

ORIGINAL ARTICLE

An updated geographical distribution of minnows (Teleostei: Leuciscinae) in Iran

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Abstract

The subfamily Leuciscinae, within Cypriniformes, consists of many species distributed widely in Eurasia. During numerous ichthyological field expeditions between 2015-2019, we collected the available species of this subfamily from different parts of Iran. Based on previous reports, and our field-collected material, the spatial distribution patterns of the Leuciscine taxa are described and mapped in the country. According to the results, the Iranian diversity of Leuciscinae consist of 42 species in 15 genera, which are distributed in 13 out of 19 Iranian drainage basins, with the highest diversity in the Caspian, Tigris and Urmia basins. We also documented the first occurrence of *Alburnoides holciki* and *Squalius turcicus* in the Caspian and Kavir basins, respectively. In addition, two new localities were discovered for *Alburnus hohenerkeri* and *Squalius turcicus* within the Esfahan and Caspian basins, respectively. The Iranian Leuciscine species are partly known; apart from the fact that their conservation status has been incompletely assessed, the known genetic, biological, ecological and distributional data on these species are also insufficient and systematic observations are needed for taking steps towards their conservation.

Keywords: Distribution pattern, Iranian drainage basins, Leuciscidae, New record.

INTRODUCTION

Freshwater ecosystems have lost a greater proportion of their biodiversity and habitats than terrestrial and marine ecosystems on land or in the oceans, and these faces increasing threats from dams, water withdrawals, pollution, invasive species and overharvesting (MEA 2005; Revenga et al. 2005). Distribution patterns of freshwater fishes could be affected by physical and chemical changes in river systems as well as biogeographic and evolutionary processes within freshwater fauna in general (Watanabe 1998). The Cypriniformes, currently with 23 families and over 4400 recognised species, is the most diverse groups of freshwater fishes with a large number of undescribed species predicted to be discovered (Nelson et al. 2016; Schönhuth et al. 2018; Fricke et al. 2023). Amongst the cyprinid families, Leuciscidae currently encompasses 694 recognised species in 92 genera, widely distributed in Europe, Asia, and North America (Kottelat & Freyhof 2007; Schönhuth et al. 2018; Fricke et al. 2023). The family

includes the subfamilies Laviniinae, Leuciscinae, Phoxininae, Plagopterinae, Pogonichthyinae and Pseudaspininae (Fricke et al. 2023). The most diverse subfamily Leuciscinae, with over 326 species in 38 genera, encompass the Eurasian genera (except those from India and Southeast Asia) and also the only known species in North America, *Notemigonus crysoleucas* (Mitchill, 1814) (Kottelat & Freyhof 2007; Schönhuth et al. 2018). The Leuciscine fishes, known as “minnows”, are morphologically distinguished based on a high number of vertebrae, pharyngeal teeth usually in two rows, and absence of barbels and maxillary foramen (Howes 1991; Nelson 2016).

The evolutionary history and patterns and processes of diversification within this subfamily, including the Iranian species, have always been a subject of discussion throughout its distributional range (Nelson 2006; Perea et al. 2010; Imoto et al. 2013; Schönhuth et al. 2018). According to several previous studies (Cavender 1991; Durand et al. 2002;

Perea et al. 2010), the subfamily Leuciscinae has originated in southwest Asia and subsequently colonized Europe through the Balkanian/Anatolian/Iranian landmass at the beginning of the Early Oligocene. They were later dispersed to other parts of Eurasia including the Circum-Mediterranean, Middle Eastern, and Ponto-Caspian regions, as well as North America through the Beringia land bridge. While, Imoto et al. (2013) proposed that an ancestral species of Leuciscinae was originated in Late Cretaceous (70.7 Mya), in Europe the divergence of the ancestral lineage of this subfamily occurred during in late Cretaceous to Paleocene. In addition, some lineages have spread from Europe, as a hotspot area, to other parts of the world such as North America. These then entered the Far East (East Asia) through the Beringia land bridge. However, recent molecular studies have reinforced the hypothesis of a close phylogenetic relationship between the North American and the Far Eastern Leuciscine species (Perea et al. 2010; Imoto et al. 2013; Schönhuth et al. 2018; Tao et al. 2019). Some material from the Iranian Leuciscine species were examined by Perea et al. (2010) and they clarified their phylogenetic placements within this subfamily. Furthermore, several Iranian authors have focused on a few species of this subfamily in their own studies (see Material and Methods). Meanwhile, a comprehensive study (first author's ongoing project and unp. data) has been carried out on the phylogenetic relationships and biogeographical patterns of the subfamily Leuciscinae in Iran (Pourshabanan et al. 2020, 2021, 2023).

