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An updated checklist of fishes of the Caspian Sea basin of Iran with a note on their zoogeography

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Abstract: Although the Southern Caspian Sea basin (SCSB) fish fauna has been studied for more than 200 years, new species continue to be discovered, reported and renamed. Here we take the opportunity to provide a new and updated checklist of the fishes of the southern Caspian Sea basin. The list is based on historical literature records and taxon occurrence data obtained from natural history collections and new fish collections. A total of 119 species belong to 63 genera, 18 families, 16 orders and two classes are listed. Exotic fishes comprise 19 species in seven families. The number of species is higher than two published checklists in 1988 (74 species and 42 genera) and in 2010 (116 confirmed species belonging to 61 genera and 18 families). The fish taxa were classified into four major groups based on the fish origin, ecoregion and ecological factors (tolerance to salt water and mode of life). Two species were new to science described since 2010, the taxonomic status of some species has been changed and some subspecies has got full specie rank. In general, the ancient origins of the south Caspian Sea (being part of Paratethys basin), the role of closing of the Tethys Sea, being important glacial refugia and colonization sources, long history of connection and isolation from fresh and marine waters, multiple sources of species, wide latitudinal extent, uneven distribution of inflows and nutrient inputs, and low to moderate salinity, different habitat types (both fresh and brackish habitats, rivers, lakes, lagoons, marshes, and marine environments), have all contributed to the high ichthyodiversity of the southern Caspian Sea basin.

Keywords: Fish diversity, Biogeography, Ichthyogeography, Ecoregion, Ponto-Caspian region, Paratethys, Iran.

Introduction

The Iranian plateau is located in the Palearctic region bordering the Oriental and African zones (Coad & Vilenkin 2004). However, based on its ichthyofauna composition, the Iranian plateau borders the Eastern Mediterranean (Western-Palearctic), the Southern Asian (Indo-Oriental) and the Ethiopian regions (Nalbant & Bianco 1998; Coad 1998). The geology of Iran suggests rapid isolation of multiple areas from one another. Extensive indentation of the Arabian plate into the Iranian plate starting 10 million years ago (Dercourt et al. 1986) caused uplifting of the Zagros mountains at the southern edge of the Iranian plate. Continued northeastern movement of the Arabian plate and a northerly movement of India resulted in additional mountain building by 5 million years ago along the northern edge of the Iranian plateau as well as along the sutures of the Iranian,

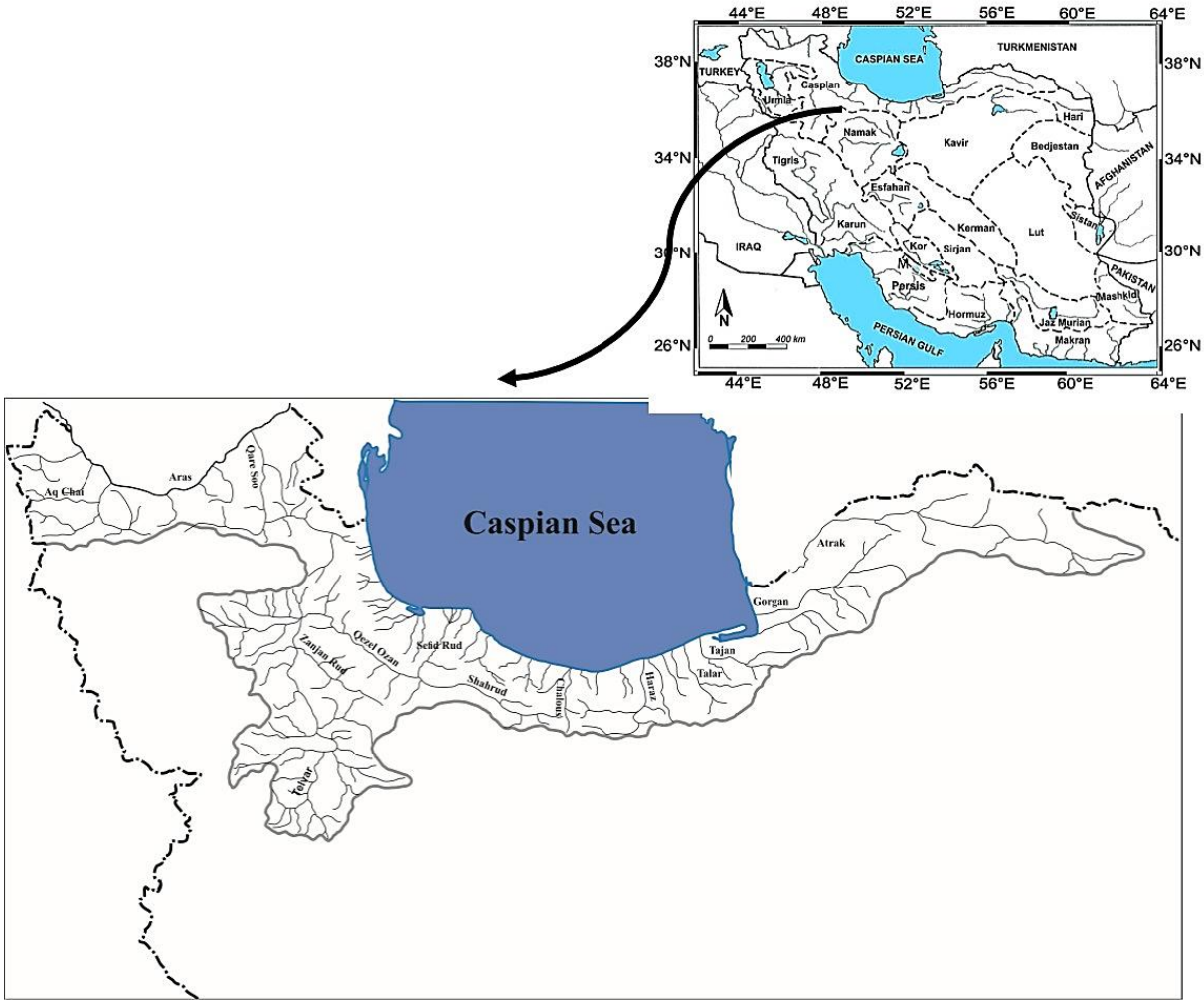

Fig.1. Map of Iran showing 19 Iranian basins and major rivers of the southern Caspian Sea basin. M, in the map of Iran shows Maharlu Lake basin.

Lut, and Helmand plates, making different drainage basins (Fig. 1). These events have affected the gene flow of different populations present in this area and have provided preliminary population isolations, promoting speciation and causing high ichthyodiversity in Iran.

Coad (1988) listed 155 species in 67 genera, 24 families, 15 orders and 3 classes found in 19 drainage basins of Iran. He reported the greatest diversity in the southern Caspian Sea basin comprising 74 species and 42 genera followed by Tigris basin with 54 species and 28 genera. These are large basins with diverse habitat and connection to a brackish or marine environment (Coad 1988) which provide such high diversity. Twenty years later, Esmaeili et al. (2010a) listed the freshwater fishes of Iran and confirmed the presence of 202 species in 104 genera, 28 families, 17 orders and 3 classes in 19 basins which is obviously higher than those listed by Coad (1988). They also reported 23 species whose presence in Iranian waters needed confirmation by specimens.

Accordingly, it can be expected that endorheic and exorheic basins of Iran represent higher diversity of freshwater fish species i.e. approximately 222 species or more (Abdoli 2000; Coad & Vilenkin 2004; Esmaeili et al. 2007, 2010a,b, 2011, 2013a,b, 2014a-d; Kamangar et al. 2014; Teimori et al. 2010, 2012, 2014; Abdoli et al. 2014; Alavi-Yeganeh et al. 2014; Gholami et al. 2014), which is considerably

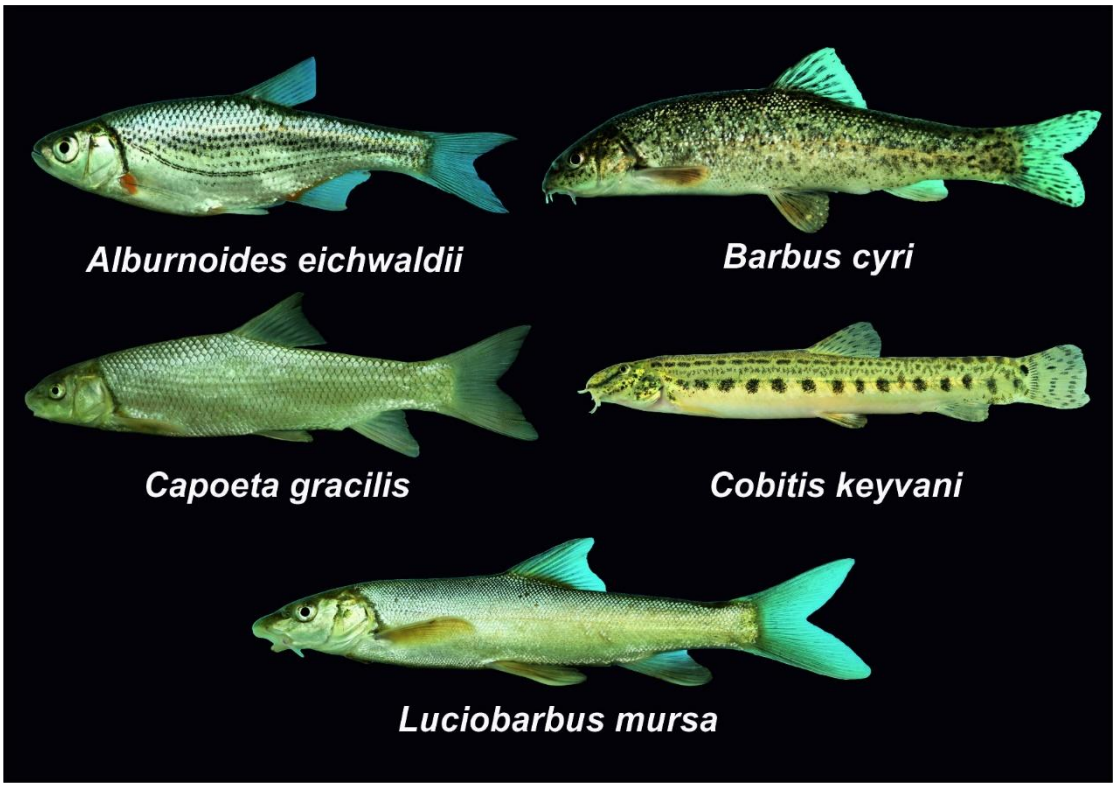

Fig.2. Some native fishes of the southern Caspian Sea basin.

higher than that given in the last checklist provided by Coad (1988) and Esmaeili et al. (2010a).

Based on Esmaeili et al. (2010a), the greatest diversity is seen in the southern Caspian Sea basin (Fig. 1) which is a part of a highly diverse area of Paratethys basin (see Naseka & Bogutskaya 2009; Fig. 2) comprises both fresh and brackish rivers lakes, lagoons, marshes and marine environments and has had a long history of connection and isolation from fresh and marine waters. Until 2010, 116 confirmed species belonging to 61 genera and 18 families were reported from the southern Caspian Sea basin of Iran. Being part of the Palearctic, the ichthyofauna of the southern Caspian Sea has been of great importance for modern biological research. A wide range of articles are now being published on the biology, biogeography and genetic variation of freshwater fishes of Iran including southern Caspian Sea basin. Hence, providing an updated checklist and an accurate use of fish scientific names is essential to communicate research results effectively.

This paper presents an updated checklist of freshwater fishes from Iranian part of the southern Caspian Sea basin (Fig. 1) including endemics, exotics and transplanted species, with notes on their taxonomy and zoogeography. The online "Catalog of Fishes" at the California Academy of Sciences provides summary taxonomic conclusions on generic placement and species validity, references for these conclusions, and type localities for synonyms mentioned in the present list. The synonyms given are those recently used in Iran and do not include those dating from the early twentieth and nineteenth centuries (see Coad (1995, 2014); Esmaeili et al. (2010a) for a fuller treatment of names).

