

**Carps and Minnows  
of Iran**  
(Families Cyprinidae and Leuciscidae)

**Volume II:**

**Minnows**  
(Family Leuciscidae)  
**and**  
**Bibliography**

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#### Bibliography

## **Acknowledgements**

Acknowledgements are in Volume I: General Introduction and Carps (Family Cyprinidae).

## Minnows (Family Leuciscidae)

An extensive **General Introduction** to cyprinoid fishes is given in Volume I covering Purpose of the Work, Materials and Methods, Environment, History of Research and Fisheries. This introductory section under Carps (Family Cyprinidae) in Volume I covers aspects of the classification, relationships, morphology and biology of the cyprinoid fishes found in Iran.

The status of the fish fauna in Iran was assessed by Coad (1980b) and Kiabi *et al.* (1999) and compared with other areas by Moyle and Leidy in Fiedler and Jain (1992). The percentage of the total fauna under some form of threat was assessed at 22%, a figure which was lower than most other areas examined. The IUCN assessments (2015; <https://newredlist.iucnredlist.org/>, downloaded at various times in 2019 and should be checked for updates) are given below for the leuciscid species over their whole distribution. Apart from Iranian endemics and species found mostly in Iran and adjacent countries, these assessments may not depend much on Iranian data. However, given human population increases and agricultural, domestic and industrial demands for water, pollution and drought in Iran, these assessments probably apply to Iran and may be conservative. Species not included have no assessment.

Critically Endangered: None.

Vulnerable: None.

Least Concern: *Abramis brama*, *Acanthobrama marmid*, *Acanthobrama microlepis*, *Alburnoides eichwaldii*, *Alburnus caeruleus*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Alburnus sellal*, *Ballerus sapa*, *Blicca bjoerkna*, *Chondrostoma cyri*, *Chondrostoma regium*, *Leucaspis delineatus*, *Leuciscus aspius*, *Leuciscus vorax*, *Pelecus cultratus*, *Scardinius erythrophthalmus*, *Squalius berak*, *Squalius lepidus*, *Squalius turcicus*.

Data Deficient: *Acanthobrama urmianus*.

## Identification Keys

The leuciscids of Iran may be identified using the following keys, the first to genera and the subsequent ones to species within genera having more than one species. Volume I: Introduction and Carps (Family Cyprinidae) has more background on keys and techniques.

Note that key characters, e.g., fin ray counts, are restricted to Iranian species; species from elsewhere may not key out here. Distributions in the keys are also for Iran only and are based on 19 drainage basins (see map below in **Biodiversity**)

The keys are in two main sections, a **Key to Genera** and a **Key to Species within Genera** where there are two or more species.

Distributions in the keys are by drainage basin, except for exotic species which may occur widely as farmed fish or as accidental and deliberate releases that have not always been well-documented. Native fishes that have been translocated are mentioned. Characters in brackets [...] may not apply to all genera or species below them in the key but are additional characters that aid identification for that particular genus or species. Illustrations are taken from the Species Accounts where the source is acknowledged.

A few general illustrations were given under Cyprinidae to show characters that appear repeatedly in the keys to both Carps and Minnows.

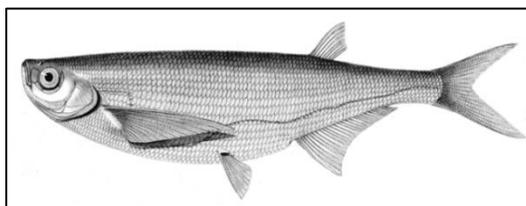
Definitions of characters may be found in the *Dictionary of Ichthyology* at [www.briancoad.com](http://www.briancoad.com). Thickened fin rays are referred to as spines for convenience in this key, although they are not true spines.

### Key to Genera of Leuciscidae

Species that are the only one in the genus will key out here and are illustrated.

1a. Scaleless (or naked) keel from the throat to the anal fin; mouth almost vertical; lateral line very wavy; dorsal fin origin behind anal fin origin; Caspian Sea basin = *Pelecus cultratus*

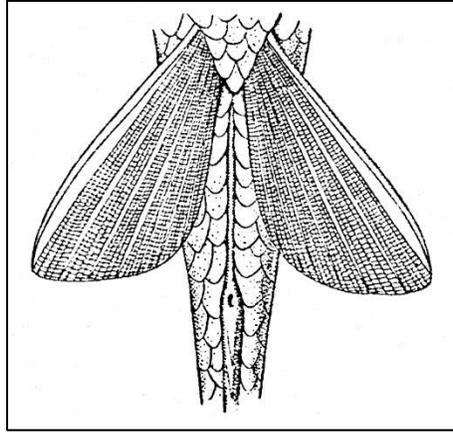
1b. Not as above ---> **2**



*Pelecus cultratus*

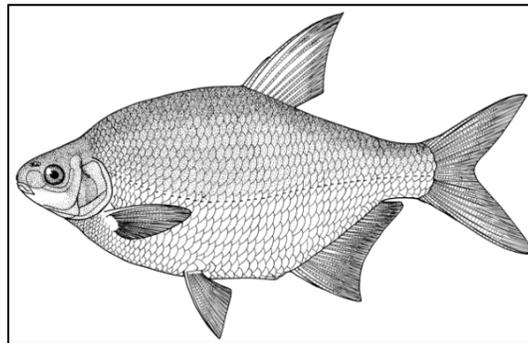
2a. Naked ventral keel of varying extent between pelvic fin bases and anal fin ---> **3**

2b. Naked ventral keel absent ---> **8**



Naked ventral keel in *Alburnoides* sp.

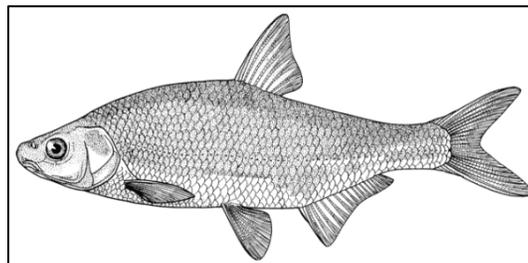
- 3a. Scaleless groove on back before dorsal fin; [mouth small, oblique and subterminal; anal fin branched rays 16-24; pharyngeal teeth usually 2,5-5,2]; Caspian Sea basin = *Blicca bjoerkna*  
 3b. No groove on back ---> **4**



*Blicca bjoerkna*

- 4a. Anal fin branched rays 16-44; pharyngeal teeth in one row (usually 5-5) ---> **5**  
 4b. Anal fin branched rays 7-21, usually less than 16; pharyngeal teeth in two rows (usually 2,5-4,2 or 2,5-5,2) ---> **7**

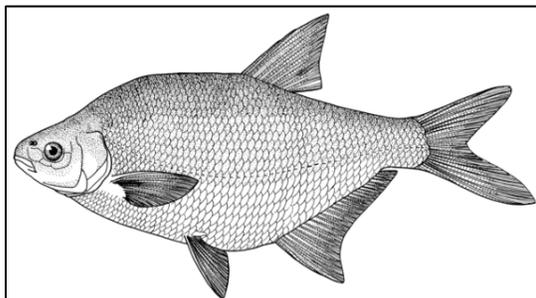
- 5a. Scaled keel behind dorsal fin; anal fin origin behind a vertical from dorsal fin end; Caspian Sea basin = *Vimba persa*  
 5b. No scaled keel behind dorsal fin; anal fin origin before a vertical from dorsal fin end ---> **6**



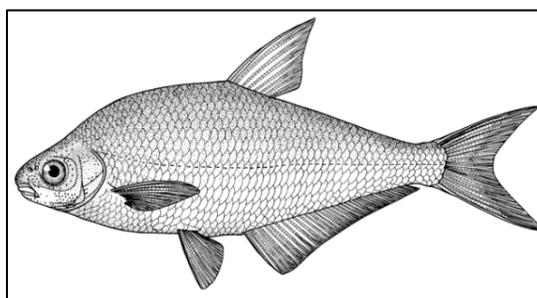
*Vimba persa*

6a. Anal fin branched rays 22-30 (mostly 24-28); dorsal fin branched rays modally 9; Caspian Sea basin = *Abramis brama*

6b. Anal fin branched rays 31-44 (mostly 34-38); dorsal fin branched rays modally 8; Caspian Sea basin = *Ballerus sapa*



*Abramis brama*



*Ballerus sapa*

7a. Gill rakers short; pharyngeal teeth usually unserrated; Caspian Sea, Dasht-e Kavir, Esfahan, Hari River, Kor River, Lake Urmia, Namak Lake, Persis, Sirjan and Tigris River basins = *Alburnoides*

7b. Gill rakers long; pharyngeal teeth usually serrated; Caspian Sea, Esfahan, Hari River, Hormuz, Kor River, Lake Maharlu, Lake Urmia, Namak Lake, Persis and Tigris River basins = *Alburnus*

8a. Last dorsal fin unbranched ray thickened as a smooth spine (note *Acanthobrama persidis* lacks this spine and keys out below); Caspian Sea, Hormuz, Kor River, Lake Maharlu, Lake Urmia, Persis and Tigris River basins = *Acanthobrama*

8b. Last dorsal fin unbranched ray not a spine ---> **9**

9a. Mouth a ventral arch; lower jaw with horny anterior edge; Caspian Sea, Esfahan, Kor River, Persis and Tigris River basins = *Chondrostoma*

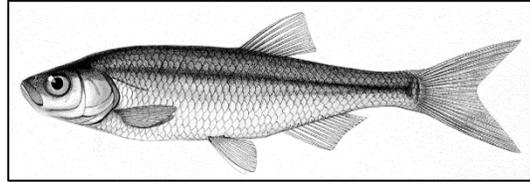
9b. Mouth terminal or subterminal, not arched; lower jaw without horny anterior edge ---> **10**



Ventral arch mouth  
of *Chondrostoma*

10a. Lateral line incomplete with 0-13 pored scales; females with large, rounded papillae around the genital opening; Caspian Sea basin = *Leucaspilus delineatus*

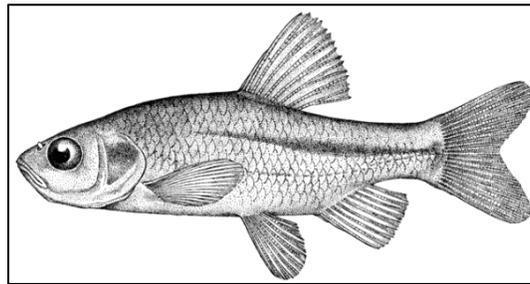
10b. Not as above ---> **11**



*Leucaspilus delineatus*

11a. Flanks with a stripe evident posteriorly but fading anteriorly and not reaching the head; pharyngeal teeth 1,5-4,1; [dorsal fin branched rays modally 7; lateral line scales 35-43]; Hormuz, Kor River, Lake Maharlu and Persis basins = *Acanthobrama persidis*

11b. Not as above ---> **12**



*Acanthobrama persidis*

12a. Lateral line scales 62-110, mostly 65 or more; large mouth with the lower jaw projecting; Caspian Sea and Tigris River basins = *Leuciscus*

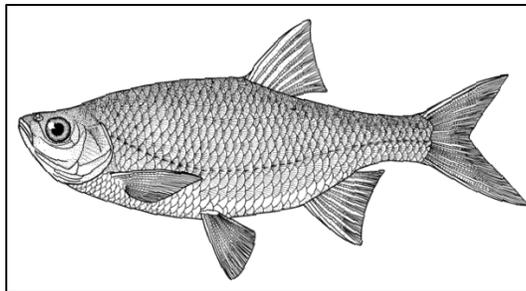
12b. Lateral line scales 36-68, mostly 58 or less; mouth relatively small, terminal or subterminal ---> **13**



Large mouth and projecting lower jaw  
in *Leuciscus*

13a. Scaled keel on belly; pharyngeal teeth 3,5-5,3; [dorsal fin branched rays 7-10, usually 8; anal fin branched rays 9-13, usually 11]; Caspian Sea basin = *Scardinius erythrophthalmus*

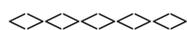
13b. Not as above ---> **14**



*Scardinius erythrophthalmus*

14a. Pharyngeal teeth in a single row, 6-5 or 5-5; [dorsal fin branched rays 8-12, usually 9-10; anal fin branched rays 8-12, usually 9-10]; Caspian Sea basin = *Rutilus*

14b. Pharyngeal teeth in two rows, usually 2,5-4,2 or 2,5-5,2; [dorsal fin branched rays 7-10, usually 7-9; anal fin branched rays 7-11, usually 8-9]; Caspian Sea, Dasht-e Kavir, Hari River Namak Lake and Tigris River basins = *Squalius*



### Verbal Key to Genera of Leuciscidae

The key characters of the genera are summarised below, restricted to Iranian species only. Characters may not be unique to a genus but the combination of characters is unique.

*Abramis*: naked ventral keel (between pelvic fin bases and anal fin); anal fin branched rays 22-30 (mostly 24-28); dorsal fin branched rays modally 9; pharyngeal teeth in one row

*Acanthobrama*: last dorsal fin unbranched ray thickened as a smooth spine; no ventral keel

*Alburnoides*: ventral keel of varying naked extent; anal fin branched rays 8-16; unserrated pharyngeal teeth in two rows; gill rakers short

*Alburnus*: ventral keel of varying naked extent; anal fin branched rays 7-21, usually 18 or less; serrated pharyngeal teeth in two rows; gill rakers long

*Ballerus*: ventral keel of varying naked extent; anal fin branched rays 31-44 (mostly 34-38); dorsal fin branched rays modally 8; pharyngeal teeth in one row

*Blicca*: ventral keel naked; scaleless groove on back before dorsal fin

*Chondrostoma*: mouth ventral and arched; lower jaw with horny edge; pharyngeal teeth 5-5, 6-5 or 6-6; last dorsal fin unbranched ray not a spine; no ventral keel;

*Leucaspius*: lateral line incomplete with 0-13 pored scales

*Leuciscus*: large mouth with the lower jaw projecting; lateral line scales 62-110

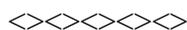
*Pelecus*: naked ventral keel from the throat to the anal fin

*Rutilus*: mouth not arched; pharyngeal teeth 6-5 or 5-5

*Scardinius*: scaled keel on belly; pharyngeal teeth 3,5-5,3

*Squalius*: mouth not arched; pharyngeal teeth 2,5-4,2

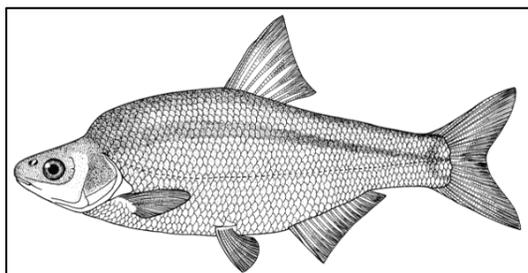
*Vimba*: naked ventral keel; anal fin branched rays 12-22; scaled keel behind dorsal fin; pharyngeal teeth 5-5



### Keys to Species within Genera of Leuciscidae

Note that some species have been defined by DNA while morphological differences comprise overlapping characters (“characters in combination, none unique”) and so individual specimens may be difficult to identify in the field, the laboratory or in the literature based on external morphology. Distribution is therefore often important. A single species is shown to represent each genus as body form is generally similar.

#### Key to *Acanthobrama*



*Acanthobrama marmid*

1a. Lateral line scales 35-43; dorsal fin branched rays modally 7; anal fin branched rays 7-11, usually 9 or less; dorsal fin spine and naked ventral keel absent; Hormuz, Kor River, Lake Maharlu and Persis basins = *Acanthobrama persidis*

1b. Lateral line scales 50 or more; dorsal fin branched rays modally 8; anal fin branched rays 10 or more; dorsal fin spine and naked ventral keel present ---> **2**

2a. Pharyngeal teeth in one row (5-5); total gill rakers 12-17; [anal fin branched rays 13-22]; Tigris River basin = *Acanthobrama marmid*

2b. Pharyngeal teeth in two rows (1 or 2 in outer row, 4 or 5 in inner row); total gill rakers 10-14; [anal fin branched rays 10-19]; Caspian Sea and Lake Urmia basins ---> **3**

3a. Anal fin branched rays 12-19; lateral line scales 60-87; Caspian Sea basin = *Acanthobrama microlepis*

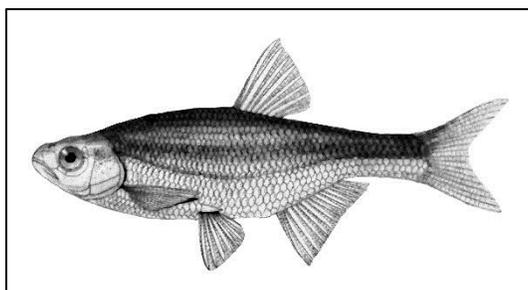
3b. Anal fin branched rays 10-13; lateral line scales 50-68; Lake Urmia basin = *Acanthobrama urmianus*

#### Key to *Alburnoides*

Modified after Coad and Bogutskaya (2009) and Mousavi-Sabet *et al.* (2015), this key is unsatisfactory as meristic and morphometric characters overlap between species, although modes and means of counts may be different, and colour pattern of the lateral line and keel development vary between and within species. Large samples of specimens of a species naturally show wider ranges in character states than in smaller samples, and thus reduce the efficacy of possible

distinctions when individual fish or small samples are to be identified. Ranges and percentages here serve to indicate degree of overlap and refine the usefulness of previous keys. DNA defines species (with some disagreements between authors) and for practical purposes in the field, in older preserved specimens and in literature records, distribution is key. The table under the genus summarises distribution.

Note that translocation of these small fish, evident in other species such as *Alburnus hohenackeri*, has not been investigated and is a potential source of confusion.



*Alburnoides eichwaldii*

1a. Snout pointed or slightly rounded; mouth terminal or upturned, tip of mouth cleft on level from slightly above middle of eye to upper margin of pupil; lower jaw slightly to moderately projecting relative to upper jaw; junction of lower jaw and quadrate on about vertical through anterior eye margin; Atrak, Hari, Kor River and Sirjan basins ---> **2**

1b. Snout slightly to markedly rounded; mouth terminal to subterminal, tip of mouth cleft on level from middle of eye to below lower margin of eye; upper jaw slightly to moderately projecting relative to lower jaw; junction of lower jaw and quadrate on about vertical through about middle of eye ---> **4**

2a. Kor River and Sirjan basins; ventral keel completely scaled = *Alburnoides qanati*

2b. Atrak and Hari River basins; ventral keel completely or almost completely scaleless ---> **3**

3a. Hari River basin; mostly 14-16 anal fin branched rays (90.7%, range 10-16) = *Alburnoides holciki*

3b. Atrak River basin; mostly 12-13 anal fin branched rays (83.3%, range 11-15) = *Alburnoides parhami*

4a. Anal fin branched rays 8-13, mostly 8-11 (96.0%) with 8-10 at 76.6%; dorsal fin branched rays 7-8, often 7 ---> **5**

4b. Anal fin branched rays 9-16, mostly 11-14 (96.4%); dorsal fin branched rays 8, rarely 7 ---> **6**

5a. Nurabad River of Tigris River basin; dorsal fin branched rays 7(91.3%); ventral keel scaleless from one-third to whole keel length; 38-40, commonly 39, total vertebrae; 19-20, commonly 20, abdominal vertebrae = *Alburnoides nicolausi*

5b. Lake Urmia basin; dorsal fin branched rays 7(49.0%) or 8(51.0%); ventral keel completely scaled; commonly 40-41 total vertebrae; 20-22, commonly 21, abdominal vertebrae = *Alburnoides petrubanarescui*

6a. Ventral keel usually completely or partly scaled ---> **7**

6b. Ventral keel usually completely or almost completely scaleless ---> **9**

7a. Tigris River basin; anal fin branched rays mostly 11-12 (94.7%, range 9-12); total scale radii 12-17; [lateral line scales 39-49] = *Alburnoides idignensis*

7b. Outside Tigris River basin in northern basins; anal fin branched rays mostly 11-14 (85.5%, range 10-16, often 13 or more at 44.2%); total scale radii 16-19 ---> **8**

8a. Western Dasht-e Kavir basin; eye located in the anterior half of head; predorsal vertebrae 13-14 (72.5 and 27.5%); orbit width smaller than interorbital width; deep body and head =

*Alburnoides coadi*

8b. Western Caspian Sea basin from Sefid River basin (or just east) and then west (except the Aras River basin; eye located in the mid-head; predorsal vertebrae mostly 12-13 (44.2 and 52.1%); orbit width about equal to interorbital width; shallow body and head = *Alburnoides samiii*

9a. Aras River basin in Caspian Sea basin; lateral line in live and preserved fish delineated by dark pigment dots above and below; predorsal vertebrae 12-15, mostly 13-14 (93.0%; 38.1% with 13) = *Alburnoides eichwaldii*

9b. Lateral line in live and preserved fish somewhat darker than surrounding flank but no strong dark dots outline canal; predorsal vertebrae 11-14, mostly 12-13 (89.1%; 31.2% with 13) ---> **10**

10a. Cheshmeh Ali and adjacent waters of the northern Dasht-e Kavir basin = *Alburnoides damghani*

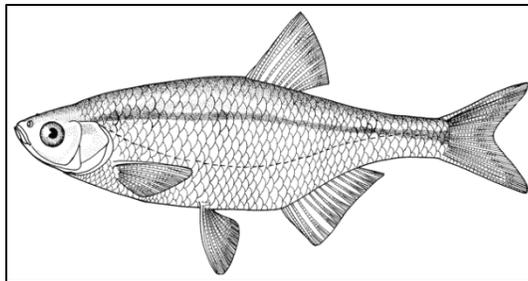
10b. Other basins ---> **11**

11a. Namak Lake basin; eye relatively large (27.7-34.5, mean 31.3 in head length) = *Alburnoides namaki*

11b. Eastern Caspian Sea basin east of the Sefid River basin (except the Atrak River); eye relatively small (23.6-34.0, mean 27.9 in head length) = *Alburnoides tabarestanensis*

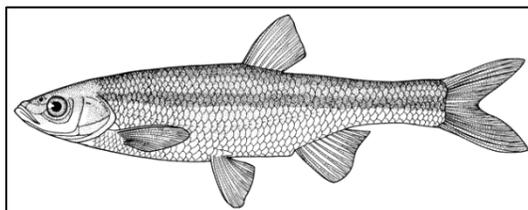
### Key to *Alburnus*

Translocation of these small species may be more widespread than documented. See, as an example, under the *Alburnus hohenackeri* description.



*Alburnus hohenackeri*

- 1a. Dorsal fin branched rays modally 7; strong mid-flank stripe [anal fin branched rays 9-13, usually 10-12; anal fin origin below or behind last dorsal fin ray; total gill rakers 12-21; lateral line scales 46-64, usually 57 or less]; Caspian Sea basin = *Alburnus filippii*  
 1b. Dorsal fin branched rays modally 8; no strong stripe in Caspian Sea species ---> **2**



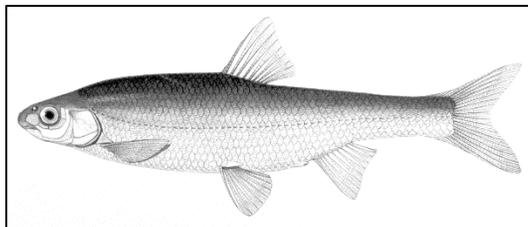
Mid-flank stripe in *Alburnus filippii*

- 2a. Total gill rakers 18-31, usually 19 or more; Caspian Sea basin ---> **3**  
 2a. Total gill rakers 8-23, usually 16 or less in all but one species; outside Caspian Sea basin ---> **4**  
 3a. Lateral line scales 54-74, usually 55 or more; abdominal keel partly covered by scales, no more than half naked; peritoneum light brown; Caspian Sea basin = *Alburnus chalcoides*  
 3b. Lateral line scales 34-55, usually 45 or less; abdominal keel mostly naked; peritoneum light silvery; Caspian Sea basin and translocated = *Alburnus hohenackeri*  
 4a. Hari River basin; [total gill rakers 13-23; lateral line scales 30-46; anal fin branched rays 9-13] = *Alburnus taeniatus*  
 4b. Outside Hari River basin ---> **5**  
 5a. Lake Urmia basin ---> **6**  
 5b. Tigris River and basins of central and southern Iran ---> **7**  
 6a. Lateral line scales 46-63; peritoneum black = *Alburnus atropatena*  
 6b. Lateral line scales 35-45; peritoneum silvery-brown = *Alburnus ulanus*  
 7a. Lateral line scales 58-89, usually 62 or more; Esfahan, Hormuz, Kor River, Lake Maharlu, Persis and Tigris River basins = *Alburnus sellal*  
 7b. Lateral line scales 43-59, usually 57 or less ---> **7**

- 8a. Anal fin branched rays 13-18; total gill rakers 10-13; Tigris River basin = *Alburnus caeruleus*  
 8b. Anal fin branched rays 9-12; total gill rakers 12-18; Esfahan, Namak Lake and Tigris River basins = *Alburnus doriae*

### Key to *Chondrostoma*

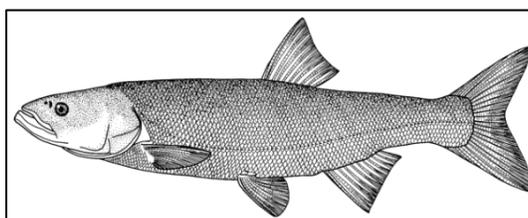
Modified after Eagderi *et al.* (2017).



*Chondrostoma cyri*

- 1a. Total gill rakers 15-17; snout short and rounded (17.1-20.8 in % of head length); mouth arched without a horny blade on lower jaw; caudal fin shallow with rounded lobes; Tigris River basin = *C. esmaeili*  
 1b. Total gill rakers 17, usually 20, or more; snout long (25.5 or more in % of head length); mouth straight to slightly arched with a horny blade on lower jaw; caudal fin forked with pointed lobes ---> **2**
- 2a. Caspian Sea basin; [lateral line scales 47-73; dorsal fin branched rays usually 8; anal fin branched rays usually 9-10; total gill rakers usually 21 or more] = *Chondrostoma cyri*  
 2b. Outside Caspian Sea basin ---> **3**
- 3a. Kor River basin; [lateral line scales 47-57; dorsal fin branched rays usually 8; anal fin branched rays usually 9; total gill rakers 25 or more] = *Chondrostoma orientale*  
 3b. Esfahan, Persis and Tigris River basins; [lateral line scales 50-73; dorsal fin branched rays usually 8-9; anal fin branched rays usually 9-11; total gill rakers 18, usually 20, or more = *Chondrostoma regium*

### Key to *Leuciscus*



*Leuciscus vorax*

The distinction of *L. aspius* and *L. vorax* has not been examined recently and characters overlap, sample sizes for gill rakers and scales in particular being very small. However, they are found in widely separated basins.

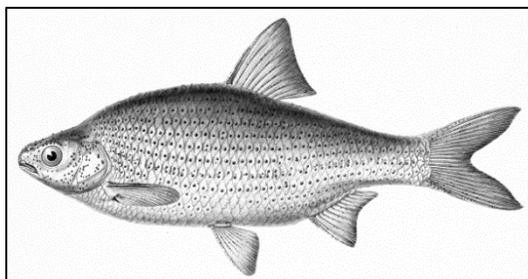
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1a. Lateral line scales 62-105; anal fin branched rays 11-16, usually 12-13; total gill rakers 8-11; total vertebrae 47-51; Caspian Sea basin = *Leuciscus aspius*

1b. Lateral line scales 82-110; anal fin branched rays 9-13, usually 10-11; total gill rakers 9-14; total vertebrae 51-53; Tigris River basin = *Leuciscus vorax*

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### Key to *Rutilus*



*Rutilus lacustris*

1a. Lateral line scales 47-68, mostly 55-58; gas bladder elongate and conical, or pointed, posteriorly; Caspian Sea basin = *Rutilus kutum*

1b. Lateral line scales 39-48, mostly 42-47; gas bladder rounded posteriorly; Caspian Sea basin = *Rutilus lacustris*

Note: *Rutilus lacustris* (formerly recognised as a single taxon in Iran: *Rutilus rutilus*, as a subspecies *R. r. caspicus* or as *R. caspicus*) and *R. rutilus* are not recognised or separated here as distinct taxa in the Iranian Caspian Sea basin. They may be distinct taxa based on migratory habits and characters listed in Kottelat and Freyhof (2007) and general literature. Some characters do not agree between studies, others overlap, or are only visible on fresh material. The key characters below have yet to be examined in detail in resident and migratory Iranian specimens.

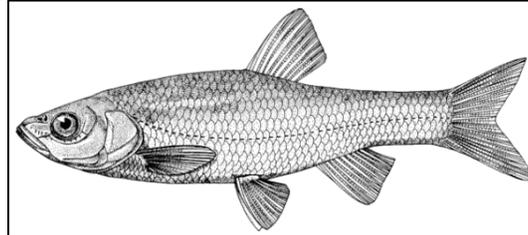
1a. Lateral line scales mostly 41-43 (or mostly 42-44); dorsal fin branched rays 8-10, mostly 9; depth of body 24-37% of standard length (mostly 29-31%); mouth subterminal and top lower than level of lower margin of eye; snout rounded; iris and pectoral, pelvic and anal fins usually without yellow, orange or red pigment (iris silvery-grey, dark margined fins, slightly red in autumn outside spawning season); migratory; Caspian Sea basin = *Rutilus lacustris*

1b. Lateral line scales mostly 43-45 (or mostly 39-41); dorsal fin branched rays 9-11, mostly 10; depth of body 25-36% of standard length (mostly 33-35%); mouth terminal or almost terminal and top above level of lower margin of eye; snout pointed; iris and pectoral, pelvic and anal fins always with yellow, orange or red pigment; non-migratory; Caspian Sea basin = *Rutilus rutilus*

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### Key to *Squalius*

Modified after Khaefi *et al.* (2016). There is more variation in characters than given in the key by Khaefi *et al.* (2016) and distribution is the key character.



*Squalius lepidus*

- 1a. Dorsal fin branched rays modally 7; Hari River basin = *Squalius latus*  
 1b. Dorsal fin branched rays modally 8-9; Caspian Sea, Dasht-e Kavir, Namak Lake and Tigris River basins ---> **2**
- 2a. Head elongate and pointed with a strongly projecting lower jaw; Tigris River basin = *Squalius lepidus*  
 2b. Not as above ---> **3**
- 3a. Knob on lower jaw symphysis wide, thick; posterior tip of each flank scale with a bold grey or brown, roundish or crescent-shaped blotch; Dasht-e Kavir and Namak Lake basins = *S. namak*  
 3b. Knob on lower jaw symphysis narrow, thin or absent; posterior tip of flank scales usually without bold blotch -> **4**
- 4a. Caudal, anal and pelvic fin rays hyaline or with a grey or yellow hue in life; knob on lower jaw symphysis absent; Tigris River basin = *Squalius berak*  
 4b. Caudal, anal and pelvic fin rays orange in life; knob on lower jaw symphysis small; Caspian Sea and Lake Urmia basins = *Squalius turcicus*
-

## Checklists

One exotic species, the fathead minnow (*Pimephales promelas* Rafinesque, 1820) from North America, recorded by Andersskog (1970), does not appear to have become established and is omitted from this work.



*Pimephales promelas*

(*Pimephales promelas*2, CC0, U.S. Fish and Wildlife Service, Duane Raver).

### Family Leuciscidae

An asterisk (\*) marks Iranian endemics as currently understood. Some species are found in basins shared with neighbouring countries but there are no records of the species outside Iran.

*Abramis brama* (Linnaeus, 1758)

*Acanthobrama marmid* Heckel, 1843

*Acanthobrama microlepis* (De Filippi, 1863)

\**Acanthobrama persidis* (Coad, 1981)

\**Acanthobrama urmianus* (Günther, 1899)

\**Alburnoides coadi* Mousavi-Sabet, Vatandoust and Doadrio, 2015

\**Alburnoides damghani* Jouladeh Roudbar, Eagderi, Esmaeili, Coad and Bogutskaya, 2016

*Alburnoides eichwaldii* (De Filippi, 1863)

*Alburnoides holciki* Coad and Bogutskaya, 2012

\**Alburnoides idignensis* Bogutskaya and Coad, 2009

\**Alburnoides namaki* Bogutskaya and Coad, 2009

\**Alburnoides nicolausi* Bogutskaya and Coad, 2009

\**Alburnoides parhami* Mousavi-Sabet, Vatandoust and Doadrio, 2015

\**Alburnoides petrubanarescui* Bogutskaya and Coad, 2009

\**Alburnoides qanati* Coad and Bogutskaya, 2009

\**Alburnoides samiii* Mousavi-Sabet, Vatandoust and Doadrio, 2015

\**Alburnoides tabarestanensis* Mousavi-Sabet, AnvariFar and Azizi, 2015

\**Alburnoides* sp. Esfahan basin

\**Alburnoides* sp. Persis basin

\**Alburnus atropatenae* Berg, 1925  
*Alburnus caeruleus* Heckel, 1843  
 \**Alburnus chalcoides* (Güldenstädt, 1772)  
 \**Alburnus doriae* De Filippi, 1865  
*Alburnus filippii* Kessler, 1877  
*Alburnus hohenackeri* Kessler, 1877  
*Alburnus sellal* Heckel, 1843  
*Alburnus taeniatus* Kessler, 1874  
 \**Alburnus ulanus* Günther, 1899

*Ballerus sapa* (Pallas, 1814)

*Blicca bjoerkna* (Linnaeus, 1758)

*Chondrostoma cyri* Kessler, 1877  
 \**Chondrostoma esmaeilii* Eagderi, Jouladeh-Roudbar, Birecikligil, Çiçek and Coad, 2017  
 \**Chondrostoma orientale* Bianco and Banarescu, 1982  
*Chondrostoma regium* (Heckel, 1843)

*Leucaspius delineatus* (Heckel, 1843)

*Leuciscus aspius* (Linnaeus, 1758)  
*Leuciscus vorax* (Heckel, 1843)

*Pelecus cultratus* (Linnaeus, 1758)

*Rutilus kutum* (Kamensky, 1901)  
*Rutilus lacustris* (Pallas, 1814)

*Scardinius erythrophthalmus* (Linnaeus, 1758)

*Squalius berak* Heckel, 1843  
*Squalius latus* Keyserling, 1861  
*Squalius lepidus* Heckel, 1843  
 \**Squalius namak* Khaefi, Esmaeili, Sayyadzadeh, Geiger and Freyhof, 2016  
*Squalius turcicus* De Filippi, 1865

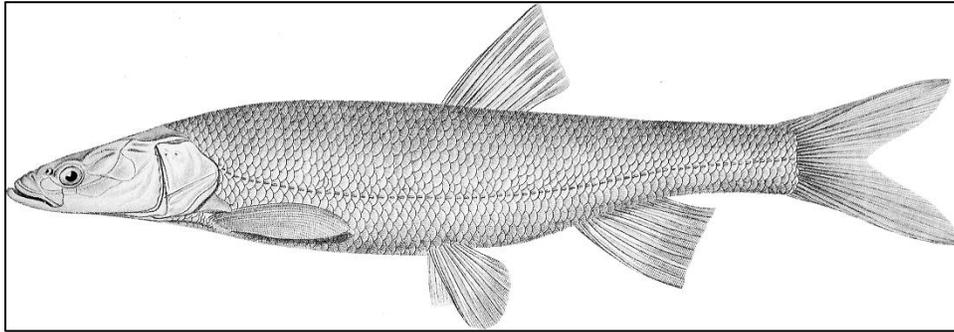
*Vimba persa* (Pallas, 1814)

The following species have been recorded in water bodies shared with, or neighbouring, Iran and eventually may be found in Iran.

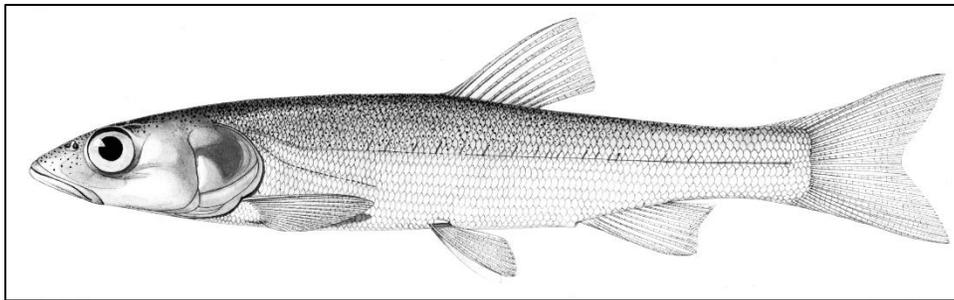
In the Hari (= Tedzhen) River basin of Afghanistan and Turkmenistan and/or the connected Karakum Canal of Turkmenistan:-

*Aspiolucius esocinus* (Kessler, 1874)

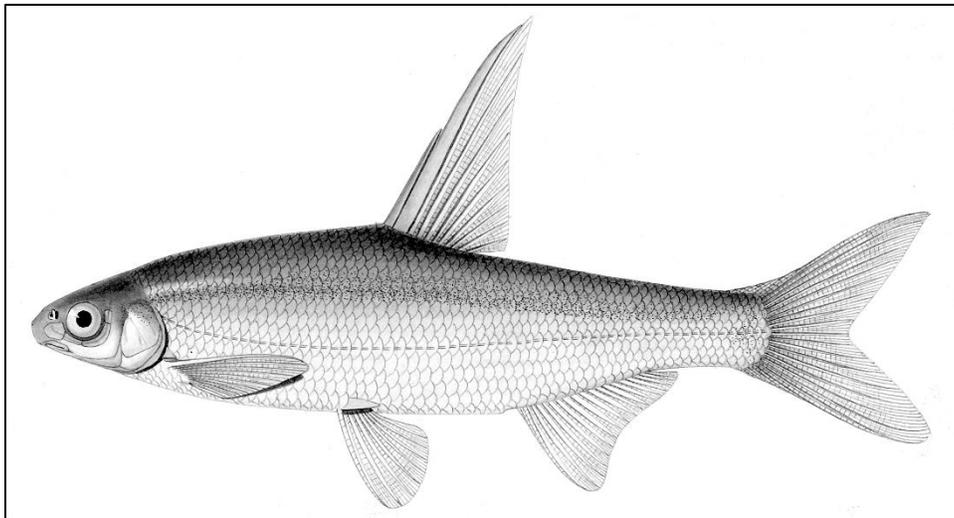
*Capoetobrama kuschakewitschi* (Kessler, 1872)



*Aspiolucius esocinus*, after Kessler (1874b).



*Aspiolucius esocinus*, fry, after Berg (1948-1949).



*Capoetobrama kuschakewitschi*, after Berg (1948-1949).

In drainages of southern Turkmenistan:-

*Alburnoides varentsovi* Bogutskaya and Coad, 2009



*Alburnoides varentsovi*, after Bogutskaya and Coad (2009).

## Biodiversity

The minnow or leuciscid fauna of Iran comprises 45-47 native species in 14 genera (two putative species not formally described hence the ranges here and below). For comparison, Turkey has 122 native species (Kuru *et al.*, 2014; Çiçek *et al.*, 2015; Sungur Birecikligil *et al.*, 2017; Çiçek *et al.*, 2020), Afghanistan has 9 native species (Coad, 2014), Iraq has 8 native species (Coad, 2010; *Catalog of Fishes*, downloaded 27 September 2018), the Arabian Peninsula has 1 native species (Freyhof *et al.*, 2020), and Pakistan has none (Mirza, 2003).

Minnows comprise about 19% of the freshwater ichthyofauna of Iran while carps comprise about 24% (Esmaeili *et al.*, 2017; *Catalog of Fishes*, downloaded 27 September 2018). New species are likely to be found and will be endemics, with a restricted distribution that enhances the biodiversity of a particular drainage basin or ecoregion but has a restricted utility in comparing basins zoogeographically on presence-absence data, unless their genetic relationships also become known.

There are 19-21 species endemic to Iran (42.2-44.6% of the minnows) (see **Checklist** above). Endemics in the Caspian Sea and Tigris River basins may eventually be found in adjacent countries (see below).

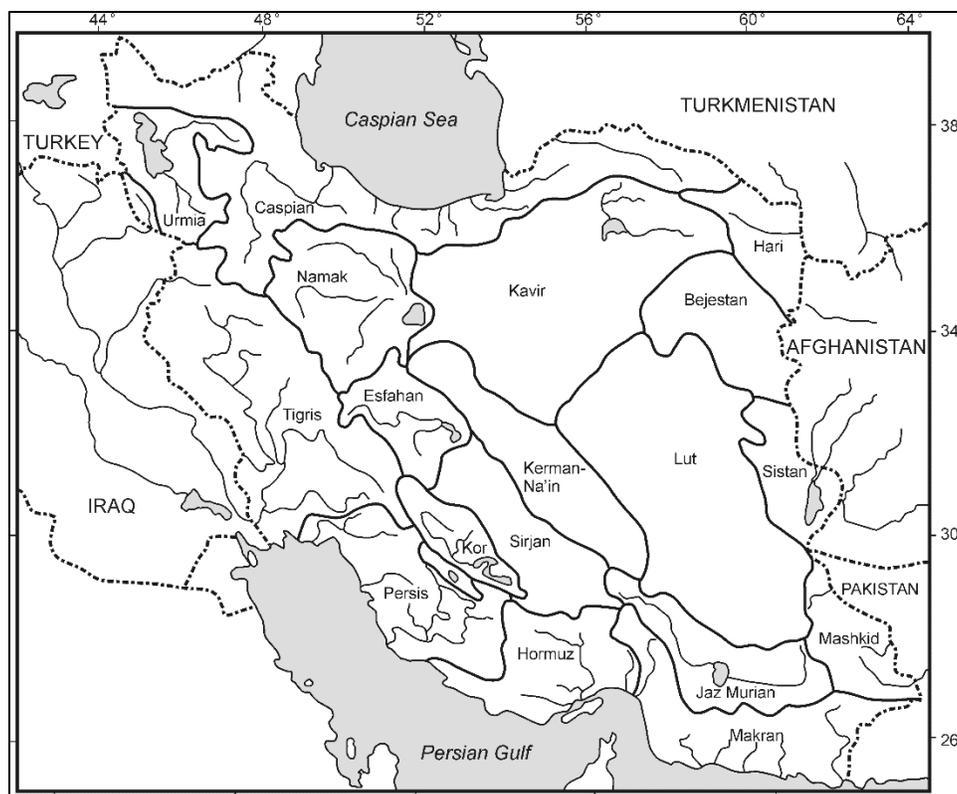
The most diverse genera are *Alburnoides* (12-14) and *Alburnus* (9) or 44.7-48.9% of the fauna. All other genera have five or less species and seven genera are monotypic. No genus is endemic to Iran.

Recent studies have increased the number of minnow species known from Iran. In the 100 years of the twentieth century (1900-1999) only 6 nominal species/subspecies of Leuciscidae were described from Iran while in the first 20 years of the twenty-first century (2000-2019) 15 species were described, 11 of these being in the genus *Alburnoides*.

Pourshabanan *et al.* (2021) assessed the biodiversity of leuciscids in the Caspian Sea basin of Iran using molecular methods and noted that the presence of *Ballerus sapa* and *Pelecus cultratus* needs confirmation.

Biodiversity by drainage basins and ecoregions are summarised below.

1) Native species distribution by drainage basins (number of species in parentheses; endemics indicated by \* - endemics are by basin which may extend beyond Iran):-



Major drainage basins of Iran  
(the Lake Maharlu basin lies between the Kor River and Persis basins),  
Susan Laurie-Bourque @ Canadian Museum of Nature.

An asterisk (\*) marks endemics which here are endemic to the basin but may include waters outside Iran (in the Caspian Sea, Tigris River and Hari River basins). An octothorpe (#) marks species requiring confirmation of this distribution.

a) Exorheic basins

Hormuz (2): *Acanthobrama persidis*, *Alburnus sellal*.

Makran (0): None.

Persis (former Gulf) (4, 1 endemic): *Acanthobrama persidis*, *\*Alburnoides sp.*, *Alburnus sellal*, *Chondrostoma regium*.

Tigris River (11, 3 endemic): *Acanthobrama marmid*, *\*Alburnoides idignensis*, *\*Alburnoides nicolausi*, *Alburnus caeruleus*, *Alburnus doriae*, *Alburnus sellal*, *\*Chondrostoma esmaeilii*, *Chondrostoma regium*, *Leuciscus vorax*, *Squalius berak*, *Squalius lepidus*.

b) Endorheic basins

Bejestan (0): None.

Caspian Sea (20, 12 endemics): *Abramis brama*, \**Acanthobrama microlepis*, \**Alburnoides eichwaldii*, \**Alburnoides parhami*, \**Alburnoides samiii*, \**Alburnoides tabarestanensis*, \**Alburnus chalcoides*, \**Alburnus filippii*, \**Alburnus hohenackeri*, *Ballerus sapa*, *Blicca bjoerkna*, \**Chondrostoma cyri*, *Leucaspis delineatus*, *Leuciscus aspius*, *Pelecus cultratus*, \**Rutilus kutum*, *Rutilus lacustris*, *Scardinius erythrophthalmus*, \**Squalius turcicus*, \**Vimba persa*.

Dasht-e Kavir (3, 2 endemics): \**Alburnoides coadi*, \**Alburnoides damghani*, *Squalius namak*.

Dasht-e Lut (0): None.

Esfahan (4, 1 endemic): \**Alburnoides* sp., *Alburnus doriae*, #*Alburnus sellal*, *Chondrostoma regium*.

Hamun-e Mashkid (0): None.

Hamun-e Jaz Murian (0): None.

Hari River (3): *Alburnoides holciki*, *Alburnus taeniatus*, *Squalius latus*.

Kerman-Na'in (0): None.

Kor River (4, 1 endemic): *Acanthobrama persidis*, *Alburnoides qanati*, *Alburnus sellal*, \**Chondrostoma orientale*.

Lake Maharlu (2): *Acanthobrama persidis*, *Alburnus sellal*.

Lake Urmia (4, 3 endemics): \**Acanthobrama urmianus*, \**Alburnoides petrubanarescui*, \**Alburnus ulanus*, *Squalius turcicus*.

Namak Lake (3, 1 endemic): \**Alburnoides namaki*, *Alburnus doriae*, *Squalius namak*.

Sirjan (1): *Alburnoides qanati*.

Sistan (0): None.

Thirteen of nineteen basins have 3 or fewer species (and 7 of these have none) and these are all eastern basins, remote from the distribution of the family Leuciscidae. Two basins have 4 species and one basin has 5 species, both adjacent to more speciose basins and with prior connections. The Lake Urmia basin is notable for its high degree of endemism, with species derived from Caspian Sea relatives that have speciated in the now isolated basin. The Caspian Sea basin has by far the most species (20) and Iranian endemics (10), a result of its long history of connection and isolation from basins to the west where leuciscids predominate, to its large size and also its diverse habitats. The Tigris River basin, also with its large size, diverse habitats and long speciation history has the second most diversity and number of endemics (3 of 11 species).

2) Native species distribution in drainage basins (unconfirmed distributions above included and indicated by a question mark):-

*Abramis brama*: Caspian Sea.

*Acanthobrama marmid*: Tigris River.

*Acanthobrama microlepis*: Caspian Sea.

*Acanthobrama persidis*: Hormuz, Kor River, Lake Maharlu, Persis.

*Acanthobrama urmianus*: Lake Urmia.

*Alburnoides coadi*: Dasht-e Kavir.

*Alburnoides damghani*: Dasht-e Kavir.

*Alburnoides eichwaldii*: Caspian Sea.

*Alburnoides holciki*: Hari River.

*Alburnoides idignensis*: Tigris River.

*Alburnoides namaki*: Namak Lake.

*Alburnoides nicolausi*: Tigris River

*Alburnoides parhami*: Caspian Sea.

*Alburnoides petrubanarescui*: Lake Urmia.

*Alburnoides qanati*: Kor River, Sirjan.

*Alburnoides samiii*: Caspian Sea.

*Alburnoides tabarestanensis*: Caspian Sea.

*Alburnoides* sp.: Esfahan basin.

*Alburnoides* sp.: Persis basin.

*Alburnus atropatena*: Lake Urmia.

*Alburnus caeruleus*: Tigris River.

*Alburnus chalcoides*: Caspian Sea.

*Alburnus doriae*: Esfahan, Namak Lake, Tigris River.

*Alburnus filippii*: Caspian Sea.

*Alburnus hohenackeri*: Caspian Sea.

*Alburnus sellal*: #Esfahan, Hormuz, Kor River, Lake Maharlu, Persis, Tigris River.

*Alburnus taeniatus*: Hari River.

*Alburnus ulanus*: Lake Urmia.

*Ballerus sapa*: Caspian Sea.

*Blicca bjoerkna*: Caspian Sea.

*Chondrostoma cyri*: Caspian Sea.

*Chondrostoma esmaeilii*: Tigris River.

*Chondrostoma orientale*: Kor River.

*Chondrostoma regium*: Esfahan, Persis, Tigris River.

*Leucaspius delineatus*: Caspian Sea.

*Leuciscus aspius*: Caspian Sea.

*Leuciscus vorax*: Tigris River.

*Pelecus cultratus*: Caspian Sea.

*Rutilus kutum*: Caspian Sea.

*Rutilus lacustris*: Caspian Sea.

*Scardinius erythrophthalmus*: Caspian Sea.

*Squalius berak*: Tigris River.

*Squalius latus*: Hari River.

*Squalius lepidus*: Tigris River.

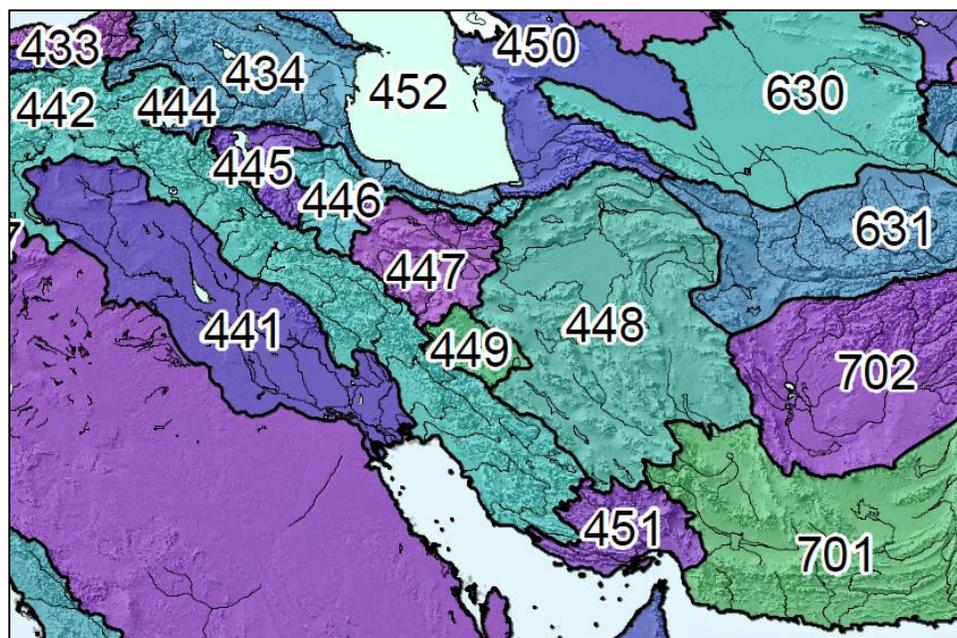
*Squalius namak*: Dasht-e Kavir, Namak Lake.

*Squalius turcicus*: Caspian Sea, Lake Urmia.

*Vimba persa*: Caspian Sea.

The most widely distributed species in terms of basins is *Alburnus sellal* (6 basins), followed by *Acanthobrama persidis* (4). Most species (40 or 85.1%) occur in a single basin with the 5 remaining species in 2-3 basins.

3) Ecoregions with native species content. See Abell *et al.* (2008) for descriptions of ecoregions. Records for the ecoregion Caspian Marine (452) are for fish entering brackish water of the nearshore Caspian Sea.



Ecoregions of Iran, after [www.feow.org/](http://www.feow.org/) and Abell *et al.* (2008)  
(note later versions show some minor boundary modifications).

- 434, Kura-South Caspian: *Abramis brama*, *Acanthobrama microlepis*, *Alburnoides eichwaldii*, *Alburnoides samiii*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Ballerus sapa*, *Blicca bjoerkna*, *Chondrostoma cyri*, *Leucaspis delineatus*, *Leuciscus aspius*, *Pelecus cultratus*, *Rutilus kutum*, *Rutilus lacustris*, *Scardinius erythrophthalmus*, *Squalius turcicus*, *Vimba persa*.
- 441, Lower Tigris and Euphrates: *Acanthobrama marmid*, *Alburnoides idignensis*, *Alburnus caeruleus*, *Alburnus sellal*, *Chondrostoma regium*, *Leuciscus vorax*, *Squalius berak*, *Squalius lepidus*.
- 442, Upper Tigris and Euphrates: *Acanthobrama marmid*, *Acanthobrama persidis*, *Alburnoides idignensis*, *Alburnoides nicolausi*, *Alburnoides qanati*, *Alburnoides* sp., *Alburnus caeruleus*, *Alburnus doriae*, *Alburnus sellal*, *Chondrostoma esmaeilii*, *Chondrostoma orientale*, *Chondrostoma regium*, *Leuciscus vorax*, *Squalius berak*, *Squalius lepidus*.
- 445, Orumiyeh (= Urmia): *Acanthobrama urmianus*, *Alburnoides petrubanarescui*, *Alburnus ulanus*.
- 446, Caspian Highlands: *Acanthobrama microlepis*, *Alburnoides samiii*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Vimba persa*.
- 447, Namak: *Alburnoides namaki*, *Alburnus doriae*, *Squalius namak*.
- 448, Kavir and Lut Deserts: *Alburnoides coadi*, *Alburnoides damghani*, *Alburnoides qanati*, *Squalius namak*.
- 449, Esfahan: *Alburnoides* sp., *Alburnus doriae*, *Alburnus sellal*, *Chondrostoma regium*.
- 450, Turan Plain: *Abramis brama*, *Alburnoides parhami*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus hohenackeri*, *Blicca bjoerkna*, *Leuciscus aspius*, *Rutilus kutum*, *Rutilus lacustris*, *Squalius turcicus*, *Vimba persa*.
- 451, Northern Hormuz Drainages: *Acanthobrama persidis*.
- 452, Caspian Marine: *Abramis brama*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Ballerus sapa*, *Blicca bjoerkna*, *Leuciscus aspius*, *Pelecus cultratus*, *Rutilus kutum*, *Rutilus lacustris*, *Vimba persa*.
- 631, Upper Amu Darya: *Alburnoides holciki*, *Alburnus taeniatus*, *Squalius latus*.
- 701, Baluchistan: None.
- 702, Helmand-Sistan: None.

The ecoregion with the most species is the Kura-South Caspian with 19 species (40.4% of all species) followed by the Upper Tigris and Euphrates with 15 species (31.9%), Caspian Marine with 11 species (23.4%) and Turan Plain with 11 species (23.4%). These all represent large areas with diverse habitats. Other ecoregions have one to eight species, two with seven and eight species and six with one to four species. Two of the 14 ecoregions have no leuciscids, being in the most eastern and southeastern parts of the country.

4) Native species distribution in ecoregions, presented in numerical order as above:-

*Abramis brama*: Kura-South Caspian, Turan Plain, Caspian Marine.

*Acanthobrama marmid*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Acanthobrama microlepis*: Kura-South Caspian, Caspian Highlands.

*Acanthobrama persidis*: Upper Tigris and Euphrates, Northern Hormuz Drainages.

*Acanthobrama urmianus*: Orumiyeh (= Urmia).

*Alburnoides coadi*: Kavir and Lut Deserts.

*Alburnoides damghani*: Kavir and Lut Deserts.

*Alburnoides eichwaldii*: Kura-South Caspian.

*Alburnoides holciki*: Upper Amu Darya.

*Alburnoides idignensis*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Alburnoides namaki*: Namak.

*Alburnoides nicolausi*: Upper Tigris and Euphrates.

*Alburnoides parhami*: Turan Plain.

*Alburnoides petrubanarescui*: Orumiyeh (= Urmia).

*Alburnoides qanati*: Upper Tigris and Euphrates, Kavir and Lut Deserts.

*Alburnoides samiii*: Kura-South Caspian, Caspian Highlands.

*Alburnoides* sp.: Esfahan.

*Alburnoides* sp.: Upper Tigris and Euphrates.

*Alburnoides tabarestanensis*: Kura-South Caspian, Caspian Highlands, Turan Plain.

*Alburnus atropatena*: Orumiyeh (= Urmia).

*Alburnus caeruleus*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Alburnus chalcoides*: Kura-South Caspian, Caspian Highlands, Turan Plain, Caspian Marine.

*Alburnus doriae*: Upper Tigris and Euphrates, Namak, Esfahan.

*Alburnus filippii*: Kura-South Caspian, Caspian Highlands, Caspian Marine.

*Alburnus hohenackeri*: Kura-South Caspian, Caspian Highlands, Turan Plain, Caspian Marine.

*Alburnus sellal*: Lower Tigris and Euphrates, Upper Tigris and Euphrates, Esfahan, Northern Hormuz Drainages.

*Alburnus taeniatus*: Upper Amu Darya.

*Alburnus ulanus*: Orumiyeh (= Urmia).

*Ballerus sapa*: Kura-South Caspian, Caspian Marine.

*Blicca bjoerkna*: Kura-South Caspian, Turan Plain, Caspian Marine.

*Chondrostoma cyri*: Kura-South Caspian.

*Chondrostoma esmaeilii*: Upper Tigris and Euphrates.

*Chondrostoma orientale*: Upper Tigris and Euphrates.

*Chondrostoma regium*: Lower Tigris and Euphrates, Upper Tigris and Euphrates, Esfahan.

*Leucaspius delineatus*: Kura-South Caspian.

*Leuciscus aspilus*: Kura-South Caspian, Turan Plain, Caspian Marine.

*Leuciscus vorax*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Pelecus cultratus*: Kura-South Caspian, Caspian Marine.

*Rutilus kutum*: Kura-South Caspian, Turan Plain, Caspian Marine.

*Rutilus lacustris*: Kura-South Caspian, Turan Plain, Caspian Marine.

*Scardinius erythrophthalmus*: Kura-South Caspian.

*Squalius berak*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Squalius latus*: Upper Amu Darya.

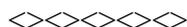
*Squalius lepidus*: Lower Tigris and Euphrates, Upper Tigris and Euphrates.

*Squalius namak*: Namak, Kavir and Lut Deserts.

*Squalius turcicus*: Kura-South Caspian, Caspian Highlands, Turan Plain.

*Vimba persa*: Kura-South Caspian, Caspian Highlands, Turan Plain, Caspian Marine.

The species are found in one to four ecoregions. Species in three or four ecoregions (29.8%) are those associated with the Caspian Sea in northern Iran and Tigris River and adjacent areas in southwestern Iran, areas of diverse habitat. Twenty species are found in a single ecoregion (42.6%), 13 in two ecoregions (27.7%), ten in three ecoregions (21.3%) and four in four ecoregions (8.5%).



The following summarises the distribution of native cyprinoids in Iran including four families not dealt with in the current work (see Coad (2018b, 2018c, 2019b, 2019c) for descriptions), i.e., the families Acheilognathidae (*Rhodeus*), Cyprinidae, Danionidae (*Barilius*, *Cabdio*), Gobionidae (*Gobio*, *Romanogobio*), Leuciscidae and Tincidae (*Tinca*).

An asterisk (\*) marks endemics which here are endemic to the basin but may include waters outside Iran (in the Caspian Sea, Tigris River and Hari River basins). An octothorpe (#) marks species requiring confirmation of this distribution.

#### a) Exorheic basins

Hormuz (14, 2 endemics): *Acanthobrama persidis*, *Alburnus sellal*, *Arabibarbus grypus*, *Barbus lacerta*, \**Capoeta anamisensis*, *Capoeta mandica*, *Capoeta saadii*, *Carasobarbus luteus*, *Cyprinion milesi*, *Cyprinion watsoni*, \**Garra* sp., *Garra persica*, *Garra rufa*,

*Luciobarbus barbulus*.

Makran (8, 1 endemic): *Cabdio morar*, *Cyprinion milesi*, *Cyprinion watsoni*, *Garra nudiventris*, *Garra persica*, \**Garra roseae*, *Garra rossica*, *Tariqilabeo diplochilus*.

Persis (former Gulf) (23, 2 endemic): *Acanthobrama persidis*, \**Alburnoides* sp., *Alburnus sellal*, *Arabibarbus grypus*, *Barilius mesopotamicus*, *Barbus lacerta*, \**Capoeta ferdowsii*, *Capoeta macrolepis*, *Capoeta mandica*, *Capoeta saadii*, *Capoeta trutta*, *Carasobarbus luteus*, *Carasobarbus sublimus*, *Chondrostoma regium*, *Cyprinion kais*, *Cyprinion macrostomus*, *Cyprinion tenuiradius*, *Garra mondica*, *Garra rufa*, *Luciobarbus barbulus*, *Luciobarbus esocinus*, *Luciobarbus kersin*, *Mesopotamichthys sharpeyi*.

Tigris River (40, 16 endemic): *Acanthobrama marmid*, \**Alburnoides idignensis*, \**Alburnoides nicolausi*, *Alburnus caeruleus*, *Alburnus doriae*, *Alburnus sellal*, *Arabibarbus grypus*, \**Barbus karunensis*, *Barbus lacerta*, *Barilius mesopotamicus*, \**Capoeta coadi*, *Capoeta macrolepis*, *Capoeta mandica*, \**Capoeta pyragyi*, \**Capoeta shajariani*, *Capoeta trutta*, *Capoeta umbla*, \**Carasobarbus kosswigi*, *Carasobarbus luteus*, \**Carasobarbus sublimus*, \**Chondrostoma esmaeili*, *Chondrostoma regium*, *Cyprinion kais*, *Cyprinion macrostomus*, \**Garra amirhosseini*, *Garra gymnothorax*, \**Garra lorestanensis*, *Garra rufa*, \**Garra tashanensis*, \**Garra typhlops*, \**Garra variabilis*, *Leuciscus vorax*, *Luciobarbus barbulus*, *Luciobarbus esocinus*, *Luciobarbus kersin*, \**Luciobarbus subquincunciatus*, \**Luciobarbus xanthopterus*, *Mesopotamichthys sharpeyi*, *Squalius berak*, *Squalius lepidus*.

b) Endorheic basins

Bejestan (3): *Capoeta fusca*, *Cyprinion watsoni*, *Garra rossica*.

Caspian Sea (31, 16 endemics): *Abramis brama*, \**Acanthobrama microlepis*, \**Alburnoides eichwaldii*, \**Alburnoides parhami*, \**Alburnoides samiii*, \**Alburnoides tabarestanensis*, \**Alburnus chalcoides*, \**Alburnus filippii*, \**Alburnus hohenackeri*, *Ballerus sapa*, *Barbus cyri*, *Blicca bjoerkna*, *Capoeta capoeta*, \**Capoeta kaput*, \**Capoeta razii*, \**Chondrostoma cyri*, *Cyprinus carpio*, *Leucaspis delineatus*, *Leuciscus aspilus*, \**Luciobarbus capito*, \**Luciobarbus caspius*, *Luciobarbus mursa*, *Pelecus cultratus*, *Rhodeus amarus* (under description as a distinct species), *Romanogobio macropterus*, \**Rutilus kutum*, *Rutilus lacustris*, *Scardinius erythrophthalmus*, \**Squalius turcicus*, *Tinca tinca*, \**Vimba persa*.

Dasht-e Kavir (9, 2 endemics): \**Alburnoides coadi*, \**Alburnoides damghani*, *Barbus miliaris*, *Capoeta aculeata*, *Capoeta buhsei*, *Capoeta fusca*, *Capoeta razii*, *Schizothorax pelzami*, *Squalius namak*.

Dasht-e Lut (5): *Capoeta fusca*, *Capoeta saadii*, *Cyprinion watsoni*, *Garra nudiventris*, *Garra rossica*.

Esfahan (7, 2 endemics): \**Alburnoides* sp., *Alburnus doriae*, #*Alburnus sellal*, *Barbus lacerta*, *Capoeta coadi*, \**Capoeta gracilis*, *Chondrostoma regium*.

Hamun-e Mashkid (6): *Bangana dero*, *Cabdio morar*, #*Cyprinion milesi*, *Cyprinion watsoni*, *Garra rossica*, *Tariqilabeo diplochilus*.

Hamun-e Jaz Murian (5): #*Capoeta saadii*, *Cyprinion milesi*, *Cyprinion watsoni*, *Garra persica*, *Garra rossica*.

Hari River (11, 1 endemic): *Alburnoides holciki*, *Alburnus taeniatus*, *Capoeta fusca*, \**Capoeta heratensis*, *Cyprinus carpio*, *Garra rossica*, *Gobio nigrescens*, *Luciobarbus conocephalus*, *Schizothorax intermedius*, *Schizothorax pelzami*, *Squalius latus*.

Kerman-Na'in (5): *Capoeta buhsei*, #*Capoeta macrolepis*, *Capoeta saadii*, *Cyprinion watsoni*, #*Garra persica*.

Kor River (9, 1 endemic): *Acanthobrama persidis*, *Alburnoides qanati*, *Alburnus sellal*, *Capoeta macrolepis*, *Capoeta saadii*, #*Carasobarbus luteus*, \**Chondrostoma orientale*, *Garra rufa*, *Luciobarbus barbulus*.

Lake Maharlu (7): *Acanthobrama persidis*, *Alburnus sellal*, *Barbus lacerta*, *Capoeta saadii*, *Carasobarbus luteus*, *Cyprinion tenuiradius*, *Garra rufa*.

Lake Urmia (9, 4 endemics): \**Acanthobrama urmianus*, \**Alburnoides petrubanarescui*, \**Alburnus ulanus*, *Barbus cyri*, \**Barbus urmianus*, *Capoeta capoeta*, *Luciobarbus mursa*, *Romanogobio persus*, *Squalius turcicus*.

Namak Lake (6, 1 endemic): \**Alburnoides namaki*, *Alburnus doriae*, *Barbus miliaris*, *Capoeta aculeata*, *Capoeta buhsei*, *Squalius namak*.

Sirjan (4): *Alburnoides qanati*, #*Capoeta buhsei*, *Capoeta saadii*, *Cyprinion watsoni*.

Sistan (10, 3 endemic): *Capoeta fusca*, *Cyprinion watsoni*, *Garra nudiventris*, #*Garra persica*, *Garra rossica*, \**Schizocypris altidorsalis*, *Schizopygopsis stolickai*, *Schizothorax intermedius*, \**Schizothorax zarudnyi*, \**Tariqilabeo adiscus*.

The following summarises distribution of native cyprinoids by ecoregion with the added families noted above.

434, Kura-South Caspian: *Abramis brama*, *Acanthobrama microlepis*, *Alburnoides eichwaldii*, *Alburnoides samiii*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Ballerus sapa*, *Barbus cyri*, *Blicca bjoerkna*, *Capoeta capoeta*, *Capoeta kaput*, *Capoeta razii*, *Chondrostoma cyri*, *Cyprinus carpio*, *Leucaspius delineatus*, *Leuciscus aspilus*, *Luciobarbus capito*, *Luciobarbus caspius*, *Luciobarbus mursa*, *Pelecus cultratus*, *Rhodeus amarus* (under description as a distinct species), *Romanogobio macropterus*, *Rutilus kutum*, *Rutilus lacustris*, *Scardinius erythrophthalmus*, *Squalius turcicus*, *Tinca tinca*, *Vimba persa*

- 441, Lower Tigris and Euphrates: *Acanthobrama marmid*, *Alburnoides idignensis*, *Alburnus caeruleus*, *Alburnus sellal*, *Arabibarbus grypus*, *Barbus lacerta*, *Barilius mesopotamicus*, *Capoeta macrolepis*, *Capoeta pyragyi*, *Capoeta shajariani*, *Capoeta trutta*, *Capoeta umbla*, *Carasobarbus kosswigi*, *Carasobarbus luteus*, *Chondrostoma regium*, *Cyprinion kais*, *Cyprinion macrostomus*, *Garra amirhosseini*, *Garra gymnothorax*, *Garra rufa*, *Garra variabilis*, *Leuciscus vorax*, *Luciobarbus barbulus*, *Luciobarbus esocinus*, *Luciobarbus kersin*, *Luciobarbus subquincunciatus*, *Luciobarbus xanthopterus*, *Mesopotamichthys sharpeyi*, *Squalius berak*, *Squalius lepidus*.
- 442, Upper Tigris and Euphrates: *Acanthobrama marmid*, *Acanthobrama persidis*, *Alburnoides idignensis*, *Alburnoides nicolausi*, *Alburnoides qanati*, *Alburnoides sp.*, *Alburnus caeruleus*, *Alburnus doriae*, *Alburnus sellal*, *Arabibarbus grypus*, *Barbus karunensis*, *Barbus lacerta*, *Barilius mesopotamicus*, *Capoeta coadi*, *Capoeta ferdowsii*, *Capoeta macrolepis*, *Capoeta mandica*, *Capoeta pyragyi*, *Capoeta saadii*, *Capoeta shajariani*, *Capoeta trutta*, *Capoeta umbla*, *Carasobarbus kosswigi*, *Carasobarbus luteus*, *Carasobarbus sublimus*, *Chondrostoma esmaeilii*, *Chondrostoma orientale*, *Chondrostoma regium*, *Cyprinion kais*, *Cyprinion macrostomus*, *Cyprinion tenuiradius*, *Garra gymnothorax*, *Garra lorestanensis*, *Garra mondica*, *Garra rufa*, *Garra tashanensis*, *Garra typhlops*, *Garra variabilis*, *Leuciscus vorax*, *Luciobarbus barbulus*, *Luciobarbus esocinus*, *Luciobarbus kersin*, *Luciobarbus subquincunciatus*, *Luciobarbus xanthopterus*, *Mesopotamichthys sharpeyi*, *Squalius berak*, *Squalius lepidus*.
- 445, Orumiyeh (= Urmia): *Acanthobrama urmianus*, *Alburnoides petrubanarescui*, *Alburnus ulanus*, *Barbus cyri*, *Barbus urmianus*, *Capoeta capoeta*, *Luciobarbus mursa*, *Romanogobio persus*.
- 446, Caspian Highlands: *Acanthobrama microlepis*, *Alburnoides samiii*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Barbus cyri*, *Capoeta razii*, *Luciobarbus capito*, *Luciobarbus mursa*, *Vimba persa*.
- 447, Namak: *Alburnoides namaki*, *Alburnus doriae*, *Barbus miliaris*, *Capoeta aculeata*, *Capoeta buhsei*, *Squalius namak*.
- 448, Kavir and Lut Deserts: *Alburnoides coadi*, *Alburnoides damghani*, *Alburnoides qanati*, *Barbus miliaris*, *Capoeta aculeata*, *Capoeta buhsei*, *Capoeta fusca*, *Capoeta macrolepis*, *Capoeta razii*, *Capoeta saadii*, *Cyprinion watsoni*, *Garra nudiventris*, *Garra persica*, *Garra rossica*, *Schizothorax pelzami*, *Squalius namak*.
- 449, Esfahan: *Alburnoides sp.*, *Alburnus doriae*, *Alburnus sellal*, *Barbus lacerta*, *Capoeta coadi*, *Capoeta gracilis*, *Chondrostoma regium*.
- 450, Turan Plain: *Abramis brama*, *Alburnoides parhami*, *Alburnoides tabarestanensis*, *Alburnus chalcoides*, *Alburnus hohenackeri*, *Blicca bjoerkna*, *Barbus cyri*, *Capoeta razii*, *Cyprinus carpio*, *Leuciscus aspius*, *Luciobarbus capito*, *Luciobarbus caspius*, *Luciobarbus mursa*, *Rhodeus amarus* (under description as a distinct species), *Rutilus kutum*, *Rutilus lacustris*, *Squalius turcicus*, *Tinca tinca*, *Vimba persa*.

- 451, Northern Hormuz Drainages: *Acanthobrama persidis*, *Capoeta anamisensis*, *Capoeta mandica*, *Capoeta saadii*, *Cyprinion milesi*, *Cyprinion watsoni*, *Garra persica*, *Garra rufa*, *Garra* sp.
- 452, Caspian Marine: *Abramis brama*, *Alburnus chalcoides*, *Alburnus filippii*, *Alburnus hohenackeri*, *Ballerus sapa*, *Blicca bjoerkna*, *Cyprinus carpio*, *Leuciscus aspius*, *Luciobarbus capito*, *Luciobarbus caspius*, *Luciobarbus mursa*, *Pelecus cultratus*, *Rutilus kutum*, *Rutilus lacustris*, *Vimba persa*.
- 631, Upper Amu Darya: *Alburnoides holciki*, *Alburnus taeniatus*, *Capoeta fusca*, *Capoeta heratensis*, *Cyprinus carpio*, *Garra rossica*, *Gobio nigrescens*, *Luciobarbus conocephalus*, *Schizothorax intermedius*, *Schizothorax pelzami*, *Squalius latus*.
- 701, Baluchistan: *Bangana dero*, *Cabdio morar*, *Capoeta saadii*, *Cyprinion milesi*, *Cyprinion watsoni*, *Garra nudiventris*, *Garra persica*, *Garra roseae*, *Garra rossica*, *Tariqilabeo diplochilus*.
- 702, Helmand-Sistan: *Capoeta fusca*, *Cyprinion watsoni*, *Garra nudiventris*, *Garra persica*, *Garra rossica*, *Schizocypris altidorsalis*, *Schizopygopsis stolicikai*, *Schizothorax intermedius*, *Schizothorax zarudnyi*, *Tariqilabeo adiscus*.

## Species Accounts

### Introduction

The leuciscids or minnows are found in North America, North Africa, Europe and northern Asia and are absent in southern or sub-Saharan Africa and southern Asia. There are about 674 species (*Catalog of Fishes*, downloaded 31 January 2019).

The relationships of this family are given Volume I. The family is defined by molecular characters and by some morphological characters in combination and with exceptions between genera and across families. Generally, minnows in Iran lack barbels and fin spines and fin denticles, lips are not fleshy, mouths are not arched with a horny lower lip nor do they have a ventral adhesive disc on the chin, they have a short dorsal fin (often 8 dorsal fin branched rays), the anal fin can be short or long (7-44 branched rays), scales are small to large, enlarged scales around the vent and anal fin are not present, a ventral scaleless keel may be present (e.g., *Alburnus*), they are often relatively small in size (under 10.0 cm total length in *Alburnoides* spp.), pharyngeal teeth are in one or two rows (usually two rows with common formulae being 2,5-4,2 or 2,5-5,2, and polyploidy is not present. Bogutskaya (1991) gave additional, osteological characters although the limits of leuciscines (or Leuciscidae) have changed since that work.

Recent major changes in taxonomy involving species found in Iran include the synonymy of such genera as *Acanthalburnus* with *Acanthobrama* and *Aspius* with *Leuciscus*. Members of the genus *Squalius* were formerly in the genus *Leuciscus*. Readers consulting older literature should be aware that species may appear under these older genera. Species biology discussed in this text may well appear under the more recent name, not the older one that appears in the literature source.

Saadati (1977) recorded a *Pseudophoxinus* species from Kermanshah, Bid Sorkh River between Sahneh and Kangavar in the Gamasiab River basin (ca. 34°23'N, ca. 47°52'E) but this material has been lost and was probably a misidentification.

Some species may enter brackish water but the family is primarily a freshwater one. Many of the morphological and biological features of minnows are the same as in carps and are shared with other cyprinoids (see Cyprinidae, Volume I). This general treatment of cyprinoids is not repeated here.

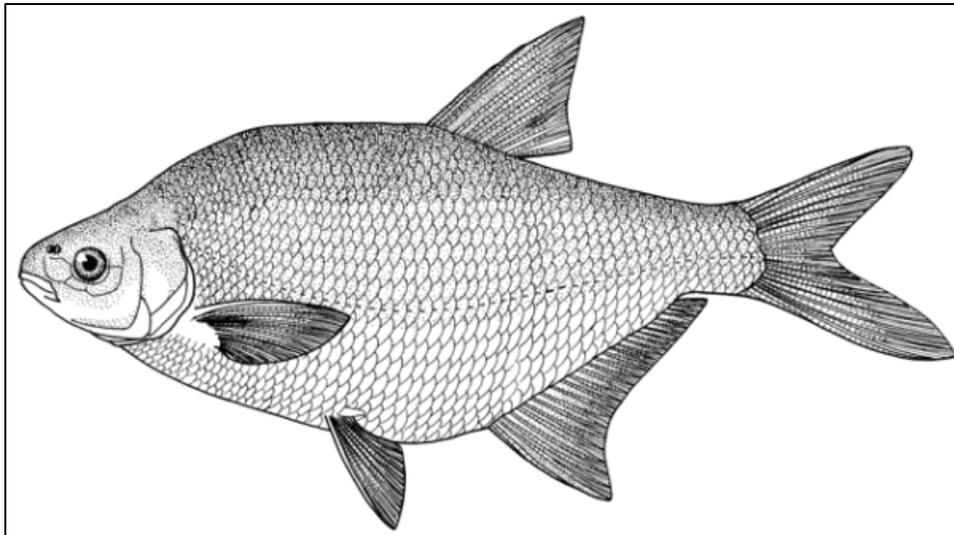
**Genus *Abramis***  
Cuvier, 1816

The bream genus comprises a single species found in Europe, Asia Minor and the Caspian and Aral Sea basins. *Ballerus sapa* was once included in this genus as were species in the genera *Blicca* and *Vimba* (*q.v.*), also found in Iran.

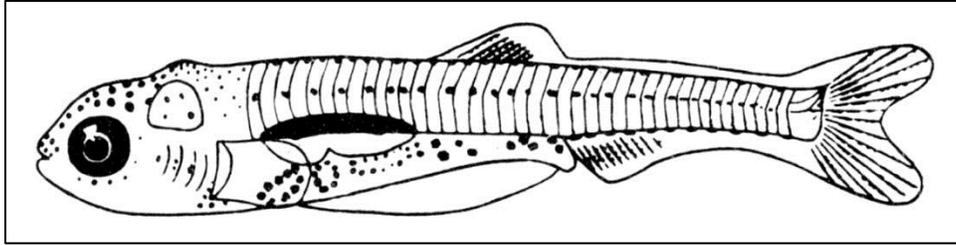
The genus is characterised by a strongly compressed and deep body, a scaleless keel between the vent and pelvic fins, a scaleless groove on the back in front of the dorsal fin but not behind the fin, pharyngeal teeth in one row, compressed and with a groove on the grinding surface, dorsal fin short and spineless, anal fin very long, and lateral line decurved.

Durand *et al.* (2002a, 2002b) studying cytochrome *b* data concluded that this genus is not monophyletic since *A. ballerus* and *A. sapa* (= *Ballerus sapa*) are placed basal to a group of species including *A. brama*, *Blicca bjoerkna*, *Vimba* species, *Acanthalburnus* (= *Acanthobrama*) *microlepis* and *Acanthobrama*. Perea *et al.* (2010) found this genus to be distinct and part of a lineage also including the genera *Acanthobrama*, *Acanthalburnus* (= *Acanthobrama*), *Ballerus*, *Blicca*, *Mirogrex* (of the Levant) and *Vimba* together with *Petroleuciscus* (= *Acanthobrama*) *persidis*. This genus is recognised here as distinct from the related genera *Ballerus*, *Blicca* and *Vimba* after Bogutskaya and Naseka (2004) and Kottelat and Freyhof (2007) although Parin *et al.* (2014) disagreed with this interpretation.

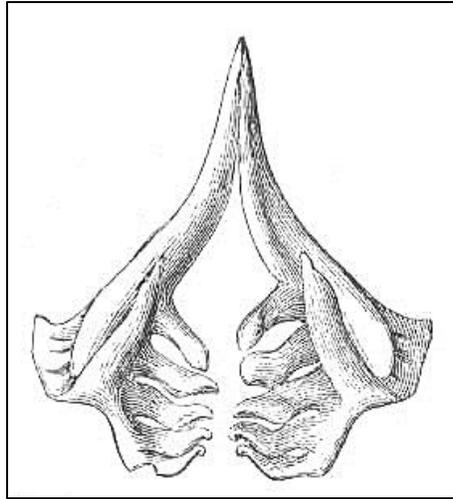
***Abramis brama***  
(Linnaeus, 1758)



*Abramis brama*  
S. Laurie-Bourque @ Canadian Museum of Nature.



*Abramis brama* fry, 9.2 mm, 14 days, Russia, Volga River delta, after Kazanskii (1915).



*Abramis brama*, pharyngeal teeth, after Seeley (1888).



*Abramis brama*, Gilan, Anzali Shore, June 2012, Keyvan Abbasi.



*Abramis brama*, aquarium fish

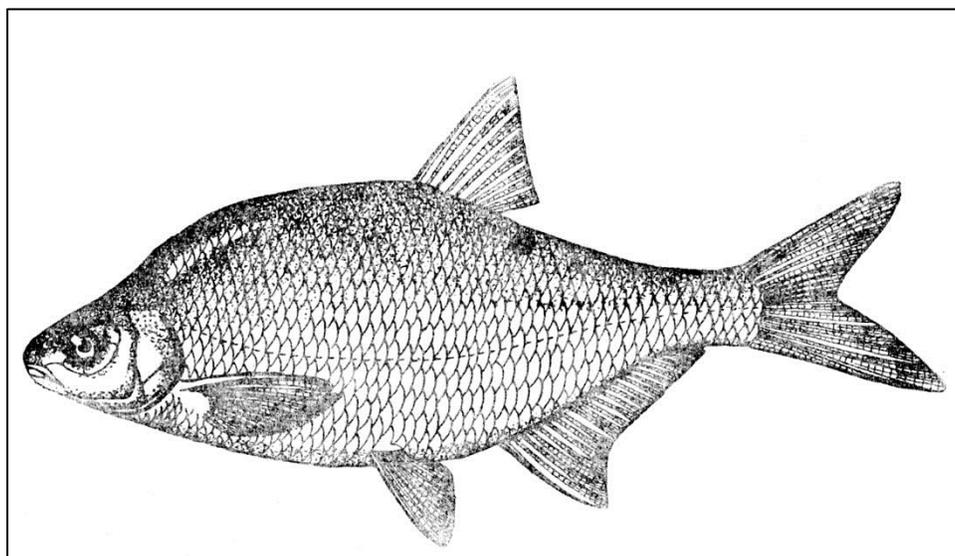
(Carp bream1, CC0, image rotated and background cleaned, Mikova Natalia (*sic*)).

**Common names.** Sim or seam (= silver), mahi-ye sim (= silver fish).

[Capag, chakag, chapakh or chipakh, all in Azerbaijan; gundogar tarany (topi) in Turkmenian; Çapak balığı, tahta balığı in Turkish (Çiçek *et al.*, 2020); vostochnyi leshch or Oriental bream in Russian; common, bronze, carp or eastern bream; sea bream from Bozorgnia *et al.* (2016)].

**Systematics.** *Cyprinus Brama* was originally described from Sweden. A syntype of *Cyprinus brama* is in the Natural History Museum, London as a skin under BM(NH) 1853.11.12:147 (Eschmeyer *et al.*, 1996).

*Abramis brama orientalis* Berg, 1949 is reported for the Caspian Sea (Lake Yashkan in Uzboi) and Aral Sea (Aral Sea at Muinak (not Muinsak as in the *Catalog of Fishes*, downloaded 15 May 2018) basins but Koshara and Izyumov (1991) restricted this subspecies to the Aral Sea with the type subspecies in the Caspian Sea basin. They did not examine any Iranian material. Kozhara and Mironovskiy (1988) using numbers of pores in the seismosensory canals for samples taken over a wide range of this species identified eight population groups but did not recognise subspecies. Some earlier works also indicated that no subspecies exist (see Reshetnikov *et al.*, 1997).



*Abramis brama orientalis*, after Abdurakhmanov (1962).

*Abramis brama bergi* Grib and Vernidub, 1935 (objectively invalid; preoccupied by *Abramis sapa bergi* Belyaev, 1930 according to Eschmeyer *et al.* (1996) and *Catalog of Fishes* (downloaded 15 November 2015)) was originally described from the Aral Sea at Muinak and Lake Yashkan in the Uzboi Valley of Turkmenistan, the latter north of the Iranian border (Berg, 1948-1949). It was replaced by *Abramis brama orientalis*.

Caspian material reportedly has more gill rakers, fewer vertebrae and fewer scales than the type subspecies from the Baltic Sea basin (Berg, 1948-1949) but further study over the whole range of the species is needed to clarify the situation, analyzing for clines, and specific distinctions. The Iranian populations are referred to the type subspecies for the moment. A molecular study would be apposite.

Khara (2006) and Khara *et al.* (2007, 2007, 2008) compared fish from the Anzali Wetland and the Caspian Sea, the Caspian Sea and Aras Dam, and Azerbaijan Republic coast fish and Aras Dam, meristically, morphometrically and genetically. Significant differences were noted in particular for morphometric characters in the first comparison and morphometrically and meristically in the second. These differences were attributed to differing habitats and environmental conditions. Azerbaijan fish had more genetic diversity than Aras Dam fish and were significantly different. Ghasemi *et al.* (2007) used five microsatellite loci in comparing Iranian and Azeri bream and found Iranian stocks had reduced genetic variability attributed to inbreeding and genetic drift. Khara *et al.* (2009) compared fish from the Anzali Wetland and the southern coast of the Caspian Sea in Iran and the southwest coast in Azerbaijan using mtDNA. The greatest genetic diversity was found in Azerbaijan which was significantly different from the Iranian samples, which were not themselves significantly different. Zeinab *et al.* (2015) examined genetic polymorphism using seven microsatellite loci on the Chamkhaleh and Bandar-e Anzali coasts and found allele frequency had declined due to inbreeding and genetic drift, and the populations lacked a desirable level of genetic diversity. Hosseinnia *et al.* (2016) using the same methods and localities came to the same conclusion.

Artificial hybrids with *Rutilus frisii kutum* (= *R. kutum*) and *Rutilus rutilus* (may involve *R. lacustris*) have been bred in Iran (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 39-40, 1996).

**Key characters.** The scaleless keel on the belly, deep body, high number of branched rays in the anal fin (22-30), modally 9 dorsal fin branched rays, and uniserial pharyngeal teeth are key characters.

**Morphology.** The body is very deep and compressed, being deepest at the dorsal fin origin. A nuchal hump develops in larger fish and the head is set off from the predorsal profile. The predorsal profile is convex with a strong dorsal ridge. The caudal peduncle is compressed and is moderately deep. The rear of the eye is at the beginning of the anterior half of the head. The snout is very rounded. The mouth is small, subterminal and oblique but highly protrusible and extends back to the level of the nostril. Lips are of moderate thickness. The dorsal fin margin is straight or emarginate. The dorsal fin origin is posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the middle of the anal fin. The caudal fin is deeply forked with rounded tips. The lower lobe of the caudal fin is larger than the upper lobe. The anal fin is very emarginated anteriorly and then has a gradual straight decline in height. The anal fin does not extend back to the caudal fin base. The pelvic fin is rounded and may almost extend to, or reaches, the anal fin origin. The pectoral fin is rounded and may extend to the pelvic fin origin or fall short.

Dorsal fin unbranched rays 3 and branched rays 8-10, usually 9, anal fin unbranched rays

3 and branched rays 22-30, pectoral fin branched rays 16-17, and pelvic fin branched rays 8. Lateral line scales 48-60. The lateral line is moderately decurved. Scales are regularly arranged, sheathing the anal fin base. There is a pelvic axillary scale. Scale shape is squarish to rounded with a rounded posterior margin, a straight to rounded dorsal margin, a more rounded ventral margin and an anterior wavy margin with 2-4 protrusions. Anterior scale corners are rounded. Scales have numerous fine circuli but only relatively few posterior and even fewer anterior radii. In a fish about 6.0 cm long there are as few as 8 total radii. The focus is almost central. The ventral keel between the pelvic fin bases and the anal fin is well-developed. Total gill rakers number 18-30, are short, and reach the raker below when appressed. They are strongly tuberculate on the inner surface. The pharyngeal tooth formula is modally 5-5, with variants of 6-5 (2.2-4.8%), 5-4 (2.2-4.4%) and 4-5 (8.6%) for collections from the Caspian and Aral seas basins in former Soviet waters (Vasil'yeva and Ustarbekov, 1991). Other variants are summarised in Tadjewska (1998). Teeth bear a small hook at the tip in the main row and have long, narrow and flat crowns. In young fish, the hook is more pronounced and the crown has a few tubercles or a series of serrations. Total vertebrae number 38-47, usually 42-44 in the Caspian populations (lower counts in literature may not include four Weberian vertebrae). The gut is s-shaped with a small anterior loop. The chromosome number is  $2n = 50-52$  (Klinkhardt *et al.*, 1995). The chromosome number based on fish from the Iranian coast of the Caspian Sea is  $2n = 50$  with the number of arms  $NF = 82$  and the karyotype being eight pairs of metacentric, eight pairs of sub-metacentric and nine pairs of acrocentric chromosomes (Nahavandi *et al.*, 2001).

Bani *et al.* (2015) gave details of larval development. Vakili *et al.* (2020) described the morphological characteristics of otoliths of fish from Fereydun Kenar.

Meristic values for Iranian specimens are:- dorsal fin branched rays 9(12) or 10(1), anal fin branched rays 24(3), 25(3), 26(1), 27(4) or 28(2), pectoral fin branched rays 16(7) or 17(6), pelvic fin branched rays 8(13), lateral line scales 49(2), 50(2), 51(3), 52(3), 54(1) or 55(2), total gill rakers 23(3), 24(2), 25(6), 26(1) or 27(1), pharyngeal teeth 5-5(12), and total vertebrae 44(12) or 45(1).

**Sexual dimorphism.** Males bear tubercles on the head, body and fins. Scale tubercles appear singly, in pairs or occasionally as three per scale. There is some evidence of differences in gill raker counts between the sexes but sometimes the males have higher mean counts and sometimes the females. Abdurakhmanov (1962) reported eye diameter, greatest body depth and predorsal distance to be greater in females and dorsal fin base length, pectoral and pelvic fin lengths and interorbital width to be greater in males from Azerbaijan.

**Colour.** In Dagestan, the resident form is darker in colour than the semi-anadromous form (Shikhshabekov, 1969). Overall colour is silvery. The iris is silvery with a little grey pigment on the upper part. The dorsal and caudal fins are pale grey, almost transparent, to a greyish-blue, the pectoral fins may be grey or colourless, or reddish, and pelvic fins are colourless to reddish mesially and blackish distally. All fins except the pectorals have black tips. Large fish are a dark olive-green on the back and bronze on the flanks and old fish may have all fins black. The peritoneum is silvery to light brown in preserved fish.

**Size.** Attains 90.0 cm total length and 11.55 kg, possibly 1.0 m and 16.4 kg (Machacek (1983-2012), downloaded 27 July 2012).

**Distribution.** Found from the British Isles across Europe north of the Pyrenees and Alps eastwards to the Black, Caspian and Aral Sea basins although not in western Transcaucasia. In Iran, this species is found in the Caspian Sea basin from the Astarra to the Atrak rivers including

the Aras, Babol, Behambar, Fereydun Kenar, Golshan, Gorgan, Haraz, Langarud, Pesikhan, Polrud (= Pol-e Rud), Qareh Su, Rasteh, Sefid, Shah, Shalman, Sheikan and Talar rivers, the Astara Talab, Gorgan Bay, the Anzali Talab and its shore, outlets and tributaries (such as the Nahang and Pir Bazar rogas and Siah Darvishan River), the Amirkelayeh Wetland and the Siahkeshim Protected Region, freshened areas of the Caspian Sea, Alagol Lake, and the Alagol, Khoda Afarin and Aras dams (Kozhin, 1957; Holčík and Oláh, 1992; Riazi, 1996; Kiabi *et al.*, 1999; Nasrollahzadeh, 1999; Abbasi *et al.*, 2007, 2017; Khara *et al.* 2007; Zareh Reshquoeeieh *et al.*, 2016; Babaei *et al.*, 2017; Mazandarani *et al.*, 2018, 2019). It is introduced to the Mahabad River and Dam and the Shahr and Zarrineh rivers of the Lake Urmia basin (Mirhasheminasab and Pazooki, 2003; Abbasi *et al.*, 2005; Ghasemi *et al.*, 2015; Jouladeh-Roudbar *et al.*, 2020). Rasouli *et al.* (2011) reported it from Marmisho Lake, west of Urmia.

This species is also recorded from the Karakum Canal and Kopetdag Reservoir in Turkmenistan (Shakirova and Sukhanova, 1994; Sal'nikov, 1995) and may eventually reach Iranian waters in the Hari River basin from the Tedzhen River where it has been reported by Aliev *et al.* (1988).

**Zoogeography.** This species is part of a northern European and northern Southwest Asian fauna. Its origins may lie in a Danubian or Sarmatian fauna.

**Habitat.** This species is found in rivers, streams, dams, lagoons, and brackish environments. The bream prefers still water and is low in numbers even in rivers with weak current. Abundant littoral vegetation and a very muddy bottom are favoured in lakes for reproduction and feeding respectively. It retreats to deeper water in winter, forming schools numbering in the many thousands, packed densely together (Muus and Dahlstrøm, 1999). Berg (1948-1949) gave details of biology in the Volga and North Caspian Sea and elsewhere and there have been numerous studies since then not summarised here.

It was more numerous in the Anzali Talab along the Caspian coast of Iran (Naderi Jolodar and Abdoli, 2004). This species can tolerate high temperatures of 33-34°C in southern areas like Iran for a time but above 28°C growth rate decreases. Adults can live in a salinity of 12.9‰, perhaps 14‰, and eggs may be fertilised at a salinity of 10.2‰. However, preferred levels are 2-4‰. Salinity and water level changes have significant effects on abundance in this species. Population densities vary markedly in both fresh and brackish water populations.

Bream living in the Caspian Sea basin are semi-migratory. They feed in the brackish sea but spawn and winter in the lower reaches and deltas of large rivers. A spring migration up rivers begins with ice melt or warmer temperatures in the sea and after spawning the fish return to disperse and feed in the sea. In the fall the fish migrate into the deeper parts of river deltas. In Russian parts of the Caspian, they are found at depths not exceeding 4-5 m but Knipovich (1921) reported them at 14.6-16.5 m, possibly deeper, in the Iranian Caspian Sea.

There are spring and winter migrants in the southwestern Caspian including the Anzali Talab (as "Bay of Murdab" from A. M. Shukolyukov in Berg, 1948-1949). The spring bream have a longer snout, deeper head, lower body, lower dorsal and anal fins, and more scales. The spring bream enter the talab for spawning only while the winter bream overwinters in bottom pools. Changing conditions in the talab environment in the late 1980s and the 1990s may have altered this migration. Riazi (1996) reported that this species migrates into the Siahkeshim Protected Region of the Anzali Talab.

**Age and growth.** Most fish examined by Razivi *et al.* (1972) from commercial catches in Iran were 3-6 years old, 25.6-39.8 cm long and weighed 249-950 g. Over a three-year period, there was a decline in average age. Young and immature fish formed most of the catch in 1998-

1999 when one-year-old fish comprised 20.3% and two-year-old fish 37.3%. The average length, weight and age for 1998-1999 were 22.5 cm, 212.2 g and 2.4 years. The rate of recruitment was 4.6% in 1991 and 2.7% in 1992 (Saiad Borani, 2001). Abdolmalaki (2005) studied Caspian Sea fish from Iran and found mean fork length, weight and age to be 21.7 cm, 191 g and 2.72 years, respectively. The length-weight relationship was  $W = 0.2312L^{2.9}$  and von Bertalanffy growth parameters were  $L_t = 45[1 - \exp(-0.125(t - 2.768))]$ , and the instantaneous rate of total (Z), natural (M) and fishing mortality (F) were  $0.92 \text{ year}^{-1}$ ,  $0.28 \text{ year}^{-1}$  and  $0.64 \text{ year}^{-1}$ , respectively. The exploitation rate (E) was 0.7. Biomass was calculated as 46.362 t and the maximum sustainable yield was 14.99 t. Khara (2006) examined 120 fish from the Anzali Wetland and 90 fish from the Caspian Sea and found bream were up to 5<sup>+</sup> years of age, while 110 Aras Dam bream reached 7<sup>+</sup> years and 125 Azerbaijan bream 9<sup>+</sup> years.

The resident form in Dagestan was slightly inferior in length (2-3 cm), weight and age to the semi-anadromous form (Shikhshabekov, 1969). In Dagestan, the resident form became sexually mature at 3 years for females and 2 years for males at lengths of 23-26 cm and weights of 200-240 g while the semi-anadromous form matured at 4 years and a length of at least 25-28 cm and a weight of 250-300 g. In Uzbekistan females matured at lengths ranging from 10.5 to 27 cm in different reservoirs, usually at age 3 (Kamilov, 1994). Maturity is attained at a younger age in southern waters generally in this species and this probably applies in Iran. The maturity range is 2-10 years with males often maturing a year earlier than females. Females predominate in the older age groups.

Maximum age exceeds 32 years although in southern waters the maximum age does not exceed 15 years. Semi-migratory bream of the Caspian Sea have a fast growth rate and a short life cycle, reaching 37.5 cm standard length by age 8.

**Food.** Young fish feed on zooplankton. Adults use a strong sucking power and a tube-like snout to feed on invertebrates and detritus in mud. This sucking action leaves evident bream pits in soft mud, depressions about 10 cm across. In the northern Caspian Sea food items include Cumacea, Corophiidae, the clams *Adacna* (69% by weight) and *Monodacna*, Tendipedidae (= Chironomidae), Polychaeta, Gammaridae, Mysidae, and Oligochaeta. When overcrowded or in turbid conditions, plankton may be eaten in addition to the normal foods (Muus and Dahlstrøm, 1999). Large specimens may feed on small fishes. A specimen from the Langarud, Gilan, 158.6 mm standard length, CMNFI 1971-0343, contained chironomids.



Gilan, Langarud at Kheshti Bridge (Kheshti (1), CC BY-SA 4.0, Elaheabed).

**Reproduction.** Bream enter the Anzali Talab, the main spawning area in the southern Caspian, in the first half of March until the beginning of May. Males precede females on the spawning ground by about three days and males outnumber females by about 3:1. Spawning begins in the first half of April in shallow water and lasts until mid-May.

Bream entered the Kura River from December to February with a peak in January (Berg, 1959) and travelled some distance upriver. These fish had an average length of 31.1 cm and an average weight of 633 g. Length and weight in Azerbaijan varied from 25.4 to 31.9 cm and 306 to 681 g. Fecundity in Dagestan reservoirs reached 191,000 eggs (Shikhshabekov, 1969), in Uzbekistan reservoirs 772,000 eggs (Kamilov, 1994) and a maximum elsewhere of 941,000 yellowish eggs was reported. Bream spawn repeatedly with different partners and although most bream spawn only once a year, multiple spawnings are known. Spawning occurs in masses over a period of 2-3 days triggered by temperatures of 12-13°C or above. The commonest spawning temperature for the species overall is 16-18°C. Spawning is most intensive at night in some populations while others show late morning and late afternoon peaks. There is much splashing of the water by their tails and the noise could be heard some distance away although the fish are easily scared into deeper water by any noise like human voices. Males probably defended territories, attracting females and scaring other males away. There could be up to 2.3 million eggs per sq m however, suggesting that many fish spawned in the same area. Eggs were deposited in quiet water, most commonly at depths of 20-80 cm, and they adhered to aquatic plants or flooded land plants. Eggs were up to 1.9 mm in diameter.