The vast country of Iran, located in west Asia, is important from a biogeographical point of view, as it acts as the crossroad and dispersal corridor among several major biogeographical realms of the world. It shares the greatest number of fish species with the Palearctic region, however two other faunal realms, including Oriental and Afrotropical have a pronounced influence on its ichthyofauna. It is also part of the Irano-Anatolian biodiversity hotspot, and is located at the conjunction of different climatic zones. As a result of these factors, and also owing to a

complex palaeogeographical and palaeoecological conditions that have triggered speciation and extinction in the region, Iran is considered as a main center of freshwater fish diversity and endemism in west Asia, as well as a very interesting area for biogeographical and evolutionary studies in general (Coad 1998; Esmaeili et al. 2018). According to Eagderi et al. (2022), there are 19 drainage basins in Iran. The highest number of fish species is seen in the Caspian and Tigris basins. The Caspian basin includes both fresh and brackish habitats, including lakes, lagoons, marshes and rivers, which harbor a high diversity of fish species (Coad 2011; Esmaeili et al. 2010, 2017 & 2018; Pourshabanan et al. 2020, 2021, 2023; Zarei et al. 2022; Eagderi et al. 2022).

Various species, genera, families and orders have been listed for the Iranian freshwater ichthyofauna in the previous studies (Günther 1899; Berg 1949; Saadati 1977; Armantrout 1981; Coad 1988 & 1995; Esmaeili et al. 2010, 2017 & 2018; Eagderi et al. 2022). According to Eagderi et al. (2022), the most diverse order is Cypriniformes with 182 out of 292 species (i.e., ca. 63% of the freshwater ichthyofauna), and that the subfamily Leuciscinae encompasses 42 species in 15 genera. The reported genera include *Abramis*, *Acanthobrama*, *Alburnoides*, *Alburnus*, *Ballerus*, *Blicca*, *Chondrostoma*, *Leucaspius*, *Leuciscus*, *Pelecus*, *Petroleuciscus*, *Rutilus*, *Scardinius*, *Squalius* and *Vimba*. There are also some species whose presence in Iranian waters needs verification by specimens (Esmaeili et al. 2010 & 2018; Eagderi et al. 2022). In recent years, several species have been introduced manually from their native ranges to other areas. For example, *Alburnus hohenackeri* Kessler, 1877, which is native to the Caspian basin, has also been transferred to the Tigris, Hari River, Urmia, Sistan and Esfahan basins (Coad 2011; Zareian et al. 2013; Mohammadian-Kalat et al. 2017).

The present study aims to update the spatial distribution patterns of the Iranian genera and species of the subfamily Leuciscinae by providing maps and comments.

MATERIAL AND METHODS

In the present study, the distribution patterns of the Leuciscine fishes were mapped within 13 drainage basins in Iran. The localities shown on the maps are based on field-collected material from expeditions conducted by the authors between 2015-2019, as well as previous and recently published references (Saadati 1977; Armantrout 1980; Abbasi et al. 1999, 2005 & 2007; Abdoli 2000; Patimar et al. 2005; Ghasemi et al. 2007; Keyvanshokoo et al. 2007; Abbasi 2009; Pourkazemi et al. 2010; Teimori et al. 2010 & 2015; Esmaeili et al. 2010, 2016a-b, 2017 & 2018; Coad 2011; Abdolhay et al. 2012; Seifali et al. 2012; Zareian et al. 2013 & 2015; Mahboobi-soofiani et al. 2014; Kohestan-Eskandari et al. 2014; Ghoghji et al. 2015; Mousavi-Sabet et al. 2015a-c, 2016 & 2018; Mohammadian-Kalat et al. 2015 & 2017; Jouladeh-Roudbar et al. 2016; Khaefi et al. 2016; Keivany et al. 2016a-b; Eagderi et al. 2017, 2022; Mazandarani et al. 2018; Hedayati et al. 2018; Sattari et al. 2019; Pourshabanan et al. 2020, 2021, 2023).

The sampling was carried out using hand nets, hooks and electrofishing (voltage of 100-120 V). The specimens were fixed in 10% formaldehyde solution and deposited in the Zoological Museum, Ferdowsi University of Mashhad (ZMFUM), Iran. Species-level identifications were based on available taxonomic keys and primary taxonomic literature, e.g., Kottelat & Freyhof (2007), Coad (2011) and Keivany et al. (2016a). The distribution maps for the genera and species were originally constructed in Q-GIS 1.8.0 (Scherman et al. 2016).

RESULTS

Our new collections and previously published data show that the Iranian Leuciscine fishes are widely distributed in the northern, northwestern, western and southwestern basins of the country (13 basins; Fig. 1). The number of species in each of these 13 basins can be summarized as follows: the Caspian Sea and its rivers (20 species), Tigris River system (13 species), Urmia Lake basin (7 species), Esfahan and Kor River (4 species), Namak and Tedzhen River (Harirud or Hari River) (3 species), Hormuz, Kavir, Maharlu, Zohreh and Persis (2 species), and Sistan (1 species).