Materials and methods

The Caspian Sea (Darya-ye Khazar, Darya-ye Mazandaran) basin is here taken to include both the rivers draining to that Caspian Sea and the Sea itself within Iranian territorial waters (Fig. 1). Zakeri (1997) records 864 small and large rivers with a catchment of 193,161 km^2. Some major river systems of the southern Caspian basin of Iran (see Coad 2014; Dolukhanov et al. 2009) from west to east are:

I) Aras River: Aras (= Araxes or Araks is a tributary

of the Kura River of Azerbaijan) in the west. The main tributaries of the Aras in Iran are the Qareh Su (= black water, draining easily eroded, volcanic soil) draining from the Sabalan mountain at 4810 m (38°15'N, 47°49'E) near Ardabil (38°15'N, 48°18'E), and the Qotur River draining past Zaki mountain at 3079 m on the Turkish border through Khvoy (38°33'N, 44°58'E) to the Azerbaijan border near Jolfa (38°57'N, 45°38'E).

II) Safidrud: Safidrud (= Sefid or White from its sediment load, up to 60 g/l), is the only river that completely pierce the Alborz Mountains and has a considerable basin (54,100 km^2) on the plateau. The Safidrud has the greatest mean discharge of Iranian Caspian Rivers. The Safidrud is formed from Qezel Owzan River from the west and Shahrud (River) from the east, which meet on the plateau and flow through a narrow gorge. The headwaters of Qezel Owzan lie in Kordestan, near the Iraqi border, and so drain part of the northern Zagros Mountains as well as areas near Lake Orumiyeh (Urmia) such as the Sahand mountain (37°44'N, 46°27'E), mountains near Hamadan (34°48'N, 48°30'E) and the southern slopes of the Alborz Mountains. The Shahrud is much shorter (ca. 175 km) than Qezel Owzan and drains the southern Alborz as far east as Takht-e Soleyman at 4819 m (36°22'N, 50°58'E).

III) Chalus River: It is situated completely at mountainous region and its head has sprung over the four hundred meters height in centeral Alborz famous to Kandevan. The main branches of Chalus River are Kandevan, Elia and Angoran.

IV) Haraz River: The Haraz (or Heraz) River drains the Alborz mountains east of Tehran and has a number of longitudinal tributaries in the mountains. Lar and Noor are two main tributaries of the Haraz, which join together making main Haraz receiving few small tributaries near Amol city and drains to Caspian Sea. It is about 185 km with a catchment area of about 5100 sq km.

V) Talar River: This river is located almost on the south east of Caspian Sea, in Ghaemshahr city of Mazandaran Province, Iran. Tuji, Tajon, Kesselian, Bezla, and Cherat are tributaries of the Talar River. It is about 140 km with a catchment area of about 4700 km^2.

VI) Tajan or Tadjan River (=Garmabrud): Tajan River is among the major rivers of Caspian Sea basin. It is about 147 km with a catchment area of about 2800 sq Km. This river originates from Hezarjarib and Poshtcouh mountains and is comprised of three main streams of Tajan, Zaromrud and Sefidrud.

VII) Gorgan and Atrak or Atrek (ancient Sarnois) river drainages are in the south-eastern corner of the Caspian (Fig. 1). Their courses are roughly east-west and parallel each other with the Atrak forming part of the border with Turkmenistan. The Qareh Su (= Gharesoo) and Madarsoo are two tributaries of Gorgan River. Gorgan River is about 253 km with a catchment area of about 13200 sq km. Atrak river is a fast-moving river which begins in the mountains of Northeastern Iran (37°10′N 59°′ E, 37.167°N 59°E), and flows 563 km westward draining into the southeastern corner of the Caspian Sea. The Atrak headwaters are close to those of the Harirud (Tedzhen) basin. Its catchment area in Iran is about 22300 km^2. Sumbar, Aqband, Garmab, Samlaqan, Tebarak, Babaaman, Shirindareh, Khartot are some of its tributaries.

This checklist has been compiled from the works listed in the references (see the references) and also by examination of ichthyological collections in Iran (e.g., ZM_CBSU, Zoological Museum of Shiraz University, Collection of Biology Department, Shiraz; CMNFI, Canadian Museum of Nature, Ottawa; BMNH, Natural History Museum, London) and extensive field expeditions till 2014 from different river systems of the southern Caspian Sea basin (Fig. 1). Fish taxa are classified according to their tolerance to salt water and mode of life to Fluvial, Aanadromous, Semi-anadromous, Estuarine and Marine following Naseka & Bogutskaya (2009). The species are listed alphabetically within the families, which have been arranged according to Nelson (2006) exept those which have been explained.

Table 1. Exotic fishes of the southern Caspian Sea basin. E= exotic; *= established; NC= not confirmed.

Order	Family	Species	Status
Anguiliformes	Anguilidae	*Anguilla anguilla*	E*
Cypriniformes	Cyprinidae	*Carassius auratus*	E*
		Carassius gibelio	E*
		Ctenopharyngogon idella	E
		Cyprinus carpio	E*
		Hemiculter leucisculus	E*
		Hypophthalmychthys molitrix	E
		Hypophthalmychthys nobilis	E
		Mylopharyngodon piceus	E
		Pseudorasbora parva	E*
Mugiliformes	Mugilidae	*Chelon aurata*	E*
		Chelon saliens	E*
		Mugil cephalus	E
Cyprinodontiformes	Poeciliidae	*Gambusia holbrooki*	E*
Gasterosteformes	Gasterosteidae	*Gasterosteus aculeatus*	E*
Gobiiformes	Gobiidae	*Rhinogobius* sp.	E
Pleuronectiformes	Pleuronectidae	*Platichthys flesus*	E, NC

Results

The total confirmed and recently not confirmed freshwater fish species of the southern Caspian Sea basin comprise 119 species in 63 genera, 18 families, 16 orders and 2 classes. The most diverse order is Cypriniformes with 45 species or 37.81% of the Southern Caspian Sea ichthyofauna, followed by Gobiiformes (37 species, 31.09%), Clupeiformes (10 species, 8.40%), Acipenseriformes (6 species, 5%), Salmoniformes (5 species, 4.2%), Mugiliformes and Perciformes each with 3 species (each, 2.5%) and Gasterosteiformes (2 species, 1.7%). Eight orders have only one species including Petromyzontiformes, Anguilliformes, Siluriformes, Esociformes, Gadiformes, Atheriniformes, Cyprinodontiformes and Syngnathiformes (each, 0.84%).

The most diverse family is Cyprinidae with 35 confirmed species (29.41%) followed by Gobiidae with 19 confirmed species (15.97%), Clupeidae (8 confirmed species, 6.72%), Acipenseridae, Cobitidae and Salmonidae (each with 5 confirmed species, 4.2%), and Nemacheilidae (4 confirmed species, 3.36%). Three families have 3 or fewer species. Eight families have only one species. The southern Caspian Sea basin comprises three endemic species (2.52% of total southern Caspian Sea ichthyofauna) in two families: Cobitidae (2, 66.66%) and Nemacheilidae (1, 33.33%). However, it is expected that the number of endemic fishes to be increased as new species are being described. An additional 22 species require confirmation of their occurrence in Iran. Gobiidae with 18 unconfirmed species (81.81%) is ranked first followed by Clupeidae with two species (9.09%) and Acipenseridae and Nemacheilidae, each with only one species.

Nineteen exotic species in seven families are listed from the Southern Caspian Sea basin (Table 1). Cyprinidae with nine species (47.37% of the total exotic species in Southern Caspian Sea basin) is ranked first followed by the Salmonidae and Mugilidae (each with 3 species, 15.79%), and four families each with only one species or 5.26% (Table 1). However, there are reports of some other exotic and transplanted species (Coad 1995), which have not been recently collected and cannot be confirmed to be present in Iran. Some species have been established, such as *Pseudorasbora parva*, *Hemiculter*

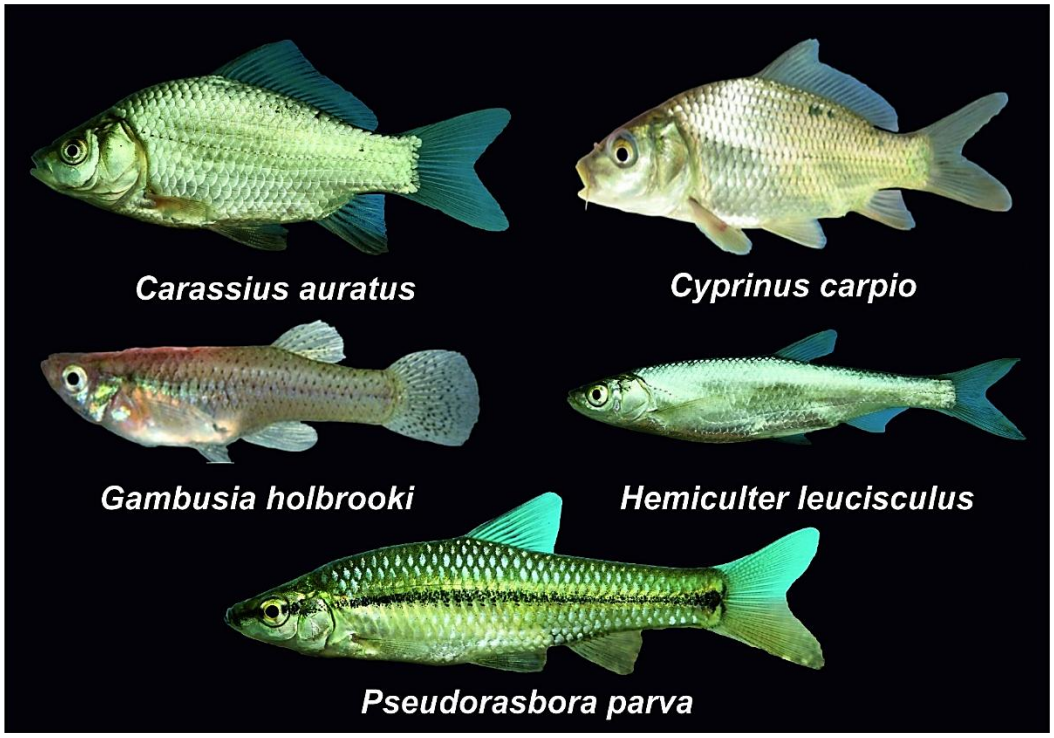

Fig.3. Some alien fishes of the southern Caspian Sea basin.

leucisculus, *Chelon auratus*, *Chelon saliens*, *Gambusia holbrooki* and *Gasterosteus aculeatus* (Table 1). Some species are questionably established but numerous in the basin due to stocking, such as *Aristichthys nobilis*, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*.

Live photos and schematic drawings of some native and exotic fishes and their habitats in the southern Caspian Sea basin are given in Figures 2-12.

We expect more species to be described as new, resurrected from synonymy, recorded for the first time from the southern Caspian Sea basin, or recorded as established introductions. Hence, the fish fauna could soon exceed from those recorded in this checklist. The listing includes selected taxonomic comments including synonyms where these have been used in recent literature. Older synonyms can be found in Coad (1995).

Checklist

* = endemic to Iranian part of Caspian Sea basin, ** = exotic. Unconfirmed species are those mentioned in the literature but without confirmatory specimens in a museum. They are included in the checklist.

Class Petromyzontida

Order Petromyzontiformes (1 family, 1 genus and 1 species)

Fig.4. *Caspiomyzon wagneri* from Caspian Sea basin.

Family Petromyzontidae (1 genus and 1 species)

Genus *Caspiomyzon* Berg, 1906

1. *Caspiomyzon wagneri* (Kessler, 1870).