**Parasites and predators.** Jalali and Molnár (1990a) recorded the monogenean *Dactylogyrus zandti* from this species in the Sefid River. Sattari and Faramarzi (1997a, 1997b) recorded *Caryophyllaeus fimbriceps* from 28% of bream in the Anzali Lagoon. Naem *et al.* (2002) found the monogenean trematodes *Dactylogyrus zandti* and *D. wonderi* on the gills of this species from the western branch of the Sefid River. Sattari *et al.* (2004, 2005) surveyed this species in the Anzali Wetland, recording *Raphidascaaris acus* larvae. Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G. elegans* from fish in the Sefid River. Masoumian *et al.* (2005) reported the protozoan parasites *Ichthyophthirius*

*multifilis* and *Trichodina perforata* from this species in the Aras Dam in West Azarbayjan. Masoumian (2007) reported on parasites from fishes in the Aras, Ghotor and Zangbar rivers in West Azarbayjan including *Diplozoon megan*. Pazooki *et al.* (2007) recorded various parasites from localities in West Azarbayjan Province, namely *Ligula intestinalis*, *Digramma* sp., *Argulus foliaceus* and *Caryophyllaeus laticeps*. Sattari *et al.* (2007) recorded the cestode *Caryophyllaeus fimbriceps* (but see Barčák *et al.* (2017) who indicated this needs confirmation), the digenean *Diplostomum spathaceum* and the monogeneans *Dactylogyrus extensus* and *Gyrodactylus* sp. in this species in the Anzali Wetland of the Caspian shore and also mentioned that the monogenean *Diplozoon* sp. is also known from this species in the Iranian Caspian Sea. Barzegar *et al.* (2008) recorded the digenean eye parasite *Diplostomum spathaceum* from this fish. Nezafat Rahimabadi *et al.* (2008) recognised *Trichodina* sp., *Gyrodactylus* sp., *Dactylogyrus* sp., *Diplostomum* sp. and *Ligula intestinalis* in fish from Aras Dam. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea* sp. on this species. Hayatbakhsh *et al.* (2011) found the following parasites from fish on the Anzali coast, *Diplostomum spathaceum*, *Trichodina* sp., *Ligula intestinalis* and *Caryophyllaeus alticeps* and provided data on prevalence, intensity and abundance. *Listeria* contaminates fish from Urmia markets (Modaresi *et al.*, 2011), this cyprinid having the highest prevalence of seven fish and crustaceans examined. This bacterium could cause serious disease in humans with a mortality rate at about 20%. Rasouli *et al.* (2011) found the crustacean *Argulus foliaceus* on fish from Marmisho Lake west of Urmia. Hayatbakhsh *et al.* (2012, 2014) recorded *Caryophyllaeus laticeps* and *Ligula intestinalis* (cestodes), *Diplostomum spathaceum* (platyhelminth) and *Trichodina* sp. (ciliophore), these infections reducing haematocrit, mean cell volume and lymphocytes, and increasing white blood cells, mean cell haemoglobin concentration and neutrophils. Ahmadiara *et al.* (2013) described the rate of infection of the cestode *Digramma interrupta* in fish from the Aras Dam and Bandar-e Anzali. Azadikhah *et al.* (2013) found the cestode *Ligula intestinalis* had a high infection rate (mean 67.5%) in fish from the Aras Dam, noting that this parasite is major threat to natural and farmed fish populations. Azizi *et al.* (2013, 2013) found the protozoans *Trichodina* sp., *Chilodonella* sp., *Ichthyobodo* sp. and *Ichthyophthirius* sp. and the monogeneans *Gyrodactylus* sp. and *Diplozoon paradoxus* in fish from the Anzali Talab, with more parasites in the polluted area of the Pir Bazar River. Rasouli (2013) found the digenean *Diplostomum spathaceum* in fish from Caspian drainages in West Azarbayjan. This parasite causes secondary infections as the metacercariae penetrate the skin and eye, lesions, appetite loss, blurry vision and reduced feeding. Bozorgnia *et al.* (2016) showed infection of, and consequent anatomical changes in, gonads, liver and kidney from *Ligula intestinalis* in fish caught at Babolsar, Mazandaran. Omidvar *et al.* (2017) examined 300 juveniles, produced at the Shahid Ansari Hatchery Center of Rasht, Gilan for introduction to the Anzali Wetland, for metacercariae of the *Diplostomum spathaceum* eye parasite and found the frequency of infection was 12.33%, the mean infection was 18.33 and the range rate was 1-4, although no fish showed blurred eye lenses. Mazandarani *et al.* (2018) recorded the cestode *Ligula intestinalis* from fish in the Alagol Lake and Gorgan River. Mazandarani *et al.* (2019) found fish from Alagol Dam in Golestan had the abdominal parasites *Anisakis simplex* and *Eustrongylides excisus* (nematodes) and *Asymphyllodora tinca* and *Pronoprymna ventricosa* (trematodes). The nematodes are zoonotics and a health hazard for consumers. Moumeni *et al.* (2020) also recorded the zoonotic *Anisakis simplex* from this fish in Iran.

The Caspian seal, *Pusa caspica*, is a predator on this species (Krylov, 1984). Various predatory fishes take bream including *Huso huso*, *Perca fluviatilis*, *Sander lucioperca* (pike-perch), *Aspius* (= *Leuciscus*) *aspius* and *Silurus glanis* (European catfish) but this is

comparatively rare especially when bream exceed 20 cm in length. Birds such as grebes, herons, divers and cormorants are also predators. Ashoori *et al.* (2017a) recorded this species as an occasional item in the diet of young black-crowned night herons (*Nycticorax nycticorax*) in the Anzali Wetland.

**Economic importance.** This species is an important food fish being both tasty and of large size. In addition, it can live out of water for some time and thus remain fresh while being transported to market. Khanipour (2016) described the production of fish protein concentrate from Anzali Wetland catches, prepared as fish patties. Shoghi *et al.* (2021) replaced wheat flour with bream fish powder in pasta and demonstrated decreased cooking time (13.30 min) and increased cooking loss (8.2%) compared with the wheat flour control pasta. However, except for the 20% level, all pasta protein samples were in the acceptable range (8 g/100 g) for cooking loss. Thus, pasta fortified with fish powder has the potential to be a technological alternative for the food industry to provide protein enriched pasta.

Nevraev (1929) gave catches for various fishing regions in Iran in the early twentieth century. For the Anzali region from 1901-1902 to 1913-1914 the catch was 2,283 to 419,117 individuals, for the Sefid River region from 1908-1909 to 1917-1918 the catch was 17,195 to 474,200 individuals (rising steadily but falling in 1917-1918) with no fish reported in the years 1899-1900 to 1907-1908 and in 1918-1919, and in the Astrabad (= Gorgan) region from 1900-1901 to 1912-1913 the catch was 20,600 to 1,381,500 individuals with no clear trend, the catches varying markedly from year to year. The commercial catch in Iran from 1956/1957 to 1961/1962 varied from 0 to 158 kg (Vladykov, 1964), from 1965/66 to 1968/69 varied from 0 to 29 tonnes (Andersskog, 1970) and from 1963 to 1967 from 0.5 to 16.0 tonnes (with no reported catch in the first three years) (RaLonde and Walczak, 1970b). The catch in the Bandar-e Anzali region from 1933/34 to 1961/62 varied between only 2 kg and over 1,394 t with some years reporting no catches. Holčík and Oláh (1992) reported a catch of 34 kg in the Anzali Talab for 1990 and for the period 1932-1964 catches ranged from none to 1,133.5 tonnes annually. The total catch of the Northern Shilat (Fisheries Company) from 1965/66 to 1968/69 varied between 13 and 74 t (RaLonde and Walczak, 1972). There are obviously wide variations in annual catches and/or in reporting statistics. The general trend is one of decline in catches with large fish being caught and the average stock size being lowered, resulting in a decreased spawning success. This species has a deep body and immature fish are easily caught. The catch in the Anzali Talab was important until the end of the 1940s but had virtually disappeared by the 1980s (Petr, 1987). Abdolmalaki (2005) gave a total catch of 17 t for the 2000-2001 fishing season, only 0.1% of the commercial catch in Iranian coastal waters of the Caspian Sea. In contrast, the total catch for Iranian waters was estimated at 26.3 tons of which 15.4 tons was from beach seines; most fish were immature and undersized (Abdolmalaki, 2006a). Khara (2006) cited a catch of 20 t from the Gilan coast and Anzali Wetland.

In former Soviet waters of the Caspian Sea, the age composition in commercial catches was 2-10 years, with the great majority being 3-5 years old. Trawls, seines, pound nets and gill nets were used in the northern Caspian Sea to catch the bream with 60-70% being taken in spring. Spawning and breeding farms were established in the former Soviet Union to rear young fish. Catches in the Volga-Caspian and Ural regions has been as high as 344,900 centners, prior to 1930, and in the Aral Sea in 1931 the catch was 115,200 centners.

The roe or eggs of this species have been implicated in poisoning (Halstead, 1967-1970; Coad, 1979) and should be avoided (see under the cyprinid genus *Schizothorax* for more information on egg poisoning). Fish should be carefully cleaned in the spawning season to

remove the eggs and ensure against contamination of flesh. Severe cases of egg poisoning in other species have resulted in death. Conversely, Adeli and Namdar (2015) mentioned the eggs of this species as a caviar substitute.

Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use as food and in aquaculture.

**Experimental studies.** This species has been used in Iran for pollution studies, e.g., on the toxicity and LC<sub>50</sub> of phenol and 1-naphthol (Shariati *et al.*, 2004, 2005), being less vulnerable than *Rutilus kutum* to these compounds. Babaei and Khodaprasad (2016) and Babaei *et al.* (2017) examined fish from the Amirkelayeh Wetland and found levels of cadmium, chromium, copper, lead and zinc were within allowable standards in muscle tissue. Jaddi *et al.* (2016) found that the pesticide diazinon in sublethal amounts in Iranian waters affected fingerling survival as indicated by haematological parameters. Safahieh *et al.* (2018) found the LC<sub>50</sub> 96 h of the pesticide diazinon was 7.316 mg/l, the maximum acceptable toxicant concentration was 0.073 mg/l, the lowest observed concentration effect was 2.63 mg/l, and this species was more resistant than others. Etefaghdoost and Alaf Noveirian (2020a) measured the bio-accumulation of eleven elements (As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn) in muscle tissue of fish captured from the Siah Darvishan River and found only arsenic, cadmium, lead and manganese were at levels higher than approved standards.

Hashemi Kaverdi *et al.* (2017) studied the effects of the using the herb silymarin derived from the milkthistle plant (*Silybum marianum*) in the diet of fry on biochemical parameters of the blood and the immune system, finding strengthening of both. Khomami (2017) studied the effects of the dietary probiotic *Pediococcus acidilactici* on haematological parameters of fry finding increased blood parameters related to red blood cells, disease resistance and improved non-specific immune response. Shoghi *et al.* (2019) replaced wheat flour with bream fish powder in pasta making and found increased protein and lipid, decreased cooking time, and increased cooking loss so fish powder has the potential to be a technological alternative for the food industry to provide protein enriched pasta.

**Conservation.** RaLonde and Walczak (1970b) reported that 90% of the bream caught in Iran in 1970 were immature and the stock was in danger of extinction.

During the 1980s and 1990s there were practically no catch figures for this species in Iran. Artificial propagation began in 1986 on an experimental basis and 6 million fish were released (Ghenaat Parast, 1993). A state supported stocking programme released about 70-80 million fingerlings into the Anzali Talab, all descended from a single pair mating eight years ago (Bartley and Rana, 1998a, 1998b). These fish are intolerant of low oxygen and so perform poorly under pond conditions. Stocks may be imported from Azerbaijan in the future (Rana and Bartley, 1998). The release of 70.46 million fry in the 1992-1993 to 1998-1999 period was not successful in restoring the stocks in Iran. Stock depletion was attributed to improper fishing methods, pollution, destruction of spawning grounds, presence of predatory *Esox lucius* (northern pike) and *Silurus glanis* (European catfish) in fry stocking areas, and lack of necessary arrangements in regard to artificial spawning (Saiad Borani, 2001).

In 1992-1993 (an Iranian calendar year), 2.4 million fingerlings were released into the Anzali Talab and nearby rivers, a 100% increase over the previous year (*Abzeeyan*, Tehran, 4(2):VI, 1993). Total production in government hatcheries for 1990 was 0.66 million fingerlings, in 1991 2.28 million and in 1992 5.3 million fingerlings (Emadi, 1993a). Fingerling production was 11.217 million in 1995 and 8.5 million in 1996 (Bartley and Rana, 1998a, 1998b). In 1999-2000, 20 million juveniles were released (*Iranian Fisheries Research Organization Newsletter*,

23:4, 2000). From October to March 2000, 14 million juveniles raised in the Shahid Ansari aquaculture and breeding centre in Gilan were released into the Caspian Sea and neighbouring water bodies (*Iranian Fisheries Research Organization Newsletter*, 26:2, 2001). Illegal fishing and non-standard nets threaten the stocks (*Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran*, pp. 19-20, 1997). Billard and Cosson (2002) gave an annual production of 15 million alevins. Omidvar *et al.* (2017) cited 20 million annual production of young by government hatcheries.

Asgari *et al.* (2013) noted that 19 million fry (about 0.5 g) are released annually from the Shahid Ansari Hatchery Centre, Gilan, mostly to the Anzali Wetland (4‰ salinity), but also to the Sefid River (0.5‰), the Sefid estuary (8‰) and the Caspian Sea proper (12‰). They experimented on mortality at these salinities and found it to be significantly lower at 4‰, confirming the Anzali site to be best for release.

Mono- and polyculture of this species has been carried out in Iran (*Annual Bulletin 1993-94, Iranian Fisheries Research and Training Organization, Tehran*, pp. 77-78, 1995). Polyculture comprised 70% *Abramis brama*, 20% silver carp (*Hypophthalmichthys molitrix*) and 10% grass carp (*Ctenopharyngodon idella*) and gave a greater yield than monoculture. From an average initial weight of 30 g, fish attained averages of 188 or 211 g in monoculture (average 200 g) and 221 or 278 g (average 250 g) in polyculture with maximum weights of 300 or 580 g at the end of two one-year periods. Water temperatures were 9-33°C (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 38-39, 1996; Danesh-e-Khoshashi, 1997).

Ramin (1997a) detailed studies on the artificial breeding of this species in Iran, based on 38 brooders, with the goal of saving it from extinction. Gonadotropic hormone extracted from the pituitary of the common carp was used to induce brooders. One or two doses at 5-6 mg/kg body weight gave optimum stripping of eggs at 18°C. Fertilisation rate was 75-95% and hatching rate was 75-85%. Incubation took nearly four days at 18-21°C. The grey, pink or yellow eggs numbered 9,142-60,050 per spawner with a swelled diameter of 1.0-1.2 mm. The yolk sac was absorbed after 72 hours and newly hatched larvae were 2.9-3.7 mm long. Koohilai *et al.* (2010a, 2010b) studied optimum doses of various hormones used to stimulate ovulation. Khara *et al.* (2009) (see above) carried out their molecular study in order to determine sources for broodstock to increase genetic diversity after losses from overfishing, pollution and loss of spawning regions.

Kiabi *et al.* (1999) considered this species to be vulnerable in the south Caspian Sea basin according to IUCN criteria. Criteria included commercial fishing, sport fishing, few in number, habitat destruction, limited range (less than 25% of water bodies), not present in other water bodies in Iran, and present outside the Caspian Sea basin. Nezami *et al.* (2000) considered this species to be endangered in Iran because of overfishing, habitat destruction and spawning ground degradation. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

The subspecies has been proposed for inclusion in the *Red Book of the U.S.S.R.* which forms the basis for measures to protect species (Pavlov *et al.*, 1985). About 19-20% of commercial catches in the Volga region are from hatchery raised stock (Petr, 1987) and it was thought that stocking could help this species.

**Sources.** The chief literature summary for earlier works is Backiel and Zawisza (1968) although little apparently refers to the Caspian basin populations and even less to those of the Iranian shore. Nevertheless, this work gave a general overview of biology and general comments above are based on it.

Iranian material:- CMNFI 1970-0542, 4, 75.4-173.7 mm standard length, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0543A, 1, 70.0 mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0553, 3, not kept, Gilan, Sowsar Roga River (37°27'N, 49°30'E); CMNFI 1970-0587, 143, not kept, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1971-0343, 1, 158.6 mm standard length, Gilan, Langarud at Chamkhaleh (37°13'N, 50°16'E); CMNFI 1979-0689, 1, not kept, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1980-0127, 3, 166.1-170.1 mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1980-0136, 1, not kept, Mazandaran, Fereydun Kenar River estuary (36°41'N, 52°29'E); CMNFI 1980-0139, 1, not kept, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0140, 12, not kept, Gilan, Astara Talab close to sea (ca. 38°26'N, ca. 48°53'E); CMNFI 1980-0142, 1, 160.6 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1980-0906, 3, 105.6-176.0 mm standard length, Iran, Caspian Sea basin (no other locality data).

### **Genus *Acanthobrama***

Heckel, 1843

This genus comprises 13 species endemic to Southwest Asia with four found in Iran (Goren *et al.*, 1973; Krupp, 1985c; Perea *et al.*, 2010).

Howes (1981) placed *Acanthobrama* Heckel, 1843 in the genus *Rutilus* Rafinesque, 1820 on osteological grounds but most other authors have retained *Acanthobrama* as a distinct genus (Coad, 1984; Krupp, 1985c; Eschmeyer, 1990; Bănărescu, 1992b) based on the scale, keel and anal fin characters listed below. Berg (1948-1949) characterised the genus *Acanthalburnus* Berg, 1916 with two species (*microlepis* and *urmianus*) as similar to *Alburnoides* but with the last dorsal fin unbranched ray thickened into a spine which is strong basally but becomes thinner and flexible on about the last third of the ray length. Durand *et al.* (2002a, 2002b) included *Acanthalburnus* in the *Abramis* clade based on cytochrome *b* data while Perea *et al.* (2010) using mitochondrial and nuclear DNA proposed synonymy of *Acanthalburnus* with *Acanthobrama* as followed here.

The genus *Trachibrama* Heckel, 1843 is a *lapsus* (Krupp and Schneider, 1989).

*Acanthobrama* is characterised by a compressed, deep body of small to moderate size, no barbels, mouth terminal or inferior, relatively small scales with reduced numbers of radii, a fleshy keel of varying extent (full to one scale length) between the base of the pelvic fins and the vent, the last dorsal fin unbranched ray is thickened, spine-like or strong and smooth, and the anal fin is long (9-22 branched rays). Pharyngeal teeth are usually in a single row on each arch, but two rows in species formerly in *Acanthalburnus*. The gut is short. *A. persidis* is included in this genus based on mitochondrial and nuclear DNA characters but differs in some morphology (see species description).

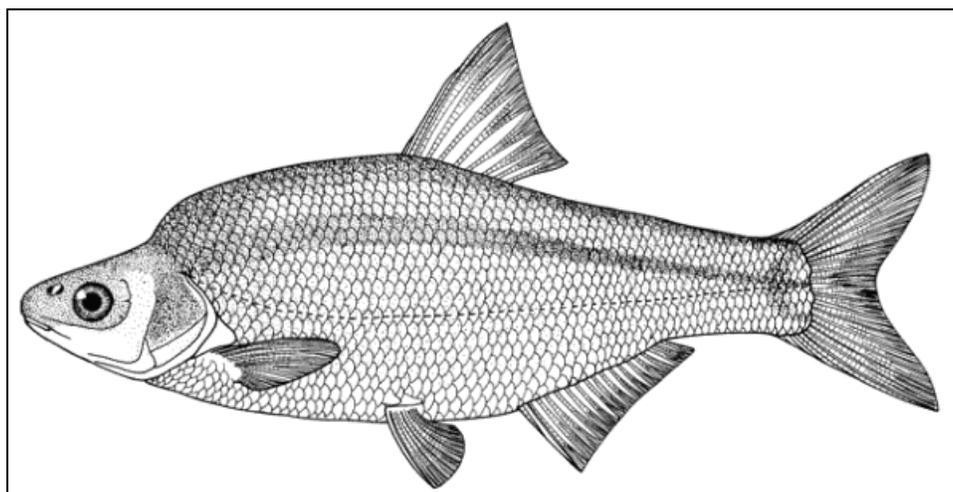
Abbasi Ranjbar *et al.* (2018) compared three Iranian species using six meristic and 16 morphometric characters. Species differed in all but pectoral fin length in morphometric characters and significant meristic differences were found in lateral line scales, dorsal fin unbranched and branched rays, and anal fin branched rays. *A. microlepis* and *A. urmianus* formed a clade separate from *A. marmid*.

The following table summarises some key distinguishing characters of the Iranian species of *Acanthobrama*.

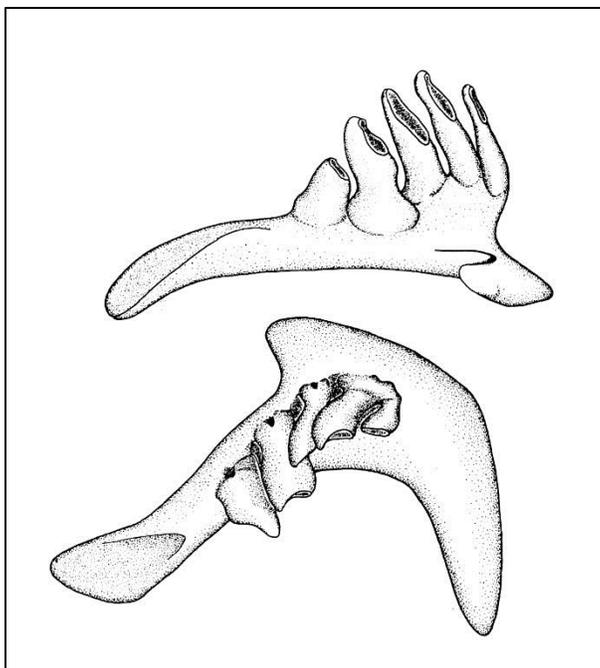
Species/ Characters	Modal dorsal fin	Lateral line	Anal fin branched	Naked ventral	Pharyngeal teeth	Distribution
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	branched rays	scales	rays	keel		
<i>Ac. marmid</i>	8	53-77	13-22	Present	5-5	Tigris River
<i>Ac. microlepis</i>	8	60-87	12-19	Present	2,5-5,2	Caspian Sea
<i>Ac. persidis</i>	7	35-43	7-9	Absent	1,5-4,1	Hormuz, Kor River, Lake Maharlu, Persis
<i>Ac. urmianus</i>	8	50-68	10-13	Present	2,5-5,2 or 2,5-4,2	Lake Urmia

***Acanthobrama marmid***  
Heckel, 1843



*Acanthobrama marmid*  
S. Laurie-Bourque @ Canadian Museum of Nature.



*Acanthobrama marmid*, pharyngeal teeth,  
Freidhelm Krupp.



*Acanthobrama marmid*, Iran, Gamasiab River, July 2008, Keyvan Abbasi.

**Common names.** Kalashpa, mahi sim nama (= bream-like fish), shebeh nazy, shebhe nazi (= resembling nazi, nazi meaning cute, Y. Keivany, pers. comm., 25 September 2018), shebeh sardin (= pseudo-sardine or resembling sardine).

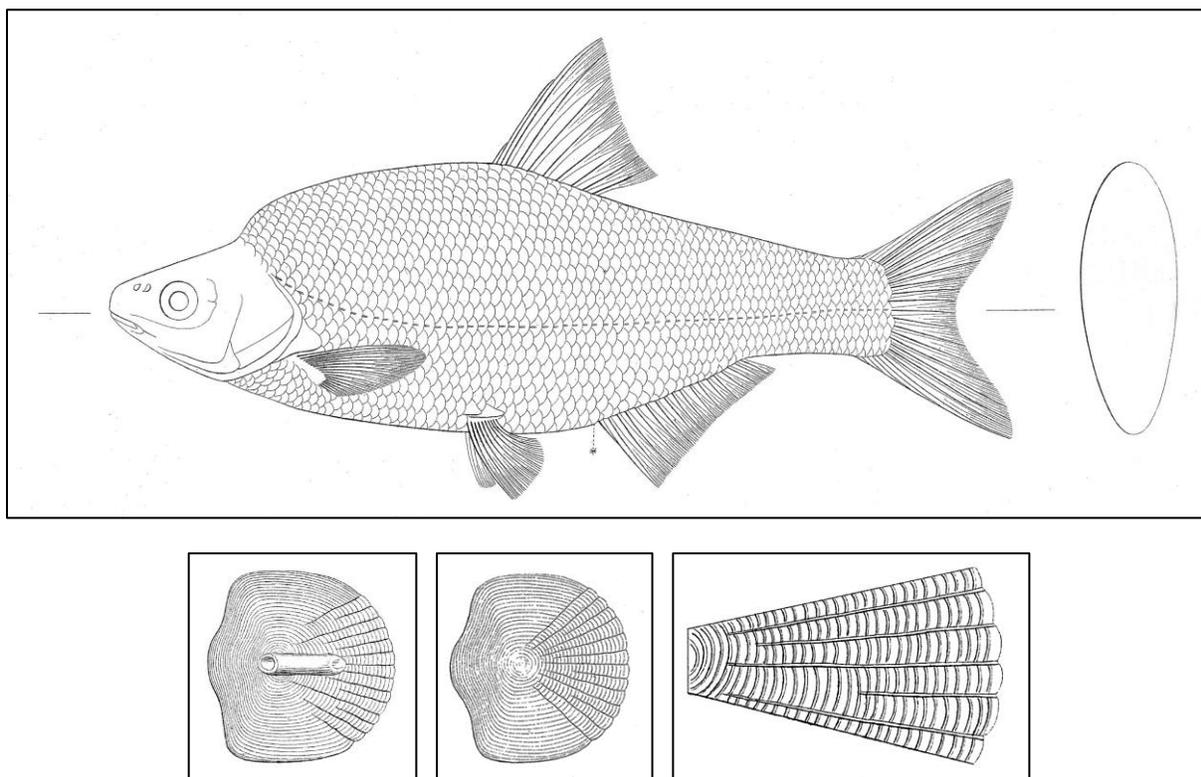
[Semnan arrez; samnan areed (samnan meaning sleek, healthy, fat, corpulent, and aridh meaning wide, broad, referring to the deep body, often humped behind the head, hence long, sleek fish (Mikaili and Shayegh, 2011)); arath (Rahemo, 2011); marmid, marmid handscherli (meaning marmid, armed with a dagger), marmid abbiad (meaning white marmid), marmid asphar (meaning yellow marmid) or marmid mablue (meaning swallowing or devouring marmid) at Aleppo, arrhada (meaning dove, lion!) at Mosul (all these latter Arabic names after Heckel (1843b, 1847a), the conflicting names for arrhada included, and are probably antiquated); Akçapak or Akçapak balığı (Turkish) and Kızılkanaat (local name in eastern Turkey) (Kaya *et al.*,

2016; Çiçek *et al.*, 2020); Tigris bream, Mesopotamian bream].

**Systematics.** *Acanthobrama Arrhada* Heckel, 1843, *Acanthobrama cupida* Heckel, 1843 and *Acanthobrama marmid* morpha *elata* Berg, 1949 are synonyms. *Acanthobrama marmid orontis* Berg, 1949 is now regarded as a distinct species.

The type locality for *Acanthobrama Marmid* is “Gewässern bei Aleppo”, for *Acanthobrama arrhada* “in Mossul”, and for *Acanthobrama cupida* “in Aleppo” according to Heckel (1843b) and “Flusse Kueik bei Aleppo” in Heckel (1847a). The type locality of *Acanthobrama marmid* morpha *elata* is Lake Balikli, 12 km from Erzurum, 8 km from the Karasu River, upper Euphrates, in Turkey. The type locality of *Acanthobrama marmid orontis* was given as the upper Euphrates region according to Eschmeyer *et al.* (1996) (but this is an error, see below, corrected in later, online versions of the *Catalog of Fishes*).

The *Catalog of Fishes* (downloaded 15 August 2020) gives the syntypes of *A. marmid* as NMW 55345-48 (2, 2, 2, 2), NMW 79068 (2), RMNH (Rijksmuseum van Natuurlijke Historie, Leiden) 2537 (4) and RMNH 2539 (2) (formerly NMW), and SMF (Senckenberg Museum Frankfurt) 543 (4) (formerly NMW). Details on the syntypes of this species and its synonyms *A. arrhada* and *A. cupida* in the Naturhistorisches Museum Wien and the Senckenberg Museum Frankfurt were given by Krupp (1985c). Lengths were NMW 55345, 2, 113-139 mm standard length, NMW 55346, 2, 86-121 mm standard length, NMW 55347, 2, 98-126 mm standard length, NMW 55348, 2, 113-132 mm standard length, NMW 79068, 2, 114-138 mm standard length, and SMF 543, 4, 82-112 mm standard length.



*Acanthobrama marmid*,

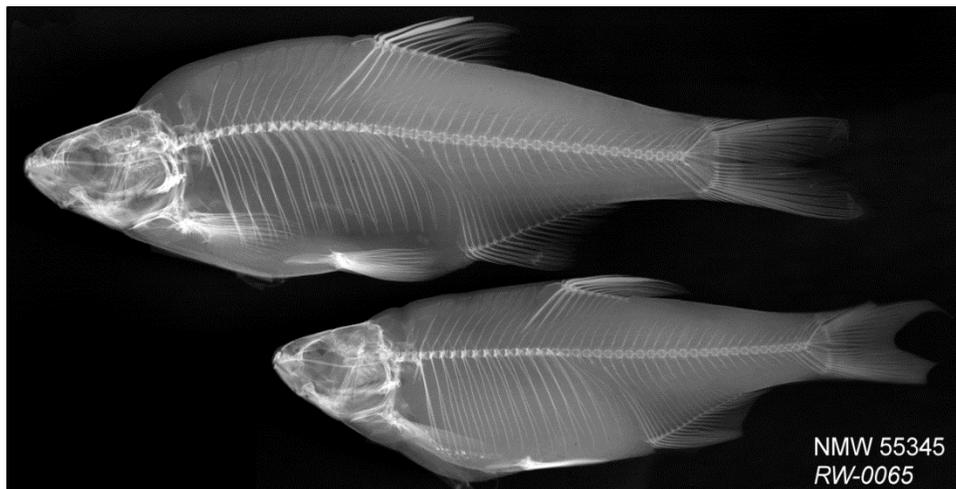
body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Acanthobrama marmid*, syntype, NMW 55345, Naturhistorisches Museum, Wien.

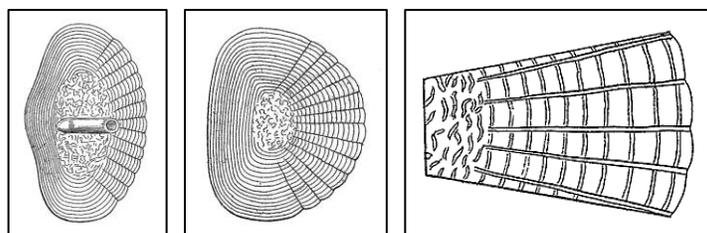
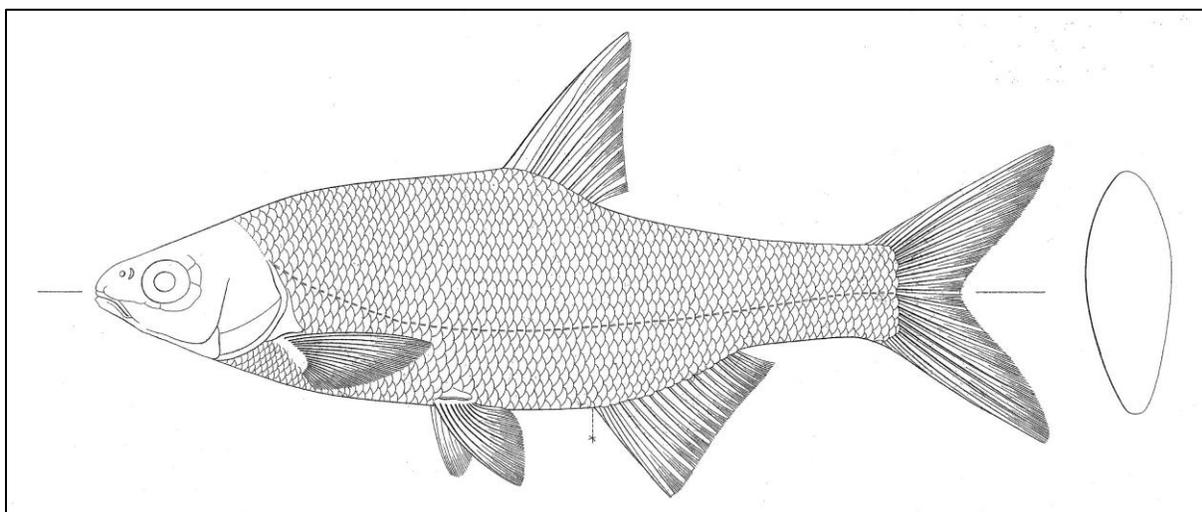


*Acanthobrama marmid*, syntype, NMW 55345, Naturhistorisches Museum, Wien.



*Acanthobrama marmid*, syntypes, NMW 55345, Naturhistorisches Museum, Wien.

Two syntypes of *A. arrhada* from Mosul, 85-92 mm standard length, are in the Senckenberg Museum Frankfurt (SMF 411, formerly NMW) (F. Krupp, pers. comm., 1985; 85.7-89.0 mm standard length) while two others are in the Naturhistorisches Museum Wien, ca. 150 mm standard length (NMW 55335) and 141 mm standard length (NMW 55336) (Krupp, 1985c). However, the Vienna catalogue listed six specimens of *A. arrhada* and in addition to the above material there was also NMW 55334 (8 fish) tagged as syntypes. Two syntypes are in the Rijksmuseum van Natuurlijke Historie, Leiden (RMNH 2538) (Eschmeyer *et al.*, 1996). Further details are in the Ichthyology Type Database, NMW.



*Acanthobrama arrhada*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line (regenerated), and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



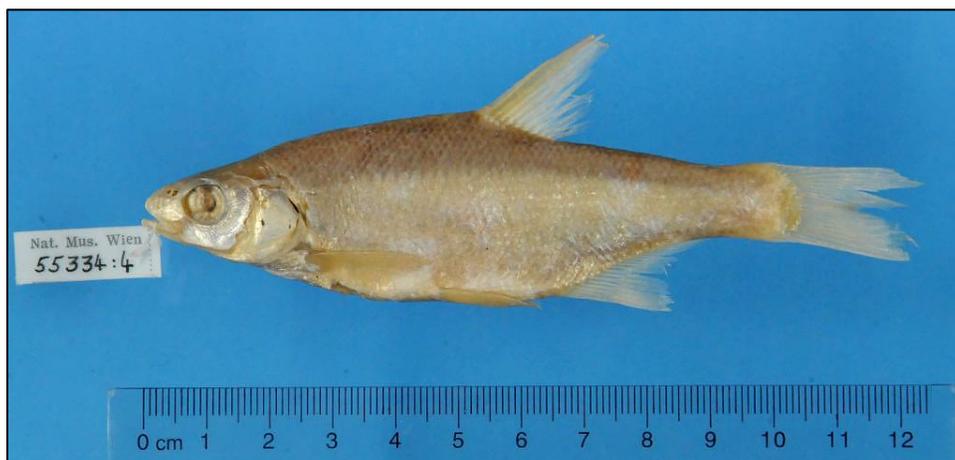
*Acanthobrama arrhada*, NMW 55334, syntype, Naturhistorisches Museum, Wien.



*Acanthobrama arrhada*, NMW 55334, syntype, Naturhistorisches Museum, Wien.



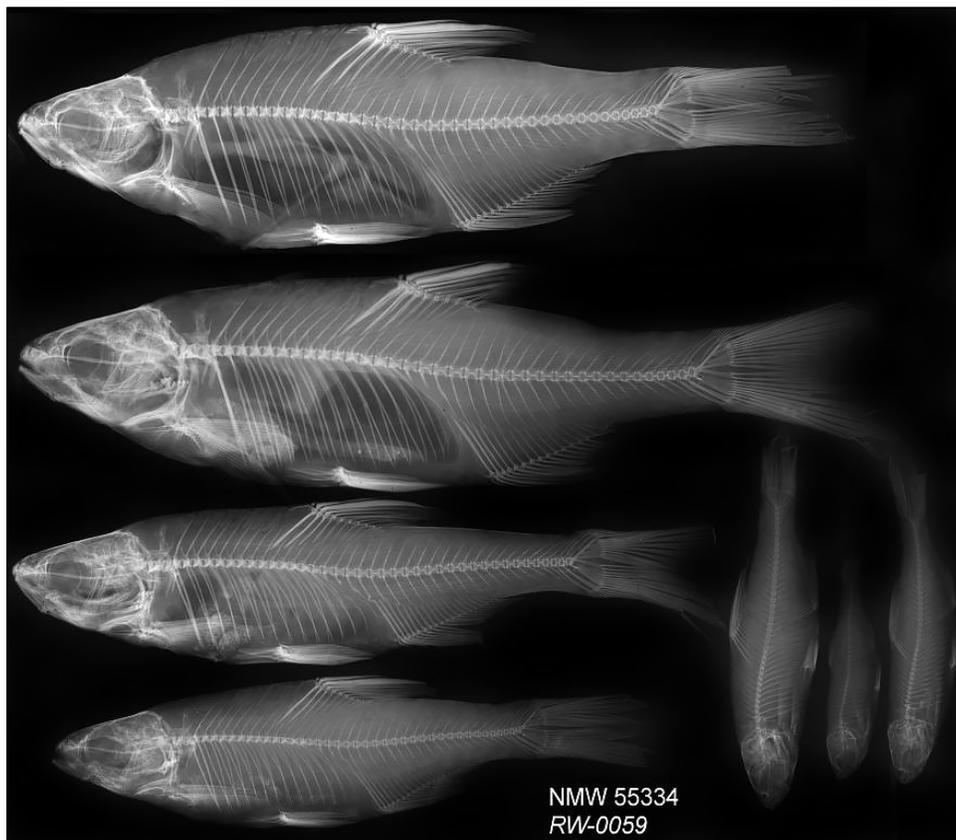
*Acanthobrama arrhada*, NMW 55334, syntype, Naturhistorisches Museum, Wien.



*Acanthobrama arrhada*, NMW 55334, syntype, Naturhistorisches Museum, Wien.



*Acanthobrama arrhada*, NMW 55334, syntypes, Naturhistorisches Museum, Wien.



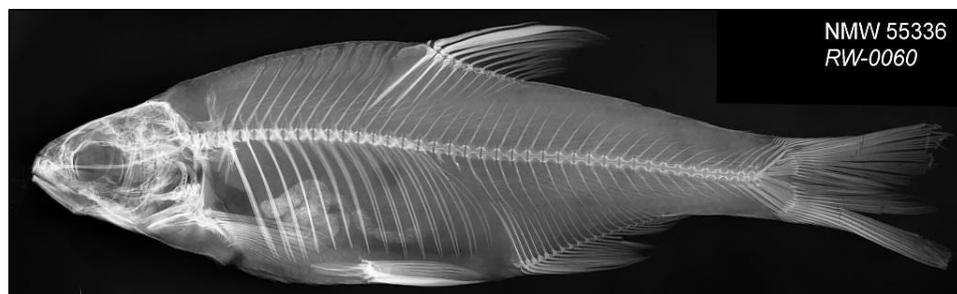
*Acanthobrama arrhada*, NMW 55334, syntypes, Naturhistorisches Museum, Wien.



*Acanthobrama arrhada*, syntype, NMW 55335, Naturhistorisches Museum Wien.

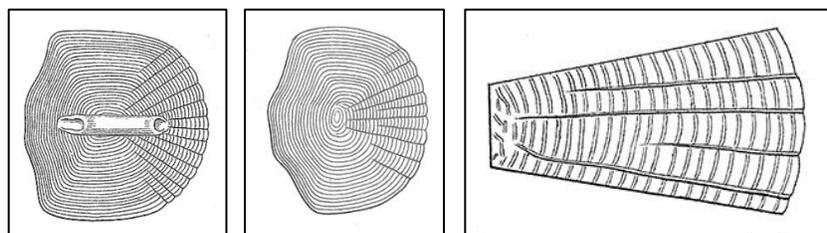
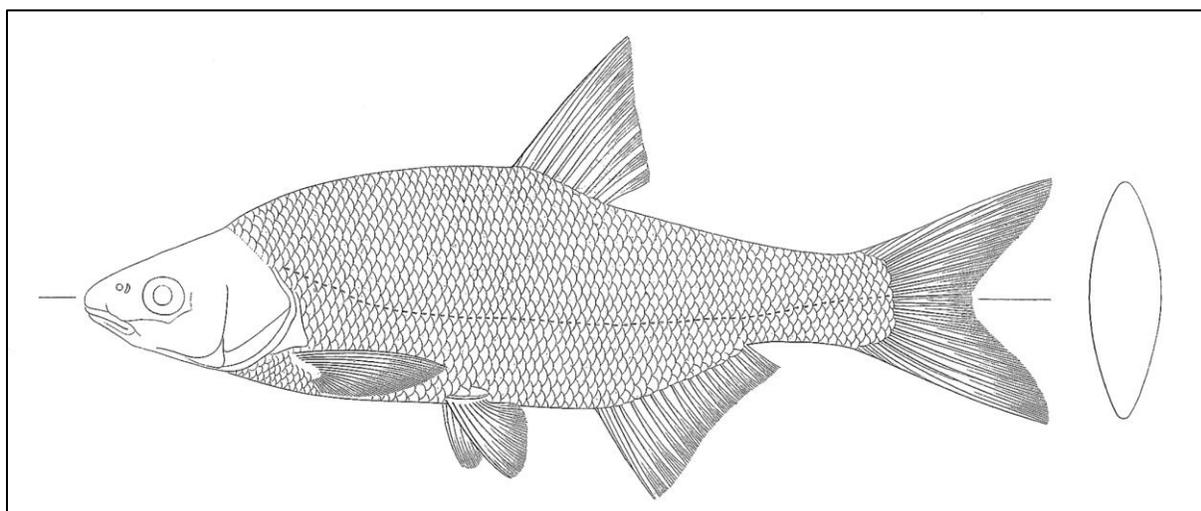


*Acanthobrama arrhada*, NMW 55336, syntype, Naturhistorisches Museum, Wien.



*Acanthobrama arrhada*, NMW 55336, syntype, Naturhistorisches Museum, Wien.

Krupp (1985c) recorded syntypes of *A. cupida*, 151 mm standard length (NMW 55340) and 152 mm standard length (NMW 55341) (the Ichthyology Type Database, NMW (downloaded 9 July 2016) gave 125 mm and 121 mm standard length for these two fish). The Vienna catalogue listed four *A. cupida* which agrees with Heckel's description although I observed only NMW 55340 (1 fish), NMW 55341 (1) and also NMW 55342 (1) (101 mm standard length in the Ichthyology Type Database, NMW (downloaded 9 July 2016)). Eschmeyer *et al.* (1996) listed NMW 55340-43 (1, 1, 1) as syntypes but the numbers indicated four fish. The card index in Vienna in 1997 also listed 55505 (5), one of which was designated as the lectotype.

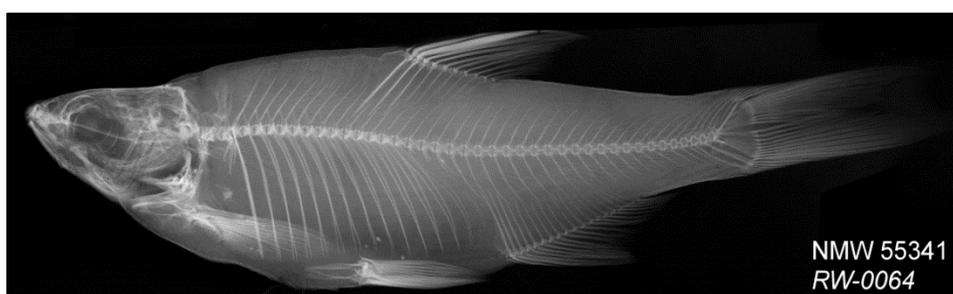


*Acanthobrama cupida*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Acanthobrama cupida*, syntype, NMW 55341, Naturhistorisches Museum, Wien.



*Acanthobrama cupida*, syntype, NMW 55341, Naturhistorisches Museum, Wien.

The two syntypes of *Acanthobrama marmid orontis* are in the Zoological Institute, St. Petersburg under ZISP 6720 from “L. Antioch, 1884, Lortet” according to Berg (1949). This subspecies is distinguished only by larger scales from the typical form but the two syntypes examined by me had lost their scales and were difficult to count; one seemed to have a count around 64, not as low as 54-55 recorded by Berg (1949). Krupp (1985c) examined type material and new specimens from the Orontes and found them not to differ from *A. marmid* from the Quwayq and Tigris-Euphrates basins. He accordingly synonymised *Acanthobrama marmid orontis* with the type subspecies but this taxon is now recognised as a distinct species (*Catalog of Fishes*, downloaded 9 July 2016).

Karaman (1972) considered *Acanthobrama arrhada* to be a subspecies of *A. marmid* rather than a synonym based on an unusually strongly ossified spiny dorsal fin ray in the former. Since *A. marmid* was described from Aleppo (= Halab, Syria) and *A. arrhada* from Mosul, the synonymy of these two taxa may warrant re-examination.

The fish reported from the Tigris River basin of Iran by Nümann (1966) as *Xenocypris macrolepidotus* was this species (Zoologisches Institut und Zoologisches Museum, Hamburg catalogue number ZMH H2700 examined by me). Saadati (1977) thought it a new species of *Acanthobrama* but I disagree.

A hybrid with *Chalcalburnus mossulensis* (= *Alburnus sellal*) was reported from the Hawr al Hammar in southern Iraq by Krupp *et al.* (1992).

**Key characters.** This species is distinguished from other members of the genus by having 53 or more lateral line scales, dorsal fin branched rays modally 8, anal fin branched rays 13 or more, and pharyngeal teeth in one row (5-5).

**Morphology.** Different body forms occur in slow-flowing and fast-flowing waters. In the

former habitat fish have a deep body, often humped behind the head, while in the latter the body is more streamlined (Karaman, 1972). It seems that *A. marmid* was founded on the humped form and *A. arrhada* and *A. cupida* on the streamlined one although the two types pictured above show both forms. The body is deepest at the dorsal fin origin. The predorsal profile is convex. The dorsal head profile is straight. The caudal peduncle is compressed and relatively deep. The eye lies almost at, or at, the beginning of the anterior half of the head. There is a groove over the head before the nostrils. The mouth is nearly horizontal to oblique, equal or lower jaw slightly behind the upper. Lips are of medium thickness. The last dorsal fin unbranched ray is a thickened, stiff and smooth spine, the rigid part varying from 15 to 26% of standard length. The spine may be strong for much of its length and then abruptly become thin and flexible or it may taper gradually to a flexible tip. Some small fish lack an enlarged dorsal fin spine. The dorsal fin margin is slightly concave. The depressed dorsal fin reaches back level with the mid-anal fin. The caudal fin is moderately forked with pointed to rounded tips, the lower tip being more rounded. The anal fin margin is straight to concave and the fin does not extend back to the caudal fin base, falling well short. The pelvic fin is rounded and extends back to the anal fin or falls short. The pectoral fin is rounded and extends back to the pelvic fin or falls just short.

Dorsal fin unbranched rays 3 and branched rays 7-9, usually 8, anal fin unbranched rays 3 and branched rays 13-22, pectoral fin branched rays 12-18, and pelvic fin branched rays 7-9. Lateral line scales 53-77, scales above the lateral 10-14, and scales between the pelvic fin and lateral line 4-7. There is a pelvic axillary scale. The belly has a fleshy keel where the ventral scales do not meet along the mid-line between the pelvic base and the anus. Scales are squarish to rounded in shape with a rounded posterior margin, gently rounded dorsal and ventral margins, and a posterior margin with a central rounded projection flanked by an indentation above and below or a rounded margin. Radii are restricted to the posterior field on scales and are moderate to few in number (5-7 according to Küçük *et al.* (2014) but up to at least 13 (see figures above)). The focus is subcentral anterior to almost central. Circuli are moderate in number. Total gill rakers number 12-17, and are short with a basal swelling, with 2-4 on the upper arch, 0-1 at the flexure and 9-12 on the lower arch. The rakers reach the one below or to its further base end when appressed. Pharyngeal teeth are usually 5-5, with the anterior tooth compressed and bluntly pointed, the remainder beveled with a cutting edge and a hooked tip. The two anterior teeth are more rounded than the others although the second one may have a slight hook and is beveled. Tigris River basin fish may have 1-2 teeth in a second row. The gut is an elongate s-shape with a large anterior loop in larger fish. Total vertebrae number 38-44 (38(3), 39(3), 40(7), 41(5), 42(7) or 43(1) combining Iranian and Iraqi material), Küçük *et al.* (2014) recording 44 vertebrae. The two syntypes of *A. marmid*, NMW 55345, have 42 and 43 total vertebrae, the syntype of *A. arrhada*, NMW 55336, has 41 total vertebrae, four of the syntypes of *A. arrhada*, NMW 55334, have 41(1) and 42(3) total vertebrae, and the syntype of *A. cupida*, NMW 55341, has 43 total vertebrae. The diploid chromosome number is  $2n = 50$ , with the karyotype consisting of eight metacentric, 13 sub-metacentric and four pairs of sub-telocentric to acrocentric chromosomes. The karyotype is nearly identical to other Eurasian leuciscine cyprinids (Gaffaroğlu *et al.*, 2006).

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(1) or 8(8), anal fin branched rays 13(2), 14(2), 15(4), 16(-) or 17(1), pectoral fin branched rays 13(2), 14(3), 15(3) .... or 18(1), pelvic fin branched rays 7(1), 8(7) or 9(1), lateral line scales 54(1), 55(2), 56(2), 57(-), 58(1), 59(1) .... or 63(1), total gill rakers 12(1), 13(-), 14(6) .... or 17(1), pharyngeal teeth 5-4(1) or 5-5(7), and total vertebrae 38(3), 39(1), 40(-), 41(2), 42(2) or 43(2).

**Sexual dimorphism.** Fine tubercles are found over the top, sides and bottom of the head

in males, particularly the operculum and snout with fewer on top of the head (CMNFI 1979-0287, 89.9-92.1 mm standard length, 7 July 1977 and CMNFI 1993-0128, 113.6 mm standard length, 11 May 1993). Tubercles line the first, pectoral fin unbranched ray irregularly with up to two branching rows. Very fine tubercles are found on the adjacent membrane and on the lower pectoral fin surface. Tubercles line the pelvic fin rays in branching rows. There are numerous very small tubercles on the anal fin rays. The lower caudal fin rays are lined with tubercles. Tubercles follow the branching of fin rays. Anterior upper flank scales, all belly scales, lower caudal peduncle scales and scales over the anal fin have their margin lined with small tubercles, the peduncle with some tubercles on the mid-scale and the belly with a concentration on the scale base.

**Colour.** The overall colour is silvery to whitish with the head and back reddish-brown. The flanks can be greyish to blackish from numerous melanophores. There may be a well-developed mid-flank stripe or it may be poorly developed or evident only posteriorly. The pelvic fins are bright red, the pectoral and anal fins less red and the dorsal and caudal fins reddish proximally and black distally. Fin colours may be more orange or yellow than red. All fin rays and membranes have melanophores and these can be quite concentrated such that some fish have dark fins. Young fish in preservative have numerous, distinctive, small to minute, rounded, square or oblong patches of pigment in 1-3, irregular, mid-flank rows. The peritoneum is black, silvery with a dorsal concentration of melanophores, or with widely scattered melanophores so it appears silvery.

**Size.** Reaches 20.8 cm (Berg, 1949).

**Distribution.** This species is found in the Tigris-Euphrates basin of Turkey, Syria, Iraq and Iran. In Iran, it is found in the Tigris River basin including the Ab-e Shur, Abloun, Arvand, Bahmanshir, Dinvar, Gamasiab, Karkheh (and its upper reaches), Karun, Mareg, Marun, Nahr-e Shavor, Qareh Su, Shahvor, Shur, Talkhab and Zard rivers, and in marshes such as the Hawr al Azim and the Khondab and Pir Salman wetlands (Abbasi *et al.*, 2009; Abbasi Ranjbar *et al.*, 2018; Khamees *et al.*, 2019; Eagderi *et al.*, 2020; Jouladeh-Roudbar *et al.*, 2020).

**Zoogeography.** The majority of species are found in the Levant which once had connections to the Tigris-Euphrates basin (Krupp, 1985c).

**Habitat.** This species is found in rivers, streams, canals, dams, marshes and springs. Hussain *et al.* (1997) reported this species to be dominant in the small fish assemblages in the Shatt al Arab near Basrah, Iraq at 70.8% of 14,084 fish caught. It favours side branches off the Shatt al Arab, presumably to avoid predators which are found in deeper water. Younis *et al.* (2001b) noted that this species dominated in the polluted and disturbed environment of a dockyard on the Shatt al Arab. This was one of the most abundant species in the recovering marshes of southern Iraq in 2005-2006 (Hussain *et al.*, 2006) and is also known from large rivers and dams.



Habitat of *Acanthobrama marmid* (and *Arabibarbus grypus*, *Capoeta trutta*, *Cyprinion macrostomus* and *Garra rufa*), CMNFI 1979-0384, Khuzestan, river in Ab-e Shur drainage, 30 January 1978, Brian W. Coad.

**Age and growth.** Eagderi *et al.* (2020) examined 9 fish, 4.85-15.49 cm total length, from the Dinvar River and found a  $b$  value of 3.29, positively allometric. Valikhani *et al.* (2020) combined fish from the Shadegan Wetland and the Dez and Karkheh rivers and reported a  $b$  value of 2.65 and a condition factor of 1.54 for 342 fish (2.7-8.7 cm total length), the only species of 16 with negative allometric growth. Mouludi-Saleh *et al.* (2021) examined 88 fish, 3.6-13.7 cm total length, from the Gamasiab River and recorded a  $b$  value of 3.13, positive allometric, and a condition factor of 1.25.

Al-Nasiri and Salman (1977) studied this species in the Little Zab River, Iraq. Their largest specimen was 13.7 cm. They described length-weight relationships and condition factors but some important length groups were missing from their samples. Condition factor showed a gradual decrease with increasing length and the means for actual and calculated weights were 1.141 and 1.118 respectively. Relative condition factor was 1.0009. Younis *et al.* (2001a) examined three populations of this species in the Shatt al Arab, Iraq and found the  $0^+$  age group to be represented by fish 2.1-11.0 cm long and  $1^+$  age group by fish 8.3-14.1cm. The length-weight relationship was  $W = -3.821L^{2.32}$ . Four age groups with a length range of 4-19 cm were found in the Qarmat Ali River of southern Iraq, with maturity in the first year (Saud, 1997).

Ünlü *et al.*, (1994) examined a population of this species in the Tigris River, Turkey and gave figures for growth in length and in weight. Females grew faster and were larger in size than males at the same age, particularly for age groups 3 and 4. Condition factor for males was 1.554 and for females 1.55. They found five age groups with age group 3 dominant for both sexes. Overall female:male sex ratio was 1.83:1. Sexual maturity was attained by 75% of females and 85% of males in the second year of life and all fish in age group 3 were mature. Alkan Uçkun and Gökçe (2015a) found that 586 Karakaya Dam fish, 11.0-19.2 cm total length, from the upper Euphrates basin of Turkey attained  $4^+$  years, length-weight relationship was  $W = 0.029FL^{2.678}$  for females and  $W = 0.03FL^{2.631}$  for males, growth in length equations were  $L_t = 17.3[1 - e^{-1.37(t+1.04)}]$  for females and  $L_t = 16.6[1 - e^{-1.29(t+1.04)}]$  for males.

**Food.** Heckel (1843b) suggested that they are ravenous feeders based on the name “swallowing marmid”. Gut contents are crustaceans, insects, and plant and gastropod shell fragments in Iranian specimens examined by me. Younis *et al.* (2001a, 2001b) found Shatt al Arab, Iraq fish to be detritivores, having organic detritus as the dominant gut content, followed by phytoplankton (blue-green algae and diatoms), small crustaceans (ostracods, cyclopoids, cladocerans), and aquatic plants, with dominance varying by month. In a study of the recovering Hammar Marsh, Iraq, diet was 70.77% insects and 9.81% algae with diatoms, plants, crustaceans and snails at less than 10% each, in the Hawr al Hawizeh 66.4% insects and 14.1% algae, with amounts of diatoms and various crustaceans being less than 10% each, and in the Al Kaba’ish (= Chabaish) Marsh 62.7% insects and 17.7% algae with diatoms, plants and various crustaceans at less than 10% each (Hussain *et al.*, 2006).

**Reproduction.** Well-developed testes were noted in fish caught on 7 July 1977 (CMNFI 1979-0287) near Ravansar, Kermanshah.

Younis *et al.* (2001a) found most females to be ripe in March and July samples, and some were spent, in Iraqi fish. Ünlü *et al.*, (1994) reported spawning in May to late June for their Tigris River, Turkey population. They cited data for a Keban Dam population (on the Euphrates River in Turkey) where the spawning season was extended and ran from April to August. Egg diameter exceeded 1.2 mm and egg numbers reached 8,125, and elsewhere may reach 11,000 eggs. In the Qarmat Ali River in southern Iraq, fecundity reached 1,759-9,293 eggs. Alkan Uçkun and Gökçe (2015a) found that Karakaya Dam, Turkey fish spawned from May to June.

**Parasites and predators.** None reported from Iran.

**Economic importance.** None in Iran. In the early 1990s in Iraq, this species was used for human consumption and for fish meal (Younis *et al.*, 2001a).

**Experimental studies.** None.

**Conservation.** This species is rarely reported from Iranian waters and its status needs to be assessed through further field work. Endangered in Turkey (Fricke *et al.*, 2007 Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

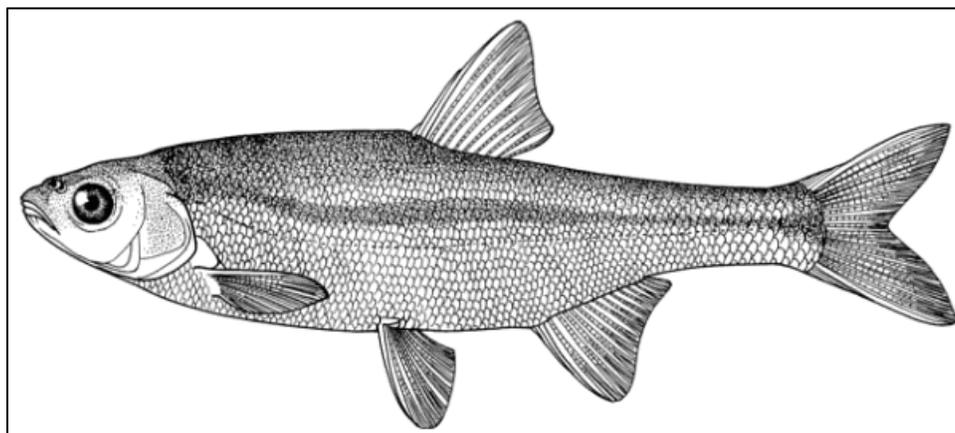
**Sources.** Type material:- See discussion above. *Acanthobrama marmid* (NMW 55345, NMW 55346, NMW 55347, NMW 55348, NMW 79068 and SMF 543), *Acanthobrama marmid orontis* (ZISP 6720), *A. arrhada* (NMW 55335, NMW 55336, NMW 55334 and SMF 411) and *A. cupida* (NMW 55340, NMW 55341, NMW 55342 and NMW 55505).

Iranian material:- CMNFI 1979-0287, 2, 89.9-92.1 mm standard length, Kermanshah, Cheshmeh Javari 2 km from Ravansar (ca. 34°42'N, ca. 46°40'E); CMNFI 1979-0360, 1, 40.6 mm standard length, Khuzestan, canal branch of Karkheh River (31°40'N, 48°35'E); CMNFI 1979-0377, 2, 28.5-34.6 mm standard length, Khuzestan, Karkheh River (ca. 32°57'N, ca. 47°50'E); CMNFI 1979-0384, 1, 23.1 mm standard length, Khuzestan, river in Ab-e Shur drainage (32°00'N, 49°07'E); CMNFI 1991-0154, 1, 113.6 mm standard length, Khuzestan, Hawr al Azim (ca. 31°45'N, ca. 47°55'E); CMNFI 1993-0128, 1, 113.6 mm standard length, Kermanshah, Sarab-e Sabz ‘Ali Khan (34°25'N, 46°32'E); CMNFI 2007-0114, 1, 82.1 mm standard length, Kermanshah, Qareh Su basin (ca. 34°28'N, ca. 46°54'E); CMNFI 2008-0102, 1, 101.7 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data); CMNFI 2008-0163, not kept, Khuzestan, Marun River at Chahar Asiab (30°40'28"N, 50°09'34"E); CMNFI 2008-0236, 2, 90.3-90.8 mm standard length, Kermanshah, Mereg River (35°25'N, 46°17'E); ZMH H2700, 1, 145.0 mm standard length, Kermanshah, Gharasu-Gamasiab-Seymarreh (Qareh Su, Gamasiab and Simareh rivers, no other locality data).

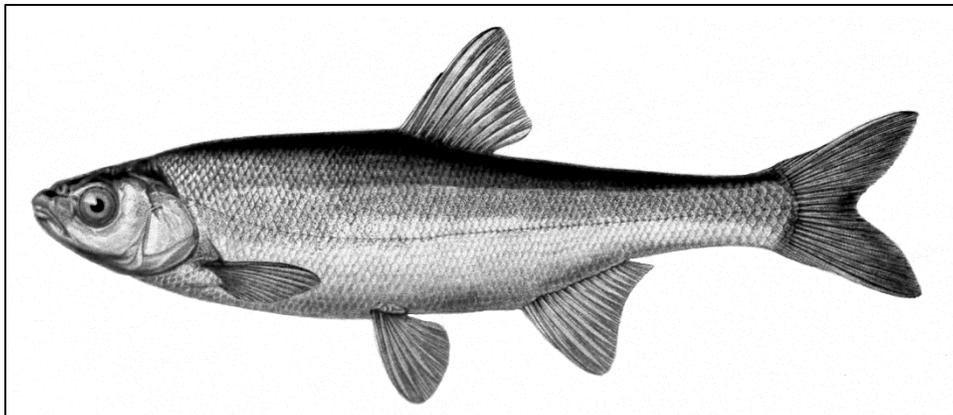
Comparative material:- BM(NH) 1920.3.3:147-156, 15, 29.5-102.0 mm standard length,

Syria, Ouadi Khneizer (no other locality data); BM(NH) 1931.12.21:22-25, 4, 65.7-84.6 mm standard length, Iraq, Mosul (ca. 36°20'N, ca. 43°08'E); BM(NH) 1968.12.13:108-112, 1 (of 5), 112.6 mm standard length, Syria, Ouadi Khneizer, Khabour (no other locality data) (collections amalgamated as BM(NH) 1968.12.13:105-341 seem to include the preceding and following collections, 224 (7 as alizarin specimens), 24.1-69.7 mm standard length); BM(NH) 1968.12.13:113-118, 6, 56.5-117.4 mm standard length, Syria, River Euphrates at Houreira (no other locality data); BM(NH) 1971.4.2:7, 96.5 mm standard length, Iraq, River Tigris near Mosul (ca. 36°20'N, ca. 43°08'E); BM(NH) 1974.2.22:1078-1083, 6, 105.2-122.8 mm standard length, Iraq, Najab Bazar (no other locality data); BM(NH) 1974.2.22:1084-1091, 7, 105.1-118.3 mm standard length, Iraq, Najab Bazar (no other locality data); BM(NH) 1974.2.22:1092, 109.5 mm standard length, Iraq, Najab Bazar (no other locality data); BM(NH) 1974.2.22:1094, 109.3 mm standard length, Iraq, Great Zab River at Aski Kalak (36°16'N, 43°39'E); CMNFI 1987-0017, 3, 83.8-108.3 mm standard length, Iraq, Hawr al Hammar (no other locality data); CMNFI 1980-0810, 2, 114.8-118.3 mm standard length, Turkey, Göksu in Tigris River basin (no other locality data); CMNFI 1980-1036, 1, 101.5 mm standard length, Turkey, Keban Dam on Murat Nehri near Elâzığ (no other locality data); ZSM 26136, 5, 55.3-80.3 mm standard length, Syria, Assad Reservoir, Euphrates basin (no other locality data).

*Acanthobrama microlepis*  
(De Filippi, 1863)



*Acanthobrama microlepis*  
S. Laurie-Bourque @ Canadian Museum of Nature.



*Acanthobrama microlepis*, ZISP 5187, Turkey, Lake Chaldyr (= Çıldır) in the Aras River basin, after Berg (1916).



*Acanthobrama microlepis*, Gilan, Sefid River, August 2010, Keyvan Abbasi.



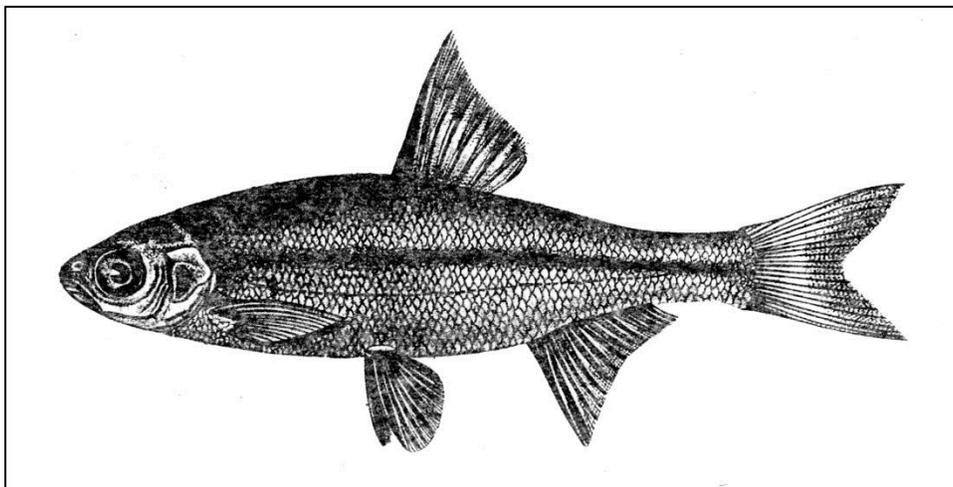
*Acanthobrama microlepis*, Turkey, Kura River at Yalnızçam, after Kaya *et al.* (2020).

**Common names.** Kuli (= general term for a small fish), morvarid mahi-e labnazok (= slender lip pearl fish).

[Garagas or taxta balig, both in Azerbaijan; İnci baliği and Kura akçapağı in Turkish (Çiçek *et al.*, 2020; Kaya *et al.*, 2020); chernobrovka and napota in Russian; blackbrow bleak, Caucasian, oriental or carp bream].

**Systematics.** *Abramis microlepis* was described from the “Kur, presso Tiflis” (= Kura River near Tbilisi, Georgia) and the holotype is in the Istituto e Museo di Zoologia della R. Università di Torino under MZUT N.673 (Tortonese, 1940; Eschmeyer *et al.*, 1996).

*Alburnus punctulatus* Kessler, 1877, described from the Kura River at Tiflis (= Tbilisi) and Borzhomi (= Borjomi), Georgia, is a synonym. A syntype of *Alburnus punctulatus* from the St. Petersburg Museum, 84.6 mm standard length, from “R. Kura, Tiflis” is in the Natural History Museum, London (BM(NH) 1897.7.5:34) and other syntypes are in ZISP 2915(5), 2924(6+) (*Catalog of Fishes*, downloaded 16 March 2018).



*Alburnus punctulatus*, syntype, after Kessler (1877).



*Alburnus punctulatus*, 84.6 mm standard length,  
BM(NH) 1897.7.5:34, Brian W. Coad.

“*Alburnus Brandtii*” is apparently a manuscript name for this species first reported without a formal description in Brandt (1880) and listed as “*Alburnus Brandtii* n. sp. 1 ex. Tschaldyr” (= Lake Çıldır in Turkey) and attributed to K. Kessler in the account of the travels of Professor A. F. Brandt in Transcaucasia (see Kavraiskii, 1897). Bogutskaya (1997) listed it as a *nomen nudum*.

*Alburnus microlepis* of Kamensky (1901), which is *Acanthalburnus microlepis*, should not be confused with *Alburnus microlepis* Heckel, 1843, a distinct species described from Aleppo (= Haleb, Syria) but a synonym of *A. sellal*.

**Key characters.** This species is distinguished from the related *A. urmianus* by having more lateral line scales, more anal fin branched rays, fewer gill rakers and gill raker morphology according to Saadati (1977). Gill raker counts are the same but scale and anal fin ray counts are generally higher with some overlap. Gill raker morphology does not appear to differ in the fish examined by me. Distribution is the easiest separating factor. Both species are distinguished from other cyprinids in Iran by the dorsal fin spine, two rows of pharyngeal teeth, and fin ray and

scale counts.

**Morphology.** The body is compressed and relatively deep, deepest at the dorsal fin origin. The predorsal profile is convex. A nuchal hump is present in larger fish. The caudal peduncle is relatively shallow and is compressed. The head is straight to a rounded snout. The rear of the eye is at the beginning of the anterior half of the head. The mouth is oblique and subterminal in adults and most young, oblique and terminal in some young. The mouth extends back to between the nostril and the eye. Lips are thin. The dorsal fin margin is concave. The last dorsal fin unbranched ray is thickened in its lower two-thirds but the last third is thin and flexible. The dorsal fin origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin tip reaches back to almost the mid-anal fin level. The caudal fin is deeply forked with pointed tips. The anal fin is emarginate and does not extend back to the caudal fin base. The pelvic fin is rounded and reaches the anal fin or falls just short. The pectoral fin is rounded and does not reach back to the pelvic fin except in some young fish.

Dorsal fin unbranched rays 3 and branched rays 7-9, usually 8, anal fin unbranched rays 2-4, usually 3, and branched rays 12-19, usually 15-17, pectoral fin branched rays 12-17, and pelvic fin branched rays 7-9, usually 8. Lateral line scales 60-87. There is a large pelvic axillary scale. Scales at the base of the anal fin are somewhat enlarged and may be vertically elongate, forming a sheath. There is an obvious scaleless keel from the pelvic fins to the vent on the belly mid-line. Scale shape is rounded to squarish with rounded posterior, dorsal and ventral margins, the ventral margin sometimes more rounded than the dorsal margin, abrupt but rounded anterior corners, and the anterior margin is wavy, indented shallowly to moderately adjacent to each corner, or a central protrusion with an indentation above and below. The scale focus is sub-central anterior with fine but not numerous circuli and very few posterior radii (less than 10 main radii in the largest fish seen). Gill rakers number 6-12 and are sickle-shaped (Saadati, 1977) but this count presumably includes only lower arch rakers. Total gill rakers number 10-14, are short and only reach the adjacent raker when appressed. The rounded raker has a triangular flap on its internal surface with the tip of the rounded raker projecting. The raker tip may be squarish or even forked in larger fish. The inner edge of the flap is finely tuberculate. Pharyngeal teeth are 2,5-5,2 with variants 2,5-5,1, 1,5-5,2, 1,5-5,1, 3,5-5,2, 2,5-4,2, 2,5-4,1, 2,4-5,1, 2,4-4,1, 1,5-4,1, 1,5-4,0, 1,4-5,2, 1,4-5,1 and 2,6-5,2. The teeth are hooked at the tip with an elongate flat area below and the largest tooth may be strongly serrated. The posteriormost major row tooth may be almost vertically above the fourth tooth rather than posterior to it. The gut is relatively short with anterior and posterior loops. Total vertebrae number 40-45. Chromosome number  $2n = 50$  (Nur *et al.*, 2008).

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(1) or 8(52), anal fin branched rays 14(4), 15(23), 16(24) or 17(2), pectoral fin branched rays 14(3), 15(36), 16(11) or 17(3), pelvic fin branched rays 8(53), lateral line scales 60(1), 61(-), 62(2), 63(4), 64(6), 65(11), 66(6), 67(7), 68(4), 69(3), 70(5), 71(-), 72(1) or 73(2), total gill rakers 10(1), 11(4), 12(18), 13(22) or 14(8), pharyngeal teeth modally 2,5-5,2(33) with variants 2,5-5,1(6), 1,5-5,2(3) or 1,5-5,1(2), and total vertebrae 43(2), 44(10) or 45(13).

**Sexual dimorphism.** Males have the head, nape and dorsal part of the body with large tubercles, there are two rows of tubercles on the pectoral and pelvic fin branched rays and there are tubercles on the free margins of scales in rows. Females also bear tubercles but they are not as well-developed as in males (Küçük *et al.*, 2014). Males and females, as well as young, may have fine tubercles distributed over the head and especially well-developed ventrally and even on the lips. Belly and lower flank scales have fine tubercles concentrated at the base of the exposed

scale, some lining the scale margin. Fine tubercles line the dorsal and ventral surfaces of the pectoral and pelvic fins concentrated on rays but also on membranes, in a single file or variably dispersed.

**Colour.** The back and upper head are olive-green to green or bluish and the upper flank has a golden sheen. Flanks below are silvery and the abdomen is silvery-white. There is a dark and wide stripe (about orbit diameter) on the flank, not always evident in fresh fish. Above the dark stripe is a narrow golden stripe, about one-third orbit diameter. Dorsal and caudal fins have black tips while paired fins can have a reddish or orange base. Dorsal, anal and caudal fins may be tinged reddish, especially near the body. The peritoneum is brown with dark blotches or speckles.

**Size.** Reaches 25.0 cm. Çakır *et al.* (2016) gave 24.2 cm total length for fish from Lake Çıldır in the Aras River basin of Turkey.

**Distribution.** In Iran, it is found in the Caspian Sea basin including the Aras (as far down as Karadonly), Marbureh, Qareh Su, Qezel Owzan, Sefid, Shah, Shahrbijar, Siah and Tutkabon rivers, in the Anzali Talab drainage such as the Nahang and Pir Bazar rogas, and in the Nazdik, Sefid (Manjil) and Zire dams on the Sefid River (Abbasi *et al.*, 1999; Kiabi *et al.*, 1999; Abdoli, 2000; Naderi Jolodar and Abdoli, 2004; Abdoli and Naderi, 2009; Zamani Faradonbeh *et al.*, 2015; Asadi *et al.*, 2017; Abbasi Ranjbar *et al.*, 2018; Aazami and Alavi Yeganeh, 2021; Mouludi-Saleh *et al.*, 2021). Records from the middle Aji Chay or Talkheh River near Tabriz and the Zarrineh River of the Lake Urmia basin are presumably of *A. urmianus* (Abdoli, 2000). Found in the Kura River of Azerbaijan as far down as Mingechaur but not the lower reaches.

**Zoogeography.** This species and its relative *A. urmianus* (formerly in a separate genus *Acanthalburnus*) are restricted to the Caspian Sea basin and the adjacent Lake Urmia basin and are presumably derived from a common ancestor related to the *Alburnoides-Alburnus* lineage.

**Habitat.** This species is found in rivers, streams, lakes, dams and marsh tributaries. Collection data included a temperature range of 5.6-24.5°C, pH 6.0, conductivity 1.6-1.7 mS, river width up to 80 m, still to fast current, clear or muddy water, mud, clay, sand, pebble or stone bottoms, and a grassy shore.

Küçük *et al.* (2014) reported Aras River, Turkey fish to be in dense populations in sandy and gravel streams at 0.5-1.0 m depths.

**Age and growth.** Zamani Faradonbeh *et al.* (2015) found a *b* value of 2.429, negative allometric growth, and a condition factor of 0.73 for 22 fish, 30.9-83.3 mm total length, from the Tutkabon River. Asadi *et al.* (2017) gave a *b* value of 3.001 for 17 fish, 1.8-9.0 cm total length, from the Shahrbijar River, Gilan with a total length condition factor of 0.96. The condition factors and *b* values for the Ghezel-Ozan (= Qezel Owzan) and Sefid River populations were 1.06 and 0.96 and 3.24 and 3.15, respectively, the latter both indicating positive allometric growth (Abbasi and Ghafouri, 2020). Eagderi *et al.* (2020) examined 11 fish, 9.19-12.59 cm total length, from the Sefid River and found a *b* value of 2.75, negatively allometric. Mouludi-Saleh *et al.* (2021) examined 98 fish, 6.3-16.6 cm total length, from the Aras, Qezel Owzan and Sefid rivers and recorded a *b* value of 3.28, positive allometric, and a condition factor of 0.99.

Females matured at 2 years in Azerbaijan (Abdurakhmanov, 1962). Türkmen *et al.* (2001) examined 1,105 fish and found them up to 7 years of age in the upper Aras River in Turkey, with three-year-old fish dominant, sex ratio equal, von Bertalanffy growth parameters were  $L_{\infty} = 29.87$  cm,  $K = 0.1049$ ,  $t_0 = -1.92$ , the length-weight relationships for males and females were  $W = 0.0099L^{3.098}$  and  $W = 0.0118L^{3.052}$  respectively, and the condition coefficients of males and females were 1.192 and 1.209 respectively. Females attained a greater

age and size than males. Çakır *et al.* (2016) examined 229 fish, 7.6-24.2 cm total length, from Lake Çıldır, Turkey where age group four was attained with most fish in age group 2 years. The length-weight relationship was  $W = 0.0058L^{3.1199}$  and the von Bertalanffy growth parameters were  $L_{\infty} = 38.37$  cm,  $K = 0.193$  year<sup>-1</sup>,  $t_0 = -0.73$  years, the growth performance index was  $\phi = 2.45$  and Fulton's condition factor was  $K = 0.75$ . Total, natural and fishing mortalities were  $Z = 0.5$ ,  $M = 0.28$ ,  $F = 0.22$  and exploitation was  $E = 0.44$ . The population was not overfished.

**Food.** Food includes aquatic insects, crustaceans and snails, and detritus. In Lake Çıldır, Turkey fish often do not feed during the May spawning season (Çakır *et al.*, 2016).

**Reproduction.** Spawning probably occurs in the spring judging from fish caught on 31 January 1962 (CMNFI 1970-0536) in Iran which had developing eggs. Fecundity is up to 19,060 eggs and egg diameter to 1.87 mm. In Armenia, maturity is reached at the end of the second year or beginning of the third year at 80-120 mm, and spawning takes place in late April to early May and may continue to late August (Pipoyan and Arakelyan, 1999). In the Turkish Aras, maturity for both sexes began at age 2 years, with all fish mature at 4 years, and spawning started in early May and continued to the end of July. Fecundity reached a mean value of 9,705 eggs and egg size reached 1.65 mm (Türkmen *et al.*, 2001).

**Parasites and predators.** None reported from Iran.

**Economic importance.** None in Iran. Used locally but not commercially in Lake Çıldır, Turkey (Çakır *et al.*, 2016).

**Experimental studies.** None.

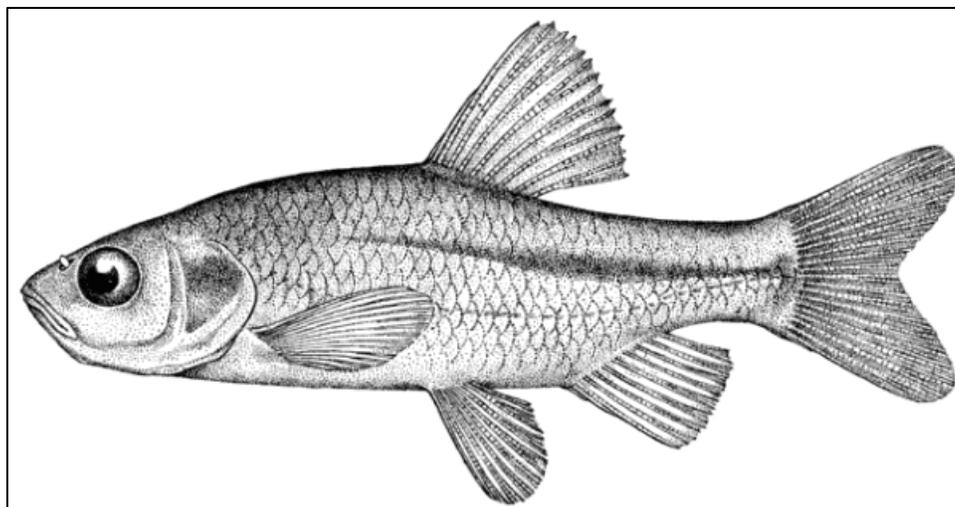
**Conservation.** Kiabi *et al.* (1999) considered this species to be conservation dependent in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, few in numbers, habitat destruction, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and absent outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Type material:- *Alburnus punctulatus* (BM(NH) 1897.7.5:34).

Iranian material:- CMNFI 1970-0522, 2, 55.1-71.3 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0536, 4, 70.9-109.3 mm standard length, Gilan, Siah River estuary near Rudbar (36°53'N, 49°32'E); CMNFI 1970-0538, 1, 70.7 mm standard length, Gilan, Qezel Owzan River above Manjil Dam (ca. 36°44'N, ca. 49°24'E); CMNFI 1970-0583, 11, 39.0-79.9 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1979-0454, 8, 37.7-64.7 mm standard length, Zanzan, Qezel Owzan River at Gilavan (36°47'N, 49°08'E); CMNFI 1979-0455, 7, 50.2-123.3 mm standard length, Qazvin, Manjil Dam (36°45'N, 49°17'E); CMNFI 1979-0695, 15, 71.6-112.7 mm standard length, Gilan, Sefid River at Manjil Bridge (36°46'N, 49°24'E); CMNFI 1980-0116, 1, 75.5 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E).

Comparative material:- CMNFI 1980-0807, 2, 138.2-143.8 mm standard length, Turkey, Ölçek Suyu (no other locality data); CMNFI 1986-0007, 1, 132.2 mm standard length, Turkey, Kars River (ca. 41°00'N, ca. 43°00'E).

***Acanthobrama persidis***  
(Coad, 1981)



*Acanthobrama persidis*  
Charles H. Douglas @ Canadian Museum of Nature.



*Acanthobrama persidis*, Fars, Ghadamgah Spring-Stream system, Azad Teimori.



*Acanthobrama persidis*, Fars, Pirbanoo Spring, Jörg Freyhof.

**Common names.** Arusmahi-ye Fars (= Fars bride fish), 'Rus mahi persidis (=persidis bride fish), both from Y. Keivany, pers. comm., 25 September 2018.

[Kor bleak, Persian bleak, Persian chub].

**Systematics.** Trewavas (1972) discussed the generic nomenclature of *Pseudophoxinus* Bleeker, 1860 in which this species was originally described. It is more closely related to the genus *Leuciscus* according to N. Bogutskaya (pers. comm., 1994, 1996). Bogutskaya (1996)

placed this species in her *Leuciscus borysthenicus* (Kessler, 1859) group which also includes *L. ulanus* and deserved subgeneric rank, but later erected a new genus *Petroleuciscus*. Doadrio and Carmona (2006) placed it in *Squalius*. Perea *et al.* (2010) using mitochondrial and nuclear DNA proposed placing this species in *Acanthobrama*. Teimori *et al.* (2016) confirmed the placement of this species in *Acanthobrama* using mtDNA and material from the Kor River, Lake Maharlu and Persis basins.

Saadati (1977) described, but did not name, a new species in the genus *Phoxinellus* Heckel, 1843 from the Bid Sorkh River in the Simareh River basin between Sahneh and Kangavar in Kermanshah (the Bid Sorkh Pass is at 34°26'N, 47°49'E). I was unable to find this species in his collections and no further material has come to light. It had 8-9 dorsal fin branched rays, 8-9 anal fin branched rays, 8 pelvic fin branched rays, 47-56 scales in a complete lateral line, and 20 long and crowded gill rakers.

The type locality of *Pseudophoxinus persidis* is the “upper Shur River drainage at “Koorseh” village, near Darab on Darab-Fasa road, 28°45.5'N, 54°24'E, Fars”. The holotype is a 54.7 mm standard length male held at the Canadian Museum of Nature, Ottawa under CMNFI 1979-0154A. Paratypes comprise 95 fish, 34.7-58.8 mm standard length, from the same locality as the holotype under CMNFI 1979-0154B, and five fish, 74.7-92.4 mm standard length, under CMNFI 1979-0499 from an “irrigation ditch at village 32 km west of Kor River bridge on road to Dariush Dam, 30°04.5'N, 52°36'E, Fars”. Paratypes were distributed to the following institutions from CMNFI 1979-0154B:- BM(NH) (2), ROM (2), UAIC (1), UBC (2) and UMMZ (2).



*Pseudophoxinus persidis*, holotype, CMNFI 1979-0154A,  
James Maclaine @ Canadian Museum of Nature.



*Pseudophoxinus persidis*, holotype, CMNFI 1979-0154A,  
Noel Alfonso @ Canadian Museum of Nature.



*Pseudophoxinus persidis*, paratype, CMNFI 1979-0154B,  
Bronwyn Jackson @ Canadian Museum of Nature.

**Key characters.** This species is characterised by having a 35-43 lateral line scales, dorsal fin branched rays modally 7, anal fin branched rays 7-9, pharyngeal tooth count of 1,5-4,1, and dorsal fin spine and naked ventral keel absent.

**Morphology.** Unlike related *Acanthobrama* species it lacks a dorsal fin spine and naked ventral keel. The body is rounded, somewhat compressed and relatively deep. It is deepest a short distance in front of the dorsal fin. The predorsal profile is steeply convex. A small nuchal hump may be apparent in larger fish. The caudal peduncle is compressed and deep. The head tapers to a rounded snout. The mouth is terminal to slightly subterminal, fairly large and quite oblique, and the rictus reaches back to a level just anterior to the anterior eye margin. The eye is well in the anterior half of the head, much more anterior than in *A. urmianus* for example. Lips are of moderate thickness. The dorsal fin origin is slightly behind the level of the pelvic fin origin. The dorsal fin margin is truncate to rounded. The depressed dorsal fin reaches back level with the beginning of the anal fin. The caudal fin is shallowly forked with very rounded tips. The anal fin margin is truncate to slightly rounded. The anal fin does not extend back to the caudal fin base. The pelvic fin has a rounded to straight margin and extends back to the anal papilla or to the anterior anal fin. The pectoral fin is rounded and does not extend back to the pelvic fin. Both the pectoral and pelvic fins can be quite small.

Dorsal fin unbranched rays 3 and branched rays 6-7, usually 7, anal fin unbranched rays 3 and branched rays 7-11, usually 8-9, pectoral fin branched rays 13-15, and pelvic fin branched rays 7-8. Lateral line scales 35-43. A pelvic axillary scale is present. The subcircular to oval scales bear numerous fine circuli and radii on the anterior and posterior fields (total radii number 23-44). The focus is subcentral and slightly anterior. Anterior radii are short, lying in mid-field and not extending to the scale margin or focus, or long and extending to the scale margin but barely reaching the focus. Total gill rakers number 10-14 and reach the adjacent raker when appressed. Pharyngeal teeth are usually 1,5-4,1. Pharyngeal teeth are strongly hooked, concave below the hook and serrated along the margins of the concave surface, particularly on the anterior edge. In the largest fish, the hook may be much reduced to absent, serrations may be absent, and anterior teeth in the main row are rounded. The gut is a short and simple s-shape. Total vertebrae number 34-37. The holotype has 36 total vertebrae.

Meristic values for Iranian specimens are:- dorsal fin unbranched rays 3 and branched rays 6(2) or 7(195), anal fin unbranched rays 3 and branched rays 7(3), 8(41), 9(11), 10(-) or 11(1), pectoral fin branched rays 13(10), 14(20) or 15(20), pelvic fin branched rays 7(31) or

8(19), lateral line scales 35(2), 36(19), 37(4), 38(10), 39(3), 40(6), 41(5), 42(-) or 43(1), total gill rakers 10(1), 11(9), 12(32), 13(6) or 14(2), pharyngeal teeth 1,5-4,1(13), 1,5-4,2(1) or 1,5-4,0(1), and total vertebrae 34(1), 35(20), 36(27) or 37(2). The chromosome number is  $2n = 50$  (Esmaeili and Piravar, 2006a; Arai, 2011).

**Sexual dimorphism.** The number of anal fin branched rays is significantly higher in females (mean 8.3 versus 8.0 in males). Pectoral and pelvic fin lengths, longest dorsal and anal fin rays and caudal peduncle length are shorter in females than in males while head length, head width and predorsal length are longer in females than in males.

**Colour.** The back and upper flanks are dark brown and the belly cream to dark brown. A golden stripe extends from the eye to the caudal peduncle on the upper flank in some live fish (Esmaeili *et al.*, 2015). The straight lateral stripe seen in preserved fish is not always evident in live ones (see photograph above). It extends from a diffuse area on the tail base to a level at or in front of the dorsal fin origin but does not reach the head. The stripe overlaps the lateral line on the caudal peduncle but lies above it on the flank, paralleling the back. The iris is golden yellow. Dorsal fin membranes are lightly speckled with melanophores which tend to be concentrated along the fin ray margins. The caudal and anal fin membranes are mostly clear with pigment restricted to fin ray margins. The pectoral fin may be pigmented on the membranes and there is often strong pigment along the posterior edge of the first unbranched ray. The pelvic fin has little or no pigmentation. Large fish are much darker overall than small fish, obscuring the stripe and with more pigment on fin rays and membranes.

**Size.** Reaches 12.2 cm standard length.

**Distribution.** This Iranian endemic is found in the Hormuz, Kor River, Lake Maharlu and Persis basins in Iran. Found in the Hormuz basin in the Kul and Shur rivers; in the Kor River basin in the Kor, Pulvar and Shad Kam rivers, Ghadamgah Spring-Stream system, Gomban Spring and Kaftar Lake; in the Lake Maharlu basin at Pirbanoo Spring and Pol-e Berengie; and in the Persis basin in the Dalaki, Helleh, Mond (middle reach) rivers and Dasht-e Arjan (Coad, 1981d; M. Hafezieh, pers. comm.; Abdoli, 2000; Barzegar and Jalali, 2002; Esmaeili *et al.*, 2014, 2015; Teimori *et al.*, 2010, 2015, 2016; Gholamifard and Kafaee, 2017; Gholamifard and Kafaee, 2021; see photographs above).

**Zoogeography.** Durand *et al.* (2000) placed this species in a *Leuciscus cephalus* “complex”, i.e., descendants of peripheral isolates of a widespread ancestral species, later re-invaded by Danubian *S. orientalis*. Further work has shown this species belongs in a different genus as outlined above.

**Habitat.** This species is found in rivers, streams, springs, dams, jubes (= irrigation channels) and qanats. Habitat knowledge is restricted to field data of collections. Habitats have in common a stream-like environment for much of the year. They are relatively shallow (20 cm to 2 m), variable width (0.5-75 m), medium to slow current, cloudy to clear and colourless water, some submergent and emergent aquatic vegetation and a bottom varying from pebbles and gravel to mud. Water temperatures varied from 15 to 23°C from October to January and presumably would be over 30°C in the summer. Conductivity ranged from 0.3 to 1.0 mS. Altitude ranged from 980 to 1,940 m. The lower reaches of some of the capture rivers are salty and may not support this species.



Habitat of *Acanthobrama persidis* (and *Alburnus sellal*) CMNFI 1979-0342, Fars, Kor River at Band-e Amir, 28 November 1977, Brian W. Coad.

**Age and growth.** Esmaeili and Ebrahimi (2006) gave a significant length-weight relationship based on 10 fish measuring 4.21-8.33 cm standard length. The  $b$  value was 3.229. Esmaeili *et al.* (2014) gave a  $b$  value for 33 fish from the Lake Maharlu basin, 4.51-7.3 cm total length, as 2.83.

**Food.** Gut contents include insect remains and fragments of large plants. Diet presumably consists mostly of aquatic invertebrates.

**Reproduction.** Reproduction in this species is unknown but egg development in adult fish collected in winter and young of the year collected in October suggest spring and early summer as the spawning season.

**Parasites and predators.** Jalali *et al.* (2000) recorded *Dactylogyrus sphyrna*, a monogenean, from the gills of this species in the Kor River basin. Barzegar and Jalali (2002) reported parasites in this species from Kaftar Lake as *Lernaea cyprinacea*, *Trichodina* sp., *Ichthyophthirius multifiliis* and *Dactylogyrus sphyrna*. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea foliaceus* on this species.

**Economic importance.** None.

**Experimental studies.** None.

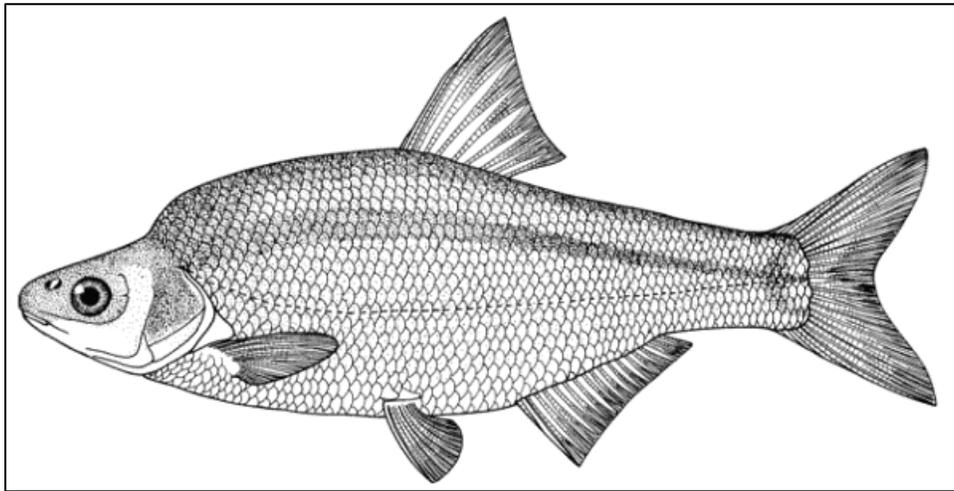
**Conservation.** The distribution of this species in various small habitats was thought to mean that it was not in immediate danger. However, water is in short supply in this part of Iran and abstraction may threaten its survival. The type locality has dried completely, Lake Maharlu and upper Helleh River basin localities are dried out or under pressure and populations are now restricted to the upper Kor River basin. Even the latter populations are now under threat from *Oncorhynchus mykiss* (rainbow trout), a carnivorous, fish-farm escapee (Teimori *et al.*, 2016). Esmaeili *et al.* (2018) stated that there are no recent records from the Hormuz basin. Jouladeh-Roudbar *et al.* (2020) listed it as Critically Endangered for these reasons.

**Sources.** Type material:- *Pseudophoxinus persidis* (CMNFI 1979-0154A, CMNFI 1979-0154B and CMNFI 1979-0499).

Iranian material:- CMNFI 1979-0025, 11, 19.4-79.6 mm standard length, Fars, Kor River

at Marv Dasht (29°51'N, 52°46'30"E); CMNFI 1979-0114, 1, 47.1 mm standard length, Fars, Mond River at road bridge (29°41'N, 52°06'E); CMNFI 1979-0156, 6, 43.8-64.3 mm standard length, Fars, qanat in Rashidabad (28°47'N, 54°18'E); CMNFI 1979-0163, 8, 31.1-48.3 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0164, 15, 28.8-52.6 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0194, 3, 48.9-58.2 mm standard length, Fars, jube 15 km from Darab (28°45'30"N, 54°24'E); CMNFI 1979-0292, 7, 37.0-54.0 mm standard length, Fars, Lapu'i spring near Zarqan (29°48'N, 52°39'E); CMNFI 1979-0305, 2, 23.8-25.5 mm standard length, Fars, Pulvar River at Pasargad (30°12'N, 53°12'E); CMNFI 1979-0342, 33, 23.6-43.2 mm standard length, Fars, Kor River at Band-e Amir (29°46'N, 52°51'E); CMNFI 1979-0503, 4, 32.2-113.5 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 2008-0250, Fars, 3, 105.5-121.9 mm standard length, Fars, Baleghloo Stream near Eqlid (30°53'56"N, 52°41'12"E); CMNFI 2008-0251, Fars, 3, 83.9-102.8 mm standard length, Fars, Shad Kam River near Eqlid (30°53'38"N, 52°41'42"E); USNM 258445, 18, 15.5-44.5 mm standard length, Fars, Chasht Khvar (ca. 29°44'N, ca. 53°12'E).

*Acanthobrama urmianus*  
(Günther, 1899)



*Acanthobrama urmianus*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



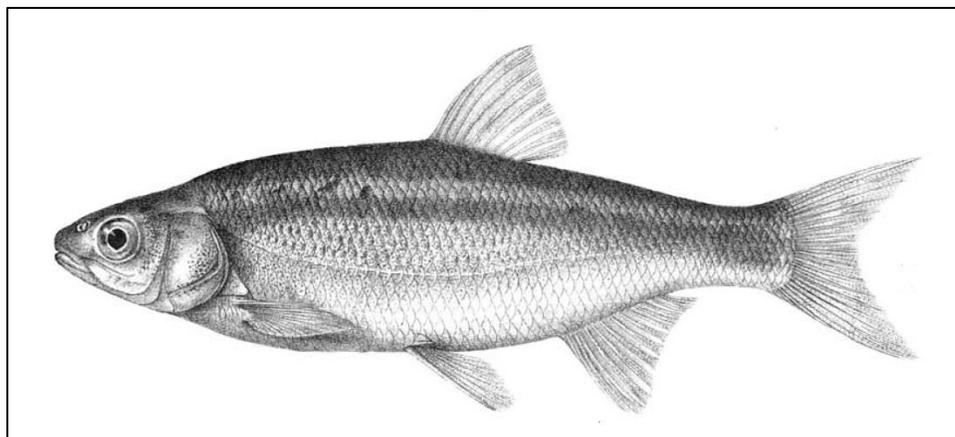
*Acanthobrama urmianus*, West Azarbaijan, Qader Chay, October 2011, K. Abbasi.

**Common names.** Kuli-ye Orumiye (= Urmia fish), aros or arus mahi Orumiye (= Urmia bride fish).

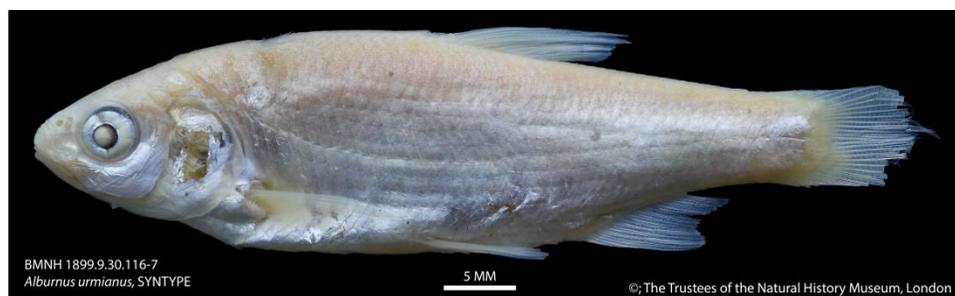
[Urmia or Urmian bleak, Urmia bream, Urmia Lake chub].

**Systematics.** Originally described in the genus *Abramis* Cuvier, 1816, Berg (1948-1949) placed this species in the genus *Alburnoides* Jeitteles, 1861, and Perea *et al.* (2010) in *Acanthobrama*. Type material in the British Museum (Natural History) was listed under the genus *Alburnus* (see photographs below).

The type material in the Natural History Museum, London comprises two specimens, 54.9-58.6 mm standard length, from the Urmi River (BM(NH) 1899.9.30:116-117), one specimen, 111.7 mm standard length, from the Ocksa River (BM(NH) 1899.9.30:118) (these three fish being labelled paralectotypes, with 118 being the lectotype, by P. M. Bănărescu in 1980), and eight specimens, 50.5-111.7 mm standard length, from the Ocksa River (BM(NH) 1899.9.30:119-126), these being syntypes. Günther (1899) referred to the type series as “Five specimens from the Gader Chai (= Qader Chay or River) and two small ones from the Urmi River; the largest is only 144 millim. Long” so there is some confusion over this material. Oksa (or Ocksa) is a label on the map by Günther (1899) (see description of the Lake Urmia basin) and is in the Qader Chay or River basin but is not coloured blue like other rivers. The label seems part of the location Plain of Solduz. The Urmi River may be the Shahr Chay or River running through the city of Urmi.



*Abramis urmianus*, syntype, after Günther (1899).



*Abramis urmianus*, syntype, BM(NH) 1899.9.30:116-117.



*Abramis urmianus*, syntype, BM(NH) 1899.9.30:118-126.