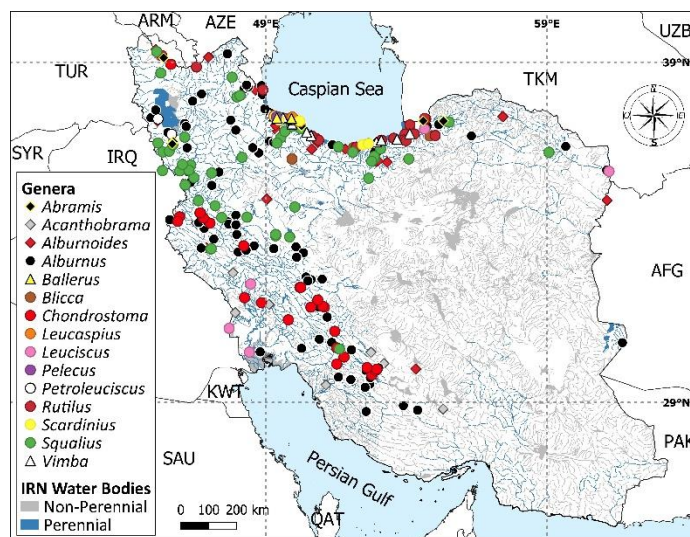


Fig.1. Geographic distribution of the subfamily Leuciscinae in Iran.

So far, no Leuciscine species have been reported from the Kerman-Na'in, Sirjan, Lut, Bedjestan, Jaz Murian, Mashkid and Makran basins (Fig. 1 & Table 1).

The geographical distribution of the Iranian Leuciscine species within each genus is mapped separately in Figures 2A-H. The results show that our sampling localities for the genera *Abramis*, *Acanthobrama*, *Alburnoides*, *Alburnus*, *Blicca*, *Chondrostoma*, *Leucaspis*, *Leuciscus*, *Rutilus*, *Scardinius* and *Vimba* are in agreement with the previous reports (Table 1). Here, we report the first occurrence of *Alburnoides holciki* Coad & Bogutskaya, 2012 from the Caspian basin and also the first occurrence of *Squalius turcicus* De Filippi, 1865 from the Kavir basin. In addition, specimens of *Squalius turcicus* and *Alburnus hohenackeri* were also collected from new localities inside some previously reported basins, e.g., *S. turcicus* from the Tabarak Abad Dam (Caspian basin), and *A. hohenackeri* from the Golpayegan Dam (Esfahan basin) (Figs. 2A-H & Table 1). Despite several attempts during different field trips, several Iranian Leuciscine species are absent from the newly material. These species include *Acanthobrama marmid*, *Alburnoides petrubaanescui*, *Ballerus sapa*, *Chondrostoma cyri*, *Chondrostoma orientale*, *Leuciscus latus*, *Pelecus cultratus* and *Petroleuciscus ulanus*. These taxa are listed and mapped in the present study based on previous records and comments (Figs. 1 & 2A-H; Table 1).

Table 1. Species list of the subfamily Leuciscinae in the Iranian drainage basins, along with the sampling locations in the present study. *=species that were not collected during the present study. 1, 3, 4= new records; 2, 5= new localities (these location codes correspond to those on Fig. 2).