Class Actinopterygii

Order Acipenseriformes (1 family, 2 genera and 6 species, 1 unconfirmed)

Family Acipenseridae (2 genera and 6 species, 1 unconfirmed)

Genus *Acipenser* Linnaeus, 1758

2. *Acipenser gueldenstaedtii* Brandt & Ratzeburg, 1833.
3. *Acipenser nudiventris* Lovetzky, 1828
4. *Acipenser persicus* Borodin, 1897
5. *Acipenser ruthenus* Linnaeus, 1758

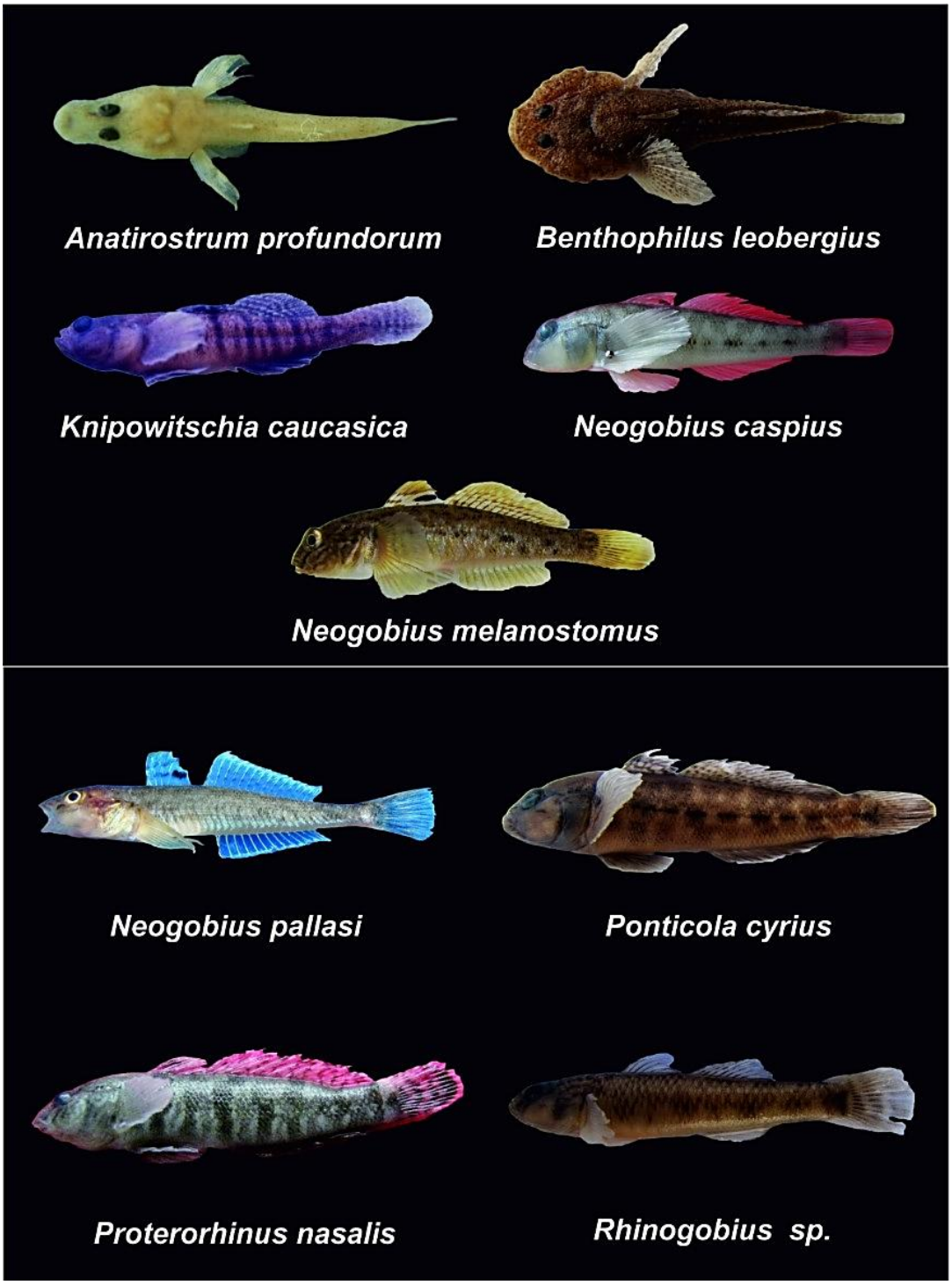

Fig.5. Some gobiid fishes of the southern Caspian Sea basin.

Comment: Reported from the middle and South Caspian Sea by Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.

6. *Acipenser stellatus* Pallas, 1771

Genus *Huso* Brandt & Ratzeburg, 1833

7. *Huso huso* (Linnaeus, 1758)

Order Anguilliformes (1 family, 1 genus and 1 species)

Family Anguillidae (1 genus and 1 species)

Genus *Anguilla* Schrank, 1798

8. *Anguilla anguilla* (Linnaeus, 1758) ** – introduced to the Caspian Sea basin (see Coad 2014;

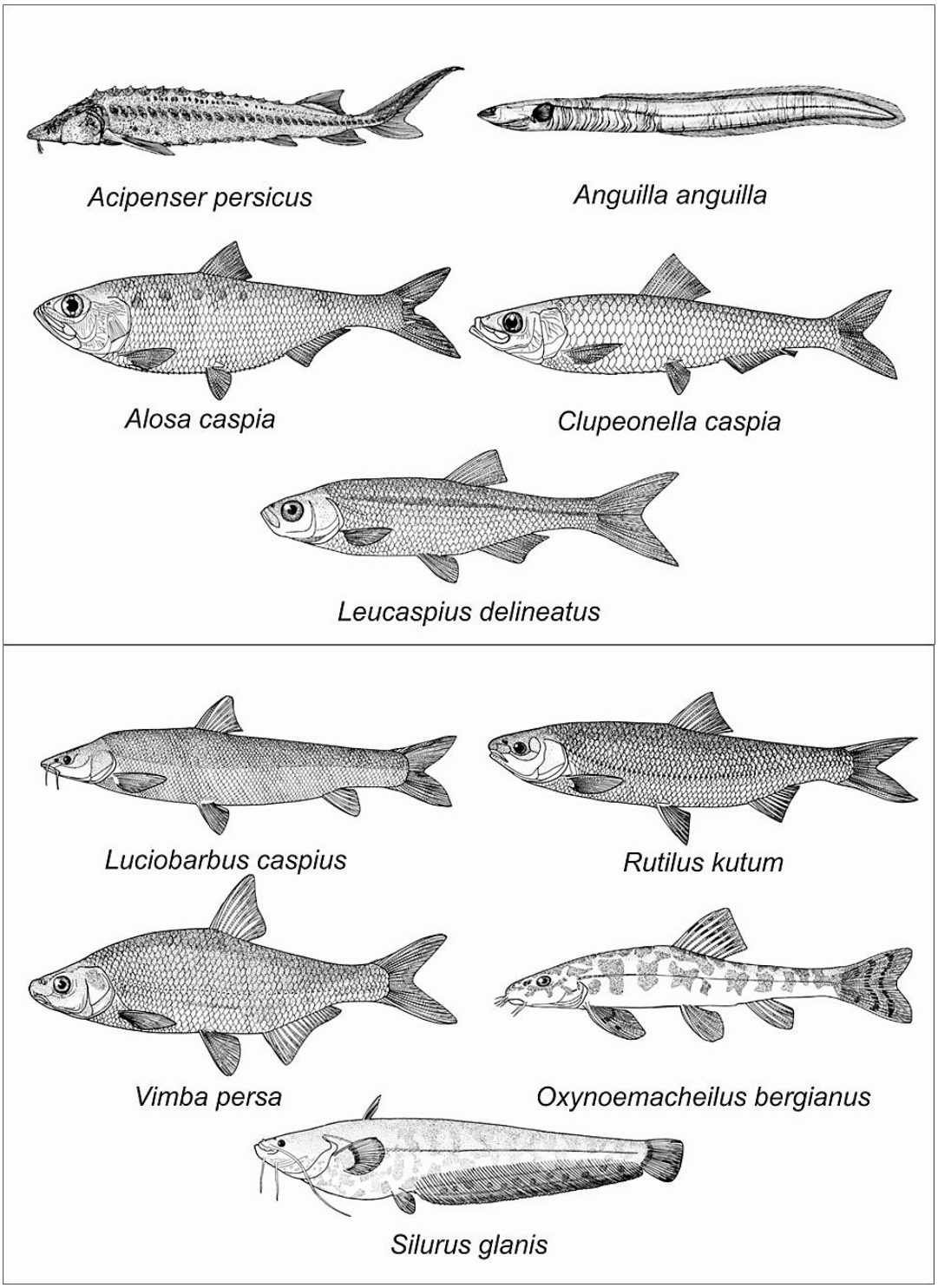

Fig.6. Schematic drawings of some selected fishes of the southern Caspian Sea basin.

Esmaeili et al. 2014c).

Order Clupeiformes (1 family, 2 genera and 10 species, 2 unconfirmed)

Family Clupeidae (2 genera and 10 species, 2 unconfirmed)

Genus *Alosa* Linck, 1790

Comment: The Caspian species of *Alosa* were formerly placed in the genus *Caspialosa* Berg, 1915. Svetovidov (1952) synonymised the genus *Caspialosa* Berg, 1915 with *Alosa* many subspecies have been described for some species in the Caspian Sea but their status has not been assessed recently.

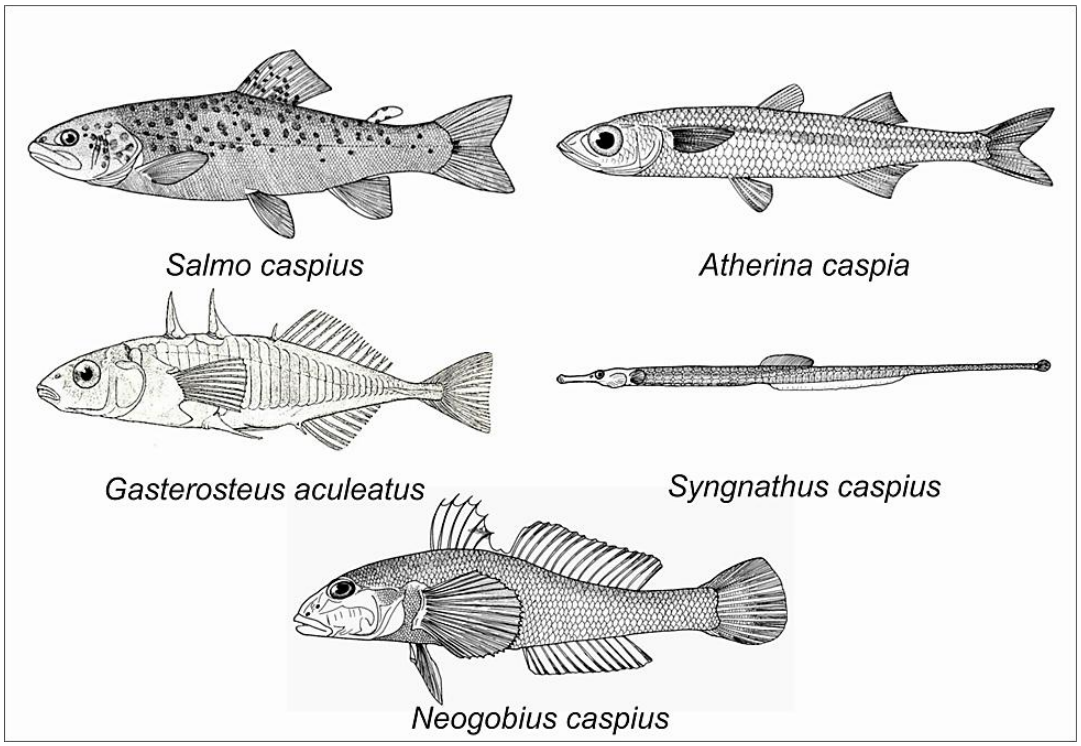

Fig.6. Continued.