**Key characters.** This species is distinguished from the related *A. microlepis* by having fewer lateral line scales, fewer anal fin branched rays, more gill rakers and gill raker morphology according to Saadati (1977). Gill raker morphology does not appear to differ in the fish examined by me. Gill raker counts are the same but scale and anal fin ray counts are generally lower with some overlap. Distribution is the easiest separating factor.

**Morphology.** The body is compressed and moderately deep, being deepest in front of the dorsal fin over the end of pectoral fin. A nuchal hump is present in larger fish. The predorsal fin profile is convex. The caudal peduncle is compressed and fairly deep. The dorsal head profile is straight and leads to a rounded snout. The rear of the eye is at the beginning of the anterior half of the head. The mouth is oblique and subterminal and extends back to a level between the nostril and the eye. Lips are of moderate thickness. The dorsal fin has a moderate spine and the dorsal fin margin is straight to slightly emarginate. The dorsal fin origin is slightly posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back to a level just past the

anal fin origin. The caudal fin is moderately to deeply forked with rounded lobes. The anal fin margin is concave and the depressed fin does not reach back to the caudal fin base. The pelvic fin is rounded and almost extends back to the anal fin origin in some or is remote in others. The pectoral fin is rounded and does not extend back to the pelvic fin origin.

Dorsal fin with 3 unbranched and 7-9, usually 8, branched rays, anal fin with 3 unbranched and 10-13 branched rays, pectoral fin branched rays 14-16, and pelvic fin branched rays 7-8. Lateral line scales 50-68. A pelvic axillary scale is present. The ventral keel extends from the anus to the base of the pelvic fins and is fleshy from half way to the whole length. One specimen (CMNFI 2008-0137) was scaled in the middle of the naked ventral keel. Scale shape is squarish, the posterior margin is rounded, the dorsal and ventral margins are straight to slightly rounded, the anterior corners are rounded to very abrupt with a rounded point, and the anterior margin is irregular, wavy and rounded, or almost vertical with a central protrusion and an indentation above and below. Scales bear only a few posterior radii and have a subcentral anterior focus. Total gill rakers number 10-14, and are short, not quite or just reaching the adjacent raker when appressed; rounded with a projected tip and distinct from its congener according to Saadati (1977) but closely resembling the structure seen in *A. microlepis* according to my observations (see above under *A. microlepis*). Pharyngeal teeth are usually 2,5-5,2 or 2,5-4,2 with variants 2,4-5,2, 1,5-4,2 or 2,4-4,2. Posterior teeth are hooked at the tip, anterior teeth being rounded, and have no, slight, moderate or even strong serrations. There is a narrow and slightly concave surface below the tip. Some fish have the anterior margin of the concave surface higher than the posterior margin, but this is variable and in some teeth the condition is the reverse. The intestine is an elongate s-shaped with a small anterior loop. Total vertebrae number 41-43.

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(1), 8(20) or 9(1), anal fin branched rays 10(1), 11(4), 12(11) or 13(6), pectoral fin branched rays 14(4), 15(17) or 16(1), pelvic fin branched rays 7(3) or 8(19), lateral line scales 50(1), 51(-), 52(2), 53(2), 54(-), 55(1), 56(1), 57(2), 58(-), 59(2), 60(3), 61(3), 62(2), 63(1), 64(1) ... or 68(1), total gill rakers 10(1), 11(2), 12(6), 13(8), or 14(5), pharyngeal teeth 2,5-5,2(1), 2,5-4,2(1), 2,4-5,2(1) or 2,4-4,2(1), and total vertebrae 41(5), 42(7) or 43(2).

**Sexual dimorphism.** Male fish bear tubercles but fully tuberculate fish have not been examined. One male had a single row of tubercles on anterior pectoral fin rays.

**Colour.** Overall colour is silvery with a greenish-olive back and flanks with numerous minute brown pigment spots which are crowded above the lateral line to form an inconspicuous darker stripe along the whole side. The dorsal fin may have a reddish base immediately adjacent to the body. The dorsal, caudal and pectoral fins have a light to evident speckling of melanophores on the rays and membranes but are almost immaculate in preserved specimens. Larger fish have pigment proximally on the anterior anal fin rays. The peritoneum is silvery but densely speckled with melanophores.

**Size.** Reaches 20.8 cm total length (Mouludi-Saleh *et al.*, 2021).

**Distribution.** This species is endemic to the Lake Urmia basin, apparently in southern and western tributaries according to Günther (1899). Records of *A. microlepis* from the middle Aji Chay or Talkheh River near Tabriz are presumably of *A. urmianus* (Abdoli, 2000). It is found in the Aji, Bitas, Hasanlu, Mahabad, Mardogh, Nazlu, Ocksa, Qader, Rozeh, Saqqez, Shahr, Simineh, Urmia and Zarrineh rivers, and the Cheragveys, Hasanlu, Kazemi (or Shahid Kazemi) and Mahabad dams (Abdoli, 2000; Mirhasheminasab and Pazooki, 2003; Abbasi *et al.*, 2005; Abdoli *et al.*, 2008; Ghasemi *et al.*, 2015; Abbasi Ranjbar *et al.*, 2018; Fathi and Ahmadifard,

2019).

**Zoogeography.** The closest relative, *Acanthobrama microlepis*, is found in the Caspian Sea basin. Connections between the Lake Urmia basin and the Caspian Sea basin have been suggested by Saadati (1977), an early one in the Pliocene to early Pleistocene resulting in endemic species and a later one in the late Pleistocene resulting in species which are the same as the Caspian or only subspecifically distinct. This species presumably dates from the earlier connection (but see the Lake Urmia drainage basin account for more details).

**Habitat.** This species is found in rivers, lakes and dams but details of habitat requirements are unknown.

**Age and growth.** Fish are mature at 14.4 cm. This species is relatively fast-growing, short-lived species with males attaining 6<sup>+</sup> years and females 7<sup>+</sup> years in the Kazemi Dam on the Zarrineh River where Abdoli *et al.* (2008) examined 1,510 fish ca. 7.3-20.7 cm total length. The von Bertalanffy growth curve was estimated as  $K = 0.427$  in males and 0.506 in females, indicating that females grow faster. The sex ratio was 598:912 male:female (1:1.53) and there were no significant differences between males and females in the linear length-weight relationships. Mouludi-Saleh *et al.* (2021) examined 168 fish, 5.9-20.8 cm total length, from the Mahabad River and recorded a  $b$  value of 3.15, positive allometric, and a condition factor of 1.09.

**Food.** Guts examined were empty except for a few plant and crustacean remains.

**Reproduction.** Sarpanah *et al.* (2021) examined 107 fish from the Mahabad and Simineh rivers and found maturity stages 4 and 5 showed an absolute fecundity of 1,567 to 27,228 eggs with a diameter of 0.35 to 1.42 mm and a relative fecundity of 87.9 to 633.9 eggs/g body weight. The results also showed that the rate of fecundity in the Mahabad River in the constant length range was less than in the Simineh River.

**Parasites and predators.** Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea* sp. and *Ergasilus* sp. on this species.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** This species is known only from the type series and a few other specimens in museum collections. Listed as Data Deficient by the IUCN (downloaded 25 February 2019) but as Endangered by Jouladeh-Roudbar *et al.* (2020) because of dam construction and drought causing many rivers to dry out for most of the year. Jouladeh-Roudbar *et al.* (2020) indicated the species is now known only from the Gedar (= Qader) and Zarrineh rivers with an area of occupancy less than 500 sq km. The middle and lower parts of this river (*sic*, presumably both) have no water flow in summer and any further reductions would lead to extinction.

**Sources.** Type material:- *Abramis urmianus* (BM(NH) 1899.9.30:116-117, BM(NH) 1899.9.30:118 and BM(NH) 1899.9.30:119-126).

Iranian material:- CMNFI 1979-0093, 2, 127.5-130.5 mm standard length, West Azarbayjan, Lake Qowpi (36°57'N, 45°52'E); CMNFI 2007-0098, 1, 156.3 mm standard length, West Azarbayjan, river south of Mahabad (ca. 36°42'N, ca. 45°41'E); CMNFI 2007-0101, 1, 129.3 mm standard length, West Azarbayjan, Simineh River south of Miandow Ab (ca. 36°54'N, ca. 46°07'E); CMNFI 2007-0105, 1, 90.8 mm standard length, Kordestan, Zarrineh River basin south of Saqqez (ca. 36°06'N, ca. 46°20'E); CMNFI 2008-0137, 1, 130.7 mm standard length, West Azarbayjan, Zarrineh River (37°05'N, 45°44'E); CMNFI 2008-0158, 1, 85.9 mm standard length, Lake Urmia basin (no other locality data); USNM 205904, 1, 84.7 mm standard length,

West Azarbayjan, Nazlu Chay near Urmia (37°40'N, 45°05'E); USNM 205934, 2, 94.5-141.9 mm standard length, West Azarbayjan, Lake Qowpi (36°57'N, 45°52'E).

### Genus *Alburnoides*

Jeitteles, 1861

This genus is found in Europe, Asia Minor and Central Asia with about 35 species, with about 9-14 in Iran, depending on varying interpretations of DNA data and possible undescribed species. Several species were initially described based on morphology with attention to a particular suite of characters, e.g., vertebral counts, and this data is repeated here with later DNA information confirming some and questioning others.

The riffle minnows or spirilins are similar in appearance to the genus *Alburnus* but have smooth rather than serrated pharyngeal teeth. Certainly, it is not uncommon to find individuals of *Alburnus hohenackeri* lacking serrations on their pharyngeal teeth. Arguably then, this distinction is insufficient to warrant a separate genus but molecular evidence sets *Alburnoides* apart from *Alburnus*.

Spirilin is a European name for these fishes, used in English as the genus does not occur in the British Isles.

Pharyngeal teeth in *Alburnoides* are in two rows (2,5-4,2) with strongly hooked tips but unserrated, scales of medium size, no groove before the dorsal fin, a keel behind the pelvic fins is usually scaleless but may be wholly scaled, short dorsal and moderate to long anal fin, last dorsal fin unbranched ray thickened, decurved lateral line often with a characteristic spotting pattern above and below each pore (a stitch-like pattern, hence the Farsi name tailor fish), gill rakers short and few, an absolutely and relatively elongated predorsal vertebral subregion (to 15-17 vertebrae which is commonly over 38% of total and 70% of abdominal vs. 33-37% and 60-66%, respectively, in most other groups of the Leuciscinae), a tendency to equality of the numbers of vertebrae in the abdominal and caudal regions (modal difference between abdominal and caudal numbers decreases from 4 or 3 to 1, 0, and [-1] versus modes 4 to 6 in the most Leuciscinae), and a large orbit with respective configuration of all the cranial elements it is formed from (Bogutskaya and Coad, 2009).

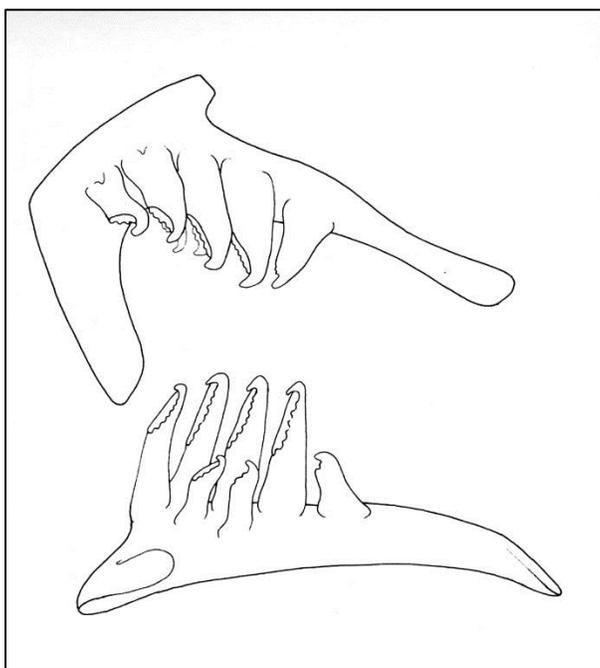
Scale morphology in these fishes is similar between species and is summarised as follows. Scale shape is a vertical oval to sub-squarish and in the latter case the anterior corners may be weakly developed (probably size-related, larger fish having squarer scales). The dorsal and ventral margins are rounded, the posterior margin is rounded and may protrude and the anterior margin is wavy, rounded or with a slight central protuberance. Circuli are moderate to many in number (presumably age related). Radii are few in number and only on the posterior field, encroaching laterally in some fish. The focus is subcentral anterior.

Jouladeh-Roudbar *et al.* (2020) noted that the species are very similar to each other and morphological characters overlap so distribution is important in differentiating species in the field and from preserved material. This works well where isolated basins in Iran are considered but some species may overlap (*eichwaldii* and *samiii* in the western Caspian Sea, *samiii* and *tabarestanensis* in the central Caspian Sea, and possibly *idignensis* and *nicolausi* in the Tigris River basin), and some confusion may result from translocations with commercial cyprinoids. DNA data may be necessary to clarify occurrence in border zones.

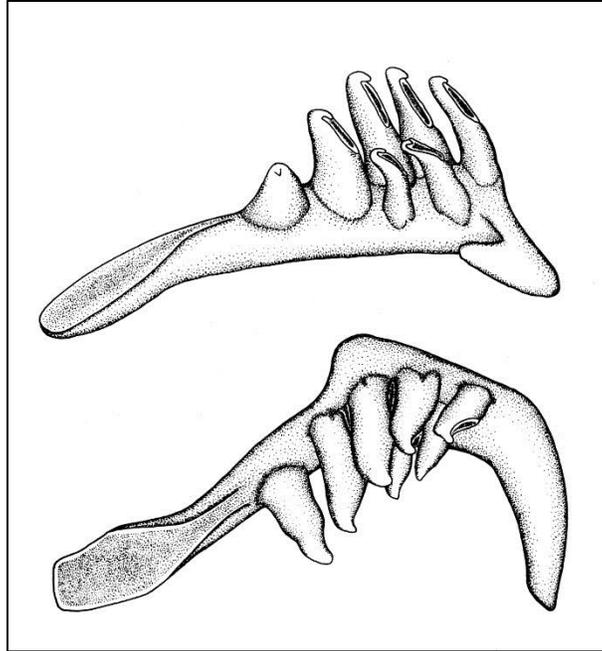
Morphology is given in such works as Bogutskaya and Coad (2009), Mousavi-Sabet *et al.* (2015) and Jouladeh Roudbar *et al.* (2016) and these works should be referred to for further information. It is probable that subtle details of morphology could be teased out of adequate

samples, but these would have to very large to allow for variation due to age, size, sex, condition, season, habitat, preservation techniques, and possible genetic isolation in remote drainages, and this is not attempted here.

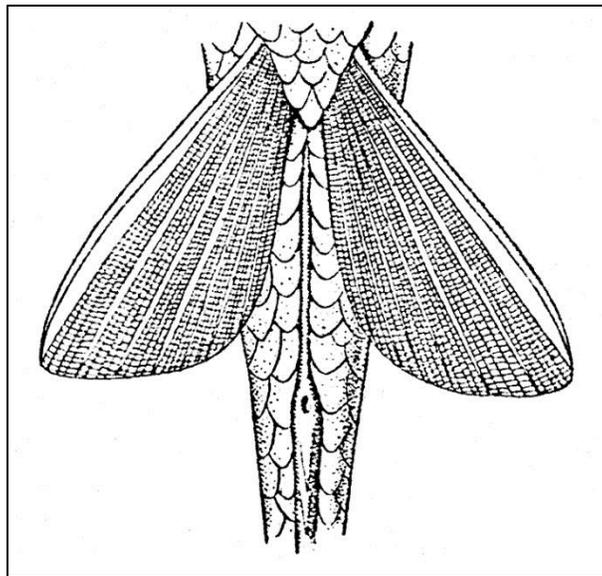
Bogutskaya and Coad (2009) found no differences in the shape of pharyngeal teeth that could be used to diagnose species and the Iranian species they examined were characterised by 2,5-4,2 counts. Most species have strong mode of 8 dorsal fin branched rays, *A. idignensis*, *A. petrubanarescui* and particularly *A. nicolausi* from Iran with high or modal frequencies of 7 rays being exceptions. Anal fin branched ray counts overlap although in the past they have been used as diagnostic characters. The Iranian species *A. petrubanarescui* with a mode of 9 and *A. nicolausi* with a mode of 10 are the lowest recorded. Cephalic lateral line canal patterns and counts were not diagnostic for species. Vertebral characters were dealt with in some detail by Bogutskaya and Coad (2009), which should be consulted, and provide reliable, statistical differences between species. As these are internal characters and require x-ray facilities to examine, they are not of use in the field and are inconvenient for rapid identification of preserved material.



*Alburnus* sp., serrated pharyngeal teeth,  
Freidhelm Krupp.



*Alburnoides* sp., unserrated pharyngeal teeth,  
Freidhelm Krupp.



Complete keel behind pelvic fins in an  
*Alburnoides* species, after Nikol'skii (1938).

*Alburnoides bipunctatus* (Bloch, 1782) was the name applied to most populations across Europe and the Middle East from France north of the Alps eastwards to the Black, Caspian and Aral Sea basins and inland waters of Iran, and *A. b. eichwaldii* was recognised as the subspecies for Iran but recent research has revealed a greater diversity (Bogutskaya and Coad, 2009; Coad and Bogutskaya, 2009; Seifali, 2012; Seifali *et al.*, 2012; Mousavi-Sabet *et al.*, 2015, 2015; Jouladeh-Roudbar *et al.*, 2016). Preserved specimens and literature records under the names *A. bipunctatus*, *A. b. eichwaldii* or *A. eichwaldii* have been re-assigned to the newer species based mainly on distribution.

Seifali (2012) studied this genus in Iran and found three clades: southern Caspian Sea, Namak Lake and Kor River basins, and Kavir and Tigris River basins. Jafari *et al.* (2014) found morphometric differences between *A. eichwaldii*, *A. namaki*, *A. nicolausi* and *A. idignensis* and between two populations in the Sefid River basin. Saifali and Yazdani Moghaddam (2014) analysed cytochrome *b* in Iranian Caspian Sea *Alburnoides* finding two major groups, western and Talar River populations considered to be *A. eichwaldii* and eastern populations perhaps being a distinct taxon. The Talar River is in the eastern Caspian Sea however.

Esmaeilipoor Poode *et al.* (2015) examined fish from the Aras (= *A. eichwaldii*), Babol and Tajan (both = *A. tabarestanensis*) rivers using meristics and morphometrics finding high overlap in the former and some distinction in the latter when analysed using multivariate statistics.

Omelchenko (2016) studied *Alburnoides* from Azerbaijan using both mitochondrial (cytochrome *b*, cytochrome oxidase subunit I) and nuclear (RAG1, rhodopsin) markers. Lineage richness within the samples from the Talysh (= Talish) Mountains hydrological network bordering the northwestern Caspian coast of Iran probably showed evidence for the existence of a glacial refugium in the region. Cytochrome *b* sequences submitted to GenBank by Seifali *et al.* (2012) from the Kaslian River, Mazandaran in the eastern part of the Caspian Sea formed a very well supported independent branch but fell within a clade from the Talish Mountains of Azerbaijan and requires further study. One sequence from M. Seifali had an Iranian origin in the Ab Parran River, Golestan which also flows into the eastern part of the Caspian Sea. It belonged to a clade formed by vouchers (*A. fasciatus*, *A. tzanevi*) from Russia and samples from the northern part of Azerbaijan. The appearance of a voucher from Iran in the clade formed by fish collected in the north of the Greater Caucasus range also requires further study. Interestingly, three samples from Istisuchay River, a tributary of the Astara River which forms part of the Iran-Azerbaijan border, all fell in different clades. It was considered unlikely that three sympatric species of the same ecological niche would inhabit one small river. Furthermore, the species were not distinguishable in the field based on morphological characters, so the existence of three independent lineages remained cryptic. Evidently, much more work needs to be done on *Alburnoides* DNA.

Stierandová *et al.* (2016) carried out a multilocus assessment of nuclear and mitochondrial sequences on European *Alburnoides*, revealing 17 Eurasian lineages with two main clades, the European and Ponto-Caspian. One lineage was identified as *A. eichwaldii* from Kura River specimens, and three un-named lineages from the Gorgan, Sefid and Talar rivers based on Seifali *et al.* (2012). The Sefid River fish are now *A. samiii* and the Gorgan and Talar rivers would be *A. tabarestanensis*. Stierandová *et al.* (2016) considered the Sefid River fish not to be *A. eichwaldii* and this species was absent from Iran in contrast to the conclusions of Seifali *et al.* (2012). From a biogeographical viewpoint, the locations of lineage richness in most cases corresponded to confirmed glacial refugia (Stierandová *et al.* 2016).

Jouladeh Roudbar *et al.* (2016) examined the genus *Alburnoides* using the COI barcode region and found four lineages, one of which was the Iranian *Alburnoides* or *Alburnoides eichwaldii* lineage. In this lineage, *A. holciki* was a sister (supported with a high posterior probability to all other species including *A. eichwaldii* plus *A. qanati* (the most northern and southern *Alburnoides* species of Iran respectively)) and a group comprising *A. idignensis*, *A. nicolausi*, *A. tabarestanensis*, *A. samiii*, *A. damghani*, and *A. namaki*. Two species from the Tigris River basin, *A. idignensis* and *A. nicolausi*, were very closely related and were not well supported as sister taxa (low posterior probability of 0.62). However, the ancestral node for *A. idignensis* was 1.0, as was the ancestral node for *A. nicolausi*, which was strong support for monophyly of each of these species. See also comments by Eagderi *et al.* (2019) under the *A.*

*nicolausi* account below. *A. damghani* (Damghan River drainage, Dasht-e Kavir basin) was sister (posterior probability = 0.999) to *A. coadi* from the Nam River, a tributary of the Hableh River drainage (Dasht-e Kavir basin) and *A. namaki* from the Qareh Chai (= Chay) River drainage (Namak Lake basin). Hableh River (Dasht-e Kavir basin) fish elements were much closer to those from the Qom River drainage (Namak Lake basin) than to the other river systems of the Dasht-e Kavir. The validity of *A. eichwaldii* from the Kura River was supported by the COI barcode region.

*Alburnoides bipunctatus armeniensis* Dadikyan, 1972 from Rivers Arpa, Vorotan, Vedi, Marrik, Kasakh, and their tributaries (Aras River system, Kura River drainage) is a synonym of *A. eichwaldii* according to Bogutskaya and Coad (2009), this being supported here by Jouladeh Roudbar *et al.* (2016) using COI barcode region of four fresh collected specimens from two localities in the Aras River (near the cities of Poldasht and Parsabad, border of Iran and Azerbaijan).

Hoshyar *et al.* (2017) used cytochrome *b* sequencing on fish from five Caspian Sea basin rivers and found three clades:- I, Zalki and Safa rivers (Sefid River basin) recognised as *A. eichwaldii* (now *A. samiii*), II, Kelisiyan River (presumably Kesilian), and III, Gorgan and Madar Su (Gorgan River basin), the last two recognised as *Alburnoides* spp. (now *A. tabarestanensis*).

Boroumandi *et al.* (2018) used the COI gene sequence to compare Iranian *Alburnoides*. On the phylogram *A. samiii*, *A. tabarestanensis*, *A. idignensis*, *A. namaki* and *A. coadi* were nested in a monophyletic group with 92 percent boot-strap support. *Alburnoides samiii* had the highest K2P genetic distance to *A. eichwaldii* (4%) and had the least genetic distance to *A. idignensis* and *A. nicolausi* (2.6%). The highest K2P genetic distance was between *A. tabarestanensis* and *A. eichwaldii* (5.2%) and the least K2P genetic distance was between *A. namaki* and *A. coadi* (0.5%).

Levin *et al.* (2018) tested the mitochondrial cytochrome c oxidase subunit I (COI) used as a DNA barcode marker on Caucasian *Alburnoides* and found species identification to be 100%, although they noted the limited ability of COI to infer phylogenetic relationships as did Nazari *et al.* (2021).

Eagderi *et al.* (2021) used a landmark-based geometric morphometric technique to analyse Iranian *Alburnoides* species. Cluster analysis showed two groups, *A. nicolausi* with *A. qanati* and the rest. Both these species were well-separated in the analysis from the each other and from other species. The greatest Mahalanobis distance was obtained between *A. holciki* and *A. nicolausi*.

In Iran, *Alburnoides* species are one of two most abundant taxa in Caspian rivers along with *Capoeta capoeta* (*sic*, presumably *C. razii*) (*Iranian Fisheries Research and Training Organization Newsletter*, 19:4, 1998).

The chromosome number for *Alburnoides* species is probably  $2n = 50$ , as it is for most related *Alburnus* species. Nazari *et al.* (2009) gave further details for fish identified as *A. bipunctatus* (= *A. samiii*) from the Anzali Wetland and cited this number for *Alburnoides* (now *Alburnus*) *taeniatus* also. Khosravanizadeh *et al.* (2013) gave a chromosome number of  $2n = 50$  for fish identified as *A. bipunctatus* from Zabol in Sistan, presumably introduced fish from the Caspian Sea basin, the species identity being uncertain.

Abdoli (2000) listed Simuliidae, Plecoptera, Ephemeroptera, Chironomidae and Trichoptera as food for fish identified as *A. bipunctatus*, presumably including many of the species considered below.

Records of parasites for fish identified as *A. bipunctatus* in Iran were as follows:- Jalali

and Molnár (1990a) recorded the monogeneans *Dactylogyrus alatus* and *D. chalcalburni* from this species in the Zayandeh River. Masoumian and Pazooki (1998) surveyed myxosporeans in this species (i.e., both *A. samiii* and *A. tabarestanensis* respectively) in Gilan and Mazandaran provinces, finding *Myxobolus ellipsoides*. Mehdipoor *et al.* (2004) recorded the monogeneans *Dactylogyrus alatus*, *D. chalcalburni* and *D. pulcher* in the Zayandeh River. Gussev *et al.* (1993b) also reported the latter species and locality.

A record of *A. bipunctatus* from a qanat at Hormak (29°58'N, 60°51'E) in the Sistan basin by Saadati (1977) is probably an error of labelling or sorting. It is not mentioned in the collector's (R. J. Behnke) original field notes nor in a typed version. Also, this species was not collected there by me. Khosravanizadeh *et al.* (2013) reported on fish identified as *A. bipunctatus* from Zabol in Sistan, presumably introduced from the Caspian Sea basin, and therefore possibly *A. samiii*, *A. tabarestanensis* or *A. eichwaldii*.

A new species, *Alburnoides diclensis* Turan, Bektaş, Kaya and Bayçelebi, 2016, was described from the upper Tigris River basin of eastern Turkey in the Great Zab River drainage. Whether it occurs in Iran in more southern tributaries of the Tigris River remains to be seen, as the Great Zab distribution precludes this.

An *Alburnoides* species was collected from the Esfahan basin (CMNFI 1979-0266, 2, 32.8-51.5 mm standard length, Esfahan, spring at Nowqan (ca. 33°10'N, ca. 50°05'E) in the Pelasgan River basin which drains to the Zayandeh River) but has not been examined in detail. Principal meristic characters overlap with other *Alburnoides* species and DNA work is required. It may prove to be a distinct species.

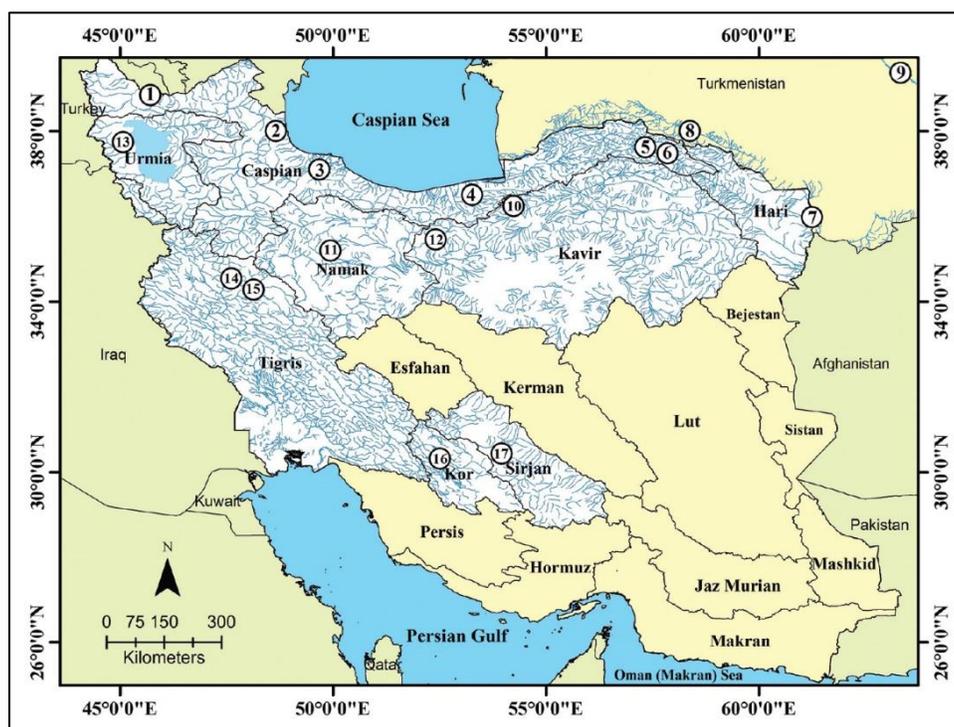
Records of an *Alburnoides* species from the Persis basin are given in the database generated by Mostafavi *et al.* (2014, 2015, 2015), from the Shapur, Shiv (= Tang-e Shib) and Zohreh rivers, and from Dasht-e Arzhan. A single small specimen (CMNFI 1979-0399, 1, 25.9 mm standard length, Fars, Tang-e Shib River in the Zohreh River drainage (30°19'30"N, 51°15'E)) was collected. The identity of this material needs further work as above.

The following table and map summarise the distribution of the Iranian species of *Alburnoides* as meristic and morphological characters overlap. *A. eichwaldii* and *A. samiii* are species with large sample size and serve to show variation within a taxon of meristic counts (see species accounts below). *Alburnoides* species in Iran have modally 8 dorsal fin branched rays (*A. nicolausi* has 7 in 91.3% of fish), 8-16 anal fin branched rays (*A. nicolausi* has 8-11 with 76.3% with 8-10, and *A. petrubaranscui* has 8-13 with 79.6% with 8-10, other species having mostly 11 or more), 39-56 lateral line scales, 5-10 total gill rakers, 2,5-4,2 pharyngeal teeth, and 37-43 total vertebrae. Distribution is key and, as noted above, earlier records are assigned to current species mostly on distributional grounds. Authors vary in recognition of species and putative synonyms are included here. Two potential species are added at the bottom of the table; these require material and DNA analyses to be verified.

I have retained all the newly-described Iranian *Alburnoides* species (11 from 2009 to 2016). Some of the species are founded on morphology, others on morphology and molecular data (usually a single mitochondrial gene). A robust phylogenetic treatment would require sequence data from many more genes than the one gene usually presented (see Liu *et al.* (2017)). More molecular sequence data, such as that from nuclear genes, would help clarify distinctions and potential synonymies.

Species/Characters	Synonym of	Distribution
<i>Al. coadi</i>	<i>Al. namaki</i>	Hableh and Nam rivers, western Dasht-e Kavir
<i>Al. damghani</i>	<i>Al. namaki</i>	Cheshmeh Ali and environs, northern Dasht-e Kavir

<i>Al. eichwaldii</i>	-	Caspian Sea (Aras River and possibly western Caspian Sea)
<i>Al. holciki</i>	-	Hari River
<i>Al. idignensis</i>	<i>Al. nicolausi</i>	Tigris River (except Nurabad River)
<i>Al. namaki</i>	-	Namak Lake
<i>Al. nicolausi</i>	<i>Al. idignensis</i>	Tigris River (Nurabad River)
<i>Al. parhami</i>	<i>Al. holciki</i>	Caspian Sea (Atrak River)
<i>Al. petrubanarescui</i>	-	Lake Urmia
<i>Al. qanati</i>	-	Kor River, Sirjan
<i>Al. samiii</i>	-	Western Caspian Sea (Sefid River or just east and then west)
<i>Al. tabarestanensis</i>	-	Eastern Caspian Sea (east of Sefid River)
<i>Al. sp. Esfahan</i>	-	Esfahan
<i>Al. sp. Persis</i>	-	Persis

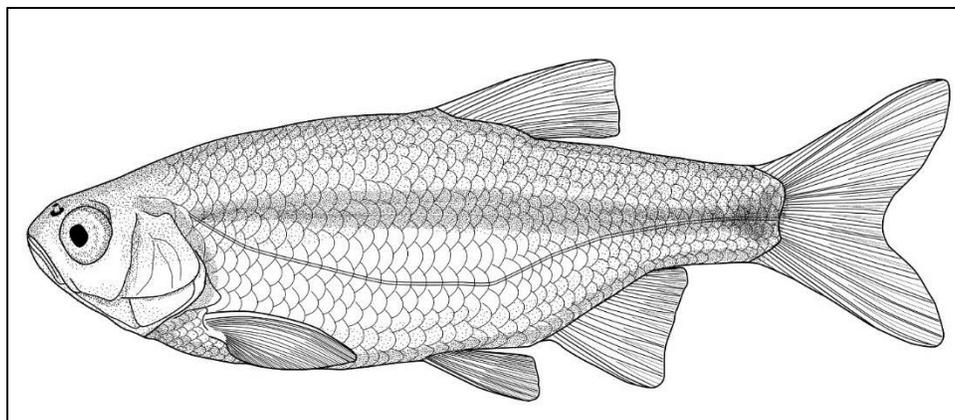


Distribution of *Alburnoides* species in Iran and neighbouring countries, caption modified after Jouladeh Roudbar *et al.* (2016).

1. *A. eichwaldii*: Aras River, Kura River drainage; 2. *A. cf. eichwaldii*: west of Safid River and here mostly *A. samiii*; 3. *A. samiii*: Safid River; 4. *A. tabarestanensis*: Tajan River; 5. *A. parhami*: Atrak River; 6. *A. parhami*: type locality Baba-Aman stream; 7. *A. holciki*: Hari River; 8. *A. varentsovi*: Ashkhabadka River, northern slope of Kopetdag Mountains (not in Iran); 9. *Alburnoides* sp. Amu Darya River (not in Iran); 10. *A. damghani*: Cheshmeh Ali, Damghan River system, Dasht-e Kavir basin; 11. *A. namaki*: Qareh Chay, Namak Lake basin; 12. *A. coadi*: Nam River, Dasht-e Kavir basin; 13. *A. petrubanarescui*: Lake Urmia basin; 14. *A. nicolausi*: Nurabad River, Tigris River system; 15. *A. idignensis*: Tigris River system; 16. *A. qanati*: Pulvar River, Kor River system and 17: Sirjan basin.

### *Alburnoides coadi*

Mousavi-Sabet, Vatandoust and Doadrio, 2015



*Alburnoides coadi*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnoides coadi*, 84.0 mm standard length, Tehran, Nam River,  
after Jouladeh Roudbar *et al.* (2016).

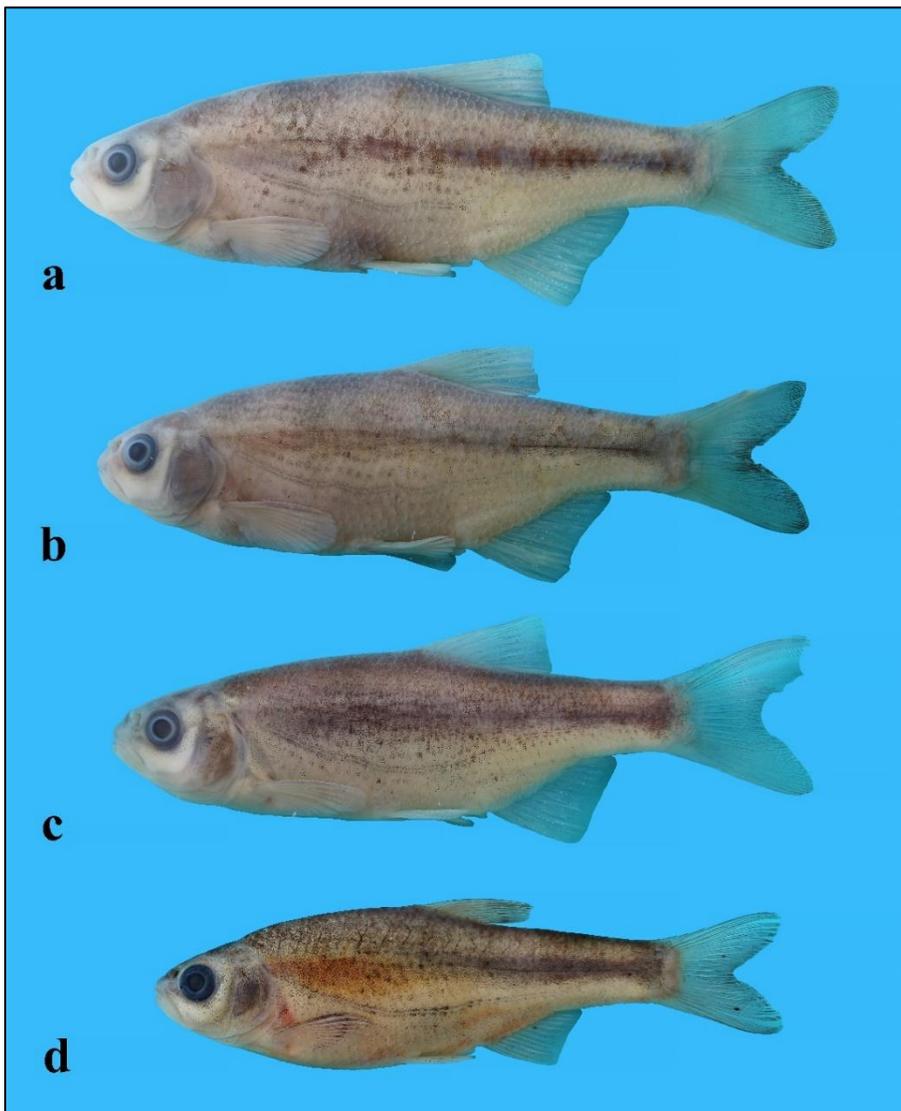
**Common names.** None.

[Coad's riffle minnow, Kavir spirilin].

**Systematics.** The holotype is under VMFC-ALK2-H (VMFC = Vatandoust and Mousavi-Sabet Fish Collection, Tehran), 107.9 mm standard length, Iran, Tehran Province, Namroud River, Hableroud River drainage, Kavir basin, 35°43'N, 52°39'E. Paratypes are under VMFC-ALK2-P1 to VMFC-ALK2-P45, 45, 55.2-81.4 mm standard length, collected with the holotype and GUIC-ALK2-P1 to GUIC-ALK2-P4 (GUIC = Ichthyological Museum of the University of Gilan), 4, 58.2-66.0 mm standard length, collected with the holotype. The species name *coadi* is in honour of Brian W. Coad (Canadian Museum of Nature, Ottawa).



*Alburnoides coadi*, holotype, VMFC-ALK2-H, Hamed Mousavi-Sabet.



*Alburnoides coadi*, paratypes, a, 81.0 mm standard length, VMFC-ALK2-P1, b, 76.0 mm standard length, VMFC-ALK2-P3, c, 71.0 mm standard length, VMFC-ALK2-P4, d, 64.0 mm standard length, VMFC-ALK2-P5, Hamed Mousavi-Sabet.

Jouladeh Roudbar and Eagderi (2017) suggested that this species is a synonym of *A. namaki* based on an analysis using the COI gene (the original description was based on morphology). Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1, COI or CO1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and merged *A. coadi*, *A. damghani* and *A. namaki* into a single putative species. Eagderi *et al.* (2019) using the COI gene to study the phylogeny of Iranian *Alburnoides* found this species to be a synonym of *A. namaki*.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the western Dasht-e Kavir basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species has a deep head with a markedly rounded and stout snout, and a small mouth which is between terminal and subterminal. The eye is of a relatively small size, the orbit diameter larger than the snout length and markedly smaller than the interorbital width. The dorsal and anal fins outer margins are truncate to slightly concave. The caudal fin lobes are rounded and the fin moderately forked. Eagderi *et al.* (2020) gave morphometric data for 16 fish, 6.62-9.67 cm total length.

Dorsal fin branched rays 7-9, usually 8, anal fin branched rays 11-14, commonly 12-13, pectoral fin branched rays 11-15, and pelvic fin branched rays 6-7. Lateral line scales 46-52, scale rows between the lateral line and the dorsal fin origin 9-11, typically 9 or 10, scale rows below lateral line to pelvic fin origin 4-6, usually 4-5, scale rows between the lateral line and the anal fin origin 4-6, usually 5-6, and scales around the caudal peduncle commonly 17-19. A pelvic axillary scale is present, its length about 3-4 scale rows. There is a variably scaled ventral keel, most commonly scaled along about two-thirds of its length, or completely scaled. Total gill rakers number 8-10. Pharyngeal teeth are 2,5-4,2. Total vertebrae 39-41, with a mode of 40, predorsal vertebrae 13-14, abdominal vertebrae 19-20, and caudal vertebrae 19-21. The caudal vertebral region is equal or slightly longer than the abdominal region (vertebral formulae 19+20, 20+20 and 20+21).

Meristic values are:- dorsal fin unbranched rays 3 and branched rays 7(4), 8(47) or 9(1), anal fin rays unbranched 3, anal fin branched rays 11(2), 12(27), 13(19) or 14(4), pectoral fin branched rays 11(8), 12(18), 13(23), 14(2) or 15(1), and pelvic fin branched rays 6(3) or 7(49). Lateral line complete with 0-2 unpored scales at the posterior end of the lateral series. Lateral line scales 46(2), 47(2), 48(18), 49(19), 50(6) or 51(5), scales above lateral line to dorsal fin origin 9(10), 10(40) or 11(4), scales below lateral line to anal fin origin 4(19), 5(24) or 6(9), scales below lateral line to pelvic fin origin 4(29), 5(22) or 6(1), and total scale radii 16(7), 17(10), 18(28) or 19(5). Total gill rakers 8(25), 9(23) or 10(2). Pharyngeal teeth 2,5-4,2(10). Abdominal vertebrae 19(12) or 20(38), caudal vertebrae 19(12), 20(27) or 21(9), predorsal vertebrae 13(37) or 14(13), and total vertebrae 39(15), 40(26) or 41(9).

**Sexual dimorphism.** The fish from CMNFI 1979-0495 collected on 10 July 1978 has the top and sides of the head with small tubercles, scale margins have 1-5 tubercles over most of the back and flank particularly evident over the anal fin and on the lower caudal peduncle, the pectoral and pelvic unbranched ray bears fine tubercles, and the anal fin has fine tubercles lining the unbranched and branched rays.

**Colour.** Overall colouration is silvery, with the bases of the pectoral (markedly), pelvic and anal fins (slightly) orange. The back and top of head are light to dark grey, with a pale olive hue. Facial bones and the opercle are silvery. The lower portion of the head and body are pearly

white. The flanks above the lateral line may have a golden hue. Faint yellow spots occur in rows along the flanks in some specimens. Preserved fish are overall tan, darker dorsally with horizontal rows of dark blotches formed by dark pigmentation concentrated on the middle of scales, moderately conspicuous, above the lateral line. The lateral line has some scale pores outlined with dark pigmentation, especially the anteriormost scales but there is generally a lack of well-marked spots or dark pigmentation in the lateral line canal. A narrow dark mid-lateral stripe is present along the lateral septum, more discernible from the vertical through the dorsal fin forwards. There is a faint to strong, broad grey to brown mid-lateral stripe, most evident posteriorly, but sometimes extending to the head. Fins are mostly hyaline, with some black pigmentation lining caudal fin rays.

**Size.** Reaches 125.5 mm total length.

**Distribution.** This species is found in the western Dasht-e Kavir basin from the Hableh and Nam (= Namrud) rivers (Mousavi-Sabet *et al.*, 2015).

**Zoogeography.** See under the genus.

**Habitat.** This species is found only in riverine habitats with a temperature of 19°C, pH 6.0, conductivity 0.45 mS (limited data from one collection), clear water and medium to fast water flow. The stream width was about 3-8 m and maximum depth was up to 1 m, with grassy shores, submergent and encrusting plants, and the stream bed was pebbles, gravel and mud. Other species collected syntopically were the cyprinids *Barbus* sp. (presumably *B. miliaris*), *Capoeta aculeata*, *Capoeta buhsei*, *Carassius auratus*, *Carassius gibelio*, *Squalius cf. orientalis* (presumably *S. namak*), the nemacheilid *Paracobitis malapterura*, and the exotic *Oncorhynchus mykiss* (rainbow trout).



Type locality of *Alburnoides coadi*, Tehran, Nam River, Hamed Mousavi-Sabet.

**Age and growth.** Mousavi-Sabet *et al.* (2017) examined 40 fish, 52.6-125.5 mm total length, from the Nam River and found a *b* value of 3.12. Eagderi *et al.* (2020) examined 16 fish,

6.62-9.67 cm total length, from the Nam River and found a  $b$  value of 3.45, positive allometric growth. The condition factor was 1.02-1.36, mean 1.21.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported.

**Economic importance.** Unknown.

**Experimental studies.** None.

**Conservation.** Known only from the type locality and therefore likely to be threatened.

**Sources.** Mousavi-Sabet *et al.* (2015).

Iranian material:- CMNFI 1979-0239, 2, 57.1-79.3 mm standard length, Tehran, Nam River near Firuz Kuh (35°43'N, 52°40'E); CMNFI 1979-0495, 1, 69.2 mm standard length, Markazi, Nam River west of Firuz Kuh (35°43'N, 52°40'E).

*Alburnoides damghani*

Jouladeh Roudbar, Eagderi, Esmaeili, Coad and Bogutskaya, 2016



*Alburnoides damghani*, Semnan, Cheshmeh Ali Damghan, after Jouladeh Roudbar *et al.* (2016).



*Alburnoides damghani*, Semnan, Cheshmeh Ali Damghan, H. R. Esmaeili.

**Common names.** Mahi-e-Khayateh-e-Damghan (= Damghan tailor fish), lapak or lapek (meaning unknown).

[Damghan riffle minnow, Damghan spirlin, Damghan tailor fish].

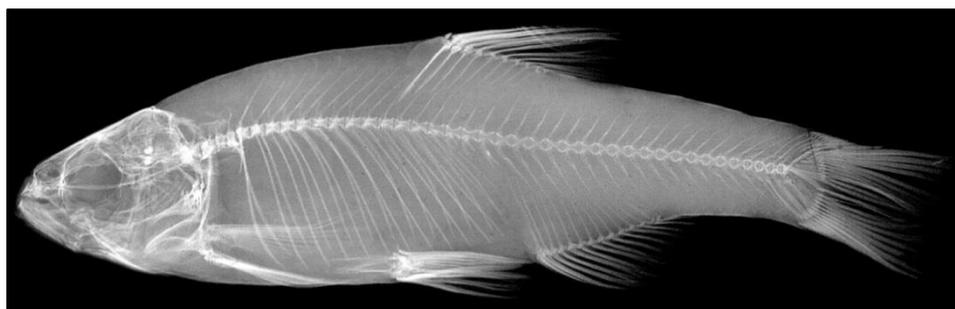
**Systematics.** The holotype is a female, 67.0 mm standard length from Semnan Province, Cheshmeh (= spring) Ali, Damghan River tributary, near Damghan city, Dasht-e Kavir basin, 36°16'45.6"N, 54°05'01.6"E under CMNFI 2015-0091. Paratypes from the same locality are under CMNFI 2015-0091A, 24, 54.6-84.4 mm standard length, ZM-CBSU (Zoological Museum of Shiraz University, Collection of Biology Department, Shiraz) 2011-1, 15, 57.1-79.0 mm standard length and ZM-CBSU 2012-1, 3, 83.9-89.7 mm standard length.



*Alburnoides damghani*, holotype, CMNFI 2015-0091,  
James Maclaine @ Canadian Museum of Nature.



*Alburnoides damghani*, paratype, CMNFI 2015-0091A,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnoides damghani*, ZM-CBSU 2011-1, paratype with 20+20 vertebral formula,  
after Jouladeh Roudar *et al.* (2016).

Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and merged *A. coadi*, *A. damghani* and *A. namaki* into a single putative species. *A. damghani* was still given as valid in the *Catalog of Fishes* (downloaded 31 May 2021) and was described and differentiated in part from DNA evidence too.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in Cheshmeh Ali and adjacent waters of the northern Dasht-e Kavir basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a weakly-developed, variably-scaled, ventral keel from completely scaleless to completely scaled, a stout short snout with tip of the mouth cleft on a level with the lower margin of the pupil or lower, and a small eye (eye horizontal diameter slightly to markedly less than interorbital width). The body is compressed but thick, the upper body profile clearly convex, similar to the lower profile. The caudal peduncle is short and relatively deep. The snout is short and stout, only slightly pointed, its length only slightly exceeds the eye diameter. The mouth is small, terminal, the mouth cleft is slightly curved, and the posterior end of the upper jaw is commonly in front of a vertical with the anterior margin of eye. The upper jaw is slightly produced over the lower jaw in most specimens, especially larger-sized ones. The posterior end of the lower jaw is on a vertical with the anterior margin of the pupil. The caudal fin lobes are rounded and the fin is shallowly forked. The dorsal fin margin is truncate to slightly convex. The anal fin margin is slightly concave. The anal fin origin is on a vertical from the posterior end of the dorsal fin base, or in front of it.

Dorsal fin unbranched rays 4, branched rays 7-9, commonly 8, anal fin unbranched rays 3, branched rays 10-13, commonly 11-12, pectoral rays 13-15, pelvic rays 6-8, total lateral line scales 40-47 (40-46 scales to posterior margin of the hypurals), pharyngeal teeth 2,5-4,2 and 2,5-4,1, total gill rakers 6-8, total vertebrae 39-42, commonly 40, predorsal vertebrae 12-14, commonly 13, and the abdominal vertebral region most commonly equal to or longer than caudal region (vertebral formulae 20+20 and 21+19).

Meristic values are:- dorsal fin unbranched rays 3(35) or 4(4), branched rays 7(5), 8(33) or 9(1), and anal fin unbranched rays 3, branched rays 10(2), 11(11), 12(20) or 13(6). Lateral line scales 40(2), 41(3), 42(7), 43(5), 44(1), 45(3) or 46(1). There is a pelvic axillary scale and scales extend over the proximal bases of the anal fin forming a sheath. The ventral keel (examined in 24 paratypes) is weakly pronounced, scaleless (7), scaleless along three-quarters of keel (4), two-thirds (4), half (5), quarter (2), fifth (1) or completely scaled (1). Total gill rakers number 6(5), 7(16) or 8(3), rakers are short, thick and widely spaced, the longest touching the adjacent one when appressed. Pharyngeal teeth are 2,5-4,2(19) or 2,5-4,1(5). Total vertebrae number 39(4), 40(28) or 41(7), predorsal vertebrae 12(5), 13(26) or 14(8), abdominal vertebrae 20(31) or 21(8) and caudal vertebrae 19(8), 20(28) or 21(4). The vertebral formulae are 20+20(24), 21+19(5), 20+21(4), 20+19(3), 21+20(3), 20+19(1) or 19+20(1). The caudal vertebral region most commonly is equal to the abdominal region (in 23 paratypes) or longer than the latter (11), the difference between abdominal and caudal counts being +2(5), +1(6), 0(23) or -1(5).

Cephalic sensory canals are typical of most *Alburnoides*. The supraorbital canal is not lengthened in its posterior section and has 8-10, commonly 9 pores with 2-4, commonly 3, and 5-7, commonly 6, canal openings on the nasal and frontal bones, respectively. The infraorbital canal has 13-17, commonly 14-15, pores with 4 (rarely 3 or 5) canal openings on the first infraorbital. The preopercular-mandibular canal is complete, with 13-17, modally 14-16, pores

and commonly 5 or 6 and 8 or 9 canal openings on the dentary and preoperculum, respectively. The supratemporal canal is complete, with 5 (rarely 6 or 7) pores.

**Sexual dimorphism.** In CMNFI 2015-0091A, fish 60.5-84.4 mm standard length caught on 22 August 2011, have mature males bearing tubercles on the unbranched and branched fin rays, in a single row branching into two distally on the branched rays. These are most prominent on the pectoral, pelvic and anal fins. Tubercles line scale margins in a single row of up to six tubercles, in particular over the anal fin and on the lower caudal peduncle. Scales below the dorsal fin are also lined with tubercles but to a much lesser extent than those above the anal fin. Flank scales generally may bear tubercles but many do not and anterior flank scales may have only a single tubercle. Minute tubercles are present on the dorsal and upper head surface.

**Colour.** A darker back fades to a silvery white belly. There are three to four rows of large dark spots above the lateral line starting from the posterior part of the operculum and ending at the posterior level of the anal fin, continuing with two rows behind the anal fin to the base of the caudal fin. A mid-flank stripe is evident, darkest on the caudal peduncle. Small black spots are on the operculum, behind and below the eye, and smaller and less dark spots are between the eye and upper jaw. The lateral line is demarcated by pigment above and below it (the typical stitched pattern in many *Alburnoides* species), the bases of the anal, pelvic, pectoral and dorsal fins are almost reddish-orange, the caudal fin base is pale or faint yellow. The pectoral fin unbranched ray is lined with melanophores on its inner margin. The posterior free margin of the dorsal, anal, caudal and pelvic fins is whitish hyaline, faint pigmentation on the caudal fin centre branches distally to follow the inner margins of the fin fork, and there is fine pigmentation on the proximal part of the dorsal and anal fin rays, darker in the dorsal fin rays. The peritoneum is silvery with fine melanophores.

**Size.** Reaches 89.7 mm standard length.

**Distribution.** Known principally from the type locality in the Dasht-e Kavir basin, a record below from a qanat at nearby Ebrahimabad is assigned to this species.

**Zoogeography.** This species is most closely related morphologically to *A. namaki*, *A. varentsovi* and *Alburnoides* sp. from the Amu Darya River. Phylogenetically, based on COI gene sequences, this species is closest to *A. namaki*.

**Habitat.** This species is found in spring, stream and qanat habitats. The spring type locality was about 5-10 m wide, with substrate consisting of coarse gravel and boulders, good riparian vegetation and almost fast-flowing and transparent waters. The physicochemical parameters at the spot were:- dissolved oxygen 7.54 mg/l, total dissolved solids 318 mg/l, salinity 0.32‰, conductivity 552  $\mu\text{m}/\text{cm}$ , pH 7.97 and water temperature 23.25°C. The site is at 1,569 m altitude.



Habitats of *Alburnoides damghani*, Semnan, Cheshmeh Ali Damghan, after Jouladeh Roudbar *et al.* (2016).

**Age and growth.** Narjes Tabatabaei *et al.* (2013) found fish from Cheshmeh Ali had age groups  $0^+$  to  $5^+$  years and  $W = 0.000021TL^{2.92}$ . Tabatabaei *et al.* (2015) gave  $b$  values of 2.9 for Cheshmeh Ali (pooled sexes, 17 females 2.77, 23 males 3.05). von Bertalanffy growth parameters were  $L_\infty = 120.0$ ,  $K = 0.29$ ,  $t_0 = -1.0$  and  $\Phi = 8.34$ . Age classes were  $1^+$  to  $5^+$ , with the most abundant age class being  $3^+$  years. Fish in Cheshmeh Ali had a higher condition factor, length and weight, perhaps because of stable conditions and food abundance, or possibly sampling error, compared to fish from the Jaj River and Qareh Chay (a different species). Mousavi-Sabet *et al.* (2017) examined 30 fish, 55.3-89.5 mm total length, from Cheshmeh Ali

and found a  $b$  value of 3.24. Eagderi *et al.* (2020) examined 45 fish, 7.13-11.07 cm total length, from Cheshmeh Ali and found a  $b$  value of 3.5, positive allometric growth. The condition factor was 0.77-1.37, mean 1.11.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported.

**Economic importance.** None.

**Experimental studies.** None.

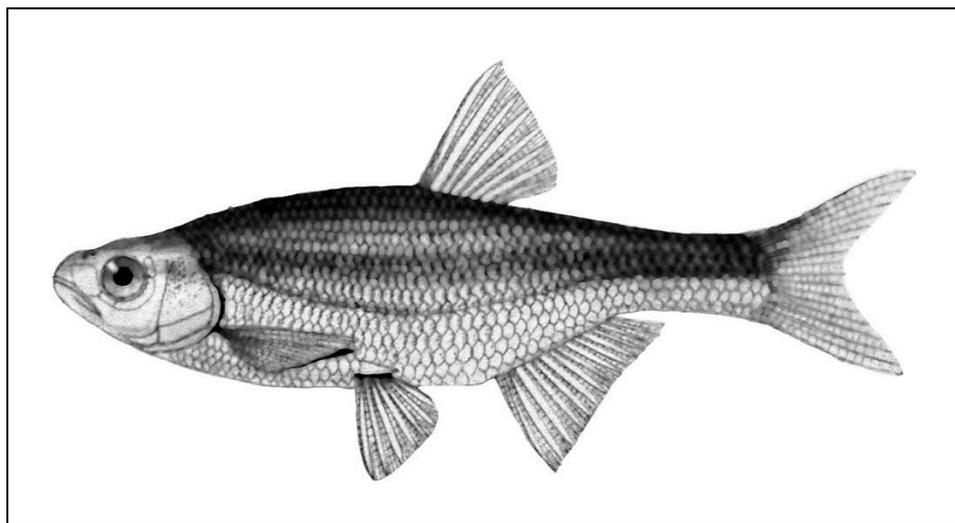
**Conservation.** Its restricted range, drought in recent years and introduction of the exotic carnivorous *Oncorhynchus mykiss* (rainbow trout) (personal observation of H. R. Esmaili), may threaten this endemic species. Jouladeh-Roudbar *et al.* (2020) listed it as Critically Endangered for the above reasons.

**Sources.** Jouladeh Roudbar *et al.* (2016).

Type material:- *Alburnoides damghani* (CMNFI 2015-0091, CMNFI 2015-0091A, ZM-CBSU 2011-1) and ZM-CBSU 2012-1).

Iranian material:- CMNFI 2008-0298, 1, 59.3 mm standard length, Semnan, qanat at Ebrahimabad (36°04'N, 54°14'E).

*Alburnoides eichwaldii*  
(De Filippi, 1863)



*Alburnoides eichwaldii*, ca. 8.9 cm total length, ZISP 10249, Georgia, Kura River at Borzhomi (= Borjomi), after Berg (1948-1949).



*Alburnoides eichwaldii*, a, 66.0 mm standard length, b, 68.0 mm standard length, GUIC AL201EI, Ardebil, Balekhlu River, Aras River basin, Hamed Mousavi-Sabet.



*Alburnoides eichwaldii*, Iran, Hamid Reza Esmaeili.



*Alburnoides eichwaldii*, Ardabil, Aras River at Parsabad, Hamid Reza Esmaeili.



*Alburnoides eichwaldii*, Turkey, Ardahan Province, Hanak Stream, Kura River drainage, after Turan *et al.* (2013).

**Common names.** Khayateh or mahi khayateh (= tailor or tailoress fish, from the lateral line pattern which resembles stitches), khayateh Khazar (= Caspian tailor), kuli (= general term for a small fish), lapak or lapek in Mazandaran (meaning unknown), parak in Gilaki (= scaly since parak is a small feather), sima (= possibly silvery).

[Gijovcu in Azerbaijan; Kura noktali incise and Noktali inci balığı in Turkish (Çiçek *et al.*, 2020; Kaya *et al.*, 2020); Armyanskaya bystryanka or Armenian bystryanka for *A. b. armeniensis*, vostochnaya bystryanka or oriental bystranka, zakavkazskaya bystryanka or Transcaucasian bystranka, all in Russian; Caspian spirlin, Eichwald's riffle minnow, Kura chub, South Caspian spirlin, southwestern Caspian spirlin; riffle bleak or riffle minnow and spirlin in general].

**Systematics.** This species was long regarded as a subspecies of a wide-ranging European and West Asian species, *Alburnoides bipunctatus* (Bloch, 1782). *Cyprinus bipunctatus* was originally described from the Weser River in Germany. *Alburnus Eichwaldii* De Filippi, 1863, described from the “Kur presso Tiflis” (= Kura River near Tbilisi, Georgia), was regarded as a Caspian Sea basin subspecies of *Alburnoides bipunctatus* but Bănărescu (1991) briefly stated that it could not be distinguished from *Alburnoides bipunctatus fasciatus* (Nordmann, 1840) of the Black Sea basin (the latter now too now recognised as a distinct species, *Catalog of Fishes*, downloaded 27 May 2018). Holčík and Jedlička (1994) considered that the observed variation was clinal and subspecies were not warranted. Reshetnikov *et al.* (1997) also considered subspecies as disputable. There is another nominal subspecies in the Aras River drainage of Armenia, *Alburnoides bipunctatus armeniensis* Dadikyan, 1972, from the rivers Arpa, Vorotan,

Vedi, Marmarik, Kasakh and their tributaries, now regarded as a synonym of *eichwaldii* (Bogutskaya and Coad, 2009).

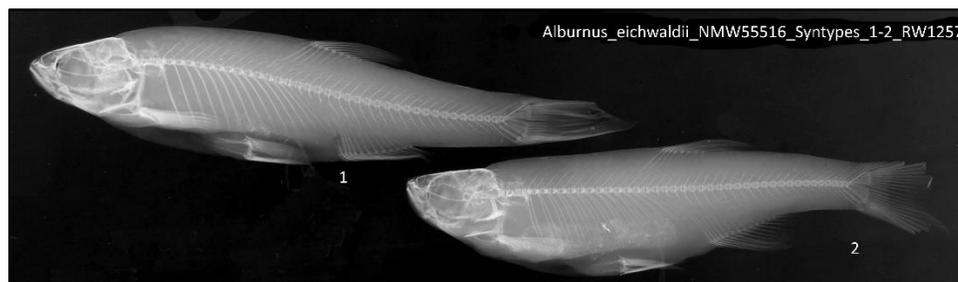
Bogutskaya and Coad (2009) resurrected *A. eichwaldii*. Turan *et al.* (2016) and Bektas *et al.* (2019) recorded it from the Aras River basin of Turkey and it also occurs in this basin in Iran.

A syntype of *Cyprinus bipunctatus* described from the Weser River, Germany is in the Museum für Naturkunde, Universität Humboldt, Berlin (ZMB 3357) (Eschmeyer *et al.*, 1996).

Two syntypes of *Alburnus eichwaldii* from “Tiflis” are in the Naturhistorisches Museum Wien under NMW 55516 (70.9-74.8 mm standard length) and four syntypes are in the Istituto e Museo di Zoologia della R. Università di Torino under MZUT N.677 (Tortonese, 1940; Eschmeyer *et al.*, 1996).



*Alburnus eichwaldii*, syntypes, NMW 55516, Naturhistorisches Museum, Wien.



*Alburnus eichwaldii*, syntypes, NMW 55516, Naturhistorisches Museum, Wien.

Syntypes of *Alburnoides bipunctatus armeniensis* are in the Zoological Institute, St. Petersburg under ZISP 37502.

Dadikyan (1973) demonstrated variability in this species in a mountainous region of Armenia within the Aras River basin. Up to 10 characters could be used to distinguish populations within the same river but taken at different altitudes. Populations at similar altitudes but in different rivers (and habitat types, e.g., rushing rocky streams compared to a bog) also varied but the characters were not necessarily the same as those distinguishing altitudinal variants within one river. Local conditions, such as temperature and flow regime, may govern the characters at any one site. Gene flow may play a part as fish are carried downstream by heavy rainfall. Populations living within the same river are presumably more closely related than populations in different river systems but may show more differences than populations at similar altitudes but which have had no gene flow for long periods. These factors could then complicate designation of subspecies in this species and accurate analysis requires large series of specimens.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Aras River basin of northwestern Iran and possibly the western Caspian Sea coast of Iran. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** There are deep-bodied and relatively elongate forms (Berg, 1948-1949). This species is characterised by moderately rounded caudal fin lobes, the caudal fin is not deeply forked, commonly a scaleless ventral keel but may be variably scaled (up to completely scaled), commonly a deep head and slightly to markedly rounded snout, the tip of the mouth cleft is slightly below the level of the middle of the eye or at about the lower margin of pupil, and the upper jaw is slightly protruding over the lower jaw.

Dorsal fin branched rays 6-9, usually 8, anal fin branched rays 10-15, usually 11-13, pectoral branched fin rays 13-15, and pelvic fin branched rays 7. Lateral line scales 44-56 (Dadikyan (1972, 1973) gave 39-56, averaging 48.7, in *A. bipunctatus armeniensis* and Esmaeilipoor Poode *et al.* (2015) gave 40-52 for Iranian Aras River fish). Total gill rakers number 5-12. Pharyngeal teeth are commonly 2,5-4,2 and other variants with four teeth in the longer row of the right ceratobranchial, also, less frequently, 2,5-5,2 or 2,5-5,1. Total vertebrae number 38-43 with a mode of 41, predorsal vertebrae 12-15 with a mode of 14, abdominal vertebrae 18-22 with a mode of 21, and caudal vertebrae 19-22 with a mode of 21. The caudal region is commonly one vertebra shorter than, equal to the abdominal region or one vertebra longer than, the abdominal region, and the difference between the abdominal and caudal numbers varies from +3 to -1 with a mode of 0, and the most common vertebral formulae are 21+21, 21+20 and 20+21. Esmaeilipoor Poode *et al.* (2015) gave 36-41 total vertebrae for Iranian Aras River fish. The syntypes NMW 55516 have 41 and 42 total vertebrae.

Meristic values are:- dorsal fin branched rays 7(14), 8(200) or 9(3), anal fin branched rays 10(4), 11(51), 12(88), 13(60) or 14(14). Abdominal vertebrae 18(1), 19(4), 20(62), 21(134) or 22(14), caudal vertebrae 19(14), 20(86), 21(99) or 22(16), predorsal vertebrae 12(2), 13(82), 14(118) or 15(13), and total vertebrae 38(1), 39(4), 40(26), 41(98), 42(71) or 43(15) (Bogutskaya and Coad, 2009; Mousavi-Sabet *et al.*, 2015; material below).

**Sexual dimorphism.** Abdurakhmanov (1962) reported pelvic fin length greater in males and snout length greater in females for this species in Azerbaijan.

**Colour.** There is a characteristic pigmentation along the lateral line with a small spot above, and another below, the lateral line opening on each scale. This only appears in preserved material as live fish are an overall silvery colour. It can be absent, mostly in lake forms (Berg,

1948-1949). The flank has a blue-grey stripe wider than the eye diameter. Above the lateral line there may be a series of 5-9 black lines formed of triangular blotches and 3-5 similar lines below the lateral line. The back and head are dark olive, almost black, dark green or dark brown. The flank above the lateral line may have purple iridescent tints. The flanks can be a golden yellow. The belly and lower head are pearly-white. The dorsal and caudal fins have some grey pigment or may be dark grey. The bases of the pectoral, pelvic and anal fins have orange to red pigmentation which is not well-developed in young. The extent and intensity of this pigment is variable between fins, although in some fish it is equally developed on all these fins.

**Size.** Attains 14.5 cm (Berg, 1948-1949).

**Distribution.** This species is found in river drainages of the southwestern Caspian coast from the Samur (according to Berg, 1948-1949) down to rivers of the Lenkoran which borders Iran. The Aras River basin also harbours this species. Mainly in the Aras River basin in Iran such as the Aghsu, Ahar, Almas, Aras, Balekhlu-Chay or Balekhlu, Ghotor, Kalibar, Qareh Su, Saghezchai (= Saqqez), Zangbar and Zilber rivers, and the Sattarkhan Dam (Masoumian, 2007; Abdoli and Naderi, 2009; Jafarzadeh *et al.*, 2015; Mousavi-Sabet *et al.*, 2015, 2017; Jouladeh-Roudbar *et al.*, 2016, 2020) but it may occur on the extreme western Caspian Sea coast of Iran as Levin *et al.* (2018) recorded it (with *A. samiii*) in the Lenkoran River of Azerbaijan. This would need testing by DNA for Iranian waters. All *Alburnoides* from the Sefid River basin and west (except the Aras River basin) in Iran are allocated to *A. samiii* in the present work, while recognising some could be *A. eichwaldii*.

**Zoogeography.** Bektas *et al.* (2019) placed this species, in their analysis of *Alburnoides* in Turkey, in an Eastern Clade and lineage IV, the Caspian Sea basin (and this Clade includes Euphrates species not found in Iran and presumably other species that are). The Eastern Clade split from the Western Clade about 7.7 MYA (the middle Tortonian), coinciding with the existence of the Balkanian-Anatolian-Iranian landmass that continued until the Late Miocene, and diversification occurred during the Late Miocene to middle Pleistocene (Calabrian). Eastern clade groups of species (Ponto-Caspian, Tigris and Euphrates, and Central Anatolia) were separated from 5.98 to 2.37 MYA during the Pliocene uplift of the eastern Anatolian region.

**Habitat.** This species is found in rivers, streams and dams but commonly inhabits small streams and is less frequent in the main flow of large rivers.

**Age and growth.** Mousavi-Sabet *et al.* (2017) examined 110 fish, 45.8-123.2 mm total length, from three localities (Aras River, 40 fish,  $b = 3.18$ , Saghezchi or Saghezchai (= Saqqez) Stream or River, 30 fish,  $b = 3.27$ , and Balekhlu River, 40 fish  $b = 3.21$ ) with an average  $b$  value of 3.03. Eagderi *et al.* (2020) examined 60 fish, 3.98-10.98 cm total length, from the Aras River and found a  $b$  value of 3.19, positive allometric growth. The condition factor was 0.82-1.44, mean 1.11.

Cicek *et al.* (2016) examined 162 fish, 3.2-13.0 cm total length, from both rivers and lakes of the Aras River basin in Turkey. They found age groups 0-3 years with 0 and 1 the most frequent. Growth was rapid in the first year and then declined. Length-weight relationships were  $W = 0.00644L^{3.2221}$  for rivers and  $W = 0.00651L^{3.3714}$  for lakes with  $b$  values not significantly different from 3.0 indicating isometric growth. von Bertalanffy growth parameters were  $L_{\infty} = 12.91$  cm,  $k = 0.548/\text{year}$ ,  $t_0 = -1.41$  year,  $\Phi' = 1.96$  and  $K = 1.08$  for rivers and  $L_{\infty} = 16.36$  cm,  $k = 0.237/\text{year}$ ,  $t_0 = -2.89$  year,  $\Phi' = 1.8$  and  $K = 1.19$  for lakes. Instantaneous total (Z), natural (M) and fishing (F) mortalities were 0.88, 0.75 and 0.13/year for rivers and 0.39, 0.37 and 0.02/year for lakes. The exploitation rate (E) was 0.15 and 0.05 for rivers and lakes respectively. Overfishing pressure was absent as these fish were not commercially fished in the Aras River.

In Azerbaijan, maturity was attained at 1-2 years and life span was 3 years (Abdurakhmanov, 1962).

**Food.** Hajipour *et al.* (2019) examined the diet of fish identified as *A. bipunctatus* (= *A. eichwaldii*) from the Kaleybar (= Kalibar) Chay in the Aras River basin based on 53 fish. The highest and lowest feeding levels were in winter and spring respectively. The species was found to be benthivorous and detritivorous, and no zooplankton were found attributed to the small size (6.7 cm mean length) and low planktonic resources. Infestation with *Ichthyophthirius multifiliis* occurred in summer and autumn. Food in Azerbaijan was taken from the bottom or from the water surface, the former being mostly insect larvae and the latter terrestrial organisms which fell on the water. Diatoms were also found in gut contents (Abdurakhmanov, 1962).

**Reproduction.** Spawning took place in spring (April-June) at 13-15.6°C and adhesive eggs were laid on sand or gravel in fast-flowing water. Fecundity reached 6,496 eggs and egg diameter 2.16 mm in Azerbaijan (Abdurakhmanov, 1962).

**Parasites and predators.** Fish from CMNFI 2007-0087 carried large black flank blotches, presumably caused by a parasite. Masoumian *et al.* (2005) reported the protozoan parasites *Ichthyophthirius multifiliis*, *Trichodina perforata* and *Chilodonella*, sp. from this species (as *A. bipunctatus*) in water bodies in West Azarbayjan. Also, Masoumian (2007) reported the parasites *Diplozoon megan* and *Trichodina perforata* from *Alburnoides bipunctatus* (= *A. eichwaldii*) in the Aras, Ghotor and Zangbar rivers in West Azarbayjan. Mortazavi Tabrizi *et al.* (2005) and Hajirostamloo (2009) recorded *Ligula intestinalis* from fish identified as *A. bipunctatus* in the Sattarkhan Dam in East Azarbayjan. Barzegar *et al.* (2008) recorded the digenean eye parasite *Diplostomum spathaceum* from this fish (as *A. bipunctatus*, possibly *A. eichwaldii* as locality is unclear) from the Saryson River in the western Caspian Sea basin.

**Economic importance.** None.

**Experimental studies.** Rahmati-holasoo *et al.* (2014) found that clove oil could be used repeatedly for at least two weeks as an anaesthetic in fish identified as *A. eichwaldii* (locality not given and probably not that species - authors have studied what are now recognised as other *Alburnoides* species). Doustdar *et al.* (2018) found that the highest level of molybdenum contamination in a study of Aras River fish was found in this species (identified as *A. bipunctatus*) at 11.7 µg/g dry weight muscle tissue, as also was arsenic.

**Conservation.** Kiabi *et al.* (1999), examining Iranian material, considered fish identified as *A. bipunctatus* to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included abundant in numbers, habitat destruction, widespread range (75% of water bodies), present in other water bodies in Iran, and present outside the Caspian Sea basin. These assessments may apply, at least in part, to the current taxon as well as other Caspian Sea *Alburnoides*. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Bogutskaya and Coad (2009).

Iranian material:- CMNFI 2007-0086, 2, 35.9-41.2 mm standard length, Ardabil, Qareh Su basin near Nir (ca. 38°02'N, ca. 48°00'E); CMNFI 2007-0087, 2, 74.6-79.2 mm standard length, Ardabil, Qareh Su north of Ardabil (38°22'N, 48°19'E); CMNFI 2007-0089, 2, 36.2-43.7 mm standard length, East Azarbayjan, Ahar Chay at Ahar (38°28'N, 47°03'E); CMNFI 2007-0090, 14, 37.7-48.1 mm standard length, East Azarbayjan, Zilber Chay north of Marand (38°29'N, 45°46'E).



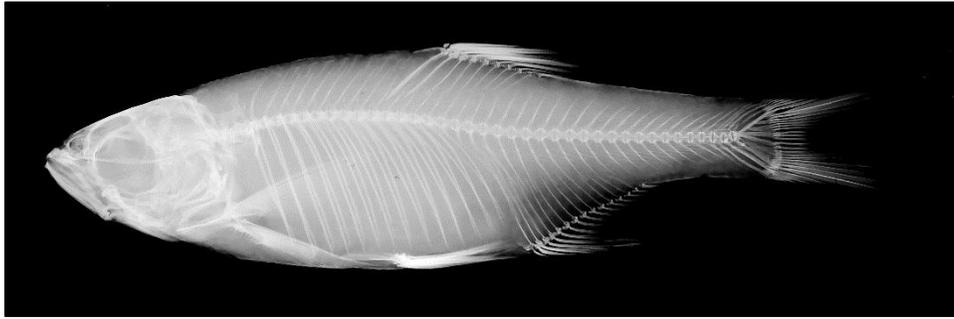
*Alburnoides holciki*, a, 64.0 mm standard length, VMFC AL201HO,  
b, 58.0 mm standard length, VMFC AL201HO,  
Razavi Khorasan, Hari River, Hamed Mousavi-Sabet.

**Common names.** Kuli-ye Harirud (= Hari River fish), khayateh-e Holčik (= Holčik tailor fish).  
[Hari spirlin, Harirud bleak, Holčik's bleak, Holčik's spirlin, Holčik's riffle minnow].

**Systematics.** The type series consists of SNM-PM 6788, holotype, 80.0 mm standard length, and 18 paratypes, 49.6-92.6 mm standard length, Afghanistan, Hari River at Herat (ca. 34°20'N, 62°12'E). The species was named after the late Juraj Holčik, Bratislava who studied Iranian fishes. Fardanian *et al.* (2016) briefly indicated the species is distinct using cytochrome oxidase 1 sequences. Levin *et al.* (2018) also used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and found this species to be distinct. *Alburnoides parhami* Mousavi-Sabet, Vatandoust and Doadrio, 2015, described from the Atrak River basin, was synonymised with this species by Eagderi *et al.* (2019) using COI gene data and Jouladeh-Roudbar *et al.* (2020) concurred stating there was less than 0.4% genetic distance using their own unpublished COI data.



*Alburnoides holciki*, holotype, SNM-PM 6788, Brian W. Coad.



*Alburnoides holciki*, holotype, SNM-PM 6788, Brian W. Coad.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Hari River basin of northeastern Iran. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a well-defined, sharp, scaleless or only slightly scaled, ventral keel, a short, slightly pointed snout, a terminal mouth with the tip of the mouth cleft on a level with the upper half of the pupil, and a large eye (orbit width about equal to interorbital width).

Dorsal fin with 3-4 unbranched and 7-9, usually 8, branched rays, anal fin with 3 unbranched and 10-16, branched rays, usually 14-15, pectoral fin branched rays 13-15, and pelvic fin branched rays 6-8. Lateral line scales 46-55, usually 47-51 (42-57 total lateral line scales), scales between lateral line and dorsal fin origin 9-11, and scales around caudal peduncle 20-26, mostly 20-23. Total gill rakers number 5-9 (Jouladeh-Roudbar *et al.* (2020) gave 6-14), reaching the raker below when appressed, often small and weakly developed, or concealed in the flesh of the gill arch. Pharyngeal teeth are 2,5-4,2, rarely 2,5-5,2. Total vertebrae are 39-42, usually 41, abdominal vertebrae 19-21, caudal vertebrae 19-22, predorsal vertebrae 12-14, usually 13 or 14, and the caudal vertebral region is longer than the abdominal region. The most frequent vertebral formulae are 20+21, 20+22 and 19+21. Levin *et al.* (2019) gave somewhat wider counts for fish from the Amu Darya basin (see below in **Distribution**) and these were incorporated above. The holotype has 41 total vertebrae. Mohammadi-Sarpiri *et al.* (2021) described the osteology of this species. They recorded 35-39 vertebrae including the four Weberian vertebrae, much lower than reported here.

Meristic values are:- dorsal fin branched rays 7(1), 8(46) or 9(7) and anal fin branched rays 10(1), 11(-), 12(1), 13(3), 14(21), 15(23) or 16(5). Abdominal vertebrae 19(9), 20(44) or 21(2), caudal vertebrae 20(5), 21(39) or 22(11), predorsal vertebrae 12(1), 13(38) or 14(15), and total vertebrae 40(5), 41(39) or 42(10) (Coad and Bogutskaya, 2012; Mousavi-Sabet *et al.*, 2015).

**Sexual dimorphism.** Unknown.

**Colour.** Overall colour in life is silvery with pectoral, pelvic and anal fin bases reddish-orange. Pigmentation in preserved material consists of a darker back and lighter abdomen. A diffuse stripe extends from the head to the tail, being expanded on the tail base, and a dark line separates the hypaxial and epaxial muscle masses and is overlain by the stripe. There are 3-4 rows of spots above the lateral line which may extend back as far as the end of the pelvic fin level. There may be 1-2 rows of spots below the anterior lateral line in front of the pelvic fin level and above the pectoral fin. A stripe occurs before and after the dorsal fin on the back. There is a characteristic pigmentation along the lateral line with a small spot or bar above, and another

below, the lateral line opening on each scale. This also appears in live material even though they are an overall silvery colour. Fins are mostly hyaline with faint pigment along the anterior dorsal fin rays, a line of pigment along the proximal edge of the pectoral fin unbranched ray and weak pigmentation on the first branched ray, and weak pigmentation on the caudal fin centre branching distally to follow the inner margins of the fin fork. The peritoneum is white-grey to light brown overall, the latter from distinct but crowded pale brown spots. Some fish may have a few, very small, black pigment spots on the peritoneum.

**Size.** Attains 92.6 mm standard length or 94.3 mm total length.

**Distribution.** This species is found in the Hari River (= Tedzhen) basin, including at Herat, Afghanistan and in Iran from the Hari and Kashaf rivers and the Kardeh and Doosti dams (Abdoli and Naderi, 2009; Coad and Bogutskaya, 2012; Mousavi-Sabet *et al.*, 2018; Jouladeh-Roudbar *et al.*, 2020). Levin *et al.* (2019) extended the distribution to the upper Amu Darya basin in Tajikistan (Kafirnigan, Khanaka, Kyzylsu, Tayirsu, Vakhsh and Yakkhsu rivers) and possibly the Zeravshan River basin (Mogian Darya and Zeravshan rivers) in Tajikistan based on morphological and COI barcode data. This species also probably inhabits the Murgab River in Turkmenistan. Also, in the Atrak River basin if *A. parhami* is a synonym. Sheraliev *et al.* (2021) extended the range to inland waters of Uzbekistan.

**Zoogeography.** Coad and Bogutskaya (2012) gave comparative details with these and other *Alburnoides*.

**Habitat.** There is no data other than capture in rivers, streams and dams for Iran.

**Age and growth.** Mousavi-Sabet *et al.* (2017) examined 30 fish, 52.6-93.4 mm total length, from the Hari River and found a *b* value of 3.25. Eagderi *et al.* (2020) examined 27 fish, 6.54-9.43 cm total length, from the Hari River and found a *b* value of 3.29, isometric growth. The condition factor was 0.72-0.93, mean 0.84.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported from Iran.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Jouladeh-Roudbar *et al.* (2020) listed it as Data Deficient as they found it only at the outlet of the Doosti Dam in Iran.

**Sources.** Type material:- *Alburnoides holciki* (SNM-PM 6788).

Iranian material:- BM(NH) 1914.1.1:30-31, 2, 83.2-92.1 mm standard length, Razavi Khorasan, Kashaf River, Mashhad (ca. 36°18'N, ca. 59°36'E).

*Alburnoides idignensis*  
Bogutskaya and Coad, 2009



*Alburnoides idignensis*, a, 51.0 mm standard length, b, 55.0 mm standard length, VMFC AL201ID, Kermanshah, Bid-e Sorkh River, Gamasiab River basin, Hamed Mousavi-Sabet.

**Common names.** Khayateh-ye Dejleh or khayateh-e Tigris (both = Tigris tailor fish), lapek or lapak (meaning unknown), shebeh zury (= resembling zury, the latter being an unknown name) in Khuzestan for *Alburnoides* spp.

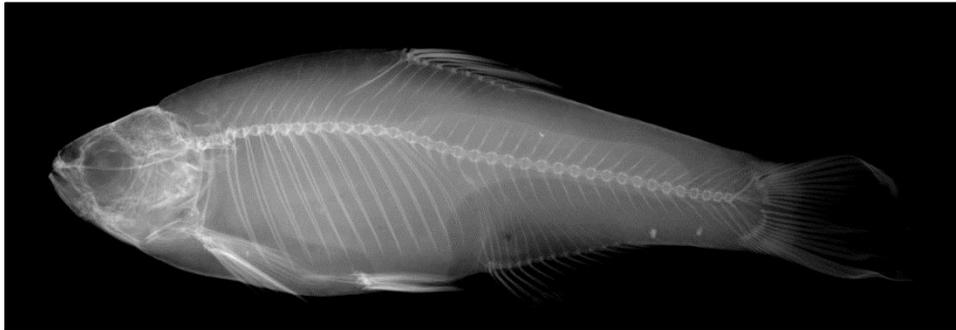
[Tigris riffle minnow, Tigris spirlin].

**Systematics.** The holotype (CMNFI 2007-0118) is a male, 89.2 mm standard length, from Kermanshah, Bid Sorkh River between Sahneh and Kangavar, Gamasiab River drainage, ca. 34°23'N, 47°52'E; paratypes (CMNFI 2007-0118A), 13, 33.5-90.0 mm standard length, same data as holotype. The species is named for the Tigris River which was called Idigna in Sumerian (Akkadian: Idiklat; biblical: Hiddekel; Arabic: Dijlah; Turkish: Dicle).

Jouladeh Roudbar *et al.* (2015) were unable to distinguish this species based on 33 morphometric and five meristic characters. Jouladeh Roudbar *et al.* (2016) found this species and *A. nicolausi* were very closely related and not well supported as sister taxa (low posterior probability of 0.62). However, the ancestral node for *A. idignensis* was 1.0, as was the ancestral node for *A. nicolausi*, which is strong support for monophyly of each of these species.



*Alburnoides idignensis*, holotype, CMNFI 2007-0118,  
James Maclaine @ Canadian Museum of Nature.



*Alburnoides idignensis*, holotype, CMNFI 2007-0118,  
Noel Alfonso @ Canadian Museum of Nature.

Levin *et al.* (2018) also used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and found this species not to be distinct from *A. nicolausi*.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Tigris River basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a moderately compressed and relatively thick body, a deep head with a markedly rounded and stout snout, a small mouth which is between terminal and subterminal, a tip of the mouth cleft on a level from the lower margin of the pupil, an eye of average size, an orbit diameter larger than the snout length and markedly smaller than the interorbital width, the junction of the lower jaw and the quadrate on about a vertical through the anterior margin of the pupil, the pectoral fin unbranched ray strongly lined with melanophores on its inner margin, the anal fin origin is in front of a vertical from the posterior end of the dorsal fin base, caudal fin lobes rounded and fin shallowly forked, and a variably scaled ventral keel though most commonly scaled along about one-third to two-thirds of its length.

Dorsal fin branched rays 6-8, commonly 8, anal fin branched rays 9-14, usually 11-12, pectoral fin branched rays 12-16, and pelvic fin branched rays 6-7, usually 7. Total lateral line scales 41-51 (39-49 scales to posterior margin of hypurals), scales above lateral line to dorsal fin origin 8-11, usually 9-10, scales around caudal peduncle 12-18, usually 14-16, pharyngeal teeth commonly 2,5-4,2 or 2,4-4,2, total gill rakers 6-10, total vertebrae 37-40, with a mode of 39, predorsal vertebrae 11-14, abdominal vertebrae 18-20, caudal vertebrae 18-20, a caudal vertebral region most commonly one vertebra shorter or one vertebra longer than the abdominal region,

the most common vertebral formulae are 20+19 and 19+20, and the difference between the abdominal and caudal counts averages 0. The holotype has 38 total vertebrae.

Meristic values are:- dorsal fin branched rays 6(1), 7(19) or 8(78) and anal fin branched rays 9(1), 10(4), 11(54) or 12(35). Abdominal vertebrae 18(1), 19(45) or 20(52), caudal vertebrae 18(1), 19(47) or 20(50), predorsal vertebrae 11(2), 12(71), 13(24) or 14(1), and total vertebrae 37(1), 38(15), 39(63) or 40(19) (Bogutskaya and Coad, 2009; Mousavi-Sabet *et al.*, 2015).

**Sexual dimorphism.** The following characters were significantly different between sexes - greater in females: head width, postorbital distance, and pelvic fin origin to anal fin origin distance; greater in males: head length, pectoral fin length in pectoral fin origin to pelvic fin origin distance, and pelvic fin length in pelvic fin origin to anal fin origin distance. In CMNFI 1979-0278, a fish 52.8 mm standard length caught on 5 July 1977, there are fine tubercles on top of the head and all fins except the caudal fin. The largest tubercles lined the anal fin rays in a single row, branching with branching ray tips. Scales over the anal fin and on the lower caudal peduncle also bore tubercles, up to four lining the scale margin.

**Colour.** Overall colour is silvery-brown with reddish bases to the pectoral, pelvic and anal fins. The anal fin may have reddish pigmentation on the anterior rays and membranes. The dorsal fin bears dark pigmentation distally. The caudal fin has dark pigmentation lining the fin rays. The head below and behind the eye is silvery. The upper flank scales are mostly light but some are darkly pigmented in no obvious pattern. The lateral line is delineated by some darker pigment above and below but not as strongly as in the *A. petrubanarescui* holotype and obscured by background pigmentation on the caudal peduncle. Some pigment on the flank scales above and below the lateral line give the impression of stripes but this is not strongly developed. A mid-flank stripe is not developed but there is contrasting dark pigment between the yellow stripe. A thin dark or yellow stripe separates the epaxial and hypaxial muscle masses. The back is dark and obscures a predorsal and postdorsal stripe. The fins are mostly immaculate, with some melanophores lining the rays of the dorsal and pectoral fins in particular. The pectoral fin unbranched ray is strongly lined with melanophores on its inner margin. The peritoneum is silvery with fine melanophores and some spots.

**Size.** Attains 113.4 total length (Mousavi-Sabet *et al.*, 2017).

**Distribution.** This species is from some upper reaches of tributaries of the Karkheh (Qareh Su) River in the Tigris River basin in the Zagros Mountains of Iran. The Karkheh drains into the Tigris just below its confluence with the Euphrates. Assuming this species is the widely-distributed *Alburnoides* of the Tigris River basin in Iran (with *A. nicolausi* very localised), it is found in the Agh Bolagh, Aran, Badavar, Bahmanshir, Bala, Bid Sorkh, Chamzarivar, Chardavol, Cheshmeh Goomle, Cheshmeh Gileh, Dez, Dinorab, Dinvar, Gamasiab, Gaznahle, Gholghol, Haramabad, Jarrahi, Kahman, Karkheh, Karun, Kashkan, Kerend, Kharchang, Khorram (Khorramabad), Kiarud, Malayer, Marun, Marvil, Merag, Nahr-e Shavor, Qareh Su, Ravand, Ravansar, Sarab Dowrah, Shush, Valam and Zardab rivers, the Aran and Gaznahle streams and the Khondab and Pir Salman wetlands (Jouladeh Roudbar *et al.*, 2016, 2020; Taghiyan *et al.*, 2016, Keivany and Zamani-Faradonbe, 2017b; Mousavi-Sabet *et al.*, 2017; Nasri, 2021).

**Zoogeography.** See under the genus.

**Habitat.** This species is found in rivers, streams, wetlands, springs and qanats. This species was captured in the Sarab Dowrah River on 5 July 1977 (CMNFI 1979-0278) at an altitude of 1,370 m, in clear water at 19°C, with pH 6.8, the shore was bushy, some plants were

present in the water, and the river had a stony bed. Other species recorded together with this species were the cyprinids *Alburnus mossulensis* (= *A. sellal*), *Barbus lacerta*, *Capoeta aculeata*, *Cyprinion macrostomus*, *Garra rufa*, the cobitid *Cobitis avicennae*, and the nemacheilids *Oxynoemacheilus kermanshahensis* and *O. kiabii*.

**Age and growth.** Keivany and Zamani-Faradonbe (2017b) examined 61 fish, 34.8-76.2 mm total length, from the Jarrahi River and found a *b* value of 3.33. Mousavi-Sabet *et al.* (2017) examined 40 fish, 57.9-84.3 mm total length, from the Aran Stream and found a *b* value of 3.36, 33 fish, 73.3-113.4 mm total length, from the Bid Sorkh Stream with a *b* value of 3.22 and 40 fish, 45.5-97.3 mm total length, from the Gaznahle Stream with a *b* value of 3.14, and with an overall *b* value of 3.11. Eagderi *et al.* (2020) examined 37 fish, 4.19-10.21 cm total length, from the Gamasiab River and found a *b* value of 3.13, isometric growth. The condition factor was 1.11-1.78, mean 1.37.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported although fish from CMNFI 2008-0236 were heavily parasitised as evidenced by black spots, possibly encysted trematode larvae.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Jouladeh Roudbar *et al.* (2020) listed it as of Least Concern for its large distribution range, abundance and no known widespread threat, threats being moderate and very local.

**Sources.** Type material:- *Alburnoides idignensis* (CMNFI 2007-0118 and CMNFI 2007-0118A).

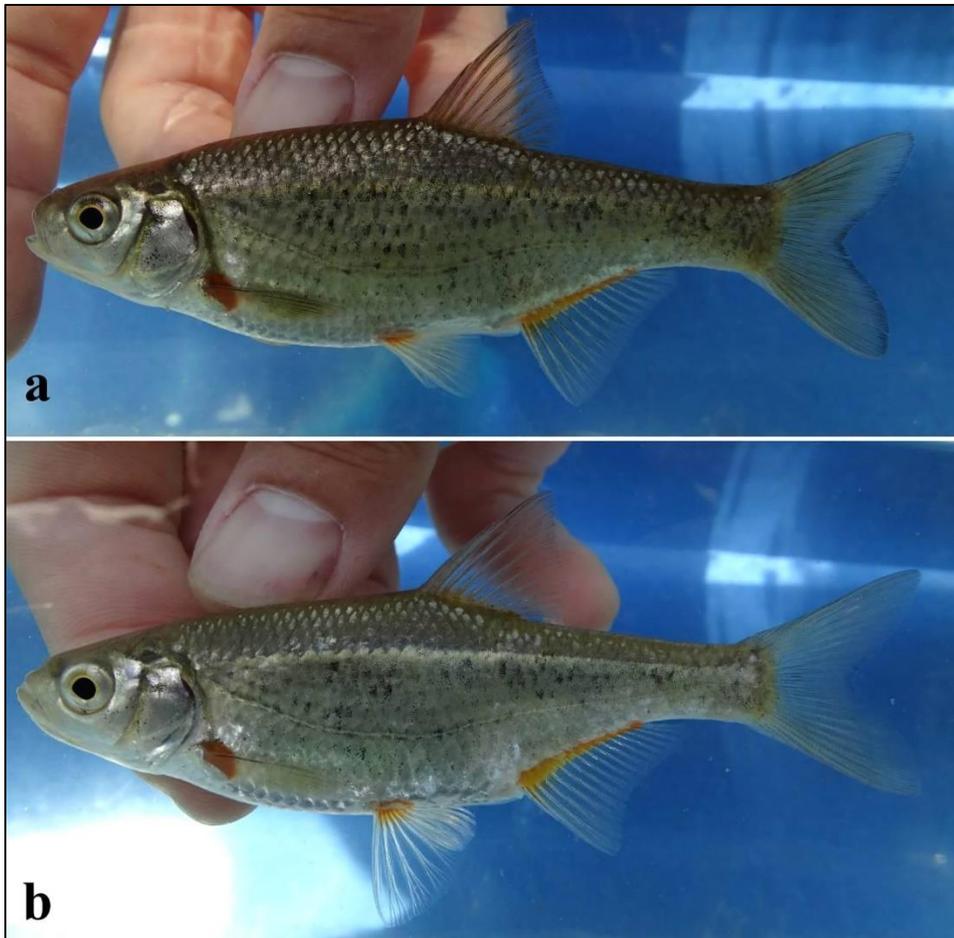
Iranian material:- CMNFI 1979-0267, 3, 36.1-38.0 mm standard length, Lorestan, river between Nowqan and Khorramabad (no other locality data); CMNFI 1979-0278, 5, 43.3-52.8 mm standard length, Lorestan, Sarab Dowrah River in Kashkan River drainage, 30 km from Khorramabad (33°34'N, 48°01'E); CMNFI 1979-0285, 1, 31.8 mm standard length, Kermanshah, Qareh Su drainage (34°26'N, 46°37'E); CMNFI 1979-0369, 1, 28.1 mm standard length, Khuzestan, Shush River at Shush (32°12'N, 48°14'30"E); CMNFI 2007-0075, 36, 38.1-72.1 mm standard length, Hamadan, Hamadan, Malayer River 5 km from Malayer (ca. 34°17'N, ca. 48°47'E); CMNFI 2007-0112, 2, 31.3-37.4 mm standard length, Kermanshah, Kerend River basin near Shahabad-e Gharb (ca. 34°06'N, ca. 46°30'E); CMNFI 2007-0115, 8, 43.3-62.7 mm standard length, Kermanshah, Qareh Su basin north of Kermanshah (ca. 34°34'N, ca. 46°47'E); CMNFI 2008-0163, 1, 42.2 mm standard length, Khuzestan, Marun River at Chahar Asiab (30°40'28"N, 50°09'34"E); CMNFI 2008-0165, not kept, Khuzestan, Dez River near Shush (32°14'40"N, 48°20'07"E); CMNFI 2008-0175, not kept, Lorestan, Kahman River at Dow Ab-e Aleshtar (33°47'N, 48°12'E); CMNFI 2008-0236, 4, 58.8-83.5 mm standard length, Kermanshah, Mereg River (35°25'N, 46°17'E).

*Alburnoides namaki*

Bogutskaya and Coad, 2009



*Alburnoides namaki*, Markazi, Bolagh Spring, Hamid Reza Esmaeili.



*Alburnoides namaki*, a, 71.0 mm standard length, b, 67.0 mm standard length, VMFC AL201NA, Markazi, Qareh Su (or Qareh Chay) River, Hamed Mousavi-Sabet.

**Common names.** Khayateh-ye namaki or khayateh-e Namak (= Namak tailor fish), lapak or lapek (meaning unknown).

[Namak riffle minnow, Namak or Namaki spirilin].

**Systematics.** The holotype, CMNFI 1979-0461, is a female, 91.2 mm standard length

from Hamadan, qanat at Taveh, 35°07'N, 49°02'E. Paratypes are under CMNFI 1979-0461A, 188, 27.2-96.9 mm standard length, same data as the holotype. The species is named for the Namak Lake. Namak means salt in Farsi and the lake itself is fishless but receives numerous freshwater tributaries. Jouladeh Roudbar *et al.* (2015) were unable to distinguish this species based on 33 morphometric and five meristic characters. Jouladeh-Roudbar and Eagderi (2017) found a 0.53% genetic distance in the COI barcode region with *A. coadi* and therefore synonymised the latter.



*Alburnoides namaki*, holotype, CMNFI 1979-0461,  
James Maclaine @ Canadian Museum of Nature.



*Alburnoides namaki*, paratype, 63.1 mm standard length, CMNFI 1979-0461A,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnoides namaki*, holotype, CMNFI 1979-0461,  
Noel Alfonso @ Canadian Museum of Nature.

Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and merged *A. coadi*, *A. damghani* and *A. namaki* into a single putative species, the former two species then being synonyms of *namaki*. Eagderi *et al.* (2019) using the COI gene to study the phylogeny of Iranian *Alburnoides* and also found *A. coadi* to be a synonym.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Namak Lake basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by the lack of strong spots or dark outline to the lateral line canal (however, some specimens have strong pigmentation above and below the lateral line pores, forming an evident pale line margined with dark (Mousavi-Sabet *et al.*, 2015)). A broad mid-flank stripe can be well-developed or weakly expressed and, on the caudal peduncle, obscures the lateral line pigment pattern. The lateral line pattern can be weak and this can be seen over the anal fin where the flank stripe does not extend down to the decurved lateral line. The eye is relatively large (27.7-34.5, mean 31.3 in head length), the orbit width about equal to the snout length but markedly smaller than the interorbital width. Caudal fin lobes are rounded and the fin is shallowly forked. There is a sharp, scaleless, ventral keel behind the pelvic fins along the abdomen to the anus. The head is deep with a stout snout which is markedly rounded. The mouth is small, almost subterminal with the tip of the mouth cleft on a level from the lower margin of the eye or below. The junction of the lower jaw and the quadrate is on about a vertical through the middle of the eye.

Dorsal fin branched rays 7-8, usually 8, anal fin branched rays 10-13, usually 11-12, pectoral fin branched rays 12-15, and pelvic fin branched rays 6-7. Lateral line scales 43-52, scales above lateral line to dorsal fin 9-13 (mostly 10-11), and scales around caudal peduncle 14-19 (mostly 16-18). Pharyngeal teeth 2,5-4,2 (or other variants with four teeth on the right ceratobranchial and 1-3 in the minor rows). Total vertebrae 39-41, a low number of predorsal vertebrae at 11-14, commonly 12-13, abdominal vertebrae 19-21, caudal vertebrae 19-21, a caudal vertebral region most commonly equal to the abdominal region, and the most common vertebral formulae are 20+20, 20+19 and 19+20. The holotype has 40 total vertebrae (a fusion counted as two vertebrae).