Species	The reported drainage basin(s)	The location/province/basin in the present study	Coordinates
<i>Abramis brama</i>	Caspian/Urmia	Anzali Lagoon/Gilan/Caspian Mahabad Dam Lake/West Azerbaijan/Urmia	37°27'30.6"N 49°22'25.0"E 36°42'34.1"N 45°40'38.1"E
<i>Acanthobrama marmid</i> *	Tigris	Not found in the present study	-
<i>Acanthobrama microlepis</i>	Caspian	Qizil Uzan River/Zanjan/Caspian	37°04'11.4"N 48°38'01.1"E
<i>Acanthobrama persidis</i>	Kor River/Persis/Maharlu/Hormuz	Tang-e Boragh/Fars/Kor River	30°37'14.0"N 52°02'45.6"E
<i>Acanthobrama urmianus</i>	Urmia	Miriseh/West Azerbaijan/Urmia	36°29'55.1"N 45°33'54.3"E
<i>Alburnoides coadi</i>	Kavir	Namrud River/Tehran/Kavir	35°43'18.1"N 52°39'26.5"E
<i>Alburnoides damghani</i>	Kavir	Cheshmeh Ali Damghan/Semnan/Kavir	36°16'38.2"N 54°05'00.7"E
<i>Alburnoides eichwaldii</i>	Caspian	Marzabad/East Azerbaijan/Caspian Khoda Afarin/East Azerbaijan/Caspian Baliglu Chay River/Ardabil/Caspian	38°52'32.9"N 46°31'28.3"E 39°08'25.7"N 46°57'45.8"E 38°04'26.0"N 48°04'57.8"E
<i>Alburnoides holciki</i>	Hari River	Atrak River, Baba Aman/North Khorasan/Caspian 1 Saraks/Razavi Khorasan/Hari River	37°28'41.9"N 57°26'02.4"E 35°57'20.3"N 61°07'11.7"E
<i>Alburnoides idignensis</i>	Tigris	Dinavar/Kermanshah/Tigris	34°35'06.1"N 47°26'19.2"E
<i>Alburnoides namaki</i>	Namak	Shazand/Markazi/Namak	34°05'02.0"N 49°20'50.1"E
<i>Alburnoides nicolausi</i>	Tigris	Nurabad Stream/Lorestan/Tigris	34°03'33.7"N 47°58'19.3"E
<i>Alburnoides parhami</i>	Caspian	Baba Aman/North Khorasan/Caspian	37°28'41.9"N 57°26'02.4"E
<i>Alburnoides petrubanarescui</i> *	Urmia	Not found in the present study	-
<i>Alburnoides qanati</i>	Kor River	Tang-e Boragh/Fars/Kor River	30°37'14.0"N 52°02'45.6"E
<i>Alburnoides samiii</i>	Caspian	Fuman/Gilan/Caspian Qaleh Gardan/Mazandaran/Caspian	37°13'42.5"N 49°20'36.5"E 36°45'33.4"N 50°49'58.3"E
<i>Alburnoides tabarestanensis</i>	Caspian	Tajan River/Mazandaran/Caspian	36°33'51.3"N 53°05'06.9"E
<i>Alburnus atropatenae</i>	Urmia	Qureh Darreh/Kurdestan/Urmia Mahabad Dam River/West Azerbaijan/Urmia Yadegarlu/West Azerbaijan/Urmia Miriseh/West Azerbaijan/Urmia	36°07'15.5"N 46°02'09.3"E 36°40'44.1"N 45°41'23.6"E 37°01'50.6"N 45°31'18.5"E 36°29'55.1"N 45°33'54.3"E
<i>Alburnus caeruleus</i>	Tigris	Goleyn River/Kermanshah/Tigris	34°14'20.1"N 45°59'11.2"E
<i>Alburnus chalcoides</i>	Caspian	Sefidrud River/Gilan/Caspian Babolrud River/Mazandaran/Caspian	36°59'04.6"N 49°57'51.4"E 36°39'21.6"N 52°38'22"E
<i>Alburnus doriae</i>	Esfahan/Namak/Tigris	Dimeh/Chaharmahal and Bakhtiari/Tigris Khamiran Dam Lake/Esfahan/Esfahan	32°30'33.6"N 50°14'35.4"E 32°45'26.6"N 51°00'14.2"E
<i>Alburnus hohenackeri</i>	Caspian/Tigris/Hari River/ Urmia/Sistan/Esfahan	Annarbar River, Golpayegan Dam /Esfahan 2 Saraks/Khorasan Razavi/Hari River	33°24'37.3"N 50°05'46.6"E 35°57'20.3"N 61°07'11.7"E
<i>Alburnus sellal</i>	Tigris/Zohreh/Persis/Hormuz/Esfahan/Maharlu/ Kor River	Tange Boragh/Fars/Kor River Doruhah/Kohgiluyeh and Boyer-Ahmad/Tigris Do Polan/Chaharmahal and Bakhtiari/Tigris Gamasiab River/Hamadan/Tigris Sarab-e Yavari/Kermanshah/Tigris Garan Dam River/Kurdistan/Tigris	30°37'14.0"N 52°02'45.6"E 30°50'57.5"N 51°20'31.6"E 31°54'59.4"N 50°36'13.2"E 34°22'10.0"N 47°56'10.0"E 34°28'33.4"N 46°54'52.4"E 35°35'57.0"N 46°18'54.5"E
<i>Alburnus zagrosensis</i>	Tigris	Aghbolagh River/Chaharmahal and Bakhtiari/Tigris Bazoft River/Chaharmahal and Bakhtiari/Tigris	31°43'50.2"N 51°13'58.6"E 32°23'47.0"N 49°50'48.0"E

Table 1. Continued.