9. *Alosa braschnikowii* (Borodin, 1904)
10. *Alosa caspia* (Eichwald, 1838)
11. *Alosa curensis* (Suvorov, 1907)
Comment: Reported from the middle and southern Caspian Sea by Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.
12. *Alosa kessleri* (Grimm, 1887)
Comment: Formerly placed in *A. pontica* (Eichwald, 1838) as a subspecies but Kottelat and Freyhof (2007), Abdoli & Naderi (2009) and Naseka & Bogutskaya (2009) consider *Alosa kessleri* as a valid species.
13. *Alosa saposchnikowii* (Grimm, 1887)
Comment: The name is often spelt saposchnikovi, in error, or with a single terminal "i"; Reshetnikov et al. (1997) revert to the original spelling of the specific name.
14. *Alosa sphaeroc*ephala (Berg, 1913)
15. *Alosa volgensis* (Berg, 1913)
Comment: Presence in Iranian waters needs confirmation. Record from Kottelat & Freyhof (2007).
Genus *Clupeonella* Kessler, 1877
16. *Clupeonella caspia* Svetovidov, 1941
Comment: Formerly identified as *Clupeonella cultriventris* (Nordmann, 1840).
17. *Clupeonella engrauliformis* (Borodin, 1904)
Comment: Formerly identified as *Clupea engrauliformis* (Borodin, 1904).
18. *Clupeonella grimmi* Kessler, 1877
Comment: *Clupeonella grimmi* was originally described from the central part of the Caspian Sea.
Order Cypriniformes (3 families, 30 genera and 45 species, 1 unconfirmed)
Family Cyprinidae (26 genera and 35 species)
Genus *Abramis* Cuvier, 1816
19. *Abramis brama* (Linnaeus, 1758)
20. *Ballerus sapa* (Pallas, 1814)
Comment: *Abramis sapa bergi* Belyaev, 1929 is the southern Caspian Sea subspecies but not recognized by some authors.
Genus *Acanthalburnus* Berg, 1916
21. *Acanthalburnus microlepis* (De Filippi, 1863)
Comment: *Abramis microlepis* (De Filippi, 1863) is a synonym.
Genus *Alburnoides* Jeitteles, 1861
22. *Alburnoides eichwaldii* (De Filippi, 1863)
Comment: Further taxa may exist in Iran. Based on

Fig.7. Balekhlochai stream, a tributary of Aras River, Caspian Sea basin, Iran.

Saifali et al. (2012) the mitochondrial gene tree largely supports the existence of three major clades. The western populations (clade I) might be considered as *Alburnoides eichwaldii*, whereas the Talar river populations (clade II) are represented as *Alburnoides* sp.1 and the eastern populations (clade III) may be a distinct taxon *Alburnoides* sp.2.

Genus *Alburnus* Rafinesque, 1820

Several members of this genus require revision.

23. *Alburnus chalcoides* (Güldenstaedt, 1772)

Comment: The subspecies iranicus Svetovidov, 1945 is a synonym.

24. *Alburnus filippii* Kessler, 1877

25. *Alburnus hohenackeri* Kessler, 1877

Comments: Previously the wide-ranging species *Alburnus alburnus* (Linnaeus, 1758) was identified as the taxon in Iran. *Alburnus charusini* Herzenstein, 1889 is a synonym. Type locality: Karabakh, Azerbaijan. Holotype (unique): ZIN 2339.

Genus *Barbus* Cuvier, 1816

26. *Barbus cyri* De Filippi, 1865

Comment: Berg (1948-1949) refers Caspian Sea basin specimens to *Barbus lacerta cyri*. It recognized as a full species by Naseka & Bogutskaya (2009).

Genus *Blicca* Heckel, 1843

27. *Blicca bjoerkna* (Linnaeus, 1758)

Comment: *Blicca bjoerkna transcaucasica* Berg, 1916 from the lower reaches of the Kura River, Araks and Lenkoran District is a valid subspecies or a synonym according to authors.

Genus *Capoeta* Valenciennes, 1842

28. *Capoeta gracilis* (Keyserling, 1861)

Comment: Caspian Sea populations have been considered as *Capoeta capoeta gracilis*. However still there is controversial debate about the systematic position of *Capoeta capoeta gracilis*.

Genus *Carassius* Jarocki, 1822

29. *Carassius auratus* (Linnaeus, 1758) ** – introduced to the Caspian Sea and Sistan basins; probably elsewhere in garden ponds.

30. *Carassius gibelio* (Bloch, 1782) ** – probably mirrors distribution of *C. auratus*.

Comment: Kottelat & Freyhof (2007); Bogutskaya et al. (2008, with question); Esmaeili et al. (2010a); Kalous et al. (2012) considered it as distinct species.

Genus *Chondrostoma* Agassiz, 1832

31. *Chondrostoma cyri* Kessler, 1877

Genus *Ctenopharyngodon* Steindachner, 1866

32. *Ctenopharyngodon idella* (Valenciennes, 1844) ** – introduced to the Caspian Sea

Genus *Cyprinus* Linnaeus, 1758

33. *Cyprinus carpio* Linnaeus, 1758 **

Comment: Native populations in the Caspian Sea basin; also introduced there and elsewhere in Iran.

Fig.8. Zaleki stream a tributary of Safidrud, Caspian Sea basin, Iran.

Genus *Hemiculter* Bleeker, 1859

34. *Hemiculter leucisculus* (Basilewsky, 1855) ** – introduced to the Caspian Sea basin; probably elsewhere in Iran.

Comment: *Culter leucisculus* was originally described from Peking, China. *Hemiculter eigenmanni* (Jordan & Metz, 1913) is a synonym.

Genus *Hypophthalmichthys* Bleeker, 1859

35. *Hypophthalmichthys molitrix* (Valenciennes, 1844) ** – introduced to Caspian reservoirs and throughout Iran.

36. *Hypophthalmichthys nobilis* (Richardson, 1844) ** – introduced to Caspian reservoirs and throughout Iran.

Genus *Leucaspius* Heckel & Kner, 1858

37. *Leucaspius delineatus* (Heckel, 1843)

Comment: *Squalius delineatus* was originally described from Wien and Mähren, Austria. The Caspian Sea basin taxon is given by Berg (1948-1949) as *Leucaspius delineatus delineatus* natio *caucasicus* Berg, 1949, described from Transcaucasia, which is distinguished by a lower average dorsal fin branched ray count (7-8 rather than 8 or rarely 9 for the typical form of Europe). This natio has no taxonomic standing but has been applied as a subspecies by some authors (Arnold & Längert 1995).

Genus *Leuciscus* Agassiz, 1832

38. *Leuciscus aspius* (Linnaeus, 1758)

Comment: *Leuciscus aspius taeniatus* (Eichwald, 1831) is the Southern Caspian Sea subspecies. *Aspius* species are placed in *Leuciscus* by Perea et al. (2010) on molecular evidence which contradicts morphology. Further study is needed.

Genus *Luciobarbus* Heckel, 1843

39. *Luciobarbus caspius* (Berg, 1914)

Comment: The subspecies *Barbus brachycephalus caspius* Berg, 1914 has also been regarded as a synonym or a distinct species in the Caspian Sea. Fricke et al. (2007) considered *Barbus brachycephalus caspius* Berg, 1914 as a distinct species. Considered as *Luciobarbus caspius* in Catalog of Fishes in 2014.

40. *Luciobarbus capito* (Güldenstaedt, 1773)

41. *Luciobarbus mursa* (Güldenstaedt, 1773)

Genus *Mylopharyngodon* Peters, 1881

42. *Mylopharyngodon piceus* (Richardson, 1846) ** – introduced to the Caspian Sea basin.

Genus *Pelecus* Agassiz, 1835

43. *Pelecus cultratus* (Linnaeus, 1758

Genus *Pseudorasbora* Bleeker, 1859

44. *Pseudorasbora parva* (Temminck & Schlegel, 1846) ** – introduced to the Caspian Sea, Namak Lake, Harirud, Sistan, Maharlu Lake, Urmia, Persian

Fig.9. Tajan River, Caspian Sea basin, Iran.

Gulf and Tigris River basins and probably elsewhere.
Genus *Rhodeus* Agassiz, 1832
45. *Rhodeus amarus* (Bloch, 1782) – Caspian Sea basin; introduced to the Lake Urmia basin.
Comment: Formerly identified as *Rhodeus sericeus* (Pallas, 1776). Naseka & Bogutskaya (2009) refer to the Caspian Sea taxon as *Rhodeus* sp.
Genus *Romanogobio* Bănărescu, 1961
46. *Romanogobio macropterus* (Kamensky, 1901)
Comment: *Gobio macropterus* Kamenskii, 1901 was originally described from the Caucasus.
Genus *Rutilus* Rafinesque, 1820
47. *Rutilus caspicus* (Yakovlev, 1870)
48. *Rutilus kutum* Kamenskii, 1901
Comment: *Leuciscus frisii kutum* Kamenskii, 1901 was originally was described from Southern Caspian Sea and its tributaries. Naseka & Bogutskaya (2009) and Esmaeili et al. (2010a) regard *Rutilus kutum* Kamenskii, 1901 as a distinct species.
49. *Rutilus rutilus* (Linnaeus, 1758)
Comment: *Rutilus caspicus* is recognised as the Caspian Sea resident species and *R. rutilus* as the freshwater species (Bogutskaya & Naseka 2004; Kottelat & Freyhof 2007).
Genus *Scardinius* Bonaparte, 1837
50. *Scardinius erythrophthalmus* (Linnaeus, 1758)
Genus *Squalius* Bonaparte, 1837
51. *Squalius orientalis* (Nordmann, 1840)
Comment: It has been considered as valid species (Doadrio & Carmona 2006; Bogutskaya & Zupančič 2010; Turan et al. 2009; Perea et al. 2010).
Genus *Tinca* Cuvier, 1816
52. *Tinca tinca* (Linnaeus, 1758)
Genus *Vimba* Fitzinger, 1873
53. *Vimba persa* (Pallas, 1814)
Comment: *Vimba vimba persa* was the subspecies in the Caspian Sea basin but is recognised as a full species by Naseka & Bogutskaya (2009).
Family Cobitidae (2 genera and 5 species)
Genus *Cobitis* Linnaeus, 1758
54. *Cobitis faridpaki* Mousavi-Sabet, Vasil'eva, Vatandoust and Vasil'ev, 2011 *
55. *Cobitis keyvani* Mousavi-Sabet, Yerli, Vatandoust, Özeren and Moradkhani, 2012*
Comment: Populations from the southern Caspian Sea were previously identified as *Cobitis taenia* Linnaeus, 1758. *Cobitis amphilekta* Vasil'eva and Vasil'ev, 2012 was described from the Kyzylagach Bay in Azerbaijan and the northeastern Caspian Sea, but till date has not been recorded from Iran.
Genus *Sabanejewia* Vladykov, 1929
Comment: Formerly in the genus *Cobitis*.
56. *Sabanejewia aurata* (De Filippi, 1863)
57. *Sabanejewia caspia* (Eichwald, 1838)

Fig.10. Talar River, Caspian Sea basin, Iran.

58. *Sabanejewia caucasica* (Berg, 1906)
Comment: Reported by Kottelat & Freyhof (2007) from Babolrud.

Family Nemacheilidae (2 genera and 5 species, 1 unconfirmed)

Comment: Formerly included in the family Cobitidae or the family was named Balitoridae (see Tang et al. 2006; Kottelat & Freyhof 2007; Freyhof et al. 2011; Esmaeili et al. 2014a) Iranian species were placed in the genera *Nemacheilus* in older literature.