Meristic values are:- dorsal fin branched rays 7(3) or 8(96) and anal fin branched rays 10(5), 11(36), 12(53) or 13(5). Abdominal vertebrae 19(28), 20(68) or 21(3), caudal vertebrae 19(21), 20(65) or 21(13), predorsal vertebrae 11(3), 12(71), 13(24) or 14(1), and total vertebrae

39(38), 40(57) or 41(4) (Bogutskaya and Coad, 2009; Mousavi-Sabet *et al.*, 2015).

**Sexual dimorphism.** The following characters were significantly different between sexes ( $p < 0.05$ ). Head depth, body depth, head width, orbit diameter, and predorsal length were greater in females while pectoral fin length, pelvic fin length, longest dorsal fin ray length, pectoral fin length in pectoral fin origin to pelvic fin origin distance, and pelvic fin length in pelvic fin origin to anal fin origin distance were greater in males.

In a fish from CMNFI 1979-0459, 56.2 mm standard length collected on 9 June 1978, fine tubercles are present on top of the head and larger, but still small tubercles, line the posterior scale margins on the flank, numbering up to six per scale. Tubercles are present on all fins on both unbranched and branched rays, following ray branching. The tubercles are largest and best developed in extent on the anal fin. Other fish may have fine tubercles developed on the side of the head and tubercles on scales are best developed on the caudal peduncle.

**Colour.** The flanks are a golden-yellow, belly white, back dark green, base of paired and anal fins orange to reddish, and other fins hyaline in life. The lateral line is somewhat darker, above and below, than the surrounding flank but there are no strong spots or dark outline to the canal in the type series. Some pigment on flank scales above and below the lateral line give a faint impression of stripes. A predorsal and postdorsal stripe is present on the back. The fins are mostly immaculate, with some melanophores lining the rays of the dorsal and pectoral fins. Some fish have a series of strong melanophores on the inner margin of the pectoral fin unbranched ray. Dorsal fin membranes may be dusky and lack pigment lining the rays. Caudal fin rays may be quite darkly pigmented, distally clear and the margin dark, or mostly clear. Some paratypes bear strong pigmentation above and below the lateral line pores, forming an evident pale line margined with dark. A broad mid-flank stripe can be well-developed or weakly expressed and, on the caudal peduncle, obscures the lateral line pigment pattern. However, the lateral line pattern can be weak and this can be seen over the anal fin where the flank stripe does not extend down to the decurved lateral line. The pigment on scales above and below the lateral line (and below the mid-flank stripe) can be strongly or weakly expressed and, in the former case, it appears as a series of thin, discontinuous stripes. The peritoneum is silvery with a few melanophores.

**Size.** Attains 96.9 mm standard length, 110.4 mm total length (Varzani *et al.*, 2017).

**Distribution.** This species is found in the Namak Lake basin of Iran including the Ab-kamar, Bahadorbaik (= Bahador Beyg), Bar, Damagh Tasran, Do Ab, Gazandar, Golushjerd, Jaj, Kaleh, Karaj, Ken, Khamigan, Khenejin, Khomeigan, Kordan, Mazdaqan, Pol-e Doab, Qareh Chay, Qom, Salehabad, Sharra, Siahdareh, Tureh, Yunji and Zehtaran rivers, a qanat at Taveh, and the Latian Dam (Touraji and Vosoughi, 2006; Jazebizadeh and Yekta, 2008; Abbasi *et al.*, 2009; Mirzaei *et al.*, 2010; Rahmati-holasoo *et al.*, 2011; Narjes Tabatabaei *et al.*, 2013; Hoghoghi *et al.*, 2015; Jouladeh Roudbar *et al.*, 2016; Jouladeh Roudbar and Eagderi, 2017; Varzani *et al.*, 2017; Tork Haram Abadi *et al.*, 2021).

Records from the Nam River (or Namrud) in the Hableh River basin of the Dasht-e Kavir basin were recognised as *A. coadi* (Mousavi-Sabet *et al.*, 2015).

**Zoogeography.** See under the genus.

**Habitat.** This species is found in rivers, streams, dams, springs and qanats. Hoghoghi *et al.* (2015) examined habitat use in the Jaj River at 18 equally-spaced sites in autumn. They found this species mostly selected the upper parts of the river (1,480-1,490 m of 1,422-1,490 m) with higher slope (1.8-2.0% of 1.2-2.9%), greater depth (35-45 cm of 13-53 cm), lower width (< 10 m of 5-24 m), lower velocity (< 1 m/sec of 0.4-1.9 m/sec), a stream bed with bedrock and boulder

cover with bed stone > 40 cm (12-40 cm stones), total dissolved solids 100-150 p.p.m. (of 100-286 p.p.m.), and deciduous and residential riparian types. This species was a good indicator of environmental quality.

Nateghi *et al.* (2017) used several species distribution models to predict future distribution of this species through a correlation between environmental factors and its current “dispersal”. On time scales to the years 2050 and 2080, results showed that in all scenarios this species will have a drastic decrease (100%) from climate change in its potential distribution.

Collection data at the type locality on 10 June 1978 included altitude 1,640 m, water temperature 15.5°C, pH 6.0, conductivity 1.2 mS, qanat stream width 1.5 m, maximum depth 75 cm, vegetation in water encrusting, shore grassy, gravel or mud bottom, medium current, and water clear in parts, others cloudy and polluted, The species was collected with *Capoeta buhsei*.



Habitat of *Alburnoides namaki*, Alborz, Kordan River, Arash Jouladeh-Roudbar.

**Age and growth.** Narjes Tabatabaei *et al.* (2013) found fish from the Jajrud (= Jaj River) and Qara (= Qareh) Chay had age groups  $0^+$  to  $5^+$  years. Condition factor, mean length and weight were higher in Cheshmeh Ali fish (= *A. damghani*, *q.v.*). Jaj River fish had higher growth rate (K and  $\Phi$  values). Length-weight relationships were  $W = 0.000005TL^{3.22}$  for the Jaj River and  $W = 0.000009TL^{3.03}$  for the Qareh Chay. Tabatabaei *et al.* (2015) gave *b* values of 3.22 for the Jaj River (pooled sexes, 21 females 3.26, 50 males 3.2) and 3.05 for the Qareh Chay (pooled sexes, 68 females 2.87, 76 males 3.05). von Bertalanffy growth parameters were  $L_\infty = 112.66$  (123.01 in text, presumably an error) and 122.43,  $K = 0.54$  and 0.27,  $t_0 = 0.18$  and - (*sic*), and  $\Phi = 8.83$  and 8.31, respectively. Age classes were both  $0^+$  to  $3^+$ , with the most abundant age classes being  $0^+$  and  $1^+$  years, respectively. The overall growth performance was higher in the Jaj River and asymptotic length ( $L_\infty$ ) was smaller. Differences were attributed to the Jaj River fish being downstream from a dam with resulting drought and flood conditions such that higher growth rates reaching sexual maturity and maximum length insured this population’s persistence. Fish in

Cheshmeh Ali (= *A. damghani*, *q.v.*) had a higher condition factor, length and weight, perhaps because of stable conditions and food abundance, or possibly sampling error. Mousavi-Sabet *et al.* (2017) examined 30 fish, 37.5-77.1 mm total length, from the Qareh Chai River (= Qareh Chay) and found a *b* value of 3.19. Varzani *et al.* (2017) studied 259 specimens from the Qareh Chay and Mazlaqan Chai (= Mazdaqan Chay) rivers and found ages of 1-4 years, a male:female sex ratio of 1:1.49, significantly different from a 1:1 ratio, and a higher instantaneous growth rate in immature 1-year age group fish. Eagderi *et al.* (2020) examined 30 fish, 5.23-9.86 cm total length, from the Qareh Chay and found a *b* value of 2.87, isometric growth. The condition factor was 0.87-1.09, mean 0.98. Tork Haram Abadi *et al.* (2021) sampled 325 specimens in the winter of 2018. Male to female sex ratios in the populations studied showed there were no significant differences between males and females in three studied areas. The length-weight relationship in the population from the Golushjerd River was  $W = 0.0097TL^{3.15}$ , in the Tureh River was  $W = 0.0062TL^{3.25}$  and in the Yunji River was  $W = 0.0138TL^{2.98}$ . Growth patterns of the Golushjerd and Tureh rivers were positive allometric and of the Yunji River was isometric. The condition factor between ages showed, that for both males and females, the highest value was observed for all ages in the Yunji River. The highest value of this coefficient was observed for males in the Golushjerd River and the Yunji River at the age of 4<sup>+</sup> and in the Tureh River at 1<sup>+</sup> and 5<sup>+</sup>. Maximum growth rate in the Golushjerd and Yunji rivers for both males and females was at the age of 2<sup>+</sup> to 3<sup>+</sup> years and in the Tureh River at 1<sup>+</sup> to 2<sup>+</sup> years. The von Bertalanffy growth model for the Golushjerd River population was  $L_t = 172.10(1 - e^{-0.10(t+1.70)})$ , for the Tureh River population was  $L_t = 193.30(1 - e^{-0.07(t+2.47)})$ , and for the Yunji River population was  $L_t = 171.95(1 - e^{-0.09(t+2.39)})$ .

**Food.** Unknown.

**Reproduction.** Varzani *et al.* (2017), for their Qareh Chay and Mazdaqan Chay fish, found a fecundity range of 331-7,060 eggs with an average of 1,591 eggs.

**Parasites and predators.** Rahmati-holasoo *et al.* (2011) recorded plerocercoids of the cestode *Ligula intestinalis* from fish in the Latian Dam and described the histopathology.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** The type locality dried up about 25 years ago (Jouladeh-Roudbar *et al.*, 2015). However, Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern because of its wide distribution and relatively high numbers in two basins (one basin if *A. coadi* is distinct) although the species has been vulnerable to drought in recent years.

**Sources.** Type material:- *Alburnoides namaki* (CMNFI 1979-0461 and CMNFI 1979-0461A).

Iranian material:- CMNFI 1979-0254, 1, 63.8 mm standard length, Markazi, qanat at Shahabiyeh (ca. 33°52'N, ca. 50°24'E); CMNFI 1979-0255, 4, 40.6-50.9 mm standard length, Markazi, Bar River drainage 2 km west of Shahabiyeh (33°51'30"N, 50°23'E); CMNFI 1979-0459, 2, 25.1-56.2 mm standard length, Hamadan, stream 2 km south of Razan (35°22'N, 49°02'E); CMNFI 1979-0462, 1, 39.8 mm standard length, Markazi, Mazdaqan River (35°06'30"N, 49°40'30"E); CMNFI 1980-0156, 5, 34.1-50.6 mm standard length, Alborz, Karaj River below village (35°47'N, 50°58'E); CMNFI 1993-0154, 1, 79.4 mm standard length, Markazi, Sharra River near Far (34°03'N, 49°20'E); CMNFI 1993-0155, 1, 80.6 mm standard length, Markazi, Sharra River near Khosbijan (34°07'N, 49°23'E); CMNFI 2007-0074, 4, 33.1-41.8 mm standard length, Markazi, Qareh Chay 32 km west of Arak (34°03'N, 49°21'E); CMNFI 2007-0121, 3, 28.0-74.8 mm standard length, Hamadan, stream in Qareh Chay basin

north of Razan (ca. 35°25'N, 49°02'E); CMNFI 2008-0152, 1, 67.8 mm standard length, Namak Lake basin (no other locality data).

*Alburnoides nicolausi*  
Bogutskaya and Coad, 2009



*Alburnoides nicolausi*, Lorestan, Nurabad Stream, after Jouladeh-Roudbar *et al.* (2020).



*Alburnoides nicolausi*, a, 67.0 mm standard length, b, 46.0 mm standard length, VMFC AL201NI, Lorestan, Nurabad Stream, by Arash Jouladeh-Roudbar, after Mousavi-Sabet *et al.* (2015).

**Common names.** Khayateh-ye Karkheh (= Karkheh tailor fish), khayateh-e Nicolaus (= Nicholas or Nikolai tailor fish), ghabghaboo (= dewlap or double chin, although relevance unclear), lapak or lapek (meaning unknown), shebeh zury (= resembling zury, the latter being an unknown name) in Khuzestan.

[Karkheh spirilin, Nicholas' riffle minnow, Nicholas' spirilin, Simareh spirilin].

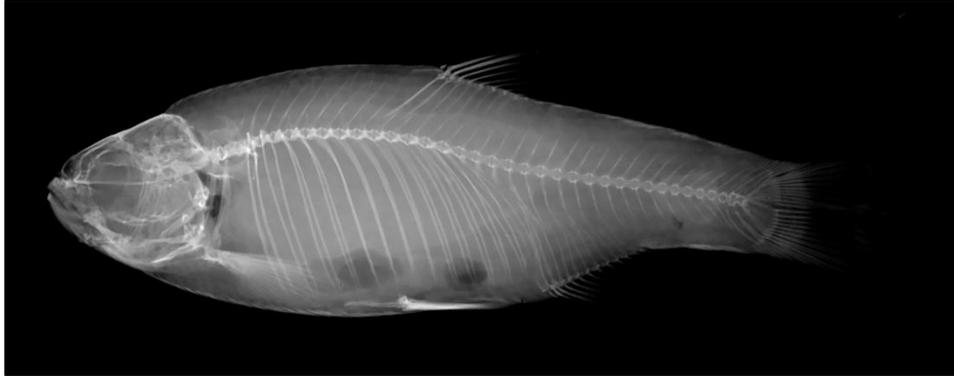
**Systematics.** The holotype (CMNFI 1979-0281) is a female, 75.0 mm standard length, Lorestan, stream in Simareh River drainage, 5 km south of Nurabad (34°03'30"N, 47°58'30"E) and paratypes (CMNFI 1979-0281A) comprise 164 specimens, 21.3-65.0 mm standard length, same data as the holotype. The species is named after a Latin male name Nicolaus, a derivative of the Greek Nikolaos (victory of the people); a Russian name Nikolay and an English name Nicholas, the names of, respectively, Nina Bogutskaya's elder son and Brian W. Coad's son, are also derivatives from Nicolaus.



*Alburnoides nicolausi*, holotype, CMNFI 1979-0281,  
James Maclaine @ Canadian Museum of Nature.



*Alburnoides nicolausi*, paratype, CMNFI 1979-0281A,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnoides nicolausi*, holotype, CMNFI 1979-0281,  
Noel Alfonso @ Canadian Museum of Nature.

Jouladeh Roudbar *et al.* (2015) were unable to distinguish this species based on 33 morphometric and five meristic characters. Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and found this species not to be distinct from *A. idignensis*. Eagderi *et al.* (2019) used the COI gene to elucidate the phylogeny of Iranian *Alburnoides* and grouped *A. nicolausi* in an *A. idignensis* complex, not the same as synonymising the species. Jouladeh-Roudbar *et al.* (2020) recognised both this species and *A. idignensis* as valid but presented no arguments. However, the low dorsal fin branched ray count of 7 (91.3%) is unusual in Iranian *Alburnoides*. The (few) specimens of *A. nicolausi* and *A. idignensis* analysed fall into two distinct groups that are congruent with the current taxonomy. They are very closely related. More molecular sequence data are needed, especially nuclear, to add to the mitochondrial data. No conclusions about synonymy, or taxonomy broadly, should be made based upon the limited molecular data presented. Eagderi *et al.* (2021) showed that this species is well-separated morphometrically from other Iranian *Alburnoides* species.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Nurabad Stream or River of the Tigris River basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** The body is moderately compressed and relatively thick. The upper body profile is convex similar to the lower profile. The head is deep. The snout is only slightly rounded, almost pointed. The mouth is oblique, slightly below than terminal, and the tip of the mouth cleft is slightly below a level of the lower margin of the pupil. The junction of the lower jaw and the quadrate is on about a vertical through the middle of the eye. The anal fin origin is somewhat behind a vertical from the posterior end of the dorsal fin base. The eye is of average size, the orbit diameter larger than the snout length and smaller than the interorbital width, caudal fin lobes are rounded and the fin is shallowly forked.

Dorsal fin branched rays 7-8, usually 7, anal fin branched rays 8-11, pectoral fin branched rays 11-14, and pelvic fin branched rays 6-7. Lateral line scales 42-50, scales between lateral line and dorsal fin origin 8-11, often 9-10, and scales around caudal peduncle 13-17, usually 14-16. A ventral keel between the pelvic and the anal fins is not sharp and is variably scaled: completely scaleless (9), scaled along about one-quarter to one-third of its length (9), scaled along half of its length (6), scaled along about two-thirds of its length (4) or completely scaled (2). There is a pelvic axillary scale and scales extend over the proximal bases of the anal fin forming a sheath. Total gill rakers number 5-9. Pharyngeal teeth are commonly 2,5-4,2 or

2,4-4,2. Total vertebrae number 38-40. The holotype has 38 total vertebrae.

Meristic values are:- dorsal fin branched rays 7(73) or 8(7) and anal fin branched rays 8(2), 9(12), 10(47) or 11(19). Abdominal vertebrae 19(23), 20(53) or 21(4), caudal vertebrae 18(15), 19(41) or 20(24), predorsal vertebrae 12(34) or 13(46), and total vertebrae 38(19), 39(53) or 40(8) (Bogutskaya and Coad, 2009; Mousavi-Sabet *et al.*, 2015).

**Sexual dimorphism.** The following characters were larger in females:- pectoral fin origin to pelvic fin origin distance, pelvic fin origin to anal fin origin distance, prepelvic fin length, and mouth width. The following were larger in males:- caudal peduncle length, pectoral fin length, pelvic fin length, longest dorsal fin ray length, longest anal fin ray length, pectoral fin length in pectoral fin origin to pelvic fin origin distance, and pelvic fin length in pelvic fin origin to anal fin origin distance.

**Colour.** Overall colour is light brown to silvery with the lower flank and belly quite pale. A few large flank blotches may be present, above and below the lateral line. The back is dark but predorsal and postdorsal stripes are evident. The lateral line is delineated by some darker pigment above and below but not as strongly as in the *A. petrubanarescui* holotype and obscured by background pigmentation on the caudal peduncle. Some fish almost entirely lack lateral line pigmentation while in others it is strongly developed. The pigment on scales above and below the lateral line (and below the mid-flank stripe) can be obvious and form a series of thin, discontinuous stripes, or it can be absent. The mid-flank stripe is weak and diffuse, fading anteriorly under the dorsal fin. The fins are mostly immaculate, with some melanophores lining rays of the dorsal and pectoral fins in particular. A thin line of yellow pigment can be evident separating the hypaxial and epaxial muscle masses, fading anteriorly or extending from head to tail. The pectoral fin unbranched ray is lined with melanophores on its inner margin, but not as strongly as in some other samples. Dorsal and anal fins can be quite heavily pigmented. The peritoneum is silvery with fine melanophores and some spots.

**Size.** Reaches 75.0 mm standard length, 88.0 mm total length (Rezamand *et al.*, 2018).

**Distribution.** The species is known from its type locality, a stream in the Simareh River drainage at Nurabad, Iran (Nurabad Stream after Mousavi-Sabet *et al.* (2017) and Norabad River after Jouladeh-Roudbar *et al.* (2020)). The Simareh (Seymareh) flows into the Karkheh (Qareh Su) River which enters the Hawr al Hawizeh (Hawr al Azim) on the Iran-Iraq border (Tigris River drainage). Nowferesti *et al.* (2014) reported it from Aligudarz, Lorestan presumably in the Aligudarz River, and Rezamand *et al.* (2016, 2018) reported it from the Huzian River, Lorestan although Jouladeh-Roudbar *et al.* (2020) regarded other identifications of this species outside the type locality as mis-identifications for *A. idignensis*.

**Zoogeography.** In tree diagrams (Bogutskaya and Coad, 2009) based on combined data, this species clustered together with another Tigris River basin species, *A. idignensis*.

**Habitat.** Habitat data is based on collection data in the type description. Fish were collected on 6 July 1977 at 2,000 m altitude, 19°C water temperature, clear water, pH 6.8, forested shore, stony river bed, moderate amounts of aquatic plants, and no other species taken.

**Age and growth.** Nowferesti *et al.* (2014) found a *b* value of 3.28 for 11 fish, 4.6-6.9 cm total length, from Aligudarz, Lorestan. Rezamand *et al.* (2016) found *b* values of 3.251-3.498 for fish from the Huzian River, Lorestan and later Rezamand *et al.* (2018) gave values of 3.494 for 28 females, 4.4-7.5 cm total length and 3.405 for 43 males, 3.9-8.8 cm total length from the same river. All the preceding may refer to *A. idignensis*. Mousavi-Sabet *et al.* (2017) examined 30 fish, 43.1-78.6 mm total length, from the Nurabad Stream and found a *b* value of 2.94.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported.

**Economic importance.** None.

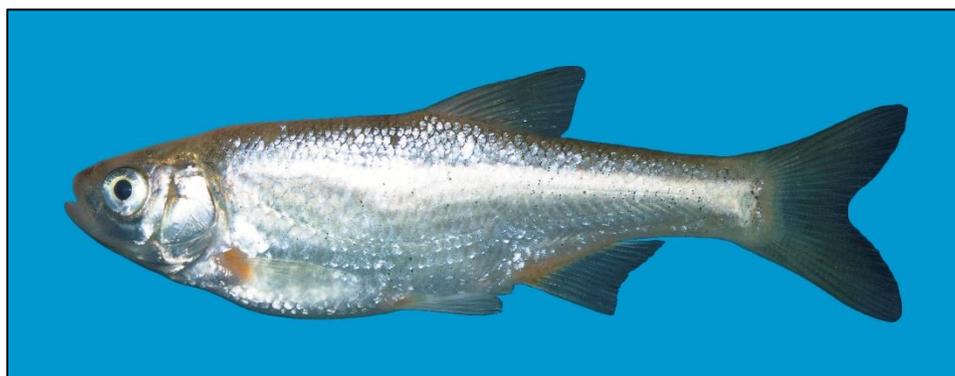
**Experimental studies.** None.

**Conservation.** Jouladeh-Roudbar *et al.* (2020) listed it as Critically Endangered because of its restricted distribution, unregulated exploitation of water resources for agriculture and seasonal use of pesticides on neighbouring fields.

**Sources.** Type material:- *Alburnoides nicolausi* (CMNFI 1979-0281 and CMNFI 1979-0281A).

*Alburnoides parhami*

Mousavi-Sabet, Vatandoust and Doadrio, 2015



*Alburnoides parhami*, North Khorasan, Atrak River at Baba Aman, Hamid Reza Esmaeili.

**Common names.** None.

[Atrak spirilin, Parham riffle minnow].

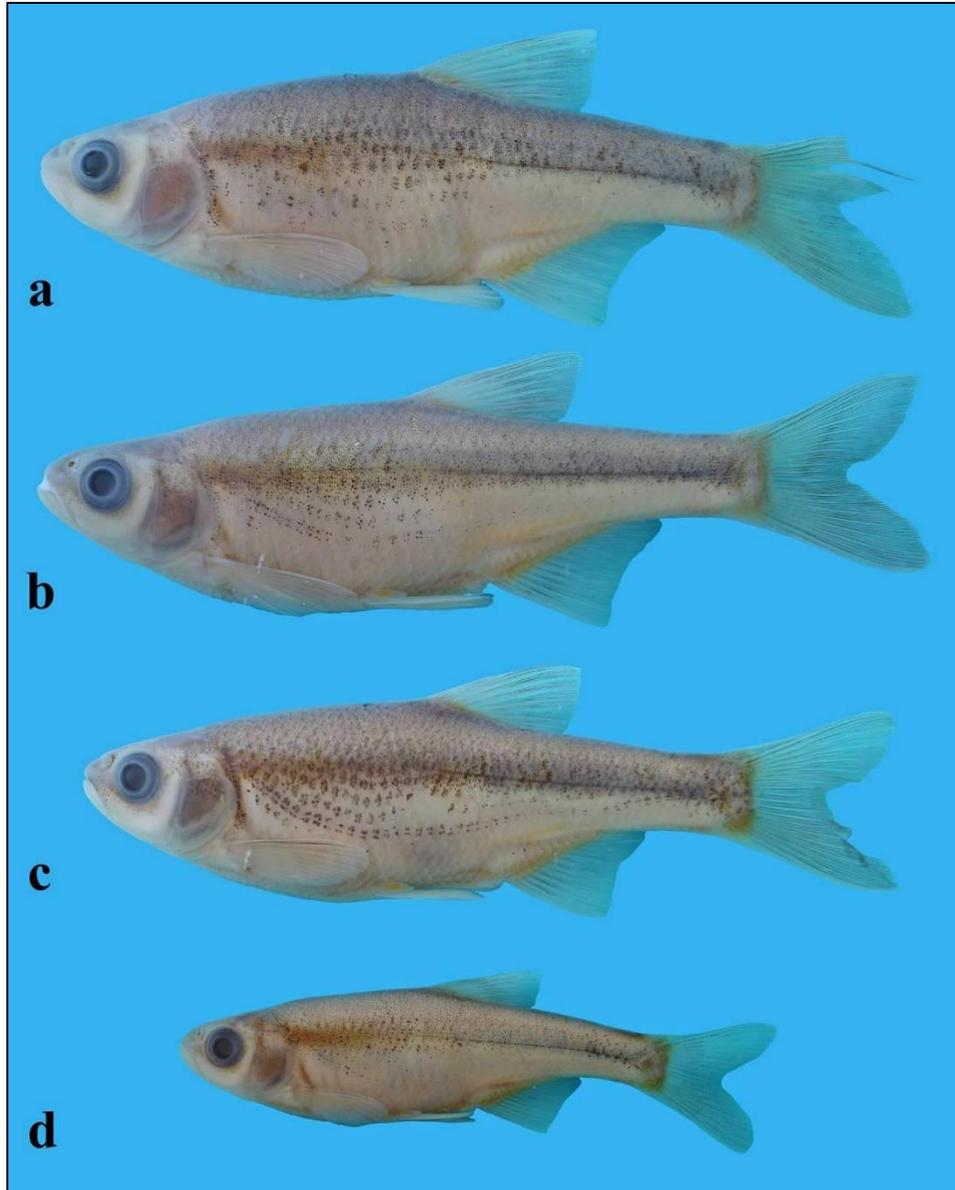
**Systematics.** The holotype is under VMFC-ALP3-H (VMFC = Vatandoust and Mousavi-Sabet Fish Collection, Tehran), 66.5 mm standard length, Iran, Khorasan-e-Shomali (= North Khorasan) Province, Baba-Aman Stream, Atrak River drainage, the southeastern Caspian Sea basin, 37°29'N, 57°26'E. Paratypes are under VMFC-ALP3-P1 to VMFC-ALP3-P45, 45, 39.9-62.0 mm standard length, and GUIC-ALP3-P1 to GUIC -ALP3-P4 (GUIC = Ichthyological Museum of the University of Gilan), 4, 43.1-53.5 mm standard length, collected with the holotype. The species name *parhami* is generally in honour of all the Iranian conservation officers who sacrificed their lives in order to keep the wild environment, and especially for Mr. Saeid Parham (1980-2009), the conservation officer in North Khorasan Province, who was killed in a battle with illegal hunters near the type locality of *Alburnoides parhami* (near the border of Turkmenistan).



*Alburnoides parhami*, a, holotype, VMFC-ALP3-H,  
b, paratype VMFC-ALP3-P7, 60.0 mm standard length, Hamed Mousavi-Sabet.



*Alburnoides parhami*, holotype, VMFC-ALP3-H, Hamed Mousavi-Sabet.



*Alburnoides parhami*, paratypes, a, 62.0 mm standard length, VMFC-ALP3-P1, b, 61.0 mm standard length, VMFC-ALP3-P2, c, 56.0 mm standard length, VMFC-ALP3-P3, d, 41.0 mm standard length, VMFC-ALP3-P5, Hamed Mousavi-Sabet.

Jouladeh-Roudbar and Eagderi (2019) examined 21 morphometric and 8 meristic characters as well as the COI gene of *A. parhami* and *A. holciki*, its closest relative, and concluded the former was a synonym of the latter. Esmaeili and Abbasi (2021) recognised this species as valid in their recent checklist and Pourshabanan *et al.* (2021) using cytochrome *b* also regarded the species as valid.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Atrak River basin of the eastern Caspian Sea. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by most commonly a sharp, scaleless ventral keel, a long, slightly pointed snout, a terminal mouth with the tip of the mouth cleft on a level

with the upper half of the pupil, the lack of well-marked spots or dark pigmentation in the lateral line canal, a large eye (orbit width about equal to interorbital width), lateral line scales 46-52, pharyngeal teeth commonly 2,5-5,2, dorsal fin branched rays usually 8, anal fin branched rays commonly 11-13, scale rows between lateral line and dorsal fin origin typically 10, total vertebrae 39-41, usually 40-41, caudal vertebral region equal or slightly longer than abdominal region (most frequent vertebral formulae 20+20 and 20+21), and predorsal vertebrae 12-13.

Meristic values are:- dorsal fin unbranched rays 3, branched rays 7(2), 8(47) or 9(1), anal fin unbranched rays 3, branched rays 11(4), 12(26), 13(24), 14(4) or 15(2), pectoral fin branched rays 11(18), 12(24), 13(7) or 14(1), and pelvic fin branched rays 6(6) or 7(44). Lateral line complete with 0-2 unpored scales at posterior end. Lateral line scales 46(1), 47(4), 48(23), 49(12), 50(5), 51(4) or 52(1), scales above lateral line to dorsal fin origin 8(1), 9(8), 10(39) or 11(2), scales below lateral line to anal fin origin 3(1), 4(47) or 5(2), and scales below lateral line to pelvic fin origin 3(3), 4(45) or 5(2). Total scale radii 16(7), 17(26), 18(14) or 19(3). Total gill rakers 6(2), 7(18), 8(27) or 9(3). Pharyngeal teeth are 2,5-5,2(8) or 2,5-4,2(2). Abdominal vertebrae number 19(1), 20(57) or 21(2), caudal vertebrae 19(2), 20(42) or 21(16), predorsal vertebrae 12(41) or 13(19), and total vertebrae 39(3), 40(42) or 41(15) (Coad and Bogutskaya, 2012; Mousavi-Sabet *et al.*, 2015).

**Sexual dimorphism.** Unknown.

**Colour.** Overall colouration is silvery, darker on the upper flank. Facial bones and the opercle are silvery. The dorsal and anterior margins of the opercle are yellow to orange. The posterior margin of the operculum is black and there is a black bar behind the operculum on the flank ending ventrally at the reddish anterior pectoral fin base. The bases of the pectoral, pelvic and anal fins and adjacent body are orange. The pectoral fin base may be redder than orange. The anal fin pigment is distally more extensive anteriorly on the fin rays and is at the base for most of the fin. In some fish there is an orange pigmentation at the fin base and an overall yellowish tinge to the fin. The caudal fin can have a yellowish tinge with a clear margin to the fin. The back and top of the head are light to dark grey, with an olive hue. The lower portion of the head and body are pearly-white. The upper margin of the pupil is yellow to orange. The flanks above the lateral line may have a golden or yellowish hue. Faint yellow spots occur in rows along the flanks. Rows of dark blotches are found along scale rows, formed by dark pigmentation concentrated on the centre of scales, more conspicuous above the lateral line and present only as scattered dark pigmentation below it. A diffuse, relatively narrow, dark stripe is present on the caudal peduncle. The lateral line is outlined by dark pigmentation, forming a weakly developed, often interrupted, but conspicuous longitudinal dark stripe. Dorsal and caudal fins have either some grey pigmentation or are dark grey. Pigmentation of preserved specimens is overall tan, darker dorsally. Horizontal rows of dark blotches formed by dark pigmentation are concentrated on the middle of scales, moderately conspicuous, above the lateral line. The lateral line has some scales with pores outlined with dark pigmentation, especially the most anterior scales. A narrow, dark mid-lateral stripe is present along the lateral septum, more discernible from a vertical through the dorsal fin forwards. Fins are mostly hyaline, with some black pigmentation lining the dorsal and caudal fins rays, the dorsalmost pectoral fin rays and the most anterior anal fin rays.

**Size.** Reaches 83.2 mm standard length.

**Distribution.** This species is known from the Caspian Sea basin where it is recorded from the Tabarak Dam and the Atrak River and Baba-Aman Stream in the Atrak River basin (Jouladeh Roudbar *et al.*, 2016; Mousavi-Sabet *et al.*, 2017).

**Zoogeography.** See under the genus.

**Habitat.** This species is found in rivers, streams and dams. The Baba-Aman Stream at the type locality had none-clear water, water flow was medium to fast, the stream width was about 3-5 m and maximum depth was up to 1.5 m, with grassy and bushy shores, submergent and emergent plants, and the stream bed was gravel and mud. Other species collected syntopically were *Capoeta gracilis* (= *C. razii*), *Luciobarbus mursa* and *Paracobitis atrakensis*. This species has been collected in one sample at 24°C, pH 6.0, conductivity 1.85 mS, river width 1-6 m, depth 20 cm, pebble and mud bottom, encrusting vegetation and a grassy shore.



Type locality of *Alburnoides parhami*, North Khorasan, Baba-Aman Stream, Atrak River basin, Hamed Mousavi-Sabet.

**Age and growth.** Mousavi-Sabet *et al.* (2017) examined 30 fish, 50.7-80.1 mm total length, from the Atrak River and found a *b* value of 3.37. Eagderi *et al.* (2020) examined 43 fish, 3.4-7.7 cm total length, from the Atrak River basin and found a *b* value of 3.07, isometric growth. The condition factor was 0.75-1.09, mean 0.93.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Confined to a single river basin in an arid region so threats are likely.

**Sources.** Mousavi-Sabet *et al.* (2015).

Iranian material:- CMNFI 1979-0486, 1, 27.8 mm standard length, Golestan, stream in Atrak River drainage (37°44'N, 56°18'E); CMNFI 2016-0050, 25, 57.4-83.2 mm standard length, Razavi Khorasan, Tabarak Dam on the Atrak River (37°10'24"N, 58°42'29"E).

*Alburnoides petrubanarescui*  
Bogutskaya and Coad, 2009



*Alburnoides petrubanarescui*, Turkey, upper Nazlu Chay, Lake Urmia basin,  
after Kaya (2020).

**Common names.** Khayateh-ye Orumiyeh or Oromiyeh (= Urmia tailor fish), lapak or lapek (meaning unknown).

[Banarescu's riffle minnow, Urmia or Urmian spirlin].

**Systematics.** The holotype is under CMNFI 1970-0558, female, 88.8 mm standard length, Iran, West Azarbayjan, Qasemlou Chay, Lake Urmia basin, ca. 37°21'N, 45°09'E. Paratypes are under CMNFI 1970-0558A, 51, 28.7-87.3 mm standard length, same locality as the holotype. The species is named after the late Petru Bănărescu who contributed significantly to our knowledge of the fishes of Eurasia.



*Alburnoides petrubanarescui*, holotype, CMNFI 1970-0558,  
James Maclaine @ Canadian Museum of Nature.



*Alburnoides petrubanarescui*, paratype, 65.5 mm standard length, CMNFI 1970-0558A, Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnoides petrubanarescui*, holotype, CMNFI 1970-0558, Noel Alfonso @ Canadian Museum of Nature.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Lake Urmia basin. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a small eye, the orbit width about equal to the snout length but markedly smaller than the interorbital width, caudal fin lobes rounded and the fin shallowly forked, a scaled but not sharp ventral keel behind the pelvic fins along the abdomen to the anus, a deep head with a stout snout which is markedly rounded, the mouth is subterminal and the tip of the mouth cleft is on the level below the lower margin of the eye, the junction of the lower jaw and the quadrate is on about a vertical through the anterior eye margin, and the anal fin origin is below the posterior end of the dorsal fin base.

Dorsal fin branched rays 7-9, almost equally 7 or 8, anal fin branched rays 8-13, commonly 9-10, pectoral fin branched rays 11-15, pelvic fin branched rays 6-7, total lateral line scales 44-51 (42-50 scales to posterior margin of hypurals), the lateral line over the pectoral and pelvic fins can be wavy rather than a smooth decurved line, scales above lateral line to dorsal fin 9-11, scales around caudal peduncle 14-19 (mostly 15-17), total gill rakers 6-8, pharyngeal teeth 2,5-4,2 (or other variants with four teeth on the right ceratobranchial), and total vertebrae 39-42. The holotype has 41 total vertebrae.

Meristic values are:- dorsal fin branched rays 7(24), 8(25) or 9(1) and anal fin branched rays 8(3), 9(21), 10(15), 11(5), 12(4) or 13(1). Abdominal vertebrae 20(3), 21(25) or 22(2),

caudal vertebrae 19(15), 20(14) or 21(1), predorsal vertebrae 13(18) or 14(12), and total vertebrae 39(1), 40(14), 41(14) or 42(1) (Bogutskaya and Coad, 2009; material below).

**Sexual dimorphism.** Unknown.

**Colour.** The lateral line is clearly delineated by darker pigment above and below, forming an evident pale line margined with dark. Overall colour is golden to olive. The operculum is silvery. The bases of the pectoral, pelvic and anal fins are orange. The belly and extreme lower flank are silvery. The upper iris margin of the pupil is yellow. Some pigment on flank scales above and below the lateral line give the impression of stripes. A mid-flank stripe is evident. The back is dark and obscures a predorsal and postdorsal stripe. The fins are mostly immaculate, with some melanophores lining the rays of the dorsal and pectoral fins. The unbranched pectoral fin ray is strongly lined with melanophores on its inner margin in some fish. The peritoneum is silvery with fine melanophores and some large spots.

**Size.** Attains 88.8 mm standard length (Bogutskaya and Coad, 2009).

**Distribution.** This species is found in the Lake Urmia basin in the Aji (= Talkheh), Balanoosh, Baranduz, Mardogh, Nazlu, Qasemlu, Simineh, Sufi and Zarrineh rivers (Banan Khojasteh *et al.*, 2012; Ghasemi *et al.*, 2015; Keivany and Zamani-Faradonbeh, 2016; Kaya, 2020).

**Zoogeography.** An endemic in the Lake Urmia basin, its closest relatives may lie in the Caspian Sea basin as shown with other Lake Urmia fish.

**Habitat.** Habitat data for the type locality (June 1962) were water temperature 18°C, fast current in stream, pebble and sand bottoms, shore grassy, much aquatic plant life, and other cyprinoids were *Alburnus atropatenae* and *Barbus cyri*.

**Age and growth.** Azh *et al.* (2012) gave a life span up to 3<sup>+</sup> years. Keivany and Zamani-Faradonbeh (2016) gave a *b* value of 3.19 for 34 fish, 2.25-7.53 cm total length, from the Talkheh (= Aji) River in the Lake Urmia basin.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** Ahmadiara *et al.* (2013) described the rate of infection of the cestode *Ligula intestinalis* in fish identified as *A. bipunctatus* (= *A. petrubanarescui*) from Maragheh, presumably the Sufi River.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Numerous sampling efforts at the type locality and around it have failed to locate modern material and the locality is polluted (Jouladeh-Roudbar *et al.*, 2015, 2020). Listed as Critically Endangered by Jouladeh-Roudbar *et al.* (2020) as, in addition to the above, the region has suffered drastically from drought, drying permanently or periodically many rivers in this region. The species may exist in some isolated spots or in dam reservoirs but was thought possibly to be extinct. However, Kaya (2020) recorded specimens from the upper reaches of the Nazlu Chay in Turkey just across the border from Iran. The Nazlu Chay drainage lies just north of the Baranduz Chay and Qasemlu Chay drainages. He noted that the original collection could have been mislabeled after Jörg Freyhof (pers. comm., 2019) but Vadim D. Vladykov's handwritten field label reads "Ghasemlou Chai June 27, 1962" and he also collected other fishes from the "Barandous Chai", which is nearby, on this date.

**Sources.** Type material:- *Alburnoides petrubanarescui* (CMNFI 1970-0558 and CMNFI 1970-0558A).

Iranian material:- CMNFI 2007-0097, 6, 38.2-54.6 mm standard length, West Azarbayjan, Baranduz Chay basin (ca. 37°16'N, ca. 45°08'E).

*Alburnoides qanati*  
Coad and Bogutskaya, 2009



*Alburnoides qanati*, Fars, Kor River, Jörg Freyhof.



*Alburnoides qanati*, Yazd, Harat, Hamd Reza Esmaeili.



*Alburnoides qanati*, Fars, Moshkan near Safashahr, Hamid Reza Esmaeili.



*Alburnoides qanati*, a, 65.0 mm standard length, b, 59.0 mm standard length, VMFC AL201QA, Fars, Kor River, Hamed Mousavi-Sabet.

**Common names.** Khayateh-ye Fars (= Fars tailor fish), khayateh-e qanati (qanat tailor fish), lapak or lapek (meaning unknown).

[Fars spirlin, Kor spirlin, qanat spirlin, qanat tailor fish (Tahami *et al.*, 2015; Jouladeh-Roudbar *et al.*, 2020)].

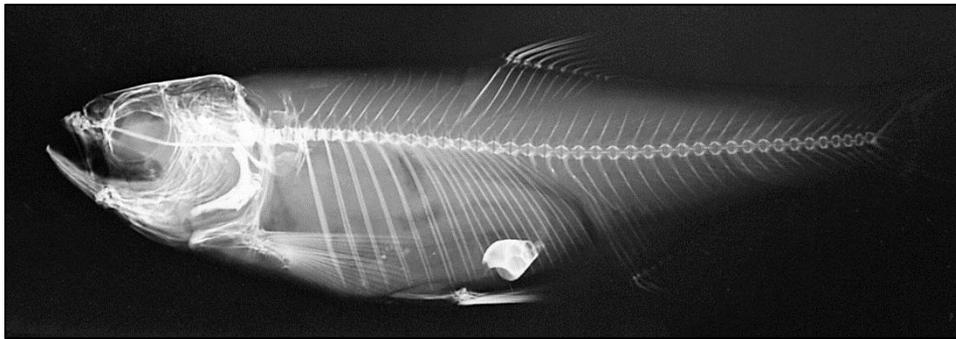
**Systematics.** The female holotype is under CMNFI 1977-0509, 81.5 mm total length, 65.0 mm standard length, Fars, at source and along stream of a qanat at Naqsh-e Rostam, Pulvar River system (29°59'30"N, 52°54'00"E). Paratypes are under CMNFI 1977-0510, 168 (not 178 as in type description) specimens, 24.9-72.5 mm standard length, same data as holotype. The species was named after the famous qanat system which taps groundwater to support human survival in desert regions and, incidentally, is a habitat for fishes.



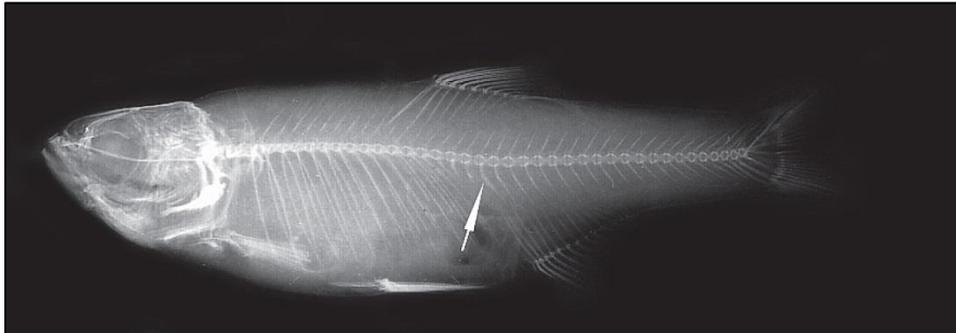
*Alburnoides qanati*, holotype, CMNFI 1977-0509, James Maclaine @ Canadian Museum of Nature.



*Alburnoides qanati*, paratype, CMNFI 1977-0510,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnoides qanati*, holotype, CMNFI 1977-0509,  
Noel Alfonso @ Canadian Museum of Nature.



*Alburnoides qanati*, 58.0 mm standard length, paratype, CMNFI 1977-0510,  
the arrow shows the first caudal vertebra, after Coad and Bogutskaya (2009).

Esmaeili *et al.* (2011) were able to separate individuals from three populations (Beiza, Moshkan and Safashahr) based on combined meristic and morphometric characters.

Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and found this species to be distinct.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution in the Kor River and Sirjan basins. Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a large eye, the orbit width exceeding both the snout length and the interorbital width, a scaled ventral keel behind the pelvic fins along the abdomen to the anus, lateral line scales commonly 43-47, dorsal fin branched rays commonly 8, anal fin branched rays 10-12, and total vertebrae 40-41.

The body is markedly compressed. The upper body profile is convex or, in larger specimens, slightly to markedly straightened while the lower profile is considerably convex. The ventral keel between the pelvics and anal fin is not sharp and is completely covered by scales in all specimens but four possessing a short scaleless portion of keel (about half of keel length) just in front of the anus. The dorsal fin outer margin is truncate to slightly rounded and the anal fin outer margin is truncate to slightly concave. The anal fin origin is behind the posterior end of the dorsal fin base. The snout is short and slightly pointed. The mouth is terminal to upturned, with the tip of the mouth cleft on a level from slightly above the middle of the eye to the upper margin of the pupil. The mouth cleft is always turned upward, never horizontal, the lower jaw slightly to moderately projecting relative to the upper jaw, and the junction of the lower jaw and the quadrate is on about a vertical through the anterior eye margin.

The lateral line is decurved and only the last few scales are elevated and on the mid-caudal peduncle. A pelvic axillary scale is present. The anal fin base is proximally overlain by flank scales. Total scale radii 8(1), 9(1), 10(4), 11(8), 12(20), 13(17), 14(16), 15(12), 16(7), 17(3) or 18(1). Esmaili and Gholami (2009) gave scanning electron microscopy details of scales in fish identified as *A. bipunctatus*, but probably this species.

Meristic values are:- dorsal fin unbranched rays commonly 3, 4 in three specimens only, dorsal fin branched rays 7(9), 8(76) or 9(1), anal fin unbranched rays 3, anal fin branched rays 10(8), 11(62) or 12(16), pectoral fin branched rays 13(4), 14(20) or 15(7), and pelvic fin branched rays 7(30). The lateral line is complete with none, 1 or 2 unpored scales at the posterior end of the lateral series. Lateral line scales 41(1), 42(2), 43(7), 44(7), 45(10), 46(13), 47(9), 48(3) or 49(1), scales above lateral line to dorsal fin origin 9(10), 10(18) or 11(3), scales below lateral line to pelvic fin origin 3(4), 4(20) or 5(7), and scales below lateral line to anal fin origin 4(17), 5(13) or 6(1). Total gill rakers 6(4), 7(4), 8(21) or 9(1). Gill rakers are very short and widely spaced, not touching the adjacent raker when appressed. Pharyngeal tooth counts are 2,5-4,2 in 10 fish examined with one additional fish being a variant with 2,4-4,0. The gut shape is a simple s-shape with an occasional specimen showing a slight flexure to the left of the anterior loop. Abdominal vertebrae 20(61) or 21(3), caudal vertebrae 20(38) or 21(26), predorsal vertebrae 13(53) or 14(11), and total vertebrae 40(35) or 41(29). The vertebral formula is 20+20(16), 20+21(12) or 21+20(2). Thus, the caudal vertebral region most commonly (in 93% of examined specimens) is equal to or slightly longer than the abdominal region, the mean difference between abdominal and caudal counts being -0.3. The holotype has 41 total vertebrae (Bogutskaya and Coad, 2009; Mousavi-Sabet *et al.*, 2015).

The general topography of cephalic sensory canals and numbers of pores is typical of most *Alburnoides*, as described by Bogutskaya (1988). The supraorbital canal is not lengthened in its posterior section and has 7-11, commonly 8-10 pores, with 2-4 (3 in 90%) and 5-7 (6 in 73%) canal openings on the nasal and frontal bones, respectively. The infraorbital canal has 10-15 pores (13 in 38%, 12 in 30%) with 4 (93%) or 5 canal openings on the first infraorbital. The preopercular-mandibular canal is complete, with 11-17, modally 13-16, pores (14 in 38%) with 3-6 (5 in 77%) and 7-10 (8 in 62%) canal openings on the dentary and preoperculum, respectively. The supratemporal canal is complete, with 4-7 (7 in 54%) pores.

**Sexual dimorphism.** Head length, pectoral fin length and pelvic fin length are longer in

males than in females.

**Colour.** Pigmentation of the holotype in 5% formalin consists of a dark lateral line dividing the hypaxial and epaxial muscle masses and a weakly developed stripe of black pigment on mid-flank prominent posteriorly on the caudal peduncle but fading over the pectoral fin and often interrupted anteriorly. The lateral line pores are lined by pigment dorsally and ventrally. A mid-dorsal line is apparent before the dorsal fin, weakly developed behind the fin. The fins are mostly hyaline with some black pigment lining the fin rays of the dorsal and caudal fins, the dorsal rays of the pectoral fins and the anterior rays of the anal fin.

Overall colouration in life is silvery to yellowish-brown with the bases of the pectoral, pelvic and anal fins pink to orange. The head below and behind the eye is silvery and there is a thin yellow bar at the anterior margin of the operculum. The flank scales may have little or no pigment or large numbers may be dark (but with a pale surround) giving the flanks above and below the lateral line a spotted appearance and, since scale rows are in lines, an appearance of interrupted stripes. An orange line parallels the anal fin base and the lateral line, lying midway between the two. The ventral surface of the head between the dentaries may be yellow-orange and similarly coloured spots may be found on either side of the dorsal mid-line extending along the whole body. Faint yellow spots occur in rows along the flanks also. Pigmentation in preserved fish is as described for the holotype although the lateral stripe is weakly-developed in some specimens, the mid-flank band of spots of black pigment may be variably developed, and the lateral line may be clearly or only faintly edged by pigment. The peritoneum is rarely dark brown but usually is white-grey to light brown with black spots.

**Size.** Attains 11.9 cm total length (Tahami *et al.*, 2015).

**Distribution.** This species is known from the Kor River and Sirjan basins. In the Kor River basin recorded from the Ghadamgah and Moshkan Spring-Stream systems, Kaftar Lake, Kor, Marghan and Pulvar rivers, Gomban Spring and Sarab-e Beyza (= Beiza Spring) (Esmaeili and Gholami, 2009; Teimori *et al.*, 2010; Tahami *et al.*, 2015, 2018; Gholamifard and Kafaei, 2021); and in the Sirjan basin reported from the Masih Spring at Harat (or Herat) at 30°01.196'N, 54°20.33'E (material from H. R Esmaeili, 2011; cytochrome *b* data also places these fish with *A. qanati* (H. R. Esmaeili, 6 October 2011; Jouladeh Roudbar *et al.*, 2016)).

**Zoogeography.** This is the southernmost *Alburnoides* species and may have entered the Kor River basin by headwater capture from the Tigris-Euphrates River basin or via a route from the Persis basin.

**Habitat.** This species is found in rivers, streams, lakes, dams, springs, qanats and irrigation channels. The qanat stream in the Pulvar River basin at 1500 hours on 6 October 1976 had clear and colourless water, a temperature of 21°C, pH 6.8, conductivity 0.475 mS, the current was slow to medium, stream width was about 2 m and maximum depth was up to 1 m, the shore was grassy, plant life in the stream consisted of encrusting and submergent types, and the stream bed was gravel and mud. The Harat locality was at an altitude of 1,585 m, pH 8.17, dissolved oxygen 7.25 mg/l, and temperature 22.9-23.3°C. Other localities had a temperature range of 16-22°C, pH 5.9-6.8, conductivity 0.48 mS, stream width 1-3 m, water depth 75 cm, water clear, slow to medium current, concrete, bedrock, stone, gravel and mud bottoms, encrusting, submergent, emergent and floating vegetation including filamentous algae and reeds.



Type locality of *Alburnoides qanati*,  
Fars, qanat mouth and stream origin at Naqsh-e Rostam, Brian W. Coad.



Habitat of *Alburnoides qanati*, Yazd, Harat, Hamid Reza Esmaeili.

**Age and growth.** Tahami *et al.* (2015) examined fish from the Moshkan Spring-Stream system and found  $b$  values were 3.3-3.45 for 219 females, 21.02-102.96 mm standard length, and 3.32-3.44 for 168 males, 20.76-75.06 mm standard length, asymptotic length ( $L_{\infty}$ ) = 123.9 mm and growth coefficient ( $K$ ) = 0.31/yr for females and 93.0 mm and 0.49/yr for males, growth performance index ( $\phi'$ ) = 8.47 for females and 8.35 for males, total mortality ( $Z$ ) = 1.56/yr for

females and 1.14/yr for males, and natural mortality ( $M$ ) = 0.44/yr for females and 0.65/yr for males. Males grew rapidly and initially and reached a larger size earlier in life than females. Females grew larger than males. Mortality parameters were lower as this spring-stream system has no predators compared to other *Alburnoides* spp. populations in Iran. Mousavi-Sabet *et al.* (2017) examined 30 fish, 48.3-75.2 mm total length, from the Kor River and found a  $b$  value of 3.11. Eagderi *et al.* (2020) examined 35 fish, 5.81-10.4 cm total length, from the Kor River and found a  $b$  value of 3.11, isometric growth. The condition factor was 0.74-1.09, mean 0.93.

**Food.** Tahami *et al.* (2015) found fish from the Moshkan Spring were omnivores feeding on Cyanophyta, Arthropoda (*Gammarus* and Trichoptera with the highest frequency), Bacillariophyta, Chlorophyta and Euglenophyta. An x-ray of the holotype of *A. qanati* shows a snail in the gut.

**Reproduction.** Tahami *et al.* (2018) studied reproduction in the Moshkan Stream based on 395 fish. The sex ratio was 1:1, except for those in January and April when they were biased in favour of females. Based on the percentage of the late gonad maturation stage (V) and high frequency of large oocytes (up to 0.7 mm), it was concluded that spawning occurred in spring with its peak in April. These results were in accordance with the three reproductive indices (gonadosomatic, modified gonadosomatic and Dobriyal). Absolute fecundity was between 732 and 2,368 (2,567 in a table) eggs and relative fecundity 9.9-27.4 eggs/g body weight. Studies on the eggs by scanning electron microscopy revealed they were adhesive, which could explain its low fecundity compared to other cyprinoids during spring.

**Parasites and predators.** None reported.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** The numbers and wider distribution of this species should be researched as it is known from only two basins. Jouladeh-Roudbar *et al.* (2020) however listed it as of Least Concern since it has a relatively large distribution range, is abundant to very abundant and lacks any known widespread threat. Esmaeili *et al.* (2011) found morphological heterogeneity between three samples and suggested that this be considered in conservation management and stock enhancement programs, especially during drought conditions in the region.

**Sources.** Type material:- *Alburnoides qanati* (CMNFI 1977-0509 and CMNFI 1977-0510).

Iranian material:- CMNFI 1979-0060, 4, 21.0-35.4 mm standard length, Fars, spring and jube, 7 km north of Sa'adatabad (30°06'N, 53°12'E); CMNFI 1979-0069, 3, 35.4-56.2 mm standard length, Fars, qanat at Naqsh-e Rostam (29°59'30"N, 52°54'E); CMNFI 2008-0257, 2, 57.2-61.0 mm standard length, Fars, Marghan River near Sepidan (30°30'14"N, 51°53'19"E).

### *Alburnoides samiii*

Mousavi-Sabet, Vatandoust and Doadrio, 2015



*Alburnoides samiii*, Gilan, Haviq River, Hamid Reza Esmacili.



*Alburnoides samiii*, Gilan, Kargan River, Hamid Reza Esmacili.



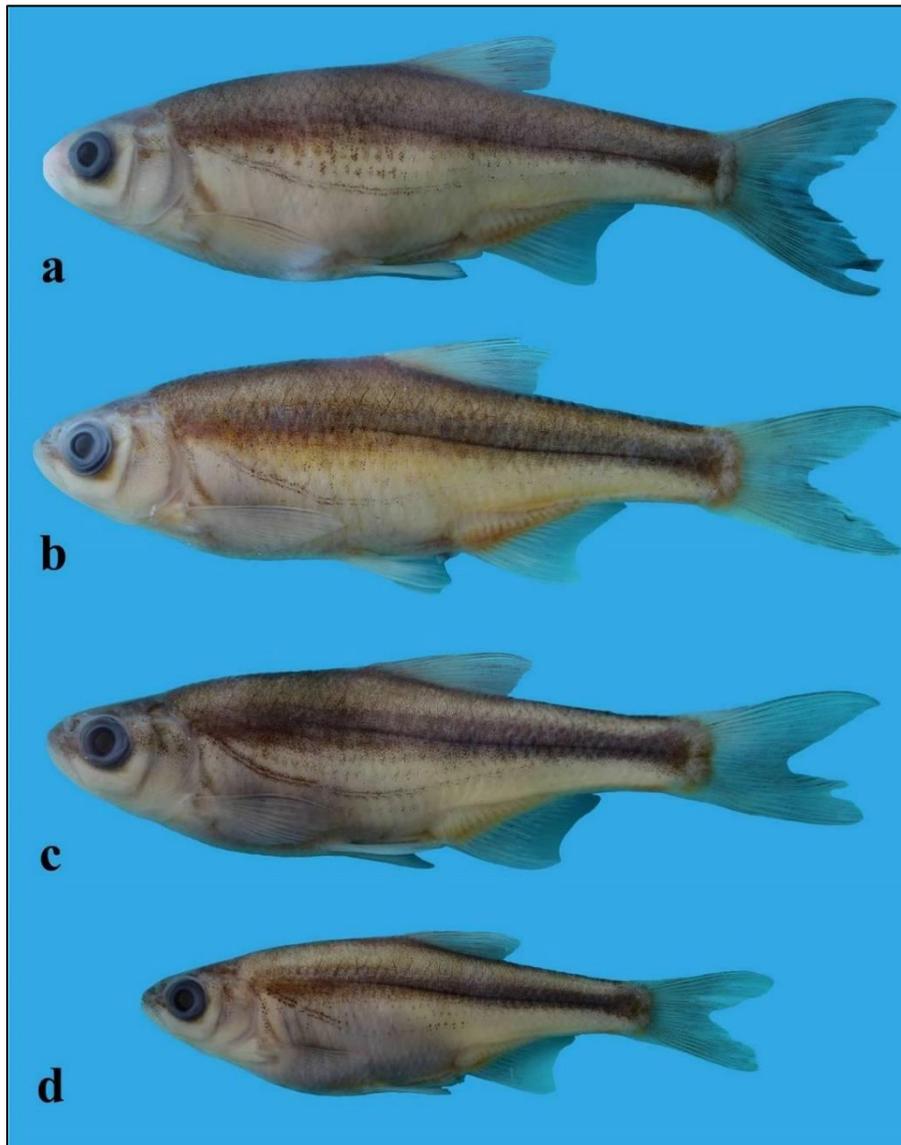
*Alburnoides samiii*, a, 67.0 mm standard length, b, 59.0 mm standard length, Gilan, Tutkabon Stream, Hamed Mousavi-Sabet.

**Common names.** Khayateh-e Samii (= Samiii's tailor fish), lapak or lapek (meaning unknown). [Samii riffle minnow, Samiii's spirlin, Sefidrud spirlin].

**Systematics.** The holotype is under VMFC-ALS4-H (VMFC = Vatandoust and Mousavi-Sabet Fish Collection, Tehran), 75.9 mm standard length, Guilan Province, upper Sefidroud River drainage, Tutkabon Stream, 36°50.756'N, 49°35.021'E. Paratypes are under VMFC-ALS4-P1 to VMFC-LS4-P45, 45, 52.9-81.5 mm standard length and GUIC-ALS4-P1 to GUIC-ALS4-P4 (GUIC = Ichthyological Museum of the University of Gilan), 4, 56.2-63.5 mm standard length, collected with the holotype. The species name *samiii* is in honor of Professor Doctor Majid Samii the world-famous Iranian neurosurgeon and medical scientist, born 19 June 1937 in Rasht, the capital city of Gilan Province, the region where the type locality of the new species is located.



*Alburnoides samiii*, holotype, VMFC-ALS4-H, Hamed Mousavi-Sabet.



*Alburnoides samiii*, paratypes, a, 75.0 mm standard length, VMFC-ALS4-P2, b, 76.0 mm standard length, VMFC-ALS4-P3, c, 68.0 mm standard length, VMFC-ALS4-P4, d, 53.0 mm standard length, VMFC-ALS4-P5, Hamed Mousavi-Sabet.

Eagderi *et al.* (2013) examined fish identified as *A. eichwaldii* from the Sefid (= *A. samiii* by distribution; and for others below), Valam and Gorgan (both = *A. tabarestanensis*) river basins morphometrically and found habitat-associated morphological divergence, phenotypic plasticity and evolutionary changes in body shape, as well as geographical distance being a factor. Fish from two streams in the Sefid River basin were not significantly different. Haghhighy *et al.* (2013) compared fish identified as *A. eichwaldii* morphometrically from the Kargan (= *A. samiii*) and Chalus (= *A. tabarestanensis*) rivers and were able to separate the two populations, attributing the variables to environmental factors such as water flow, river slope, physicochemical conditions of the water and feeding conditions. Astara, Kargan and Lamir (= Lomir) river populations in Gilan identified as *A. eichwaldii* were distinguishable on morphometry (Haghhighy *et al.*, 2013). Eagderi *et al.* (2014) compared fish identified as *A. eichwaldii* morphometrically above and below the Tarik Dam on the Sefid River, finding a smaller head, shorter snout, smaller caudal peduncle depth and smaller eye diameter in the upstream population, perhaps related to altered habitats and hydrological conditions. Haghhighy *et al.* (2015) compared fish from the Kargan and Lamir (= Lomir) rivers identified as *A. eichwaldii* finding meristic characters (caudal peduncle scales, scales above the lateral line and anal fin rays) could separate the populations but not morphometric characters. However, they cited nine meristic and 19 morphometric characters that were significantly different between the populations. Hosseini *et al.* (2016) described the genetic structure of fish identified as *A. eichwaldii* from three sections of the Polrud (= Pol-e Rud) using five microsatellite markers, finding an acceptable level of allelic richness and considerable genetic diversity. Vajargah and Hedayati (2014) examined morphometrically 35 fish identified as *A. eichwaldii* from the Vajargah River, Gilan (appropriately) both before, and six months after, preservation in 10% formalin. Total and standard length showed shrinkage while head length increased, the latter attributed to water and formalin absorption in gill tissue. Jahangiri and Shabany (2016) studied microsatellite polymorphism in fish identified as *A. eichwaldii* from the Kaboodval and Sefid rivers and found allelic diversity and genetic variation were at an acceptable level, most variation was within populations and genetic distance indicated that the populations were separate (now *A. tabarestanensis* and *A. samiii* respectively). Mousavi-Sabet and Heidari (2019) investigated the morphology of 30 fish from above, and 30 fish below, the Sefid River dam and a discriminant analysis classified 97.1% of individuals into their original population. Different habitat conditions caused by the dam may have led to different morphologies. Vajargah *et al.* (2020) examined 100 specimens morphometrically from the Toolkhone River, Gilan from populations isolated above and below a flood dam about 10 years ago. Significant differences were found in morphological variables associated with hydrodynamic balance and swimming ability despite this short separation time, namely a more streamlined body, smaller body width and total length, upstream where water velocity was higher.

Levin *et al.* (2018) used DNA barcoding (cytochrome c oxidase subunit 1) to assess the *Alburnoides* species of the Caucasus and neighbouring areas and found this species to be distinct.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution principally from the Sefid River basin (or just east) and then west in the Caspian Sea basin of Iran (except the Aras River basin in Iran which has *A. eichwaldii*, *q.v.*). Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** This species is characterised by a terminal mouth, with the tip of the mouth cleft on a level with the middle of the eye or below, a mostly or completely scaled ventral keel, the lack of well-marked spots or dark pigmentation in the lateral line canal, the dorsal fin outer

margin truncate to slightly concave, the anal fin outer margin markedly concave, a large eye (eye diameter about equal to interorbital width), a long and shallow caudal peduncle (its length 22.8-26.5%, mean 24.5%, in standard length), a shallow head (head depth 61.2-74.6%, mean 68.9%, in head length), caudal fin lobes are pointed and the fin is clearly forked, dorsal fin branched rays 7-9, usually 8, anal fin branched rays 10-16, pectoral fin branched rays 11-16, usually 12-13, pelvic fin branched rays 6-8, usually 7, lateral line scales 41-56, total gill rakers 5-10, total vertebrae 39-42, commonly 40-41, predorsal vertebrae 11-14, commonly 12-13, abdominal vertebrae 19-21, and caudal vertebrae 19-22.

Meristic values are:- dorsal fin branched rays 7(9), 8(195) or 9(5), anal fin branched rays 11(10), 12(59), 13(112), 14(57), 15(12) or 16(1), pectoral fin branched rays 11(9), 12(30), 13(54), 14(61), 15(21) or 16(6), and pelvic fin branched rays 6(8), 7(159) or 8(11). Lateral line complete with 0-2 unpored scales at the posterior end of the lateral series. Lateral line scales 43(4), 44(5), 45(24), 46(26), 47(27), 48(28), 49(24), 50(15), 51(12), 52(7), 53(1), 54(2), 55(2) or 56(1), scales above lateral line to dorsal fin origin 8(4), 9(41), 10(67), 11(54), 12(9) or 13(2), scales below lateral line to anal fin origin 3(8), 4(60), 5(65), 6(42) or 7(2), scales below lateral line to pelvic fin origin 3(6), 4(87), 5(72), 6(11) or 7(3), and scales around the caudal peduncle 14(1), 15(9), 16(33), 17(29), 18(35) or 19(8). Total scale radii 15(4), 16(14), 17(14), 18(16) or 19(2). Total gill rakers 5(1), 6(4), 7(35), 8(79), 9(54) or 10(5). Pharyngeal teeth are 2,5-4,2(10). Abdominal vertebrae number 19(41), 20(108) or 21(16), caudal vertebrae 19(9), 20(79), 21(76) or 22(2) predorsal vertebrae 11(1), 12(73), 13(84) or 14(7), and total vertebrae 39(5), 40(96), 41(62) or 42(2). The caudal vertebral region is most commonly equal to the abdominal region or one vertebra longer than it. Most common vertebrae formulae are 19+20, 19+21, 20+20 or 20+21 (Bogutskaya and Coad, 2009; Coad and Bogutskaya, 2012; Mousavi-Sabet *et al.*, 2015; material below).

**Sexual dimorphism.** A fish from CMNFI 1979-0452, 51.2 mm standard length caught on 8 June 1978, has very small tubercles on the top of the head and on the side of the head in the opercular region. Slightly larger ones are present along the mid-line of the back to the dorsal fin origin with 1-2 on each rear scale margin. Tubercles on the back behind the dorsal fin are only present near the caudal fin. Scales over the anal fin have 1-4 tubercles lining the scale margin. Tubercles are also present on scales on the upper flank and on the lower flank from the level of the end of the dorsal fin back to the caudal fin. Tubercles are present on the unbranched and up to six branched rays of the pectoral fin, and follow the terminal branches of the rays. The pelvic fin has a similar pattern on up to four branched rays in addition to the unbranched ray. All dorsal and anal largest unbranched and all branched rays bear tubercles.

**Colour.** Overall colouration is silvery, with the bases of the pectoral, pelvic and anal fins orange. The back and top of head are light to dark grey, with an olive hue. The lower portion of the head and body are pearly-white. Facial bones and opercle are silvery. The flanks above the lateral line may have golden and/or cobalt-blue hues. Faint yellow spots occur in rows along the flanks. Faint dark pigmentation on flank scales above the lateral line form diffuse stripes, and are present only as scattered dark pigmentation below it. Dorsal, anal and caudal fins have either some grey pigmentation or are dark grey. Preserved fish are overall tan to cream, darker dorsally. Horizontal rows of dark blotches formed by dark pigmentation are concentrated on the middle of scales, moderately conspicuous, above the lateral line. The lateral line has some scales with pores outlined with dark pigmentation, especially the anteriormost scales. A relatively thick dark stripe is present at the caudal peduncle. A narrow dark midlateral stripe runs along the lateral septum, less discernible from the vertical through the dorsal fin onwards. Fins are mostly

hyaline, with some black pigmentation lining dorsal and caudal fins rays, dorsalmost pectoral fin rays and anteriormost anal fin rays.

**Size.** Reaches 11.6 cm total length (Asadi *et al.*, 2017).

**Distribution.** This species is recorded from the Caspian Sea basin. All *Alburnoides* from principally the Sefid River basin (or just east) and west in the Caspian Sea basin of Iran (except the Aras River basin in Iran) are here allocated to *A. samiii*. There may be some *A. eichwaldii* (*q.v.*) in the westernmost Caspian Sea basin of Iran adjacent to Azerbaijan but DNA data is needed to confirm this. There may be some overlap in distribution with *A. tabarestanensis* as far east as the Chalus River (51°25'E) but this remains to be refined (Jouladeh-Roudbar *et al.*, 2020; and see below under *A. tabarestanensis*).

Found in the Alamut, Astara, Barkili, Chalkheh, Chavrud, Chelond, Chelvand, Chenar Rudkhan, Chubar, Dorudkhan, Gohar, Haviq, Kargan, Khow'in, Lasht Nesha', Lavandevil, Lisar, Lomir, Masoleh, Masuleh-Rukhan, Molahadi, Nahang Roga, Nesa, Pir Bazar, Polrud (= Pol-e Rud), Qal'eh, Qalehrudkhan, Qezel Owzan, Safa (presumably Shafa), Sajas, Sefid, Shafa, Shah, Shahrbijar, Shalman, Siah, Taleghan (= Taleqan), Toolkhone, Tutkabon, Vajargah, Zanjan and Zalki (presumably Zeleki) rivers, the Karfestan Ab-bandan at Rudsar, the Anzali Talab and tributaries, and the Golabar, Manjil, Nazdik, Taham, Tarik and Zire dams (Karimpour, 1998; Nazari, 2002; Aghili *et al.*, 2008; Abdoli and Naderi, 2009; Ashoori, 2010; Mirzajani, 2010; Mirzajani *et al.*, 2012; Seifali *et al.*, 2012; Haghhighy *et al.*, 2013; Vajargah and Hedayati, 2014; Mousavi-Sabet *et al.*, 2015; Zamani Faradonbeh *et al.*, 2015; Jouladeh Roudbar *et al.*, 2016; Abbasi *et al.*, 2017; Babaei, 2017; Matveyev *et al.*, 2017; Boroumandi *et al.*, 2018; Shahnazari *et al.*, 2020; Vajargah *et al.*, 2020; Aazami and Alavi Yeganeh, 2021; Abbasi *et al.*, 2021, 2021).

Also recorded via DNA barcoding in the Lenkoran River of Azerbaijan where it co-occurs with *A. eichwaldii* (Levin *et al.*, 2018), indicative perhaps of a presence in neighbouring Iran.



Gilan, Gohar River in Rasht  
(Gohar Rud (The river in 2008 Snow) – panoramio, CC BY-SA 3.0, Mehrab Pourfaraj).

**Zoogeography.** See under the genus.

**Habitat.** This species is found in rivers and streams, and may occur in Caspian Sea estuaries. The upstream portion of Sefid River at the type locality had clear water, water flow was medium, the stream width was about 5-15 m and maximum depth was up to 1.5 m, and the stream bed was rock and gravel. Other species collected were the cyprinids *Barbus lacerta* (= *B. cyri*), *Capoeta gracilis* (*sic*, presumably *C. razii*), *Luciobarbus capito*, *L. mursa* and *Squalius cf. orientalis* (= *S. turcicus*) the cobitid *Cobitis keyvani*, the nemacheilid *Oxynoemacheilus bergianus* and the gobiid *Ponticola iranicus*.



Type locality of *Alburnoides samiii*, Gilan, Tutkabon River, upper Sefid River basin, Hamed Mousavi-Sabet.

This species, identified as *A. eichwaldii*, had the highest frequency in the Siah River (Sefid River basin) especially in upstream reaches (Asadi *et al.*, 2014a). It preferred well-oxygenated water, low in pollution, with hard stream beds. Asadi *et al.* (2014b) also found the main habitat requirements governing presence in the Tutkabon River (a Sefid River tributary) of fish identified as *A. eichwaldii* were depth and width of the river. Asadi *et al.* (2016) examined this species (as *A. eicwaldii, sic*) in the Tootkabon (= Tutkabon) River at 13 sites. They found this species with *Alburnus filippii*. The sampling sites were 130-230 m above sea level, 15-75 cm water depth, 1.5-13 m wide, 0.35-0.71 m/s water velocity, 0.4-2.4% slope, stone diameter 10-50 cm and also cobble and bedrock substrate, the most available cover was boulders, and the riparian habitat was deciduous forest. The habitat selection pattern of *A. samiii* was elevation higher than 180 m, water depth greater than 50 cm, channel width less than 10 m, channel slope 0.5-1.5%, water velocity less than 0.72 m/s, bedrock substrate, average diameter of bed stones 30-50 cm, and deciduous forest and residential areas as the riparian type. This fish mostly selected upper parts of the river with higher water velocity, greater depth, and bedrock and larger bed stone substrates. These factors provided protection from predators, ameliorated seasonal changes in habitat, provided spawning habitat and allowed periphyton growth for food. The selection of deciduous forest and residential areas (rather than grassland or unvegetated riparian

areas) could be associated with organic matter input and the development of the riverine food chain. Mansouri-Chorehi *et al.* (2016) described a sample site from the lower Sefid River as 9.4-26.7°C, pH 7.29-8.04, dissolved oxygen 5-10 mg/l and water hardness 175.0-199.5 mg/l. Zarkami *et al.* (2019) examined fish identified as *A. eichwaldii* (presumably *A. samiii*) from seven sites, mouth to source, of the Shafarud or Shafa River for 42 fish presence and 42 fish absence data and found water quality variables had more contribution to the prediction than physical-habitat ones. The important variables were dissolved oxygen, pH, water temperature, river depth, electric conductivity, total hardness, nitrite, orthophosphate and sulphate. Three of the selected variables (dissolved oxygen, water temperature and pH) might increase the probability of fish presence.



Habitat of *Alburnoides samiii*, Gilan, Shafa River, Arash Jouladeh-Roudbar.

**Age and growth.** Mansouri-Chorehi *et al.* (2015) gave a  $b$  value of 2.9385 for 46 fish, mean total length 78.16 mm, from the Sefid River identified as *A. eichwaldii* (= *A. samiii* here and below). Zamani Faradonbeh *et al.* (2015) found a  $b$  value of 3.056 (isometric growth) and a condition factor of 0.89 for 62 fish identified as *A. eichwaldii*, 48.8-101.4 mm total length, from the Tutkabon River. Mansouri-Chorehi *et al.* (2016) examined 312 fish, 4.5-11.2 cm total length, from the Sefid River and the age range was 1<sup>+</sup> to 3<sup>+</sup> years, the majority was 2<sup>+</sup> years old (56.09%), some were 1<sup>+</sup> (30.77%) and a small percentage was 3<sup>+</sup> (13.14%). Sexual maturity was at 45 and 49 mm total length (1<sup>+</sup> in age) for females and males respectively. The overall ratio of females to males was 1:1.19. Mousavi-Sabet *et al.* (2016) examined 311 fish, 4.5-11.2 cm total length (the same sample as the preceding) and found a  $b$  value of 3.086. Values for 152 males, 127 females and 32 immature fish were 3.018, 3.155 and 3.362 respectively.  $K$  values in males and females were 0.76-2.76 and 0.78-1.46 respectively, with minimum values found in September and June and maximum values in June and February respectively. Amoui *et al.* (2017) examined fish from the Sefid River including 126 males, 44-95 mm total length, and 266 females, 36-102 mm, collected in the spawning season. The female:male sex ratio was 2.1:1, the length-weight relationship was  $W = 0.000007L^{3.11}$  through the sampling period, and age was

determined as 1<sup>+</sup> to 4<sup>+</sup> years. Asadi *et al.* (2017) gave a *b* value of 2.985 for 52 fish, 24-116 mm total length, identified as *A. eichwaldii* from the Shahrbijar River, Gilan with a total length condition factor of 1.01. Mansouri-Chorhi *et al.* (2017) found a *b* value of 3.028 (positive allometric growth) for 50 fish from the Sefid River. Mousavi-Sabet *et al.* (2017) examined 30 fish, 62.2-101.2 mm total length, from the Sefid River and found a *b* value of 3.26. Eagderi *et al.* (2020) examined 41 fish, 6.43-10.83 cm total length, from northern Gilan and found a *b* value of 3.27, isometric growth. The condition factor was 0.8-1.39, mean 1.02.

**Food.** See under genus.

**Reproduction.** Mansouri-Chorehi *et al.* (2016) found the spawning period in the lower Sefid River started in May and continued until late September at 19.7-22.8°C. Oocytes ranged from 0.1 to 1.7 mm with a mean of 0.732 mm. They were largest in April (mean 1.1 mm) and May (1.14 mm) and lowest in November (0.51 mm). There was a peak in the number of yellowish-yolk oocytes (1.0-1.7 mm diameter) in May. The absolute fecundity varied from 763 to 2,901 eggs, mean 1,571.1, and relative fecundity was 88 to 412, mean 202.7. Fish examined by Amoui *et al.* (2017) from the Sefid River had the most frequent oocyte diameter at 0.6 and 0.7 mm with maximum oocyte diameter at 2.0 mm. The average potential and relative fecundities were calculated at 1,802 eggs and 351.6 eggs/g respectively.

**Parasites and predators.** Pazooki *et al.* (2005) recorded *Trichodina perforata* from fish identified as *A. bipunctatus* (presumably *A. samiii*) and Pazooki *et al.* (2006) recorded the monogeneans *Dactylogyrus vistulae*, *Gyrodactylus* sp. and *Paradiplozoon* sp., also from this species and both in waterbodies of Zanzan Province. Jahangiri *et al.* (2014) found bivalve mollusc glochidia in 3 of 25 fish sampled from the Sefid River identified as *A. eichwaldii*. Ashoori (2010) recorded that little egret chicks (*Egretta garzetta*) in the Karfestan Ab-bandan, Rudsar, Gilan Province were fed *A. bipunctatus eichwaldii* (= *A. samiii*).

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Mansouri-Chorehi *et al.* (2016) found the Sefid River population was under pressure by habitat degradation and illegal sport fishing and urged habitat protection and a limited fishing activity. Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern because it is very abundant with a relatively large distribution range.

**Sources.** Mousavi-Sabet *et al.* (2015).

Iranian material:- CMNFI 1970-0506, 29, 33.5-58.3 mm standard length, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0511, 1, not kept, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0515, 3, 33.8-36.7 mm standard length, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0516, 43, 19.2-52.6 mm standard length, Gilan, Lomir River (38°14'N, 48°52'30"); CMNFI 1970-0518, 6, 34.3-50.4 mm standard length, Gilan, Haviq River estuary (38°10'N, 48°54'E); CMNFI 1970-0519, 18, 32.2-45.1 mm standard length, Gilan, Chelvand River (ca. 38°18'N, ca. 48°52'E); CMNFI 1970-0520, 2, 32.4-35.1 mm standard length, Gilan, Astara River (ca. 38°25'N, ca. 48°52'E); CMNFI 1970-0521, 3, 55.2-73.4 mm standard length, Gilan, Sefid River near Lulaman (no other locality data); CMNFI 1970-0522, 22, 40.4-80.3 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0536, 3, 71.9-89.6 mm standard length, Gilan, Siah River estuary near Rudbar (36°53'N, 49°32'E); CMNFI 1970-0537, 14, 30.5-78.8 mm standard length, Gilan, Shah River above Manjil Dam (36°44'N, 49°24'E); CMNFI 1970-0538, 1, 49.2 mm standard length, Gilan, Qezel Owzan River above Manjil Dam (ca. 36°44'N, ca. 49°24'E); CMNFI 1970-0546, 3, 57.1-69.4 mm standard length, Gilan, Sefid River canal (no other locality data); CMNFI 1970-0551, 1, 108.4

mm standard length, Gilan, Ghaleh (= Qal'eh) River near Fowman (37°13'N, 49°19'E); CMNFI 1970-0583, 16, 40.7-87.3 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1971-0327A, 6, 59.3-81.0 mm standard length, Gilan, Shafa River (37°35'N, 49°09'E); CMNFI 1979-0435, 3, 28.7-42.5 mm standard length, Gilan, stream west of Ramsar (36°57'N, 50°37'E); CMNFI 1979-0439A, 4, 53.4-72.2 mm standard length, Gilan, Shafa River (37°35'30"N, 49°05'30"E); CMNFI 1979-0440, 11, 53.7-88.6 mm standard length, Gilan, Lomir River (37°37'N, 49°02'30"E); CMNFI 1979-0441, 4, 52.4-55.7 mm standard length, Gilan, river 14 km south of Hashtpar (37°42'N, 48°58'E); CMNFI 1979-0443, 3, 39.0-44.2 mm standard length, Gilan, river 34 km north of Hashtpar (38°06'N, 48°53'E); CMNFI 1979-0444, 10, 37.1-55.8 mm standard length, Gilan, Chubar River (38°11'N, 48°52'30"E); CMNFI 1979-0445, 1, 70.6 mm standard length, Gilan, stream 10 km south of Astara (38°21'N, 48°51'E); CMNFI 1979-0452, 3, 47.1-51.7 mm standard length, East Azarbayjan, Qezel Owzan River 6 km from Mianeh (37°23'N, 47°45'E); CMNFI 1979-0453, 2, 45.8-65.1 mm standard length, Zanjan, Zanjan River (37°06'N, 47°56'E); CMNFI 1979-0454, 6, 39.6-56.0 mm standard length, Zanjan, Qezel Owzan River at Gilavan (36°47'N, 49°08'E); CMNFI 1979-0456, 4, 42.1-47.5 mm standard length, Gilan, Shah River at Lowshan (36°37'30"N, 49°31'E); CMNFI 1979-0626, 3, 46.6-62.2 mm standard length, Gilan, Sefid River (no other locality data); CMNFI 1979-0695, 74, 34.1-71.1 mm standard length, Gilan, Sefid River at Manjil Bridge (36°46'N, 49°24'E); CMNFI 1980-0116, 19, 41.1-70.3 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0147, 11, 19.0-42.7 mm standard length, Gilan, Lashtenesha (= Lasht Neshā') River (37°21'N, 49°52'E); CMNFI 2007-0080, 12, 41.9-73.1 mm standard length, Zanjan, Khow'in River basin north of Qeydar (ca. 36°11'N, ca 48°36'E); CMNFI 2007-0081, 13, 44.0-85.9 mm standard length, Zanjan, Zanjan River near Soltaniyeh (ca. 36°27'N, ca. 48°45'E); CMNFI 2007-0106, 2, 52.3-60.7 mm standard length, Kordestan, Qezel Owzan River basin near Divan Darreh (ca. 35°52'N, ca. 47°05'E).

*Alburnoides tabarestanensis*

Mousavi-Sabet, AnvariFar and Azizi, 2015



*Alburnoides tabarestanensis*, Mazandaran, Talar River, Hamid Reza Esmaeili.



*Alburnoides tabarestanensis*, Mazandaran, Tajan River, Hamid Reza Esmaeili.

**Common names.** Khayateh-e Tabarestani (= Tabarestan tailor fish), lapak or lepak (meaning unknown).

[Tabarestan riffle minnow, Tabarestan spirlin, Tajan spirlin].

**Systematics.** The holotype is a male, 68.3 mm standard length, from Mazandaran Province, Tajan River, southern Caspian Sea basin, 36°11'N, 53°19'E under VMFC AL201MH (VMFC = Vatandoust and Mousavi-Sabet Fish Collection, Tehran). Paratypes are VMFC AL2049P, 45, 33.7-83.0 mm standard length, 19 males 35.5-74.6 mm standard length and 26 females 33.7-83.0 mm standard length collected with the holotype and GUIC ALT-P (GUIC = Ichthyological Museum of the University of Gilan), 4, 36.4-65.2 mm standard length, 2 males 36.4-47.2 mm standard length and 2 females 38-1-65.2 mm standard length collected with the holotype. The species is named for the historical region of Tabarestan.



*Alburnoides tabarestanensis*, a, holotype, VMFC AL201MH,  
b, paratype, 66.0 mm standard length, VMFC AL2049P,  
Mazandaran, Tajan River, Hamed Mousavi-Sabet.

Ahmadi *et al.* (2011) examined 809 fish, identified as *A. bipunctatus* (= *A. tabarestanensis* here and below) from the Talar River and its tributary the Keselian (= Kaslian) River and found 13 morphometric and seven meristic character differences. Fish identified as *A. eichwaldii* (= *A. tabarestanensis* here and below) from the Tilabad and Shirabad streams of Golestan showed low genetic differentiation between populations based on six microsatellite loci and most variation (99%) was within populations (Jahangiri, 2013; Jahangiri *et al.*, 2013) but a population in the Kaboodval stream was separable (Jahangiri *et al.*, 2014). Azizi *et al.* (2015, 2018) found moderate overlap in morphometry between populations identified as *Alburnoides* sp. (= *A. tabarestanensis*) above and below the Shahid Rajaei Dam on the Tajan River but suggested the two populations (50 fish each examined) were distinct through isolation. Eight of 53 morphometric characters and six of 16 meristic characters separated the fish in a principal components analysis and 93% morphometric and 78% meristic characters in a detrended fluctuation analysis. Ghojoghi *et al.* (2019) examined 95 fish from the Tilabad, Yelcheshmeh, Zarrin Gol and Zav rivers for 36 morphometric and nine meristic characters and were able to distinguish the populations on morphometry.

**Key characters.** This species is distinguished from other Iranian *Alburnoides* by a distribution along the eastern coast of the Caspian Sea, east of the Sefid River basin except the Atrak River (which has *A. parhami*, *q.v.*). Morphological characters overlap to varying degrees and reference should be made to the key above.

**Morphology.** The mouth is terminal with the tip of the mouth cleft between the level of

the middle of the pupil and its lower margin. The eye is relatively small, 23.6-34.0, mean 27.9 in head length.

Dorsal fin branched rays 7-9, usually 8, anal fin branched rays 11-14, usually 12-13, pectoral fin branched rays 11-16, usually 11-13, and pelvic fin branched rays 6-9, usually 7. Lateral line scales 45-55 (Esmailipoor Poode *et al.* (2015) gave 33-54 lateral line scales for fish from the Babol and Tajan rivers, the lower counts being suspect), typically scale rows between the lateral line and the dorsal fin origin 9-10, scale rows between the lateral line and the anal fin origin usually 4-5, and scales around the caudal peduncle 15-19. There is a completely scaleless ventral keel. There is a pelvic axillary scale and 0-2 unpored scales at the end of the lateral line. Total gill rakers number 7-10. Pharyngeal teeth are 2,5-4,2. Total vertebrae number 39-41 (Esmailipoor Poode *et al.* (2015) gave 34-41 total vertebrae for fish from the Babol and Tajan rivers, the lower counts being suspect). The caudal vertebral region is equal to or slightly longer than the abdominal region (vertebral formulae 19+20, 20+20 and 20+21).

Meristic values are:- dorsal fin unbranched rays 3, branched rays 7(4), 8(58) or 9(1), anal fin unbranched rays 3, branched rays 11(3), 12(31), 13(24) or 14(5), pectoral fin branched rays 11(10), 12(19), 13(24), 14(6), 15(3) or 16(1), and pelvic branched fin rays 6(5), 7(48) or 8(10). Lateral line scales 45(1), 46(1), 47(2), 48(23), 49(11), 50(10), 51(6), 52(7), 53(-), 54(1) or 55(1), scales above lateral line 8(4), 9(16), 10(34), 11(7), 12(1) or 13(1), scales below lateral line 3(4), 4(38), 5(18) or 6(3), and scales around the caudal peduncle 15(1), 16(1), 17(2), 18(7) or 19(2). Total gill rakers number 7(8), 8(24), 9(27) or 10(3). Pharyngeal teeth are 2,5-4,2(10). Abdominal vertebrae number 19(18) or 20(43), caudal vertebrae 20(31) or 21(30), predorsal vertebrae 12(49) or 13(12), and total vertebrae 39(14), 40(33) or 41(14) (Coad and Bogutskaya, 2012; Mousavi-Sabet *et al.*, 2015; material below).

**Sexual dimorphism.** Morphometric characters differing between males and females are dorsal fin base, anal fin base, pectoral fin length, pelvic fin length (all longer in males) pectoral-pelvic distance, predorsal distance, preanal distance and pelvic-anal distance (all longer in females).

**Colour.** Overall colouration is silvery with the pectoral, pelvic and anal fin bases orange to red. The caudal fin is an overall reddish but less intense than the pectoral and anal fin bases. The back and top of the head are light to dark grey with an olive hue. The eye above the pupil is yellowish. The upper flank has a bluish hue. The lower part of the head and body are pearly-white. The flanks above the lateral line may have a golden hue. Faint yellow spots occur in rows along the flanks. Faint dark pigmentation on flank scales above and below the lateral line forms diffuse stripes. Dorsal and caudal fins have either some grey pigment or are dark grey. Dorsal, caudal and anal fins have dark pigment on their fin rays as does the pectoral fin unbranched ray. Preserved fish are overall tan, darker dorsally, and with horizontal rows of dark blotches formed by dark pigment on scale centres, moderately conspicuous above the lateral line. The lateral line has some scales with the pores outlined in dark pigment, especially anterior scales, but there is a general absence of well-marked spots or dark pigmentation in the lateral line canal. There is a narrow dark midlateral stripe along the lateral septum, more discernible from a vertical through the dorsal fin forwards. A faint midlateral stripe is also more discernible from the dorsal fin level anteriorly. Fins are mostly hyaline.

**Size.** Attains 15.0 cm (Abdoli, 2000).

**Distribution.** This species is recorded from the Caspian Sea basin presumably in all rivers of the southeastern Caspian Sea east of the Sefid River basin in Iran except the Atrak River. There may be some overlap in distribution with *A. samiii* as far west as the Chalus River

(51°25'E) but this remains to be refined (Jouladeh-Roudbar *et al.*, 2020) and samples below are referred to *A. tabarestanensis*. DNA work would be needed to clarify any transitional zone as morphometric, meristic and key characters are variable and overlap in the two species and within samples.

Recorded from the Babol, Chalus, Cheshmeh, Dogh, Garmrud, Googgol, Gorgan, Haraz, Harisak, Kaboodval, Kelarud, Keslian or Keselian (= Kaslian), Lavij, Madar Su, Mobarakabad, Neka, Qonbad, Ramian, Safarud, Sardab, Shah, Shirabad, Shirin, Shirud, Siah, Tajan, Talar, Tilabad, Toji or Tuji, Tonekabon, Valam, Yasalegh, Yelcheshmeh, Zarrin Gol and Zav rivers, the Uzineh qanat in Golestan, and the Alborz Dam. sometimes as *A. cf. tabarestanensis* (Abdoli, 2000; Banagar *et al.*, 2008; Abdoli and Naderi, 2009; Patimar *et al.*, 2012; Seifali *et al.*, 2012; Abbasi *et al.*, 2013, 2014; Eagderi *et al.*, 2013; Ghorbani *et al.*, 2013; Mazaheri Kohanestani *et al.*, 2013, 2014; Abdoli *et al.*, 2014; Gholizadeh *et al.*, 2014; Hosseinifard *et al.*, 2014; Mousavi-Sabet *et al.*, 2015; Jouladeh Roudbar *et al.*, 2016, 2020; Ghoghghi *et al.*, 2017, 2018; Matveyev *et al.*, 2017; Taheri Mirghaed *et al.*, 2017; Danaie *et al.*, 2018; Rustami *et al.*, 2018).

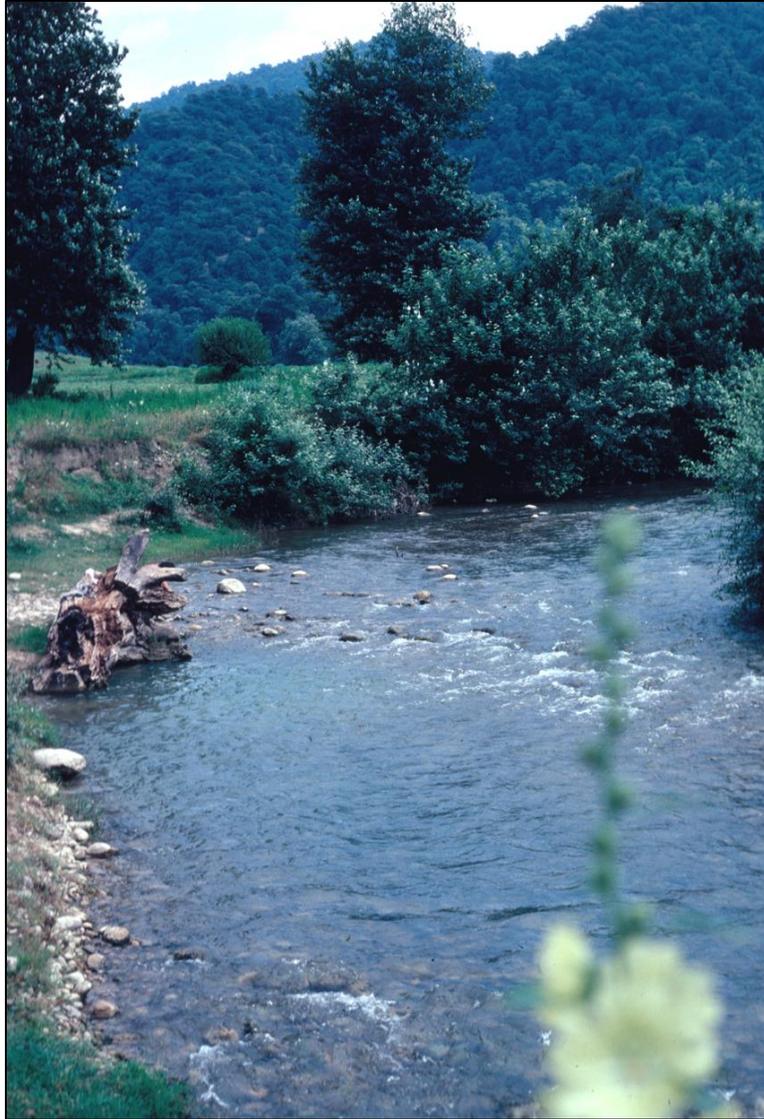
**Zoogeography.** See under the genus.

**Habitat.** This species is found in rivers, streams, dams and qanats. The type locality on 14 February 2013 had clear, medium to fast water, gravel to mud bed, submergent plants and grassy shores, water 9.3°C, pH 6.8, turbidity (*sic*, presumably conductivity) 1,130 µS, salinity 0.3 p.p.t., stream width about 3 m, and maximum depth up to 1.5 m. Other species present were the cyprinids *Barbus lacerta* (= *B. cyri*), *Capoeta gracilis* (= *C. razii*), *Luciobarbus capito*, *L. mursa*, *Squalius cephalus* (= *S. turcicus*), the cobitid *Cobitis faridpaki* and the nemacheilid *Paracobitis hircanica*. Mazaheri Kohanestani *et al.* (2013) examined fish from the Zarrin Gol Stream in Golestan identified as *A. eichwaldii* (= *A. tabarestanensis* here and below) and found that seasonal variations in haematological parameters reflected environmental conditions and the physiological status of the fish. Ghorbani *et al.* (2015) found a positive correlation with the amount of vegetation and channel insection for this fish identified as *A. eichwaldii* in the Tilabad Stream in Golestan. Naderi Jolodar *et al.* (2017) mentioned that fish identified as *A. bipunctatus* (= *A. tabarestanensis* here and below) was the dominant fish in the Tajan River at 44%. Rustami *et al.* (2018) found the abundance of fish from the Lavij River, Noor, Mazandaran identified as *A. eichwaldii* was influenced by changes in temperature and ammonium levels. Fazel *et al.* (2019) found *A. bipunctatus* presence in the Tilabad and Zarrin Gol streams was highly correlated with snag percent, pool and sand within streams.

Other collection data had a temperature range of 10-19°C, pH 6.0, conductivity 0.45-1.0 mS, clear to muddy water, medium to fast current, river width 2-12 m, water depth 50-100 cm, pebble, stone, sand and mud bottoms, and bushy and forested shores.



Habitat of *Alburnoides tabarestanensis*, Mazandaran, Talar River, Hamid Reza Esmaili.



Habitat of *Alburnoides tabarestanensis* (and *Capoeta razii*),  
CMNFI 1979-0483, Golestan, Cheshmeh River, 6 July 1978,  
Brian W. Coad.

**Age and growth.** Ahmadi *et al.* (2011) examined 809 fish identified as *A. bipunctatus* (= *A. tabarestanensis* here and below) from the Talar River and its tributary the Keselian (= Kaslian) River and found four age classes with age group 2<sup>+</sup> dominant at 49%. The maximum length was 96.14 mm and the maximum weight was 9.27 g. Growth was negatively allometric. Seifali *et al.* (2012) examined 1,019 fish, 3.4-11.2 cm fork length, from the Kesselian Stream (or Kaslian River), identified as *Alburnoides* sp. (= *A. tabarestanensis* here and below). They found a length-weight relationship  $W = 0.000006L^{3.1221}$  (isometric growth), asymptotic length ( $L_{\infty}$ ) = 104.48 mm, growth coefficient (K) = 1.19/yr, growth performance index ( $\phi'$ ) = 4.113, total mortality (Z) = 3.44/yr, fishing mortality (F) = 2.43/yr, natural mortality (M) = 0.97/yr and exploitation rate (E) = 0.71, indicating the stock was over exploited. Recruitment was continuous throughout the year with two major peaks, in June-July and November-December.

Fish identified as *A. bipunctatus* in the Tajan River showed negative allometric growth

with  $W = 0.014L^{2.901}$  (Patimar *et al.*, 2012). Aazami *et al.* (2015b) gave a  $b$  value of 3.12 for 1,867 fish, 3.98-11.09 cm total length, from the Tajan River. Azizi *et al.* (2015) examined 621 fish identified as *Alburnoides* sp. from the Tajan River and found significant differences in length above and below the Shahid Rajaei Dam but differences in weight and condition factor only in males. The mean fork length and weight were 49.11 cm (*sic*, presumably mm) and 3.29 g above the dam and 52.94 cm (*sic*, presumably mm) and 3.92 g below. Upstream of the dam females had four age classes,  $0^+$  to  $3^+$  years, while males upstream and males and females downstream had three age classes,  $0^+$  to  $2^+$  years. Females dominated in the sex ratio both up- and downstream. Downstream males showed isometric growth while the rest showed positive allometric growth. Tabatabaei *et al.* (2015) investigated 43 Tajan River fish identified as *A. eichwaldii* and found  $b$  values of 3.27 (pooled sexes), 3.26 (females) and 3.3 (males). von Bertalanffy growth parameters were  $L_\infty = 123.01$ ,  $K = 0.29$ ,  $t_0 = -1.0$  and  $\Phi = 8.4$ . Age classes were  $2^+$  to  $5^+$  years, with the most abundant age class being  $2^+$ . Mousavi-Sabet *et al.* (2017) examined 30 fish, 55.8-70.1 mm total length, from the Tajan River and found a  $b$  value of 3.09. Eagderi *et al.* (2020) examined 93 fish, 3.54-11.98 cm total length, from the Tajan River and found a  $b$  value of 2.98, isometric growth. The condition factor was 0.81-1.3, mean 1.0.

Patimar *et al.* (2012) examined 240 fish, 4.8-11.1 cm total length, from the Uzineh qanat in central Golestan Province identified as *A. bipunctatus*. They found a five-year life cycle (to age  $4^+$ ), length-weight relationships were  $W = 0.0068TL^{3.2559}$  for males,  $W = 0.0079TL^{3.2607}$  for females and  $W = 0.0072TL^{3.2387}$  for the population, positive allometric growth for all. The von Bertalanffy growth functions were  $L_t = 14.07(1 - e^{-0.27(t+0.92)})$  for males,  $L_t = 15.37(1 - e^{-0.23(t+1.08)})$  for females (indicating males grew faster than females) and  $L_t = 14.83(1 - e^{-0.24(t+1.04)})$  for the population. Nowferesti *et al.* (2014) found a  $b$  value of 3.29 for 21 fish, 2.5-6.2 cm total length, from Tilabad identified as *A. eichwaldii* (= *A. tabarestanensis* here and below). Monajjemi *et al.* (2014) examined a population (661 fish) from the Shirud in Mazandaran finding fish identified as *A. eichwaldii* to age  $3^+$ ,  $0^+$  fish dominating,  $b$  value was 2.94 (negatively allometric), von Bertalanffy parameters were  $L = 12.08$ ,  $K = 0.55$  and  $t_0 = -0.47$ , growth performance index was up to 3.65, total mortality ( $Z$ ) = 2.41, natural mortality ( $M$ ) = 1.19 and fishing mortality ( $F$ ) = 1.22.

