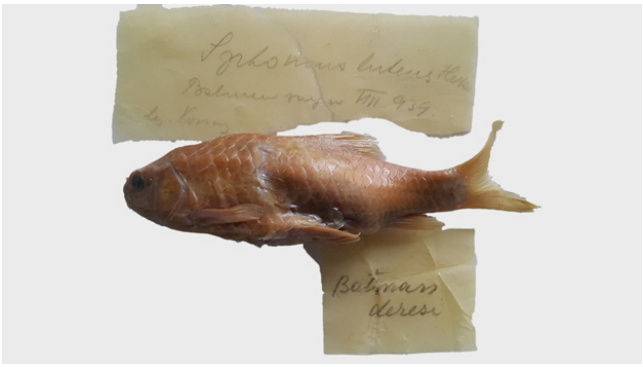

Figure 8. *Carasobarbus luteus* caught from Batman Creek in 1939 (uncatalogued).

The species seen in Fig. 9 is *Petroleuciscus borysthenicus*. The label only depicts the collection locality as "K. çekmece 2/XII/938" (4 specimens; SL: 27-45 mm). Battalgil (1941) examined *Petroleuciscus borysthenicus* samples from Emirgan and Küçükçekmece Lagoon. This information confirms that the samples were examined by Battalgil. Fish have one dorsal fin, and the number of lateral line scales is less than 40. In a study conducted about 50 years later (Meriç, 1986), it was determined that *P. borysthenicus* lived in the lake. Küçükçekmece is a lagoon lake and both marine and freshwater species together with brackish water species can survive there. *Petroleuciscus borysthenicus* can also survive in less saline waters (Geldiay & Balık, 2009). In a recent study, it was determined that the fish lives in the streams flowing into the Küçükçekmece lagoon (Özuluğ & Saç, 2019).

Figure 9. Label information of *P. borysthenicus* samples caught in Küçükçekmece Lagoon Lake in 1938 (uncatalogued).

The current name of the species in Fig. 10 is *Capoeta trutta* (Heckel, 1843). The fish has partially dried and deformed due to the evaporation of the protective liquid. Labels both outside and inside the jar are consistent with each other. The caption on the labels is "*Varicorhinus Trutta* Heckel Urfa 1939" (1 specimen; SL: 152 mm). It is thought that the species was studied by Fahire Battalgazi in 1939 when it was obtained.

Figure 10. *Capoeta trutta* caught from Şanlıurfa in 1939 (uncatalogued).

The label in Fig. 11 is typewritten and "*Vimba vimba* (Linne) Det. Fahire Battalgazi Yeşilirmak 1945" (1 specimen; SL: 142 mm). *Vimba vimba* (Linnaeus, 1758) was identified by Fahire Battalgazi from Yeşilırmak River.

Figure 11. *Vimba vimba* caught from Yeşilırmak in 1945 (uncatalogued).

Discussion

The samples were collected and identified by very important researchers of Turkey's science history. The names of researchers that obtained from the label information on

the jars in the collection are Prof. Ord. Curt Kosswig, Prof. Dr. Fahire Battalgazi, Prof. Recai Ermin, Dr. Fethi Akşıray and laboratory officer Hüseyin Gümrükçü. Unfortunately, because of the damaged or destroyed labels, not all the names were available and some had been lost. According to the labels presented in this study, several samples were collected by Prof. Dr. Fahire Battalgazi and some of them had likely been diagnosed by her.

The collection (IUFASFC) is preserved in the I.U. Faculty of Aquatic Sciences Department of Marine and Freshwater Resources Management laboratory. The species identification of the fish samples in these 250 jars still continues without damaging the labels and fish samples. This collection will give us important information about past and present change of inland fish biodiversity of Turkey.

However, in case that the biological material is well preserved, but the information about the material is inaccessible or poorly displayed, this collection cannot serve efficiently. Therefore, the labels of the samples are expected to be clear, and accurate. The collection derives its value not only from the fish species it has but also from its unique scientific labels.

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