Genus *Oxynoemacheilus* Bănăraescu & Nalbant, 1967

59. *Oxynoemacheilus angorae* (Steindachner, 1897)
Comment: This taxon may be a catchall species in Iran, e.g. *Nemacheilus angorae lenkoranensis* Abdurakhamanov, 1962 may be a distinct taxon and the species in the Caspian Sea basin in Iran.

60. *Oxynoemacheilus araxensis* (Bănărescu & Nalbant, 1978)
Comment: *Orthrias angorae araxensis* Bănărescu and Nalbant, 1978 in Bănărescu, Nalbant and Balik (1978), is described from the Aras River basin of Turkey. The holotype of *Orthrias angorae araxensis*, 62.0 mm standard length, from the "Kandili Karassu, oberes Araxes-Becken, Osttürkei" is in the Zoologischen Instituts und Zoologischen Museums der Universität Hamburg (ZMH 4827). This subspecies was formerly referred to as *Nemacheilus angorae bureschi* (Drensky, 1928) by Bănărescu & Nalbant (1964) and Bănărescu (1968). Nalbant and Bianco (1998), Fricke et al. (2007) and Freyhof et al. (2010, 2011) elevate this taxon to a species. Presence in Iran needs confirmation.

61. *Oxynoemacheilus bergianus* (Derzhavin, 1934) *
Comment: The type locality of *Nemachilus bergianus* in Latin from Derzhavin (1934) is "Systema fluminis Sefidrud" (= Safid River system). Berg (1948-1949) gives "Sefid-rud basin: Kisum village; Shah-rud R., falling into the Sefid-rud". The former is at Kisom at 37°14'N, 49°51'E or 37°12'N, 49°54'E in a gazetteer. Freyhof et al. (2010, 2011) considered *O. bergianus* (Derzhavin, 1934) as a valid species. However it might be a part of the *O. angorae* complex group.

62. *Oxynoemacheilus brandtii* (Kessler, 1877)
Comment: Placed in the genus *Orthrias* by Nalbant & Bianco (1998) and in *Oxynoemacheilus* by Freyhof et al. (2011).

Genus *Paracobitis* Bleeker, 1863

63. *Paracobitis* sp.
Comment: The taxonomy of the nemacheilid loaches of the genus *Paracobitis* was reviewed by Freyhof et al. (2014), who recognized nine species in the Middle East (Iran, Iraq, Turkey). *Paracobitis* are widespread

Fig.11. Zarin Gol, a tributary of Gorgan River, Caspian Sea basin, Iran.

in the southern Caspian Sea basin where they are found in all rivers from the Babol River in the west to the Atrak River in the east (Abdoli 2000; Esmaeili et al. 2010a). For a long time, *Paracobitis iranica* Nalbant & Bianco, 1998 had been considerd as endemic species to Namak Lake basin and *Paracobitis malapterura* (Valenciennes, 1846) as Caspian Sea basin species. However, Freyhof et al. (2014) considered Namak populations as *P. malapterura* and treated *P. iranica* as a synonym of *P. malapterura*.

Order Siluriformes (1 family, 1 genus and 1 species)

Family Siluridae (1 genus and 1 species)

Genus *Silurus* Linnaeus, 1758

64. *Silurus glanis* Linnaeus, 1758

Order Salmoniformes (1 family, 3 genera and 5 species)

Family Salmonidae (3 genera and 5 species)

Genus *Oncorhynchus* Suckley, 1861

65. *Oncorhynchus keta* (Walbaum, 1792) ** – introduced to the Caspian Sea basin.

66. *Oncorhynchus mykiss* (Walbaum, 1792) ** – introduced to the Tigris River, Caspian Sea, Lake Urmia, Namak Lake, Kavir, Esfahan and Kor River basins, and widely farmed.

Genus *Salmo* Linnaeus, 1758

67. *Salmo caspius* Kessler, 1877

Comments: *Salmo trutta* Linnaeus, 1758 was recognised in the Caspian Sea but its subspecies is now regarded as a full species (Naseka & Bogutskaya, 2009). Probably not valid at species level. Other taxa probably exist in Iran, particularly in the Lake Urmia basin. *Salmo salar* Linnaeus, 1758 has been introduced to the Caspian Sea but no Iranian record.

68. *Salmo trutta* Linnaeus, 1758 ** – widely introduced to streams, lakes and reservoirs.

Genus *Stenodus* Richardson, 1836

69. *Stenodus leucichthys* (Güldenstaedt, 1772)

Order Esociformes (1 family, 1 genus and 1 species)

Family Esocidae (1 genus and 1 species)

Genus *Esox* Linnaeus, 1758

70. *Esox lucius* Linnaeus, 1758

Order Gadiformes (1 family, 1 genus and 1 species)

Family Lotidae (1 genus and 1 species)

Genus *Lota* Oken, 1817

71. *Lota lota* (Linnaeus, 1758)

Order Mugiliformes (1 family, 2 genera and 3 species)

Family Mugilidae (2 genera and 3 species)

Genus *Chelon* Artedi, 1793

Comment: The type species of the genus *Liza* is *Mugil capito* (currently *L. ramada*). The phylogenetic results imply that *L. ramada* be placed under genus

Fig.12. Tabarak stream, a tributary of Atrak River, Caspian Sea basin, Iran.

Chelon, which in turn implies that *Liza* is a junior synonym of *Chelon*. Hence, the name *Liza* is now unavailable (see Durand et al. 2012).

72. *Chelon auratus* (Risso, 1810) ** – introduced to the Caspian Sea basin.

Comment: (see Durand et al. 2012). Still under *Liza* in Catalogue of Fishes.

73. *Chelon saliens* (Risso, 1810) ** – introduced to the Caspian Sea basin.

Comment: (see Durand et al. 2012). Still under *Liza* in Catalogue of Fishes.

Genus *Mugil* Linnaeus, 1758

74. *Mugil cephalus* Linnaeus, 1758 –**

Comments: Jolodar & Abdoli (2004) and Yelghi et al. (2012) reported it from the Gomishan Lagoon but only in farms there. According to Yelghi et al. (2012) the grey mullet fingerling were imported to Iran in 1997 from Hong Kong and in coastal fish ponds of northern part of Iran were successfully cultured in order to obtain broodstocks and induce artificial reproduction.

Order Atheriniformes (1 family, 1 genus and 1 species)

Family Atherinidae (1 genus and 1 species)

Genus *Atherina* Linnaeus, 1758

75. *Atherina caspia* Eichwald, 1831

Comment: *Atherina mochon pontica* natio *caspia* Eichwald, 1831 was recognised as the taxon in Iran, later synonymised with *Atherina boyeri* Risso, 1810, but now considered distinct (Naseka & Bogutskaya 2009).

Order Cyprinodontiformes (1 family, 1 genera and 1 species)

Family Poeciliidae (1 genera and 1 species)

Genus *Gambusia* Poey, 1854

76. *Gambusia holbrooki* Girard, 1859 ** – introduced to all basins.

Order Gasterosteiformes (1 family, 2 genera and 2 species)

Family Gasterosteidae (2 genera and 2 species)

Genus *Gasterosteus* Linnaeus, 1758

77. *Gasterosteus aculeatus* Linnaeus, 1758 ** – introduced to the Caspian Sea, Kavir and Tedzhen River basins.

Genus *Pungitius* Coste, 1848

78. *Pungitius platygaster* (Kessler, 1859)

Order Syngnathiformes (1 family, 1 genera and 1 species)

Family Syngnathidae (1 genus and 1 species)

Genus *Syngnathus* Linnaeus, 1758

79. *Syngnathus caspius* Eichwald, 1831

Comment: *Syngnathus nigrolineatus caspius* Eichwald, 1831 was considered to be the taxon in Iran, later synonymised with *Syngnathus abaster*

Risso, 1827 but now recognised as distinct (Naseka & Bogutskaya 2009). Betancur et al. (2013) placed Syngnathidae in order Syngnathiformes.

Order Perciformes (1 family, 2 genera 3 species)

Family Percidae (2 genera and 3 species)

Genus *Perca* Linnaeus, 1758

80. *Perca fluviatilis* Linnaeus, 1758

Genus *Sander* Oken, 1817

81. *Sander lucioperca* (Linnaeus, 1758) – Caspian Sea basin; introduced to lakes and reservoirs throughout Iran.

82. *Sander marinus* (Cuvier, 1828)

Order Gobiiformes (1 family, 12 genera 37 species)

Family Gobiidae (12 genera and 37 species, 18 unconfirmed)

Genus *Anatirostrum* Iljin, 1930

83. *Anatirostrum profundorum* (Berg, 1927)

Genus *Babka* Iljin, 1927

Comment: Members of this genus were formerly placed in the genus *Neogobius* Iljin, 1927.

84. *Babka gymnotrachelus* (Kessler, 1857)

Comment: Presence in Iranian waters needs confirmation. Record from Kottelat and Freyhof (2007).

85. *Babka macrophthalma* (Kessler, 1877)

Comment: Reported from the Middle and South Caspian Sea by Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

Genus *Benthophiloides* Beling & Iljin, 1927

86. *Benthophiloides brauneri* Beling & Iljin, 1927

Comment: Reported from the Middle and South Caspian Sea by Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

87. *Benthophiloides turcomanus* (Iljin, 1941)

Comment: Reported from the Middle and South Caspian Sea by Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

Genus *Benthophilus* Eichwald, 1831

88. *Benthophilus abdurahmanovi* Ragimov, 1978

Comment: Reported from the middle and south Caspian Sea by Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

89. *Benthophilus baeri* Kessler, 1877

90. *Benthophilus casachicus* Ragimov, 1978

Comment: Reported from the middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

91. *Benthophilus ctenolepidus* Kessler, 1877

92. *Benthophilus granulosus* Kessler, 1877

Comment: Presence in Iranian waters needs confirmation. Record from Kottelat & Freyhof (2007).

93. *Benthophilus grimmi* Kessler, 1877

Comment: Reported from the middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka and Bogutskaya (2009) but not confirmed by specimens for Iran.

94. *Benthophilus kessleri* Berg, 1927

Comment: Reported from the middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.

95. *Benthophilus leobergius* Berg, 1949

Comment: Originally described as a subspecies of *B. stellatus* (Sauvage, 1874), a taxon now restricted to the Black Sea.

96. *Benthophilus leptocephalus* Kessler, 1877

Comment: Reported from the middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.

97. *Benthophilus leptorhynchus* Kessler, 1877

Comment: Reported from the middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.

98. *Benthophilus macrocephalus* (Pallas, 1787)

99. *Benthophilus mahmudbejovi* Ragimov, 1976

Comment: Reported from the Middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.

100. *Benthophilus pinchuki* Ragimov, 1982

Comment: Formerly a subspecies of *B. ctenolepidus*.