Danaie *et al.* (2017) examined 203 fish identified as *A. cf. tabarestanensis* from the Mobarakabad River, Golestan and found a male:female sex ratio of 1:0.8 (no significant difference), the length-weight relationship for females was  $W = 0.0118 TL^{3.03}$ , for males was  $W = 0.0101TL^{3.12}$  and for the population was  $W = 0.011TL^{3.07}$  (positive allometric growth for the population and males, isometric for females), and the highest recorded condition factor was observed in males in May (1.01) and for materials (*sic*, presumably the population) in April (1.1). Danaie *et al.* (2018) again sampled fish identified as *A. cf. tabarestanensis* from the Mobarakabad River (325 fish) and found maximum total length and weight were 11.5 cm and 18.18 g for females and 10.5 cm and 11.48 g for males, a male:female sex ratio of 1:0.93 showing no significant difference between sexes, the length-weight relationship of females was  $W = 0.0091TL^{3.13}$ , of males was  $W = 0.0091TL^{3.15}$ , and of the total population was  $W = 0.0091TL^{3.14}$ , all showing positive allometric growth, the condition factor showed the lowest value for both sexes in July and the highest value for males in March and for females in April, the highest instantaneous growth rate was observed for both males and females at zero to one year old, growth parameters were estimated as  $L_\infty = 122.4$  mm for males,  $L_\infty = 127.14$  mm for females and  $L_\infty = 133.53$  mm for the population, von Bertalanffy growth equations were estimated as  $L_t = 127.14(1 - e^{-0.15(t+1.08)})$  and  $L_t = 122.4(1 - e^{-0.24(t+1.07)})$  for female and male fish,

respectively.

Ghojoghi *et al.* (2017) studied 195 fish, 2.8-11.1 cm total length, identified as *A. cf. tabarestanensis* from the Zav Stream, a Gorgan River tributary, and found a sex ratio of 1:1.22 in favour of males but not significantly different from a 1:1 ratio, maximum age was 5<sup>+</sup> years with 2<sup>+</sup> years most common in both sexes, the highest growth rate was between 3<sup>+</sup> and 4<sup>+</sup> in females and between 4<sup>+</sup> and 5<sup>+</sup> in males, the length-weight relationship was  $W = 0.0151TL^{2.9784}$  for males (negative allometric),  $W = 0.0119TL^{3.1214}$  for females, and  $W = 0.013TL^{3.067}$  for sexes combined (both positive allometric), the highest and lowest condition factors were in May and February, and the von Bertalanffy growth equations showed females grew faster than males and were  $L_t = 12.9(1 - e^{-0.23(t+0.664)})$  for males and  $L_t = 13.97(1 - e^{-0.23(t+0.156)})$  for females. Ghojoghi *et al.* (2018) examined 191 fish identified as *A. eichwaldii* from the Googgol River in the Gorgan River basin and found the largest male was 9.3 cm total length and the largest female was 10.2 cm total length, a sex ratio of 1:1, growth was positive allometric for both sexes and the population (*b* values for males, females and the population were 3.1277, 3.1527 and 3.1781), age groups 2<sup>+</sup> to 4<sup>+</sup> were present, and the von Bertalanffy growth equations were  $L_t = 12.28(1 - e^{-0.304(t+0.154)})$  for females and  $L_t = 10.11(1 - e^{-0.251(t+0.512)})$  for males.

**Food.** Tajan River fish identified as *A. eichwaldii* (= *A. tabarestanensis* here and below) were analysed for diet by Esmaeilpoor Poode *et al.* (2015) who found them to be gluttonous and tending to be carnivorous. Trichoptera was the preferred food of both sexes in different seasons and ages. The condition factor was higher in females than males. Abbasi *et al.* (2013) examined fish identified as *A. eichwaldii* from the Kaboodval, Shirabad and Tilabad streams in Golestan Province and found the most frequent prey was Diptera and Ephemeroptera, with Trichoptera and Amphipoda also significant with minor amounts of other taxa. Abbasi *et al.* (2014) found fish identified as *A. eichwaldii* in streams of the Gorgan River basin fed on Ephemeroptera, Trichoptera and Chironomidae as main foods and Odonata larvae, green algae, Simuliidae and Strachironomidae as accidental foods.

**Reproduction.** Patimar *et al.* (2012) found a qanat population at Uzineh, Golestan identified as *A. bipunctatus* (= *A. tabarestanensis*) had a sex ratio not significantly different from parity, the reproductive season extended from April to August with peaks in April, June and August for females and April and June for males. Absolute fecundity was 234-7,728 eggs, mean 1,407, relative fecundity was 60-550 eggs/g, mean 255 eggs/g, and egg diameters attained 1.7 mm. Seifali *et al.* (2012) found Kesselian (= Kaslian) Stream fish identified as *Alburnoides* sp. (= *A. tabarestanensis*) had a mean absolute fecundity of 1,772.9 eggs, individual fecundity was 668-3,042 eggs, a gonadosomatic index of 6.88 indicated sexual maturity in females and egg diameters (up to 1.67 mm) indicated spawning once a year in June-July, and the highest peak of relative condition was 0.126 during June.

**Parasites and predators.** The monogenean *Diplozoon paradoxum* was recorded from *A. bipunctatus* (= *A. tabarestanensis* here and below) in the Tajan River, Mazandaran (*Iranian Fisheries Research and Training Organization Newsletter*, 6:7, 1994). Shamsi *et al.* (1997) reported *Clinostomum complanatum*, a parasite causing laryngo-pharyngitis in humans, from *Alburnoides bipunctatus* in the Shirud. Halimi *et al.* (2013) reported on the cestode *Ligula intestinalis* in *Alburnoides bipunctatus* in Iran without specifying a locality (but the authors were from Babol institutions and so presumably *A. tabarestanensis*). Serum samples from infested fish showed a polymorphism band which indicated a different immune response from that reported for *Rutilus rutilus* (= *R. lacustris*). Youssefi *et al.* (2012) investigated the electrophoretic pattern of somatic and excretory-secretory proteins of the cestode *Ligula intestinalis* in fish identified as

*A. bipunctatus*, presumably *A. tabarestanensis* as authors were from the Islamic Azad University in Babol. Ahmadiara *et al.* (2013) described the rate of infection of the cestode *Ligula intestinalis* in fish identified as *A. bipunctatus* from Ramsar. Hosseinifard *et al.* (2014) recorded *Dactylogyrus*, *Diplozoon*, *Bothriocephalus* and various nematodes from *A. bipunctatus* in the Garmrud at Amol, Mazandaran. Mazaheri Kohanestani *et al.* (2014, 2014) recorded the digenean *Posthodiplostomum cuticola* in fish identified as *A. eichwaldii* (= *A. tabarestanensis* here and below) from the Zarrin Gol Stream in Golestan Province. Rahmati-holasoo *et al.* (2014) also recorded metacercariae of the digenean *Posthodiplostomum* in fish identified as *A. eichwaldii* from the Zarrin Gol Stream. The average number of cysts was 3.29, with more cysts higher on the body. Shokrolahi *et al.* (2014) recorded *Bothriocephalus gowkongensis* (cestode), *Paradiplozoon* sp. (monogenean) and *Rhabdocona* sp. (nematode) from fish in the Alborz Dam on the Babol River identified as *Alburnoides bipunctatus*. Other parasites were mentioned but not assigned specifically to this species. Taheri Mirghaed *et al.* (2017) recorded parasites from fish in the Alborz Dam and Babol River in Mazandaran, namely *Ichthyophthirius multifiliis* (dam and river) (Ciliophora), *Dactylogyrus chalcalburni* (river), *Gyrodactylus prostrae* (river) and *Paradiplozoon homoion* (dam and river) (Monogenea), *Bothriocephalus opsariichthydis* (dam and river) and *Ligula intestinalis* (dam) (Digenea). Barzegar *et al.* (2018) reported the monogeneans *Gyrodactylus prostrae* and *G. varicorhini* from fish identified as *A. bipunctatus* from the Tajan and Talar rivers and the Talar River, respectively, in Mazandaran.

**Economic importance.** None.

**Experimental studies.** Gholipour Kanani *et al.* (2013) found an LC<sub>50</sub> for glyphosate was 28.65 for *Alburnoides* sp., showing a high sensitivity (authors worked at Gonbad-e Kavus, Golestan so the species was probably *A. tabarestanensis*). Vajargah *et al.* (2013) found that larvae were more sensitive to pesticides than fingerlings of fish identified as *A. bipunctatus* (presumably *A. tabarestanensis* because the researchers were from Gorgan University, Golestan) and LC<sub>50</sub> values indicated that deltamethrin was more toxic than diazinon.

**Conservation.** Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern for its relatively wide distribution range and very abundant populations.

**Sources.** Mousavi-Sabet *et al.* (2015).

Iranian material:- CMNFI 1970-0533, 29, 33.5-82.1 mm standard length, Mazandaran, Chalus River (ca. 36°39'N, ca. 51°25'E); CMNFI 1979-0429, 3, 25.0-43.7 mm standard length, Mazandaran, Chalus River (36°34'N, 51°23'E); CMNFI 1979-0483, 2, 93.0-98.6 mm standard length, Golestan, Cheshmeh River (37°23'30"N, 55°51'30"E); CMNFI 1979-0493, 11, 51.1-82.8 mm standard length, Mazandaran, stream in Tajan River drainage (36°19'N, 53°23'E); CMNFI 1991-0158, 1, 82.4 mm standard length, Golestan, Madar Su (37°23'N, 55°47'E); CMNFI 1991-0160, 3, 68.2-75.3 mm standard length, Golestan, Abgeer-e Avanness (37°03'N, 54°47'E); CMNFI 1993-0139, 2, 73.9-74.1 mm standard length, Golestan, Dogh River (37°23'30"N, 55°47'E).

### **Genus *Alburnus***

Rafinesque, 1820

The bleaks and shemayas are found in Europe and the northern parts of Southwest Asia with about 43 species (depending on definitions of the taxa). There are eight to nine species in Iran, mapped by Mohammadian-kalat *et al.* (2015). Records of *Alburnus orontis* Sauvage, 1882 from Iran by Armantrout (1969), Banarescu (1977) and Wossughi (1978) are in error (Krupp, 1985c).

*Chalcalburnus* Berg, 1933 is now regarded as a synonym of *Alburnus* Rafinesque, 1820

and was used for several Iranian species in older literature. There have been numerous variant views of this synonymy. Bogutskaya (1990) considered *Chalcalburnus* as distinct but later (Bogutskaya 1997; Bogutskaya *et al.*, 2000; Bogutskaya and Naseka, 2004) synonymised it with *Alburnus*. Reshetnikov *et al.* (1997) retained *Chalcalburnus* as a distinct genus as did *Catalog of Fishes* (downloaded, 10 August 2007) but was later synonymised (downloaded, 16 September 2015). Banister (1980) pointed out that the distinction of the genus from *Alburnus* is based on the relative lengths of the ventral keel and the relative thickness of the last dorsal fin unbranched ray, characters which he viewed with suspicion in the absence of other corroborating evidence. Mangit and Yerli (2018) in their analysis of Turkish *Alburnus* species found the genus to be paraphyletic with three lineages, *A. filippii* occurring in Iran (along with non-Iranian species) formed one lineage *Alburnus sensu stricto*, and the two other lineages should be excluded. One excluded lineage included *A. sellal* and the other *A. caeruleus* of Iranian relevance. They noted the two lineages may include more than one genus and did not therefore erect new genera for the two lineages. *A. chalcoides aralensis* was listed in the online data as a synonym of *A. filippii* (they had no data for *A. chalcoides* from the Caspian Sea). *A. mossulensis* was confirmed as a synonym of *A. sellal* and they lacked data for other species found in Iran.

This genus is characterised by an elongate, compressed, moderately deep body of small to moderate size, a terminal mouth, no barbels, scales of moderate size, pharyngeal teeth in two rows (2,5-5,2 or 2,5-4,2) with hooked tips and usually serrations (but serrations can be absent), short dorsal fin without a thickened ray, a relatively long anal fin, long and relatively numerous gill rakers, a fleshy keel between the base of the pelvic fins and the vent (the naked part usually not reaching as far forward as the pelvic fin bases in species formerly placed in *Chalcalburnus*), and a light to brown or black peritoneum. Some authors considered the genus *Alburnoides* to be a synonym of *Alburnus* (e.g., Saadati (1977)) while others disagreed (e.g., Bogutskaya (1990)). These two genera are treated separately here to accord with common usage in Southwest Asia, a conservative measure when there are conflicting opinions.

Saadati (1977) referred to an unknown species of *Alburnus* from the Qom River but this material was lost. Also, an unknown *Alburnus* from the Lake Urmia basin was probably *A. ulanus*.

Schönhurth *et al.* (2018) noted that fish identified as *Alburnus mossulensis* (and presumably these would be *A. sellal*, see above) were the sister group to *Acanthobrama*.

Khataminejad *et al.* (2013) distinguished *Alburnus* species in Iran based on morphometrics, *A. hohenackeri* and *A. caeruleus* having a greater body depth and shorter caudal peduncle than others. Khataminejad *et al.* (2015, 2015b) partly distinguished the five species *atropatense*, *chalcoides*, *filippii*, *hohenackeri* and *mossulensis* (= *A. sellal*) from the Miriseh, Babol, Baleqlu, Mahabad and Gamasiab rivers morphometrically using truss network analysis.

Mohammadian-kalat *et al.* (2013) considered the genus to be taxonomically problematical in Iran with Zagros Mountain populations and widely distributed species such as *A. chalcoides* needing revision.

Jalali *et al.* (2002) and Jalali and Barzegar (2006) recorded several parasites from an undescribed “*Chalcalburnus*” species in Lake Zaribar, namely *Ichthyophthirius multifiliis*, two species of *Argulus*, a *Trichodina* species, *Dactylogyrus alatus*, *Diplostomum spathaceum*, *Myxobolus molnari* and *Ligula intestinalis*. Masoumian *et al.* (2007) recorded the myxosporean parasite *Myxobolus saidovi* from *Alburnus maculatus* (*sic*) in the Zayandeh River and Mehdiipoor *et al.* (2004) recorded the monogenean *Dactylogyrus alatus* from *Alburnus maculatus* (*sic*), also in the Zayandeh River. These “*Alburnus maculatus*” were probably *A. doriae*. Barzegar *et al.*

(2008) recorded eye parasites from fish identified as *Alburnus alburnus* from the Chaghakhour (= Chagha Khur) and Gandoman lagoons of the Tigris River basin including the digeneans *Diplostomum spathaceum* and *Tylodelphys clavata*. The identity of these fish is uncertain as they could possibly be *A. doriae* or transplanted *A. hohenackeri*. Rahimi *et al.* (2016) described the prevalence and antimicrobial resistance of *Listeria* species in *Alburnus* species from retail stores in Esfahan and Bandar Anzali. There was a potential risk of infection for people consuming raw or under cooked smoked and salted fish.

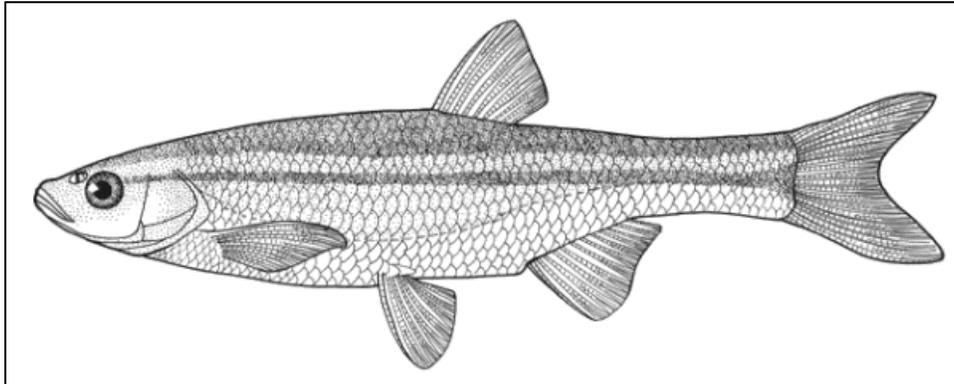
Esmaeili *et al.* (2018) tested the impact of climate change on members of this genus in Iran, finding that basins along the Elburz and Zagros mountains had the highest climatic suitability with precipitation playing a more important role than temperature. All species were likely to be affected negatively in the future and a comprehensive management plan is needed. Yousefi *et al.* (2019) reviewed recent studies on climate change which is now a major problem for many organisms in Iran, including fishes.

Small fishes and members of the genus *Alburnus* are called kuli in Farsi or Gilaki. Kuli may derive from kul which can mean any pond or sheet of water. In Gilan, kuli are eaten with their heads on and are said to full of phosphorus, conferring open-mindedness, intelligence and sophistication on the Gilanis.

The following table summarises some key distinguishing characters of the Iranian species of *Alburnus*.

Species/ Character	Modal dorsal fin branched rays	Anal fin branched rays	Total gill rakers	Lateral line scales	Peritone- um colour	Flank stripe	Distribution by basin
<i>Al. atropatena</i>	8	9-12	11-16	46-63	black	+	Lake Urmia
<i>Al. caeruleus</i>	8	13-18	10-13	43-58	brown to black	+ -	Tigris River
<i>Al. chalcoides</i>	8	10-21 (mostly 14-15)	18-31 (mostly 20-23)	54-74 (mostly 57-63)	light brown	-	Caspian Sea
<i>Al. doriae</i>	8	9-12	12-18	44-59	silvery	+	Esfahan, Namak Lake, Tigris River
<i>Al. filippii</i>	7	9-13 (mostly 10-12)	12-21 (mostly 12-17)	46-64 (often 57 or less)	light brown	+	Caspian Sea
<i>Al. hohenackeri</i>	8	10-16	19-25	34-55 (often 45 or less)	light silvery	+ or -	Caspian Sea
<i>Al. sellal</i>	8	9-14	8-18 (mostly 11-16)	58-89 (often 62 or more)	brown to black	+	Hormoz, Kor River, Lake Maharlu, Persis, Tigris River
<i>Al. taeniatus</i>	8	9-13 (mostly 10-12)	13-23 (lower counts suspect)	30-46	-	+	Hari River
<i>Al. ulanus</i>	8	7-11 (mostly 8-9)	12-16	35-45	silvery- brown	+	Lake Urmia

*Alburnus atropatenae*  
Berg, 1925



*Alburnus atropatenae*,  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus atropatenae*, East Azarbayjan, Ghalechai (= Qal'eh River), Lake Urmia basin,  
October 2011, Keyvan Abbasi.

**Common names.** Shah kuli-ye Orumiyeh (= Urmia king fish).

[Urmia or Urmian bleak, Urmia or Urmian Lake bleak, Urmia kingfish (Moshaeidi *et al.*, 2014), Urmia shemaya].

**Systematics.** The type series is the material called *Alburnus filippii* by Günther (1899) from “Sujbulak and Superghan near the mouth of the Nazlu Chai” as noted in Berg (1925). This material is in the Natural History Museum, London under BM(NH) 1899.9.30:127, syntype, 89.7 mm standard length, West Azarbayjan, Superghan near the mouth of the Nazlu Chai (Sopurghan on the Nazlu Chay is at 37°45'N, 45°12'E) and BM(NH) 1899.9.30:128-30, syntypes, 3, 70.7-96.3 mm standard length, West Azarbayjan, Tatawa Chai near Sujbulak (the Tata'u Chay or Simineh River is not close to Saujbulagh or Mahabad at 36°45'N, 45°43'E so the exact locality of this collection is unclear). These syntypes bear an external label, apparently in A. Günther's handwriting, listing these fish under the name “brevianalis” which is crossed out and *filippii* substituted. It appears that Günther originally intended to describe them as distinct and subsequently changed his mind.



*Alburnus atropatenaе*, syntype, BM(NH) 1899.9.30:127.



*Alburnus atropatenaе*, syntype, BM(NH) 1899.9.30:128-130.

Berg's (1925) material was not found in a search of the collections of the Zoological Institute, St. Petersburg (ZISP) in November 1993. Eschmeyer *et al.* (1996) gave the following data:- Syntypes (46) ZIL (ZIL being the old acronym for ZISP) but this material is presumably comparative specimens mentioned by Berg (1925).

Coad and Holčík (1999) demonstrated variation between three populations, eastern, western and southern, isolated by the salt Lake Urmia but considered this variation as insufficiently different to warrant taxonomic distinction. Nonetheless, the analysis demonstrated that the three populations have diverged in a measurable manner, presumably through geographical isolation, although ecological factors may have played a part as one sample was from a lacustrine rather than a riverine environment. Moshaeidi *et al.* (2014) morphometrically distinguished fish of the Zarrineh River from those of the Baneh, Saghez (= Saqqez) and Simineh rivers combined, the latter having a smaller head size and caudal peduncle for example. Mohammadian-kalat *et al.* (2015) were also able to discriminate populations (in five rivers) with morphometric characters more reliable than meristic ones. Radkhah *et al.* (2016) found fish from the Simineh and Zarrineh rivers had significant differences in such morphometric characters as prepelvic distance and body depth and that depth and water flow rate had the highest influence on morphology. Tajik and Keivany (2015a) compared fish from the Baranduz and Nazlu rivers finding that the latter had longer heads, wider caudal peduncles and a higher location for the anal fin position. Keivany (2017, 2018) and Tajik and Keivany (2018) studied 274 specimens from the Aghdarreh, Baranduz, Nazlu, Sarough, Senteh, Talkheh (= Aji) and Zarrineh rivers for 17 morphometric and 17 meristic traits, finding various differences between populations and groups of populations, e.g., the Talkheh population was separate to some extent from the others morphometrically, and the Nazlu populations were completely separate from the Senteh and Zarrineh populations, and there were no differences between the Baranduz and Talkheh, Baranduz and Nazlu, and Senteh and Zarrineh. Eagderi *et al.* (2019) compared 163 fish morphometrically from the Baneh, Saghez (= Saqqez), Simineh and Zarrineh rivers and found the latter three clustered together, the Baneh, Saghez (= Saqqez) and Simineh populations had a deeper body and were distinguishable by a smaller head, posterior eye position and shorter anal fin base respectively, and the Zarrineh population was distinguishable by a more fusiform body and less body depth. These differences were attributed to ongoing evolutionary trends as a result

of differing environmental conditions and isolation.

**Key characters.** This species is distinguished by having modally 8 branched dorsal fin rays, 11-16 total gill rakers, 46-63 lateral line scales 46-63, a black peritoneum, and a distribution in the Lake Urmia basin.

**Morphology.** The body is rounded and moderately deep, being deepest at a level between the end of the pectoral fin and the pelvic fin origin. A slight nuchal hump is present in some fish. The predorsal profile is straight in front of the dorsal fin and then convex leading down to the head, or a continuous convex curve. The caudal peduncle is slightly compressed but quite rounded and is moderately deep. The snout is rounded. The rear of the eye is at the beginning of the anterior half of the head. The mouth is terminal and oblique and extends back level with the nostril. The lower jaw is rounded and may protrude slightly. Lips are thin with the centre of the upper lip thickest. The dorsal fin margin is straight. The dorsal fin origin is well posterior to the level of the pelvic fin origin and is over the depressed mid-fin or further back. The depressed dorsal fin extends back level with middle of the anal fin. The caudal fin is shallowly forked and tips are rounded. The anal fin is rounded and is remote from the caudal fin base. The pelvic fin is rounded and does not reach back to the anus but may reach the anterior anal papilla in some fish. The pectoral fin is rounded and does not extend back to the pelvic fin origin.

Dorsal fin with 3 unbranched rays and 7-9, modally 8, branched rays, anal fin with 3 unbranched rays and 9-12 branched rays, pectoral fin branched rays 13-16, and pelvic fin branched rays 7-8. Lateral line scales 46-63. There is a pelvic axillary scale. Scale shape is a vertical oval or somewhat more squarish. All margins are rounded and there are no abrupt anterior corners in some while others have distinct but rounded corners. The anterior margin has a central protrusion with an indentation above and below, or the protrusion lacks obvious adjacent indentations, or the margin is wavy. The scale focus is slightly anterior or central and there are relatively few anterior and posterior radii about equal in number. The exposed fleshy keel in front of the anus is about 1-4 scales lengths, usually 2, long. Gill rakers are lanceolate but short, less than half eye width, reaching between the first and second adjacent rakers or touching the second when appressed, total rakers being 11-16. Pharyngeal teeth are hooked at the tip and usually bear a few, large serrations on the larger major row teeth or more rarely have no serrations, apparently size independent. The posteriormost major row tooth may be dorsal rather than posterior to the tooth ahead of it. Tooth counts are usually 2,5-4,2. The gut is an elongate s-shape, sometimes with an anterior loop to the left. Total vertebrae 41-43. Chromosome number is  $2n = 50$  (Nazari *et al.*, 2011).

Meristic values are:- dorsal fin branched rays 7(2), 8(102) or 9(1), anal fin branched rays 9(5), 10(49), 11(45) or 12(6), pectoral fin branched rays 13(7), 14(44), 15(41) or 16(13), pelvic fin branched rays 7(17) or 8(88), lateral line scales 46(4), 47(5), 48(12), 49(15), 50(13), 51(15), 52(14), 53(5), 54(5), 55(5), 56(2), 57(-), 58(6), 59(-), 60(-), 61(-), 62(-) or 63(1), total gill rakers 11(12), 12(30), 13(35), 14(16), 15(7) or 16(2), pharyngeal teeth 2,5-4,2(54), 2,4-4,2(2), 2,4-5,2(1), 2,5-5,2(1), 1,5-4,2(1) or 2,5-3,2(1), and total vertebrae 41(4), 42(12) or 43(3). Meristic counts by Khataminejad *et al.* (2015) for fish from the Miriseh River fall within the ranges above.

**Sexual dimorphism.** Male specimens have small scattered tubercles on the top of the head with fewer tubercles on the side of the head. Tubercles are variably distributed on the head depending on the specimen, or even be different on each side of a single fish. A distinct row may parallel the upper lip, another row may follow the upper eye margin, a patch may be present

between the nostril and the upper lip, and there may be tubercles between the mouth and the eye. Very small tubercles line the scale margins on the back, flank and belly, and belly scales have a fine row of tubercles on the scale base. Tubercles line the rays of the pectoral, dorsal, pelvic and anal fins and weakly on the caudal fin, the rows branching with the fin rays.

**Colour.** The back is a dark olive brown to grey, with a narrow stripe. The flank has a dark stripe, as wide as the pupil of the eye or narrower at its maximum width, extending onto the head as far as the eye and back to the middle of the caudal fin. The stripe is black to dark green. The flank above the stripe is often lighter in contrast to the darker back and accentuates the distinctiveness of the stripe. The flank below this stripe, the belly and the lower head are silvery, and the stripe is clearly set off from the lower flank. The front of the lower jaw is dark and some of this pigment extends into the floor of the mouth. The iris is silvery on the lower half and dark above. The dorsal fin is faintly pigmented grey along its rays, the caudal fin is grey and the other fins are colourless. Melanophores are present on the dorsal and caudal fin rays and the anterior rays of the pectoral, pelvic and anal fin rays. The nostrils may be dark. The peritoneum is black.

**Size.** Reaches 21.8 cm.

**Distribution.** This species is endemic to the Lake Urmia basin and is recorded from the Aghdarreh, Balanoosh, Baneh, Baranduz, Bitas, Chamalton, Chamsaqez (= Saqqez), Cheagia, Ghale (= Qal'eh), Godar, Haladj, Hasanlu, Kazim, Koter, Mahabad, Mardogh, Miriseh, Nazlu, Ozband, Qader, Qasemlu, Qonbad, Rozeh, Saghez (= Saqqez), Sarough, Senteh, Shahr, Simineh, Sufi, Talkheh (= Aji) and Zarrineh rivers, the Ghaleh (= Qaleh) and Guru (= Guru Gowl) lakes, and the Cheragveis, Hasanlu and Mahabad dams (Günther, 1899; Berg, 1925; Abdoli, 2000; Mirhasheminasab and Pazooki, 2003; Abbasi *et al.*, 2005; K. Abbasi, pers. comm., 2012; Banan Khojasteh *et al.*, 2012; Khataminejad *et al.*, 2013, 2015, 2015; Moradi and Eagderi, 2014; Moshaeidi *et al.*, 2014; Mousavi-Sabet *et al.*, 2014; Ghasemi *et al.*, 2015; Tajik and Keivany, 2015a; Dadai Ghandi *et al.*, 2017; Eagderi and Moradi, 2017; Mohammadian-Kalat *et al.*, 2017; Eagderi *et al.*, 2019; Fathi and Ahmadifard, 2019; Kaya, 2020; Mouludi-Saleh *et al.*, 2021).

Khataminejad *et al.* (2013) recorded it from the Quareh-Chay (= Qareh Chay) of the Namak Lake basin at 34°53'.250"N, 50°022'51"E. These fish were later described as a new species, *A. amirkabiri* Mousavi-Sabet *et al.* (2015) but are *A. doriae* according to Mohammadian-Kalat *et al.* (2017).

**Zoogeography.** Lake Urmia was formed during the late Pliocene-Pleistocene, lies at 1,275-1,295 m, and may well have had a Pleistocene connection to the Caspian Sea basin although this has been disputed (Scharlu, 1968; Schweizer, 1975). Pleistocene shorelines from 30 to 115 m above the present level have been confirmed, and the lake covered twice its present area, but this would not permit an external discharge. Berg (1940) reported benches at levels of about 1,800 m, 1,650-1,550 m and 1,500-1,360 m, which may represent shorelines, and a level of about 1,570 m would have had an outlet to the Aras River basin through the Kara-tepe Pass in the northwest and across the plain near the city of Khvoy. Saadati (1977) suggested two connections with the Caspian Sea, an early one in the Pliocene to early Pleistocene resulting in endemic species and a later one in the late Pleistocene resulting in species which are the same as the Caspian or only subspecifically distinct. *A. atropatense* may have its origin in the earlier transgression.

**Habitat.** This species is found in rivers, streams, lakes and dams. Abbasi *et al.* (2005) stated this is the second most abundant fish species in the Mahabad River of the Lake Urmia basin. Collection data were 16.5-27°C, sand and pebble bottoms, still to fast water, and the shore grassy or bushy. The photograph below shows habitat alteration.



Habitat of *Alburnus atropatenae*, West Azarbayjan, Gadar (= Qader) River, Hamid Reza Esmaeili.

**Age and growth.** Esmaeili *et al.* (2014) gave a  $b$  value for 36 fish, 8.0-12.0 cm total length, from Lake Urmia as 3.18. Mousavi-Sabet *et al.* (2014) gave a  $b$  value of 3.313 for 30 fish, 7.55-9.74 cm total length, from the Mahabad River. Radkhah and Eagderi (2015a) gave a  $b$  value for 40 fish from the Zarrineh River, 7.6-12.5 cm total length, as 3.26, positive allometric growth. Condition factor was 1.021. Tajik and Keivany (2015b) also examined fish from the Zarrineh River (59, 4.43-12.82 cm total length) and found a length-weight relationship of  $W = 0.0111TL^{2.89}$  indicating in contrast negative allometric growth. Keivany and Zamani-Faradonbeh (2016) gave a  $b$  value of 2.73 for 39 fish, 3.14-6.51 cm total length, from the Talkkeh (= Aji) River. Mouludi-Saleh *et al.* (2021) examined 180 fish, 3.92-19.6 cm total length, from the Ghale (= Qaleh), Godar and Mahabad rivers and recorded a  $b$  value of 3.38, positive allometric, and a condition factor of 0.95.

**Food.** Gut contents are insects, crustaceans and worms. Filamentous algae are also present, possibly as accidental inclusions.

**Reproduction.** A fish captured 25-26 June 1962 (115.7 mm standard length, CMNFI 1979-0785) carried mature eggs.

**Parasites and predators.** None reported.

**Economic importance.** Unknown.

**Experimental studies.** None.

**Conservation.** Biology is poorly known and numbers and habitat requirements would have to be examined for a conservation assessment.

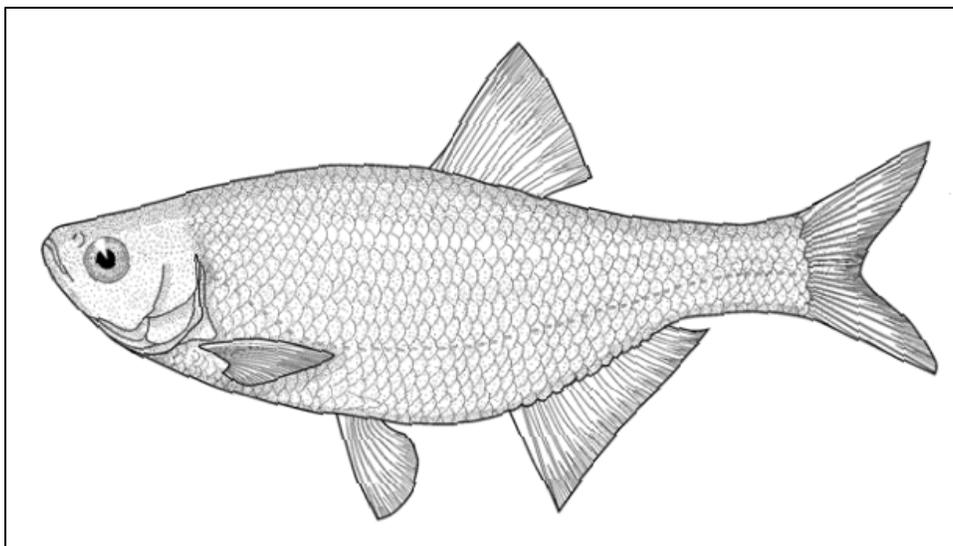
**Sources.** Type material:- *Alburnus atropatenae* (BM(NH) 1899.9.30:127 and BM(NH) 1899.9.30:128-30).

Iranian material:- CMNFI 1970-0557, 26, 17.9-31.6 mm standard length, West Azarbayjan, Shahr Chay (ca. 37°27'N, ca. 44°55'E); CMNFI 1970-0558, 8, 25.0-88.7 mm standard length, West Azarbayjan, Qasemlu Chay (ca. 37°21'N, ca. 45°09'E); CMNFI 1970-0559, 48, 31.4-85.2 mm standard length, West Azarbayjan, Baranduz Chay (37°25'N, 45°10'E);

CMNFI 1970-0561, 3, not kept, possibly West Azarbayjan, Cheagia Chay (no other locality data, possibly Ghaie Chay); CMNFI 1979-0785, 11, 72.6-123.8 mm standard length, West Azarbayjan, Shahr Chay (ca. 37°27'N, ca. 44°55'E); CMNFI 1979-0786, 26, 65.0-92.2 mm standard length, East Azarbayjan, Guru Lake (37°55'N, 46°24'E); CMNFI 2007-0096, 1, 54.7 mm standard length, West Azarbayjan, Qasemlu River in Baranduz Chay basin (ca. 37°25'N, ca. 45°10'E); CMNFI 2007-0097, 2, 42.0-54.9 mm standard length, West Azarbayjan, Baranduz Chay basin (ca. 37°16'N, ca. 45°08'E); CMNFI 2007-0103, 6, 43.3-73.3 mm standard length, Kordestan, Zarrineh River basin north of Saqqez (ca. 36°18'N, ca. 46°16'E); CMNFI 2007-0104, not kept, Kordestan, Zarrineh River basin south of Saqqez (ca. 36°12'N, ca. 46°18'E); CMNFI 2007-0105, 6, 67.3-112.1 mm standard length, Kordestan, Zarrineh River basin (ca. 36°06'N, ca. 46°20'E); CMNFI 2008-0137, 2, 72.2-80.9 mm standard length, West Azarbayjan, Zarrineh River (37°05'N, 45°44'E); CMNFI 2008-0158, 1, 88.8 mm standard length, Lake Urmia basin (no other locality data); OSU 8122, 2, 73.1-83.5 mm standard length, West Azarbayjan, Shahr Chay (ca. 37°27'N, ca. 44°55'E); USNM 205904, 2, 73.0-82.6 mm standard length, West Azarbayjan, Nazlu Chay (37°40'N, 45°05'E); uncatalogued, 1, 81.6 mm standard length, West Azarbayjan, Haladj River near Mahabad (ca. 36°45'N, ca. 45°43'E) (Coad and Holčík, 1999).

*Alburnus caeruleus*

Heckel, 1843



*Alburnus caeruleus*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus caeruleus*, Iran, Gamasiab River, July 2008, Keyvan Abbasi.



*Alburnus caeruleus*, Khuzestan, Sabzab, Andimeshk, Hamid Reza Esmaeili.



*Alburnus caeruleus*, Turkey, Tigris River, Diyarbakır, Jörg Freyhof.



*Alburnus caeruleus*, 9.0 cm, Iraq, Irbil  
(CC BY 3.0, cropped and lightened, Haider Ibrahim al Timimi).

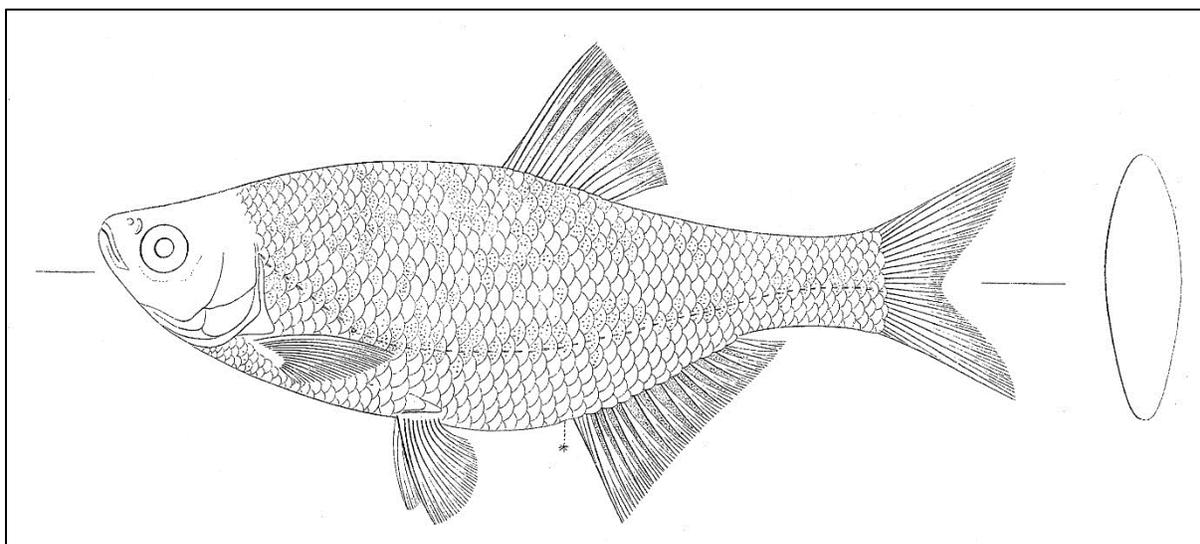


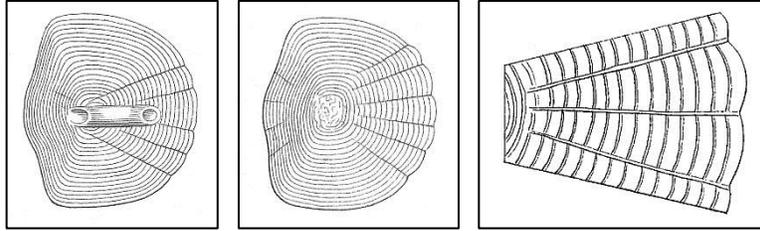
*Alburnus caeruleus*, Turkey, Euphrates River basin, Adiyaman, Jörg Freyhof.

**Common names.** Kuli-ye Dejleh (= Tigris fish), morvarid mahi khaldar (= spotted pearl fish).

[Lassafa (= fluorescent, from Mikaili and Shayegh (2011); taffaf (= little worm) or teffaf asrak (= little blue worm) at Aleppo (= Halab, Syria) in Heckel (1843b); İnci balığı in Turkish (Kaya *et al.*, 2016); black spotted bleak, Tigris bleak].

**Systematics.** The type locality is Aleppo (= Halab), Syria and material is held in the Naturhistorisches Museum Wien. Syntypes are listed in Eschmeyer *et al.* (1996) as NMW 16688 (4, 65.7-86.6 mm standard length as measured by me), NMW 55511-13 (2, 64.5-75.4 mm standard length, 2, 61.2-71.1 mm standard length, 2, 74.1-77.4 mm standard length), NMW 57161 (3, 59.6-71.1 mm standard length), and additionally possibly RMNH 2656 (Rijksmuseum van Natuurlijke Historie, Leiden, ex NMW, 4), and SMF 100 (Senckenberg Museum Frankfurt, ex NMW, 4, 61.3-75.7 mm standard length). B. Riedel (pers. comm., 11 April 2019) also listed NMW 79191 as a syntype (dry bone, *sic*, probably a dried or stuffed specimen in this case).



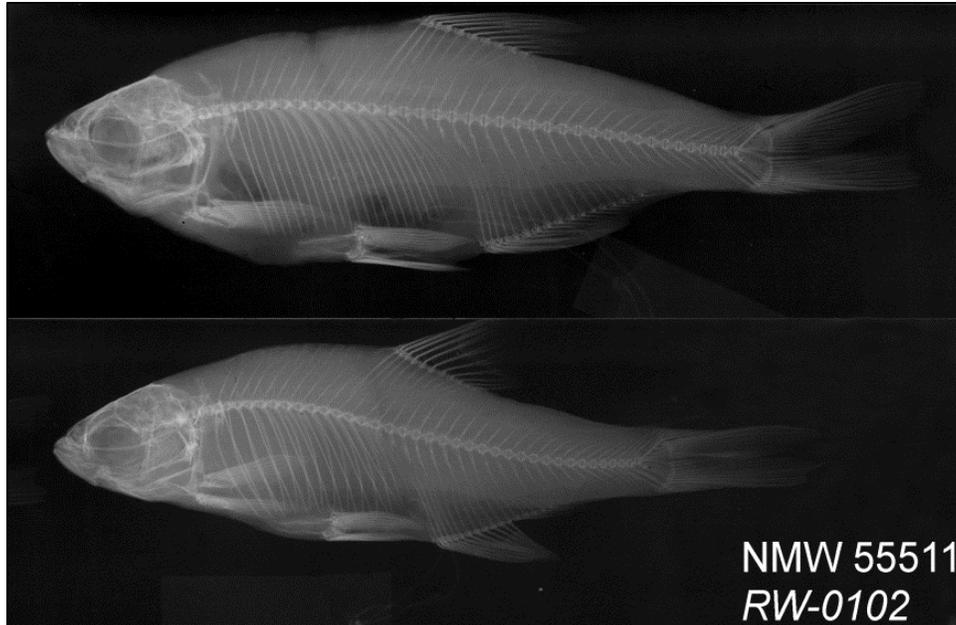


*Alburnus caeruleus*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line (regenerated), and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Alburnus caeruleus*, syntypes, NMW 55511, Naturhistorisches Museum, Wien.



*Alburnus caeruleus*, syntypes, NMW 55511, Naturhistorisches Museum, Wien.

*Alburnoides recepi* Turan, Kaya, Ekmekçi and Doğan, 2014 described from the Merzimen Stream in the Turkish Euphrates River drainage is a synonym (Birecikligil *et al.* 2017).

Dorafshan *et al.* (2014) found a high level of polymorphism although there was more interspecific (94%) than intraspecific (4%) genetic variation compared with *A. mossulensis* (= *A. sellal*).

**Key characters.** This species is distinguished from its relatives by a combination of the lateral line scale count, anal fin branched ray count and total gill raker count, along with a deep body (2.8-3.5 in standard length).

**Morphology.** The body is relatively deep, 2.8-3.5 times in standard length, with a slight nuchal hump, or the back is rounded in front of the dorsal fin. Young fish are not as deep as adults. The caudal peduncle is relatively deep. The mouth is oblique and does not reach back to the eye. The dorsal fin has a truncate margin and its origin lies over the pelvic fin, well posterior to the pelvic fin origin. The caudal fin is moderately forked with rounded to pointed tips. The anal fin is long with an obliquely truncate margin (Heckel, 1843b) or the margin is emarginate. The anal fin origin lies almost below the centre of the dorsal fin. The pectoral fin extends back to, or just short of, the pelvic fin origin. The pelvic fin reaches back just short of the anal fin origin.

Dorsal fin with 3 unbranched and 7-10 branched rays, usually 8, anal fin with 3 unbranched and 13-18 branched rays, mostly 14-16, pectoral fin branched rays 11-15, and pelvic fin branched rays 6-8. Lateral line scales 43-58. The lateral line is moderately to strongly decurved, and may be irregular in part. Scale shape is a vertical oval with a rounded posterior margin, short and rounded dorsal and ventral margins, and a rounded central posterior margin with shallow indentations dorsally and ventrally. Scales lack radii on the anterior field or may have a few radii, have few posterior radii (six in fish illustrated above), a sub-central anterior focus, and a moderate number of circuli. The naked ventral keel is obvious. Total gill rakers number 10-13, just reaching past the adjacent raker when appressed. Pharyngeal teeth are hooked

at the tip and deeply notched or serrated below, modally 2,5-4,2, with variants 2,5-5,2, and 2,5-4,1. The gut is s-shaped. Total vertebrae number 38-40. The syntypes NMW 55511 have 40(2), NMW 55512 39(2), NMW 55513 39(2) and NMW 16688 38(1) and 39(3) total vertebrae. Chromosome number is  $2n = 50$  (Nazari *et al.*, 2011).

**Sexual dimorphism.** Males have tubercles on the lower jaw, the sides and dorsal surface of the head and on flank scales. Tubercles are evident on the pectoral fin and appear as traces on the pelvic fins.

**Colour.** The back is blackish, with flanks silvery and sometimes overall olive-green. The horizontal stripe along the flank is sky-blue, more diffuse or absent in larger fish but very evident in smaller ones. Flanks, even lower flanks, and head are heavily speckled. The lateral line may bear pigment spots above and below each pore but the stitched effect is not as marked as in some *Alburnoides* species. Fins are generally yellowish, the dorsal, anal and pelvic fins apically black to sky blue. The membranes of the dorsal and anal fins are heavily pigmented while the rays are clearer. This pigmentation is more evident anteriorly on small fish but in both large and small fish fins appear dark, especially when the fins are collapsed. On the anal fin some fish have dark pigment on all membranes, others, even large fish, have less pigmentation distally on the posterior membranes. In larger fish, the pectoral and pelvic fins have dark membranes, the pigmentation fading on the smaller rays. The pectoral and pelvic fins can be orange. In some specimens the edge of the caudal fin is quite dark. The peritoneum is brown to black.

**Size.** Attains 13.0 cm total length (Saç, 2020).

**Distribution.** This species is found in the Tigris-Euphrates and Quwayq River systems. The Orontes (= Asi) River is not a locality (Krupp, 1985c). In Iran, recorded from the Tigris River basin in the Arvand, Dinvar, Do Ab, Chardoval, Gamasiab, Kashkan, Marun, Qareh Su, Sarabeleh (= Sar Ableh) and Simareh rivers (K. Abbasi, *Iranian Fisheries Research Organization Newsletter*, 57:2, 2009; Khataminejad *et al.*, 2013; Dorafshan *et al.*, 2014; Mousavi-Sabet *et al.*, 2015; Zareian *et al.*, 2015; Mohammadian-Kalat *et al.*, 2017; Khamees *et al.*, 2019; Jouladeh-Roudbar *et al.*, 2020). It may be more widely distributed in Iran than records suggest.

**Zoogeography.** The relationships of this species zoogeographically have not been studied.

**Habitat.** This species is found in rivers, streams, lakes, dams and ponds. In Iran, it was recorded by K. Abbasi (*Iranian Fisheries Research Organization Newsletter*, 57:2, 2009) from the Gamasiab and Do Ab rivers (34°22'16"N, 47°54'51"E at 1,412 m altitude and 34°27'11"N, 47°39'34"E at 1,322 m) and, given the fishing effort, were quite rare (0.02% of fishing sites, eight individuals). Khalifa (1989) reported this species as widely distributed in rivers and ponds, and it is also found in streams, dams and reservoirs in Iraq. Epler *et al.* (2001) found it to be the third most dominant species of fish in the Iraqi lakes Habbaniyah, Tharthar and Razzazah, comprising 8.7% of all fish collected.



Habitat of *Alburnus caeruleus*, Ilam, Chardoval River, Hamid Reza Esmaili.

**Age and growth.** Mousavi-Sabet *et al.* (2014) gave a  $b$  value of 3.072 for 13 fish, 6.61-8.21 cm total length, from the Sarabeleh (= Sar Ableh) River. Valikhani *et al.* (2020) combined fish from the Shadegan Wetland and the Dez and Karkheh rivers and reported a  $b$  value of 2.84 (isometric growth) and a condition factor of 2.81 for 55 fish, 3.2-8.5 cm total length.

Saç (2020) found  $b$  values for Euphrates (56 fish, 3.4-6.2 cm total length) and Tigris River (30 fish, 4.3-6.8 cm total length) populations in Turkey were 3.243 and 3.34, both indicating positive allometric growth. Seçer *et al.* (2020) determined the population parameters of this fish in the Merzimen Stream of the Euphrates River basin of Turkey. A total of 347 specimens were analyzed and the age varied from 0 to 3 age classes with the majority at age class 2 (44.45%) followed by the 1, 3 and 0 age classes, respectively. Total length ranged from 2.6 to 8.4 cm and weight varied from 0.11 to 6.82 g. The average length and weight were calculated as  $5.53 \pm 1.12$  cm and  $1.83 \pm 1.23$  g, respectively. The length-weight relationship was  $W = 0.0062TL^{3.221}$ . The von Bertalanffy growth parameters were  $L_{\infty} = 10.50$  cm,  $k = 0.3665$ ,  $t_0 = -0.89$ , growth coefficient ( $\Phi'$ ) = 3.7 and condition factor ( $K$ ) = 0.37. Total, natural and fishing mortalities rates and exploitation rate were estimated as  $Z = 0.79$ ,  $M = 0.55$ ,  $F = 0.24$  and  $E = 0.30$ , respectively.

**Food.** Unknown.

**Reproduction.** Large eggs were visible in fish from Syria caught on 19 May, suggesting spring spawning.

**Parasites and predators.** None reported from Iran.

**Economic importance.** None.

**Experimental studies.** None.

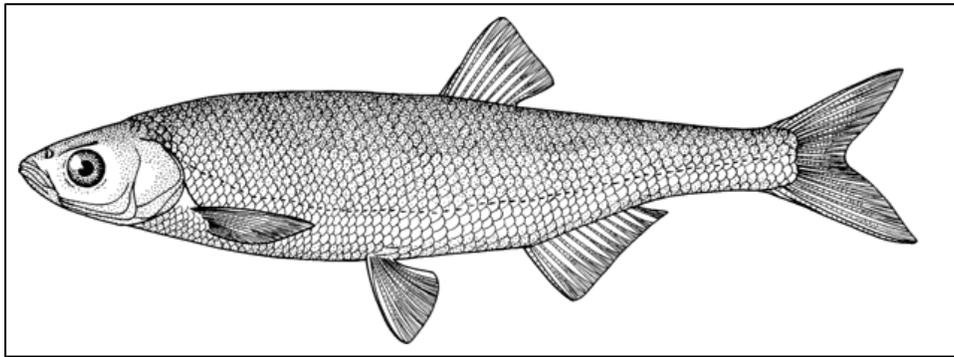
**Conservation.** This species is poorly known and documented in Iran so its conservation status is unknown. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Type material:- *Alburnus caeruleus* (NMW 16688, NMW 55511, NMW 55512, NMW 55513, NMW 57161 and SMF 100).

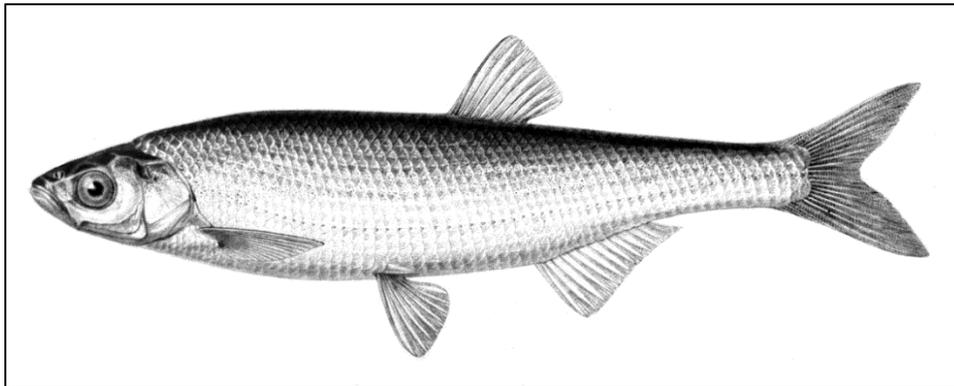
Iranian material: None.

Comparative material:- BM(NH) 1974.2.22:83, 1, 67.9 mm standard length, Iraq, Sirwan, Tigris River near Faish Khabur (ca. 37°08'N, ca. 42°38'E); SMF 28638, 14, 69.1-100.7 mm standard length, Syria, Euphrates River, Deir ez-Zor (35°31'N, 39°54'E); SMF 28678, 3, 59.0-98.8 mm standard length, Syria, Euphrates River upstream Deir ez-Zor (35°31'N, 39°57'E); SMF 28698, 4, 84.4-105.6 mm standard length, Syria, Euphrates River, downstream Baath Lake (35°55.723'N, 39°00.572'E); SMF 28712, 3, 51.8-59.3 mm standard length, Syria, Euphrates River Raqqa to Halebye-Zalebye (35°36.083'N, 39°00.572'E to 53°50.029'N, 39°20.797'E); ZMB 3364 (possibly syntypes as marked from Vienna Museum), 4, 55.6-65.8 mm standard length, Syria, Aleppo (= Halab).

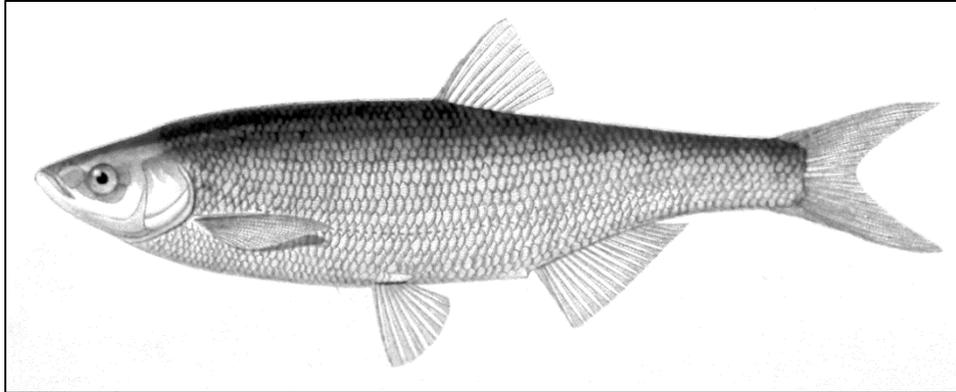
*Alburnus chalcoides*  
(Güldenstädt, 1772)



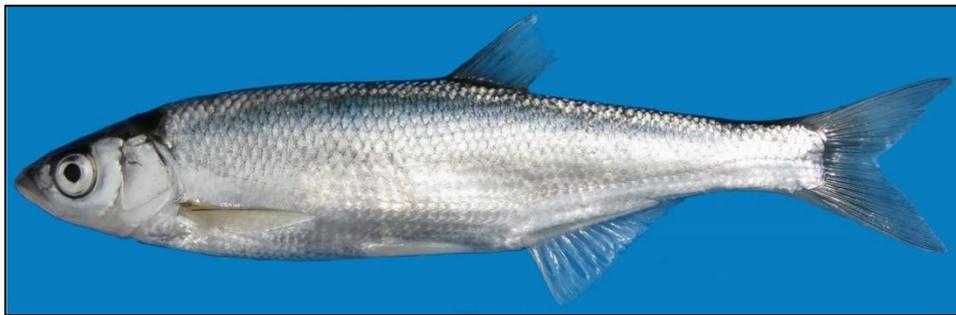
*Alburnus chalcoides*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus chalcoides*, 23.0 cm total length, ZISP 10701,  
Kazakhstan, Caspian Sea at Fort-Shevchenko, after Berg (1948-1949).



*Alburnus chalcoides*, ZISP 10793, Russia, Terek River at Shchedrinskaya, after Berg (1948-1949).



*Alburnus chalcoides*, Gilan, Shalman River, Keyvan Abbasi.



*Alburnus chalcoides*, Mazandaran, Tajan River, Jörg Freyhof.



*Alburnus chalcoides*, Gilan, Shafa River, June 2009, Keyvan Abbasi.

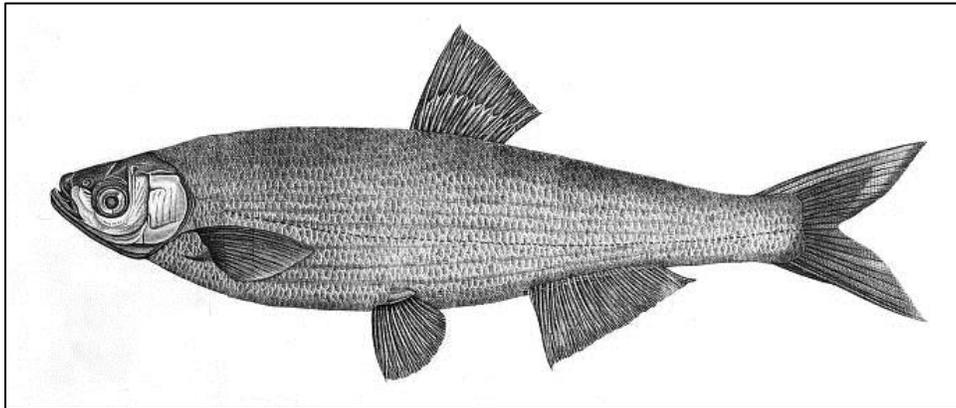


*Alburnus chalcoides*, Gilan, Shafa River, June 2009, Keyvan Abbasi.

**Common names.** Aslak in Mazandaran; kas-e kuli (= cup or bowl fish?); kuli, shah kuli or shah kooli, shah mahi in Gilaki (= royal fish or king fish in the sense of the best or most important fish); mahi shah kuli; sefid kuli (= white fish), shahkuli-ye Khazar (= Caspian king fish); siah kole (= presumably siah kuli, black fish).

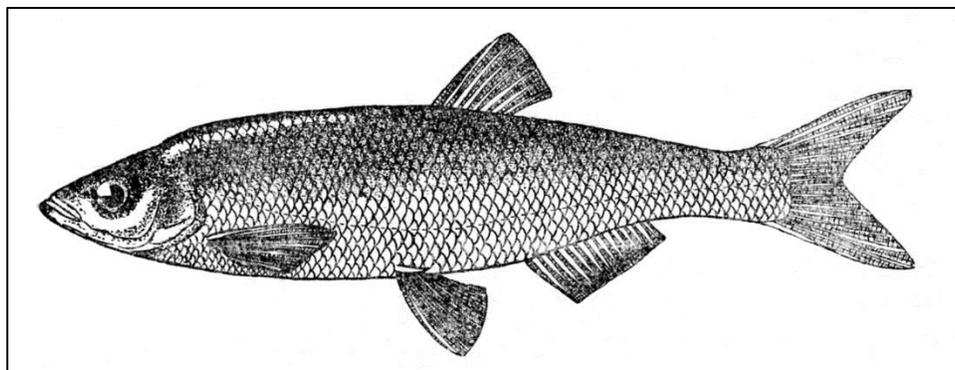
[Samayi, schamay or schumai, Lankaran samayisi for *A. chalcoides longissimus*, Kur samayisi for *A. chalcoides*, all in Azerbaijan; Iranskaya shemaya or Iranian shemaya, Lenkoranskaya shemaya or Lenkoran shemaya, shemaya or shamaya in Russian; bleak, Caspian shemaya, Danube bleak; gypsy king fish (Garedaghi and Mohammadi Hefz Abad, 2012)].

**Systematics.** *Cyprinus chalcoides* was originally described from the Terek, Sulak and Cyrus (= Kura) rivers, Russia. No types are known.

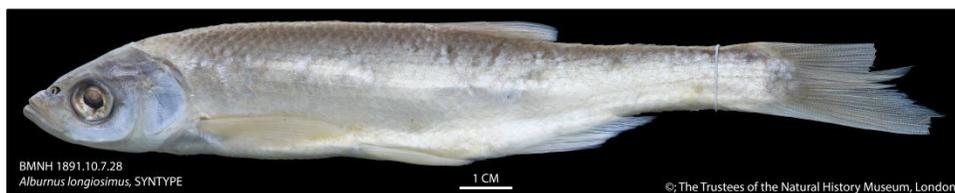


*Cyprinus chalcoides*, after Gldenstdt (1772).

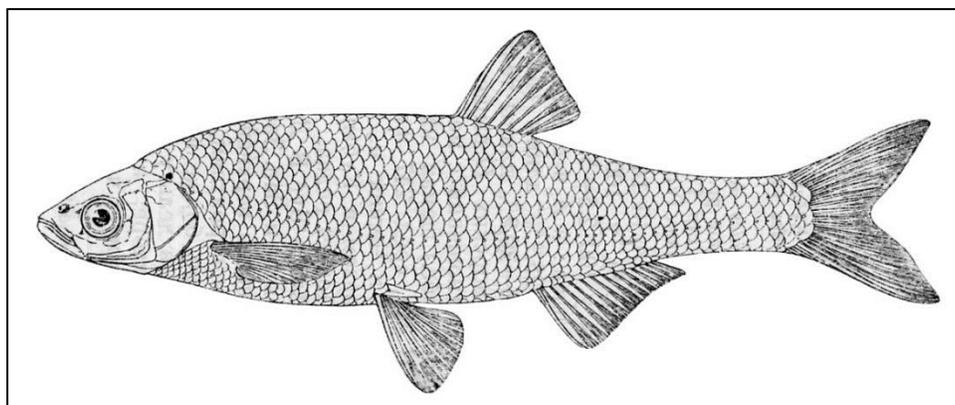
*Cyprinus clupeoides* Pallas, 1776 from the Caspian Sea, Terek and Kura rivers (also spelled *clupoides* in error) (no types known), possibly *Leuciscus albuloides* Valenciennes, 1844 from “rivires de Perse” (types not given in *Catalog of Fishes*, downloaded 30 May 2018), *Alburnus longissimus* Warpakhovskii, 1892 from the Geoktapinka River, Lenkoran District, Azerbaijan and *Alburnus latissimus* Kamensky, 1901 (no types known) from the mouth of the Kura River, Azerbaijan are synonyms. Since *Alburnus latissimus* occurs with *Alburnus chalcoides* in the Kura River, its status is necessarily equivocal.



*Alburnus longissimus*, after Abdurakhmanov (1962).



*Alburnus longissimus*, syntype, BM(NH) 1891.10.7:28.



*Alburnus latissimus*,  
ZISP 14714, Azerbaijan, Kumbashi, Lenkoran District, after Berg (1932b).

*Chalcalburnus chalcoides iranicus* Svetovidov, 1945 was described as the subspecies of the Iranian shore of the Caspian Sea basin and *Alburnus chalcoides longissimus* Warpakhovskii, 1892 as the subspecies of the Lenkoran in Azerbaijan neighbouring Iran. Coad (1996a) examined the types of *iranicus* and *longissimus* and found them not to be distinguishable. The latter name has priority but both these nominal subspecies, and *latissimus*, are most probably not distinct from the type subspecies. They were founded on small samples from relatively homogenous spawning populations. Variation may be clinal or related to local temperature and other environmental variables. A very large series of specimens would be necessary to define this. The Caspian Sea species may be *Alburnus chalcoides chalcoides* with a distinct subspecies, *Alburnus chalcoides mento* (Heckel, 1836) in the Black Sea basin (now recognised as a distinct species), although up to 13 subspecies were named from Anatolia and the basins of the Black, Caspian and Aral seas.

The type material of *Chalcalburnus chalcoides iranicus* is in the Zoological Institute, St. Petersburg (ZISP 31221, holotype, see below), and three paratypes 142.0-199.9 mm standard length), the type locality being “a small stream near the hospital near Shahi, Talar River basin”

on labels in the Zoological Institute, St. Petersburg and “a small river in the vicinity of town Shakhi (basin of the river Talar, running into the Caspian Sea west of the Gorgan Bay” (Svetovidov, 1945). Shahi or Qa'emshahr is at 36°28'N, 52°53'E. Svetovidov (1945) listed the holotype as a female of total length 263.5 mm and body length 226 mm but the holotype in ZISP is 216.7 mm standard length (Coad, 1996a). The *Catalog of Fishes* (downloaded 30 May 2018) gives further syntypes as ZISP 31222 (6+).

The type material of *Alburnus longissimus* is in the Zoological Institute, St. Petersburg (ZISP 8653, 2 syntypes, 164.8-185.9 mm standard length, from “Fl. Geoktapinka” (Lenkoran). The locality is probably near Prishib at 39°08'N, 48°36'E (Coad, 1996a). ZISP 8654 (6 fish, 121.2-164.4 mm standard length) from the type locality are listed as types in Berg (1911-1914) and the *Catalog of Fishes* (downloaded 30 May 2018) but not in the ZISP catalogue. Also, an *A. longissimus* syntype from St. Petersburg is in the Natural History Museum, London from “R. Geotapinka” (BM(NH) 1891.10.7:28).

Bagherian and Rahmani (2007, 2009) examined two populations, from the Haraz River and the Shirud, morphometrically. The males and the females between the two populations were different, but this was attributed to environmental factors. Truss analysis separated the two populations. Rahmani and Hasanzadeh Kiabi (2007) were able almost to separate the two populations using meristic characters. Rahmani *et al.* (2006) were able to separate populations from the Gzafrud and Haraz rivers using morphometric characters but not meristic ones. Rahmani *et al.* (2009, 2012) used the 18S rRNA and cytochrome *b* genes and found populations from the Gzafrud, Haraz and Shirud rivers were homogenous. Mohaddasi *et al.* (2013) analysed morphometric differentiation in fish from the Babol, Lisa and Shirud rivers and the Anzali region and found samples from the Anzali region were clearly distinct and diverged from the other three populations probably because of difference in habitat conditions. Generally, female samples showed more morphometric differences than male samples did. Mohammadian-kalat *et al.* (2013) suggested this species may be a species complex based on morphology and molecular data. Mouludi-Saleh *et al.* (2020) compared fish from the Chelvand (Astara), Khalesara (Talesh), Siah Darvishan (Anzali Wetland), Sefid and Pol (Gilan), and Tonekabon and Babol (Mazandaran) rivers using meristics and morphometrics and were able to distinguish the populations, with the Chelvand River population in a distinct clade. Abbasi *et al.* (2021) collected fish from the Sefid River (45 autumn and 113 spring samples) and the Siah Darvishan River (22 autumn and 28 spring samples) in the southern Caspian Sea basin and a total of 22 morphometric and eight meristic characters were recorded. The autumn and spring migratory populations had significant differences in seven and two morphometric traits, respectively, but no differences in meristic characters.

A hybrid of *Alburnus chalcoides* and *Vimba vimba persa* (= *V. persa*) was reported from the Sefid River (Petrov, 1926) and a hybrid between *Leuciscus cephalus (sic)* and *Alburnus chalcoides* is reported from Turkey (Ünver and Erk'akan, 2005; Ünver *et al.*, 2008).

**Key characters.** This Caspian Sea species is distinguished by having modally 8 branched dorsal fin rays, 54-74 lateral line scales, an abdominal keel partly covered by scales (no more than half naked), and a light brown peritoneum.

**Morphology.** Body form varies with habitat, fish from the Anzali Lagoon having a larger and more curved body shape, increasing with size, compared to fusiform fish from rivers although the amount of curvature could be independent of the environment (Mohadasi *et al.*, 2014). The body is compressed and moderately deep, being deepest between the end of the pectoral fin and the pelvic fin origin. The predorsal profile is straight in front of the dorsal fin,

falling to the head or mostly straight or gently convex. A slight nuchal hump may develop. The caudal peduncle is compressed and shallow. The head tapers to a pointed snout. The eye lies at the beginning of the anterior half of the head and can be quite large. The mouth is oblique and superior or terminal with the lower jaw projecting. It extends back level with the nostril. Lips are thin. The dorsal fin has a straight, slightly rounded or slightly concave margin and its origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the beginning to middle of the anal fin. The caudal fin is moderately to deeply forked with rounded to pointed tips and a larger, more rounded lower lobe. The anal fin margin is rounded at its beginning and slightly emarginate thereafter or mostly straight. The fin does not extend back to the caudal fin base. The pelvic fin is rounded and does not reach back to the anal fin. The pectoral fin is rounded and falls short or extends back to the pelvic fin origin.

Dorsal fin with 2-3, usually 3, unbranched and 7-9, usually 8, branched rays, anal fin with 3 unbranched and 10-21 branched rays (usually 14-15), pectoral fin branched rays 13-16, and pelvic fin branched rays 7-9. Ginzburg (1936) gave counts of 13(7), 14(34), 15(52), and 16(7) for anal fin rays from Iranian material, modally different from my counts below (possibly the last two rays were counted separately but variation between samples is also possible). Lateral line scales 54-74. There is a well-developed pelvic axillary scale. The ventral keel is only naked near the vent (Berg, 1948-1949) and rarely may be scaled along its entire length although Kottelat and Freyhof (2007) have an exposed keel of 8-12 scale lengths, up to 80% of the anus to pelvic fin base distance. Scale shape is a vertical oval. The dorsal and ventral scale margins are parallel or rounded. The anterior margin is wavy or has a pronounced central protuberance with indentations above and below. The posterior scale margin can be rounded and more or less smooth, or rounded and finely crenulate. Crenulation may be related to size or sexual maturity but is not always evident even in spawning males. Circuli are numerous and fine, radii are few and present on the anterior and posterior fields (a few fish had some scales with no anterior radii), and the focus is slightly subcentral anterior. Total gill rakers 18-31 (usually 20-23), serrated medially and elongate, reaching the second or third adjacent raker when appressed. Pharyngeal teeth are 2,5-5,2, more rarely 2,5-5,1, 2,5-5,3, 2,5-5,4 or 3,5-5,3. Teeth are elongate, slender, curved inward, strongly hooked at the tip and strongly serrated with serrations on the anterior margin of the long, narrow and concave grinding surface. The most posterior main row tooth may lie medial to the second tooth. The gas bladder is pointed posteriorly (rounded in *Alburnus hohenackeri* and *A. filippii*). The gut is an elongate s-shape. Total vertebrae number 41-45.

Shabanipour and Haghi (2019) detailed the retinal structure in embryos, larvae and adults. Zakeri Nasab *et al.* (2018, 2018, 2018) described the morphology, histology and histochemistry of the gut and accessory glands in this species. Zakeri Nasab *et al.* (2018) used histology and electron microscopy to describe the ontogenetic development of the digestive system in larvae and juveniles and Zakeri Nasab *et al.* (2020) general morphology, in particular the mouth, useful in the timing of a practical diet for fry.

Meristic values for Iranian specimens are as follows (the types of *C. chalcoides iranicus* are included here):- dorsal fin branched rays 7(3), 8(55) or 9(2); anal fin branched rays 12(1), 13(4), 14(33), 15(19) or 16(3), pectoral fin branched rays 13(4), 14(9), 15(34) or 16(13), pelvic fin branched rays 7(2), 8(57) or 9(1), lateral line scales 54(1), 55(2), 56(2), 57(5), 58(8), 59(5), 60(14), 61(7), 62(5), 63(6), 64(2), 65(1), 66(1) or 67(1), total gill rakers 18(1), 19(5), 20(12), 21(15), 22(14), 23(9), 24(3) or 25(1), pharyngeal teeth 2,5-5,2(30), 2,5-4,2(1), 2,4-5,2(1) or 2,5-5,3(1), and total vertebrae 42(2), 43(9), 44(32) or 45(7). Khataminejad *et al.* (2015) found fish

from the Babol River had 13-19 anal fin branched rays and 60-68 lateral line scales.

**Sexual dimorphism.** Abdurakhmanov (1962) reported the eye diameter and anal fin base to be larger in males on average for fish from the Kura River basin in Azerbaijan. Iranian males taken in July have small tubercles scattered on top of the head and fine tubercles lining the anterior flank scales. Females are larger than males (Bagherian and Rahmani, 2007).

**Colour.** The overall colour is metallic silvery and the back is a contrasting olive-green to dark green. The iris is bright silver. There is no dark band along the sides. The dorsal and caudal fins are greyish and the other fins colourless to whitish. The peritoneum is light brown but with numerous melanophores in contrast to the dark peritoneum in some other *Alburnus* species.

**Size.** Reaches 50.0 cm and 1.5 kg (Machacek (1983-2012), downloaded 27 July 2012). Shemaya on the Kura River of Azerbaijan are larger than those in the south Caspian, up to 36 cm as opposed to 29 cm.

**Distribution.** Found from central Europe to the basins of the Black, western and southern Caspian and Aral seas. It is recorded from the entire southern coast of the Caspian Sea and its rivers, including the Aras, Astara, Atrak, Babol, Behambar, Chalus, Chamkhaleh, Chapak, Chelond, Chelvand, Chobar, Fereydun Kenar, Gazafud, Ghasemlou, Gholab Ghir, Golshan, Gorgan, Haraz, Haviq, Kargan, Khalesara, Khazar, Kheyrod, Kia, Lale, Langarud, Larim, Lashtenesha (= Lasht Neshah), Lavandevil, Lisar, Lomir, Marbureh, Masuleh-Rukhan, Molahadi, Nahang, Nerissi, Nesa, Pir Bazar, Polrud (= Pol-e Rud), Qareh Su, Qezel Owzan, Rasteh, Sardab, Sefid, Shafa, Shah, Shalman, Sheikan, Shirabad, Shirud, Siah, Siah Darvishan, Sorkh, Sowsar, Tajan, Talar, Tonekabon and Valiabad rivers, the Manjil, Nazdik, Saungar, Sefid and Zire dams, the Anzali Talab including the Siahkeshim Protected Region, Anzali Port, Ghazian region at Anzali, Fereydun Kenar International Wetland, Valasht Lake, Gorgan Bay, and the southeast, southwest and south-central Caspian Sea generally (Derzhavin, 1934; Svetovidov, 1945; Kozhin, 1957; Holčík and Oláh, 1992; Shamsi *et al.*, 1997; Karimpour, 1998; Abbasi *et al.*, 1999, 2007, 2017; Kiabi *et al.*, 1999; Abdoli, 2000; Nazari, 2002; Bagherian and Rahmani, 2007, 2009; Rahmani *et al.*, 2007, 2009; Banagar *et al.*, 2008; Abdoli and Naderi, 2009; Daei *et al.*, 2009; Piri *et al.*, 2009; Shirvani and Jamili, 2009; Nikoo *et al.*, 2010; Patimar *et al.*, 2010; Ahmadpour *et al.*, 2012; Garedaghi and Mohammadi Hefz Abad, 2012; Khataminejad *et al.*, 2013, 2015; Mohadasi *et al.*, 2013; Rahbar *et al.*, 2013; Abdoli *et al.*, 2014; Amouei *et al.*, 2014; Mohammadian-Kalat *et al.*, 2017; Neurasteh *et al.*, 2017; Moshfegh *et al.*, 2018; Mouludi-Saleh *et al.*, 2020; Shahnazari *et al.*, 2020; Aazami and Alavi Yeganeh, 2021; Abbasi *et al.*, 2021).

*Alburnus chalcoides aralensis* Berg, 1926 is reported from the Karakum Canal in Turkmenistan (Shakirova and Sukhanova, 1994; Sal'nikov, 1995) and may eventually be found in the Hari River and Caspian Sea basins of Iran. It is recognised as a synonym of *A. chalcoides* however (*Catalog of Fishes*, downloaded 30 May 2021).

**Zoogeography.** A widespread species with numerous nominal subspecies which have not all been fully investigated. It presumably originated as part of a Danubian or Sarmatian fauna and the subspecies have become isolated in parts of this former basin.

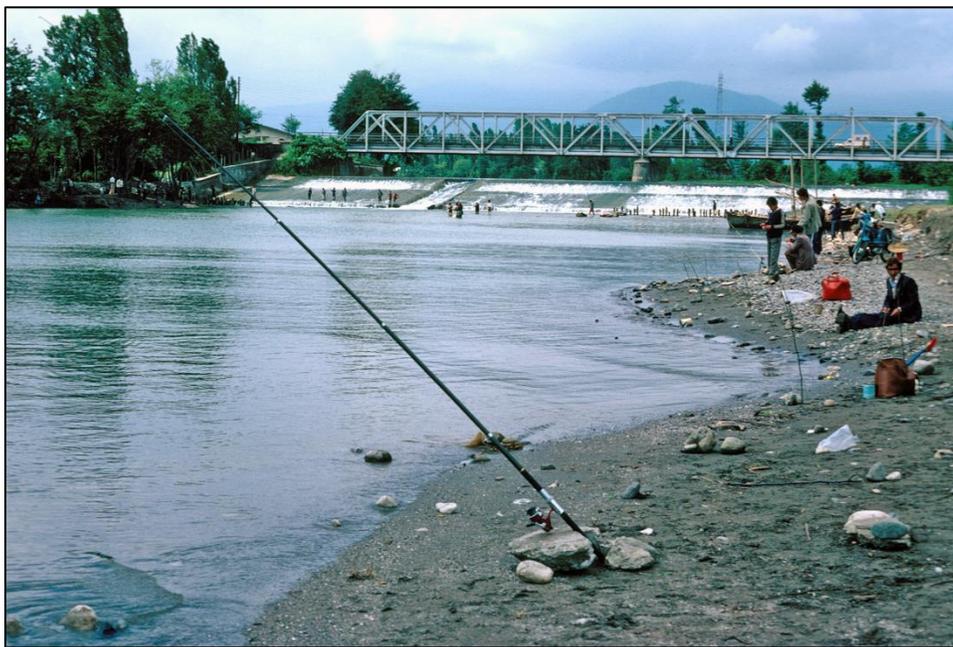
**Habitat.** This species is found in rivers, streams, dams, lagoons, marshes and brackish environments. Some populations are landlocked while others are semi-anadromous. Knipovich (1921) reported this species from depths of 23.8-25.6 m in the Iranian Caspian Sea. Kottelat and Freyhof (2007) recorded a tolerance of 14‰ salinity generally, and Moshfegh *et al.* (2018) 10.5‰ for the Lale River in Gilan. Riazi (1996) reported that this species is native (resident) to the Siahkeshim Protected Region of the Anzali Talab. It has been caught at 31-32°C in the Sefid River estuary on 9 July 1962 (CMNFI 1970-0565, CMNFI 1980-0908) and at 9°C in the Caspian

Sea near the Lale River.

Young are rheophilous (Abdurakhmanov, 1975). A migration to piedmont and montane zones used to occur before dams and weirs obstructed movements.

Shahlapour *et al.* (2018) found only a low abundance of juveniles of this species in the eastern Caspian Sea, attributed to destruction of riverine habitats and illegal fishing of adults.

Shape differences found by Bagherian and Rahmani (2007) in two Iranian rivers were attributed to the Haraz River having a muddy estuary, a shallow slope to the bottom, high turbidity and low water flow in contrast to the Shirud which was sandy with high water flow and high clarity. The latter population developed a slenderer body due to increased resistance to water flow. Mohadasi *et al.* (2013) also found shape differences between fish from a lagoon (Anzali) and three rivers, the former being larger, more fusiform and slimmer in the caudal peduncle. The fusiform shape was discrete from water flow (slow in the Anzali Lagoon), and was related to larger size when fish attained this shape. One river population (Lisar) had a larger abdominal circumference, smaller size and an upturned mouth, compared to fish from the Babol and Shirud. This was attributed to a poor environment and surface feeding in the former, while the two latter rivers were environmentally similar and less remote. These anadromous fishes have a common origin but habitat features might create selective pressures resulting in morphological divergence.



Habitat of *Alburnus chalcoides* (and *Alburnoides tabarestanensis*, *Alburnus hohenackeri*, *Capoeta razii* and *Vimba persa* among cyprinoids),  
CMNFI 1979-0435, Gilan, river west of Ramsar, 4 June 1978, Brian W. Coad.

**Age and growth.** Life span is 5 years with a theoretical limit of 6.5 years in Azerbaijan (Abdurakhmanov, 1975) and at least 5 years in Iran (Holčík and Oláh, 1992) and Turkey (Tarkan *et al.*, 2005). Azari Takami and Rajabi Nezhad (2003) gave 8<sup>+</sup> years for fish from the Sefid River. Sexual maturity was attained at 3 years of age in Azerbaijan and growth was most rapid at an age of 2 years, decreasing thereafter because of high natural mortality (Abdurakhmanov, 1975). The fishes on the spring spawning run in the Anzali Talab were 10.5-29.0 cm standard length, average 14.0 cm, and 2-5 years old with most (63%) fish in age group 3. Males matured

at 2-4 years and females at 3-5 years. Growth was high during the first 3 years of life and then declined (Holčík and Oláh, 1992). Karimpour *et al.* (1993) found the Anzali Talab population to be smaller than the Kura River population but the talab fish showed greater growth after maturation. The spawning migration into the talab began in March and peaked in May and at the beginning of June. Length range was 10.0-24.0 cm, average 16.2 cm, with a mean weight of 64.7 g. Age composition was 2-5 years with three-year-olds comprising 62.5% of the fish. Females formed 57% of the migrating fish. Rahmani (2008) investigated 704 specimens in the Haraz and Shirud rivers and found maximum length and weight in a five-year-old female at 25.1 cm and 96 g, the most abundant age groups were 2<sup>+</sup> and 3<sup>+</sup> years for males and females respectively, males in the Shirud population were heavier and longer on average in younger ages while differences in females were not significant, and females of the Shirud population has isometric growth while Haraz fish had positive allometry. The von Bertalanffy growth parameters were  $L_t = 405.9 (1 - e^{-0.1(t+1.54)})$  for males in Haraz and  $L_t = 442.6 (1 - e^{-0.1(t+1.43)})$  for females in Haraz, and  $L_t = 359.5 (1 - e^{-0.145(t+1.002)})$  for males in Shirud and  $L_t = 405.9 (1 - e^{-0.1(t+1.54)})$  for females in Shirud. Females had a higher  $L_\infty$  while K values for males were relatively higher in the two rivers. Rahmani *et al.* (2009) found growth was better in the Shirud compared with other populations because this river had desirable biological parameters for immigration. Patimar *et al.* (2010) compared fish up to 24.3 cm total length from the Siah and Gorgan rivers and found a five-year life cycle, with negative allometric growth for Siah males and positive allometric growth for Siah females and for both sexes in the Gorgan, and sex ratios were unbalanced in favour of females in both rivers. The von Bertalanffy growth parameters were  $L_t = 370.08 (1 - e^{-0.15(t+0.70)})$  for males in Siah and  $L_t = 432.52 (1 - e^{-0.11(t+1.21)})$  for females in Siah, and  $L_t = 371.79 (1 - e^{-0.14(t+0.96)})$  for males in Gorgan and  $L_t = 436.10 (1 - e^{-0.11(t+1.34)})$  for females in Gorgan. Amouei *et al.* (2014) examined fish from the Shirud, Haraz River, Gazafrud and fish markets finding a maximum age of 4<sup>+</sup> years with a maximum total length of 28.3 cm. The length-weight relationship was  $W = 0.141TL^{2.199}$  indicating negative allometric growth. The male:female sex ratio was 1:2.12 but this was based on 53 fish grouped from various localities.



Mazandaran, Haraz River at Vana Bridge  
(Haraz river and Vana bridge, CC BY 3.0, Alireza Javaheri).

Poorpoode and Rahmani (2013) found a length-weight relationship of  $W = 0.000002TL^{3.295}$  for males (positively allometric) and  $W = 0.000009TL^{2.972}$  for females (isometric) for fish from the Shirud. The average length and weight of females was higher than males. von Bertalanffy growth equations were  $L_t = 245.2(1 - e^{-0.32(t-0.017)})$  for males and  $L_t = 238.6(1 - e^{-0.25(t+1.45)})$  for females. In both sexes the highest instantaneous growth rate was at the age of 1 year, significantly decreasing with age. Mousavi-Sabet *et al.* (2014) gave a  $b$  value of 2.672 for 30 fish, 12.46-18.47 cm total length, from the Babol River. Sorosh Hadad *et al.* (2018) examined 77 fish caught in beach seines from Astara, Anzali and Kiashahr and found a mean length of 19.25 cm, a mean weight of 76.78 g, an age range of 0-4 years with age class 0-1 accounting for 81.8% of the catch, heterogeneous or allometric growth, condition factors of 0.83 and 0.82 in males and females, mean gonadosomatic indices of 8.04 and 3.05 in females and males, and mean hepatosomatic indices of 0.79 and 0.75 in males and females. Abbasi *et al.* (2021) found length-weight relationship parameters revealed that Sefid River populations have an isometric growth pattern and the autumn and spring populations of the Siah Darvishan River showed positive allometric and isometric growth patterns, respectively.

**Food.** Holčík and Oláh (1992) reported a feeding migration in July to September in the western basin of the Anzali Talab. Gut contents included diatoms and algae, dragonfly larvae, and copepods in Azerbaijan (Abdurakhmanov, 1962). Rajabi Nezhad and Azari Takami (2009) found fish caught from the estuary to Kisom on the Sefid River fed on Chrysophyta, Chlorophyta, Cyanophyta, Copepoda and Cladocera, along with some chironomid larvae and the diatom *Gomphonema*. The main food was zooplankton. Iranian fish examined by me had plant fragments, sand grains, crustaceans, insect remains and chironomid larvae in gut contents.

**Reproduction.** Svetovidov (1945) considered that Iranian populations (his *iranicus*

subspecies) spawned nearly throughout the year since fish having ripe sex products were caught in both July and February and young were found along the Iranian coast throughout the year. Spawning took place in the sea, in areas such as Gorgan Bay, and in the lower reaches of rivers. Nikoo *et al.* (2010) measured serum sex steroids during spawning in the Valiabad River and concluded that this fish may be a multiple spawner. Khaval (1998) reported a spawning migration into the Sefid River despite construction, sand removal and pollution. Holčík and Oláh (1992) reported a migration into the Anzali Talab for spawning in late February to early April (but see above; possibly a confusion between the migration at an earlier date than the spawning act).

Karimpour *et al.* (1993) gave an absolute fecundity of 6,630 eggs in the Anzali Talab population while mean relative fecundity was 140 eggs/g of body weight. Iranian fish had 1.5 mm eggs as early as 13 March (fish standard length 213.2 mm) and 1.7 mm eggs on 4 June (fish length 154.6 mm) while eggs are only 1.3 mm on 15 July (fish length 142.8 mm). Larger fish may mature and spawn earlier than younger fish. Rahbar *et al.* (2008) found Anzali Wetland or Talab spawning migrants had a highest absolute fecundity of 8,301.21 eggs and average number of ovules per gramme body weight was 821.79 for three-year-olds (minimum for two-year-olds). Maximum average relative fecundity (109.89) and gonadosomatic index (14.49%) were found in in two-year-olds (minimum in three-year-olds). Rahbar *et al.* (2013) found Anzali Wetland fish age 2 years had an absolute fecundity of 4,447.84 eggs, a relative fecundity of 86-177 (mean 109.89), and an egg diameter of 1.13-1.26 (mean 1.17 mm) while in three-year-old fish it was 8,301.21 eggs, 75-133 (mean 99.21).and 1.13-1.27 (mean 1.18). Pouresmaeilian *et al.* (2015) examined male migrants to the Anzali Wetland describing the histology of the gonads and the rate of sex steroid production, finding that the physiological role of testosterone is more in spermiation than spermatozoa. Pouresmaeilian *et al.* (2016, 2017) described sex steroid levels, reproductive indices and the histology of gonads in males and females from the Anzali Wetland. Absolute fecundity was 7,467.23 eggs in 2<sup>+</sup> matured fish and 568.01 eggs in 3<sup>+</sup> fish. Oocyte diameter was 774.21 and 806.6  $\mu\text{m}$  respectively and in ripe fish averaged 792.4  $\mu\text{m}$ . This species is probably a multiple spawner with a protracted spawning period and showed higher levels of sex steroids in matured fish, compared to maturing fish, probably as a consequence.

Azari Takami and Rajabi Nezhad (2003) collected 539 specimens of this species from the sea shore to Kisum (= Kisom) on the Sefid River, finding Astaneh and Kisom were favourable sites for spawning. The maximum fecundity was 18,860 eggs for eight-year-old fish and the minimum was 2,929 eggs for three-year-old fish. Relative fecundity was 132 and there were 72 eggs/g (*sic*). Rahmani *et al.* (2009) found a peak gonadosomatic index for males in May and for females in early June in the Shirud. Average fecundity was about 3,900 eggs with diameter reaching 1.17 mm. Patimar *et al.* (2010), in their study of Siah and Gorgan River fish, found spawning between April and July in the Siah and March and June in the Gorgan, peaking in May in both rivers. Absolute fecundity was up to 38,340, mean 8,426 eggs, in the Siah and up to 17,263, mean 4,215 eggs, in the Gorgan. Relative fecundity was up to 599, mean 212 eggs/g, of body weight in the Siah and up to 696, mean 112 eggs/g, in the Gorgan. Mean egg diameters were 1.4 mm in the Siah and 1.27 mm in the Gorgan. These differences in life history (see also **Age and growth** above) were attributed to differing habitat characteristics.

Rahbar *et al.* (2013) found fish from the Sefid, Chamkhaleh and Shirud rivers had egg diameters 1.07-1.25 (mean 1.18), 0.64-1.24 (1.11) and 1.03-1.23 (1.12) mm, absolute fecundity 1,665-3,642 (mean 2,613.97), 1,971-5,550 (3,659.0) and 1,829-8,206 (3,728.7) eggs, and relative fecundity 67-165 (mean 108.7), 69-158 (101.06) and 81-149 (113.15) eggs/g, all respectively.

Fish from the Sefid had the maximum gonadosomatic index and those from the Chamkhaleh the lowest. Values varied between the three localities in reproductive characters.

This species is an intermittent spawner with three batches of eggs, only two of which are laid at an interval of 18-19 days in Azerbaijan. Fecundity reached 54,700 eggs there but this was less than that of diadromous populations. Egg diameter was up to 1.9 mm. Spawning took place in the second half of July to the end of August at water temperatures of 18-25°C in the Mingechaur Dam in Azerbaijan. Sticky eggs were laid on rocky bottoms in 15-20 cm of water after a migration into streams or on rocky grounds of reservoirs (Abdurakhmanov, 1962, 1975; Elanidze, 1983). There is a spawning migration into the Kura River from October to April, peaking in December-January, with spawning taking place in spring in the upper reaches (Berg, 1959). In Lake Tuş, Turkey spawning occurred in May-June, egg numbers reached 20,971 and average egg diameter 1.05 mm (Balik *et al.*, 1996).

**Parasites and predators.** Molnár and Jalali (1992) reported the monogeneans *Dactylogyrus minor*, *D. alatus* and *D. vistulae* from this species in the Ghasemlu River, an inland watershed, with the latter species also in the Sefid River. They also described a new species of monogenean, *Dactylogyrus holciki*, from this species in the Beshar River of the Persian Gulf drainage, possibly confusing this Caspian Sea basin cyprinid with *A. sellal*. Molnár and Jalali (1992) also recorded the monogenean *Dactylogyrus chalcalburni* from the Sefid and Zayandeh rivers, although this Caspian Sea basin species does not occur in the latter locality, possibly being *A. doriae*. Shamsi *et al.* (1997) reported *Clinostomum complanatum*, a parasite causing laryngo-pharyngitis in humans, from this species in the Shirud. Masoumian and Pazooki (1998) surveyed myxosporeans in this species in Gilan and Mazandaran provinces, finding *Myxobolus pseudodispar*. The helminths *Pentagramma symmetrica* and *Mazocea alaosa* were recorded from the guts of *Chalcalburnus tarichi* (*sic*, presumably *A. chalcoides*) from the Anzali Wetland (Ataee and Eslami, 1999; [www.mondialvet99.com](http://www.mondialvet99.com), downloaded 31 May 2000). Naem *et al.* (2002) found the monogenean trematodes *Dactylogyrus chalcalburni* and *Gyrodactylus* sp. on the gills of this species from the western branch of the Sefid River. Sattari *et al.* (2004, 2005) surveyed this species in the Anzali Wetland, recording *Anisakis* sp. Maleki and Malek (2007) examined fish from the Shirud and recorded the digeneans *Posthodiplostomum cuticola*, *Diplostomum spathaceum*, *Clinostomum complanatum* and *Allocreadium* sp. Sattari *et al.* (2007) found the nematode *Anisakis* sp., the digenean *Diplostomum spathaceum* and the monogenean *Dactylogyrus extensus* in this species in the Anzali Wetland. Miar *et al.* (2008) examined fish in Valasht Lake and the Chalus River, Mazandaran and found the metazoan *Argulus foliaceus*. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Argulus foliaceus* on this species. Garedaghi and Mohammadi Hefz Abad (2012) found plerocercoid larvae of *Ligula intestinalis* in the abdomen of fish from the Saungar Dam in Gilan. Mirhashemi Nasab *et al.* (2017) found *Diplostomum spathaceum* in fish from the Anzali Wetland with prevalence (25.0%) and range (1-6 worms in a fish). Barzegar *et al.* (2018) reported the monogenean *Gyrodactylus prostaе* from the Tajan and Talar rivers in Mazandaran. Moumeni *et al.* (2020) recorded the zoonotic *Clinostomum complanatum* from this species in Iran.

Ashoori *et al.* (2017a) recorded this species as an occasional item in the diet of young black-crowned night herons (*Nycticorax nycticorax*) in the Anzali Wetland.

**Economic importance.** The shemaya was a valuable edible fish on the Kura River of Azerbaijan with catches as high as 500 centners (1 centner = 100 kg) prior to construction of the Kura dam. The catch for Azerbaijan in 1933 was 1,950 centners or 2,029,000 fish. Catches in the Mingechaur Dam were 133 centners in 1972 (Abdurakhmanov, 1975). Reputedly delicious

eating (Lönnberg, 1900b). They are fished for on the spawning run when fatty. In Iran, they are caught by cast nets in the inlets and outlets of the Anzali Talab in spring on the spawning run and by gill nets in the western basin on the feeding migration. Holčík and Oláh (1992) reported a catch of 956 kg in the Anzali Talab in 1990 but catches in recent years may have been confused with the exotic *Hemiculter leucisculus* (Holčík and Olah, 1990). It has been termed a commercial or semi-commercial species by Falahatkar *et al.* (2015). Moradinasab *et al.* (2015) noted its presence in the kilka by-catch (*Clupeonella* spp., Clupeidae) on the Bandar-e Anzali fishing grounds although it, along with five other species, only comprised 0.2% of the kilka catch.

Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use in aquaculture and as food.

**Experimental studies.** Zolfaghari *et al.* (2007) found mercury levels in muscle of fish (identified as *Chalcalburnus chalcalburnus*, presumably the present species) from the Anzali Wetland were below dangerous levels. Shirvani and Jamili (2009) found excessive levels of cadmium and lead in this fish from regions of Anzali where oil ship traffic was highest. Daei *et al.* (2009) reported on the effects of cadmium and lead on the iron solute in blood. Panahandae *et al.* (2013) examined levels of cadmium, chromium and lead in fish from the Anzali Talab and found no levels exceeded international standards. Sadeghi *et al.* (2018) found average accumulation of chromium and cobalt in fish from the Anzali Lagoon and Shirud was not significantly different, chromium in skin and gill tissues (but not muscle) at both stations was higher than standard levels, and cobalt was higher than standard levels in the Anzali Lagoon.

This species has been artificially bred without hormones on the Shirud with a fertilisation rate of 90-98%. Hatching took six days and the hatching rate was 57% (*Iranian Fisheries Research Organization Newsletter*, 36:4, 2003). On the Tajan River, induction of ovulation has been carried out using LRH-Aa with metoclopramide and carp pituitary extract (Yousefian *et al.*, 2008). Fertilisation rate was 83%, hatching rate 90% and survival of larvae 81%. Nosrati *et al.* (2017) studied the effects of injection of pituitary extract, ovaprim (a commercial spawning inducing agent) and HCG hormones in combination with metoclopramide for inducement of maturation and artificial reproduction performance in fish from the Sefid River. A wide variation in reproductive parameters was found and the best dose for germinal replenishment was 20 µg/kg ovaprim. Nosrati *et al.* (2017) injected various pituitary doses at different temperatures for artificial reproduction. The most suitable dose was 1-3 mg/kg at a temperature of 17-20°C. Sufficient duration of egg washing with ordinary water was 30 minutes. The rate of fertilisation was between 85-98%, incubation dry egg diameter was 1.5 mm and swollen ones 1.8 mm, absolute fecundity varied between 3,227-14,654 eggs, during 3 months of culture the fry had an average weight of 2.8 g, and survival rate of the larvae was 65-80%.

Neurasteh *et al.* (2017) found that fish consumed a high level of energy just after breeding and while returning to the Caspian Sea based on gill chloride cell numbers (highest in the sea, lowest in the river) and plasma prolactin levels (the reverse). Bahrpeyma *et al.* (2017) examined haematological parameters and found red blood cell count, haemoglobin and haematocrit values were significantly higher in males than in females, these parameters were significantly higher in the river than in the sea and estuary, and in the summer than other seasons. Blood factors had significant negative correlations with water salinity and total length as well as weight of fish, and a significant positive correlation with water temperature. Bahrpeyma *et al.* (2018) studied the distribution of lymphoid cells in the kidney of fish from Gilan and found a significant negative correlation with salinity so that their distribution in the sea was significantly less than that in the river and estuary. Distribution of lymphoid cells was not

statistically significant based on fish gender but had a reverse correlation with age, total length and weight. Moshfegh *et al.* (2018) demonstrated differences in sex, habitat and seasonal variation caused variation in haematology and plasma chemistry intervals for migrating fish. Zakeri Nasab *et al.* (2020) studied the ontogeny of alterations in digestive enzymes, important in culturing the species.

**Conservation.** Holčík and Oláh (1992) reported a decline in the numbers of this species owing to damming of rivers where it used to spawn. Kiabi *et al.* (1999) considered this species to be near threatened in the south Caspian Sea basin according to IUCN criteria. Criteria included commercial fishing, sport fishing, abundant in numbers, habitat destruction, widespread range (75% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. Mostafavi (2007) listed it as near threatened in the Talar River, Mazandaran. Pouresmaeilian *et al.* (2017) and Moshfegh *et al.* (2018) considered this species to be vulnerable to endangered in the south Caspian Sea basin because of damming of rivers, overfishing during the spawning season and deterioration of spawning grounds. Endangered in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

Lelek (1987) classified this species as vulnerable to endangered in Europe.