<i>Ballerus sapa</i> *	Caspian	No sample in the present study	-
<i>Blicca bjoerkna</i>	Caspian	Anzali Lagoon/Gilan/Caspian	37°27'30.6"N 49°22'25.0"E
<i>Chondrostoma cyri</i> *	Caspian	No sample in the present study	-
<i>Chondrostoma esmaeili</i>	Tigris	Sarab-e Ravansar/Kermanshah/Tigris	34°42'31.6"N 46°39'08.2"E
<i>Chondrostoma orientale</i> *	Kor River	No sample in the present study	-
<i>Chondrostoma regium</i>	Tigris/Zohreh/Esfahan	Dimeh/Chaharmahal and Bakhtiari/Tigris Shah Mokhtar/Kohgiluyeh and Boyer-Ahmad/Tigris	32°30'33.6"N 50°14'35.4"E 30°40'47.3"N 51°31'44.3"E
<i>Leucaspius delineatus</i>	Caspian	Anzali Lagoon/Gilan/Caspian	37°27'30.6"N 49°22'25.0"E
<i>Leuciscus aspius</i>	Caspian	Aras Dam Lake/West Azerbaijan/Caspian Anzali Lagoon/Gilan/Caspian	39°09'46.0"N 45°17'28.4"E 37°28'53.7"N 49°19'33.1"E
<i>Leuciscus latus</i> *	Hari River	No sample in the present study	-
<i>Leuciscus vorax</i>	Tigris	Hawizeh Marshes/Khuzestan/Tigris Shadegan Pond/Khuzestan/Tigris	31°17'35.0"N 47°44'29.3"E 30°35'42.0"N 48°33'44.6"E
<i>Pelecus cultratus</i> *	Caspian	No sample in the present study	-
<i>Petroleuciscus ulanus</i> *	Urmia	No sample in the present study	-
<i>Rutilus lacustris</i>	Caspian	Anzali Lagoon/Gilan/Caspian Aras River/East Azerbaijan/Caspian	37°30'13.1"N 49°17'40.6"E 38°52'02.5"N 46°32'06.8"E
<i>Rutilus frisii</i>	Caspian	Anzali Lagoon/Gilan/Caspian	37°27'30.6"N 49°22'25.0"E
<i>Scardinius erythrophthalmus</i>	Caspian	Anzali Lagoon/Gilan/Caspian	37°29'13.1"N 49°19'40.6"E
<i>Squalius berak</i>	Tigris	Gavehroud/Kermanshah/Tigris Dinavar/Kermanshah/Tigris Boeen-e Sofla/Kurdestan/ Tigris	34°55'34.5"N 47°12'00.9"E 34°34'50.0"N 47°25'57.3"E 35°56'08.3"N 45°56'30.4"E
<i>Squalius lepidus</i>	Tigris	Palangan/Kurdistan/Tigris	35°04'17.5"N 46°36'08.0"E
<i>Squalius namak</i>	Namak	Esken/Markazi/Namak Cheshmeh Bolagh/Markazi/Namak Jalayer/Markazi/Namak	34°05'02.0"N 49°20'50.1"E 34°00'38.0"N 49°50'51.0"E 34°53'14.9"N 50°02'05.5"E
<i>Squalius turcicus</i>	Caspian/Urmia	Shipanju/Kurdestan/Urmia Qureh Darreh/Kurdestan/Urmia Miriseh/West Azerbaijan/Urmia Mahabad Dam/West Azerbaijan/Urmia Qarquluq-e Olya/West Azerbaijan/Caspian Baliglu Chay River/Ardabil/Caspian Saravan/Gilan/Caspian Kashpel/Mazandaran/Caspian Galeshkola/Mazandaran/Caspian Namrud River/Tehran/Kavir 3 Cheshmeh Ali Damghan/Semnan/Kavir 4 Tabarak Dam/Razavi Khorasan/Caspian 5	35°57'18.8"N 46°15'42.8"E 36°07'15.5"N 46°02'09.3"E 36°29'55.1"N 45°33'54.3"E 36°40'44.1"N 45°41'23.6"E 39°17'22.3"N 45°07'07.3"E 38°04'26.0"N 48°04'57.8"E 37°03'42.5"N 49°40'34.6"E 36°28'22.1"N 52°05'46.1"E 36°12'28.8"N 52°45'53.9"E 35°43'18.1"N 52°39'26.5"E 36°16'38.2"N 54°05'00.7"E 37°06'29.3"N 58°36'48.7"E
<i>Vimba persa</i>	Caspian	Anzali Lagoon/Gilan/Caspian	37°30'28.0"N 49°18'39.6"E

DISCUSSION

Here, we described and mapped the current distribution of the subfamily Leuciscinae in Iran. The reported fishes include 15 genera and 42 species, distributed in 13 out of 19 drainage basins of Iran.

The northern, northwestern and western basins, i.e., the Caspian, Urmia and Tigris basins, harbor the highest diversity of the Leuciscine in Iran. The other 10 basins from different parts of Iran showed lower levels of Leuciscine diversity (Figs. 1 & 2A-H; Table

1). Our newly collected material confirmed the presence of previously reported species from these basins. In addition, we documented the first occurrence of *Alburnoides holciki* and *Squalius turcicus* in the Caspian and Kavir basins, respectively.

It should be noted that Jouladeh-Roudbar et al. (2020) have also mapped the presence of *A. holciki* in the Caspian basin but they did not present any material; they also did not mention to the presence of *S. turcicus* in the Kavir basin.