101. *Benthophilus ragimovi* Boldyrev &

Bogutskaya, 2004
Comment: Reported from the Middle and south Caspian Sea by Boldyrev and Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.
102. *Benthophilus spinosus* Kessler, 1877
Comment: Reported from the Middle and south Caspian Sea by Boldyrev & Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.
103. *Benthophilus svetovidovi* Pinchuk & Ragimov, 1979
Comment: Reported from the middle and south Caspian Sea by Boldyrev & Bogutskaya (2007) and Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.
Genus *Chasar* Vasil'eva, 1996
Comment: Members of this genus were formerly placed in the genus *Neogobius* Iljin, 1927.
104. *Chasar bathybius* (Kessler, 1877)
Genus *Hyrcanogobius* Iljin, 1928
Comment: Placed as a synonym of *Knipowitschia* by authors.
105. *Hyrcanogobius bergi* Iljin, 1928
Comment: Presence in Iranian waters needs confirmation. Record from Kottelat & Freyhof (2007).
Genus *Knipowitschia* Iljin, 1927
106. *Knipowitschia caucasica* (Berg, 1916)
107. *Knipowitschia iljini* Berg, 1931
108. *Knipowitschia longecau*data (Kessler, 1877)
Comment: Presence in Iranian waters needs confirmation. Record from Kottelat & Freyhof (2007).
Genus *Mesogobius* Bleeker, 1874
109. *Mesogobius nigronotatus* (Kessler, 1877)
Comment: Reported from the middle and south Caspian Sea by Naseka & Bogutskaya (2009) but not confirmed by specimens for Iran.
110. *Mesogobius nonultimus* (Iljin, 1936)
Genus *Neogobius* Iljin, 1927
111. *Neogobius caspius* (Eichwald, 1831)
112. *Neogobius melanostomus* (Pallas, 1814
Comment: *Gobius affinis* Eichwald, 1831 is synonym or subspecies depending on authors.
113. *Neogobius pallasi* (Berg, 1916)
Comment: This taxon was regarded as a subspecies of *N. fluviatilis* (Pallas, 1814).
Genus *Ponticola* Iljin, 1927
Comment: Members of this genus were formerly placed in the genus *Neogobius* Iljin, 1927.
114. *Ponticola cyrius* (Kessler, 1874)
Comment: See Vasil'eva (1995) and Vasil'eva & Vasil'ev (1995) for taxonomy.
115. *Ponticola goebelii* (Kessler, 1874)
Comment: Regarded as a subspecies of *Ponticola ratan* (Nordmann, 1840) by authors although Naseka & Bogutskaya (2009) give it full species status.
116. *Ponticola gorlap* (Iljin, 1949)
Comment: Formerly a subspecies of *Gobius kessleri* Günther, 1861. *Neogobius iljini* Vasil'eva & Vasil'ev, 1996 is a synonym (Kottelat, 1997).
117. *Ponticola syrman* (Nordmann, 1840)
Comment: *Ponticola syrman eurystomus* (Kessler, 1877) is the subspecies in Iran.
Genus *Proterorhinus* Smitt, 1900
118. *Proterorhinus nasalis* (De Filippi, 1863)
Comment: Previously recognised as *P. marmoratus* (Pallas, 18l4); some authors consider it a synonym of this species.
Genus *Rhinogobius* Gill, 1859
119. *Rhinogobius* sp. ** – Reported from Anzali wetland by K.A (see, Esmaeili et al. 2014c).
The identity of intoduced *Rhinogobius* in Iran needs to be confirmed. Vasil'eva (2007) and Vasil'eva & Kuga (2008) have identified the introduced Central Asian species as *R. cheni* (Nichols, 1931).

Discussion

Freshwater fishes are more and less confined to drainage systems and cannot disperse without connections of the freshwater systems. They provide relatively conservative system for examining zoogeographical patterns. These features make them one of the most zoogeographically important groups of animals (Berra 2007). Changes in river systems

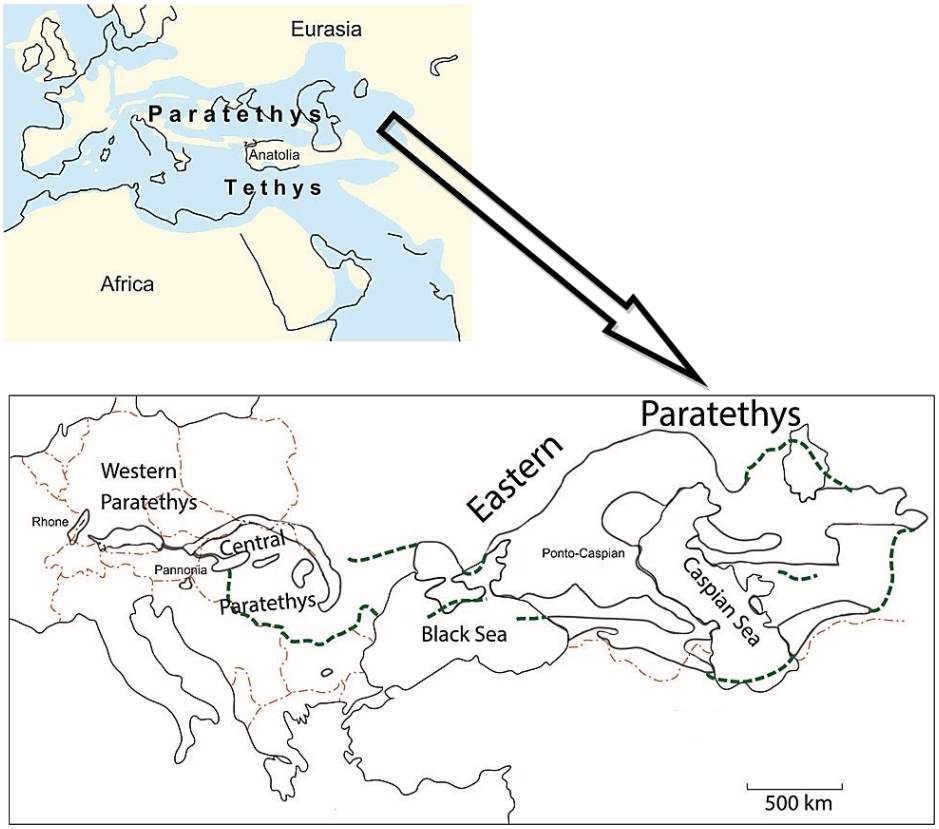

Fig.13. Western, Central and Eastern Paratethys basin. Modified after Veto (1987).

and evolution of the fishes might be affecting on heterogeneity in the geographic distribution of the strict freshwater fishes (Watanabe 1998). In other word zoogeographic patterns form strong evidence of evolution (Berra 2007). However, anthropogenic effects have played a significant role in changing distribution pattern of freshwater fishes especially in the past few decades (Esmaeili et al. 2014c) which can be well understood in the case of some of the southern Caspian Sea fish species.

Based on its ichthyofauna composition, the Iranian plateau borders the Eastern Mediterranean (Western-Palearctic), the Southern Asian (Indo-Oriental) and the Ethiopian regions (Nalbant & Bianco 1998; Coad 1998). This zoogeographical situation, the past geological history, vicariance events and recent anthropogenic effects have played a significant role on ichthyodiversity of Iran in different endorheic and exorheic drainage systems including the southern Caspian Sea basin.

The Caspian Sea is the world's largest lake of inner drainage, with no outlet to the ocean (Dolukhanov et al. 2009) and the world's largest brackish waterbody (Mordukhai-Boltovskoi 1960; Dumont 1998). One of the remarkable aspects of its fauna is the high level of endemism (Dumont 2000). Among the 950 extant aquatic metazoan species recorded, 424 taxa are endemic or shared partly with the Black–Azov and Aral Seas (Mordukhai-Boltovskoi 1964, 1979; Kasymov 1982; Grigorovich et al. 2003). Caspian Sea is a part of highly diverse ancient area of Paratethys basin (Figs. 13-14). According to Naseka & Bogutskaya (2009), Black, Azov, Caspian and Aral Seas are remnants of the intercontinental Paratethys basin, possess a spectacular diversity of the biota (Figs. 13-14). The term "Paratethys" was coined by Laskarev (1924) to designate the string of epicontinental basins originally stretching from the Alps to what was the Aral Sea that has been separated from the rest of the Tethys by the uplift of the Alpine-Caucasian mountain chain since the Early Oligocene (Naseka & Bogutskaya 2009).

Aggregate basins, located from the valley of the

Fig.14. Map of Ponto-Caspian region showing the location of Paratethys area. Greater Caucasus (GC), Lesser Caucasus (LC), Talesh (Talysh, TL), Alborz (AM) and Kopet Dagh (KD).

river Rhone in Western Europe up to Central Asia in the Miocene are usually called the Parathetis in Paleontological literature (Fig. 13). Traditionally three parts are distinguished: Western, Central and East Parathetis (Fig.13). The first relates to the region of the Rhone (Rhône-Alpes), the second – the Pannonian or Middle Danube lowland (the Pannonian Basin or Carpathian Basin, a large basin in East-Central Europe), and the third – the Black, Asov, Aral and the Caspian Seas (Fig. 13). In terms of modern mobilistic conceptions, this large continental water border formed due to movements of small continental platforms such as Iranian, Anatolian and Rhodopian. According to these notions, the basins of the southern Caspian and the Black Seas are considered as basins with oceanic crust, which enclosed as a result of movements of the above and some smaller other platforms (Naseka & Bogutskaya 2009).

Many groups of aquatic organisms including fishes have radiated in Paratethys region (e.g., Mordukhai-Boltovskoi 1979; Dumont 1998). Diversification in the Paratethys has been traditionally linked to isolation events from the Mediterranean and the Atlantic and Indian Oceans resulted in restricted marine, brackish lacustrine, and freshwater lacustrine environments, and induced the evolution of endemic species and higher taxa among molluscs, ostracods, fish, and other groups of animals (e.g., Băcescu 1940; Zenkevtich 1963; Starobogatov 1970, 1994; Bănărescu 1991; Jones & Simmons 1996, 1997; Dumont 2000; Naseka & Bogutskaya 2009).

Moreover, the Black and Caspian Seas of ancient east Paratethys Sea have experienced alternating periods of isolation and interconnection over many Milankovitch climate oscillations and most recently became separated when the meltwater overflow from the Caspian Sea ceased at the end of the last glaciation. Climate-induced habitat changes have indisputably had profound impacts on distribution and demography of aquatic species, yet uncertainties remain about the relative roles of isolation and dispersal in the response of species shared between the Black and Caspian Sea basins (Kotlík et al. 2008). The endorheic southern Caspian Sea basin is one of the 19 drainage basins of Iran and a part of East Paratethys (Figs. 1, 13, 14). In its land part, is elongated, extending from the Turkish border almost to the Afghanistan border, and only acquires some width where the Safidrud and its tributaries penetrate the Alborz Mountains in the west (Fig. 14). The southern Caspian basin underlies the southern part of the Caspian Sea, between the ranges of the eastern Greater Caucasus (GC), Lesser Caucasus (LC), Talesh (Talysh, TL), Alborz Montains (northern Iran,

AM) and Kopet Dagh (KD), all of which are situated within the Alpine–Himalayan collision zone (Jackson et al. 2002; Reilinger et al. 2006):

I) Greater Caucasus: The Greater Caucasus range lies northeast of the Black Sea and northwest of the south Caspian Basin (Fig. 14). It lies along trend from the Kopet Dagh, and also represents the zone of active deformation at the northern side of the Arabia-Eurasia collision. The present structure of the Greater Caucasus indicates major late Cenozoic shortening and inversion of a Mesozoic - lower Tertiary basin. The Moho under the range is at depths of up to 60 km (Ruppel & McNutt 1990). Palaeozoic basement is exposed in dominantly southward-directed thrust slices west of 44 E. Mesozoic strata are present in tight or isoclinal folds across the range all around the exposed Palaeozoic core (Rogozhin & Sholpo 1988; Allen et al. 2003b). These folds are commonly associated with thrusts. The vergence of these structures is predominantly toward the south. However, there are north-directed structures on the northern margin, especially in the northeast (Dagestan). Pliocene-Quaternary strata are folded intoelon-gate, linear, south-vergent anticlines on the southern side of the range, between the extant Kura and Rioni basins. Fault plane solutions show a predominance of thrusts that dip toward the range interior (Philip et al. 1989; Triep et al. 1995; Jackson et al. 2002). Late Cenozoic magmatism in the range is Pliocene and Quaternary in age (Gazis et al. 1995; Allen 2003).

II) The Talesh (Talysh) is an actuate fold and thrust belt in northwest Iran and Azerbaijan (Fig. 14), which deforms Paleogene volcanics and deep marine clastics and a Neo-gene succession that broadly shallows upward (Allen et al. 2003b). Summits reach 2000 m at the Iran-Azerbaijan border, but the foreland of the range is below Sea level at the margin of the Caspian Sea. Seismogenic thrusts at the eastern side of the range trend north-south, dip very gently west, and have hypocenters in the depth range of 15–27 km (Jackson et al. 2002), showing that the basement to the Talesh presently over thrusts the South Caspian Basin to the east (Allen 2004).