**Sources.** A review of this species was given by Falahatkar *et al.* (2015).

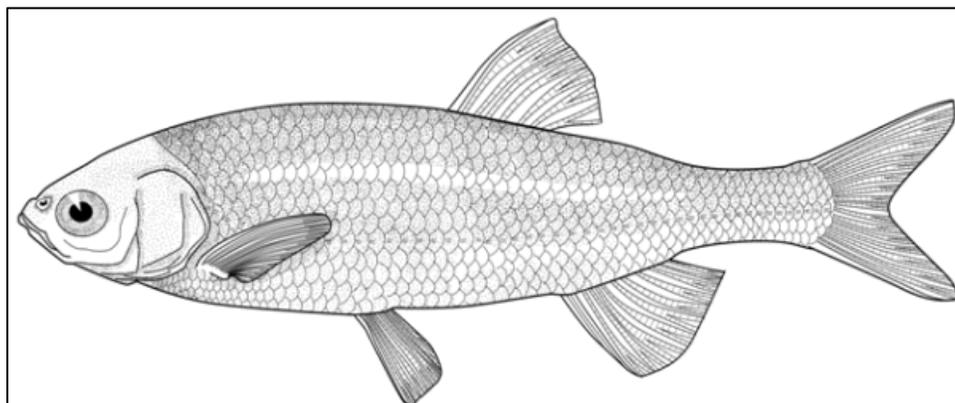
Type material:- *Chalcalburnus chalcoides iranicus* (ZISP 31221) and *Alburnus longissimus* (ZISP 8653, possibly ZISP 8645 and BM(NH) 1891.10.7:28).

Iranian material:- CMNFI 1970-0507, 16, not kept, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0509, 40, 34.4-61.2 mm standard length, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0510, 10, 31.8-42.8 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0512, 1, not kept, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0513, 4, 29.4-34.3 mm standard length, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0516, 12, 16.8-35.2 mm standard length, Gilan, Lomir River (38°14'N, 48°52'30"); CMNFI 1970-0518, 26, 20.5-38.6 mm standard length, Gilan, Haviq River estuary (38°10'N, 48°54'E); CMNFI 1970-0519, 55, 16.5-41.8 mm standard length, Gilan, Chelvand River (ca. 38°18'N, ca. 48°52'E); CMNFI 1970-0520, 8, 33.3-47.4 mm standard length, Gilan, Astara River (ca. 38°25'N, ca. 48°52'E); CMNFI 1970-0522, 75, 22.1-71.2 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0525, 9, 36.1-52.9 mm standard length, Gilan, Sefid River near Mohsenabad (ca. 37°22'N, ca. 49°57'E); CMNFI 1970-0526, 7, 45.6-64.5 mm standard length, Gilan, Sefid River below Astaneh Bridge (37°19'N, 49°57'30"E); CMNFI 1970-0527, 36, 16.9-27.2 mm standard length, Gilan, Sefid River near Kisom (37°12'N, 49°54'E); CMNFI 1970-0528, 3, not kept, Mazandaran, Tajan River estuary (36°49'N, 53°06'30"E); CMNFI 1970-0531, 4, 64.5-74.9 mm standard length, Mazandaran, Larim River talab (36°46'N, 52°58'E); CMNFI 1970-0537, 1, not kept, Gilan, Shah River above Manjil Dam (36°44'N, 49°24'E); CMNFI 1970-0542, 4, not kept, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0543, 26, 34.5-50.1 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0548, 3, not kept, Mazandaran, Qareh Su (no other locality data); CMNFI 1970-0549, 2, 39.0-41.2 mm standard length, Mazandaran, Qareh Su near Alm Emamzadeh (no other locality data); CMNFI 1970-0553, 2, 101.9-163.1 mm standard length, Gilan, Sowsar Roga River (37°27'N, 49°30'E); CMNFI 1970-0563, 74, not kept, Gilan, Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0565, 1, 50.3 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1970-0570, 19, not kept, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0578, 8, 29.7-46.4 mm standard length, Gilan, Sefid River below Astaneh Bridge

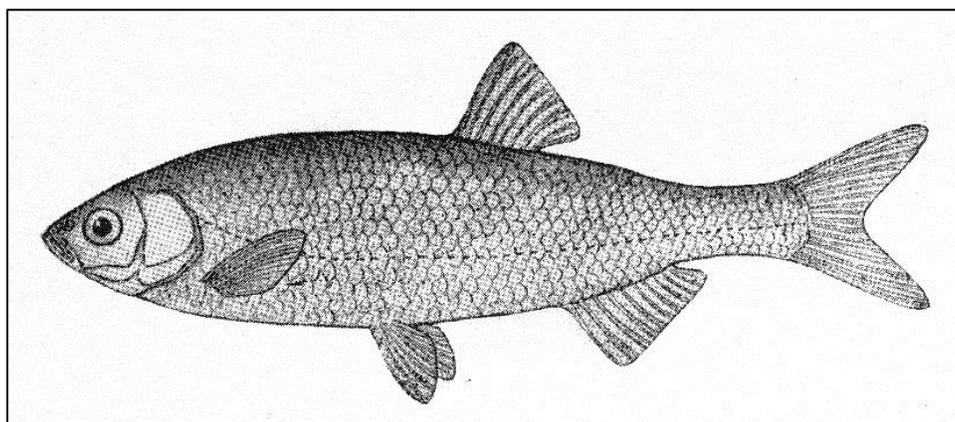
(37°19'N, 49°57'30"E); CMNFI 1970-0581, 18, 24.8-56.5 mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0583, 3, 38.0-47.2 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0587, 8, not kept, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0589, 3, 26.4-53.6 mm standard length, Gilan, Sefid River opposite Kisom (37°12'N, 49°54'E); CMNFI 1971-0327A, 2, 54.5-116.9 mm standard length, Gilan, Shafa River (37°35'N, 49°09'E); CMNFI 1971-0343, 1, 45.3 mm standard length, Gilan, Langarud at Chamkhaleh (37°13'N, 50°16'E); CMNFI 1979-0081, 7, 77.8-106.5 mm standard length, Mazandaran, Caspian Sea 3 km west of Chalus (36°41'N, 51°24'E); CMNFI 1979-0430, 6, 39.4-39.8 mm standard length, Mazandaran, river 1 km east of Now Shahr (36°39'N, 51°31'E); CMNFI 1979-0434, 4, 47.3-154.6 mm standard length, Mazandaran, Shirud River (36°51'N, 50°49'E); CMNFI 1979-0435, 1, 170.5 mm standard length, Gilan, river west of Ramsar (36°57'N, 50°37'E); CMNFI 1979-0437, 2, 164.5-175.6 mm standard length, Gilan, Sefid River 2 km west of Astaneh (37°16'30"N, 49°56'E); CMNFI 1979-0438, 12, 114.9-158.9 mm standard length, Gilan, Gholab Ghir River (37°27'N, 49°37'E); CMNFI 1979-0439, 2, 156.6-173.2 mm standard length, Gilan, Anzali Talab (ca. 37°27'N, ca. 49°25'E); CMNFI 1979-0441, 1, 109.8 mm standard length, Gilan, river 14 km south of Hashtpar (37°42'N, 48°58'E); CMNFI 1979-0443, 1, 159.6 mm standard length, Gilan, river 34 km north of Hashtpar (38°06'N, 48°53'E); CMNFI 1979-0445, 1, 114.9 mm standard length, Gilan, stream 10 km south of Astara (38°21'N, 48°51'E); CMNFI 1979-0455, 1, 88.5 mm standard length, Qazvin, Manjil Dam (36°45'N, 49°17'E); CMNFI 1979-0473, 2, 24.1-24.2 mm standard length, Mazandaran, Babol River (36°38'N, 52°38'E); CMNFI 1979-0474, 1, 141.0 mm standard length, Mazandaran, Tajan River (36°34'N, 53°05'E); CMNFI 1979-0626, 3, 33.7-46.5 mm standard length, Gilan, Sefid River (no other locality data); CMNFI 1979-0685, 10, 42.1-54.8 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0686, 23, 25.5-111.0 mm standard length, Gilan, Sefid River above ferry (37°24'N, 49°59'E); CMNFI 1979-0696, 17, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1979-0788, 48, 35.2-74.7 mm standard length, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0116, 49, 28.3-70.1 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0117, 2, 45.0-45.4 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0120, 17, 55.3-71.6 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1980-0122, 19, 26.0-50.4 mm standard length, Mazandaran, Nerissi River (36°38'N, 52°16'E); CMNFI 1980-0123, 2, 97.0-106.4 mm standard length, Gilan, Sefid River around Dakha (ca. 37°22'N, ca. 49°57'E); CMNFI 1980-0126, 3, 182.1-213.2 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1980-0129, 1, 35.2 mm standard length, Mazandaran, Tajan River (36°49'N, 53°06'30"E); CMNFI 1980-0131, 2, 34.7-58.9, Iran Caspian Sea basin (no other locality data); CMNFI 1980-0132, 7, 18.7-142.8 mm standard length, Gilan, Sefid River at Kisom (37°12'N, 49°54'E); CMNFI 1980-0135, 5, 27.7-48.7 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1980-0136, 9, 27.6-45.1 mm standard length, Mazandaran, Fereydun Kenar River estuary (36°41'N, 52°29'E); CMNFI 1980-0138, 14, 24.6-55.7 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1980-0142, 2, 135.0-187.2 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1980-0144, 29, not kept, Mazandaran, Sorkh River (36°40'N, 52°25'E); CMNFI 1980-0147, 1, 39.3 mm standard length, Gilan, Lashtenesha (= Lasht Nesha') River (37°21'N, 49°52'E); CMNFI 1980-0149, 1, not kept, Gilan, Chapak River (37°21'N, 49°50'E); CMNFI 1980-0157, 27, 36.2-77.2 mm standard length, Golestan, Gorgan River estuary (36°59'N, 53°59'30"E); CMNFI 1980-

0905, 3, not kept, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0908, 3, 45.4-155.2 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 2008-0221, 1, 60.3 mm standard length, Gilan, Sefid River (no other locality data).

*Alburnus doriae*  
De Filippi, 1865



*Alburnus doriae*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus doriae*, after Tortonese (1934).



*Alburnus doriae*, Chahar Mahall and Bakhtiari, Beheshtabad River,  
after Jouladeh-Roudbar *et al.* (2020).

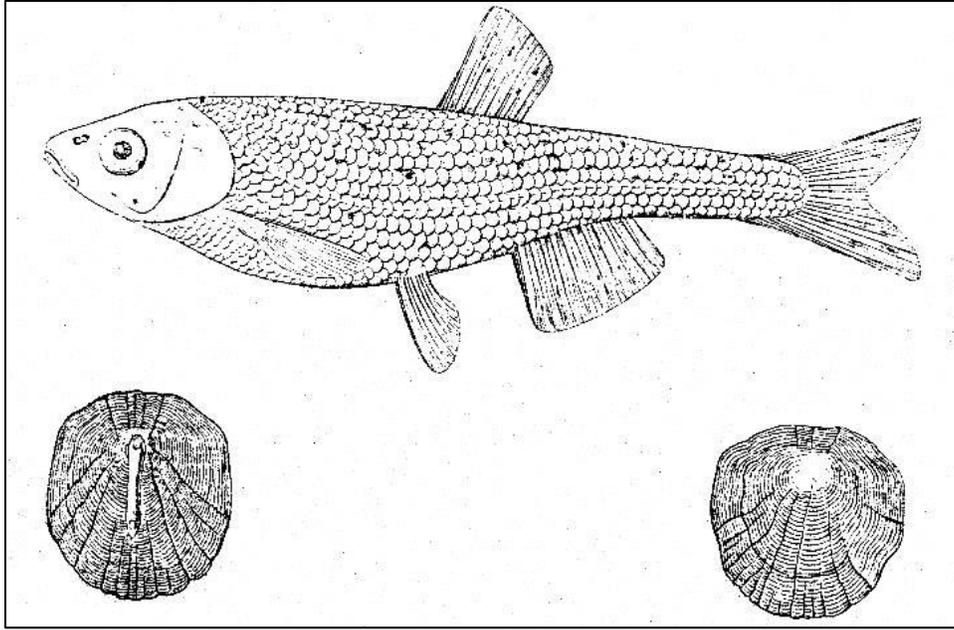


*Alburnus doriae*, Esfahan, Zayandeh River, January 2007, Keyvan Abbasi.

**Common names.** Aroos or arus mahi (= bride fish), arus mahi-ye Zayandehrud (= bride Zayandeh River fish, Y. Keivany, pers. comm., 25 September 2018).

[Doria bleak; Zayandeh Rud chub (Shojaee *et al.*, 2014)].

**Systematics.** *Alburnus maculatus* Keyserling, 1861 described from “Wasserleitung bei Gaes einige Meilen von Isphahan” (a canal near Gaz a few miles from Esfahan - Wasserleitung may also be translated as water conduit and aqueduct and may have been referring to a qanat stream as canals in the European sense were not present in Iran) (no types kept) is objectively invalid, preoccupied by *Alburnus maculatus* Kessler, 1859 (= *Alburnoides maculatus*) of eastern Europe, the Crimea Peninsula and the Black Sea basin of Ukraine and Russia (*Catalog of Fishes*, downloaded 13 March 2021). *Petroleuciscus esfahani* Coad and Bogutskaya, 2010 described from a stream at Dizaj in the southern Zayandeh River basin, and *Alburnus amirkabiri* Mousavi-Sabet, Vatandoust, Khataminejad, Eagderi, Abbasi, Nasri, Jouladeh and Vasil’eva, 2015 described from the Ghareh Chay River, Namak Lake basin are synonyms (Mohammadian-Kalat *et al.*, 2017; Jouladeh-Roudbar *et al.*, 2020). However, H. Mousavi-Sabet (*in litt.*, 19 January 2021) noted both of the latter are distinct taxa from *A. doriae*, but differences between *A. esfahani* and *A. amirkabiri* need more study. I have retained the synonymies above until further work confirms or rejects them, bearing in mind reservations about DNA evidence expressed elsewhere (see under the description of the genus *Garra* for example). Either or both of these putative synonyms may be distinct but further work is required and the exact type locality of *A. doriae* being unknown (Namak Lake, Esfahan or Tigris River basin) renders untangling synonymies nugatory.



*Alburnus maculatus*, with lateral line and flank scales, after Keyserling (1861).

*Alburnus doriae* De Filippi, 1865 has a type locality of “dintorni di Schiraz” (surroundings of Shiraz in Fars) but fish resembling this species have not been caught there in late twentieth and early twenty-first century collections. It seems probable that the fish were collected north of Shiraz, once presumed to be in a Tigris River basin stream based on the other species included in the jar. These materials may, however, have been mixed and the type locality of this species is obscure.

Krupp (1985c) referred five specimens from the type series of *Alburnus doriae* to his *Alburnus sellal* and two specimens to *Squalius lepidus*. The lectotype (MZUT N.720 or MZUT P1110) of *Alburnus doriae* is stored in the Istituto e Museo di Zoologia della R. Università di Torino (122.0 mm standard length as measured by me) and five paralectotypes (MSNG C.E. 9102) of this species are in the Museo Civico di Storia Naturale di Genova (Tortonese, 1934, 1940, 1961), only one of which is *A. doriae* (109.1 mm standard length as measured by me, 122 mm standard length as measured by Mohammadian-Kalat *et al.* (2017)).



*Alburnus doriae*, lectotype, MZUT N.720, Franco Andreone.



*Alburnus doriae*, lectotype, MZUT N.720, Brian W. Coad.

The type locality of *Petroleuciscus esfahani* is Esfahan, stream at Dizaj in the southern Zayandeh River basin, 31°55'N, 51°30'E (holotype, CMNFI 1979-0249, female, 106.7 mm standard length). Paratypes are from Esfahan, stream 1 km east of Daran, Pelasegan River tributary in the northern Zayandeh River basin, 32°59'N, 50°26'E (CMNFI 1979-0251, 134, 22.1-83.7 mm standard length). The species was named after the central Iranian drainage basin in which it was found, itself named for the principal city of Esfahan, then the third largest city in Iran.



*Petroleuciscus esfahani*, holotype, CMNFI 1979-0249,  
James Maclaine @ Canadian Museum of Nature.



*Petroleuciscus esfahani*, paratype, CMNFI 1979-0251,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Petroleuciscus esfahani*, holotype, CMNFI 1979-0249, Brian W. Coad.

The type locality of *Alburnus amirkabiri* is Markazi Province, Ghareh-Chay (= Qareh Chay) River, in the Namak Lake basin, 34°53'N, 050°02'E. The holotype is under VMFC ALB201H H (VMFC = Vatandoust and Mousavi-Sabet Fish Collection, Tehran), male, 113.2 mm standard length. Paratypes are VMFC AL2010P, male, 101.2 mm standard length and 8 females, 104.0-117.2 mm standard length, same locality as holotype, VMFC AL2040P, 8 males, 73.5-95.6 mm standard length and 22 females 58.2-86.1 mm standard length, same locality as the holotype, and ZMMU P-23620 (Zoological Museum of Moscow State University), 3 males, 101.4-107.5 mm standard length and 7 females 67.5-80.7 mm standard length, same locality as the holotype.



*Alburnus amirkabiri*, holotype, VMFC ALB201H H, Hamed Mousavi-Sabet.

Shojaee *et al.* (2014) sampled fish identified as *Petroleuciscus esfahani* from Chamgordan (= Cham-e Gordan), Cheshmeh Dineh, Khersoonak and Safaeye Bridge on the Zayandeh River and using microsatellite data found the four populations to be highly diverse, probably because of river landscape fragmentation. Pishkahpour *et al.* (2019a) also found morphometric differences between six populations from Beheshtabad and Junaqan rivers (Karun River basin), at Morshid and Roodbar (Esfahan basin) and the Karaj River and Qareh Chay (Namak Lake basin).

**Key characters.** This species is distinguished from other *Alburnus* species in Iran by having modally 8 dorsal fin branched rays, 9-12 anal fin branched rays, 44-59 lateral line scales, 12-18 total gill rakers, and a distribution in the Esfahan, Namak Lake and upper Tigris River basins.

**Morphology.** The body is moderately slender and markedly compressed laterally. It is deepest at the level of the rear of the pectoral fin. The back is slightly convex or almost straight. The caudal peduncle is compressed and moderately deep. The interorbital region is concave. The snout is short and pointed, its length equal to or slightly smaller than the orbit width. The tip of the mouth cleft is on a level with the upper margin of the pupil in large-sized individuals such that the mouth is slightly superior or somewhat below, and at about the level of the middle of the eye in small-sized ones. The lower jaw projects slightly compared to the upper jaw, often forming a distinct chin especially visible in larger specimens. Rarely, the upper and lower lips are at the same level. Lips are moderate in size. The eye is at the beginning of the front half of the head. The dorsal fin margin is straight to slightly convex or slightly emarginate and its origin lies over the level of the last pelvic fin ray or slightly behind, well posterior of the pelvic fin origin level. The depressed dorsal fin extends back level with middle of the anal fin. The anal fin margin is rounded and the fin does not extend back to the caudal fin base. The caudal fin is deeply to moderately or even shallowly forked with the lobes slightly pointed to rounded. The rounded pectoral fin does not reach back to the pelvic fin and the rounded pelvic fin does not reach the anus but may reach the anterior anal papilla.

Dorsal fin with 3 unbranched and 7-9 branched rays, modally 8, anal fin with 3 unbranched and 9-12 branched rays, pectoral fin branched rays 13-17, and pelvic fin branched rays 7-9. Lateral line with 44-59 scales, predorsal scales 23-27, scale rows between lateral line and dorsal fin origin 8-12, scales between lateral line and anal fin origin 4-6, scales between lateral line and pelvic fin origin 2-5, and scales around the caudal peduncle 14-26. A pelvic axillary lobe is present and is elongate. A shallow ventral keel extends between the pelvic and anal fins almost completely covered by scales, being exposed for 2-4 (usually 2) transverse scales rows in front of the anus only. The keel is almost absent in some fish. Scales are oval in

shape with all margins rounded, although the anterior margin may be somewhat wavy. The focus is subcentral anterior, circuli are fine, and radii are few anteriorly and more numerous posteriorly. Total gill rakers 12-18, long reaching the second or third adjacent raker when depressed. Pharyngeal teeth usually 2,5-4,2, hooked at the tip and strongly to weakly serrated below it. The gut is an elongate s-shape. Total vertebrae number 39-45, the abdominal + caudal vertebral formulae being usually 22+19, 22+20 and 21+20. The lectotype has 41 total vertebrae and the holotype of *Petroleuciscus esfahani* has 41 total vertebrae.

Meristic values are:- dorsal fin branched rays 7(36), 8(233) or 9(7), anal fin branched rays 9(16), 10(124), 11(118) or 12(18), pectoral fin branched rays 13(11), 14(55), 15(70), 16(33) or 17(3), pelvic fin branched rays 7(10), 8(140) or 9(22), lateral line scales 44(1), 45(4), 46(5), 47(16), 48(25), 49(16), 50(15), 51(25), 52(10), 53(24), 54(10), 55(7), 56(5), 57(6), 58(1) or 59(2), eight specimens of *P. esfahani* with the lateral line widely interrupted (28-40 pored lateral-line scales from 50-53 scales in lateral series), scales above lateral line 8(1), 9(51), 10(106), 11(13) or 12(1), scales below lateral line 2(2), 3(41), 4(111) or 5(18), scales around caudal peduncle 14(3), 15(12), 16(15), 17(2), 18(37), 19(-), 20(33), 21(1), 22(21), 23(10), 24(12), 25(24) or 26(2), total gill rakers 12(5), 13(16), 14(37), 15(51), 16(35), 17(14) or 18(2), and pharyngeal teeth 2,5-4,2(8), 2,5-5,2(2) or 2,4-4,2(2) (last variant after S. Dorafshan, 24 November 2014). Total number of vertebrae 39(2), 40(22), 41(71), 42(35) or 43(5), abdominal (precaudal) vertebrae including the Weberian and intermediate vertebrae (those vertebrae that lost articulation with ribs and differ in the degree of transformation of the parapophyses into the haemal arch with the haemal spine) 21(39), 22(87) or 23(9), caudal vertebrae 18(12), 19(66), 20(53) or 21(4), and the vertebral formula is 22+19(47), 22+20(28), 21+20(23), 21+19(13), 22+18(9), 23+19(6), 22+21(3), 23+20(2), 21+18(2), 23+18(1) or 21+21(1). The number of predorsal vertebrae (in front of the first dorsal pterygiophore) is 14(52), 15(76) or 16(7) and the number of intermediate vertebrae is 3(17), 4(69), 5(46) or 6(2).

The meristic values above were combined after Coad (1985), Coad and Bogutskaya (2010), Mousavi-Sabet *et al.* (2015) and Mohammadian-Kalat *et al.* (2017) and material listed below. Note the very wide range for scales around the caudal peduncle is probably indicative of different counting methods.

The sensory canal system was examined in the holotype and 19 paratypes of *P. esfahani*, so the numbers of examined paired canals is 40. The supraorbital canal is not lengthened in its posterior section and has 8-12, commonly 9 or 10 pores (mean 9.6, standard deviation 1.33), with 3 or 4 (3 in 66%) and 5-8 (counts 6 and 7 found each in 30%) canal openings on the nasal and frontal bones, respectively. The infraorbital canal has (14, 15)16-18 pores (a mode of 16 found in 38% of canals, mean 16.6, standard deviation 1.01) with 4 or 5 (in 75%) canal openings on the first infraorbital. The preoperculo-mandibular canal is complete, with 15-17 pores (15 in 58%, 15.5, 0.74) with 4 or 5 (in 83%) and (8)9-10 (9 in 50%) canal openings on the dentary and preoperculum, respectively. It always communicates with the infraorbital canal in the pterotic, passing through the antero-dorsal process of the operculum. The supratemporal canal is complete (60% of specimens) or incomplete, with 4-6 pores. Other osteological characters were given in Coad and Bogutskaya (2010) and Jalili *et al.* (2015) also described the osteology of this species, identified as *A. amirkabiri*.

**Sexual dimorphism.** Males have a longer dorsal fin base and females a longer anal fin base, possibly associated with pair spawning. Tubercles on two male fish, 79.2-80.5 mm standard length (CMNFI 1979-0245, 9 June 1977) are fine and scattered on the upper head extending down onto the sides of the head but sparser before the eye and in 1-2 rows on the

lower jaw. Fine and numerous tubercles lining scales are prominent on the upper flank and caudal peduncle but become less evident posteriorly and ventrally. Small tubercles are evident on the unbranched and branched dorsal, anal pelvic and pectoral rays, becoming weaker and less extensive to none on the posterior rays.

**Colour.** Live fish are silvery overall with the head and nape dark dorsally. The back is dark olive-brown to grey with the flank, belly and lower part of the head silvery. Some fish may have an underlying brownish colour. Most fins are clear but the caudal fin in particular having dark pigmentation on the fin rays and with some dark pigmentation on dorsal and pectoral fins. The base of the paired fins is usually orange. There is no distinctive colour pattern in preserved fish. Preserved fish have a pale brown back and upper part of the flank and are yellowish on the lower part of the flank and belly. The lateral stripe is a faint dark grey with hazy margins and runs between the posterior margin of the orbit and the caudal fin base, its width slightly less than the eye pupil diameter. The flank above the lateral line bears a fine dark speckling of melanophores and is mostly unpigmented below the lateral line. There is dark brown speckling along the lateral line above and below pores. Melanophores are present on the upper part of the operculum and extend down along the posterior edge. Melanophores on the cheek ring the lower orbit. Melanophores on the lateral sides of the head are larger and more evident particularly in smaller fish. The back bears a predorsal and postdorsal stripe. The dorsal and caudal fins have very fine melanophores on the rays only. The pectoral fin has similar fine melanophores on its anterior rays only. The anal and pelvic fins are almost unpigmented. The peritoneum is silvery to cream with very few, widely scattered, melanophores, or may appear as a silvery-brown.

**Size.** Reaches 21.94 cm total length as *Petroleuciscus esfahani* (Alavi-Yeganeh *et al.*, 2018).

**Distribution.** This species is found in the Esfahan, Namak Lake and upper Tigris River basins. In the Esfahan basin it is recorded at Morshid and Roodbar, streams at Damaneh and Dizaj, the Paherahneh qanat, the Zayandeh Reservoir at Chadegan, the Zayandeh River at Azadegan, Cheshmeh-Dimeh, Khersoonak, Chamgordan (= Cham-e Gordan) and Pol-e Safaiyeh, and in the Khorbeh and Mini rivers; in the Namak Lake basin from Emamzadeh (Nazi) Spring in the Qom River basin and the Qareh Chay River at Jalayer, the Morghab Stream and Robot Mahmoud Spring at Golpayegan, at Khomein, the Jaj, Karaj, Kordan and Qom rivers, and at Saveh in Markazi Province; and in the Tigris River basin in the Ab-e Shalamzar, Beheshtabad River, Cheshmeh-Langan, Junaquan and Toof-Sefid rivers, the Shahr-e Kord Stream and Spring and at Ghale Shahrokh and Iskandari (Pelasegan) (Coad and Bogutskaya, 2010; Dorofshan *et al.*, 2015; Mohammadian-Kalat *et al.*, 2017; Alavi-Yeganeh *et al.*, 2018; Pishkauptour *et al.*, 2019a; Eagderi *et al.*, 2020; Jouladeh-Roudbar *et al.*, 2016, 2020).

Shojaee *et al.* (2014) gave several localities in the Zayandeh River above and below the dam, and also mentioned the Karun River incorrectly based on Coad and Bogutskaya (2010).

**Zoogeography.** This species is morphologically closest to *A. ulanus* of the Lake Urmia basin.

**Habitat.** This species is found in rivers, streams, springs and qanats. Habitat data based on the type locality of *Petroleuciscus esfahani* showed a fresh, clear stream at an altitude of 2,300 m. Water temperature at 1705 hours on 9 June was 22°C, pH was 6.2, conductivity was 0.455 mS, stream width was 2-8 m, maximum depth was 1 m, current was slow to moderate, aquatic plant material was of the submergent type, the shore was grassy, and the stream bottom was a mix of pebbles and mud. *Capoeta coadi* was also caught. The second locality was a fresh stream with clear water at an altitude of 2,410 m. Water temperature at 1225 hours on 10 June

was 17°C, pH was 6.2, conductivity was 0.4 mS, stream width was 4.0 m, maximum depth was 70 cm, current was slow to moderate, aquatic plant material was of the encrusting type, the shore was grassy, and the stream bottom was a mix of pebbles, sand and mud. Other collection data included a temperature range of 17-25°C, pH 6.2-6.5, conductivity 0.35-1.85 mS, river width 2.5-80.0 m, slow to fast current, river depth 50-150 cm, capture depth 75-150 cm, clear to cloudy water, mud, sand, pebbles or stone bottoms, encrusting, submergent and emergent vegetation, and a grassy or forested shore.



Habitat of *Alburnus doriae*, Markazi, Qareh Chay at Jalayer, Arash Jouladeh-Roudbar.

**Age and growth.** Alavi-Yeganeh *et al.* (2018) examined 85 fish identified as *Petroleuciscus esfahani*, 2.82-21.94 cm total length, from the Cheshmeh-Langan River and found a *b* value of 3.176 showing positive allometric growth. Eagderi *et al.* (2020) examined 28 fish, 7.7-14.15 cm total length, from the Toof-Sefid River, Chahar Mahall and Bakhtiari and found a *b* value of 3.04, isometric growth. Zare-Shahraki *et al.* (2020) measured 145 fish, 4.0-16.3 cm total length, from the Karun River system and recorded a *b* value of 3.11.

**Food.** Food is mainly aquatic invertebrates and insects.

**Reproduction.** Unknown.

**Parasites and predators.** Fish from CMNFI 1979-0259 have black spots, possibly encysted trematode larvae.

**Economic importance.** None.

**Experimental studies.** Dorofshan *et al.* (2015) found levels of cadmium and chromium increased downstream in fish identified as *Petroleuciscus esfahani* from the Zayandeh River and levels were higher than international standards at all stations. Raki *et al.* (2015, 2015) showed that silver nanoparticles and silver nitrate had adverse effects on haematological indices, and caused lesions in gill and liver tissues of fish identified as *Petroleuciscus esfahani*. Gilannejad *et al.* (2016) examined vitellogenin expression as a measure of endocrine disrupting chemicals in sites

up- and downstream of a major pollution source (a steel mill plant) in fish identified as *Petroleuciscus esfahani* from the Zayandeh River and found a higher vitellogenin expression in males with reduced gonad size and condition factor downstream from the steel mill.

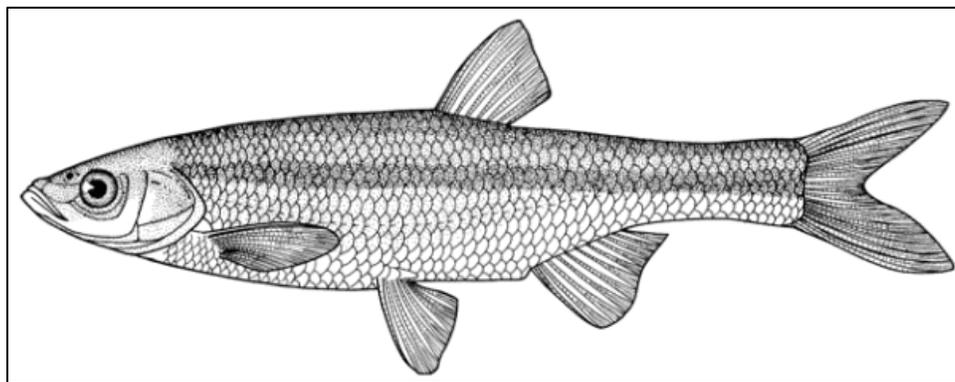
**Conservation.** Dam construction on the Zayandeh River may have altered the ecology of that river system, exacerbated by population growth and its demands on limited water resources in a desert environment. However, the species may be relatively secure in higher tributary streams. It is now known from three basins, has large population sizes and lack of any particular threats leading Jouladeh-Roudbar *et al.* (2020) to list it as of Least Concern.

**Sources.** Type material:- *Alburnus doriae* (MZUT N.720) and *Petroleuciscus esfahani* (CMNFI 1979-0249 and CMNFI 1979-0251).

Iranian material:- CMNFI 1979-0243, 18, 26.1-48.7 mm standard length, Esfahan, Zayandeh River at Falavarjan (32°33'N, 51°31'E); CMNFI 1979-0244, 3, 60.6-74.6 mm standard length, Chahar Mahall and Bakhtiari, spring at Shahr Kord (32°19'N, 50°52'E); CMNFI 1979-0245, 125, 31.6-100.6 mm standard length, Chahar Mahall and Bakhtiari, stream in Ab-e Shalamzar drainage (Khersan River basin) (32°08'N, 50°51'E); CMNFI 1979-0250, 28, 26.3-88.4 mm standard length, Esfahan, stream at Damaneh (33°01'N, 50°29'E); CMNFI 1979-0253, 5, 47.6-77.0 mm standard length, Qom, river in Qareh Chay drainage (34°52'N, 50°49'E); CMNFI 2007-0072, 15, 55.6-84.0 mm standard length, Esfahan, Paherahneh qanat (ca. 32°43'N, ca. 52°40'E); CMNFI 2007-0073, 10, 43.0-74.1 mm standard length, Esfahan, Zayandeh River at Tanderan (32°47'N, 51°02'E); CMNFI 2007-0077, 10, 47.1-100.0 mm standard length, Markazi, Qom River (ca. 34°18'N, 50°32'E).

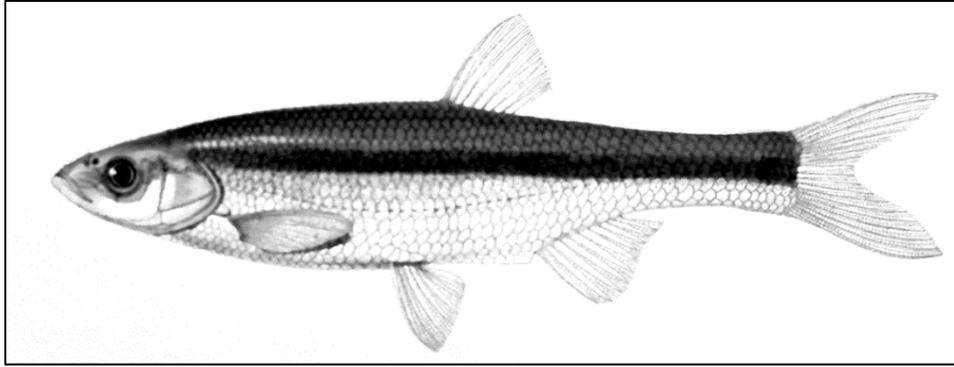
### *Alburnus filippii*

Kessler, 1877



*Alburnus filippii*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus filippii*, 14.2 cm total length, ZISP 14722  
(the last 2 in the catalogue number is missing from the illustration in Berg),  
Turkey, Merdenek, a tributary of Lake Chaldyr-gel' (= Çıldır) in the Aras River basin,  
after Berg (1948-1949).

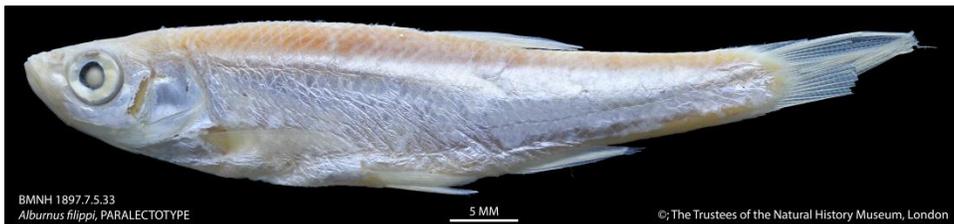


*Alburnus filippii*, Iran, Qareh Su, Aras River basin, January 2011, Keyvan Abbasi.

**Common names.** Kuli-ye Kura (= Kura River fish), mahi morvarid or morvarid mahi (= pearl fish).

[Kur kumuscasi in Azerbaijan; Kura incisi and İnci balığı in Turkish (Çiçek *et al.*, 2020; Kaya *et al.*, 2020); Kurinskaya ukleika or Kura bleak, ukleika filippi or Filippi's bleak, both in Russian].

**Systematics.** The lectotype of *Alburnus Filippii* as designated by N. Bogutskaya is in the Zoological Institute, St. Petersburg (ZISP 2926) and is from "Fl. Kura pr. Tiflis", Acad. Brandt, 1867, 75.3 mm standard length. Paralectotypes are ZISP 2925, 13 fish, same data as lectotype, 43.0-84.4 mm standard length, ZISP 2914, 2 fish, "Fl. Kura pr. Borshoma", Acad. Brandt, 1867, 83.6-87.6 mm standard length, and ZISP 50412, 16 fish, "Reka Kura Tiflis", Acad. Brandt, 1867, 60.6-88.6 mm standard length. A syntype or paralectotype, 57.3 mm standard length, is in the Natural History Museum, London from Tiflis (BM(NH) 1897.7.5:33, formerly in ZISP).



*Alburnus filippii*, paralectotype, BM(NH) 1897.7.5:33.

*Alburnus filippii* var. Kessler in Brandt, 1880 from the Tchaldyr Lake (= Çıldır in Turkey) is also this species. Knipovich (1921) reported a Caspian basin species “*Alburnus philippii*” Kessler which is presumably a misspelling of *filippii*. The specific name is sometimes spelt *filippi*, which is incorrect.

Abdurakhmanov (1962) compared a sample from the Kura River basin with one from the Kendalanchaya in the Aras River basin of Azerbaijan and found 15 characters were significantly different on average. Fish from the Kura had a longer head, greater dorsal and anal fin heights, and longer pectoral, pelvic and upper and lower caudal fin lobes while fish from the Aras had more scales in the lateral line, a deeper head, body and caudal peduncle, and a longer anal fin base, pectoral-pelvic fin distance and snout, and a greater interorbital width. No taxonomic status was assigned to these two populations. Jalili *et al.* (2015) found fish from the mainstream Aras River showed more morphological variation than those from the tributary Ahar Chay indicating availability of more diverse habitats. Differences included a form with a more elongate body in the Aras presumably associated with stronger water current and a relatively upturned mouth associated with surface feeding.

A hybrid with *Alburnus charusini hohenackeri* (= *Alburnus hohenackeri*) was reported by Petrov (1926) from the Sefid River and the Kumbashinka in Lenkoran.

**Key characters.** This species is distinguished from its relative (*Alburnus chalcoides*, also with a long, naked ventral keel) and other *Alburnus* in Iran by having modally 7 dorsal fin branched rays and generally lower anal fin ray counts although these do overlap (10-21, usually 14-15 in Iran for *chalcoides*; 9-13, usually 10-12, for *filippii*).

**Morphology.** The body is moderately elongated, compressed and moderately deep. It is deepest at the pectoral fin level. The predorsal profile is slightly convex to almost straight. The caudal peduncle is compressed and moderately deep. The head tapers to pointed snout. The eye is partly in the posterior half of the head or at the beginning of the anterior half. The mouth is oblique and extends back to the end of the nostril level. The snout tip is at the level of the upper third of the eye or almost its upper margin. The lower jaw projects a little. Lips are thin. The dorsal fin margin is straight to slightly rounded. The dorsal fin origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the middle of the anal fin. The caudal fin is moderately forked with pointed tips. The anal fin is slightly emarginate and does not extend back to the caudal fin base. The pelvic fin is rounded and does not reach back to the anus or reaches the anterior edge of the anal papilla. The pectoral fin is rounded and almost reaches back to the pelvic fin origin or falls short.

Dorsal fin with 3 unbranched and 6-8, usually 7, branched rays, anal fin with 2-3, usually 3, unbranched and 9-13 branched rays, usually 10-12, pectoral fin branched rays 12-16, and pelvic fin branched rays 6-8, usually 7. Lateral line scales 46-64. Counts by Khataminejad *et al.* (2016, 2017) agree with this summary. There is a large pelvic axillary scale. Scales have an overall vertical oval shape, sometimes tapering to a rounded posterior point and sometimes more rounded, a wavy anterior margin, few anterior and posterior radii, and a subcentral anterior focus. The naked ventral keel usually extends more than half way from the anal papilla to the pelvic fin insertion but is often completely scaled, notably in fish from the Sefid River basin. Total gill rakers number 12-21, reaching the second or third adjacent raker when appressed. Pharyngeal teeth are 2,5-5,2 (but see below for Iranian specimens) with variants 2,5-5,1, 1,5-5,2, 1,5-5,1, 2,5-4,2, 2,4-5,2, 2,5-4,1, 2,4-4,2, 1,5-4,1, 1,4-5,1, and 1,5-4,2. Teeth are strongly hooked and strongly serrated. Serrations are on the anterior margin of each tooth. The degree of hook and serration development varies individually and does not seem to be size related. Some fish

have little development of either character. The area below the hook is an elongate, flat to concave surface. The gut is an elongate s-shape with a small anterior loop. The gas bladder has a rounded end in contrast to the pointed end in *Alburnus chalcoides*. Total vertebrae number 38-43. The chromosome number is  $2n = 50$  and Nazari *et al.* (2009, 2011) gave further details.

The skeletal structure of this species is described by Nikmehr *et al.* (2017).

Meristic values for Iranian specimens are:- dorsal fin branched rays 6(1), 7(44) or 8(5), anal fin branched rays 9(1), 10(19), 11(24), 12(5) or 13(1), pectoral fin branched rays 12(3), 13(19), 14(20), 15(7) or 16(1), pelvic fin branched rays 6(3), 7(42) or 8(5), lateral line scales 46(1), 47(-), 48(-), 49(1), 50(5), 51(5), 52(4), 53(12), 54(5), 55(2), 56(5), 57(6), 58(1), 59(-), 60(2), 61(-), 62(-) or 63(1), total gill rakers 12(4), 13(8), 14(19), 15(10), 16(6) or 17(3), pharyngeal teeth 2,5-4,2(10), 2,4-5,2(2), 2,4-4,2(2), 2,5-5,2(1), 1,5-4,2(2), 1,5-5,2(1), 1,5-4,1(1) or 1,4-5,1(1), and total vertebrae 38(2), 39(8), 40(18), 41(9) or 42(1).

**Sexual dimorphism.** Males and females have moderate-sized tubercles widely scattered on the top of the head, on the snout and lining the lower edge of the jaw. Much smaller tubercles are scattered among the ones on top of the head.

**Colour.** The back is brown, flanks silvery and the belly white. A characteristic dark streak, as wide as the eye, runs along mid-flank. Fins are hyaline. The peritoneum is brown or light with large scattered melanophores.

**Size.** Reaches 17.0 cm standard length.

**Distribution.** Found only in the Caspian Sea basin from the Kura River of Azerbaijan to the Sefid River of Iran including headwaters in Turkey, Armenia and Iran at altitudes over 3,000 m. It is distributed in the Ahar, Aras, Babol, Baleqlu, Chaysalman, Chelond, Chelvand, Chobar, Ghor, Lomir, Marbureh, Pir Bazar, Qarangho, Qareh Su, Qezel Owzan, Sefid, Shah, Shalman, Sheikan, Siah Darvishan, Sowsar, Tootkabon (= Tutkabon) and Zanjan rivers, the Anzali Talab, and the Golabar, Manjil, Nazdik, Sattarkhan, Taham and Zire dams (Holčík and Oláh, 1992; Abbasi *et al.*, 1999, 2007, 2017; Karimpour, 1998; Kiabi *et al.*, 1999; Abdoli and Naderi, 2009; Hajirostamloo, 2009; Mirzajani, 2010; Mirzajani *et al.*, 2012; Jalali Roshan *et al.*, 2013; Khataminejad *et al.*, 2013b, 2015, 2017; Jalili *et al.*, 2015; Asadi *et al.*, 2016; Babaei, 2017; Mohammadian-Kalat *et al.*, 2017; Nikmehr *et al.*, 2017; Shahnazari *et al.*, 2020; Aazami and Alavi Yeganeh, 2021). Esmaeili *et al.* (2018) stated that it is known only from the Aras and Sefid rivers and the Anzali Lagoon.

Records from the Talkheh (= Aji) River (Lake Urmia basin) and the Sirvan River (Tigris River basin) are presumably mis-identifications (Mohammadian-Kalat *et al.*, 2017; Hasankhani *et al.*, 2019) but may be introductions.

**Zoogeography.** The relationships of this species with other *Alburnus* need to be examined. It presumably originated as part of a Sarmatian fauna, isolated in the Caspian Sea.

**Habitat.** This species is found in rivers, streams, dams, lagoons, marshes and brackish environments. Primarily a freshwater species, this minnow may be found in the brackish outlets of the Anzali Talab (Holčík and Oláh, 1992). Naderi Jolodar and Abdoli (2004) noted that it is found more in upstream waters than *A. alburnus* (*sic*, presumably *A. hohenackeri*). Collection data included a temperature range of 5.6-25.5°C, pH 6.2, conductivity 1.5-1.95 mS, river width 10-100 m, slow to fast current, depth up to 100 cm, clear or muddy water, mud, clay, sand, gravel, pebble or stone bottoms, encrusting vegetation, and a bushy or grassy shore.

**Age and growth.** Life span is about 5 years with maturity at 1 year for males and 2 years for females. Hasankhani *et al.* (2013) gave a *b* value of 3.382 (in the Abstract, or 3.384 in a table) for 81 fish, 5.2-15.03 cm total length, from the Sirvan River (Tigris River basin) but this is

presumably a misidentification. Mousavi-Sabet *et al.* (2014) gave a *b* value of 3.115 for 30 fish, 78.5-107.79 mm total length, from the Baleqlu River.

**Food.** Gut contents include plant remains, mayflies and algae in Azerbaijan (Abdurakhmanov, 1962). Iranian specimens examined by me contained insect remains, a few crustaceans and sand grains. One sample from the Qareh Su north of Ardabil had been feeding on water beetles (Hydrophilidae) but also spiders and scarab beetles (*Euoniticellus* sp.) indicating food could also be taken from the surface.

**Reproduction.** Eggs number reach up to 14,210 and diameters up to 1.51 mm. May is the principal spawning month in Azerbaijan (Abdurakhmanov, 1962). A male fish caught on 6 June 1978 (70.9 mm standard length, CMNFI 1979-0448) in Iran had tubercles scars on top of the head while female fish from another locality taken on 8 June 1978 (73.3 mm standard length, CMNFI 1979-0453) had mature eggs measuring 1.2-1.3 mm. Spawning probably occurs in May and June in Iran, depending on local conditions.

**Parasites and predators.** Mortazavi Tabrizi *et al.* (2005) recorded *Ligula intestinalis* and *Bothriocephalus acheilognathi* in this species from the Sattarkhan Dam in East Azarbayjan, the former also recorded by Hajirostamloo (2009). Pazooki *et al.* (2005) recorded *Trichodina perforata* from this species in waterbodies of Zanjan Province and Pazooki *et al.* (2006) the monogeneans *Dactylogyrus vistulae* and *Gyrodactylus* sp. in Zanjan Province fish.

Undoubtedly food for various predatory fishes.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Kiabi *et al.* (1999) considered this species to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included medium numbers, habitat destruction, medium range (25-75% of water bodies), absent in other water bodies in Iran, and absent outside the Caspian Sea basin. Mostafavi *et al.* (2018) modelled the distribution of this species in all climatic scenarios and found 100% reduction on two temporal scales (2050 and 2080) with no new potential areas available. Vulnerable in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

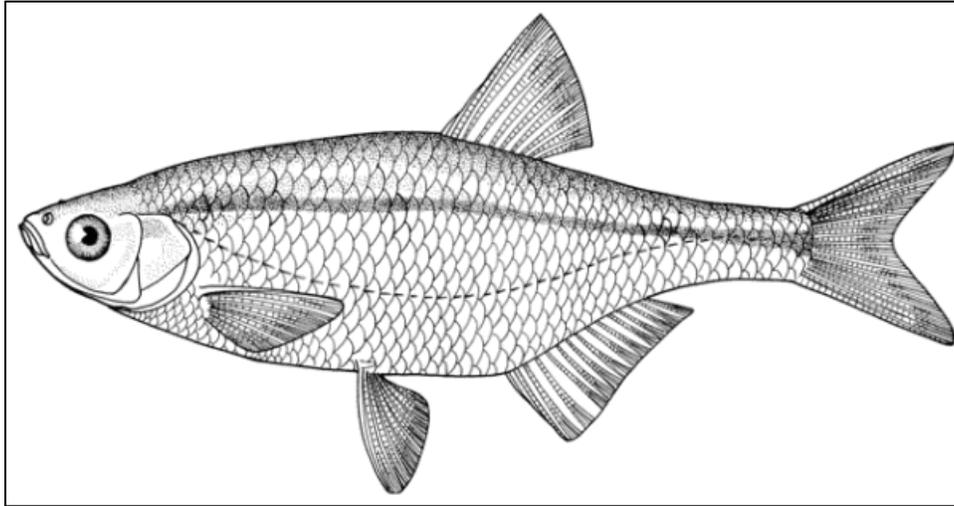
**Sources.** Type material:- ZISP 2914, ZISP 2925, ZISP 2926, ZISP 50412 and BM(NH) 1897.7.5:33.

Iranian material:- CMNFI 1970-0516, 10, not kept, Gilan, Lomir River (38°14'N, 48°52'30"); CMNFI 1970-0519, not kept, Gilan, Chelvand River (ca. 38°18'N, ca. 48°52'E); CMNFI 1970-0522, 1, 49.5 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0538, 8, 34.9-61.8 mm standard length, Gilan, Qezel Owzan River above Manjil Dam (ca. 36°44'N, 49°24'E); CMNFI 1979-0448, 1, 70.9 mm standard length, Ardabil, Ahar Chay 8 km from Ardabil (38°18'30"N, 48°22'E); CMNFI 1979-0452, 2, 52.4-54.9 mm standard length, East Azarbayjan, Qezel Owzan River 6 km from Mianeh (37°23'N, 47°45'E); CMNFI 1979-0453, 9, 43.7-73.3 mm standard length, Zanjan, Zanjan River (37°06'N, 47°56'E); CMNFI 1979-0455, 17, 42.8-62.5 mm standard length, Qazvin, Manjil Dam (36°45'N, 49°17'E); CMNFI 1979-0695, 3, 61.3-63.5 mm standard length, Gilan, Sefid River at Manjil Bridge (36°46'N, 49°24'E); CMNFI 2007-0081, 1, 51.0 mm standard length, Zanjan, Zanjan River near Soltaniyeh (ca. 36°27'N, ca. 48°45'E); CMNFI 2007-0082, 11, 41.2-59.6 mm standard length, Zanjan, Zanjan River basin near Zanjan (ca. 36°36'N, ca. 48°32'E); CMNFI 2007-0087, 6, 55.7-83.1 mm standard length, Ardabil, Qareh Su north of Ardabil (38°22'N, 48°19'E); CMNFI 2007-0089, 1, 33.5 mm standard length, East Azarbayjan, Ahar Chay at Ahar (38°28'N, 47°03'E); CMNFI 2007-0106, 16, 50.3-93.0 mm standard length, Kordestan, Qezel

Owzan River near Divandarreh (ca. 35°52'N, 47°05'E); CMNFI 2007-0107, 3, 41.1-42.3 mm standard length, Kordestan, Qezel Owzan River basin near Bijar (ca. 35°54'N, ca. 47°20'E).

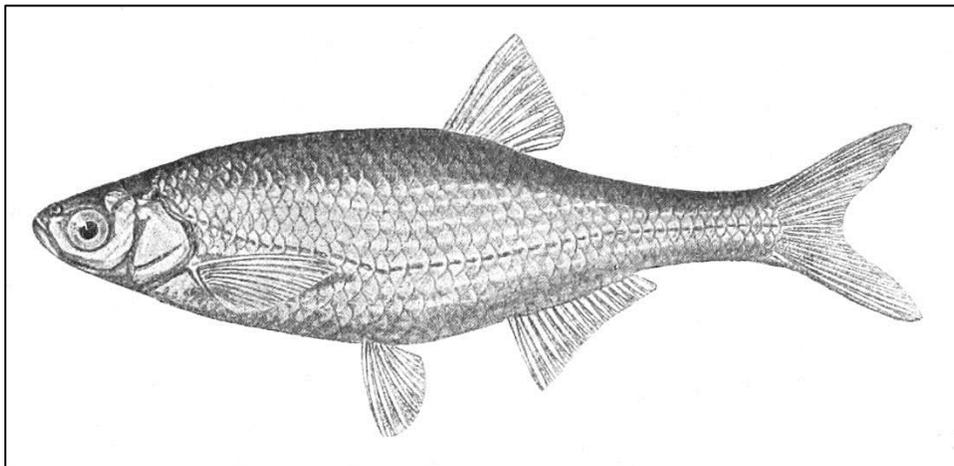
*Alburnus hohenackeri*

Kessler, 1877

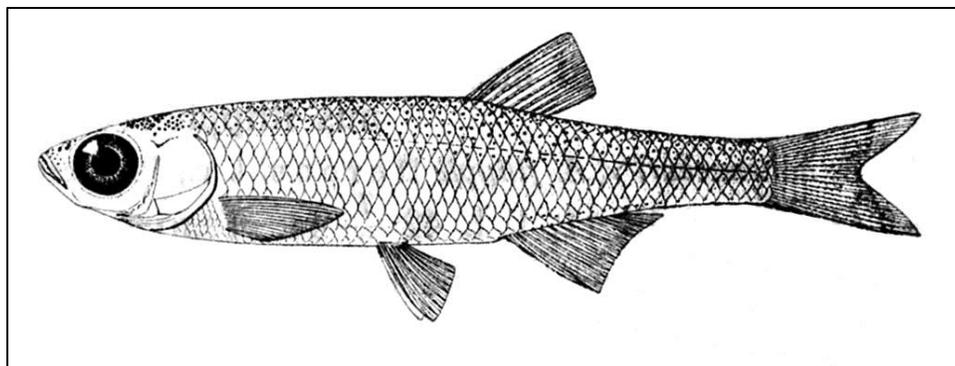


*Alburnus hohenackeri*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus hohenackeri* (as *A. charusini*), Russia, Terek River at Chervlenaya, after Berg (1916).



*Alburnus hohenackeri* fry, 33 mm total length, Kazakhstan, Ural River delta (after Berg, 1932b).



*Alburnus hohenackeri*, Gilan, Anzali Wetland, November 2011, Keyvan Abbasi.



*Alburnus hohenackeri*, Khuzestan, Marun River, Kai Borkenhagen.

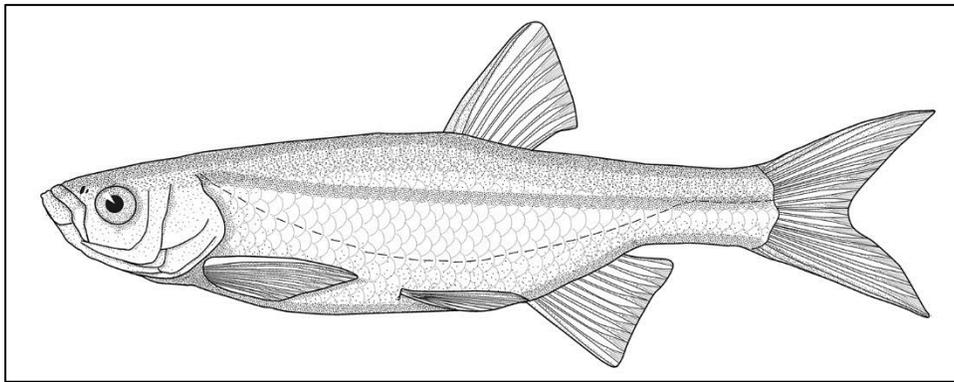
**Common names.** Kuli (= general term for a small fish), kuli-ye Irani (= Iranian fish), mahi morvarid or morvarid mahi (= pearl fish).

[Simali gafgaz kumuscasi for *A. c. charusini* or zagafgaziya kumuscasi for *A. c. hohenackeri*, both in Azerbaijan; Hazar Denizi incise in Turkish (Kaya *et al.*, 2020); ukleika or bleak, persidskaya ukleika or Persian bleak, sefidrudskaya ukleika or Sefid River bleak, zakavkazskaya ukleika or Transcaucasian bleak, all in Russian; Caucasian bleak (as *A.*

*hohenackeri*]).

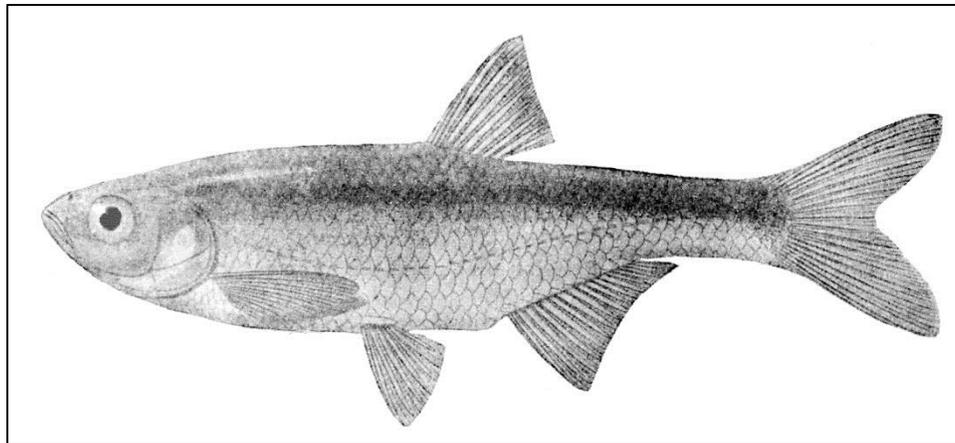
**Systematics.** *Alburnus Hohenackeri* was originally described from Karabakh, Azerbaijan, on the Kura River. The taxon in Iran was formerly included within the wide-ranging species *Alburnus alburnus* (Linnaeus, 1758). *Cyprinus Alburnus* was originally described from Europe.

A synonym common in older literature is *Alburnus charusini* Herzenstein in Zograff and Kavraiskii, 1889 described from the Maly Uzen River mouth and Kamysh-Samarskie lakes between the Volga and Ural rivers in Kazakhstan. *Alburnus alasanicus* Kamensky, 1901 from the Alasan, Alazan' or Alazani River, a left bank Kura River tributary in Georgia is a synonym of *Chondrostoma oxyrhynchum* Kessler, 1877 (*Catalog of Fishes*, downloaded 30 May 2018) despite being described in *Alburnus*. Other synonyms are *Alburnus lucidus* var. *macropterus* Kamensky, 1901 described from the Alazan' River, Georgia (no types known), *Alburnus alburnus charusini* natio *elata* Petrov, 1926 from the Prorva River (lower reaches of the Terek River), the Sulak River and the Divichi Liman, western Caspian Sea (not available, infrasubspecific, no types listed in the *Catalog of Fishes*, downloaded 30 May 2018), *Alburnus striatus* Petrov, 1926 from "Kizil-Agachskogo Zaliva" (Kizil-Agach Bay, Turkmenistan) and "Astrabadskogo Zaliva" (= Astrabad or Gorgan Bay, Iran) (syntypes exist but deposition is not given in the *Catalog of Fishes*, downloaded 30 May 2018, presumably the Bakinskoi ikhtiologicheskoi laboratorii, Baku, Azerbaijan), and *Alburnus alburnus* natio *dagestanicus* Petrov, 1930 (*sic*) but later in the same paper given, and probably originally meant, as *A. a. charusini* n. *dagestanicus*) described from the "Kaukasusküste des Kaspische Meeres" (not available, infrasubspecific, no types listed in the *Catalog of Fishes*, downloaded 30 May 2018).



*Alburnus striatus*, after Petrov (1926),  
re-drawn by Susan Laurie-Bourque @ Canadian Museum of Nature.

*Alburnus pseudospirlinus* Petrov, 1926 from "Novaya Rechkaya (nizov'ya Sefid-Rud)" (= new stream, lower Sefid River) is a hybrid of this species and *Alburnoides bipunctatus* (*sic*, presumably *A. samiii*) according to Berg (1948-1949) (13 syntypes exist but deposition not listed in the *Catalog of Fishes*, downloaded 30 May 2018, presumably the Bakinskoi ikhtiologicheskoi laboratorii, Baku, Azerbaijan). A hybrid with *Alburnus filippii* was described from the Kumbashinka River in the Lenkoran and from the Sefid River (Petrov, 1926).



*Alburnus pseudospirlinus*, 7.5 cm total length, ZISP 20864, Gilan, Sefid River, after Berg (1948-1949).

The holotype of *Alburnus hohenackeri* is in the Zoological Institute, St. Petersburg (ZISP 2339). The holotype of *Alburnus charusini* is in the Zoological Museum of Moscow State University under MMSU P.1314. Four fish are listed as questionable syntypes under MMSU P.1812 by Svetovidova (1978) although according to Eschmeyer *et al.* (1996) the original says P.1314 with a unique holotype only.

This species was long recognised as *Alburnus charusini* in Iran but characters overlap with *Alburnus alburnus*, a highly variable species (Gäsowska, 1974). In any case *hohenackeri* has priority over *charusini*. Literature sources conflicted on the correct name. Petrov (1926, 1930) referred to *Alburnus alburnus hohenackeri* Kessler, 1877 for fish in northern Iran with natio *persicus* Petrov, 1926 in the Sefid River, natio *dagestanicus* Petrov, 1930 in the Dagestan area of Azerbaijan and natio *kumbashensis* Petrov, 1926 from the Kumbashinka River and Lake Ol'khovskoye in the Lenkoran area of Azerbaijan. Natio are not recognised by the Zoological Code of Nomenclature (Ride *et al.*, 1985). Liška and Pivnička (1985) referred southern and southeastern populations of this species to *Alburnus alburnus albidus* Costa, 1838, and this would include the Iranian populations. These fish are separated from the type subspecies by having 39-47 lateral line scales, most frequently 42-44 (44-54, most frequently 47-50 in *A. a. alburnus*), anal fin branched rays 10-17, most frequently 13-15 (14-21, most frequently 16-19), and head length as per cent of body length 22-27 most frequently 23-25 (19-25, most frequently 21-23). N. Bogutskaya (pers. comm., 1995) and Reshetnikov *et al.* (1997) referred Iranian fish to *Alburnus alburnus hohenackeri* as there is a definite character break at the Terek River separating northern populations from southern ones. Petrov (1930) came to a similar conclusion on the name of the Iranian populations in his study as noted above. Aburakhmanov (1962) too referred the taxon *hohenackeri* to fish found in the Kura and Aras rivers and in rivers of the Lenkoran coast (and presumably the Iranian coast) while his *charusini* are north of the Apsheron Peninsula. Bogutskaya and Naseka (2004) and Kottelat and Freyhof (2007) recognised *A. hohenackeri* as a distinct species.

**Key characters.** This species can be confused with *Alburnoides* spp. which are superficially similar in scale and fin ray counts. A key distinction is the total gill raker count of 15-29 (usually 20 or more) in this species as opposed to 5-12, usually 7-10 in *Alburnoides* species. *Alburnus* rakers are more than twice as long as those in *Alburnoides* and, being more numerous, are crowded on the arch without the large gaps between individual rakers which characterise *Alburnoides*. It is distinguished from other Caspian Sea species by having modally 8

branched dorsal fin rays, 34-55 (mostly 45 or less) lateral line scales, a mostly naked abdominal keel, and a light silvery peritoneum.

**Morphology.** The body is compressed and moderately deep, being deepest midway between the dorsal fin origin and the end of the head. The predorsal profile is convex. The caudal peduncle is compressed and moderately deep. The snout is gently rounded to pointed and the lower lip protrudes. The rear of the eye is at the beginning of the anterior half of the head. The mouth is very oblique with its tip almost at the level of the upper eye margin and it extends back to the level of the anterior nostril. Lips are thin. The dorsal fin margin is straight. The dorsal fin origin is over the rear of the pelvic fin or just past its middle. The depressed dorsal fin extends back level with the middle of the anal fin. The caudal fin is moderately forked with pointed to rounded tips. The anal fin is emarginate and does not extend back to the caudal fin base. The pelvic fin is rounded and does not extend back to the anus or just reaches the anterior part of the anal papilla. The pectoral fin is rounded and does not reach back near to the pelvic fin or almost reaches it.

Dorsal fin with 2-4 unbranched rays and 7-9 branched rays, usually 8, anal fin unbranched rays 3-4 and branched rays 10-16, pectoral fin branched rays 11-16, and pelvic fin branched rays 6-9. Lateral line scales 34-55, mostly 45 or less. Scale shape is oval with the posterior margin protruding, rounded dorsal and ventral margins and anterior corners, and an anterior margin with a central protrusion and an indentation above and below. Or, shape is more squarish with a rounded posterior margin, straight or slightly rounded dorsal and ventral margins, and an anterior margin with a central protrusion and indentations on each side or wavy and irregular. Overall, scale shape is very irregular, even among adjacent scales. Scales bear both anterior and posterior radii with a few curved radii in the lateral fields. The focus is subcentral anterior and circuli are numerous and fine. The naked ventral keel is often wholly or partially covered by scales. There is a long pelvic axillary scale. Total gill rakers number 15-29 (possibly including some lower arch only counts - but see below), and are dense and elongate reaching the third, or rarely second, below when appressed. Pharyngeal teeth are 2,5-5,2 with variants 2,5-5,1, 2,5-5,3, 1,5-5,2, 1,5-5,1, 2,5-4,2, 2,4-5,2, 2,4-5,1, 2,4-4,2, 1,5-4,2, 2,5-4,1, 1,5-4,1, 1,4-4,1. The elongate and narrow teeth bear a strongly hooked tip and have evident serrations in most specimens although some lack them entirely. The gut is an elongate s-shape with a small anterior loop. The posterior end of the gas bladder is rounded (pointed in *Alburnus chalcoides*). Total vertebrae number 36-46, a very wide range from literature, see below. The chromosome number is  $2n = 50-52$ , generally 50 (Klinkhardt *et al.*, 1995).

The natio *persicus* from the Sefid River has dorsal fin branched rays 7-9, anal fin branched rays 12-16 and lateral line scales 40-45. Fish from the Kura-Aras basin and Lenkoran (*hohenackeri*) have anal fin branched rays 10-15, lateral line scales 38-48, pharyngeal teeth 2,5-5,2, total gill rakers 16-25 and total vertebrae 37-42 (courtesy of N. Bogutskaya, Zoological Institute, St. Petersburg).

Meristic values for Iranian fish including Petrov's (1930) counts of dorsal and anal branched rays and lateral line scales for Sefid River fish are:- dorsal fin branched rays 7(7), 8(76) or 9(8), anal fin branched rays 12(6), 13(37), 14(28), 15(16) or 16(2), pectoral fin branched rays 12(2), 13(18), 14(17) or 15(3), pelvic fin branched rays 7(11) or 8(29), lateral line scales 39(2), 40(8), 41(10), 42(28), 43(13), 44(9), 45(7), 46(1), 47(1), 48(1), 49(-) or 50(1), total gill rakers 19(1), 20(2), 21(18), 22(7), 23(5), 24(4) or 25(3), pharyngeal teeth 2,5-5,2(13), 2,5-4,2(11), 2,5-4,1(1), 2,4-5,2(2) or 2,4-4,2(1), and total vertebrae 37(2), 38(24), 39(20), 40(7) or 41(1). Khataminejad *et al.* (2013) gave meristic values in line with those above for fish from the

Mahabad River in the Lake Urmia basin (presumably introduced) except for having 8-10 anal fin branched rays - the identity of these fish needs verification.

**Sexual dimorphism.** Tubercles line the edge of each scale and in single file line the rays of all fins. Fine tubercles cover the whole head.

**Colour.** The overall colour is bright silvery with the posterior scale margins grey on the upper flank. The back is dark blue to olive or bluish-green and is sharply distinct from the lighter flanks. The mid-line of the back has a narrow dark line. The lateral line and the area above it have some pigmentation, concentrated along the lateral line itself, but there is no dark stripe or it is only faintly developed and is bluish or greyish. Above this stripe is an iridescent golden-green stripe only visible at a certain angle. The bluish or greyish stripe is more evident in preserved material. The belly and lower head surface are pearly-white. The iris is silvery with a yellow ring along the outer eye rim but very little around the pupil. The upper part of the iris may have some dark pigment. The dorsal and caudal fins have dark rays and transparent membranes but may be a dirty yellow. Membranes may have some pigment, particularly on the dorsal fin. The upper anterior edge of the pectoral fin has a little dark pigment while the rest of the fin is colourless to grey or orange. Some fish have a yellow base to the pectoral fin. The pelvic and anal fins are usually colourless, although the anal rays may have some grey or there may be some yellow, orange or red on the fin generally. The caudal fin tip is dark grey.

In preserved fish, most flank pigment is above the lateral line. Lateral line scales have pigment both above and below the pore so the pore stands out. This is not as distinctive as in some *Alburnoides* spp. A mid-dorsal stripe is more evident in smaller fish and is obscured by the generally darker back and upper flank pigmentation in larger fish. A flank stripe may be developed although not as strongly as in *Alburnus filippii*; the stripe is more a darker area along the muscle mass divide between a lighter upper flank and lower flank. The peritoneum is a light silvery with scattered melanophores.

**Size.** Reaches 10.6 cm.

**Distribution.** This species is found in the Caspian Sea basin including along the Iranian coast. It is reported from the Aras, Babol, Baleqlu, Feryedun Kenar, Golshan, Gorgan, Harisak, Haraz, Haviq, Kargan, Kia, Langarud, Lashtenesha (= Lasht Nesha'), Masoleh, Nahang, Nerissi, Nesa, Pir Bazar, Polrud (= Pol-e Rud), Qareh Su, Qezel Owzan, Rasteh, Sardab, Sefid, Shafa, Shah, Shalman, Shesh Deh, Shirud, Siah, Siah Darvishan, Sorkh, Tajan, Talar, Tonekabon and Zarrin Gol rivers, the Aliabad, Voshmgir and Zire dams, possibly the Golabar Dam, and the Anzali Talab (Derzhavin, 1934; Holčík and Oláh, 1992; Karimpour, 1998; Kiabi *et al.*, 1999; Abbasi *et al.*, 1999, 2007, 2017; Nasrollahzadeh, 1999; Abdoli and Naderi, 2009; Ahmadpour *et al.*, 2012; Jafarzadeh *et al.*, 2015; Khataminejad *et al.*, 2015; Babaei, 2017; Mohammadian-Kalat *et al.*, 2017; Naderi Jolodar *et al.*, 2017; Shahnazari *et al.*, 2020).

Also widely introduced across western, central and eastern Iran, including in the Sirvan River in the upper Diyala River, the Beheshtabad River in the upper Karun River basin, the Marun River (K. Borkenhagen photograph, see above), the Miriseh River, Lake Zaribar and Choghakor (= Chagha Khur) Wetland in the Tigris River basin (Raissy *et al.*, 2010); the Aji, Mahabad, Qader and Shahr rivers in the Lake Urmia basin (Ghasemi *et al.*, 2015; Mohammadian-kalat *et al.*, 2015, 2017); the Zayandeh River of the Esfahan basin; the Jajarm, Kal-e Shur and Qareh Su rivers of the northeastern Dasht-e Kavir basin; the Doosti and Kardeh dams in the Hari River basin and the Hari River (Mohammadian-kalat *et al.*, 2015; Asgharnia *et al.*, 2018; Mousavi-Sabet *et al.*, 2018); and in the Hamun Kushk, Chahnimeh Reservoirs, and Kahak and Sistan dams of the Sistan basin; and possibly in the Minab (= Esteghlal) Dam of the

Hormozgan basin (A. Abdoli, pers. comm., 1995; J. Holčík, *in litt.*, 1996; Abdoli, 2000; Ghorbani Chafi, 2000; A. Afzali, pers. comm., 2002; Esmaeili *et al.*, 2011, 2013; Khataminejad *et al.*, 2013; Mehraban *et al.*, 2014; Mousavi-Sabet *et al.*, 2014; Zareian *et al.*, 2013; Ghasemi *et al.*, 2015; Jouladeh Roudbar *et al.*, 2015; Mohammadian-kalat *et al.*, 2015; Abbasi *et al.*, 2016; Jouladeh-Roudbar *et al.*, 2016). Also found in Chitgar Lake, an artificial water body in northwest Tehran (Bagheri *et al.*, 2016; Ramin *et al.*, 2016; Abbasi *et al.*, 2017; Ramin and Doustdar, 2017b).

**Zoogeography.** This is a widespread species showing great morphological variability over its range, sometimes recognised as distinct taxa. Zoogeographical relationships of these taxa and of the species to other *Alburnus* have still to be worked out.

**Habitat.** This species is found in rivers, streams, lakes, dams, lagoons, marshes, ditches and brackish environments. It is found in open waters of lakes along the shore or in slow rivers, avoiding turbid conditions and heavy vegetation. There was a mass mortality, presumed to be of this species, on the Babol Sar beach on 24 June 1963 (USNM 270909). It is found more abundantly at river estuaries along the Iranian Caspian shore than *Alburnus filippii* (Naderi Jolodar and Abdoli, 2004). Collection data included a temperature range of 13.3-31°C, pH 6.9, conductivity 0.3-1.5 mS, river width 6-120 m, still to fast current, depth 40 cm or more, clear and colourless, muddy or cloudy water, mud, clay, sand, pebble, stone or concrete bottoms, encrusting, submergent (such as *Ceratophyllum*, *Potamogeton* and *Ranunculus*), emergent (such as *Phragmites* and *Typha*) and floating vegetation, and a grassy, bushy or forested shore.

**Age and growth.** Maturity is attained at 3 years and life span is up to 9 years. In more northern waters, most spawning males are 3<sup>+</sup> and 4<sup>+</sup> years while females are 5<sup>+</sup> and 6<sup>+</sup> years. Iranian populations probably have a similar structure but the age groups would be lower. Mature males averaged 9.7 cm and females 10.5 cm in one study in Russia (Berg, 1948-1949). Esmaeili *et al.* (2014) gave a *b* value for 30 fish from the Tigris River, 7.31-11.2 cm total length, as 3.29. Esmaeili *et al.* (2014) gave a *b* value for 36 fish, 8.0-12.0 cm total length, as 3.18. Mousavi-Sabet *et al.* (2014) gave a *b* value of 2.822 for 30 fish, 4.89-6.54 cm total length, from the Miriseh River. MoradiChafi *et al.* (2017) recorded the average age of fish in Chitgar Lake, Tehran as 3.5 years.

**Food.** Food is planktonic crustaceans, benthic crustaceans such as amphipods, flying insects which land on the water surface, aquatic insects such as backswimmers (Notonectidae), algae, diatoms, and fish eggs and fry. MoradiChafi *et al.* (2017) recorded the diet of fish in Chitgar Lake, Tehran as algae, phytoplankton, zooplankton and benthos. The fish fed on Chironomidae, Ephemeroptera, Betidae, Odonata larvae, Diptera eggs and some fish larvae, along with some filamentous algae and periphyton which included *Cyclops*, Copepoda and Cladocera. The highest number of food item was Chironomidae at 94.1%. The average condition factor was 0.86, intestine length was 0.6 and feeding intensity was 253.8. This fish was more carnivorous in the lake, and the feeding rate was good.

**Reproduction.** Iranian specimens had 1.1 mm diameter eggs in a sample caught on 11 June 1962 (CMNFI 1979-0265) and mature males were collected on 10 July 1962 (CMNFI 1979-0686). Specimens collected in September showed egg resorption while those taken in December had small, developing eggs and those taken in April with better developed eggs. The specimens were small and spawning probably occurred in July for these fish and possibly June for larger ones.

June was the main spawning month in Azerbaijan judging by egg diameters and condition factors (Abdurakhmanov, 1962). Older fish spawned first. Water temperature was

usually at 15-16°C or more. Spawning took place in 3-6 stages at intervals of 9-11 days. The eggs adhered to stones, branches or vegetation. Fecundity was up to 10,000 eggs and egg diameter to 1.4 mm. Incubation lasted about one week.

**Parasites and predators.** Molnár and Jalali (1992) recorded the monogeneans *Dactylogyrus parvus*, *D. alatus* and *D. chalcalburni* from fish identified as *Alburnus charusini* (= *A. hohenackeri*) on the Sefid River. Shamsi *et al.* (1997) reported *Clinostomum complanatum*, a parasite causing laryngo-pharyngitis in humans, from this species in the Shirud. Daghigh Roohi (2016) recorded a *Dactylogyrus* sp. from fish identified as *A. charusini* in the Anzali Wetland. Mirhashemi Nasab *et al.* (2017) found *Diplostomum spathaceum* in fish from the Anzali Wetland with prevalence (64.51%) and range (1-5 worms in a fish). Barzegar *et al.* (2018) reported the monogeneans *Gyrodactylus gobioninum* and *G. mutabilitas* from the Talar and Babol rivers and Talar and Shirud rivers respectively in Mazandaran.

Gussev *et al.* (1993b) reported the monogenean, *Dactylogyrus chalcalburni*, from this species in the Zayandeh Rud but this fish does not occur there. The parasite may have been found in *Alburnus doriae*. Raissy *et al.* (2009, 2013) reported on a parasitic outbreak of *Lernaea cyprinacea* in the Choghakhor (= Chagha Khur) Lagoon, Chahar Mahall and Bakhtiari Province in *Alburnus alburnus*, presumably translocated specimens of this species. Mehraban *et al.* (2014) found the cestode *Ligula intestinalis* plerocercoids in this fish introduced to the Chahnimeh Lakes or Reservoirs in Sistan where it was a major threat to indigenous species.

Some European populations of *Sander lucioperca* (pike-perch) feed almost exclusively on this species. Spent adults are known to eat their own eggs. It is an important prey item for other fishes generally.

**Economic importance.** The scales of related species contain silvery crystals of guanine which have been extracted and used to make *essence d'orient* (or pearl essence) for artificial pearls. About 5,000 fish are required for 100 g of essence. This abundant species is of indirect commercial importance as food for more valued fishes.

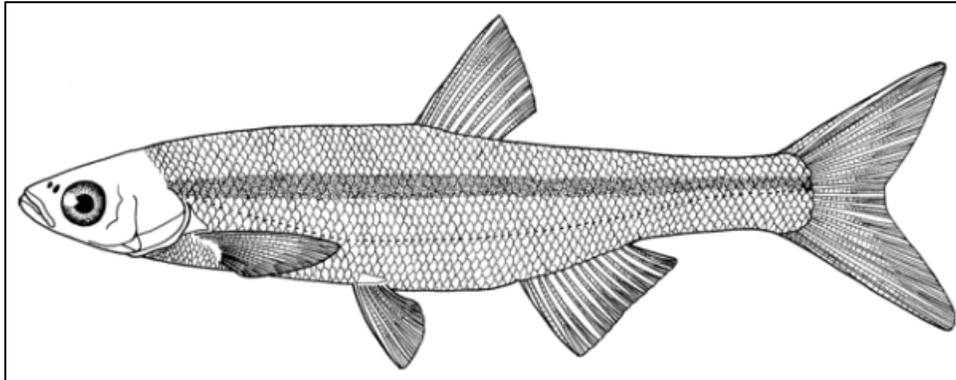
**Experimental studies.** Doustdar *et al.* (2018) found that the highest level of mercury contamination in a study of Aras River fish was found in this species (identified as *A. alburnus*) at 13.1 µg/g dry weight muscle tissue.

**Conservation.** Kiabi *et al.* (1999) considered this species to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included abundant in numbers, habitat destruction, widespread range (75% of water bodies), and present in other water bodies in Iran. Endangered in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

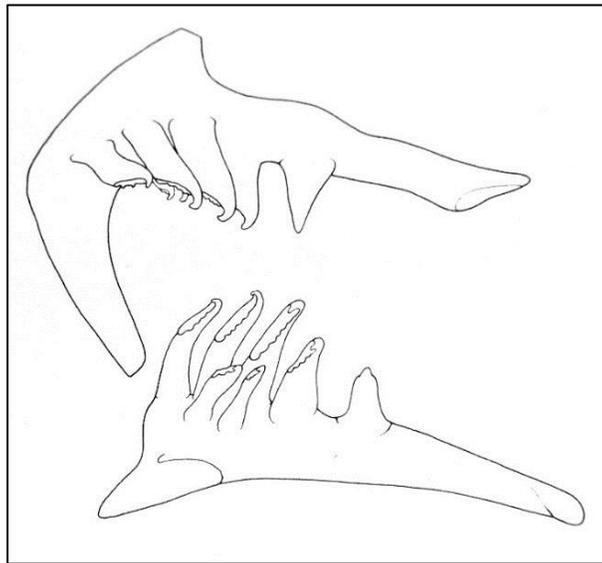
**Sources.** Iranian material:- CMNFI 1970-0506, 12, not kept, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0510, 8, 44.5-72.1 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0512, 3, 32.5-42.5 mm standard length, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0521, 3, 51.2-60.7 mm standard length, Gilan, Sefid River near Lulaman (no other locality data); CMNFI 1970-0522, 3, 41.1-49.5 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0526, 15, 51.9-78.7 mm standard length, Gilan, Sefid River 16 km below Astaneh Bridge (37°19'N, 49°57'30"E); CMNFI 1970-0532, 1, 64.5 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0543, 1, 37.9 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0579, 1, 49.4 mm standard length, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0580, 27, 33.9-56.1 mm standard length, Mazandaran, river near Iz Deh (36°36'N, 52°07'E); CMNFI 1970-0581, 33, 34.4-69.1 mm

standard length, Gilan, Caspian Sea near Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0582, 1, 45.2 mm standard length, Golestan, Aliabad Reservoir (*sic*) (36°56'N, 54°50'E); CMNFI 1970-0583, 4, 47.2-61.5 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0587, 1, not kept, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0589, 21, 22.5-67.9 mm standard length, Gilan, Sefid River opposite Kisom (37°12'N, 49°54'E); CMNFI 1970-0590, 1, not kept, Mazandaran, Shesh Deh River near Babol Sar (ca. 36°43'N, ca. 52°39'E); CMNFI 1971-0343, 1, 63.5 mm standard length, Gilan, Langarud at Chamkhaleh (37°13'N, 50°16'E); CMNFI 1979-0265, 30, 61.6-90.4 mm standard length, Gilan, head of Anzali Talab at Abkenar (37°28'N, 49°20'E); CMNFI 1979-0430, 16, 38.1-59.5 mm standard length, Mazandaran, river 1 km east of Now Shahr (36°39'N, 51°31'E); CMNFI 1979-0432, 22, 34.4-54.3 mm standard length, Mazandaran, Sardab River branch (36°41'N, 51°22'E); CMNFI 1979-0434, 21, 44.9-53.6 mm standard length, Mazandaran, Shirud River (36°51'N, 50°49'E); CMNFI 1979-0435, 1, 51.9 mm standard length, Gilan, stream west of Ramsar (36°57'N, 50°37'E); CMNFI 1979-0472, 52, 25.4-63.6 mm standard length, Mazandaran, stream 7 km west of Mahmudabad (36°37'N, 52°12'E); CMNFI 1979-0475, 3, 32.4-34.7 mm standard length, Golestan, stream on road to Gorgan (36°46'N, 54°00'E); CMNFI 1979-0476, 8, 25.7-35.6 mm standard length, Golestan, Qareh Su near Kord Kuy (36°51'N, 54°05'E); CMNFI 1979-0478, 6, 19.7-29.5 mm standard length, Golestan, ditch on road to Shah Mazra'eh (37°09'N, 54°36'E); CMNFI 1979-0479, 76, 14.3-51.0 mm standard length, Golestan, dam on Gorgan River (37°09'30"N, 54°41'30"E); CMNFI 1979-0480, 6, 14.4-64.3 mm standard length, Golestan, Gorgan River at Gonbad-e Kavus (37°15'30"N, 55°09'E); CMNFI 1979-0685, 2, 57.4-60.7 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0686, 8, 50.5-70.9 mm standard length, Gilan, Sefid River above ferry (37°24'N, 49°58'E); CMNFI 1979-0695, 1 of 119, 47.8 mm standard length, Gilan, Sefid River at Manjil Bridge (36°46'N, 49°24'E); CMNFI 1979-1236, 4, 46.1-55.3 mm standard length, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0116, 23, 41.7-85.0 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0122, 41, 29.8-59.0 mm standard length, Mazandaran, Nerissi River (36°38'N, 52°16'E); CMNFI 1980-0123, 1, 53.1 mm standard length, Gilan, Sefid River around Dakha (ca. 37°22'N, ca. 49°57'E); CMNFI 1980-0128, 1, 56.5 mm standard length, Golestan, Qareh Su (36°49'30"N, 54°03'30"E); CMNFI 1980-0132, 2, 24.3-66.9 mm standard length, Gilan, Sefid River at Kisom (37°12'N, 49°54'E); CMNFI 1980-0136, 3, 33.5-50.1 mm standard length, Mazandaran, Fereydun Kenar River estuary (36°41'N, 52°29'E); CMNFI 1980-0142, 1, 53.7 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1980-0144, 2, 31.9-37.1 mm standard length, Mazandaran, Sorkh River (36°40'N, 52°25'E); CMNFI 1980-0147, 5, 44.3-61.5 mm standard length, Gilan, Lashtenesha (= Lasht Nesha') River (37°21'N, 49°52'E); CMNFI 1980-0155, 1, 38.5 mm standard length, Ardabil, Qareh Su near Ardabil (ca. 38°15'N, ca. 48°18'E); CMNFI 1980-0905, 4, not kept, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0908, 1, 70.6 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1980-0925, 27, not kept, Iran, Caspian Sea basin (no other locality data); CMNFI 1993-0134, 5, 51.0-76.7 mm standard length, Golestan, Gorgan-Aliabad (37°01'30"N, 54°47'36"E); CMNFI 2008-0113, 4, 20.1-29.3, Gilan, Caspian Sea coast near Khoshk Bijar (37°22'N, 49°47'E); CMNFI 2008-0204, 4, 58.1-71.0 mm standard length, Sistan (no other locality data); CMNFI 2008-0223, 3, 80.4-85.4 mm standard length, Iran, Aras River (no other locality data).

*Alburnus sellal*  
Heckel, 1843



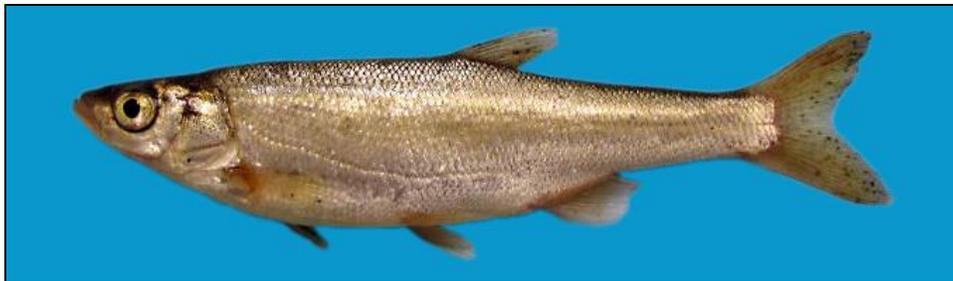
*Alburnus sellal*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus sellal*, pharyngeal teeth, Freidhelm Krupp.



*Alburnus sellal*, Fars, Kor River, Jörg Freyhof.



*Alburnus sellal*, Hamadan, Haramabad, Gamasiab River, January 2010, Keyvan Abbasi.

**Common names.** Shah kuli (= king fish), shah kuli-ye jonubi (= southern king fish), shah mahi (= king fish), shah kuli mosulensis (from *A. mossulensis*); shahkuli-ye Zagros (= Zagros king fish) for *A. zagrosensis*.

[Samnan, semnan or simnan, semnan tuyel (from samnan = sleek, healthy, fat, corpulent and tawil (meaning long), hence long sleek fish) (Mikaili and Shayegh, 2011)); lassaf (meaning fluorescent), shilik (perhaps from shilig meaning a cucumber-shaped melon) and shanak and sink (perhaps variants of shilig) (Mikaili and Shayegh, 2011)); zurri at Mosul (zurri also used for *Chondrostoma regium* according to Heckel (1847a), but is also used for Oriental killifishes (Aphaniidae), *Gambusia* (Poeciliidae) and any small fishes or large fishes when young); all in Arabic; Gümüs balığı and İnci balığı in Turkish (Çiçek *et al.*, 2020; Kaya *et al.*, 2016); Mesopotamian bleak, Mosul bleak; Zagros bleak for *A. zagrosensis*].

**Systematics.** *Alburnus* (or *Chalcalburnus*) *mossulensis* Heckel, 1843 was the name under which this species was widely known in the literature of Iran but it is now regarded as a synonym as explained below. The type locality of *Alburnus mossulensis* is the “Tigris bei Mossul” according to Heckel (1843b).

Synonyms of *A. sellal* are *Leuciscus maxillaris* Valenciennes, 1844 from “rivières de Perse”, probably *Alburnus capito* Heckel, 1843 from “Gebirgsflüssen Kurdistans” (mountain streams of Kurdistan in Heckel (1843b) or “Gebirgsbache in Kurdistan” in Heckel (1847a)), *Alburnus caudimacula* Heckel, 1847 described from the “Flusse Kara-Agatsch und bei dem Dorfe Geré” (= Qarah Aqaj or upper Mond River, Fars and at the village Geré - it is not clear whether the village is a second locality or is on the Qarah Aqaj - see under *Luciobarbus barbulus*); Geré is Jereh or Jireh at 29°15'N, 51°58'E according to Edmondson and Lack (2006) and is in the Hilleh River drainage, a Dalaki River tributary (see map in Hohenacker (1845); possibly Geré is near Kereft (29°01'N, 52°52'E) as “Geré” takes a hard G in German, not a J; there may be some confusion of names and rivers here), *Alburnus Iblis* Heckel, 1847 described from the “Gegend um Persepolis oder den Gewässern des Araxes” (= probably the Pulvar (= Sivan) River near Persepolis and the Kor River, both in Fars), *Alburnus megacephalus* Heckel, 1847 described from the “Araxes”, *Alburnus Schejtan* Heckel, 1847 described from the “Araxes bei Persepolis”, and *Alburnus zagrosensis* Coad, 2009 described from a stream in the upper Karun River basin (Eagderi *et al.*, 2019).

*A. sellal* (including its major synonym *A. mossulensis*) is apparently a widely-distributed species and unlike some other species in the Middle East has not been found to harbour localised taxa when DNA studies were carried out. The reservations noted in the **Methods** and under the genus *Alburnoides* may apply here regarding molecular data where studies involving multiloci and nuclear DNA may be apposite (and see Liu *et al.* (2017)). Since the type locality is dry, fish used in the DNA analyses were based on samples from the Gandoman Wetland or Lagoon nearby and the fish were assumed to be the same as *A. zagrosensis*. This can not now be verified.

Mousavi-Sabet *et al.* (2015) separated *A. zagrosensis* from Iranian *A. mossulensis*, now *A. sellal*, in a scatter plot of the first two principal components based on 24 morphometric characters. This may indicate further work needs to be done to clarify the limits of these putative taxa, or may simply be variation due to habitat differences documented widely for other cyprinoids herein.

Note that Eagderi *et al.* (2019) stated that Coad (2009) counted the last two dorsal and anal fin rays in *A. zagrosensis* as two when these were in fact counted as one arising from the same pterygiophore base as in all cyprinoid counts herein. This makes the counts one higher for both these fins as interpreted for my data by them in their Table 3, and thus more similar to the wide-ranging *A. sellal*.

A hybrid with *Acanthobrama marmid* with *A. mossulensis* (= *A. sellal*) was reported from the Hawr al Hammar in southern Iraq by Krupp *et al.* (1992) who also noted that *A. mossulensis* is probably a synonym of *Alburnus sellal* Heckel, 1843, a species originally described from the Quwayq River at Aleppo. However, they retained *mossulensis* as a distinct species because of colour differences and the difficulty of obtaining fresh material of *sellal* in its polluted habitat at Aleppo in Syria (see Vesiland (1993) for habitat photograph). Heckel (1847a) differentiated *mossulensis* from *sellal* by the former being slenderer and more elongate, the pelvic, dorsal and anal fins are more anterior so the caudal peduncle is more elongate, the eyes are larger and lower on the head, and there is a lead-coloured stripe separating the upper third of the body from the lower part. Berg (1949) considered that *A. mossulensis* may be nothing more than a subspecies of *A. sellal*. A principal components analysis on the types of *mossulensis* and *sellal* by me using 32 morphometric and meristic characters showed some separation between the two taxa and a Discriminant Function Analysis separated most, but not all, specimens. However, molecular evidence from Mohammadian-Kalat *et al.* (2017) placed *mossulensis* in *sellal*. Abbas Jasim (pers. comm., 17 April 2020) noted that this study used *A. sellal* from headwaters of the Quwayq in Turkey, but the Quwayq was connected to the Euphrates River not long ago, and it was possible the *sellal* material of Mohammadian-Kalat *et al.* (2017) was *mossulensis*. The synonymy of *mossulensis* with *sellal* is generally accepted, however. Birecikligil *et al.* (2016) used mitochondrial DNA to compare *Alburnus* material from Turkey including specimens identified as *sellal* and *mossulensis* and also *adanensis* (recognised as a subspecies or synonym of *sellal* from the Seyhan River near Adana, southern Turkey). Neither the *sellal* nor the *mossulensis* materials were from the type localities of these species but they were distinct and *adanensis* was recognised as synonym of *sellal* (or least material identified as *sellal*). Mangit and Yerli (2018) stated that *mossulensis* is a synonym of *sellal* in their analysis of Turkish *Alburnus* species (see online data).

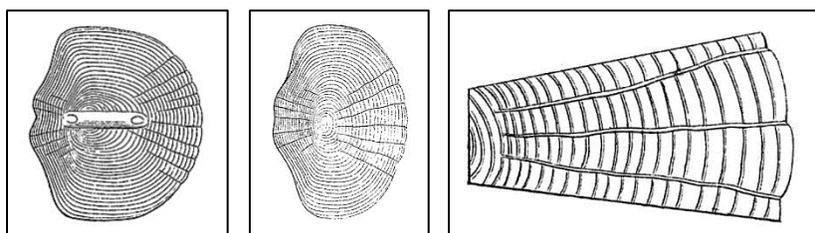
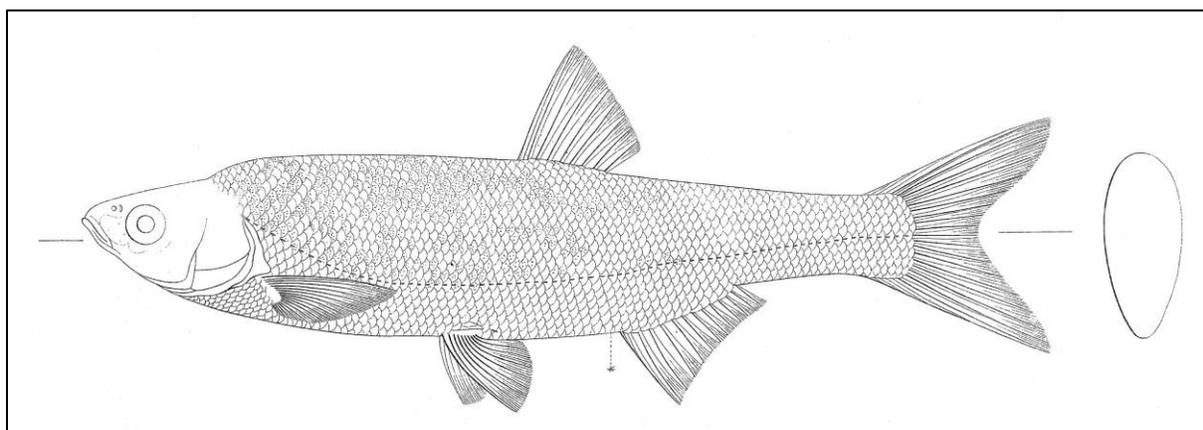
Saadati (1977) considered *Alburnus caudimacula* to be a distinct species found in the Mond River of Fars based on head length being longer (but the ranges overlap) and a shorter scaleless keel (which is individually variable in these fishes according to my observations).

A subspecies, *Alburnus mossulensis delineatus* Battalgi, 1942, of uncertain status is reported from Diyarbakir on the Tigris River in Turkey and is presumably a synonym of *A. sellal*.

As *mossulensis* is a synonym of *sellal*, the nominal taxa from outside Iran *Alburnus hebes* Heckel, 1843, *Alburnus microlepis* Heckel, 1843 and *Alburnus pallidus* Heckel, 1843, all from the Kueik (= Quwayq) River at Aleppo (Heckel, 1843b), are added to the synonymy of *sellal* as indicated by Berg (1949), Krupp (1985c) and the *Catalog of Fishes* (downloaded 1 September 2007). The three syntypes of *Alburnus hebes* seen by me in the Naturhistorisches Museum Wien

were 58.8-156.5 mm standard length (NMW 17558-17560) (but Eschmeyer *et al.* (1996) and the Ichthyology Type Database, NMW (downloaded 9 July 2016) listed NMW 55523 for these syntypes, and the card index had this number in 1997; possibly they were renumbered). One of these fish is designated as the lectotype. The holotype of *Alburnus microlepis* (NMW 55655) measures 119 mm standard length (Krupp, 1985c). The holotype of *Alburnus pallidus* (NMW 55720) measured 76.6 mm standard length. The types of these taxa are illustrated below alphabetically along with types from Iran.

Krupp (1985c) gave details on the syntypes of *Alburnus sellal* held at the Naturhistorisches Museum Wien. Six syntypes of *A. sellal*, 124-140 mm standard length, were listed as under NMW 55665 (2 fish, 137.2-141.3 mm standard length, my measurements), NMW 55666 (4, 126.9-142.7 mm standard length), and 3, 110-152 mm standard length, were under NMW 55664 (1, 110.5 mm standard length) and NMW 55667 (2, one of which is designated as the lectotype, 140.7-155.4 mm standard length). Eschmeyer *et al.* (1996) listed NMW 55664-67 as having 1, 2, 4, and 2 fish in each number in the series and also two syntypes (RMNH 2666) in the Rijksmuseum van Natuurlijke Historie, Leiden from NMW. The catalogue in Vienna listed eight specimens of *A. sellal*. B. Riedel (pers. comm., 11 April 2019) also listed NMW 94797 as a syntype (dry bone, *sic*, probably a dried or stuffed specimen in this case).

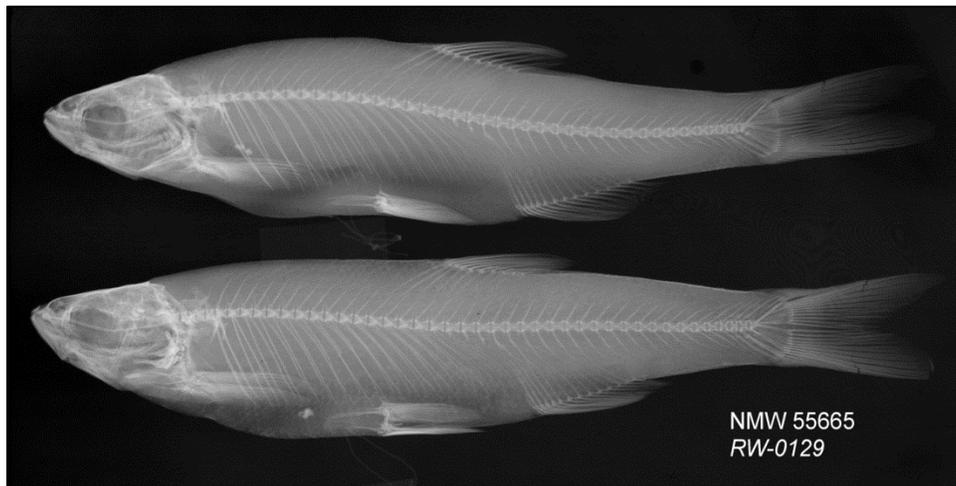


*Alburnus sellal*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.