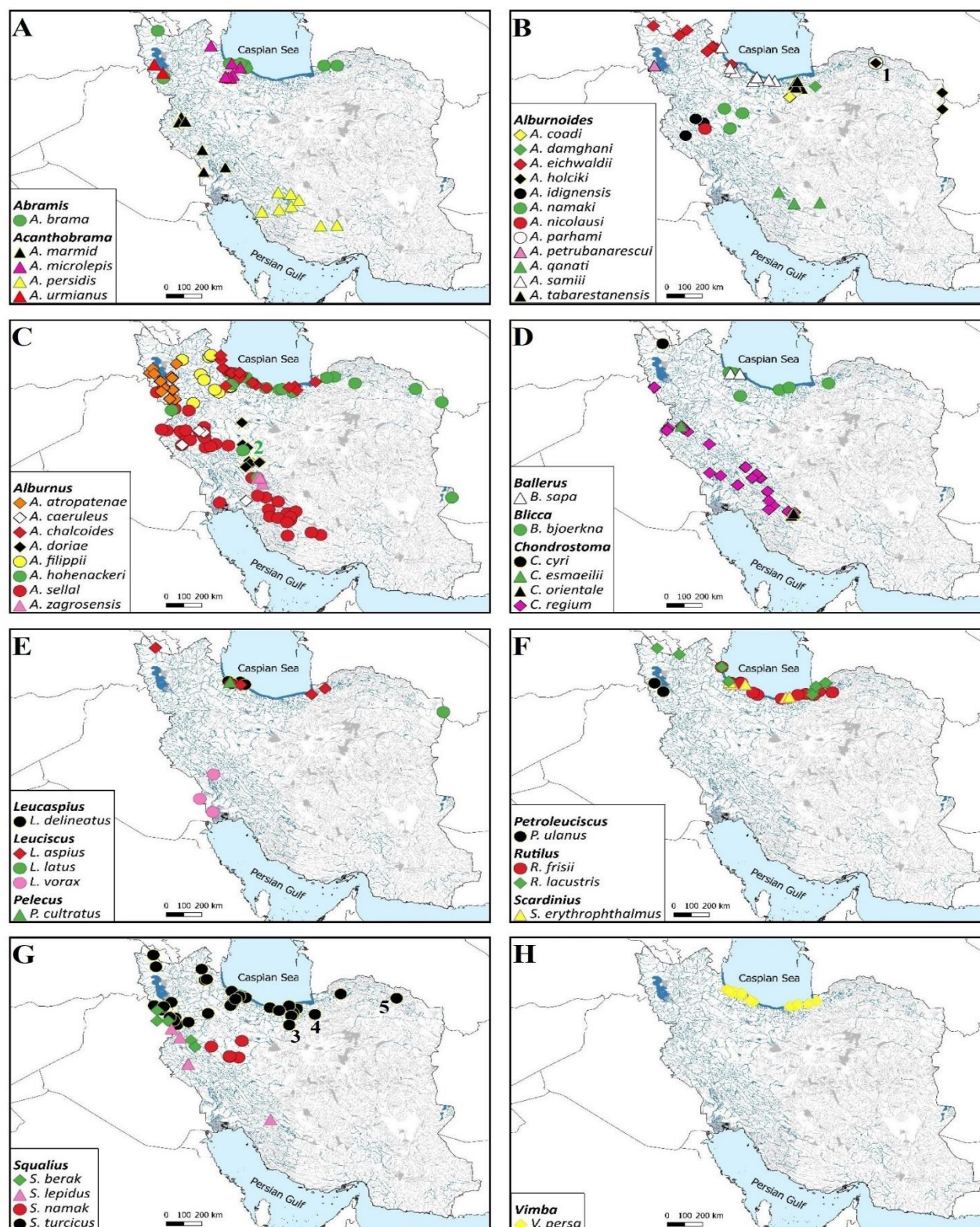


Fig.2. Geographic distribution of the Iranian Leuciscine species by genera. A: *Abramis* and *Acanthobrama*. B: *Alburnoides*; 1= new record of *A. holciki* in the Caspian basin. C: *Alburnus*; 2= new locality of *A. hohenackeri* in the Esfahan basin. D: *Ballerus*, *Blicca* and *Chondrostoma*. E: *Leucaspis*, *leuciscus*, and *Pelecus*. F: *Petroleuciscus*, *Rutilus*, and *Scardinius*. G: *Squalius*; 3, 4= new records of *S. turcicus* in the Kavir basin, 5= new locality record for *S. turcicus* in the Caspian basin. H: *Vimba*. The location codes correspond to those in Table 1.

Furthermore, new localities for *S. turcicus* and *Alburnus hohenackeri* were also documented within the Caspian and Esfahan basins, respectively.