III) The Alborz range in northern Iran is roughly 600 km long and 100 km across, running along the southern side of the Caspian Sea (Allen 2004).

IV) The Kopet Dagh trends at 120–300 for 700 km through northeast Iran and Turkmenistan between the Caspian Sea and the Afghanistan border (Fig. 14). It separates the Turan region from central Iran, and so shows how plate convergence happens at the northern side of the collision zone. The range is up to 3000 m in altitude, some 2000 m higher than the Turkmen foreland to the north. Jurassic-Miocene marine carbonates and clastics were deposited across a region now deformed into a series of folds and thrusts. The range is much broader in the west than the east, which may mean it rotates clockwise about its eastern limit. The right-lateral Ashgabat Fault lies at the northern margin of the range (Trifonov 1978). This fault also has a component of thrust motion to the north (Priestley et al. 1994; Allen 2003).

So, the diversity found in SCSB might be linked to these 4 major geographical barriers located at a part of the East Paratethys Sea basin and some other factors. It is well shown in the distribution patterns, evolutionary history and taxonomic status of fishes especially some specific genera (e.g., *Alburnoides*, *Alburnus*, *Chondrostoma*, *Paracobitis* and *Capoeta*; see Saifali et al. 2012; Coad 2014; Freyhof et al. 2014).

In general, the ancient origins of the Caspian Sea, the role of closing of the Tethys Sea, long history of the connection and isolation from fresh and marine waters, multiple sources of species, wide latitudinal extent, uneven distribution of inflows and nutrient inputs, and low to moderate salinity, different habitat types (both fresh and brackish habitats, rivers, lakes, lagoons, marshes, and marine environments), (Jackson et al. 2002; Allen 2004; Naseka & Bogutskaya 2009; Esmaeili et al. 2010a; Coad 2014) all have contributed to the greatest ichthyodiversity in the southern Caspian Sea basin.

Grouping of the Southern Caspian Sea fishes

The fish taxa listed from the southern Caspian Sea

basin might be classified to the following major groups based on fish origin, ecoregions and ecological parameters:

A) Fish origin grouping:

I) Native Ponto-Caspian fishes: The Ponto-Caspian region includes three water bodies: the Black and Azov Seas, as well as the more distant Caspian Sea, which represent the remnants of a formerly vast ocean basin known as Paratethys (Nahavandi et al. 2013) bearing the high degree of endemism among aquatic taxa. Majority of fish species reported here are listed in this category: Petromyzontidae, (1) Acipenseridae (5), Clupeidae (9), Esocidae (1), Salmonidae (1), Lotidae (1), Atherinidae (1), Gasterosteidae (1), Syngnathidae (1), Percidae (3) and Gobiidae (?17). Generally, alternating subdivisions and reconnections among Ponto-Caspian basins and correlated environmental changes are commonly considered to be the principal factors promoting species divergence (Dumont 1998). Indeed, numerous extinction events and appearances of novel endemic lineages, as recorded in the fossil records during the last 20 MY, seem to correspond to an abruption or decrease in salinity as a result of inflow of saline waters, followed by a slow return to more brackish conditions (Mordukhai-Boltovskoi 1979; Reid & Orlova 2002; Nahavandi et al. 2013). The Ponto-Caspian region represents one of the most important refugial areas that supported fish populations during past glaciations (Bănărescu 1991; Durand et al. 1999; Kotlík et al. 2004; Kotlík & Berrebi 2007). It is now well established that the Pleistocene glacial–interglacial cycles have had major evolutionary consequences, as many temperate species were repeatedly displaced from their distribution ranges into multiple, allopatric glacial refugia (Hewitt 1996; Carstens & Knowles 2007). These range shifts and the accompanying demographic changes resulted in divergence between refugial populations, which may have proceeded towards speciation (Knowles 2001; Carstens & Knowles 2007). There are a growing number of phylogeographical studies in freshwater fishes suggesting the Ponto-Caspian region as one of important glacial refugia and colonization sources, including the chub *Squalius cephalus* (Durand et al. 1999), perch *Perca fluviatilis* (Nesbø et al. 1999) and brown trout *Salmo trutta* (Osinov & Bernatchez 1996; Bernatchez 2001). The extent to which this refugium contributed to the origin of modern populations varied between species. In the European catfish *Silurus glanis*, the Ponto-Caspian region was implied as the only refugium and colonization source for its wide western-Palaearctic range (Triantafyllidis et al. 2002).

II) Non native Ponto-Caspian fishes (Palaearctic): These are west Palaearctic fish elements but not native to Ponto-Caspian region: Siluridae (*Silurus glanis*), Cyprinidae (e.g., *Capoeta*, *Barbus cyri*, *Luciobarbus capito*, *L. caspius*, *Alburnus*).

III) Exotic fishes: Exotics comprise nineteen fish species in 7 families (Table 1) introducing to Iran for different purpose (Esmaeili et al. 2014c).

IV) Endemic fishes: Endemic taxa include those fishes which are restricted to southern Caspian Sea basin of Iran and there is no record of them in other neighboring countries (e.g., *Cobitis keyvani* and *C. faridpaki*).

A significant proportion of the families and genera in the Tigris-Euphrates basin is found in the Ponto-Caspian basin (the Black-Caspian Sea basin). Such widespread, northern cyprinid genera as *Alburnoides*, *Alburnus*, *Aspius*, *Barbus*, *Chondrostoma* and *Squalius* reach their southern limit in the Tigris-Euphrates basin (and neighboring Iranian basins) suggesting that they reached the Tigris-Euphrates basin from the north (see Coad 1996). Headwaters of a number of Tigris-Euphrates rivers interdigitate with the upper reaches of Black-Caspian Seas basin, e.g. the Aras River of the Caspian Sea and the Kizilirmak of the Black Sea with the Euphrates near Erzurum and Silvas respectively; the Qezel Owzan (a tributary of Safidrud) of the Caspian Sea with Tigris tributaries (Coad 1996). Headwater capture is common in the Zagros Mountains (Oberlander 1965) and in Anatolia and

pluvial conditions in the past would have facilitated fish dispersal (Coad 1996).

B) Ecoregion grouping:

A new map depicting the global biogeographical regionalisation of Earth's freshwater systems was published (Abell et al. 2008). This map of freshwater ecoregions is based on the distributions and compositions of freshwater fish species and incorporates major ecological and evolutionary patterns (see also Naseka 2010). In this new classification, south Caspian basin lies in East Transcaucasia ecoregion (Palearctic realm, Temperate floodplain rivers and wetlands).

East Transcaucasia (Kura-South Caspian Drainages and Caspian Highlands ecoregions in Abell et al. 2008: 409). In a zoogeographical sense, this name is applied to the Kura-Aras drainage, rivers of the Lenkoranskaya (Talyshskaya) lowland flowing from the slopes of the Talyshskiy [Talysh] Ridge, and rivers in the Lesser Caucasus. The main rivers in the region include the Kura with tributaries Araks [Aras, Araxes], Razdan [Zanga], Aragvi, Iori, Alazani, Chra-mi, Atstev [Akstafa], Arpa, then Vilyashchay, Lenko-ran, and Safidrud. The eastern border of this region (the border with the Harirud and Murghab, and the Amu Darya historical watershed in general) needs to be further investigated; it is tentatively accepted here that the East Transcaucasia extends further eastward to include the Atrek (Turan Plain Ecoregion in Abell et al. 2008: 409). The fish faunas of drainages from Kura to Safidrud are very close. Some fish taxa classified in this category are: *Acanthalburnus microlepis*, *Alburnoides eichwaldii*, *Alburnoides* cf. *eichwaldii* (from Safid Rud), Alburnus filippii, Leuciscus aspius, Blicca bjoerkna, *Capoeta sevangi*, *Capoeta* cf. *gracilis*, *Chondrostoma cyri*, *Ponticola cyrius*, *Rhodeus amarus*, *Romanogobio macropterus*, *Rutilus rutilus*, *Oxynoemacheilus bergianus*, *O. brandtii*, *O. lenkoranensis* (see Naseka 2010).

C) Ecological grouping:

We followed classification introduced by Kessler (1877) and also Naseka & Bogutskaya (2009) for Ponto-Caspian fishes which is based on criteria of physical habitats and the presence/absence of migrations between them. However some fish taxa may be classified in more than one category (Table 2).

I) Fluvial: fluvial, 'of various waters' ["raznovodnyye"] species are those which rarely met in the Sea occurring only in deltas and freshened coastal shallows. Freshwater and fluvial belong to 6 families (Acipenseridae, Cyprinidae, Cobitidae, Nemacheilidae, Lotidae and Percidae). Examples are: *Acipenser ruthenus*, *Ballerus sapa*, *Acanthalburnus microlepis*, *Alburnoides eichwaldii*, *Alburnus filippii*, *Alburnus hohenackeri*, *Barbus cyri*, *Capoeta gracilis*, *Chondrostoma cyri*, *Cobitis faridpaki*, *Cobitis keyvani*, *Sabanejewia aurata*, *Sabanejewia caspia*, *Sabanejewia caucásica*, *Oxynoemacheilus angorae*, *Oxynoemacheilus araxensis*, *Oxynoemacheilus bergianus*, *Oxynoemacheilus brandtii*, *Paracobitis* sp., *Lota lota*. As indicated in Table 2, most of the fluvial freshwater species mentioned above belong to the families Cyprinidae followed by Cobitidae and Nemacheilidae which are primary division families sensu Myers (1938, 1951) (i.e. those families whose members are strictly intolerant of salt water, both currently and historically). Lotidae and Percidae are secondary division families (i.e. those families which are supposed to be of marine origin but contain members that now live in fresh water, see Naseka & Bogutskaya 2009).

II) Aanadromous: Anadromous species comprise those taxa that spawn in rivers, often much farther upstream than semi-anadromous fishes, and forage all over the Sea under-taking long-distance migrations (Naseka & Bogutskaya 2009). However, as stated by Naseka & Bogutskaya (2009) Caspian fishes of this group are not strictly diadromous sensu Myers because they migrate between fresh and oligohaline-mesohaline waters rather than between fresh and true Sea (euhaline) water. They belong to the primary division families Cyprinidae, Petromyzontidae, Acipenseridae and Salmonidae;

origin of the latter three families are still debated in literature (for Acipenseridae see discussion in Artyukhin 2008). Degree of endemism is high in this group, 11 from 17 (64%). Most anadromous species, especially those from the family Cyprinidae and Salmonidae, are (historically were) much more numerous in the middle and south Caspian being rare or occasional migrants in the North Caspian (entering the Volga). Examples are: *Caspiomyzon wagneri*, *Acipenser gueldenstaedtii*, *Acipenser nudiventris*, *Acipenser persicus*, *Acipenser stellatus*, *Huso huso*, *Alburnus chalcoides*, *Leuciscus aspius*, *Luciobarbus caspius* (anadr & fluv), *Luciobarbus capito* (anadr & fluv), Vimba persa, *Oncorhynchus keta*, *Salmo caspius* (anadr & fluv) (see Table 2).

III) Semi-anadromous: Semi-anadromous fishes keep spawning in fresh water (limnetic waters, 0.5 ppt and less) but forage in oligohaline water (around 0.5–5 ppt). Some species of the families Cyprinidae, Siluridae, Esocidae and Percidae are listed in this category (Table 2). Examples are: *Abramis brama*, *Blicca bjoerkna* (fluv & semi anadr), *Cyprinus carpio* (fluv & semi anadr), *Pelecus cultratus* (fluv & semi anadr), *Rutilus caspicus*, *Scardinius erythrophthalmus* (fluv & semi anadr), *Silurus glanis* (fluv & semi anadr), *Esox lucius* (fluv & semi anadr), *Sander lucioperca* (fluv & semi anadr).