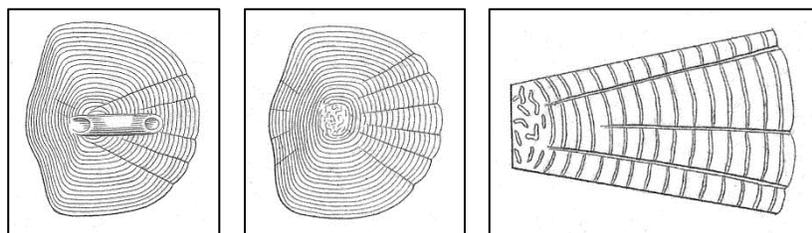
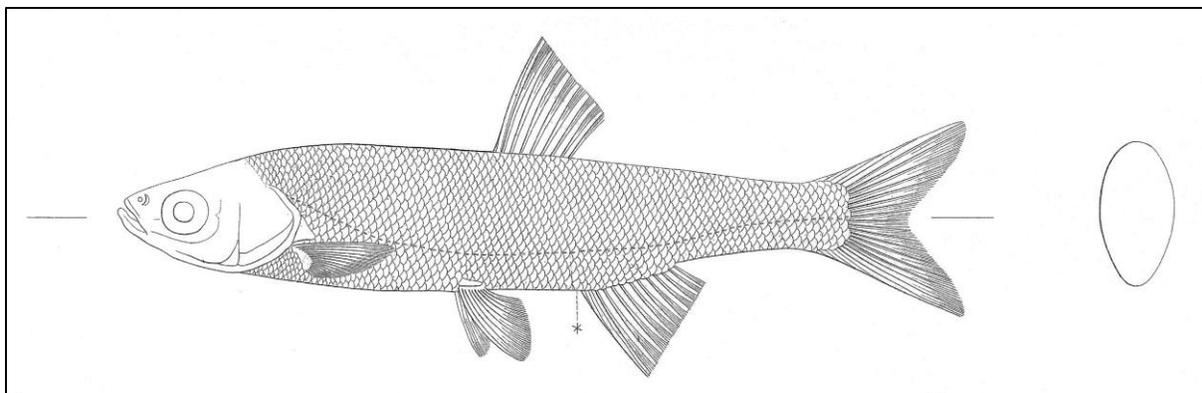


*Alburnus sellal*, syntypes, NMW 55665, Naturhistorisches Museum, Wien.



*Alburnus sellal*, syntypes, NMW 55665, Naturhistorisches Museum, Wien.

Five syntypes of *Alburnus capito* measure 48.7-101.9 mm standard length (NMW 55505) although the catalogue in Vienna only listed four fish at an earlier visit (corrected to five in the *Catalog of Fishes*, downloaded 9 August 2020).



*Alburnus capito*,  
body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line,  
and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Alburnus capito*, syntypes, NMW 55505, Naturhistorisches Museum, Wien.



*Alburnus capito*, syntypes, NMW 55505, Naturhistorisches Museum, Wien.

Fifteen syntypes of *Alburnus caudimacula* are under NMW 55506 and measure 38.5-118.4 mm standard length; the catalogue in Vienna listed eight specimens in one column and what appeared to be 26 specimens in the adjacent column although this may be 20 fish with six set aside for *A. schejtan*. The Rijksmuseum van Natuurlijke Historie, Leiden has four syntypes under RMNH 2654, formerly in NMW (Eschmeyer *et al.*, 1996). B. Riedel (pers. comm., 11 April 2019) also listed NMW 94792 as a syntype (dry bone, *sic*, probably a dried or stuffed specimen in this case).



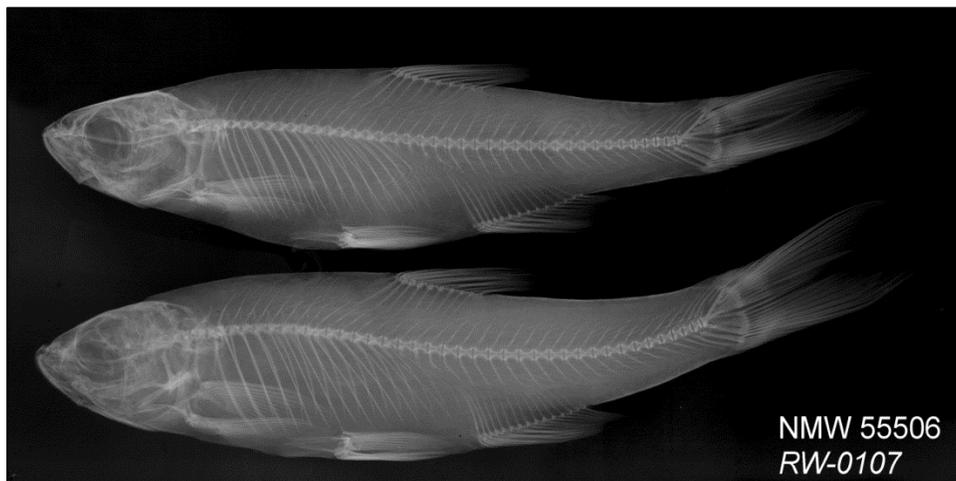
*Alburnus caudimacula*, syntypes, NMW 55506, Naturhistorisches Museum, Wien.



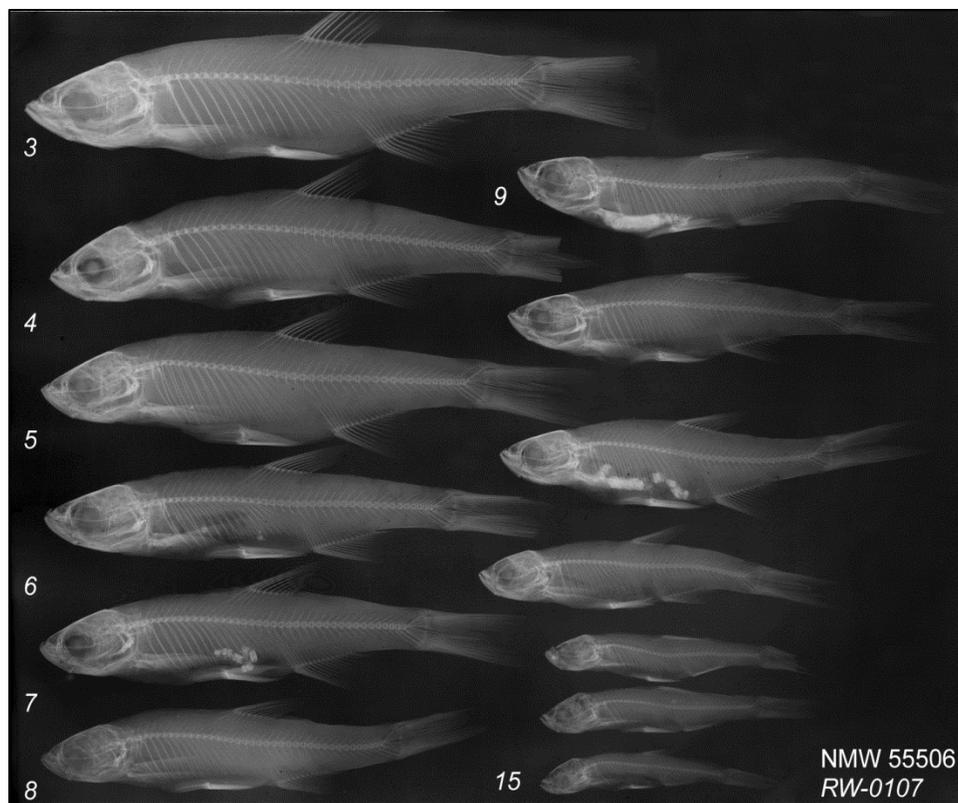
*Alburnus caudimacula*, syntypes, NMW 55506,  
Naturhistorisches Museum, Wien.



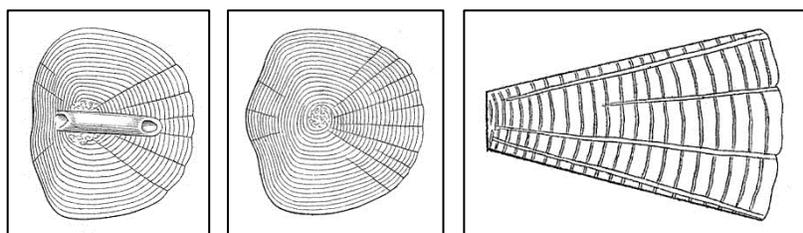
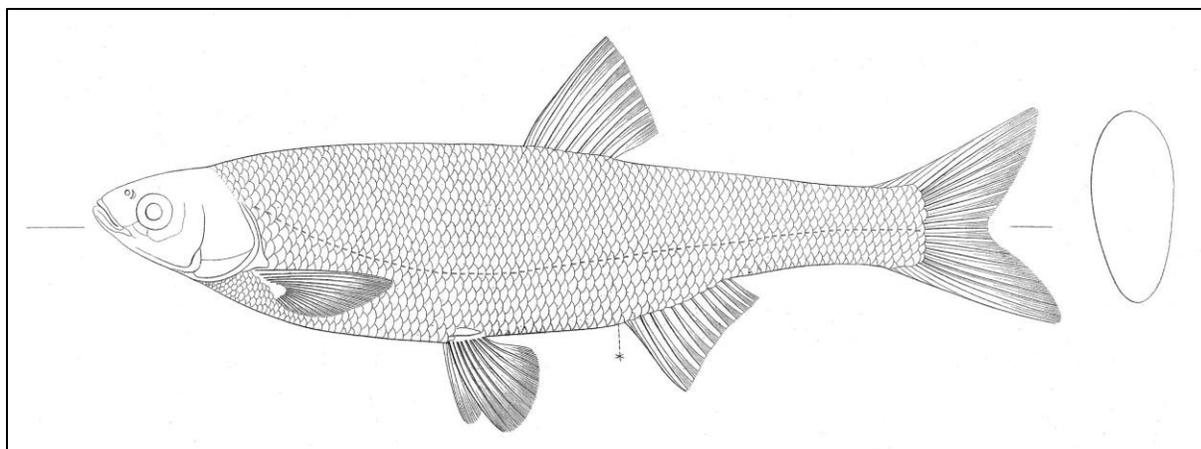
*Alburnus caudimacula*, syntypes, NMW 55506, Naturhistorisches Museum, Wien.



*Alburnus caudimacula*, syntypes, NMW 55506, Naturhistorisches Museum, Wien.



*Alburnus caudimacula*, syntypes, NMW 55506, Naturhistorisches Museum, Wien.



*Alburnus hebes*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Alburnus hebes*, syntype, NMW 55523, Naturhistorisches Museum, Wien.



*Alburnus hebes*, syntypes, NMW 55523, Naturhistorisches Museum, Wien.



*Alburnus hebes*, syntypes, NMW 55523, Naturhistorisches Museum, Wien.

Seven syntypes of *Alburnus iblis* are in the Naturhistorisches Museum Wien under NMW 55524 and measure 91-165 mm standard length (Kähsbauer, 1964; 92.9-172.3 mm standard length by my measurements). One of these fish is designated as the lectotype by P. Bănărescu but does not appear to have been published (Ichthyology Type Database, NMW, downloaded 9 July 2016). The catalogue in Vienna listed eight specimens in one column and 38 in the adjacent column. B. Riedel (pers. comm., 11 April 2019) also listed NMW 94794 as a syntype (dry bone, *sic*, probably a dried or stuffed specimen in this case).



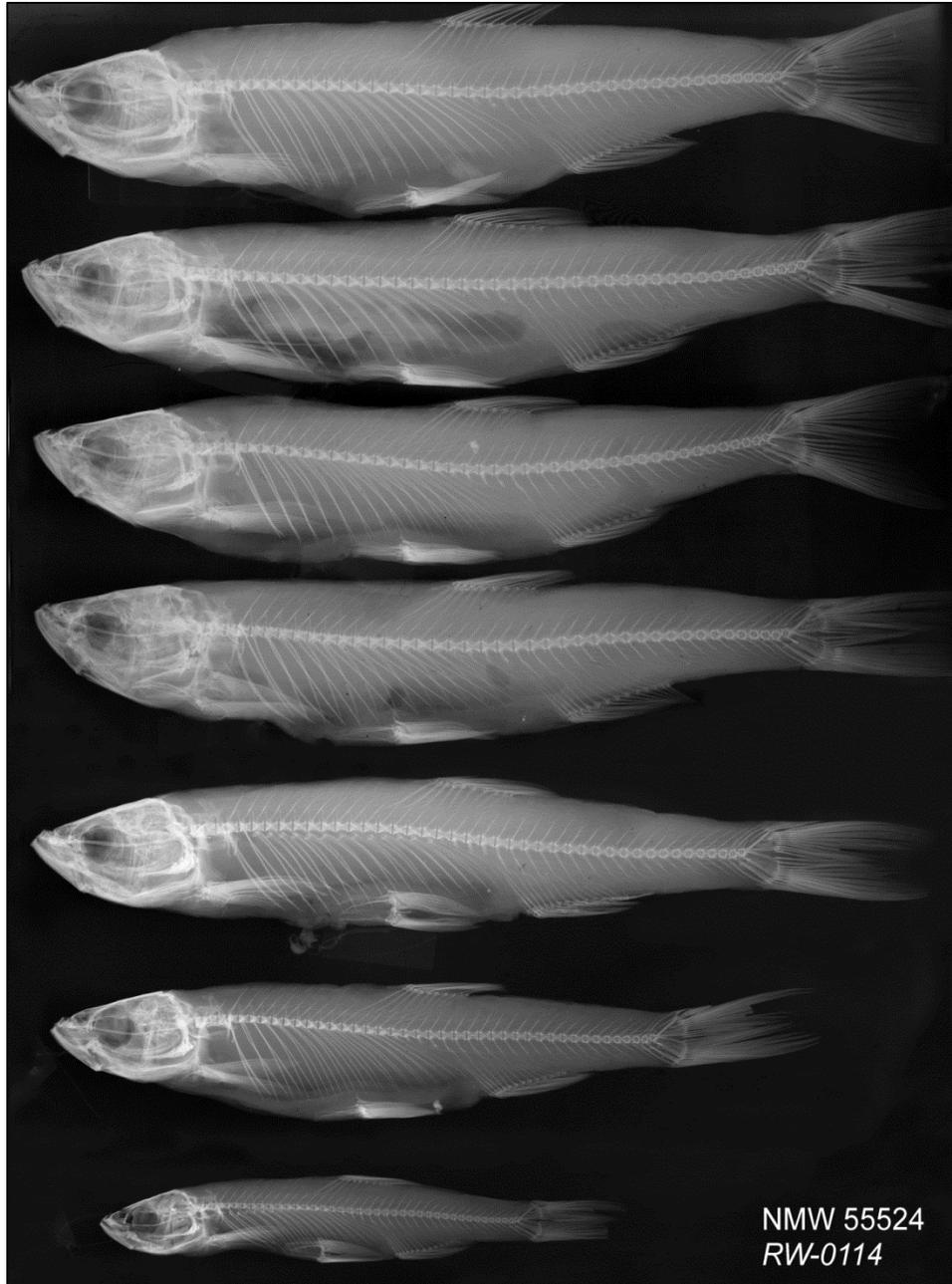
*Alburnus iblis*, syntypes, NMW 55524, Naturhistorisches Museum, Wien.



*Alburnus iblis*, syntypes, NMW 55524, Naturhistorisches Museum, Wien.



*Alburnus iblis*, syntypes, NMW 55524, Naturhistorisches Museum, Wien.



*Alburnus iblis*, syntypes, NMW 55524, Naturhistorisches Museum, Wien.

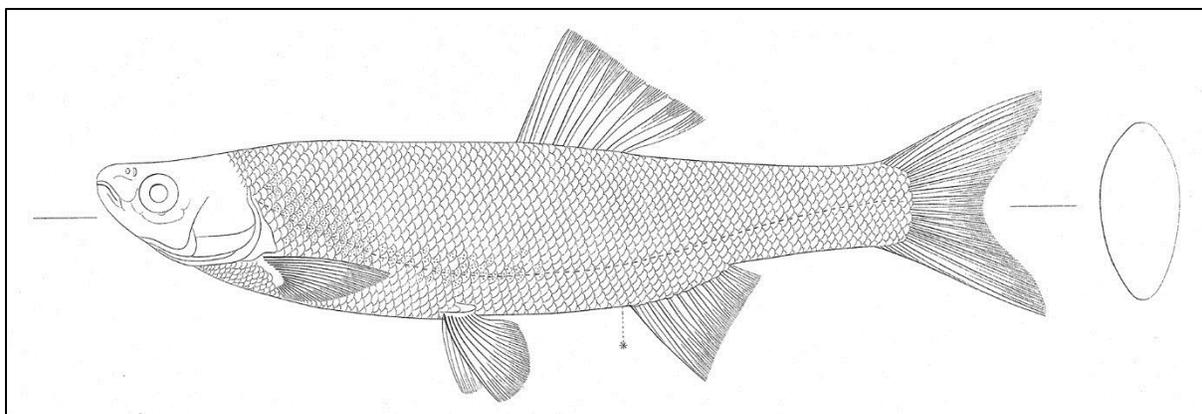
Two syntypes of *Alburnus megacephalus* are under NMW 55627 and measure 160-162 mm standard length (Kähsbauer, 1964; 162.9-166.1 mm standard length by my measurements); two specimens are listed in the Vienna catalogue. One of these fish is the lectotype.

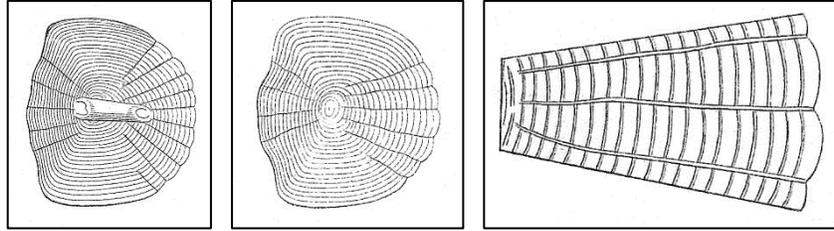


*Alburnus megacephalus*, syntypes, NMW 55627, Naturhistorisches Museum, Wien.



*Alburnus megacephalus*, syntypes, NMW 55627, Naturhistorisches Museum, Wien.



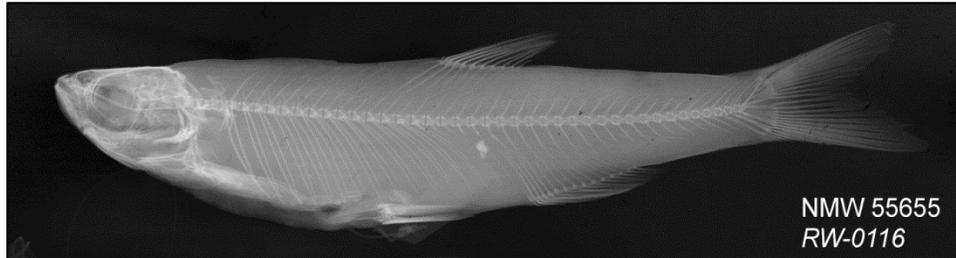


*Alburnus microlepis*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.

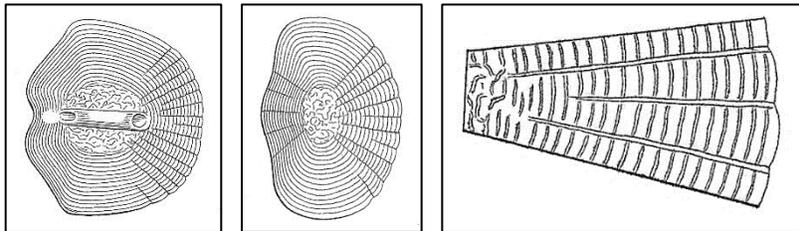
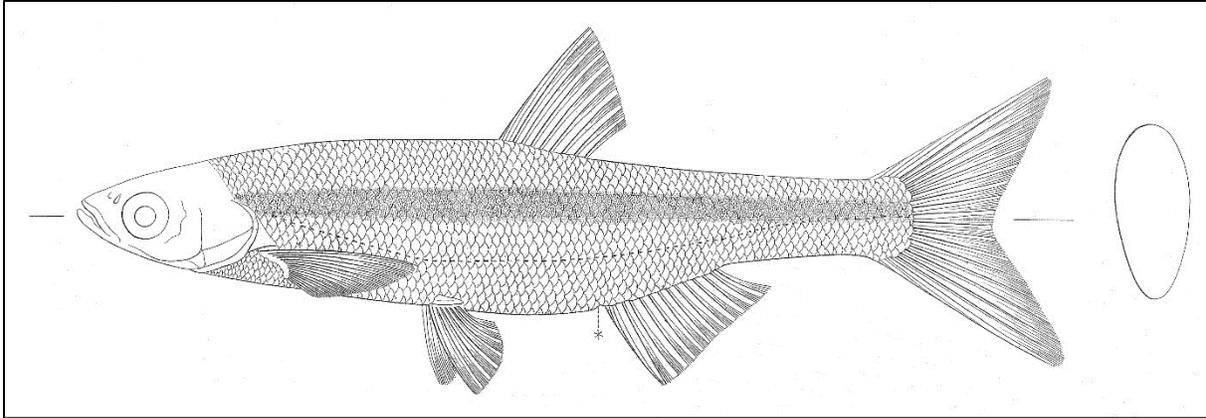


*Alburnus microlepis*, holotype, NMW 55655, Naturhistorisches Museum, Wien.



*Alburnus microlepis*, holotype, NMW 55655, Naturhistorisches Museum, Wien.

The syntypes of *A. mossulensis* are under NMW 55656 (2 fish, 111.2-118.4 mm standard length, my measurements), NMW 55717 (2, 83.0-89.4 mm standard length), and NMW 55718 (2, 101.9-131.5 mm standard length). Two syntypes of *Alburnus mossulensis* are in the Senckenberg Museum Frankfurt (SMF 402, formerly NMW) (F. Krupp, pers. comm., 1985; 80.1-102.7 mm standard length). Eschmeyer *et al.* (1996) also listed NMW 77723 (2, 90.4-135.4 mm standard length) and one possible syntype in the Rijksmuseum van Natuurlijke Historie, Leiden (RMNH 2644). The catalogue in Vienna listed six specimens of *A. mossulensis*, with one specimen from NMW 77723 as the lectotype.



*Alburnus mossulensis*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line (regenerated), and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



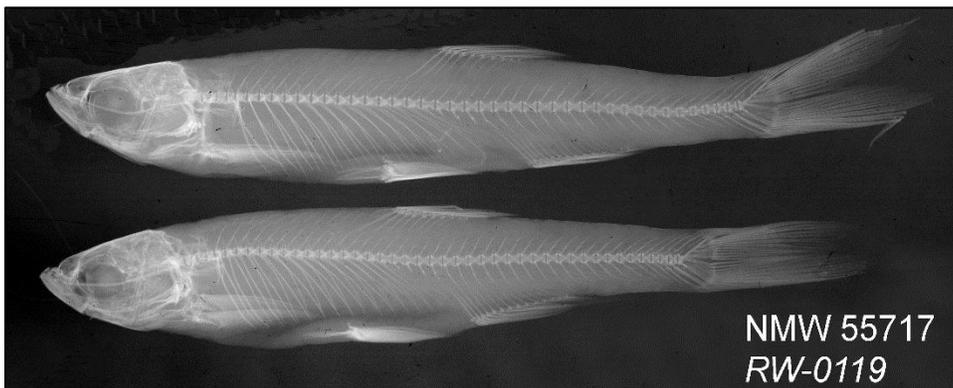
*Alburnus mossulensis*, syntypes, NMW 55656, Naturhistorisches Museum, Wien.



*Alburnus mossulensis*, syntypes, NMW 55656, Naturhistorisches Museum, Wien.



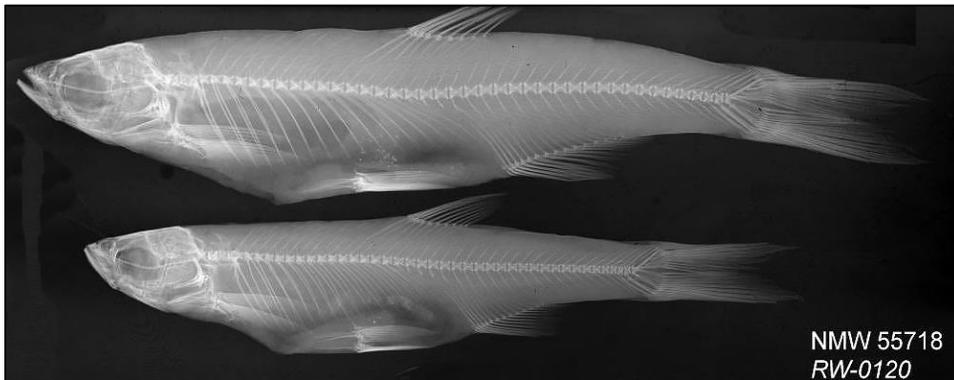
*Alburnus mossulensis*, syntypes, NMW 55717, Naturhistorisches Museum, Wien.



*Alburnus mossulensis*, syntypes, NMW 55717, Naturhistorisches Museum, Wien.



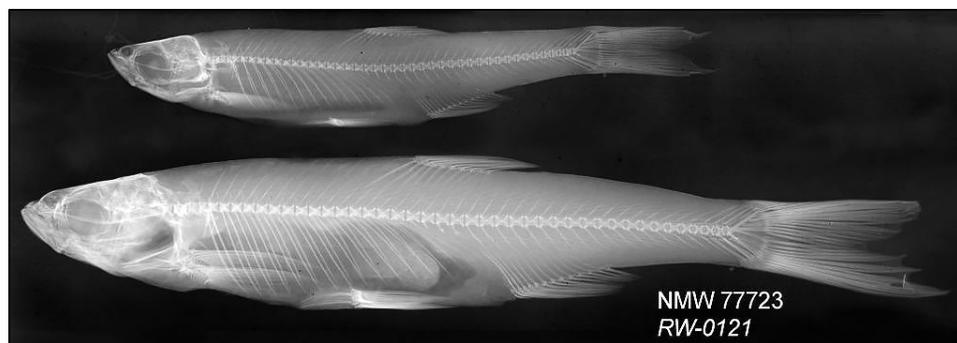
*Alburnus mossulensis*, syntypes, NMW 55718, Naturhistorisches Museum, Wien.



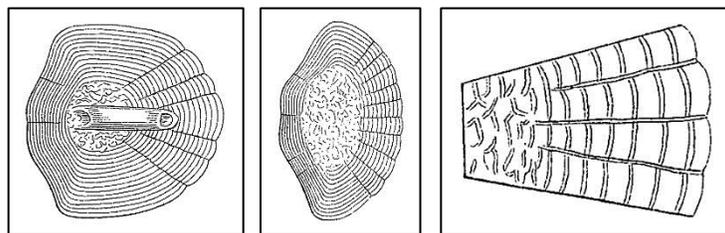
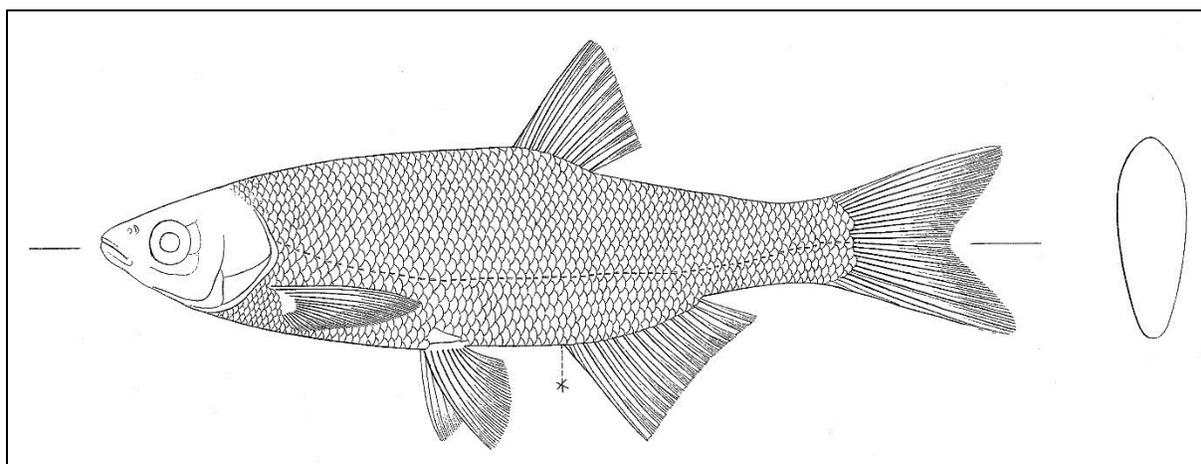
*Alburnus mossulensis*, syntypes, NMW 55718, Naturhistorisches Museum, Wien.



*Alburnus mossulensis*, syntypes, NMW 77723, Naturhistorisches Museum, Wien.



*Alburnus mossulensis*, syntypes, NMW 77723, Naturhistorisches Museum, Wien.



*Alburnus pallidus*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line (regenerated), and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Alburnus pallidus*, holotype, NMW 55720, Naturhistorisches Museum, Wien.

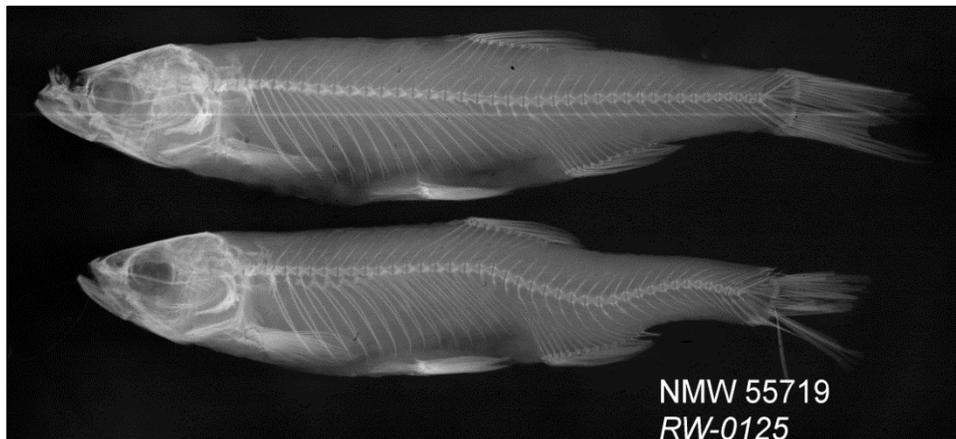


*Alburnus pallidus*, holotype, NMW 55720, Naturhistorisches Museum, Wien.

Four syntypes of *Alburnus schejtan* measure 71.7-112.6 mm standard length (NMW 22281) and one of these is designated as the lectotype, two syntypes measure 104.5-112.3 mm standard length (NMW 55663), two syntypes measure 91.8-100.0 mm standard length (NMW 55719), two syntypes measure 89-100 mm standard length (NMW 55719, after the Ichthyology Type Database, NMW, downloaded 9 July 2016), and two syntypes measure 81.6-94.4 mm standard length (NMW 55721).

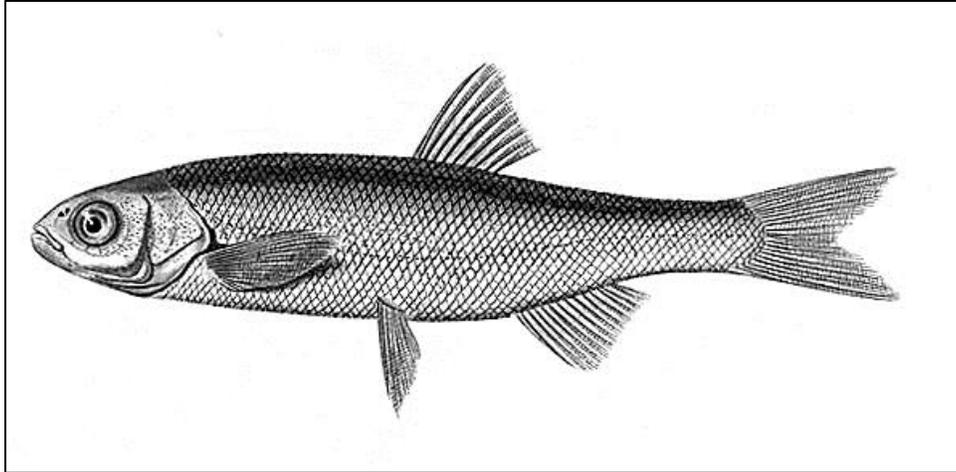


*Alburnus schejtan*, syntypes, NMW 55719, Naturhistorisches Museum, Wien.



*Alburnus schejtan*, syntypes, NMW 55719, Naturhistorisches Museum, Wien.

Two syntypes of *Leuciscus maxillaris*, 165-166 mm total length, are stored in the Muséum national d'Histoire naturelle, Paris (as 13954 according to Fang (1942) or as A.3954 according to Bertin and Estève (1948), M. L. Bauchot, *in litt.*, 1982, and my observations). Fang (1942) regarded *maxillaris* as a distinct species in *Alburnus*. My measurements were 136.7-136.9 mm standard length.



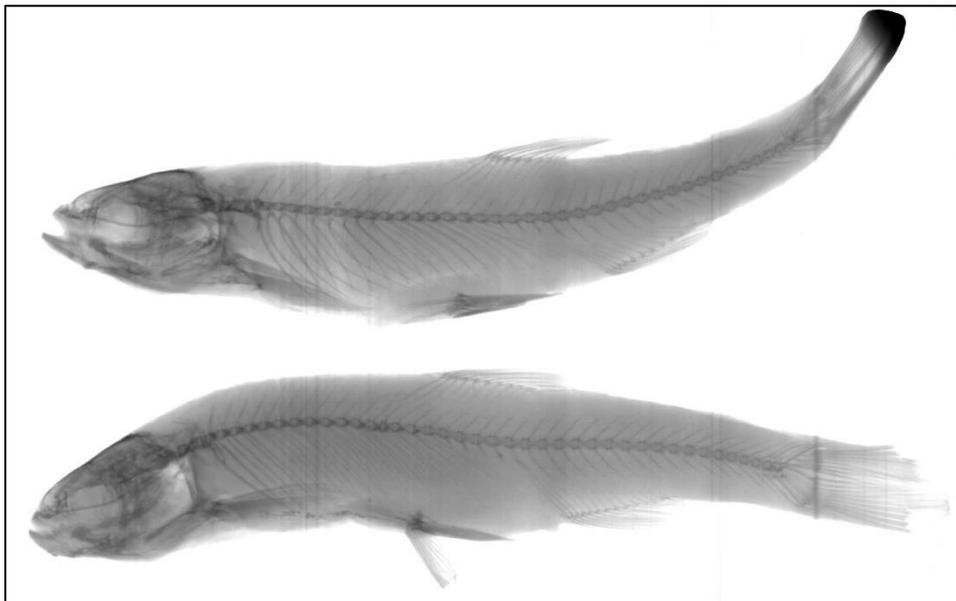
*Leuciscus maxillaris*, syntype, after Valenciennes (1844).



*Leuciscus maxillaris*, syntypes, MNHN-IC-A-3954, S. Grosjean and M. Silvain (CC BY-NC-ND 4.0).



*Leuciscus maxillaris*, syntypes, MNHN-IC-A-3954, S. Grosjean and M. Silvain (CC BY-NC-ND 4.0).



*Leuciscus maxillaris*, syntypes, MNHN-IC-A-3954, S. Grosjean and M. Silvain (CC BY-NC-ND 4.0).

Eagderi *et al.* (2019) synonymized *A. zagrosensis* Coad, 2009 based on morphometric, meristic and molecular (COI) characters and Jouladeh-Roudbar *et al.* (2020) concurred based on their unpublished data of fish from nearby Gandoman Wetland (see above).



*Alburnus zagrosensis*, holotype, CMNFI 1979-0248,  
James Maclaine @ Canadian Museum of Nature.



*Alburnus zagrosensis*, holotype, CMNFI 1979-0248,  
Noel Alfonso @ Canadian Museum of Nature.



*Alburnus zagrosensis*, paratype, CMNFI 1979-0248A,  
Bronwyn Jackson @ Canadian Museum of Nature.



*Alburnus zagrosensis*, paratype, CMNFI 1979-0246,  
Bronwyn Jackson @ Canadian Museum of Nature.

Krupp (1985c) referred five specimens from the type series of *Alburnus doriae* to his *Alburnus sellal* and two specimens to *Leuciscus* (= *Squalius*) *lepidus*.

Bianco and Banarescu (1982) felt that their samples showed clinal variation from northwest to southeast, with numbers of anal fin branched rays, lateral line scales and gill rakers gradually decreasing. Their fish from the upper Tigris River basin in Turkey not far from Mosul (the type locality of *A. mossulensis*) and from the Pulvar River (Kor River basin of Fars) formed one subspecies while those from the Mond and Kul River basin draining to the Persian Gulf in Fars were a distinct subspecies. Available names for the former subspecies included *capito*, *iblis*, *schejtan* and *megacephalus*, the latter required a new name according to Bianco and Banarescu (1982). The Tigris-Kor sample could be *A. mossulensis mossulensis* and the Mand-Kul sample *A. mossulensis caudimacula* (see above). However, Bianco and Banarescu (1982) were correct to point out that variation in this species had not been fully examined, local environmental conditions such as temperature could affect scale counts and the problem of the relationship of *A. sellal* remained to be resolved. They found in seven specimens of *sellal* that scale counts at 71-77 (in contrast to 66-70 in Berg (1949)) overlapped with *mossulensis* counts. Berg's (1949) and my counts are very wide for fish initially identified as *A. mossulensis*, suggesting that local environment may govern meristic characters as widely demonstrated for fishes. Subspecies recognition would require much further work as Bianco and Banarescu (1982) acknowledged by not proposing a new name for the Mand-Kul fish.

Saadati (1977) referred to an unknown species of *Chalcalburnus* from Fars (CMNFI 2007-0065) here identified as *Alburnus sellal*.

Shafee *et al.* (2013) used microsatellite markers to investigate this species (referred to as *mossulensis* and as did other authors below) in the Tigris River basin of Iran finding little genetic differentiation. Yousefian *et al.* (2013) using principal components analysis found differences between populations from four rivers in the Gamasiab basin, largely in meristic characters. Dorafshan *et al.* (2014) found a high level of polymorphism although there was more interspecific (94%) than intraspecific (4%) genetic variation compared with *A. caeruleus*. Hasanpour *et al.* (2014, 2015, 2016) examined morphometric characters between populations (Gamasiab, Kashkan and Sepidbarg (= Sefid Barg) rivers versus the Khersan River versus the Karun River) in the Tigris River basin of Iran using elliptic Fourier analysis. The results showed significant shape differences between populations, e.g., the Sepidbarg population was distinguishable by having a fusiform-shaped body and other populations were distinguishable based on such a character as a shorter caudal peduncle. The differences were attributed to different environmental conditions. Jalili *et al.* (2015) distinguished this species osteologically from other members of the genus in Iran by straight dorsal and posterior opercle margins, an L-shaped and right-angled preopercle, a blunt posterior part to the vomer, by having 11 supraneurals and 43 centra, by a developed zygopophysis process, a short and thick anterior part of the palatine, and a dorsally-bent coronoid process. Keivany *et al.* (2016) examined 229 fish from eight rivers in the Tigris River basin of Iran for 18 morphometric and 12 meristic characters. A discriminant function analysis showed a low degree of separation among four populations from the Abdanan, Leileh, Little Zab and Shoishah rivers, but high separation from other populations and among these other populations (Haran, Kangir, Rabat and Sirvan). Keivany *et al.* (2016) studied 195 specimens from ten rivers in the Karun River basin for 22 morphometric and 14 meristic characters with 21 and 13 of these significantly different between populations. The Khersan, Ivan-e Abbasi and Darband rivers were different from other populations and, although specimens from Bashar and Marbor rivers overlapped with

populations from the Banestan, Shirvan, Dopolan, Aligodarz and Sepidar rivers, these populations were different from each other. Mohammadian Kalat *et al.* (2017) sampled southern rivers in the Hormuz, Kor River, Persis and Tigris River basins and used 39 morphological characters and cytochrome *b* data for analysis. The Kor River population differed from the Hormuz and Persis populations but not from the Tigris River population. Divergence was evaluated as being at intra-specific levels. Keivany *et al.* (2018) examined 705 specimens from 27 rivers of five basins, namely Bushehr, Fars, Karkheh, Karun and tributaries of the Tigris (Diyala), for 22 morphometric and 11 meristic characters. Discriminant function analysis showed that populations from the Fars and Karun basins were different from each other and from other populations, while populations from the Diyala, Karkheh and Bushehr basins overlapped, perhaps indicating similar environmental conditions.

Abedi *et al.* (2016) found fish identified as *A. zagrosensis* from the Choghakhor (= Chagha Khur) Wetland had a wider body and larger head while fish from the Cheshmeh Ali and Hamzeh Ali areas had a lower body depth. Hedayati *et al.* (2016b) carried out a morphometric comparison of fish identified as *A. zagrosensis* from the Cheshmeh Ali, Hamze Ali and Choghakhour (= Chagha Khur) Wetland and found a partial separation of populations attributed to geographical isolation. Total length and head length were the main features that differed, with eye diameter and dorsal fin base length.

**Key characters.** This species is distinguished by having modally 8 branched dorsal fin rays, 8-18 total gill rakers (usually 16 or less), 58-89 (usually 60 or more) lateral line scales, and a distribution in the Tigris River basin and basins of central and southern Iran.

**Morphology.** The body is compressed, vertically oval, shallow and elongate and is deepest between the end of the pectoral fin and the origin of the pelvic fin. The predorsal profile varies from convex to straight. The caudal peduncle is compressed and moderately deep. The head tapers to a pointed snout. The posterior eye lies in the anterior half of the head. The mouth is oblique and extends back level with the nostril. The lower lip projects so the mouth opening is superior. Lips are of moderate thickness. The dorsal fin margin is straight to slightly rounded and the fin origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the anterior part of the anal fin. The caudal fin is deeply forked with pointed tips. The anal fin margin is rounded anteriorly and emarginate posteriorly or gently rounded overall. The anal fin does not extend back to the caudal fin base. The pelvic fin is rounded and remote from the anal fin base. The pectoral fin is rounded and does not extend back to the pelvic fin.

Dorsal fin with 3 unbranched and 6-9 branched rays and anal fin with 3 unbranched and 8-14 branched rays (Keivany *et al.* (2016) gave a range of 7-12 anal rays for their upper Tigris River fish), pectoral fin branched rays 12-18, and pelvic fin branched rays 7-10. Lateral line scales 58-89, scales around caudal peduncle 20-25, predorsal scales 32-42, scales between lateral line and dorsal fin origin 12-18, scales between lateral line and anal fin origin 5-7, and scales between lateral line and pelvic fin origin 4-7. From 0 to 5 scales at the end of the lateral line may not be pored. The ventral keel can be very short or almost not apparent or extend to the scales between the pelvic fin bases. The keel may be flanked by one to 11 scales. A pelvic axillary scale is present. Scale shape varies from a vertical oval to a more squarish shape, the latter with rounded but abrupt dorsal and ventral anterior corners. The posterior, dorsal and ventral margins are rounded and the anterior margin is wavy or indented on each side of a central rounded projection. The focus is slightly subcentral anterior. Circuli are numerous and fine. Radii are few on both the anterior and posterior fields with fewer on the anterior field. Total gill rakers number

8-18 short and usually reach past the anterior base of the adjacent raker when appressed. Pharyngeal teeth are 2,5-4,2 or 2,5-5,2, with strongly hooked tips and serrated edges to the crowns. Variants include 2,5-5,3, 2,5-4,1, 1,5-4,2, 3,5-5,3 and 2,4-4,2. Keivany *et al.* (2016) gave 2,3,5-5,3,2 and 2,4,5-5,4,2 as counts for their fish. The gut is an elongate s-shape with a small anterior loop to the left. Total vertebrae number 39-45. Populations vary sympatrically in total vertebral counts: 40-43 and 42-45; and in abdominal counts 20-22 and 22-24 (Bogutskaya *et al.*, 2000) and Keivany *et al.* (2016) gave 40-45 for their fish. Two syntypes of *A. sellal*, NMW 55665, shown above have 42 and 43 total vertebrae. Three of the syntypes of *A. capito*, NMW 55505, have 43(2) or 44(1) total vertebrae. Selected syntypes (as some are faint and difficult to count) of *A. caudimacula*, NMW 55506, have 41(8) vertebrae. The two larger syntypes of *A. hebes*, NMW 55523, have 43 and 44 total vertebrae. Seven syntypes of *A. iblis*, NMW 55524, have 41(1), 42(3) or 43(3) vertebrae. Two syntypes of *A. megacephalus*, NMW 55627, have 42 and 43 vertebrae. The holotype of *A. microlepis*, NMW 55655, has 42 total vertebrae. The four syntypes of *A. mossulensis*, NMW 55718 and NMW 77723, all have 43 total vertebrae, the syntypes NMW 55656 have 43 and 44 total vertebrae, and the syntypes NMW 55717 have 42 and 44 total vertebrae. The holotype of *A. pallidus*, NMW 55720, has 41 total vertebrae. Two syntypes of *A. schejtan*, NMW 55719, both have 41 vertebrae. The holotype of *A. zagrosensis* has 42 total vertebrae. Two syntypes of *Leuciscus maxillaris*, MNHN-IC-A-3954, have 41 and 43 total vertebrae. The chromosome number of fish from the Kızılırmak River in Turkey was  $2n = 48$  (Gül *et al.*, 2000) but this species does not occur in this area. Yüksel and Gaffaroğlu (2008b) gave a karyotype of  $2n = 50$  for fish from Karakaya Dam Lake, Turkey. Arai (2011) gave  $2n = 48-50$ .

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(33), 8(336) or 9(13), anal fin branched rays 9(29), 10(41), 11(200), 12(104) or 13(8), pectoral fin branched rays 13(2), 14(35), 15(134), 16(149), 17(56) or 18(6), pelvic fin branched rays 7(61), 8(307) or 9(18), lateral line scales 58(1), 59(-), 60(2), 61(1), 62(5), 63(3), 64(9), 65(8), 66(9), 67(13), 68(11), 69(10), 70(21), 71(19), 72(32), 73(26), 74(30), 75(24), 76(25), 77(33), 78(31), 79(24), 80(17), 81(13), 82(5), 83(2), 84(2), 85(2), 86(2), 87(1), 88(1) or 89(1), total gill rakers 11(7), 12(73), 13(130), 14(123), 15(46), 16(11), 17(1) or 18(1), pharyngeal teeth 2,5-4,2(9), 2,5-5,2(5), 2,5-5,3(1), 2,5-4,1(2), 2,4-4,2(1) or 1,5-4,2(2), and total vertebrae 39(1), 40(10), 41(78), 42(163), 43(113), 44(12) or 45(1).

**Sexual dimorphism.** A male specimen (CMNFI 1993-0129, 140.3 mm standard length 14 May 1993) had small tubercles scattered over the top and sides of the head, up to seven small tubercles lining scale edges on the upper flank and back before the dorsal fin and a single row of tubercles on each pectoral fin ray. Tubercles may even be found on the middle of the upper lip (131.3 mm standard length, 6 July 1977, CMNFI 1979-0282).

In fish identified as *A. zagrosensis* from the type series, small tubercles are present on the mature male, on the sides and top of the head, on the dentaries, as fine ones lining the scale margins, most evident on caudal peduncle scales, and on the upper pectoral fin rays. Significant differences between males and females were found in interorbital width (wider in males), caudal peduncle depth (deeper in males), and dorsal, anal, pectoral and pelvic fin lengths (longer in males).

**Colour.** Overall colour is silvery. The back is a bluish- or reddish-brown, bluish-black or blackish. A dark, lead-coloured stripe runs along and above the mid-flank and has a width about the same, or less than, the eye diameter. The stripe may only be evident posteriorly. Scales above the lateral line have fine melanophores at their base. Lateral line scales can have pigment spots

above and below the tube near the base of each scale, but this is not as marked as in some *Alburnoides* spp. The dorsal, anal and caudal fins are margined with black, the latter the darkest. There may be a black spot at the caudal fin base and the first pectoral fin ray may be black dorsally. All fins can be clear or coloured. The pectoral, pelvic and anal fins are yellowish at their base. All fins may be reddish, with caudal fin the darkest. The peritoneum is brown but may be thickly speckled with black-brown spots and thus appear almost black.

In the the type series of *A. zagrosensis* the body is darker dorsally and the upper flank is much darker than the lower flank with an abrupt transition in pigmentation between the two halves along the midline. A live fish showed a more gradual transition from an olive-green back, a lighter upper flank to a white belly. The lower flank may be brownish. The anterior flank has a less defined transition with some thin bars extending downward for a short distance. The mid-flank dark pigmentation forms a weak stripe, well-defined by its ventral edge above the anal fin level but the dorsal edge is less well-defined and merges with the upper flank pigmentation. The end of the caudal peduncle has a broad, fan-shaped pigmentation. A broad stripe is present predorsally and postdorsally. The predorsal stripe may be separated into two thin stripes, one on each side of the mid-line with a very thin stripe between them. After 32 years in preservative, this pigment pattern is less evident and the division between the epaxial and hypaxial muscle masses is marked by an apparent thin line of dark pigment as the most prominent feature. Fins are mostly immaculate with only slight traces of melanophores although the caudal fin can be quite dark. The peritoneum is silvery with numerous scattered melanophores grading to fish with continuous melanophores and dark brown overall.

**Size.** Reaches about 22.0 cm (Ergene, 1993). Fish in the Gamasiab attained 15.5 cm standard length (females) and 14.5 cm (males) (Mousavi-Sabet *et al.*, 2013) or 15.7 cm (Mousavi-Sabet *et al.*, 2014).

**Distribution.** Earlier records appeared under *A. mossulensis*. This species is found in the Tigris-Euphrates basin and adjacent basins. In Iran it is recorded from the Hormuz, Kor River, Lake Maharlu, Persis and Tigris River basins. In the Hormuz basin in the Korbal, Koshake, Kul, Rudbal (= Rudbar) and Shur rivers; in the Kor River basin in the Ghadamgah Spring-Stream system, Gomban Spring, Kaftar and Kamfirooz lakes, the Kor, Marghan, Shadkam, Shesh Pir, and Sivand (= Pulvar) rivers, and Dorudzan Dam; in the Lake Maharlu basin in springs and qanats such as Ab-e Paravan and Barm-e Dalak; in the Persis basin in the Dalaki, Dasht-e Palang, Fahlian, Helleh, Jereh, Kohmarreh Sorkhi, Maran, Mond, Qara Aqaj, Qasook, Shapur, Shiv, Shur, Tangab and Zohreh rivers, in the Chehel Cheshmeh and Dadina springs and in Parishan Lake; and in the Tigris River basin in the Abdanan, Ab-e Barik, Abloum, Abshalamzar, Agh Bolagh, A`la, Aligodarz, Alvand, Armand, Arvand, Avar, Badavar, Bahmanshir, Banestan, Bazoft, Beheshtabad, Beshar, Bibi-Sayeddan, Bonestan, Chameshk, Chardavol, Darband, Darreh Asir, Davoud Arab, Dehno (= Deh Now), Dez, Dinvar, Dinorab, Divandarreh, Doab, Do Rud, Do Polan, Eivan Abbasi, Gamasiab, Gangir, Gaveh, Geravand, Godarkhosh, Haramabad, Haran, Harud, Houzian, Ivan-e Abbasi, Jagiran, Jarrahi, Kahman, Kahnak, Kalwi, Kangavar Kohneh, Kangir, Kanjan Cham, Karkheh, Karun, Kashkan, Kelas, Kerend, Khersan, Kheyrabad, Khondab, Khorram (Khorramabad), Komasi, Kupal, Lyleh, Little Zab, Malayer, Marbor, Marun, Marvil, Meymeh, Nahr-e Shavor, Pir Salman, Qareh Su, Qeshlaq, Rabat, Ravand, Razavar (= Raz Avar), Sarab Gamasiab, Semeh, Sepidbarg (= Sefid Barg), Sepidan, Shilaghhab, Simareh, Shoishah, Shoshir, Shur, Sirvan, Sulgan, Tangab, Yuzidar, Zard and Zimakan rivers, the Gandoman and Choghakhor (= Chagha Khur) lagoons or wetlands, Gamasiab, Haramabad, Pir Salman and Shadegan wetlands, Azad, Dez, Gamasiab, Kamal Saleh and Qeshlaq dams,

sarabs at Kermanshah, and the Cheshmeh Ali, Hamzeh Ali and Mirsolayman springs (M. Hafezieh, pers. comm.; Berg, 1949; Bianco and Banarescu, 1982; Gh. Izadpanahi, pers. comm., 1995; González-Solís *et al.*, 1997; Abdoli, 2000; Fadaei Fard *et al.*, 2001; Barzegar and Jalali, 2002; Barzegar and Jalali Jafari, 2006; Eskandari *et al.*, 2007; Abbasi *et al.*, 2009; Teimori *et al.*, 2010; Biokani *et al.*, 2011; Parsa Khanghah *et al.*, 2011; Bahrami Kamangar *et al.*, 2012a; Bozorgnia *et al.*, 2012; Zareian *et al.*, 2012; Biukani *et al.*, 2013; Hasankhani *et al.*, 2013; Khataminejad *et al.*, 2013; Pirani *et al.*, 2013; Shafee *et al.*, 2013; Yousefian *et al.*, 2013; Dadashi *et al.*, 2014; Golchin Manshadi *et al.*, 2014; Hasanpour *et al.*, 2014; Pirali-khierabadi *et al.*, 2014, 2015; Reyahi-Khoram *et al.*, 2014; Tabiee *et al.*, 2014; Abdolhahi, 2015; Hasanpoor *et al.*, 2015; Zamaniannejad *et al.*, 2015; Abedi *et al.*, 2016; Alizadeh Marzenaki *et al.*, 2016; Hedayati *et al.*, 2016b; Keivany *et al.*, 2016, 2016, 2017, 2018; Sayyadzadeh *et al.*, 2016; Taghiyan *et al.*, 2016; Afraei Bandpei *et al.*, 2017; Azizi *et al.*, 2017; Keivany and Zamani-Faradonbe, 2017a, 2017b; Mirzergar and Kulivand, 2017; Mohammadian-Kalat *et al.*, 2017; Pirali Khierabadi *et al.*, 2017; Zamanpoore and Yaripour, 2017; Darvishi *et al.*, 2018; Fazli *et al.*, 2018; Maleki *et al.*, 2018; Rezamand *et al.*, 2018; Fatemi *et al.*, 2019; Hasankhani *et al.*, 2019; Khamees *et al.*, 2019; Pishkahpour *et al.*, 2019b; Nasri, 2021).

Records from the Dinvar and Razavar (= Raz Avar) rivers near Bisotun (Reyahi-Khoram *et al.*, 2014) as *Chalcalburnus chalcoides* are presumably misidentifications for *A. sellal*.

Also recorded, questionably, from the Esfahan basin (Abdoli, 2000).

**Zoogeography.** Its former position in the genus *Chalcalburnus* indicates a relationship with fishes occurring in the Black-Caspian seas basin.

**Habitat.** This species is found in rivers, streams, lakes, dams, marshes, springs, ditches and qanats. Abbasi *et al.* (2009) in their study of wetlands in Hamadan Province found this species was dominant out of 23 species at 28%. Pirani *et al.* (2013) found it to be the second most abundant species at 29.4% after *Cyprinion macrostomus* at 31.3% in the Godarkhosh River, Ilam. Darvishi *et al.* (2018) reported fish identified as *A. mossulensis* were the most abundant species in the Khorramabad River. Zarkami *et al.* (2018) sampled fish identified as *Alburnoides mossulensis* (presumably *Alburnus sellal*) from eight sites from the source to the mouth of the Gamasiab River and recorded presence/absence and a set of river characteristics to analyse occurrence. Using an optimisation method, almost one-third of total recorded variables in the sampling sites including electric conductivity, bicarbonate, river width, river depth, water temperature, pH, sulphate and orthophosphate appeared to influence occurrence while based on the outcomes of a binary logistic regression model, electrical conductivity and bicarbonate were the most important ones. Hasankhani *et al.* (2019) found this species was the one most frequently caught in their survey of the Sirvan River. Pishkahpour *et al.* (2019b) investigated the effects of ecological conditions and physical and hydrological parameters and calculated the habitat suitability index for each station sampled. The average arithmetic model was the best method for calculating the index which could be used to manage the ecosystem and protect the habitat of this species.

Coad (2009) recorded habitat data for the synonym *A. zagrosensis* from the Zagros Mountains at 2,360-2,380 m on 9 June 1977 as water temperature 22-25°C, pH 6.2, conductivity 0.4-0.45 mS, stream width 1-4 m, water depth 1 m, water clear or muddy, bottom stones or mud, current slow to fast, aquatic vegetation mostly *Myriophyllum*, and the shore grassy. Some of this material was caught while leaping up a raceway. Other species caught were the cyprinoids *Capoeta coadi*, *Chondrostoma regium* and the aphanIID *Esmaeilius vladkovi*.

Hedayati *et al.* (2016b) reported the Cheshmeh Ali and Hamzeh Ali sites for the synonym

*A. zagrosensis* were mineral springs with strong current and little aquatic vegetation while the Chagha Khur Wetland had a gentle current and dense aquatic vegetation.

Al-Habbib (1981) demonstrated experimentally for specimens taken from the Aloka River, north of Mosul, Iraq that this species could survive temperatures in the range of about 1.25-36.2°C when acclimated (fish were identified incorrectly as *Chalcalburnus chalcoides*). Epler *et al.* (2001) found it to be the second most dominant species of fish (identified as *A. sheitan*) in lakes Habbaniyah, Tharthar and Razzazah in Iraq, comprising 10% of all fish collected. This was one of the most abundant species in the recovering marshes of southern Iraq in 2005-2006 (Hussain *et al.*, 2006).



Habitat of *Alburnus sellal*, CMNFI 1979-0020, Fars, Mond River outside Kavar, 26 January 1976, Brian W. Coad.



Habitat of *Alburnus sellal*, CMNFI 2008-0130,  
Khuzestan, Kupal Stream, 20 September 1995, Brian W. Coad.



Habitat of *Alburnus sellal*, Fars, Shur River near Jahrom, Persis basin  
(Jahrom Shour River (1), CC BY-SA 4.0, Rizorius).

**Age and growth.** Esmaeili and Ebrahimi (2006) gave a significant length-weight relationship based on 76 Iranian fish measuring 3.15-8.14 cm standard length. the  $b$  value being 2.903. Hasankhani *et al.* (2013) gave a  $b$  value of 3.086 (in abstract, 3.111 in table) for 75 fish, 5.26-16.63 cm total length, from the Sirvan River. Mousavi-Sabet *et al.* (2013) found a  $b$  value of 3.172 for 325 fish, 7.0-15.5 cm standard length, in the Gamasiab River, indicating positive allometric growth, with condition factor (K) values significantly high in April, May and June. Mousavi-Sabet *et al.* (2014) gave a  $b$  value of 3.279 for 30 fish, 10.09-15.69 cm total length, from the Gamasiab River in a separate study. Esmaeili *et al.* (2014) gave a  $b$  value for 475 fish from the Persian Gulf basin, 2.03-10.9 cm total length, as 3.04 and from the Kor River basin for 68 fish, 5.78-22.4 cm total length, as 3.0 (total 3.095). Nowferesti *et al.* (2014) found a  $b$  value of 3.14 for 102 fish, 1.9-14.8 cm total length, from the Sefid Barg and Dinvar rivers. Hedayati *et al.* (2016a) gave a  $b$  value of 3.135 for 120 fish, 3.1-11.59 cm total length, from the Gamasiab Reservoir (2.9996 in the summary where the species is stated as *A. zagrosensis*). Keivany *et al.* (2016) gave a  $b$  value for 544 fish, 2.9-16.8 cm total length, from the Bibi-Sayyedeh River of 3.0729. Radkhah (2016) found 40 fish, 19.2-74.1 mm total length, in the Hamzeh-Ali Region of Chahar Mahall and Bakhtiari Province had a mean value of  $b$  of 3.09 indicating positive allometric growth. Mean condition factor was 0.71. Keivany and Zamani-Faradonbe (2017a) gave a  $b$  value of 3.15 for 26 fish, 3.0-10.1 cm total length, from the Zohreh River. Keivany and Zamani-Faradonbe (2017b) examined 239 fish, 24.2-112.5 mm total length, from the Jarrahi River and found a  $b$  value of 3.42. Paighambari *et al.* (2020) gave a  $b$  value of 3.13 for 20 fish, 8.6-15.1 cm total length, identified as *A. mossulensis* from the Dorudzan Dam, Fars. Valikhani *et al.* (2020) combined fish, identified as *A. mossulensis*, from the Shadegan Wetland and the Dez and Karkheh rivers and reported a  $b$  value of 3.01 (isometric growth) and a condition factor of 7.15 (*sic*) for 62 fish, 6.3-13.8 cm total length. Zare-Shahraki *et al.* (2020) measured 1,435 fish,

1.2-16.8 cm total length, from the Karun River system and recorded a  $b$  value of 2.95.

Keivany *et al.* (2017) found age groups  $0^+$  to  $5^+$  years in fish from the Bibi-Sayyedani River in the Tigris River basin, the male:female sex ratio was 1:2.2, males outnumbered females in younger age classes and the reverse was true for older classes, males matured at age 1 year (4.6-9.1 cm total length) and females at age 2 (5.3-9.9 cm), the mean condition factor was not significantly different between sexes among all fish during different months, and length-weight relationships were  $W = 0.0169L^{3.0355}$  for males (isometric growth),  $W = 0.0061L^{3.1751}$  for females (positive allometric growth) and  $W = 0.0066L^{3.139}$  for males, females and immature fish (positive allometric growth). Mousavi-Sabet *et al.* (2017) examining fish from the Gamasiab River found age groups  $1^+$  to  $5^+$  years, with age groups  $2^+$  (27.4%),  $3^+$  (35.6%) and  $4^+$  (24.6%) dominant. Fazli *et al.* (2019) studied 522 fish (as *A. mossulensis*) from the Komasi River and Azad Dam in Kordestan, 466 fish being from the dam, and found the fork length range was 7.0 to 16.4 cm (average 11.4 cm), total length range was 7.5-17.5 cm (average 12.75 cm) and the weight range was 4.3 to 48.1 g (average 18.2 g). Age range was 1-4 years with age 2 fish predominant at 56.2%. The length-weight relationship was  $W = 0.0003FL^{2.7434}$  indicating a negative allometric growth. The male:female sex ratio was 1:0.49 for 134 adults in the dam, which differed significantly from the expected 1:1 ratio. Males predominated in winter and spring. The von Bertalanffy growth parameters were estimated as  $L_\infty = 170.3$  mm,  $K = 0.46/\text{year}$ ,  $t_0 = -0.59$  year or  $L_t = 170.3(1 - e^{-0.46(t - (-0.59))})$ . The instantaneous coefficient of natural mortality was estimated at 0.85/yr. The growth performance index ( $\Phi'$ ) was 2.12. The instantaneous coefficient of natural mortality was 0.85/year. The average condition factor was 1.23 in the river and 1.28 in the dam and statistically significant differences were found in condition factors by seasons, being highest in spring. The average of relative condition factors ( $K_n$ ) was 1.06. The  $K_n$  values were 0.97 and 1.07 in the Komasi River and Azad Dam, respectively. These results suggested the wellbeing of the fish was good.

Mousavi-Sabet *et al.* (2014) gave a  $b$  value of 3.102 for 15 fish identified as *A. zagrosensis*, 5.33-12.97 cm total length, from the Gandoman Lagoon. Hedayati *et al.* (2016b) found condition factors for their samples identified as *A. zagrosensis* were 0.93 (Cheshmeh Ali), 0.82 (Hamze Ali) and 0.74 (Choghakhour Wetland), significantly different suggesting variation in environmental conditions with the wetland suffering from pollution. Jafari *et al.* (2016) examined 145 fish identified as *A. zagrosensis*, 3.11-11.59 cm total length, from three populations and found a  $b$  value of 3.19 for the Cheshmeh Ali River, 3.69 for the Hamzeh Ali Spring and 2.97 for the Polmari River, indicating a positive allometric growth pattern for Hamzeh Ali and isometric growth in the two other populations. The condition factor was 0.74 (Polmari), 0.82 (Hamzeh Ali) and 0.93 (Cheshmeh Ali). Rezamand *et al.* (2018) gave  $b$  values for fish from the Houzian River, Lorestan identified as *A. zagrosensis* as 3.387 for 25 females, 5.8-8.1 cm total length and 3.341 for 56 males, 4.5-8.4 cm total length.

Jawad (2004) used eye lens diameter for ageing the young (up to age 3) of this species from the marshes north of Basrah, Iraq. Mohamed *et al.* (2015) examined 2,307 fish, 3.7-18.4 cm total length, from the Chybaish (= Chabaish) region of the lower Euphrates River in Iraq where it constituted 48.3% of the catch. Fish 7.0-12.0 cm dominated the catch, length-weight relationships were  $W = 0.003L^{3.087}$  for immature fish,  $W = 0.004L^{3.027}$  for males and  $W = 0.002L^{3.195}$  for females, the mean relative condition factor was 1.05 for immature fish, 0.99 for males and 1.06 for females, maximum age was 4 years, von Bertalanffy growth equation was  $L_t = 20.4(1 - e^{-0.35(t + 0.277)})$ , the male:female sex ratio was 1:1.7, and the mean  $L_{m50}$  was 8.0 cm for both sexes.

Ergene (1993) studied the growth of this species in the Karasu River of Turkey and found 4 age groups, and mentioned 5 age groups for another Turkish study. Mean fork length was 118.2 mm, 131.0 mm, 145.2 mm and 163.3 mm respectively. Condition factors for these age groups were 0.87, 0.85, 0.84 and 0.86. Türkmen and Akyurt (2000), also working on this species in the Karasu River, examined 375 fish with 8.5-18.5 cm fork length, and found age groups 1 to 6 with age group 3 the most abundant. The mean condition factor for males and females was 1.023 and 1.047 respectively. Age-length, age-weight (von Bertalanffy equations) and length-weight relationships were also calculated as  $l_t = 20.41[1 - e^{-0.2485(t+1.47)}]$ ,  $l_t = 21.59[1 - e^{-0.1978(t+2.13)}]$ ,  $W = 80.77(1 - e^{-0.2485(t+1.47)})^{2.828}$ ,  $W = 103.63(1 - e^{-0.1978(t+2.13)})^{3.082}$ ,  $\text{Log}W = -1.796 + 2.828 \text{Log}FL$  ( $r = 0.943$ ) and  $\text{Log}W = -2.097 + 3.082 \text{Log}FL$  ( $r = 0.946$ ) respectively. Length and age at first maturity were 1.26 years and 9.24 cm for males and 1.81 years and 9.65 cm for females in the Karasu River; age group 7 was the oldest recorded (Yıldırım *et al.*, 2007). Alkan Uçkun and Gökçe (2015a) found that 626 fish, 12.3-20.4 cm total length, from the Karakaya Dam on the upper Euphrates basin of Turkey attained 4<sup>+</sup> years, length-weight relationship was  $W = 0.206FL^{2.065}$  for females and  $W = 0.119FL^{2.138}$  for males, growth in length equations were  $L_t = 19.6[1 - e^{-0.14(t+1.39)}]$  for females and  $L_t = 20.1[1 - e^{-0.14(t+1.04)}]$  for males.

**Food.** Fish from the Azad Dam, Sanandaj (numbering 73 or 75 in the abstract and text) were examined for stomach contents and the zooplankter Bosminidae dominated at 50.2% with *Bosmina longirostris* dominant by numerical percentage (Afraei Bandpei *et al.*, 2017). The next major food group was Daphniidae (36.3%), followed by Sididae (11.3% in abstract, 11.2% in text), Cyclopidae (1.5%), Acartidae (0.7%), Nematoda (0.1%) and Testudinelidae (0.1%). Fish fed on a wider variety of foods in spring and the lowest feeding activity was in summer. Spring feeding increase was associated with the spawning season and energy preservation for gonad development. Diet also varied with age groups.

Younis *et al.* (2001b) found Shatt al Arab, Iraq fish feeding on phytoplankton (algae and diatoms) at 44%, followed by organic detritus at 36.7% (33% in a table), and arthropods at 3.1%. It had a dietary overlap of 89% with *Barbus (= Carasobarbus) luteus* in May, the highest in the study. In a study of the recovering Hammar Marsh, Iraq diet was 67.95% insects and 14.34% algae with diatoms, plants, crustaceans and fish at less than 10% each, in the Hawr al Hawizeh 66.2% insects and 19.2% algae, with amounts of diatoms and crustaceans being less than 10% each, and in the Al Kaba'ish (= Chabaish) Marsh 73.7% insects and 13.1% algae with diatoms, plants and crustaceans at less than 10% each (Hussain *et al.*, 2006). Mohamed *et al.* (2016) found fish from the southern Euphrates River in Iraq fed on insects (41.2%), algae (28.74%), diatoms (15.94%), aquatic plants (12.36%), fish (3.74%) and snails (0.3%) according to the index of relative importance. Feeding activity ranged from 60.5% in March to 87.7% in October and feeding intensity varied from 6.08 point/fish to 8.7 point/fish in July.

**Reproduction.** Berg (1949) reported a female 15.5 cm long with mature eggs (ZISP 24014, 9 July 1914, Bani (probably Baneh) River basin, a tributary of the Little Zab River, at Germab, southwest of Sardasht, West Azarbayjan). Keivany *et al.* (2017) described reproduction in 543 fish from the Bibi-Sayyedana River. The male:female sex ratio was 1:2.2 with females outnumbering males in all age classes, age and total length at first maturity were 1 year and 5.3 cm for females and 2 years and 4.4 cm for males, minimum, maximum and average absolute fecundity were 2,064, 10,316 and 5,505 eggs, relative fecundity was 203 eggs/g body weight, egg diameters reached 2.0 mm in June with highest mean value in May, gonadosomatic indices and gonad analyses suggested spawning from March to June with a peak in April, and this fish was a group-synchronous spawner with the capacity for multiple spawnings within a

reproductive season. Mousavi-Sabet *et al.* (2017) examined 325 fish from the Gamasiab River and found a significantly different female:male sex ratio of 1:1.3, all males 70.0 mm standard length and over and all females 75.0 mm and over, and those fish approximately 2 years of age, were ripe, mean egg diameter reached 0.84 mm in May when spawning peaked at 18-22°C, gonadosomatic indices showing the reproduction season beginning in March and breeding occurring from April to June, and average absolute and relative fecundities were 1,920 eggs (range 118-5,720 eggs) and 99 eggs/g body weight (range 10.8-205.3). Abbasi *et al.* (2020) collected 47 females from the Gamasiab River and found an absolute fecundity of 1,160-13,021, mean 5,571.7 eggs and a relative fecundity of 124.5-506.6, mean 263.4 eggs/g. Egg diameter was 0.2-1.7, mean 0.83 mm. Spring and summer was the spawning season.

Qarmat Ali River, Iraq fish had a fecundity of 1,926-11,779 eggs (Saud, 1997). Mohamed *et al.* (2015) found a peak gonadosomatic index in January for both sexes, spawning began in February and absolute fecundity was 1,119-5,022 eggs for Euphrates River fish in Iraq.

Yıldırım *et al.* (2007) examined this species in the Karasu River of Turkey and found a male:female sex ratio of 1:1.08, not significantly different from 1:1, a fecundity range of 3,012 to 11,427 eggs, significant correlations between fecundity and fork length, total weight, age and gonad weight, and a spawning season from June to August when water temperature attained 15°C. Alkan Uçkun and Gökçe (2015a) found that Karakaya Dam, Turkey fish spawned from May to August.

**Parasites and predators.** Molnár and Jalali (1992) described a new species of monogenean, *Dactylogyrus holciki*, from this species in the Beshar River of the Persian Gulf drainage. González-Solís *et al.* (1997) reported *Rhabdochona denudata*, *Contracaecum* sp. larvae and Proleptinae larvae (Nematoda) from this species in the drainage of Lake Maharlu and *Contracaecum* sp. larvae in the drainage of the Kor River, both in Fars. Barzegar and Jalali (2002) reported parasites in this species from Kaftar Lake as *Lernaea cyprinacea* and *Diplostomum spathaceum*. Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G.* sp. from the Beshar River of the Tigris basin in a *Chalcalburnus* sp., presumably this species. Jalali *et al.* (2005) also recorded *Gyrodactylus elegans* in the Beheshtabad River on fish identified as *A. filippii*, presumably *A. sellal* too. Barzegar *et al.* (2008) also recorded the digenean eye parasite *Diplostomum spathaceum* from this fish. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea cyprinacea* on this species. Khanghah (or Parsa Khanghah, 2010) found that *Ligula intestinalis*-affected fish in Vahdat (= Qeshlaq) Dam, Kordestan, lowering sex steroid hormone levels, reducing gonad maturation steps and causing degenerative changes in the gonads. Parsa *et al.* (2010) also found the cestode *Ligula intestinalis* caused degeneration in gonads. Parsa and Bahramian (2011) and Parsa Khanghah *et al.* (2011) found *Ligula intestinalis* in fish from Gheshlagh (= Qeshlaq) Lake (= Dam), Kordestan where it caused negative effects on condition index and gonadosomatic ratio and degenerative changes in the reproductive organs. Parsa *et al.* (2012) found 32% of fish from the Vahdat (= Qeshlaq) Dam had ligulosis (*Ligula intestinalis*) and noted also its presence in *Oncorhynchus mykiss* (rainbow trout) in this area, so interrupting the parasite life cycle is important for commercial reasons. Pirali-khierabadi *et al.* (2014) recorded the protozoan *Ichthyophthirius multifiliis* and Pirali-Khierabadi *et al.* (2015) identified the metazoans *Dactylogyrus lenkorani* and *Gyrodactylus elegans* in fish from the Bazoft River, Chahar Mahall and Bakhtiari Province. Sayyadzadeh *et al.* (2016) found the anchor worm *Lernaea cyprinacea* in fish from the Kor River basin, presumably from the introduced species *Carassius auratus* and/or *Cyprinus carpio*). Golchin Manshadi *et al.* (2017) recorded *Allocreadium* sp.,

*Dactylogyrus holciki*, *Dactylogyrus* sp., *Gyrodactylus* sp., *Lamproglena* sp. and *Rhabdochona* sp. from fish identified as *Chalcalburnus sellal* from the Shapur River, Fars. Golchin Manshadi *et al.* (2018) reported *Allocreadium* sp., *Bothriocephalus* sp., *Cucullanus* sp. and *Rhabdochona* sp. from fish identified as *A. mossulensis* from the Fahlian River, Fars. Maleki *et al.* (2018) recorded metacercariae of the trematode *Clinostomum complanatum* from fish in the Qeshlaq River basin.

**Economic importance.** This species has been used in the preparation of fish meal in Iraq. Yousefian *et al.* (2013) noted that it is used as food locally in the Gamasiab River basin of Iran as did Keivany *et al.* (2017) in the Tigris River basin in Semirom. It has been caught on worm bait in the Dalaki River by A. Shiralipour (November 1976, CMNFI 1979-0125).

**Experimental studies.** Ansari and Raissy (2011) found fish, identified as *A. alburnus* and possibly *A. sellal*, from the Beheshtabad River had mean concentrations of 211.6, 183.3 and 68.5 µg/kg for copper, iron and zinc, attributable to fertilisers from agriculture, but levels were safe for human consumption. Banaee *et al.* (2014) found fenprothrin, a pyrethroid insecticide, had the potential to disrupt biochemical parameters and to induce oxidative stress in this species from the Marun River. This chemical was highly toxic to the fish. Nematdoost Hagi and Banaee (2016) found adverse effects on liver biochemical parameters caused by the treated effluent from Pars Paper Industries in Khuzestan.

**Conservation.** An abundant species where studied, it appears to be under no threat in Iran. Endangered in Turkey as *A. mossulensis* and Vulnerable as *A. sellal* (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019). The type locality of the synonym *A. zagrosensis* is dried out although populations exist nearby (Eagderi *et al.*, 2019).

**Sources.** Type material:- *Alburnus capito* (NMW 55505), *Alburnus caudimacula* (NMW 55506), *Alburnus hebes* ((NMW 17558-17560 or NMW 55523), *Alburnus iblis* (NMW 55524), *Alburnus megacephalus* (NMW 55627), *Alburnus microlepis* (NMW 55655), *Alburnus mossulensis* (NMW 55656, 55717, 55718, 77723, SMF 402), *Alburnus schejtan* (NMW 22281, NMW 55663, 55719, 55721), *Alburnus sellal* (NMW 55664, 55665, 55666, 55667), *Leuciscus maxillaris* (MNHN A.3954), and *Alburnus zagrosensis* (CMNFI 1979-0248, CMNFI 1979-0248A, CMNFI 1979-0246).

Iranian material:- CMNFI 1970-0541, 10, 26.1-35.1 mm standard length, Fars, small brook near Shiraz on road to Kazerun (no other locality data); CMNFI 1977-0510A, 44, 35.7-154.6 mm standard length, Fars, qanat stream at Naqsh-e Rostam (29°59'30"N, 52°54'E); CMNFI 1979-0020, 50, 20.2-85.2 mm standard length, Fars, Mond River outside Kavar (29°11'N, 52°41'E); CMNFI 1979-0021, 42, 10.8-32.4, mm standard length, Iran, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0022, 81, 11.4-106.6 mm standard length, Iran, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0024, 1,435, 10.3-109.7 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0025, 87, 19.1-138.2 mm standard length, Fars, Kor River at Marv Dasht (29°51'N, 52°46'30"E); CMNFI 1979-0026, 13, 21.2-45.6, mm standard length, Fars, Shapur River at Shapur (29°47'N, 51°35'E); CMNFI 1979-0027, 24, 59.8-105.0 mm standard length, Fars, Chehel Cheshmeh (ca. 29°43'N, ca. 52°04'E); CMNFI 1979-0028, 55, 19.1-122.6 mm standard length, Fars, Zarqan, Kor River drainage (no other locality data); CMNFI 1979-0032, 1, 91.7 mm standard length, Fars, Bid-e Zard (no other locality data); CMNFI 1979-0036, 24, 82.3-115.1 mm standard length, Fars, Shapur River at Shapur (29°47'N, 51°35'E); CMNFI 1979-0047, 7, 41.4-78.2 mm standard length, Fars, spring source of Ab-e Paravan marshes (ca. 29°34'N, ca. 52°42'E); CMNFI 1979-0053, 1, 56.8 mm standard length, Fars, Shur River tributary (ca. 28-29°58-03'N, ca. 52°34-35'E); CMNFI 1979-0054, 17, 39.8-95.6 mm standard length, Fars, Shur River tributary (28-

29°58-03'N, 52°34-35'E); CMNFI 1979-0057, 16, 33.0-52.5 mm standard length, Fars, stream 4 km from Shapur (29°49'N, 51°34'E); CMNFI 1979-0059, 334, 24.8-68.5 mm standard length, Fars, Pulvar River 8 km south of Sivand (30°01'30"N, 52°57'E); CMNFI 1979-0061, 51, 32.9-131.1 mm standard length, Fars, stream tributary to Pulvar River (30°04'N, 53°01'E); CMNFI 1979-0067, 55, 11.1-107.9 mm standard length, Fars, qanat at Zarqan (ca. 29°46'N, ca. 52°43'E); CMNFI 1979-0069, 2, 40.8-46.5 mm standard length, Fars, qanat at Naqsh-e Rostam (29°59'30"N, 52°54'E); CMNFI 1979-0070, 44, 35.0-98.5 mm standard length, Fars, Pulvar River near Naqsh-e Rostam (29°59'N, 52°54'E); CMNFI 1979-0071, 12, 65.3-104.3 mm standard length, Fars, qanat 23 km from Pol-e Khan (ca. 30°00'N, ca. 52°38'E); CMNFI 1979-0073, 27, 50.0-93.3 mm standard length, Fars, Mond River beyond Chehel Chashhmeh (ca. 29°42'30"N, ca. 52°01'30"E); CMNFI 1979-0074, 48, 23.8-94.0 mm standard length, Fars, Mond River backwater (29°41'N, 52°06'E); CMNFI 1979-0075, 234, 27.8-72.1 mm standard length, Fars, Mond River at Pol-e Kavar (29°11'N, 52°41'E); CMNFI 1979-0092, 1, 74.2 mm standard length, Fars, Qarah Aqaj River (ca. 29°11'N, ca. 52°41'E); CMNFI 1979-0109, 2, 69.9-73.2 mm standard length, Fars, Mond River at Shahr-e Khafr (28°56'N, 53°14'E); CMNFI 1979-0114, 136, 25.9-71.4 mm standard length, Fars, Mond River at road bridge (29°41'N, 52°06'E); CMNFI 1979-0116, 27, 25.3-57.7 mm standard length, Fars, Kor River near Marv Dasht (29°51'N, 52°46'30"E); CMNFI 1979-0117, 16, 33.4-130.0 mm standard length, Fars, Pulvar River at Naqsh-e Rostam (29°59'N, 52°54'E); CMNFI 1979-0125, 1, 102.6 mm standard length, Bushehr, Dalaki River near Dalaki (ca. 29°28'N, ca. 51°21'E); CMNFI 1979-0128, 9, 43.2-102.5 mm standard length, Fars, Shur River between Atashkadeh and Firuzabad (28°51'N, 52°31'E); CMNFI 1979-0135, 1, 42.7 mm standard length, Fars, tributary to Mond River (28°08'N, 53°10'E); CMNFI 1979-0154B, 1, 46.9 mm standard length, Fars, stream channels at Koorsiah (28°45'30"N, 54°24'E); CMNFI 1979-0155, 2, 56.2-64.7 mm standard length, Fars, spring at Gavanoo (28°47'N, 54°22'E); CMNFI 1979-0156, 11, 49.0-74.4 mm standard length, Fars, qanat in Rashidabad (28°47'N, 54°18'E); CMNFI 1979-0157, 53, 31.8-86.6 mm standard length, Fars, qanat stream at Hadiabad (28°52'N, 54°13'E); CMNFI 1979-0158, 13, 73.5-108.9 mm standard length, Fars, qanat jube over Qasook River (28°54'N, 53°53'30"E); CMNFI 1979-0159, 73, 24.5-77.5 mm standard length, Fars, qanat at Qaziabad (ca. 28°54'N, ca. 53°43'E); CMNFI 1979-0160, 22, 32.4-106.0 mm standard length, Fars, spring at Arteshkhadeh Pomp (29°09'N, 53°37'E); CMNFI 1979-0163, 12, 43.3-97.4 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0164, 12, 50.7-115.2 mm standard length, Fars, neighbourhood of Shiraz (no other locality data); CMNFI 1979-0195, 1, 71.8 mm standard length, Fars, jube on road to Fasa (ca. 28°54'N, ca. 53°53'30"E); CMNFI 1979-0200, 7, 27.6-37.4 mm standard length, Fars, Mond River tributary 13 km from Jahrom (28°36'N, 53°36'30"E); CMNFI 1979-0241, 6, 47.7-92.0 mm standard length, Fars, Shapur River at Shapur (29°47'N, 51°35'E); CMNFI 1979-0271, 51, 40.0-50.0 mm standard length, Lorestan, river in Kashkan River drainage (33°39'N, 48°32'30"E); CMNFI 1979-0272, 11, 40.5-130.0 mm standard length, Lorestan, river at Nokhor (ca. 33°40-47'N, ca. 48°28-45'E); CMNFI 1979-0273, 1, 54.7 mm standard length, Lorestan, Kashkan River drainage 5 km from Khorramabad (33°26'N, 48°19'E); CMNFI 1979-0276, 22, 43.5-65.3 mm standard length, Lorestan, Chameshk River (ca. 33°19'N, ca. 47°53'30"E); CMNFI 1979-0278, 4, 75.5-88.2 mm standard length, Lorestan, Kashkan River drainage (33°34'N, 48°01'E); CMNFI 1979-0279, 3, 68.7-91.4 mm standard length, Lorestan, Khorramabad River (33°37'N, 48°18'E); CMNFI 1979-0282, 19, 40.2-131.3 mm standard length, Lorestan, river at Nurabad (34°05'N, 47°58'E); CMNFI 1979-0283, 6, 46.1-50.4 mm standard length, Kermanshah, river in Qareh Su drainage (34°21'N, 47°07'E); CMNFI 1979-0284, 30, 73.1-98.3 mm standard

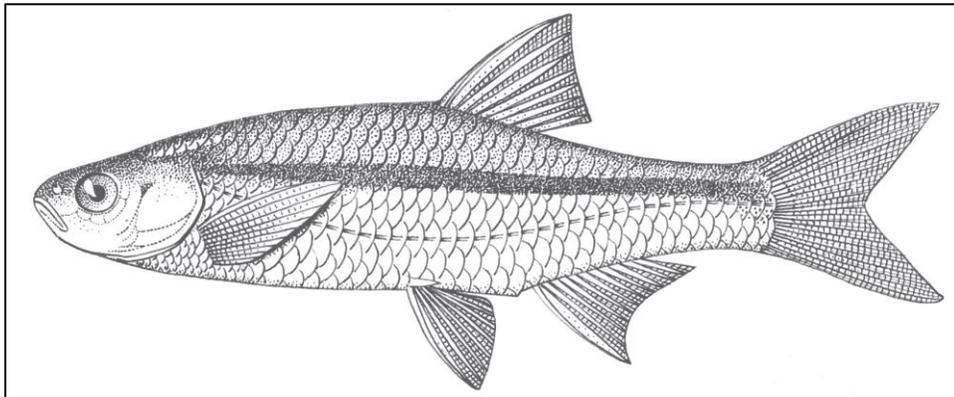
length, Kermanshah, Ab-e Barik (34°16'N, 46°48'30"E); CMNFI 1979-0285, 4, 124.7-136.8 mm standard length, Kermanshah, Qareh Su drainage (34°26'N, 46°37'E); CMNFI 1979-0287, 1, 97.5 mm standard length, Kermanshah, Cheshmeh Javari 2 km from Ravansar (ca. 34°42'N, ca. 46°40'E); CMNFI 1979-0288, 111, 24.8-73.3 mm standard length, Ilam and Poshtkuh, Gangir River at Juy Zar (33°50'N, 46°18'E); CMNFI 1979-0289, 2, 125.3-142.1 mm standard length, Kermanshah, river in Diyala River drainage (34°28'N, 45°52'E); CMNFI 1979-0290, 4, 146.9-171.4 mm standard length, Kermanshah, river in Qasr-e Shirin (34°31'N, 45°35'E); CMNFI 1979-0291, 5, 18.5-32.5 mm standard length, Kermanshah, river in Diyala River drainage (34°24'N, 45°37'E); CMNFI 1979-0305, 17, 27.5-35.6 mm standard length, Fars, Pulvar River at Pasargad (30°12'N, 53°12'E); CMNFI 1979-0342, 1, 49.9 mm standard length, Fars, Kor River at Band-e Amir (29°46'N, 52°51'E); CMNFI 1979-0348, 4, 68.0-78.8 mm standard length, Fars, stream at Somduldul (ca. 29°28'N, ca. 52°32'E); CMNFI 1979-0352, 2, 88.5-93.9 mm standard length, Khuzestan, marsh in Jarrahi River drainage (30°33'30"N, 48°48'E); CMNFI 1979-0388, 1, 32.3 mm standard length, Khuzestan, Zard River 21 km north of Ramhormoz (31°19'N, 49°44'E); CMNFI 1979-0392, 1, 44.5 mm standard length, Khuzestan, Zard River 25 km north of Ramhormoz (ca. 31°32'N, ca. 49°48'E); CMNFI 1979-0396, 2, 30.7-40.0 mm standard length, Kheyrahad River 20 km from Behbahan (30°32'N, 50°23'30"E); CMNFI 1979-0399, 1, 64.4 mm standard length, Fars, Tang-e Shib River in the Zohreh River drainage (30°19'30"N, 51°15'E); CMNFI 1979-0421, 1, 102.6 mm standard length, Kohgiluyeh and Bowyer Ahmad, stream in Khersan River drainage (30°24'N, 51°47'E); CMNFI 1979-0423, 66, 31.8-78.4 mm standard length, Kohgiluyeh and Bowyer Ahmad, river in Khersan River drainage (30°31'N, 51°31'E); CMNFI 1979-0499, 3, 104.8-133.6 mm standard length, Fars, irrigation ditch 32 km from Kor River bridge (30°04'30"N, 52°36'E); CMNFI 1979-0497, 6, 26.1-38.2 mm standard length, Fars, Mond River at Band-e Bahman (29°11'N, 52°40'E); CMNFI 1979-0500, 2, 112.2-116.5 mm standard length, Fars, Pulvar River at Naqsh-e Rostam (29°59'N, 52°54'E); CMNFI 1979-0501, 6, 27.8-34.0 mm standard length, Fars, Mond River at Kavar (29°11'N, 52°41'E); CMNFI 1980-0134, 3, 111.2-126.5 mm standard length, Iran, Shiraz-Esfahan (no other locality data); CMNFI 1991-0156, 1, 67.4 mm standard length, Hamadan, Gamasiab River (34°16'N, 48°10'E); CMNFI 1993-0129, 1, 140.3 mm standard length, Kermanshah, Sarab Najibaran (34°00'-30'N, 47°00'-30'E); CMNFI 1993-0130, 1, 109.9 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data); CMNFI 2007-0063, 3, 34.4-50.0 mm standard length, Fars, Mond River tributary outside Jahrom (28°36'N, 53°37'E); CMNFI 2007-0064, 9, 36.6-82.5 mm standard length, Fars, Mond River (ca. 28°50'N, ca. 53°20'E); CMNFI 2007-0065, 3, 85.1-88.5 mm standard length, Fars, Barm-e Dalak (ca. 29°35'N, ca. 52°38'E); CMNFI 2007-0075, 26, 33.4-91.5 mm standard length, Hamadan, Malayer River 5 km south of Malayer (ca. 34°17'N, ca. 48°47'E); CMNFI 2007-0099, 7, 40.7-81.2 mm standard length, West Azarbaijan, Kalwi Chay west of Mahabad (ca. 36°35'N, ca. 45°25'E); CMNFI 2007-0100, 8, 62.5-87.3 mm standard length, West Azarbaijan, Kalwi Chay near Piranshahr (ca. 36°44'N, ca. 45°10'E); CMNFI 2007-0109, 7, 36.9-78.7 mm standard length, Kordestan, Qeshlaq River south of Sanandaj (ca. 35°16'N, ca. 47°01'E); CMNFI 2007-0110, 1, 40.7 mm standard length, Kordestan, Yuzidar River drainage (ca. 35°05'N, ca. 46°56'E); CMNFI 2007-0111, 2, 116.5-170.2 mm standard length, Kermanshah, Alvand River near Sar-e Pol-e Sahab (ca. 34°36'N, ca. 45°56'E); CMNFI 2007-0112, 1, 51.2 mm standard length, Kermanshah, Kerend River basin near Shahabad-e Gharb (ca. 34°06'N, ca. 46°30'E); CMNFI 2007-0113, 1, 117.8 mm standard length, Kermanshah, Razavar (= Raz Avar) River (ca. 34°25'N, ca. 47°01'E); CMNFI 2007-0114, 13, 95.6-142.0 mm standard length, Kermanshah, Qareh Su basin north of Kermanshah (ca. 34°28'N,

ca. 46°54'E); CMNFI 2007-0116, 3, 35.2-60.1 mm standard length, Kermanshah, Gamasiab River basin west of Sahneh (ca. 34°28'N, ca. 47°36'E); CMNFI 2007-0119, 2, 34.3-39.2 mm standard length, Kermanshah, Gamasiab River basin near Kangavar (ca. 34°31'N, ca. 48°03'E); CMNFI 2008-0102, 2, 144.0-154.2 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data); CMNFI 2008-0130, not kept, Khuzestan, stream at Kupal (31°15'N, 49°10'E); CMNFI 2008-0132, 1, 167.1 mm standard length, Khuzestan, neighbourhood of Ahvaz (no other locality data); CMNFI 2008-0161, not kept, Khuzestan, A`la River at Pol-e Tighen (31°23'30"N, 49°53'E); CMNFI 2008-0163, not kept, Khuzestan, Marun River at Chahar Asiab (30°40'28"N, 50°09'34"E); CMNFI 2008-0168, not kept, Khuzestan, Dez River at Harmaleh (31°57'08"N, 48°33'48"E); CMNFI 2008-0175, not kept, Lorestan, Kahman River at Dow Ab-e Aleshtar (33°47'N, 48°12'E); CMNFI 2008-0182, 1, 69.7 mm standard length, Chahar Mahall and Bakhtiari, Ab-e Bazoft Sofla (31°38'06"N, 50°28'30"E); CMNFI 2008-0185, 2, 57.8-70.0 mm standard length, Chahar Mahall and Bakhtiari, Sulgan River (31°30'N, 50°50'E); CMNFI 2008-0237, 1, 124.9 mm standard length, Kermanshah, Yavari Spring (34°28'N, 46°56'E); CMNFI 2008-0246, 1, 110.0 mm standard length, Fars, stream at Sepidan (29°58'19"N, 52°24'04"E); CMNFI 2008-0255, 4, 72.7-99.9 mm standard length, Fars, Kor River (30°00'N, 52°44'58"E); CMNFI 2008-0257, 3, 94.4-106.3 mm standard length, Fars, Marghan River near Sepidan (30°30'14"N, 51°53'19"E); CMNFI 2008-0261, 4, 79.7-101.3 mm standard length, Fars, Shesh Pir River near Sepidan (29°58'19"N, 52°24'04"E); CMNFI 2008-0266, 3, 52.7-85.3 mm standard length, Fars, qanat at Kherak (29°42'36"N, 52°08'54"E); CMNFI 2008-0290, 15, 54.6-150.4 mm standard length, Esfahan, Hanna Dam in Semirom (31°25'N, 51°34'E).

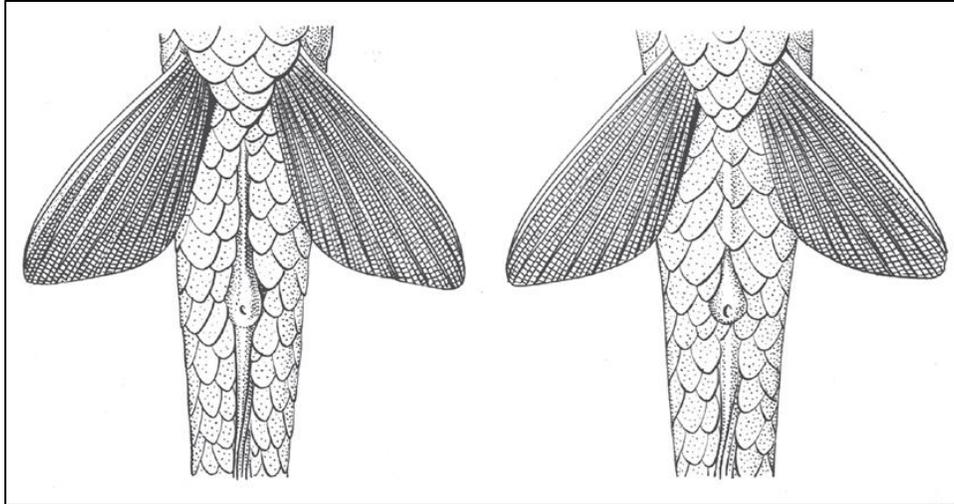
Comparative material:- BM(NH) 1981.4.13:9-11, 3, 64.3-72.8 mm standard length, Aloka River near Mosul (no other locality data); CMNFI 1980-0186, 3, 32.9-42.9 mm standard length, Iraq, Shatt al Arab (no other locality data); CMNFI 1980-0815, 2, 88.9-107.2 mm standard length, Turkey, Pisyar Suyu near Kozluk (38°07'N, 41°30'E).

*Alburnus taeniatus*

Kessler, 1874



*Alburnus taeniatus*, after Nikol'skii (1937).



*Alburnus taeniatus*, variation in keel development, after Nikol'skii (1937).



*Alburnus taeniatus*, Razavi Khorasan, Hari River near Pol-e Khatun, Hamid Reza Esmaili.

**Common names.** Morvarid mahi navar dar (= ribboned pearl fish), morvarid mahi Harirud (Hari River pearl fish).

[Polosataya bystranka or striped bystranka in Russian; striped riffle minnow, striped tailor; all these names referring to the species when it was in the genus *Alburnoides* and so now incorrect, and perhaps striped bleak should be used].

**Systematics.** *Alburnus taeniatus* was described originally from the Syr Darya. No types are known. It was placed in the genus *Alburnoides* by authors (see *Catalog of Fishes*, downloaded 23 June 2018) but molecular evidence places it in its original genus (Jouladeh-Roudbar *et al.*, 2016; Schönhuth *et al.*, 2018).

**Key characters.** The absence of a strong stitched pattern along the lateral line, lower scale count on average, a higher gill raker count, and distribution in the Hari River basin serve to identify this species.

**Morphology.** The body is moderately deep with a deep caudal peduncle. The back in front of the dorsal fin is gently convex and is straight behind the dorsal fin. The mouth is oblique and does not reach back as far as the anterior eye margin. The tip of the lower jaw may project slightly. The dorsal fin origin lies well behind the level of the pelvic fin origin. The insertion of the dorsal fin lies over the front of the level of the anal fin and the tip of the depressed dorsal fin reaches back to about the middle of the anal fin level. The dorsal fin margin is very slightly concave. The caudal fin is moderately forked with rounded to pointed tips. The anal fin margin is

concave. The pelvic and pectoral fins have rounded margins. The pelvic fin extends back to, or slightly beyond, the anal fin origin. The pectoral fin falls short of the origin of the pelvic fin.

Dorsal fin unbranched rays 2-3, dorsal fin branched rays 7-9, commonly 8, rarely 9, anal fin unbranched rays 3-4, anal fin branched rays 9-13 in literature but 10-12, commonly 11 is more accurate, pectoral fin branched rays 10-13, and pelvic fin branched rays 6-8. Lateral line scales 30-46, usually 40-41 (from literature, the range seems rather wide and may be commonly less). There is a pelvic axillary scale. The ventral keel is scaled, partly scaled or entirely scaleless. Total gill rakers number 13-23 (this wide range suggests some counts may be lower arch only). Rakers are long and dense. Pharyngeal teeth are 1,5-5,1, 2,5-5,2, 2,4-5,2 and 1,5-5,2 (Berg, 1948-1949) with presumably the middle two counts most common. Total vertebrae number 36-39.

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(1) or 9(1), anal fin branched rays 11(2), pectoral fin branched rays 10(1), 11(-) or 12 (1), pelvic fin branched rays 7(2), and total lateral line scales 41(1) or 42(1).

**Sexual dimorphism.** Unknown.

**Colour.** The flanks and side of the head are silvery to light golden, fins mostly hyaline with some pigmentation lining rays. A wide flank stripe is present above the lateral line in preserved fish. The stitched pattern along the lateral line seen in *Alburnoides* species is absent.

**Size.** Attains 11.0 cm total length.

**Distribution.** This species is found in the Amu Darya, Syr Darya, Zeravshan and Chu rivers of Central Asia, (Berg, 1948-1949; Aliyev *et al.*, 1988). Reported also from the Karakum Canal, Kopetdag Reservoir and Uzboi lakes (Shakirova and Sukhanova, 1994; Sal'nikov, 1995) in Turkmenistan on the northern border of Afghanistan and Iran and so was predicted to enter the Morghab and Tedzhen (= Hari) rivers by Coad (2014) and confirmed from the latter in Iran near Pol-e Khaton (= Pol-e Khatun) by Jouladeh-Roudbar *et al.* (2016) and in the Hari River just below the Dusti (= Doosti) Dam (Jouladeh-Roudbar *et al.*, 2020).

**Zoogeography.** The relationships of this species lie to the west where the genus is most speciose.

**Habitat.** This species prefers slow-moving or still waters.

**Age and growth.** It attained 7.6 cm by 3<sup>+</sup> years of age in ponds near Frunze, Kyrgyzstan (Berg, 1948-1949). Life span is 9<sup>+</sup> years.

**Food.** Food includes gnatworms and other aquatic insects and crustaceans.

**Reproduction.** Females at Frunze had ripe eggs at age 2<sup>+</sup> and spawning there and near Tashkent occurred in June-July. Fecundity reached 9,135 eggs up to 1.0 mm in diameter. Pavlovskaya and Zholdasova (1991) recorded the descent of prolarvae and larvae in the middle Amu Darya from 12 May through 22 May.