The type locality of *A. holciki* is the Hari River in Herat, Afghanistan. It is also found in Uzbekistan, Western Tajikistan, the Hari River basin in Iran, as well as in Southern Turkmenistan (Coad & Bogutskaya 2012; Fricke et al. 2023). Surprisingly, we collected this species from both the Hari River and the Caspian basins in Iran (Fig. 2B & Table 1). According to Coad & Bogutskaya (2012), the type material of *A. holciki* show both morphological similarities and differences with the samples from the Atrak River in Turkmenistan and the Kashaf River in Iran. The Atrak River is a border river between Iran and Turkmenistan and this species has been reported from Southern Turkmenistan (Coad & Bogutskaya 2012; Fricke et al. 2023). Therefore, it can be hypothesised that our material from the Atrak River in the Caspian basin, has penetrated to Iran from Turkmenistan. It should be noted that Mousavi-Sabet et al. (2015) morphologically described *Alburnoides parhami* from the same locality (Baba Aman Stream, Atrak River drainage, North Khorasan Province), which the Eschmeyer's Catalog of Fishes (Fricke et al. 2023) currently considers it as a junior synonym of *A. holciki* based on a checklist by Jouladeh-Roudbar et al. (2020), although the authors did not provide any justification or discussion for their taxonomic decision. Hence, more morphological and phylogenetic studies are needed to compare both species and also the *A. holciki* populations from the Hari River and the Caspian basins in Iran. Khaefi et al. (2016) demonstrated that the congeneric *Squalius* species in Iran are distributed within three drainage basins: *S. berak* and *S. lepidus* in the Tigris basin and *S. turcicus* in the Caspian and Urmia basins. The *Squalius* material from the Kavir basin, including the Nam River (Tehran Province) and Cheshmeh Ali Damghan (Semnan Province) belong to *S. turcicus*, where this species has not been previously recorded. Furthermore, we identified an unreported population of *S. turcicus* in the eastern part of the Tabarak Dam

in the Razavi Khorasan Province. The Atrak River headwaters are close to those of the Hari River basin (Esmaeili et al. 2017) and it will be interesting to study the possible presence of this species in the Hari River basin.

Alburnus hohenackeri, which is native to the Caspian basin, has been introduced to the Tigris, Hari River, Urmia, Sistan, Esfahan (and possibly, Makran) basins along with exotic Chinese carps, *Hypophthalmichthys molitrix*, *H. nobilis* and *Cyprinus carpio* (Abdoli 2000; Coad 2011; Zareian et al. 2013; Mohammadian-kalat et al. 2015). According to Coad (2011), this species has been introduced to the Zayandeh River in the Esfahan basin. However, the *A. hohenackeri* specimens in this study were recorded in the Anaarbar River (Golpayegan Dam) as a new locality record for this species.

Eight out of 42 Leuciscinae species distributed within 13 Iranian basins including *Acanthobrama marmid*, *Alburnoides petrubanarescui*, *Ballerus sapa*, *Chondrostoma cyri*, *Chondrostoma orientale*, *Leuciscus latus*, *Pelecus cultratus* and *Petroleuciscus ulanus*, were not collected during the present study, which might be related to the ambiguous taxonomic status of most of these species in Iran (Coad 2011; Esmaeili et al. 2018). Teimori et al. (2015), based on a molecular study by Perea et al. (2010), have explained the close phylogenetic affinity of *Acanthobrama persidis* from the Kor and Persis basins to the *A. marmid* from the Tigris basin. Therefore, a detailed morphological and molecular analysis on the presence of *A. marmid* in Iran remains of interest. The type material of *Alburnoides petrubanarescui* Bogutskaya & Coad, 2009 was originally collected from Qasemlou Chay (West Azerbaijan Province) in the Urmia Lake basin. However, this species has not been recently collected by other authors, which may indicate population decline or extinction (Mousavi-Sabet et al. 2015; Jouladeh Roudbar et al. 2016).

Chondrostoma cyri has recently been studied by Jouladeh-Roudbar et al. (2016) from the Aras River, but we were not able to collect it with new material. The distribution range of *C. orientale* is limited to the Kor River basin and many attempts have failed to

collect it over the last 15 years. This is a rare species, with only three specimens having been collected in 2005, and it is sometimes regarded as a synonym of *C. regium* (Sayyadzadeh & Jouladeh- Roudbar 2014; Eemaيلي et al. 2018).

The presence and taxonomic status of *L. latus* in Iran has always been a subject of discussion. Due to previous reports of this species from Afghanistan (Coad 2015) and Turkmenistan (Fet & Atamuradov 2012), the possibility of its presence in Iranian waters has been suggested by several authors (Saadati 1977; Armantrout 1981; Coad 1980, 1998 & 2011). However, no record of this species has been reported from Iranian waters so far (see Coad 2011; Yazdani-Moghaddam et al. 2015; Jouladeh-Roudbar et al. 2016; Mousavi-Sabet et al. 2018; Pourshabanan et al. 2021). The genus *Ballerus* might be invalid generic name for the Iranian species, as it has never been reported in the recent decades in Iran, and further integrative studies are needed to clarify this issue. In the present study similar to Mohammadian-Kalat et al. (2017), the specimens morphologically assigned to *Petroleuciscus esfahani* from the Esfahan basin, were genetically clustered with the *Alburnus* clade. However, *P. ulanus* has been reported as a valid species from Iran (Esmaيلي et al. 2018; Mouludi-Saleh et al. 2022; Eagderi et al. 2022). The species *Pelecus cultratus* has been collected from the Bandar Anzali's shore a few years ago (K. Abbasi's personal communication), but no recent study has confirmed its presence in the Iranian waters by specimens. With the clarification of the taxonomic status of these species and genera in the future, a more detailed overview of their distribution range can also be provided. For example, Eagderi et al. (2019) indicated that *Alburnus zagrosensis* should be treated as a junior synonym of *A. sellal*. Further taxonomic and geographic examination of the Iranian Leuciscinae genera and species remains of interest.