IV) Estuarine: Species that are classified as 'estuarine' mostly inhabiting deltaic areas and adjacent coastal shallows, some of them being distributed also in lower reaches of rivers and/or open marine habitats. Most species belong to the family Gobiidae. This group contains those species which can be classified as vicarious sensu Meyers, i.e. strictly or preferably freshwater or oligohaline species of primarily marine families. Some species from this group are endemic for the Caspian Sea (Table 2). Examples are: *Pungitius platygaster* (fluv & estuarine), *Benthophiloides brauneri* (marine & estuarine), *Benthophilus bdurahmanovi* (marine & estuarine), *Benthophilus granulosus* (marine & estuarine), *Benthophilus macrocephalus* (marine & estuarine), *Benthophilus mahmudbejovi* (marine & estuarine), *Hyrcanogobius bergi* (marine & estuarine), *Knipowitschia caucasica* (marine & estuarine), *Knipowitschia longecaudata* (marine & estuarine) *Neogobius melanostomus* (marine & estuarine & fluv) *Neogobius pallasi* (marine & estuarine & fluv) *Ponticola gorlap* (marine & estuarine), *Ponticola syrman* (marine & estuarine).

V) Marine: Strictly 'marine" or almost marine (mostly inhabiting the open Sea, benthic or pelagic waters) form a largest group of species from the secondary division families of Clupeidae Atherinidae, Syngnathidae, Mugilidae, Percidae and Gobiidae. Many species of this group are tolerant for the whole range of Caspian salinity though some clearly prefers the upper part of the range, up to 13.7 ppt in South Caspian, and historically could even occur and spawn in areas with higher salinity such as the former Mertvyy Kultuk [= Zaliv Tsesarevicha, Zaliv Komsomolets] and Kaydak bays (Naseka & Bogutskaya 2009). For example, *Alosa caspia* was known to spawn in the Mertvyy Kultuk Bay at a salinity of up to 32.2 ppt and its larvae were found in areas with salinity up to 45.6 ppt, and *Alosa braschnikowi* was reported in the Kaydak Bay at a salinity of 47.7 ppt (Svetovidov 1952; Naseka & Bogutskaya 2009).

Examples are: *Alosa braschnikowii*, *Alosa caspia*, *Alosa curensis*, *Alosa kessleri*, *Alosa saposchnikowii*, *Alosa sphaerocephala*, *Clupeonella caspia*, *Clupeonella engrauliformis*, *Clupeonella grimmi*, *Chelon aurata*, *Chelon saliens*, *Mugil cephalus*, *Atherina caspia*, *Syngnathus caspius*, *Sander marinus*, *Anatirostrum profundorum*, *Babka gymnotrachelus*, *Babka macrophthalma*, *Benthophiloides brauneri*, *Benthophiloides turcomanus*, *Benthophilus abdurahmanovi*, *Benthophilus baeri*, *Benthophilus casachicus*, *Benthophilus ctenolepidus*, *Benthophilus granulosus, Benthophilus grimmi, Benthophilus kessleri, Benthophilus leobergius, Benthophilus leptocephalus, Benthophilus leptorhynchus, Benthophilus macrocephalus, Benthophilus mahmudbejovi, Benthophilus pinchuki,*

Table 2. List of fish taxa of southern Caspian Sea basin in different ecological group. fluv, Fluvial; anadr, Aanadromous; semi anadr, Semi-anadromous.

Family	*Species*	Ecological group	Family	*Species*	Ecological group
Petromyzontidae	*Caspiomyzon wagneri*	anadr	**Nemacheilidae**	*Oxynoemacheilus bergianus*	fluv
Acipenseridae	*Acipenser gueldenstaedtii*	anadr		*Oxynoemacheilus brandtii*	fluv
	Acipenser nudiventris	anadr		*Paracobitis* sp.	fluv
	Acipenser persicus	anadr	**Siluridae**	*Silurus glanis*	fluv-semi anadr
	Acipenser ruthenus	fluv	**Salmonidae**	*Oncorhynchus keta*	
	Acipenser stellatus	anadr		*Oncorhynchus mykiss*	fluv
	Huso huso	anadr		*Salmo caspius*	fluv-anadr
Anguillidae	*Anguilla anguilla*	catadromous		*Salmo trutta*	fluv
Clupeidae	*Alosa braschnikowii*	marine		*Stenodus leucichthys*	anadr
	Alosa caspia	marine	**Esocidae**	*Esox lucius*	fluv-semi anadr
	Alosa curensis	marine	**Lotidae**	*Lota lota*	fluv
	Alosa kessleri	marine	**Mugilidae**	*Chelon aurata*	marine
	Alosa saposchnikowii	marine		*Chelon saliens*	marine
	Alosa sphaerocephala	marine		*Mugil cephalus*	marine
	Alosa volgensis	anadr	**Atherinidae**	*Atherina caspia*	marine
	Clupeonella caspia	marine	**Poeciliidae**	*Gambusia holbrooki*	fluv
	Clupeonella engrauliformis	marine	**Gasterosteidae**	*Gasterosteus aculeatus*	fluv
	Clupeonella grimmi	marine		*Pungitius platygaster*	fluv-estuarine
Cyprinidae	*Abramis brama*	semi anadr	**Syngnathidae**	*Syngnathus caspius*	marine
	Ballerus sapa	fluv	**Percidae**	*Perca fluvatilis*	fluv
	Acanthalburnus microlepis	fluv		*Sander lucioperca*	fluv-semi anadr
	Alburnoides eichwaldii	fluv		*Sander marinus*	marine
	Alburnus chalcoides	anadr	**Gobiidae**	*Anatirostrum profundorum*	marine
	Alburnus filippii	fluv		*Babka gymnotrachelus*	marine
	Alburnus hohenackeri	fluv		*Babka macrophthalma*	marine
	Barbus cyri	fluv		*Benthophiloides brauneri*	marine-estuarine
	Blicca bjoerkna	fluv-semi anadr		*Benthophiloides turcomanus*	marine
	Capoeta gracilis	fluv		*Benthophilus abdurahmanovi*	marine-estuarine
	Carassius auratus	fluv		*Benthophilus baeri*	marine
	Carassius gibelio	fluv		*Benthophilus casachicus*	marine
	Chondrostoma cyri	fluv		*Benthophilus ctenolepidus*	marine
	Ctenopharyngodon idella	fluv		*Benthophilus granulosus*	marine-estuarine

Table 2. Continued.

Cyprinidae	*Cyprinus carpio*	fluv-semi anadr	**Gobiidae**	*Benthophilus grimmi*	marine
	Hemiculter leucisculus	fluv		*Benthophilus kessleri*	marine
	Hypophthalmichthys molitrix	fluv		*Benthophilus leobergius*	marine
	Hypophthalmichthys nobilis	fluv		*Benthophilus leptocephalus*	marine
	Leucaspius delineatus	fluv		*Benthophilus leptorhynchus*	marine
	Leuciscus aspius	anadr		*Benthophilus macrocephalus*	marine-estuarine
	Luciobarbus caspius	anadr-fluv		*Benthophilus mahmudbejovi*	marine-estuarine
	Luciobarbus capito	anadr-fluv		*Benthophilus pinchuki*	marine
	Luciobarbus mursa	fluv		*Benthophilus ragimovi*	marine
	Mylopharyngodon piceus			*Benthophilus spinosus*	marine
	Pelecus cultratus	fluv-semi anadr		*Benthophilus svetovidovi*	marine
	Pseudorasbora parva	fluv		*Chasar bathybius*	marine
	Rhodeus amarus	fluv		*Hyrcanogobius bergi*	marine-estuarine
	Romanogobio macropterus	fluv		*Knipowitschia caucasica*	marine-estuarine
	Rutilus caspicus	semi anadr		*Knipowitschia iljini*	marine
	Rutilus kutum	anadr		*Knipowitschia longecaudata*	marine-estuarine
	Rutilus rutilus	fuv		*Mesogobius nigronotatus*	marine
	Scardinius erythrophthalmus	fluv-semi anadr		*Mesogobius nonultimus*	marine
	Squalius orientalis	fluv		*Neogobius caspius*	marine
	Tinca tinca	fluv		*Neogobius melanostomus*	marine-estuarine-fluv
	Vimba persa	anadr		*Neogobius pallasi*	marine-estuarine-fluv
Cobitidae	*Cobitis faridpaki*	fluv		*Ponticola cyrius*	
	Cobitis keyvani	fluv		*Ponticola goebelii*	marine
	Sabanejewia aurata	fluv		*Ponticola gorlap*	marine-estuarine-fluv
	Sabanejewia caspia	fluv		*Ponticola syrman*	marine-estuarine
	Sabanejewia caucasica	fluv		*Proterorhinus nasalis*	marine
Nemacheilidae	*Oxynoemacheilus angorae*	fluv		*Rhinogobius* sp.	-
	Oxynoemacheilus araxensis	fluv			

Benthophilus ragimovi, Benthophilus spinosus, Benthophilus svetovidovi, Chasar bathybius, Hyrcanogobius bergi, Knipowitschia caucasica, Knipowitschia iljini, Knipowitschia longecaudata, Mesogobius nigronotatus, *Mesogobius nonultimus*, *Neogobius caspius*, *Neogobius melanostomus*, *Neogobius pallasi*, *Ponticola goebelii*, *Ponticola gorlap*, *Ponticola syrman*, *Proterorhinus nasalis* (Table 2).

Threats

Similar to threats observed in other countries, habitat modification, pollution, introduction of exotic aquatic species, droughts, human population growth and illegal fishing are main threats to fish diversity in the southern Caspian Sea basin (see Esmaeili et al. 2014c).

Finally, it is suggested that maps of conservation hot spots to be drawn based on a combination of characters (e.g., fish diversity, population density, ecological requirements, threats), and risk level of incurring losses to local–global biodiversity (e.g., number of critically endangered species). Moreover, the potenial distribiution of many species especially key or/and endangered species regarding zoogeographical point of view and conservation management strategies can be modelled in future according to Mostafavi et al. (2014).

Summary and Conclusion

A total of 119 species belonging to 63 genera and 18 families, 16 orders and two classes are listed here. The number of species is higher than fishes in the previous checklists published by Coad (1988) and Esmaeili et al. (2010a).

The listed fishes here reveal the followings:

1) Two species were new to science described since 2010 (*Cobitis faridpaki* and *Cobitis keyvani*).

2) The taxonomic status of *Paracobitis* populations in the southern Caspian Sea basin has been changed and it seems that *P. malapterura* is restricted to Namak and parts of Kavir basins and *P. iranica* is treated as synonym (see Freyhof et al. 2014).

3) *Alburnoides eichwaldii* is likely restricted to the western river tributaries of south Caspian Sea basin {(Aras river system) (see Saifali et al. 2012)}.

4) *Chondrostoma cyri* shows narrow distribution range in western river tributaries of the south Caspian basin (Aras river system).

5) Some taxa with wide distribution range from Aras to Atrak might deserve to be considered as distinct species.

6) Alien fishes invaded different river systems of the south Caspian Sea basin (see Esmaeili et al. 2014c).

7) Some of native fishes are being translocated along with exotic carps to other Iranian basins accidentally by exotic carps (*A. hohenakeri*, *Rhodeus*) or have been translocated to enhance fish production in fisheries sections {(e.g., *Huso huso*) (see Esmaeili et al. 2014c)}.

8) Some subspecies has got full specie rank. *Barbus brachycephalus caspius* Berg, 1914 has been regarded as a distinct species in the Caspian Sea by Fricke et al. (2007).

9) The data presented above clearly confirm and even emphasize a well-known fact that some Clupeidae and Gobiidae represent in the Caspian Sea are examples of adaptive diversification.

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