Our results also confirmed that, so far, no Leuciscine species has been reported from the Kerman-Na'in, Sirjan, Lut, Bedjestan, Jaz Murian, Mashkid and Makran basins (Pourshabanan et al. 2020, 2021, 2023). It is worth mentioning that the

natural distribution of species may be affected by both ecological and historical factors. Iran is located at the intersection of three climatic zones: the Mediterranean, the arid West Asian, and the temperate humid/semi-humid Caspian zones. However, it is located mostly in an arid environmental zone. In addition, most of the perennial waterbodies are located in the western and northern parts of the country (Esmaيلي et al. 2017), which have provided suitable habitats for diversification and living of freshwater fish. In contrast, the dry and semi-arid areas and wide deserts in the other parts of Iran, mainly include non-perennial waterbodies and seasonal rivers. Furthermore, severe recent droughts, water abstraction for agriculture, pollution of rivers and waterbodies, and emergence and spread of parasites and pathogens, compounded by climate change, have become serious threats to the freshwater fish in these already threatened dry and semi-arid areas (Sayyadzadeh & Jouladeh- Roudbar 2014; Keivany et al. 2016a).

From an historical and evolutionary point of view, Berg (1949) and Coad (1996) have suggested that the Middle Eastern freshwater ichthyodiversity is diverged from the Euro-Mediterranean (Palearctic) ichthyofauna. This was investigated by Durand et al. (2002) and Perea et al. (2010) and they concluded that all Leuciscine lineages sampled in the Middle East also occurred in the Euro-Mediterranean region. Based on their conclusion, we may hypothesize that the Leuciscine species found in western Iran have originated from the Euro-Mediterranean region and subsequently dispersed to the Tigris and Urmia basins and other adjacent areas. In addition, different nuclear and mitochondrial DNA markers have been recently employed to test this hypothesis (A. Pourshabanan's unpub. data). However, other historical and biogeographic factors such as tectonics and the formation of the Zagros and Alborz mountains that have shaped the current hydrographic basins of Iran, need to be considered to uncover the patterns and processes of diversification and distribution of Leuciscine fishes in the region (Wiens 2011; Mohammadian-Kalat et al. 2017).

The Iranian Leuciscine species are partly known; apart from the fact that their conservation status has been incompletely assessed, the known genetic, biological, ecological and distributional data on these species are also insufficient and systematic observations are needed for taking steps towards their conservation.

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مقاله کامل

پراکندگی جغرافیایی بروز شده قنات ماهیان (ماهیان استخوانی، زیر خانواده Leuciscinae) در ایران

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چکیده: زیر خانواده قنات ماهیان در راسته کپور ماهی سانان، شامل طیف وسیعی از گونه ها بوده که به طور گسترده در اوراسیا پراکنده شده اند. در طی فعالیتهای میدانی ماهی شناسی متعدد بین سال های ۱۳۹۵ تا ۱۳۹۸، گونه های موجود از این زیر خانواده از نقاط مختلف حوضه های آبریز ایران صید و جمع آوری گردید. بر پایه مطالعات و گزارش های قبلی و همچنین نمونه های صید شده در مطالعه حاضر، الگوی پراکنش مکانی گونه های این زیر خانواده در ایران توصیف و روی نقشه به نمایش درآمد. بر این اساس، اعضای این زیر خانواده شامل ۱۵ جنس و ۴۲ گونه بوده که در ۱۳ حوضه از ۱۹ حوضه آبریز ایران به ترتیب با بیشترین تنوع گونه ای در حوضه های خزر، دجله و ارومیه یافت می شوند. در این مطالعه همچنین برای اولین مرتبه حضور گونه *Alburnoides holciki* در حوضه خزر و گونه *Squalius turcicus* در حضور کویر گزارش گردید. علاوه بر این، دو مکان جدید و قبلاً گزارش نشده برای گونه های *Alburnus hohenerkeri* و *Squalius turcicus* به ترتیب در حوضه های آبریز اصفهان و خزر به ثبت رسید. در ایران گونه های این زیر خانواده تا حدودی شناخته شده هستند و نیازهای اکولوژیک و زیستگاهی آنها باید برای ارزیابی حفاظتی مورد بررسی قرار گیرد و بنابراین نیاز به توجه و مطالعه بیشتر در مورد جغرافیای زیستی تاریخی و پراکنش گونه ها می باشد.

کلمات کلیدی: الگوی پراکندگی، حوضه های آبریز ایران، Leuciscidae، ثبت جدید.