**Parasites and predators.** None reported from Iran.

**Economic importance.** This species has appeared in the aquarium trade.

**Experimental studies.** None.

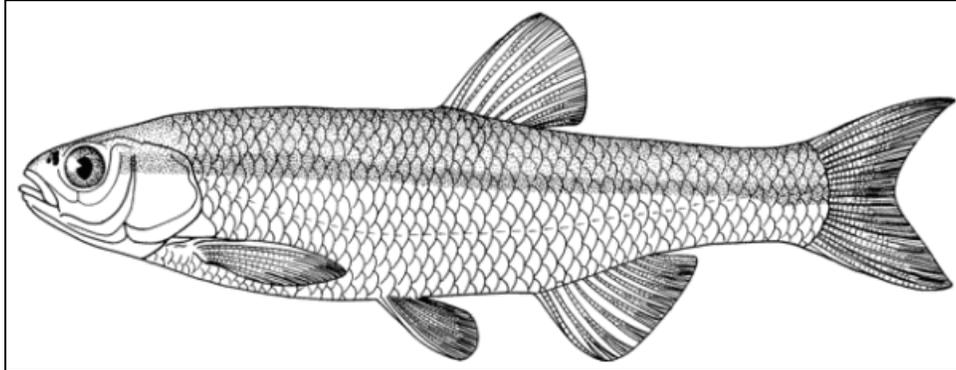
**Conservation.** Jouladeh-Roudbar *et al.* (2020) listed it as Data Deficient.

**Sources.** Jouladeh-Roudbar *et al.* (2016).

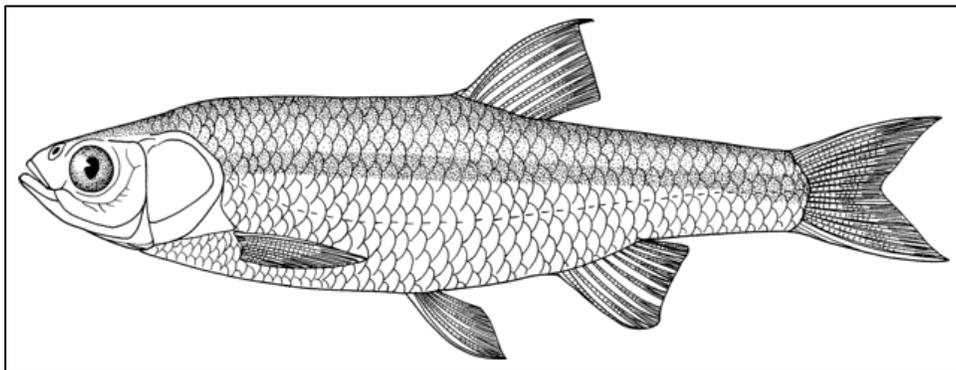
Iranian material:- None.

Comparative material:- SNM-PM 6806, 1, 59.5 mm standard length, Afghanistan, Khanabad River (no other locality data).

*Alburnus ulanus*  
(Günther, 1899)



*Alburnus ulanus*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus gaderanus*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Alburnus ulanus*, West Azarbayjan, Mahabad River, Lake Urmia,  
October 2011, Keyvan Abbasi.

**Common names.** Arus mahi-ye Orumiyeh (= bride Urmia fish, Y. Keivany, pers. comm., 25 September 2018).

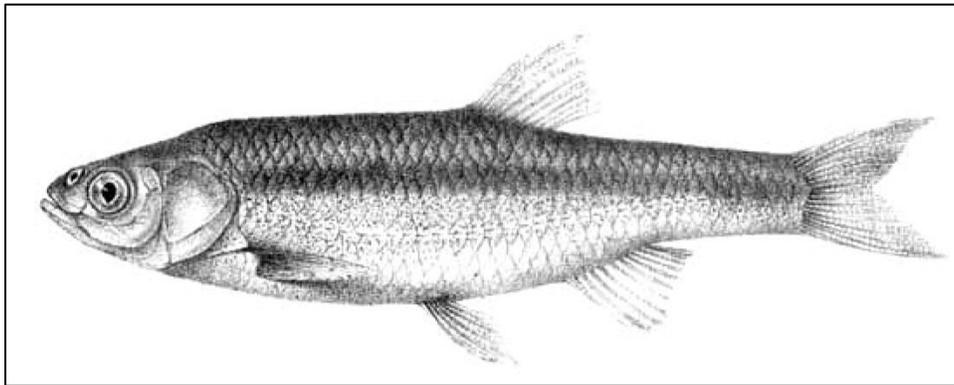
[Urmia or Urmian chub].

**Systematics.** This species was originally described in the genus *Leuciscus*. Saadati

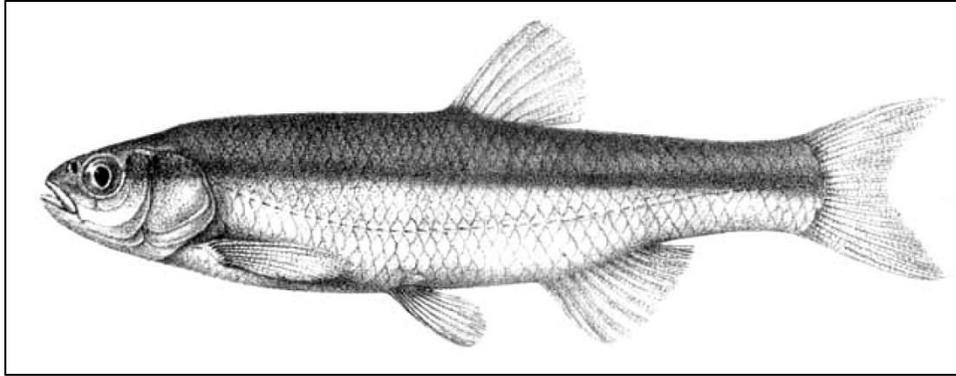
(1977) considered this species to be in the genus *Alburnus* but did not examine the types. *Leuciscus gaderanus* Günther, 1899 is a synonym, even Günther (1899), the describer of the two species, indicated that this may be the case. *Alburnus atropatenae* Berg, 1925 is also a synonym according to Jouladeh-Roudbar *et al.* (2020) based on unpublished molecular and morphological data but it is retained here until data are published (and lateral line scale counts are non-overlapping and would be 36-63 for the synonymised taxa, an unusually wide range).

Perea *et al.* (2010) and Schönhuth *et al.* (2018) using mitochondrial and nuclear DNA concluded that *Petroleuciscus* Bogutskaya, 2002 was not monophyletic and the species listed should be re-examined for generic placement. *P. ulanus* is now in *Alburnus* after Jouladeh-Roudbar *et al.* (2020).

The two syntypes of *Leuciscus ulanus*, 68.0-84.5 mm standard length, are in the Natural History Museum, London and are “from Ula on the Zola Chai” (= Zowla River; BM(NH) 1984.10.10:1-2). The three syntypes of *Leuciscus gaderanus*, 44.6-73.0 mm standard length, are “from the Gader Chai” (= Qader River) which is near Ocksa (BM(NH) 1899.9.30:113-115). Additionally, there are five specimens of *Leuciscus gaderanus*, 11.0-54.5 mm standard length “from near the mouth of the Nazlu Chai at Superghan” (= Sopurghan at 37°45'N, 45°12'E) (BM(NH) 1899.9.30:108-112). Günther (1899) referred to three young specimens from the latter locality as syntypes but of these five fish under this catalogue number and locality given as “Superghan” on the label only two fish are small (11.0-12.5 mm SL) and the other three fish are larger (45.8-54.5 mm SL). Another collection comprising one specimen, 27.0 mm standard length, is from the Urmi River according to the label (BM(NH) 1899.9.30:107). Its type status is unclear since the locality is wrong but the size is small and it could be the third of Günther’s “three young specimens” since its catalogue number is in sequence.



*Leuciscus gaderanus*, syntype, after Günther (1899).



*Leuciscus ulanus*, syntype, after Günther (1899).

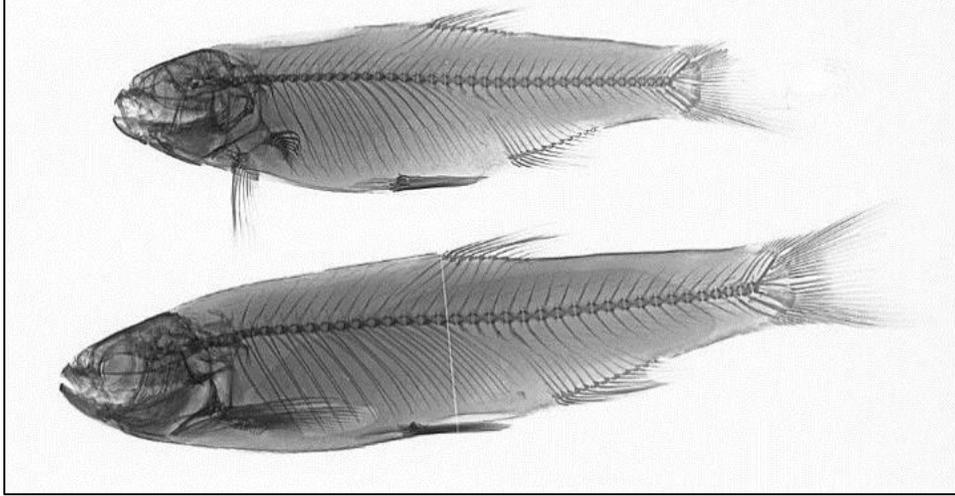


*Leuciscus gaderanus*, syntype, BM(NH) 1899.9.30:108-112.



*Leuciscus ulanus*, syntype, BM(NH) 1984.10.10:1-2.

BMNH 1984.10.10.1-2  
*Leuciscus ulanus* SYNTYPES



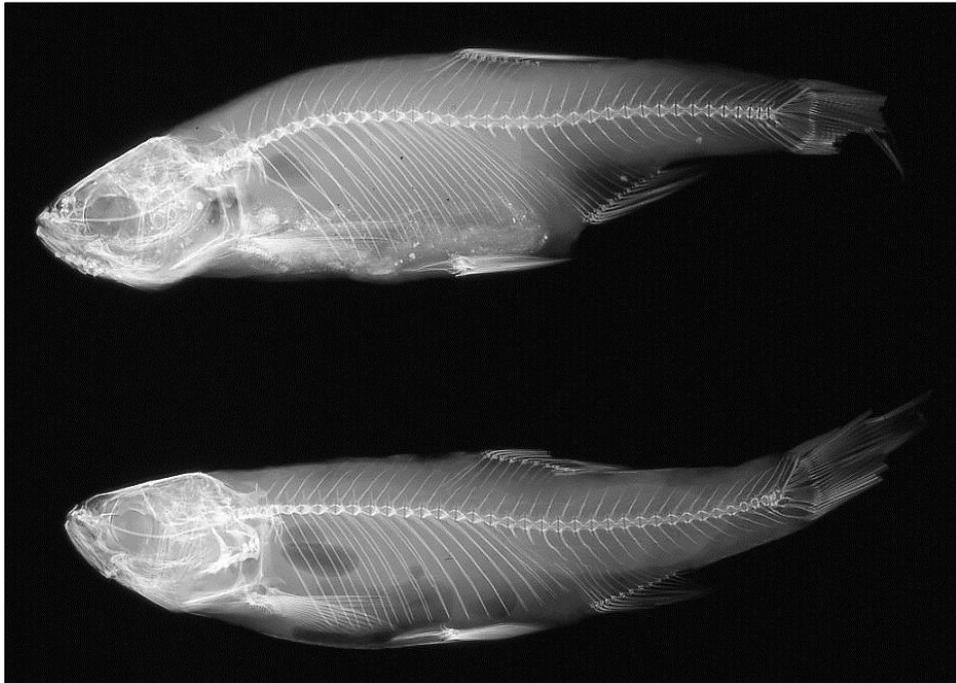
*Leuciscus ulanus*, syntypes, BM(NH) 1984.10.10:1-2.



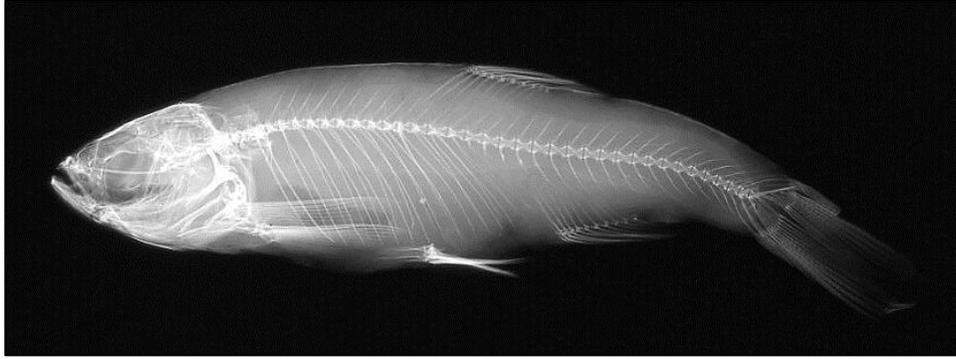
*Leuciscus gaderanus*,  
BM(NH) 1899.9.30:108-112, Brian W. Coad.



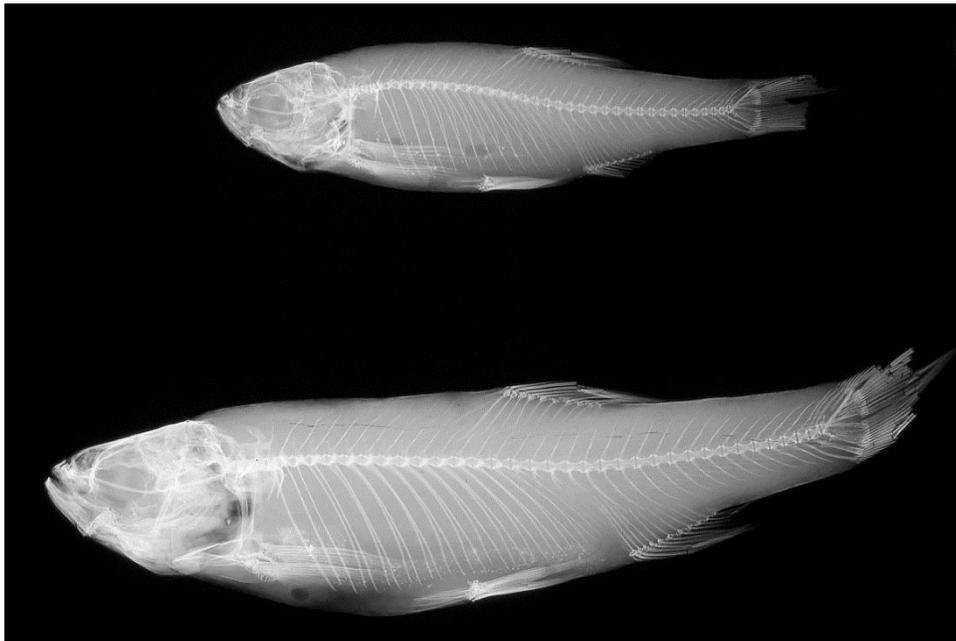
*Leuciscus gaderanus*, syntypes,  
BM(NH) 1899.9.30:113-115, Brian W. Coad.



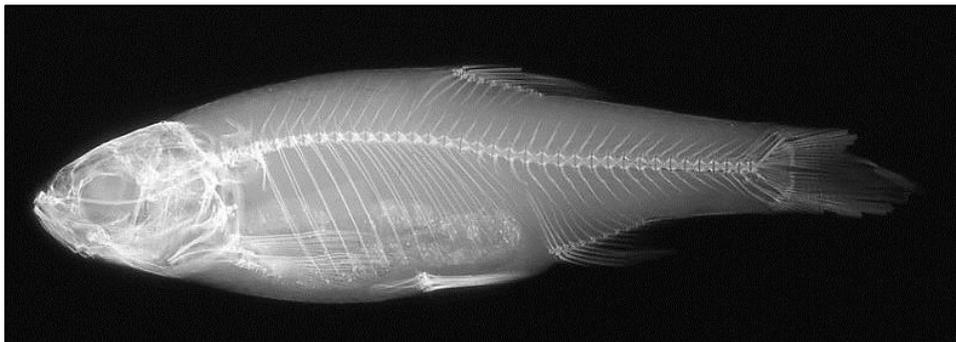
*Leuciscus gaderanus*, syntypes, BM(NH) 1899.9.30:108-112, Brian W. Coad.



*Leuciscus gaderanus*, syntype, BM(NH) 1899.9.30:108-112, Brian W. Coad.



*Leuciscus gaderanus*, syntypes, BM(NH) 1899.9.30:113-115, Brian W. Coad.



*Leuciscus gaderanus*, syntype, BM(NH) 1899.9.30:113-115, Brian W. Coad.

**Key characters.** This species is distinguished by having 8 branched dorsal fin rays, 12-16 total gill rakers, 36-45 lateral line scales, a silvery-brown peritoneum, and a distribution in the Lake Urmia basin.

**Morphology.** The body is compressed and fairly deep, being deepest between the end of

the pectoral fin and the origin of the pelvic fin. A slight nuchal hump may develop. The predorsal profile is very to slightly convex. The caudal peduncle is compressed and moderately deep. The head tapers to a rounded snout. The posterior eye margin lies at the beginning of, or anterior to, the mid-point of the head. The mouth is oblique and extends back to the nostril level or just behind the front margin of the eye and the lower jaw protrudes slightly or hardly at all (Günther (1899) has the upper jaw slightly overlapping the lower). Lips are of moderate thickness and the upper lip is thickest at the centre. The dorsal fin has a straight to slightly rounded margin. The dorsal fin origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the middle of the anal fin. The caudal fin has a shallow fork and pointed tips. The lower caudal fin lobe is larger than the upper lobe. The anal fin margin is straight to rounded and the fin does not reach back to the caudal fin base. The pelvic fin is rounded and almost or evidently reaches back to the anus. The pectoral fin is rounded and falls short or reaches the pelvic fin origin.

Dorsal fin unbranched rays 3, branched rays 7-9, modally 8, anal fin unbranched rays 3, branched rays 7-11, pectoral fin branched rays 12-14, and pelvic fin branched rays 7-8. Lateral line scales 35-45. There is a pelvic axillary scale. Scale shape is rounded with the dorsal and ventral margins merging into a posterior rounded margin. The anterior margin is rounded, or indented on each side of a central protrusion, or irregular in shape. Scales have a slightly anterior focus, numerous fine circuli, and relatively few to numerous radii on the anterior and posterior fields about equal in number. Anterior radii may be lacking. Total gill rakers number 12-16, reaching the first or second raker below when appressed. Pharyngeal teeth are 2,5-4,2, more rarely 2,4-5,2, 2,5-5,2 or 2,4-4,2, hooked at the tip and strongly serrated below on the larger teeth. The gut is an elongate s-shape and may have an anterior loop to the left. Total vertebrae number 37-39.

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(5) or 8(20), anal fin branched rays 7(1), 8(7), 9(16) or 10(2), pectoral fin branched rays 12(8), 13(11) or 14(5), pelvic fin branched rays 7(22) or 8(3), lateral line scales 35(1), 36(-), 37(1), 38(5), 39(6), 40(6), 41(1), 42(2), 43(1), 44(-) or 45(2), total gill rakers 12(2), 13(7), 14(7), 15(4) or 16(6), pharyngeal teeth 2,5-4,2(9), 2,4-5,2(2), 2,5-5,2(1) or 2,4-4,2(1), and total vertebrae 37(4) or 38(1). Syntypes of *L. gaderanus* illustrated above all have 37 total vertebrae and syntypes of *L. ulanus* 38 and 39 total vertebrae.

**Sexual dimorphism.** Males bear obvious tubercles on the pectoral fins mostly in a single file, occasionally two together, branching with the rays. Tubercles also line the rays of the dorsal, pelvic and anal fins and weakly on the caudal fin, the rows branching with the fin rays. Small tubercles are also found thickly on the top and sides of the head but no pattern was discernible in the specimens examined (types of *L. ulanus*).

**Colour.** There is a narrow, straight black stripe running from the upper half of the eye to the end of the lateral line separating the bluish back from the silvery flanks (Günther, 1899), best developed in preserved specimens posteriorly. Live fish have a grey-silver flank with some spots, a brown-green back to dark olive brown to grey and a light silver abdomen. Scales on the upper flank anteriorly are outlined with pigment. Lower fins are pale to light yellow and the dorsal and caudal fins are light grey (Abbasi and Sabkara, 2004a, 2004b). The lower half of the operculum below the mid-eye level has few or no spots while the upper half is heavily pigmented. There is also no pigment below the eye or it is restricted to a thin line around this lower margin. The iris may have a ventral red spot. The flanks are dotted with minute pigment spots. The back mid-line has a black stripe, most obvious predorsally. The rays and membranes

of the dorsal fin, caudal fin and anterior pectoral fin bear melanophores, and melanophores are weak to absent on the anal and pelvic fins. The peritoneum is silvery brown with scattered melanophores.

**Size.** Reaches 14.2 cm fork length (Abbasi and Sabkara, 2004b).

**Distribution.** This species is endemic to the Lake Urmia basin (Günther, 1899). Recorded from the Baranduz, Gadar or Godar (= Qader), Halaj, Hasanlu, Mahabad, Mamiyand, Nazlu, Qader, Qodor (= Qader), Shahr, Sufi, Urmia and Zowla rivers, and the Hasanlu and Mahabad dams (Günther, 1899; Abdoli, 2000; Abbasi *et al.*, 2005; K. Abbasi, pers. comm., 2012; Ghasemi *et al.*, 2015).

This species was found only in the Gadarchai (= Qader River) and Mahabad River and was not caught in the Baranduz, Nazlu and Zola (= Zowla) rivers and sampled areas of the Simineh and Zarrineh rivers in recent collections by Abbasi and Sabkara (2004a, 2004b).

**Zoogeography.** *Alburnus kurui* (Bogutskaya, 1995) from the upper Tigris River system of Turkey is the closest relative of this species although other members of the Lake Urmia ichthyofauna are related to fishes from the Caspian Sea basin.

**Habitat.** This species is found in rivers, streams, lakes and dams.

**Age and growth.** Fish caught by Abbasi and Sabkara (2004b) in the Gadarchai (= Qader River) and Mahabad River were 34-142 mm in fork length and 1.4 years old. Males comprised 28.8% and females 71.2% of the total population. Maturity was attained at 2 years. Esmaili *et al.* (2014) gave a *b* value for 30 fish from the Lake Urmia basin, 2.77-4.49 cm total length, as 2.55. Mouludi-Saleh *et al.* (2021) examined 156 fish, 3.8-9.7 cm total length, from the Godar and Mahabad rivers and recorded a *b* value of 3.04, isometric, and a condition factor of 1.25.

**Food.** Traces of insects, crustaceans, worms and large quantities of filamentous algae were found in the gut contents of a few specimens examined by me. The algae may be an accidental inclusion as the gut is short and probably cannot digest plant material. Fish caught by Abbasi and Sabkara (2004a, 2004b) however, contained a wide range of phytoplankton (19 genera) and zooplankton (7 groups), as well as benthic organisms (4 groups). *Daphnia*, *Chydorus* and chironomids were dominant gut contents. It was considered to be an omnivorous fish preferring to feed on zooplankton and other mid-water animals.

**Reproduction.** Spawning of fish caught by Abbasi and Sabkara (2004b) took place from 1 April until 1 July with absolute fecundity estimated at 1,810-16,115, average 6,437 eggs.

**Parasites and predators.** Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G. sp.* in fish from the Baranduz and Halaj rivers.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Modern collections are few (see above and below). This suggests that it is now quite rare and/or has a restricted habitat preference. However, Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern as they included the widespread *A. atropatense* as a synonym.

**Sources.** Type material:- *Leuciscus ulanus* (BM(NH) 1984.10.10:1-2) and *Leuciscus gaderanus* (BM(NH) 1899.9.30:108-112 and BM(NH) 1899.9.30:113-115).

Iranian material:- CMNFI 1970-0560, 35, 11.4-48.8 mm standard length, West Azarbayjan, Mamiyand Chay (ca. 36°59'N, ca. 45°39'E); CMNFI 2007-0096, 6, 38.8-68.5 mm standard length, West Azarbayjan, Baranduz Chay basin (ca. 37°25'N, ca. 45°10'E); CMNFI 2008-0225, 6, 53.1-65.0 mm standard length, Lake Urmia basin (no other locality data);

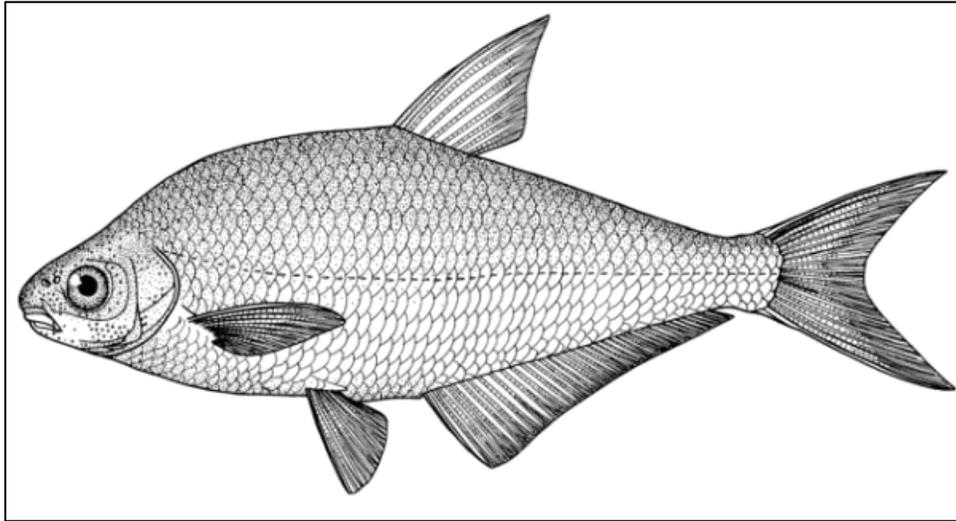
BM(NH) 1899.9.30:107, 1, 27.0 mm standard length, West Azarbayjan, Urmi River (no other locality data).

**Genus *Ballerus***  
Heckel, 1843

This genus comprises two species found in Europe and Southwest Asia in the North, Baltic, Black, Caspian and Aral Sea basins. One species is found in Iran. The species were formerly placed in the genus *Abramis*. This genus was resolved as the sister group to a clade including *Abramis*, *Acanthobrama*, *Blicca* and *Vimba* (Schönhuth *et al.*, 2018).

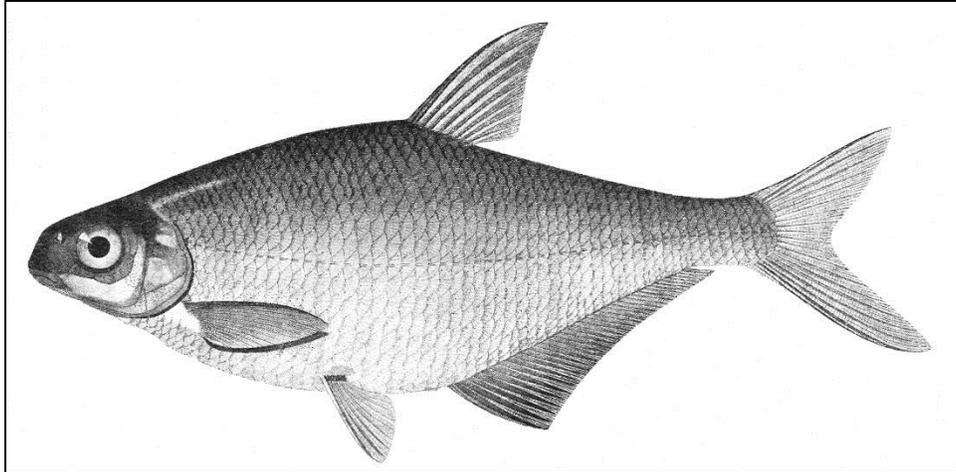
The genus is characterised by a strongly compressed and deep body, a scaleless keel between the vent and pelvic fins, pharyngeal teeth in one row, dorsal fin short and spineless (8 branched rays modally), and anal fin very long (31-44 branched rays).

***Ballerus sapa***  
(Pallas, 1814)

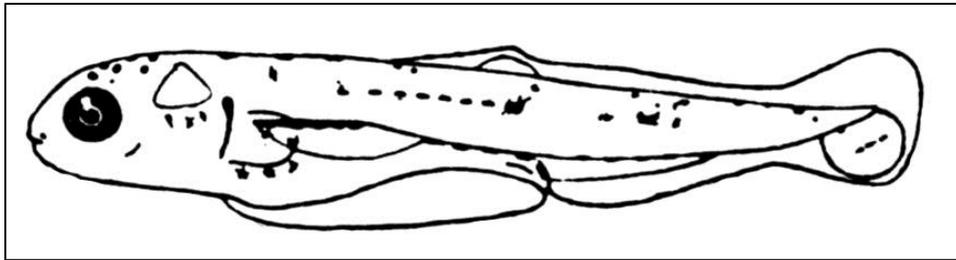


*Ballerus sapa*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Ballerus sapa*, Ukraine, Dnieper River at Kiev, after Berg (1916).



*Ballerus sapa* fry, age 10 days, Russia, Volga River delta , after Kazanskii (1928).



*Ballerus sapa*, Russia, Oka River (Volga River basin)  
(CC BY-SA 3.0, rotated and cropped, Vladimir. Yu. Arkhipov, Arkhivov).

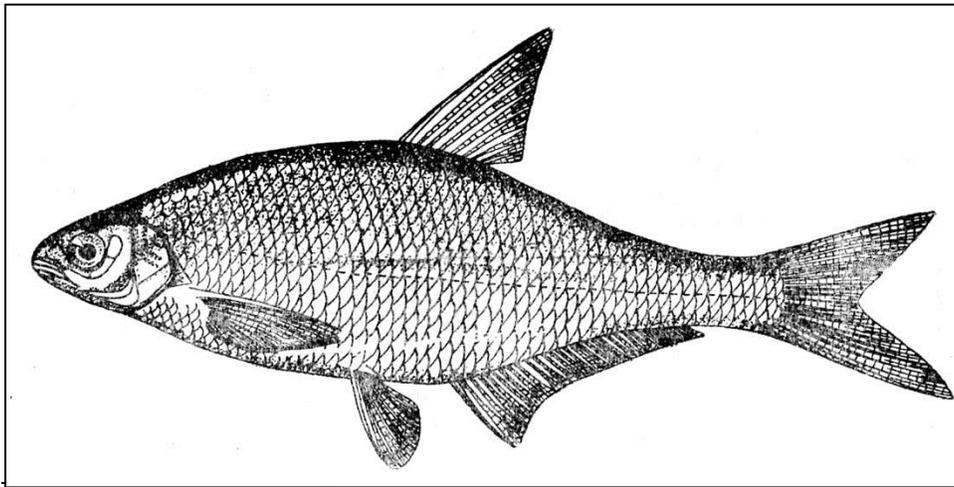
**Common names.** Mahi sim kondpuzeh (= bluntsnout silver fish), saba (from the species name), sim (= silver).

[Pori or poru, both in Azerbaijan; rybets, taran' and tarashka erroneously in Azerbaijan (Berg, 1948-1949); sinets, yuzhnokaspiiskaya beloglazka or South Caspian white-eye bream in Russian; Danube bream, southern white-eye bream, white-eye bream].

**Systematics.** *Cyprinus Sapa* was originally described from the Sura, Samara and Kinel' rivers in the Volga River basin. No types known.

May be placed in the genera *Abramis* or *Ballerus* Heckel, 1843 (see Shcherbukha (1973), Hensel (1978), Howes (1981), Bogutskaya (1986) and Bogutskaya and Naseka (2004) for various opinions). The nominate subspecies was described from the Volga River and tributaries.

The subspecies reported from the southern Caspian Sea basin is *Abramis sapa bergi* Belyaev, 1929 (also spelled Belyaeff), described from the Kura River in Azerbaijan. Eschmeyer *et al.* (1996) date this subspecies to 1930 although the article is dated 1929, and this was corrected in the online *Catalog of Fishes* (downloaded 7 March 2018). Recognition of subspecies is disputable (Reshetnikov *et al.*, 1997) and the *Catalog of Fishes* (downloaded 1 June 2021) lists it as a synonym of the type subspecies.



*Abramis sapa bergi*, after Abdurakhmanov (1962).

The status of this species in Iran should be assessed by field surveys. It is apparently quite rare and was not caught during two collecting trips along the Caspian shore in the 1970s. It is recorded only from two localities in Iran in 1929 and 1934.

**Key characters.** The scaleless keel on the belly, deep body, very high number of branched rays in the anal fin (31-44), modally 8 dorsal fin branched rays, and uniserial pharyngeal teeth are key characters.

**Morphology.** The body is compressed and very deep. It is deepest at, or just in front of, the dorsal fin origin. A nuchal hump is often present. The predorsal profile is convex to slightly convex, with a notch at the head and the head straight. The caudal peduncle is compressed and moderately deep but narrow in relation to the deep anterior body. The snout is thick, very rounded and convex, and falls back posteriorly to the upper lip. The mouth is subterminal and slightly oblique and extends back to the nostril level. Lips are thin. The eye is large and lies in the anterior half of the head. The dorsal fin margin is straight to slightly concave. The dorsal fin origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back to the level of the anterior to mid-anal fin. The caudal fin is deeply forked with pointed to rounded lobes. The lower caudal fin lobe is longer than the upper lobe and is more rounded. The anal fin is emarginate anteriorly, then straight and may become slightly convex at the end. The anal fin almost reaches back to the base of the caudal fin because of its length. The pelvic fin is rounded and may, or may not, reach back to the anal fin origin. The pectoral fin is rounded and may, or may not, reach back to the pelvic fin origin. These last two fins are longer in males.

Dorsal fin with 2-3, usually 3, unbranched and 7-9, usually 8, branched rays, anal fin with

3 unbranched and 31-44 (mostly 34-38 branched rays in Kura River fish after Berg (1948-1949)), pectoral fin branched rays 13-16, and pelvic fin branched rays 7-8. Lateral line scales 42-55, mostly 51-52 in the Kura River, regularly arranged over the body. A pelvic axillary scale is present. There is an evident, scaleless keel on the belly between the pelvic fin bases and the anal fin. Scale shape is squarish to very rounded with a rounded posterior margin, gently rounded dorsal and ventral margins and a wavy and irregular anterior margin. Anterior scale corners are rounded to sharp. Scales bear numerous very fine circuli, an almost central focus, numerous to few posterior radii (quite variable between scales of similar size) and few to none anterior radii. The anterior scale margin is wavy. Total gill rakers number 18-25, short, reaching the raker below or almost the second raker when appressed. Pharyngeal teeth are 5-5, with elongate, narrow and flattened, concave or rounded crowns below a hooked tip. The gut is s-shaped with a small anterior loop. Total vertebrae number 45-48. The chromosome number is  $2n = 50$  (Klinkhardt *et al.*, 1995; Arai, 2011).

Belyaev (1929) for Kura River fish gave lateral line scale counts as 48(3), 49(6), 50(24), 51(50), 52(54), 53(16) or 54(7) and anal fin branched rays as 32(1), 33(5), 34(22), 35(32), 36(38), 37(47), 38(25), 39(9), 40(5), 41(2) or 42(1). The nominal Caspian Sea subspecies is distinguished from the type form in the Black Sea (Don River) by fewer lateral line scales and anal fin branched rays, a longer snout, smaller eyes, less deep body, lower dorsal fin, shorter anal fin, and longer postorbital length but is not recognised as distinct (see above).

**Sexual dimorphism.** Unknown.

**Colour.** The Caspian Sea population has a dark back with a bluish tint, flanks and belly are silvery, fins are a greyish-white and sometimes have a black margin (dorsal, anal and caudal fins), and the iris is silvery. The peritoneum is dark brown in preserved fish.

**Size.** Attains 41.0 cm and 0.8 kg.

**Distribution.** This species is found in the basins of the Black, Caspian and Aral seas. Reported from the Anzali Talab by Derzhavin (1934) but not captured in recent years (Holčík and Oláh, 1992). Other reports are from the lower Sefid River at Hasan Kiadeh (Belyaev, 1929; Derzhavin, 1934) and in the Aras River at Karadonly (Berg, 1948-1949). Jouladeh-Roudbar *et al.* (2020) considered reports from Iran might be misidentified *Abramis brama* and its presence needed confirmation.

**Zoogeography.** This species is part of a northern European and northern Southwest Asian fauna whose zoogeographical history has not been researched.

**Habitat.** This species is found in rivers, lagoons and brackish environments. It feeds in brackish water but spawns and overwinters in the lower reaches of rivers and is commonest along the western shore of the middle and southern Caspian Sea.

**Age and growth.** Females are 28-29 cm long on average, maximum 39 cm, while males are about 24 cm, maximum 30 cm (Belyaev, 1929). Males and females mature at 2-3 years and life span is 5 years in Azerbaijan (Abdurakhmanov, 1962).

**Food.** Food items include small molluscs, crustaceans and insect larvae as well as some plant fragments and detritus. Young feed on zooplankton.

**Reproduction.** A migration into rivers, particularly the Kura, occurred in winter when temperatures fluctuated from 5 to 10°C (Belyaev, 1929). The run began in November, peaked in January and ended in the middle of March. The Kura migration was once over 700 km from the mouth. Spawning occurred in rivers with gravel bottoms or dense vegetation from April to May. Fecundity reached about 150,000 eggs with diameters up to 1.8 mm. Eggs adhered to stones or plants.

**Parasites and predators.** This species is eaten by *Silurus glanis* (European catfish) (Derzhavin, 1934).

**Economic importance.** Up to 1-2 million fish were caught in the Kura at spawning (Belyaev, 1929). The annual average catch in Azerbaijan in 1931-1935 was 1,860,000 fish weighing 6,200 centners.

**Experimental studies.** None.

**Conservation.** The subspecies *A. sapa bergi* was proposed for inclusion in the “Red Book of the U.S.S.R.” which formed the basis for measures to protect species (Pavlov *et al.*, 1985). This species has always been very rare in Iran and its absence from the Anzali Talab may be due to loss of spawning grounds (Holčík and Oláh, 1992). Lelek (1987) classified this species as rare to vulnerable in Europe. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Iranian material:- None.

Comparative material:- CMNFI 1986-0458, 2, 209.0-211.7 mm standard length, Germany, Danube River (48°58'N, 12°18'E); BC 59-301, 2, 136.3-154.2 mm standard length, Ukraine, Tisa, Danube drainage (no other locality data).

### **Genus *Blicca***

Heckel, 1843

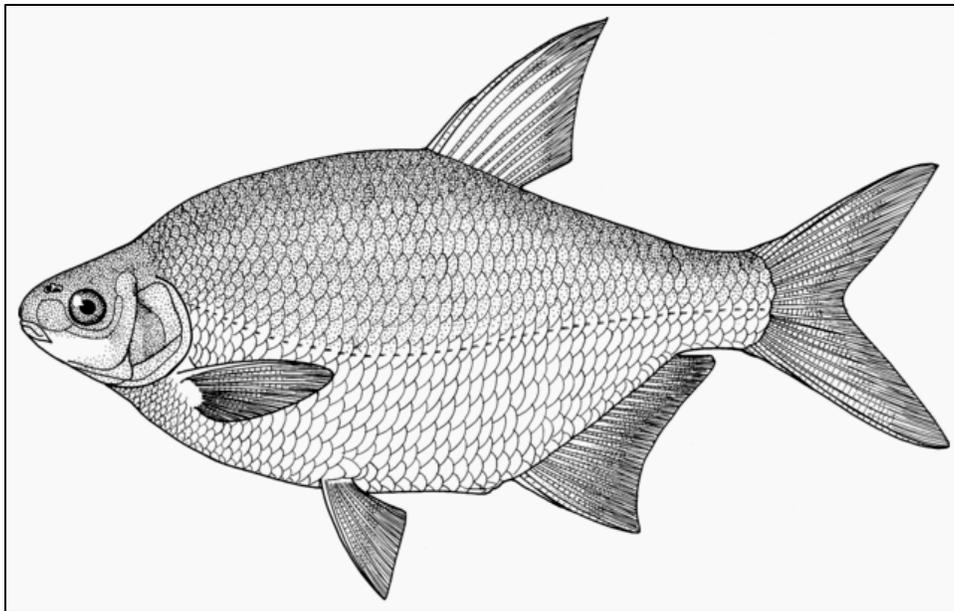
Shutov (1969) placed this genus and species in the genus *Abramis* Cuvier, 1816 on the basis of literature data as did analyses by Shcherbukha (1973) and Howes (1981). Hensel (1978) and Tadjewska (1998) also placed this genus in *Abramis* on the basis of the lateral line system structure, pharyngeal teeth, scale and dermal bone morphology along with data on ecology, behaviour, ontogenesis, osteology and parasitofauna. Hänfling and Brandl (2000) considered *Blicca* a junior synonym to *Abramis* based on allozyme data. In contrast, Bogutskaya (1986) using skull morphology reaffirmed its generic status.

The white bream genus contains a single species found from Europe to the Caspian Sea basin including Iran.

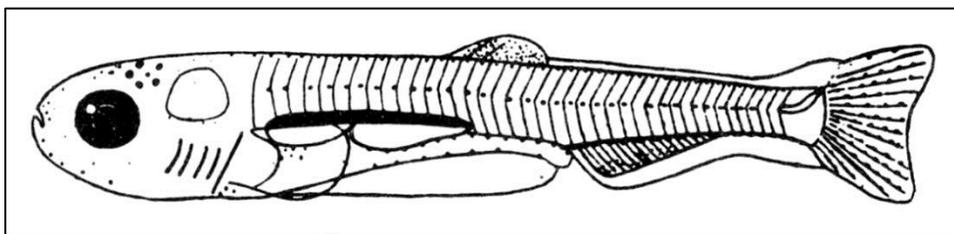
The genus is characterised by a deep and strongly compressed body, scales absent on the back behind the dorsal fin thus forming a narrow groove, a scaleless keel between the vent and the pelvic fins, pharyngeal teeth in two rows, a small, oblique and subterminal mouth, moderate number of gill rakers, scales of moderate size, a short and spineless dorsal fin and a long anal fin, and a light peritoneum.

### ***Blicca bjoerkna***

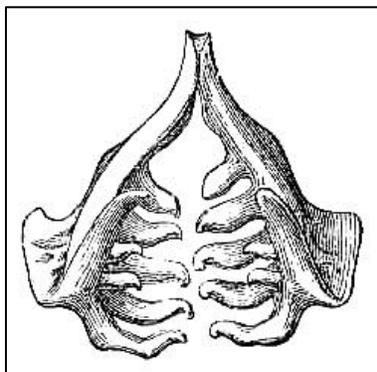
(Linnaeus, 1758)



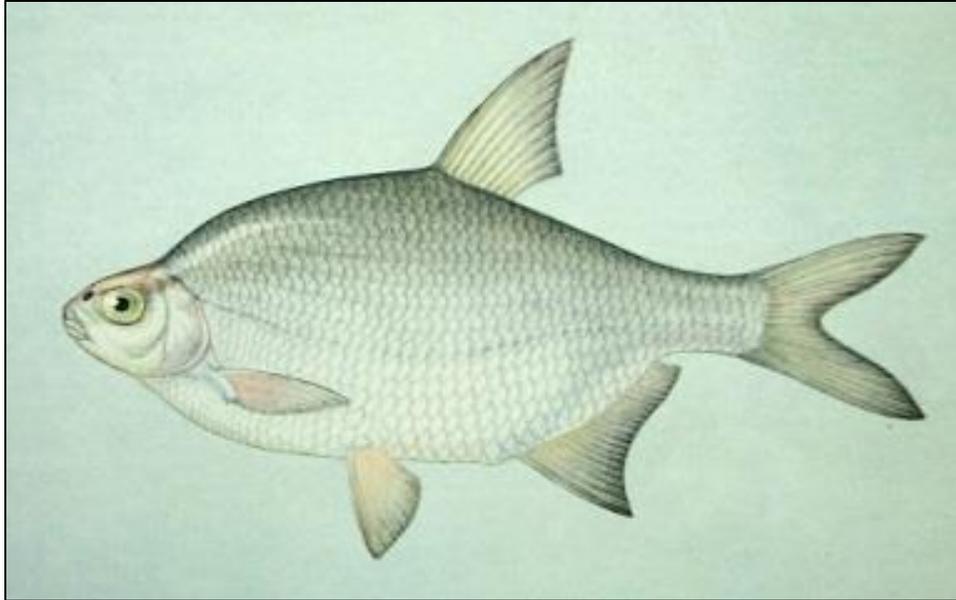
*Blicca bjoerkna*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Blicca bjoerkna* fry, 8.7 mm, age two weeks, Russia, Volga River delta,  
after Kazanskii (1915).



*Blicca bjoerkna*,  
pharyngeal teeth,  
after Seeley (1886).



*Blicca bjoerkna*  
(CC0, NOAA Photo Library, N. N. Kondakov).



*Blicca bjoerkna*, Gilan, Anzali Wetland, November 2011, Keyvan Abbasi.



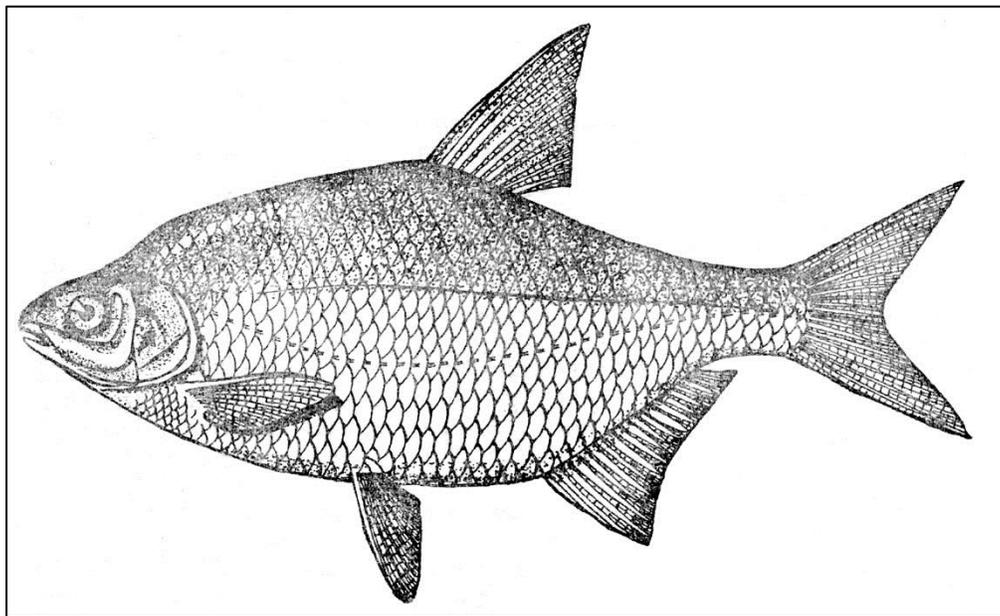
*Blicca bjoerkna*, ca. 30 cm, Netherlands, Waal River  
(anal fin rounded from contact with hard bottom)  
(SilverBreamBliccaBjoerknaCropped, CC BY-SA 3.0, Viridiflavus).

**Common names.** Simparak or seamparak (= silver scales, probable meaning since parak is a small feather), mahi sim nama or sim nama (= silvery-like fish or sim-like fish in reference to *Abramis brama*).

[Yastigarin in Azerbaijan; Tahta balığı in Turkish (Kaya *et al.*, 2020); Zakavkazskaya gusteru or Transcaucasian white bream, Armyanskaya gusteru for *A. b. derjavini*, all in Russian; flat bream, silver bream, white bream].

**Systematics.** *Cyprinus Björkna* was originally described from Greifswald, Mecklenburg-Vorpommern, Germany. *Cyprinus Blicca* Bloch, 1782 described from lakes in Germany, *Cyprinus gibbosus* Pallas, 1814 described from the Sura and Volga rivers and *Blicca argyroleuca* Heckel, 1843 are synonyms. It appears that the latter taxon is first described in Heckel's work on fishes of Syria, but in the section devoted to classification based on the pharyngeal teeth of cyprinids; the taxon is later described from Europe in Heckel and Kner (1858) and is not a Southwest Asian species. Syntypes of *Blicca argyroleuca* are in the Naturhistorisches Museum Wien under NMW 16901 (2 fish), NMW 54918 (6), NMW 54919 (4) and NMW 54920 (1) (Eschmeyer *et al.*, 1996). The spelling *bjorkna* is incorrect (Eschmeyer *et al.*, 1996).

The Caspian Sea basin subspecies is *Blicca bjoerkna transcaucasica* Berg, 1916, described from the lower reaches of the Kura River, Aras, Lenkoran District, Transcaucasia. It is distinguished by “somewhat” fewer rays in the anal fin (17-21) and “a tendency to have” fewer lateral line scales (40-45) than in the type form which mostly has 21-22 anal fin rays and 45-48 lateral line scales (Berg, 1948-1949). Abdurakhmanov (1962) expanded these ranges to 17-22 and 40-48 respectively but gave low means ( $\pm$  standard error) for 100 fish from Azerbaijan of  $19.88 \pm 0.13$  and  $43.56 \pm 0.05$  respectively. This may be a valid subspecies but the possibility of clinal variation has not been examined.



*Blicca bjoerkna transcaucasica*, after Abdurakhmanov (1962).

*Blicca bjoerkna derjavini* Dadikyan, 1970 is described from the “Sevdzhur River, (tributary of Aras River, in Armenian SSR) and the canal and lake system connected with it”. It is distinguished from *transcaucasica* by lower mean number of dorsal fin branched rays and branched anal rays, a higher mean lateral line scale count, and various morphometric characters.

The *Catalog of Fishes* (downloaded 1 June 2021) considers both subspecies to be synonyms of *Blicca bjoerkna*.

**Key characters.** The scaleless ventral keel, postdorsal scaleless groove, long anal fin, lateral line scale count and small and oblique mouth are characteristic.

**Morphology.** The body is compressed and very deep, being deepest at the dorsal fin origin. A nuchal hump is present. The predorsal profile is convex with the head set off from the back by a dip. The head is small. The caudal peduncle is compressed and deep. The snout is rounded and protrudes beyond the upper lip. The rear of the eye is positioned at the beginning of the anterior half of the head. The mouth is subterminal and lips are moderately thick. The dorsal fin margin is slightly concave. The dorsal fin origin lies well posterior to the level of the origin of the pelvic fin. The depressed dorsal fin reaches back to a level with the middle or more of the anal fin. The caudal fin is deeply forked with pointed lobes, the lower lobe being slightly more rounded. The anal fin is emarginate and does not extend back to the caudal fin base. The pelvic fin is rounded and extends almost back to, or back to, the anal fin origin. The pectoral fin is rounded and does not extend back to the pelvic fin origin, or almost reaches that fin or overlaps it.

Dorsal fin with 3 unbranched and 7-10 branched rays, usually 8, anal fin with 3 unbranched and 16-24 branched rays, pectoral fin branched rays 14-16, and pelvic fin branched rays 7-9. Lateral line scales 40-55. There is a pelvic axillary scale. Scales have numerous fine circuli, an almost central focus, a wavy anterior margin and a crenulate posterior margin, and few primary anterior and posterior radii, as few as two in each field (there may be numerous secondary radii which do not reach the focus). Total gill rakers number 12-21, touching the adjacent raker when appressed. Pharyngeal teeth are 2,5-5,2 with variants 2,5-5,1, 1,5-5,2, 1,5-5,1, 2,5-4,2, 2,5-4,1, 1,5-4,1, 3,5-5,2, and 3,5-5,3 (among others, see below and Tadaiewska (1998)), weakly hooked (strongly hooked in young), compressed, concave below the tip and smooth (anterior tooth margin serrated in young). In young fish, the first major row tooth may be medial to the second tooth rather than in line. Tadaiewska (1998) gave details of tooth development. The intestine is s-shaped with a small anterior loop. Total vertebrae number 37-43. The chromosome number is  $2n = 50$  (Klinkhardt *et al.*, 1995; Pourkazemi *et al.*, 2010; Arai, 2011).

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(49) or 9(1), anal fin branched rays 17(3), 18(15), 19(21), 20(9) or 21(2), pectoral fin branched rays 14(15), 15(24) or 16(7), pelvic fin branched rays 7(1), 8(47) or 9(2), lateral line scales 41(2), 42(10), 43(9), 44(13), 45(10), 46(5) or 47(1), total gill rakers 13(2), 14(25), 15(18), 16(4), 17(-) or 18(1), pharyngeal teeth 2,5-5,2(3), 2,5-5,1(4), 1,5-5,2(4), 2,5-4,1(1), 2,5-5,0(1), 0,5-5,2(1), 1,5-5,1(1), 1,5-5,0(2), 1,5-4,1(2) or 2,4-4,1(1), and total vertebrae 38(8), 39(33) or 40(12).

**Sexual dimorphism.** Breeding males have fine tubercles on the top of the head, operculum and lining the exposed scale margins on the flank. There are occasionally tubercles in mid-scale. Small tubercles are found on the pectoral fin rays, 1-3 rows on the unbranched ray, 1-2 on the first branched ray and usually one on the other rays, branching to follow the branching rays. Other fins bear fine tubercles following the fin rays. Larger tubercles are found in clumps on the scales overlapping the anal fin base. Tubercles are absent from the belly. CMNFI 1979-0472 (63.6 mm standard length, 4 July 1978) has fine tubercles on all head surfaces and on all scales, and on the pelvic fin rays but less developed than on other fins. Fine unculi are present on the snout, under the eye and between the tubercles on the head generally as well as on the underside of the pectoral fin.

**Colour.** The back is a bluish-green and the rest of the body silvery. The pectoral and pelvic fins are orange-red with grey tips. The peritoneum is silvery with scattered melanophores.

**Size.** Reaches 54.5 cm and 2.13 kg, perhaps 2.25 kg (Machacek (1983-2012), downloaded 27 July 2012). Berg (1948-1949) gave 20.5 cm for *B. bjoerkna transcaucasica*.

**Distribution.** Found from England through Europe north of the Alps and Pyrenees to the Caspian Sea basin. Apparently, it does not penetrate to the higher reaches of even major rivers like the Kura and Aras. In Iran it is found from the Aras River (including its middle reaches in Iran) to the Atrak River in the Caspian Sea basin including the Babol, Chapak, Golshan, Gorgan, Haraz, Masuleh, Nahang, Nerissi, Pesikhan, Pir Bazar, Rasteh, Sardab, Sefid, Shah, Sheikan, Shesh Deh, Siah Darvishan, Sowsar, Tajan, Tonekabon and Zarrin Gol rivers, the Anzali Talab, Boojagh and Amirkelayeh wetlands, a swamp near Hendeh Khaleh, the Aliabad and Aras dams, and the Caspian Sea near Bandar-e Anzali and Babol Sar (Derzhavin, 1934; Holčík and Oláh, 1992; Nejatsanatee, 1994; Karimpour, 1998; Abbasi *et al.*, 1999, 2007, 2017; Kiabi *et al.*, 1999; Nasrollahzadeh, 1999; Abdoli, 2000; Abdoli and Naderi, 2009; Tajbakhsh *et al.*, 2010; Khara *et al.*, 2011; Eagderi *et al.*, 2020).

**Zoogeography.** This species is part of a northern European and northern Southwest Asian fauna whose zoogeographical history has not been thoroughly researched. The relationships with similar genera are reviewed under the genus.

**Habitat.** This species is found in rivers, streams, lakes, dams, lagoons, marshes and brackish environments. It is often found in the shallows of warm lakes with heavy vegetation and in the slower reaches of rivers including river estuaries in Iran (Naderi Jolodar and Abdoli, 2004). It overwinters in deeper water. There was a mass mortality of this species on the Babol Sar beach on 24 June 1963 (USNM 271217). Collection data included a temperature range of 14.2-24°C, pH 6.0, conductivity 0.8 mS, river width 8-20 m, still to fast current, depth 40-50 cm, mud, clay, sand, pebble or stone bottoms, encrusting, submergent and emergent vegetation including *Ceratophyllum*, *Potamogeton*, *Phragmites* and *Ranunculus*, and a grassy shore.

**Age and growth.** Growth is slow with maturity attained at 3-5 years and 10-12 cm. Some males may mature at 2 years. Females are much larger than males of the same age. Life span is up to 16 years. Stunted populations comprising large numbers of individuals develop where predators are absent. Jamali *et al.* (2015) examined fish from Aras Dam and found a maximum age of 5<sup>+</sup> years with the most frequent age class 2<sup>+</sup> years. The length-weight relationship was  $W = 1E-06TL^{3.44}$  for females,  $W = 1E-06TL^{3.45}$  for males and  $W = 1E-06TL^{3.44}$  for sexes combined (positive allometric growth for all). The sex ratio was 1:1.42 in favour of males and the calculated maximum condition factor was 0.34 in males and 0.37 in females. Farzi and Fallahkar (2018) found growth in the Anzali Wetland was positively allometric. Eagderi *et al.* (2020) examined 392 fish, 13.7-27.8 cm total length, from the Aras River and found a *b* value of 3.44, positively allometric.

**Food.** Food items included insect larvae such as chironomids, worms and molluscs, and some vegetation. This is a euryphagous species. Young fish fed principally on copepods and cladocerans. Even adults fed on plankton and it was less of a bottom feeder than *Abramis brama*.

**Reproduction.** Spawning in the Volga delta took place about the beginning of May at around 11°C water temperature but may run from the end of April to the middle of July in the Volga generally. Spawning in the Aras flood plain occurs in the middle of April. Generally spawning occurs later than in *Abramis brama* and *Rutilus rutilus* (possibly *R. lacustris*) but may overlap and infertile hybrids result. Shallow weedy areas were preferred. Each female was pursued by several males. Fecundity reached 109,000 eggs and egg diameter 1.44 mm. Eggs

adhered to plants or stones on the bottom. There could be three spawnings at intervals of 10-11 days when water temperatures were at least 16-17°C. Batch spawning showed much individual variation as well as varying between localities and by year at the same locality.

**Parasites and predators.** Khara *et al.* (2006a) recorded the digenean eye fluke *Diplostomum spathaceum* for this fish in the Amirkelayeh Wetland in Gilan as did Khara *et al.* (2008) in fish from Boojagh Kiashahr Wetland in Gilan. Barzegar *et al.* (2008) also recorded this eye parasite. Tajbakhsh *et al.* (2010) reported the nematode *Philometra rischta* from fish in the Anzali Wetland. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea* sp. on this species. Khara *et al.* (2011) listed the monogenean *Dactylogyrus* sp. and the crustacean *Lernaea cyprinacea* from this fish in the Boojagh Wetland of the Caspian Sea. Pazooki *et al.* (2011) examined fish from the Anzali Talab and found *Trichodina perforata*, *Myxobolus musayevi*, *Dactylogyrus difformis*, *D. sphyrna*, *Diplostomum spathaceum*, *Posthodiplostomum cuticula*, *Ripidocotyle* sp., *Contracaecum osculatum*, *Philometra rischta* and *Raphidascaris acus*, more than in the introduced *Hemiculter leucisculus*. Mirhashemi Nasab *et al.* (2017) found *Diplostomum spathaceum* in fish from the Anzali Wetland with the highest prevalence (70%) and range (1-66 worms in a fish) of eight species examined. Moumeni *et al.* (2020) recorded the zoonotics *Contracaecum osculatum* and *Philometra rischta* from this species in Iran.

The Caspian seal, *Pusa caspica*, is a predator on this species (Krylov, 1984) as are a variety of other fishes such as perch (*Perca fluviatilis*) and pike-perch (*Sander* sp.). *Silurus glanis* (European catfish) eats this species in the Boojagh Wetland in the spring and summer (Ershad Langroudi *et al.*, 2017). Ashoori *et al.* (2012) found that grey herons (*Ardea cinerea*) in the Siahkeshim Protected Area of the Anzali Wetland ate this species and Ashoori *et al.* (2017a) recorded this species as the third most dominant in the diet of young black-crowned night herons (*Nycticorax nycticorax*) in the Anzali Wetland. Mirzajani *et al.* (2021) found the Eurasian otter (*Lutra lutra*) ate this species in the Anzali Wetland where it comprised 47% of the fish diet.

**Economic importance.** Holčík and Oláh (1992) reported a catch of 144 kg in the Anzali Talab in 1990. Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use in aquaria and in textbooks.

**Experimental studies.** None.

**Conservation.** Lelek (1987) classified this species as intermediate in Europe (liable to be transferred to vulnerable or rare categories if their habitat deteriorates further). Kiabi *et al.* (1999) considered this species to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, abundant in numbers, habitat destruction, widespread range (75% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Iranian material:- CMNFI 1970-0510, 1, 56.0 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0521, 1, 45.2 mm standard length, Gilan, Sefid River near Lulaman (no other locality data); CMNFI 1970-0522, 4, 40.0-62.6 mm standard length, Gilan, Sefid River at Astaneh Bridge (36°16'30"N, 49°56'E); CMNFI 1970-0532, 6, 30.0-63.2 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0553, 4, 62.1-80.1 mm standard length, Gilan, Sowsar Roga River (37°27'N, 49°30'E); CMNFI 1970-0579, 2, 52.6-56.9 mm standard length, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0580, 31, 31.8-86.3 mm standard length, Mazandaran, river near Iz Deh (36°36'N, 52°07'E); CMNFI 1970-0582, 1, 70.9 mm standard length, Golestan, Aliabad

Reservoir (*sic*) (36°56'N, 54°50'E); CMNFI 1970-0585, 39, 32.4-52.5 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0587, 36, 34.6-55.4 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0590, 6, not kept, Mazandaran, Shesh Deh River near Babol Sar (ca. 36°43'N, ca. 52°39'E); CMNFI 1979-0470, 2, 44.5-51.2 mm standard length, Mazandaran, stream 21 km west of Alamdeh (36°35'N, 51°43'E); CMNFI 1979-0472, 30, 38.7-69.6 mm standard length, Mazandaran, stream 7 km west of Mahmudabad (36°37'N, 52°12'E); CMNFI 1979-0685, 3, 63.1-67.1 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1980-0116, 3, 39.0-49.4 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0117, 1, 80.0 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0122, 15, 38.7-45.3 mm standard length, Mazandaran, Nerissi River (36°38'N, 52°16'E); CMNFI 1980-0125, 21, 39.8-53.2 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1980-0130, 2, not kept, Mazandaran, Iz Deh near Shilat Post (36°36'N, 52°07'E); CMNFI 1980-0149, 6, 60.1-63.7 mm standard length, Gilan, Chapak River (37°21'N, 49°50'E); CMNFI 2008-0110, 1, 63.2 mm standard length, Gilan, swamp near Hendeh Khaleh (37°23'N, 49°28'E).

### **Genus *Chondrostoma***

Agassiz, 1832

The nases are found from the Iberian Peninsula and France to the Caspian Sea, Tigris-Euphrates and internal Iranian basins. There are about 27 species of which four are known for Iran (note that some European species have been placed in new genera (Corse *et al.*, 2015; Küçük *et al.*, 2017)). *Chondrochylus* Heckel, 1843 and *Chondrochilus* Heckel, 1843 are synonyms.

Eschmeyer (1990) gave the year of publication for the genus as 1832 as opposed to other authors who gave 1835 (e.g., Berg, 1948-1949; Reshetnikov *et al.*, 1997). Doadrio and Carmona (2004) confirmed the monophyly of the genus based on the cytochrome *b* gene with vicariant events accounting for distribution of taxa better than a dispersalist model. Middle East taxa belong to a single lineage with the more differentiated and basal species in the Caucasus and Mesopotamia, having been isolated in the Upper Miocene-Pliocene. Çiftci *et al.* (2020) gave a phylogeography of the genus in Anatolia using cytochrome *b*. *C. cyri* and *C. regium*, the only Iranian species examined, were in their own clades in different haplogroups. A *Regium* lineage (including *C. regium*) diverged from its sister group, the *Nasus* lineage (including *C. cyri*) approximately 4.77 MYA. Separation of *C. cyri* within the *Nasus* lineage occurred 1.37 MYA. Speciation events in the *Regium* lineage took place between the Late Pliocene and Early Pleistocene, a period coinciding with the uplifting of the Anatolian plateau 2.5-3.0 MYA.

This genus is characterised by being of moderate size, with a somewhat compressed body, scales of moderate to small size (44-106 in the lateral line (Robalo *et al.* (2007) gave a range of 52-78 for their more restricted genus)), scales squarish with radii in the anterior and posterior fields and a subcentral anterior focus, no barbels, an inferior and transverse or crescentic mouth with a cutting edge to the lower jaw, thin upper lip and no lower lip, pharyngeal teeth knife-like and in one row with a high count (5, 6 or 7, the same number on each arch or one more on the left or right), gill rakers short and moderately numerous (up to 40), a short dorsal fin without a thickened ray opposite the pelvic fins, 7-10 dorsal fin branched rays, a moderately elongate anal fin with 8-12 branched rays, deeply forked caudal fin and usually concave dorsal and anal fins, a pelvic axillary process always present, 42-49 total vertebrae, a black peritoneum, and a long, coiled gut. Elvira (1997) and Robalo *et al.* (2007) gave

osteological characters and Jouladeh-Roudbar (2014) gave an overview of the Iranian species using morphological and molecular characters.

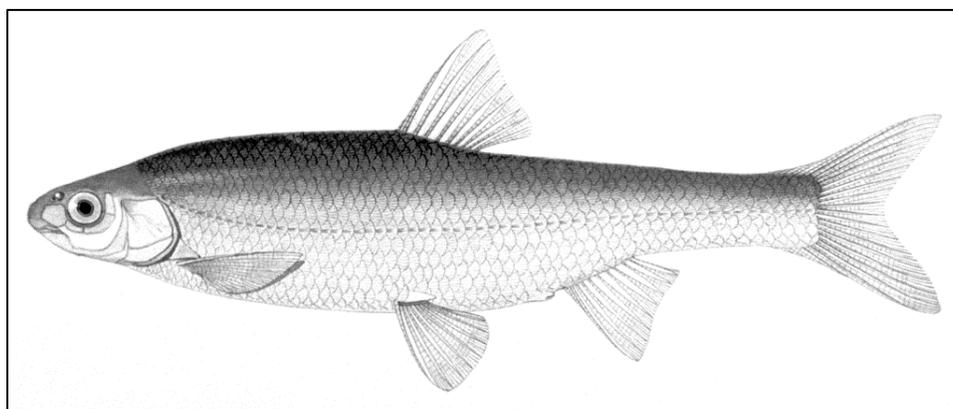
Bogutskaya (1997) placed the Iranian species, *C. regium* and *C. orientale*, in a group characterised by a straight or only slightly arched mouth cleft, high vertebral counts (total vertebrae modes 45-47 and abdominal modes 26-28) and often or commonly 4 unbranched rays in the dorsal fin.

These fishes exhibit trophic and habitat use morphological differences, from diet generalists to diet specialists for example, and show adaptive evolution (Corse *et al.*, 2015).

Species/ Characters	Dorsal fin branched rays	Lateral line scales	Total gill rakers	Lower jaw horny edge	Distribution
<i>C. cyri</i>	8	48-73	17-32	Present	Caspian Sea
<i>C. esmaeili</i>	8	51-58	15-17	Absent	Tigris River
<i>C. orientale</i>	8	47-57	25-34	Present	Kor River
<i>C. regium</i>	8-9	50-73	17-36	Present	Esfahan, Persis, Tigris River

### *Chondrostoma cyri*

Kessler, 1877



*Chondrostoma cyri*, Georgia, Kura River at Borzhomi (= Borjomi), after Berg (1932b).



*Chondrostoma cyri*, Iran, Aras River, March 2012, Keyvan Abbasi.



*Chondrostoma cyri*, Turkey, Kars Stream, Aras River basin  
(CC BY 4.0 after Kaya *et al.* (2020)).

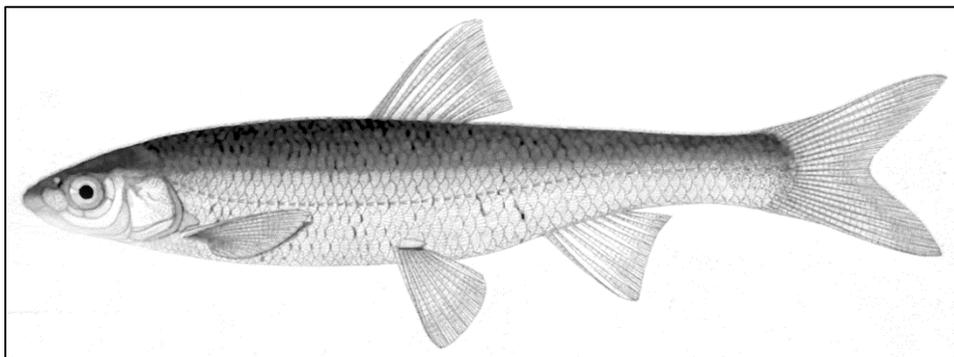
**Common names.** Mahi-ye nazok-e Aras (= slender Aras fish), shekamsiah-e Aras (= Aras black belly).

[Kur altagizi in Azerbaijan; Kura kababurunu in Turkish (Kaya *et al.*, 2020); chernobryushka or blackbelly, Kurinskii podust or Kura nase, uzkotelii Kurinskii podust, all in Russian; blackbelly undermouth, Kura nase, Kura undermouth, Southern Caspian nase].

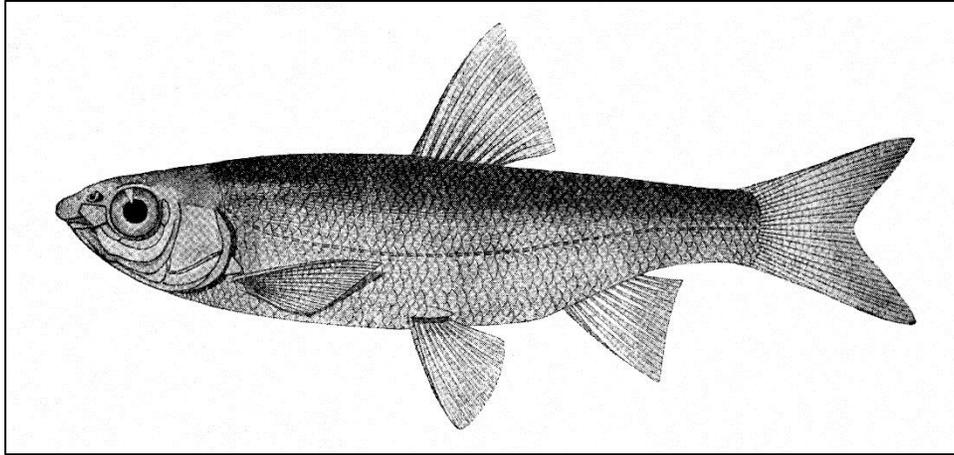
**Systematics.** Earlier works by Elvira (1986, 1988, 1991) placed this species as a subspecies of *C. oxyrhynchum* Kessler, 1877 but in Elvira (1997), using the phylogenetic species concept and following the studies of Smirnov (1992), this taxon was recognised as a species. *C. oxyrhynchum* is then found in more northerly rivers of the western Caspian Sea basin remote from Iranian waters. *C. cyri orientalis* Bianco and Banarescu, 1982 was described from Fars (see below under *C. orientale*).

*Chondrostoma cyri* Kessler, 1877 was described from the Kura River, Tiflis (= Tbilisi), Georgia and *Chondrostoma oxyrhynchum* from the Kuma River near Georgiyevsk, Russia in the Caspian Sea basin.

*Alburnus alasanicus* Kamensky, 1901 described in part from the Alasan, Alazan' or Alazani River, a left bank Kura River tributary in Georgia, *Chondrostoma schmidtii* Berg, 1910 from the Alazan' River at Naporiri and *Chondrostoma leptosoma* Berg, 1914 from the Kars-tchai, a tributary of the Aras River in Turkey, the Aras by Kopri-kei, near Erzurum, Turkey, and the lower Aras at Karadonly and Dzhulfa (latter on the Iran border, the Iranian town opposite being Julfa) in the former U.S.S.R. are synonyms of *C. oxyrhynchum* according to the *Catalog of Fishes* (downloaded 1 June 2021) but zoogeographically would seem to be *C. cyri* synonyms. *C. leptosoma* was founded on an elongate form from the Karasu in the Aras River basin. Berg (1948-1949) recognised *C. schmidtii* as distinct with *C. alasanicus* as a synonym.

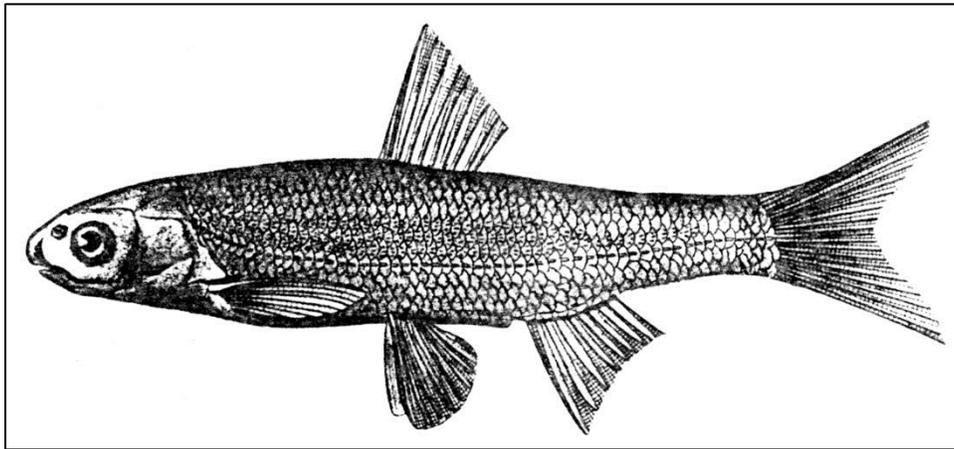


*Chondrostoma leptosoma*, syntype, 15.7 cm total length, ZISP 15516, Azerbaijan, Aras River at Dzhulfa (= Julfa), after Berg (1948-1949).



*Chondrostoma schmidti*, 10.6 cm total length, Georgia, Alazan' River at Naporiri, after Berg (1932).

Two syntypes of *Chondrostoma cyri* are under ZISP 10919 from “Tiflis” collected by Kessler in September 1875. A syntype of *Chondrostoma oxyrhynchum* is in the Zoological Institute, St. Petersburg (ZISP 2881) from “Fl. Sunsha” collected in 1830 by Ménétries. According to Elvira (1988), the type locality is the Kuma R. at Georgijewsk and two syntypes are under ZISP 10922. Another syntype of *Chondrostoma oxyrhynchum* is in the Natural History Museum, London (BM(NH) 1897.7.5:28, 184.8 mm standard length), formerly in ZISP, as is other syntype of *Chondrostoma cyri* (BM(NH) 1897.7.5:27, correctly numbered 27, 78.4 mm standard length), formerly in ZISP (Elvira, 1988; personal observations).



*Chondrostoma cyri*, syntype, after Kessler (1877).

Five syntypes of *Chondrostoma leptosoma* are in the Zoological Institute, St. Petersburg (ZISP 9098) according to (Elvira, 1988) but there are 15 syntypes under this number from the “Reka Araks”, 1888, Warpochowsky as well as additional material listed as syntypes with numbers ZISP 9099 (“Reka Araks”, 1888, Warpochowsky, 4 fish), ZISP 9107 (“Fl. Araxes”, 1888, Warpochowsky, 12 fish, but now 4 in the *Catalog of Fishes*, downloaded 1 June 2021), ZISP 5180 (“Kars-tschai”, 1879, Dr. A. Brandt, 3 fish), ZISP 15264 (“Reka Araks”, 20.III.1911, 2 fish), and ZISP 15516 (“Reka Araks near settlement Djulfa”, 17.VI.1911, 13 fish, but 6 in the *Catalog of Fishes*, downloaded 1 June 2021).

Two syntypes of *Alburnus alasanicus* may be in ZMT (S. Janashia State Museum of Georgia, Zoological Section, Georgian Academy of Sciences, Tbilisi, Georgia), none in the Zoological Institute, St. Petersburg, and no types are listed for *Chondrostoma schmidti* (*Catalog of Fishes*, downloaded 1 June 2021).

**Key characters.** This species is the only one in its genus in northern Iran and can be recognised by generic characters. The snout is long (25.5% of head length or more), dorsal fin branched rays are usually 8, anal fin branched rays usually 9-10, lateral line scales 48-73, and total gill rakers usually 21 or more.

**Morphology.** The body is moderately elongate and its depth exceeds head length. The body is deepest in front of the dorsal fin. The predorsal profile is convex. The dorsal head profile is straight to rounded. The caudal peduncle is compressed and moderately deep. The mouth is strongly arched, slightly wider than or as wide as the eye, with a thin horny layer on the lower jaw. Smaller fish have a u-shaped mouth. The snout projects slightly, overlapping the upper lip. Lips are of moderate thickness. The eye is in the anterior half of the head. The dorsal fin margin is straight. The dorsal fin origin lies over or anterior to that of the pelvic fin. The depressed dorsal fin reaches back level with the anal fin origin or falls short. The caudal fin is moderately forked, with pointed to rounded tips and the lower lobe larger. The anal fin is emarginate to straight and the fin does not reach back to the caudal fin base. The pelvic fin is rounded and does not extend back to the anus or just reaches the anterior anal papilla. The pectoral fin is rounded and does not extend back to the pelvic fin.

Kuru (1981) gave the following meristic characters for 103 specimens from the Aras and Kura river basins in Turkey:- 10-12 dorsal fin rays, 10-11 anal fin rays, 9-10 pelvic fin branched rays, 9-15 pectoral fin branched rays, and lateral line scales 52-62 with 13-18 scales around the caudal peduncle. There is clinal variation in scale numbers, the number increasing from south to north. Note that the statistical treatment in this paper is in error and the conclusion that species of *Chondrostoma* in Turkey are not distinct is therefore incorrect. There is a pelvic axillary scale. Scales are rounded in overall shape with indentations above and below a central, rounded protuberance on the anterior margin. The anterior margin may be wavy. There are few anterior and posterior radii, few circuli and a subcentral anterior focus. Total gill rakers number 17-32. There are 5-6 pharyngeal teeth on each arch. Elvira (1988, 1991) gave the total range for characters of this species as dorsal fin branched rays 7-9, usually 8, anal fin branched rays 8-10, usually 9-10, pectoral fin branched rays 13-18, usually 14-16, pelvic fin branched rays 7-8, usually 8, lateral line scales 50-68 (to 73 in Kazanchev (1981) and from 48 in Chikova (1967)), scales above the lateral line 7-10, usually 8-10, scales below the lateral line 3-6, usually 4-6, pharyngeal teeth 6-5 or 5-5, more rarely 6-6 and mode 6-5, and total gill rakers 21-29 (to 30 in Eagderi *et al.*, 2017). The gill rakers are short and reach the one below or just past it when appressed. Pharyngeal teeth are compressed and thin but deep with a long, thin and concave grinding surface. Teeth tips may be slightly hooked. The gut has numerous anterior loops. Total vertebrae number 43-45.

Thirteen specimens from Djulfa (presumably in Azerbaijan opposite the Iranian town across the Aras River) had dorsal fin branched rays 8(12) or 9(1), anal fin branched rays 9(9) or 10(4), and pharyngeal teeth 6-5(5) or 6-6(1).

Moezi and Keivany (2020) described the osteology of this species.

**Sexual dimorphism.** Unknown.

**Colour.** The flanks are silvery but may have dark pigment spots which may, or may not, form a stripe. Paired fins are orange to reddish and median fins grey to reddish. The dorsal and

caudal fins have dark margins. The peritoneum is black.

**Size.** Reaches 80.0 cm and about 5.0 kg.

**Distribution.** This species is found in the rivers draining to the western coast of the Caspian Sea principally the Kura and Aras river basins in the south. Recorded from the Aras River basin of Iran (Abdoli, 2000). Jouladeh Roudbar *et al.* (2014c) confirmed presence in the Aras River based on DNA barcoding.

**Zoogeography.** This genus has a European and Middle Eastern distribution. Its relationships to other taxa are poorly known.

**Habitat.** Found principally in streams and rivers, habitat details are unknown for Iran

**Age and growth.** Fish are mature at 2 years of age and life span is at least 5 years. Abbasi *et al.* (2019) gave a *b* value of 3.05 for 68 fish, 10.3-25.2 cm total length, from the Aras River.

**Food.** Diet is assumed to consist of bottom organisms including aquatic insect larvae, detritus and vegetation scraped from the substrate.

**Reproduction.** Up to 16,217 eggs are produced and maximum diameter is 1.69 mm. The spawning season is in the spring, peaking in April in the Kura River basin (Abdurakhmanov, 1962).

**Parasites and predators.** None reported from Iran.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Kiabi *et al.* (1999) considered this species to be conservation dependent, in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, possibly few in numbers, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and absent outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Type material:- *Chondrostoma cyri* (BM(NH) 1897.7.5:25), *Chondrostoma leptosoma* (ZISP 15516) and *Chondrostoma oxyrhynchum* (BM(NH) 1897.7.5:28).

Iranian material:- None.

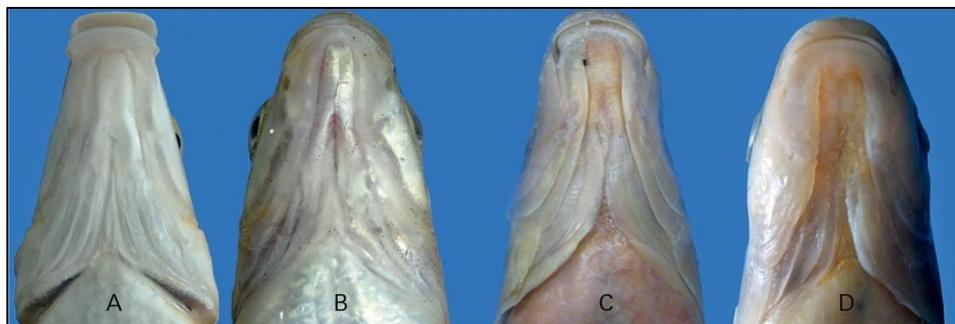
Comparative material:- CMNFI 1980-0812, 2, 101.9-107.9 mm standard length, Turkey, Kars, Selim Çayı (40°28'N, 42°47'E).

### *Chondrostoma esmaeilii*

Eagderi, Jouladeh-Roudbar, Birecikligil, Çiçek and Coad, 2017



*Chondrostoma esmaeilii*, paratype, 104.0 mm standard length, IMNRF-UT 1045-2, Kermanshah, Sarab-e Ravansar Stream, after Eagderi *et al.* (2017).



Ventral heads of *Chondrostoma* species, A = *C. regium*, 221.0 mm standard length, B = *C. esmaeili*, 125.0 mm standard length, C = *C. orientale*, 152.0 mm standard length, D = *C. cyri*, 207.0 mm standard length, after Eagderi *et al.* (2017).

**Common names.** None.

[Esmaeili's nase, Tigris nase].

**Systematics.** The holotype is deposited in the Ichthyological Museum of Natural Resources Faculty, University of Tehran under IMNRF-UT 1045-1, female, 136.4 mm standard length) from Kermanshah Province, Ravansar, Sarab-e Ravansar Stream, 34°42'38"N 46°39'14"E, and 10 paratypes, 91.0-120.3 mm standard length, are under IMNRF-UT 1045, same data as holotype. The species is named for and dedicated to Professor Dr. Hamid Reza Esmaeili, Shiraz University. Jafari *et al.* (2017) distinguished this species from *C. regium* morphometrically. Jouladeh-Roudbar *et al.* (2014, 2015) referred to an undescribed species from the Tigris River basin which was this species.

**Key characters.** This species is distinguished from the other species of the genus *Chondrostoma* in Iran and the Tigris-Euphrates River drainage by a combination of characters, including lacking a horny blade on the lower jaw, an arched mouth, a short rounded snout, 8 dorsal fin branched rays (9 in the holotype), 10 anal fin branched rays, a lower number of lateral line scales (mean 53.7, range 51-58), a lower number of scales above the lateral line (mean 8.4, range 8-9), a lower number of scales below the lateral line (mean 5.2, range 5-6), short and fewer gill rakers (mean 16.4, range 15-17) along the entire gill arch, and the snout is short and rounded (17.1-20.8 in % of head length versus 25.5% or more). It is also distinguished from other specimens from the Tigris and Euphrates rivers by cytochrome *b* gene characters (Jouladeh-Roudbar, 2014).

**Morphology.** The body is deep and compressed laterally with a marked nuchal hump. The body is deepest midway between the dorsal fin and the head. The dorsal profile of the head is straight and the dorsal profile of the body is convex. The caudal peduncle is compressed and deep. The mouth is subterminal. Dorsal and anal fin margins are slightly concave. The dorsal fin origin is slightly in advance of, or over, the pelvic fin origin level. The dorsal fin when pushed back does not extend to the level of the anal fin origin. The caudal fin is shallowly forked with rounded lobes. The pectoral and pelvic fins are rounded. The pelvic fins are under the anterior third of dorsal-fin base. The pelvic fins do not reach back to the anus and the pectoral fins do not reach back to the pelvic fins.

Meristic values are:- dorsal fin branched rays 8(10) or 9(1), anal fin branched rays 9(3) or 10(8), pectoral fin branched rays 15-17, and pelvic fin branched rays 8(11). Lateral line scales 51(1), 52(2), 53(3), 54(1), 55(3), 56(-), 57(-) or 58(1), scales above lateral line 8(7) or 9(4), scales below lateral line 5(9) or 6(2), and scales around caudal peduncle 14-16. There is a triangular pelvic axillary scale. Pharyngeal teeth are 6-6. Total gill rakers are 15(3), 16(2) or

17(8). Some populations of *Chondrostoma* in springs or sarabs of Kermanshah Province have relatively low gill raker counts, e.g., the Yavari Spring (18 rakers) (CMNFI 2008-0237) and Sarab Najibaran (20 rakers) (CMNFI 1993-0129) but the snout is long unlike in *C. esmaeili*. These fish are referred to *C. regium* while recognising further work needs to be done, particularly with molecular characters, to elucidate the status of these spring populations. Total vertebrae number 43.

**Sexual dimorphism.** Unknown.

**Colour.** In live fish, the back is olive-brown with greyish tinges and the flanks and belly are silvery-white. The dorsal, anal, pectoral and pelvic fins are orange with a hyaline posterior margin, the caudal fin is bold orange with black posterior margin and sometimes a dark brown base or a thin bar. In some specimens the dorsal fin has a black margin.

**Size.** Attains 136.4 mm standard length.

**Distribution.** Sarab-e Ravansar Stream, Kermanshah.

**Zoogeography.** A taxon currently restricted to a single spring and stream system within the Tigris River basin related to the more widespread *C. regium*.

**Habitat.** This species inhabits the Sarab-e Ravansar Stream where the current was slow to medium, width was 3-10 m, maximum depth was up to 0.8 m, the bed was muddy and, in some parts, sandy, and there was dense vegetation. The species *Carassius auratus*, *Alburnoides idignensis*, *Oxynoemacheilus kiabii* (Nemacheilidae), and *Gambusia holbrooki* (eastern mosquitofish) were also found in this stream.



Kermanshah, Sarab-e Ravansar Stream, after Eagderi *et al.* (2017).

**Age and growth.** Eagderi *et al.* (2020) examined 11 fish, 9.7-13.65 cm total length, from the Sarab-e Ravansar and found a *b* value of 3.37, positively allometric.

**Food.** Unknown but presumably similar to its relative *C. regium*.

**Reproduction.** None reported.

**Parasites and predators.** None reported.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Known only from a single spring and stream locality, this species is susceptible to loss and measures should be taken to conserve it.

**Sources.** Eagderi *et al.* (2017).

*Chondrostoma orientale*  
Bianco and Banarescu, 1982



*Chondrostoma orientale*, Fars, Kor River, Hamd Reza Esmaeili.

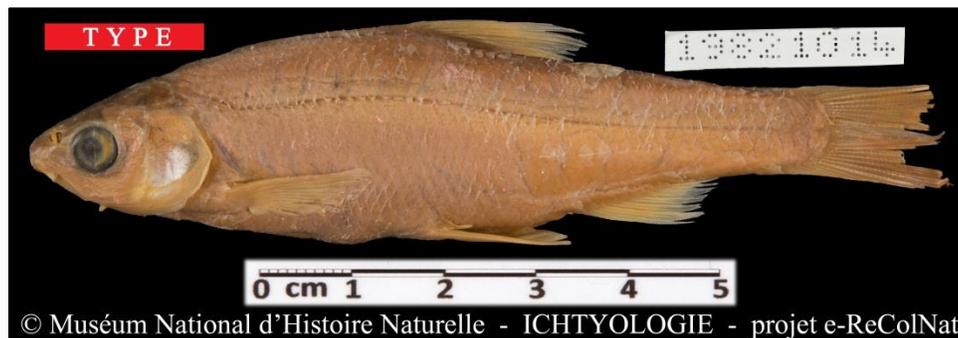
**Common names.** None.

[Kor nase, Oriental nase].

**Systematics.** *Chondrostoma cyri orientalis* Bianco and Banareescu, 1982 was originally described from the “Pulwar River near Persepolis”. Note that the author name Banareescu is spelled without accents in the type description.

Elvira (1988, 1991, 1997) considered *Chondrostoma orientale* to be a valid species while Nelva *et al.* (1988) retained it as a subspecies of *C. cyri*. Bianco and Banareescu (1982) placed *orientalis* in *C. cyri* on the basis of similar dorsal and anal fin ray counts, scale counts and, to a certain degree, pharyngeal tooth formula.

The holotype (IZA 8170, 93.7 mm standard length, examined by me) and 19 paratypes (IZA 7833, 51 specimens under this number, 35.4-90.1 mm standard length) of *Chondrostoma cyri orientalis* are in the Istituto di Zoologia dell'Università di L'Aquila, Italy (Elvira, 1988). Two paratypes of *Chondrostoma cyri orientalis* are stored in the Field Museum of Natural History, Chicago (FMNH 94519) (Ibarra and Stewart, 1987), one paratype is in the Muséum national d'Histoire naturelle, Paris (1982-1014), one paratype is in the United States National Museum, Washington (USNM 227934), two paratypes are in the Academy of Natural Sciences, Philadelphia (ANSP 150985), and six paratypes are in the Canadian Museum of Nature, Ottawa (CMNFI 1982-0365 (cited under the old acronym as NMC 82-365 in the *Catalog of Fishes*, downloaded 15 May 2018), formerly IZA 7833, 37.8-88.7 mm standard length). The total number of paratypes is 75, originally under IZA 7833 but some dispersed as noted above, with 10 further fish in the Institutul de Stiinte Biologice, București, Romania (ISBB) but uncatalogued (Bianco and Banareescu, 1982).



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*Chondrostoma cyri orientalis*, paratype, MNHN 1982-1014, L. Randrihasipara  
(CC BY 4.0).



*Chondrostoma cyri orientalis*, paratype, CMNFI 1982-0365,  
Bronwyn Jackson @ Canadian Museum of Nature.

**Key characters.** This is the only *Chondrostoma* species in the Kor River basin. Dorsal fin branched rays usually 8 (usually 8-9 in *regium*), anal fin branched rays usually 9 (usually 9-11) and lateral line scales 47-57 (50-69).

**Morphology.** The body is rounded and moderately deep, being deepest at the dorsal fin origin. A nuchal hump probably develops in large fish. The caudal peduncle is compressed and moderately deep. The predorsal profile is convex. The dorsal head has a straight to slightly rounded profile. The snout is rounded and overlaps the upper lip. The eye lies in the anterior half of the head. The subterminal mouth is a shallow arch with a horny edge and reaches back level with the posterior nostril edge. Lips are of moderate size. The dorsal fin margin is straight to slightly concave. The dorsal fin origin is slightly to obviously anterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back almost to, or to, the beginning of the level of the anal fin origin. The caudal fin is moderately forked with rounded tips, the lower lobe being more rounded. The anal fin is slightly emarginate and does not reach back to the caudal fin base. The pelvic fin is rounded and extends almost to the anus in some fish, more remote in others. The pectoral fin is rounded and does not extend back to the pelvic fin origin.

Dorsal fin unbranched rays 3, branched rays 7-9, usually 8, anal fin unbranched rays 3, branched rays 9-10, pectoral fin branched rays about 16, and pelvic fin branched rays 7-9. Lateral line scales 47-57. Scales are a vertical oval in shape with a rounded posterior margin, short, rounded and wavy dorsal and ventral margins, and a wavy anterior margin with the dorsal and ventral corners pointed. The focus is subcentral anterior and circuli are fine. There are few anterior radii in some with more posterior radii or the anterior and posterior numbers are similar. Total gill rakers number 22-28, 22-30 or 28-32 by different authors (some lower counts may be lower arch rakers only) and see below. Pharyngeal teeth are 6-6. Total vertebrae number 42-45. Moezzi *et al.* (2020) described the osteology of this species and compared it to a European species, *C. nasus*.

Meristic values are:- dorsal fin branched rays 7(1) or 8(30), anal fin branched rays 9(23) or 10(8), pelvic fin branched rays 7(1), 8(29) or 9(1), lateral line scales 49(1), 50(2), 51(3), 52(8), 53(3), 54(7), 55(3), 56(-) or 57(4), scales above lateral line 8(9), 9(19) or 10(3), scales below lateral line 5(22), 6(8) or 7(1), total gill rakers 25(1), 26(-), 27(1), 28(6), 29(6), 30(6), 31(4), 32(1), 33(1) or 34(1), pharyngeal teeth 6-6(19), and total vertebrae 42(5), 43(20), 44(5) or 45(1).

**Sexual dimorphism.** Unknown.

**Colour.** Preserved fish have a dark back which becomes lighter ventrally often with the

pigmentation ceasing just below the lateral line. The belly may appear dark from the underlying dark peritoneum. The back may have pre- and postdorsal stripes but these are not always evident. The head is dark dorsally and the underside is immaculate. Pigment is present broadly behind the eye and narrowly below it. Pigment lines the rays of the dorsal, caudal and pectoral fins while the anal and pelvic fins are immaculate or only weakly pigmented.

**Size.** Attains 17.0 cm total length.

**Distribution.** This species is found in the Kor River basin including the Kor, Pulvar and Shad Kam rivers, the Ghadamgah Spring-Stream system, and the Kaftar Wetlands (Barzegar and Jalali, 2002; Rahimi and Tabiee, 2013).



Fars, Ghadamgah Stream (Sedeh2, CC BY-SA 4.0, Farsinevisaneiran).

**Zoogeography.** This species is related to its congener in the Tigris-Euphrates basin and presumably entered and became isolated in the Kor River basin by headwater capture.

**Habitat.** Recorded from springs, streams and rivers, pools, and even ditches. Collection data included a temperature range of 9.8-20°C, pH 6.8-7.0, conductivity 0.6-1.0 mS, river width 10-50 m, slow to medium current, depth 1.5 m, clear, cloudy or muddy water, mud, sand, gravel or pebble bottoms, submergent, emergent and floating vegetation including rushes and reeds, and a grassy shore.

**Age and growth.** Unknown.

**Food.** Unknown.

**Reproduction.** None reported.

**Parasites and predators.** Barzegar and Jalali (2002) reported parasites in this species from Kaftar Lake as *Unio* sp., *Lernaea cyprinacea*, *Ichthyophthirius multifiliis* and *Diplostomum spathaceum*. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea cyprinacea* on this species (as *C. regium*). Sayyadzadeh and Joladeh Roudbar (2014) recorded the copepod *Lernaea cyprinacea*, accidentally introduced to Iran with exotic fish species, from this species in the Kor River basin. The presence of pelicans on the Kor River may indicate feeding on this species (see photograph in description of this basin in Volume I).

**Economic importance.** None.

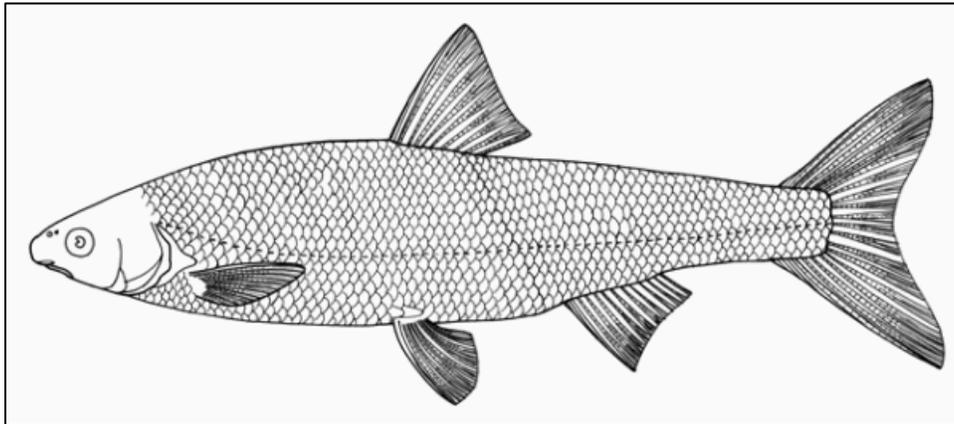
**Experimental studies.** None.

**Conservation.** Sayyadzadeh and Joladeh Roudbar (2014) noted that during the past 10 years only three specimens were collected from Kor River basin, in 2005, and it is therefore quite rare. The reasons for this decline are unknown specifically but presumably include drought, water diversions, pollution and similar factors affecting Iranian fishes generally. Simple gear (a small seine net) in shallow water caught this species easily in the 1970s (see below).

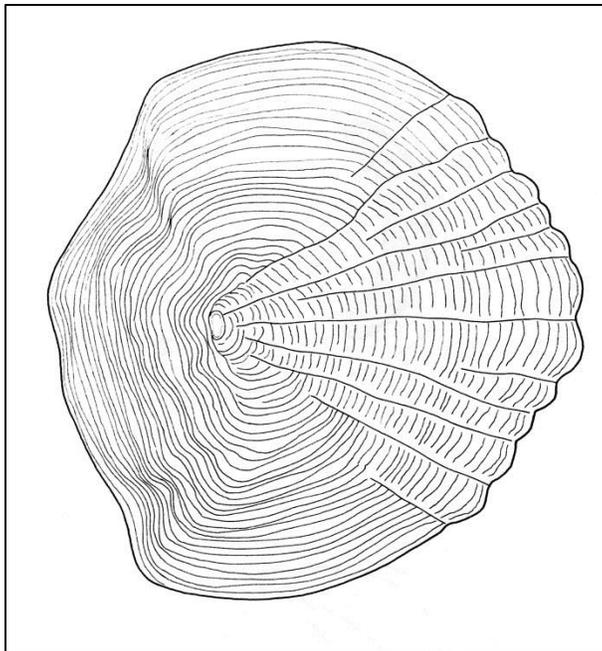
**Sources.** Type material:- *Chondrostoma cyri orientalis* (CMNFI 1982-0365, IZA 8170 and IZA 7833).

Iranian material:- CMNFI 1979-0025, 16, 22.1-119.0 mm standard length, Fars, Kor River at Marv Dasht (29°51'N, 52°46'30"E); CMNFI 1979-0028, 14, 32.2-139.1 mm standard length, Fars, Zarqan, Kor River drainage (no other locality data); CMNFI 1979-0059, 1, 72.2 mm standard length, Fars, Pulvar River 8 km south of Sivand (30°01'30"N, 52°57'E); CMNFI 1979-0061, 14, 9.5-56.5 mm standard length, Fars, stream tributary to Pulvar River (30°04'N, 53°01'E); CMNFI 1979-0117, 1, 77.8 mm standard length, Fars, Pulvar River at Naqsh-e Rostam (29°59'N, 52°54'E); CMNFI 1979-0499, 1, 113.0 mm standard length, Fars, irrigation ditch 32 km from Kor River bridge (30°04'30"N, 52°36'E); CMNFI 1979-0500, 7, 94.8-110.5 mm standard length, Fars, Pulvar River at Naqsh-e Rostam (29°59'N, 52°54'E); CMNFI 2008-0246, 2, 118.7-133.1 mm standard length, Fars, stream at Sepidan (29°58'19"N, 52°24'04"E).

*Chondrostoma regium*  
(Heckel, 1843)



*Chondrostoma regium*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Chondrostoma regium*, scale,  
Freidhelm Krupp.



*Chondrostoma regium*, Hamadan, Haramabad, Gamasiab River,  
January 2010, Keyvan Abbasi.



*Chondrostoma regium*, Chahar Mahall and Bakhtiari, Gandoman Wetland,  
Hamid Reza Esmaeili.

**Common names.** Jokhorak (= barley eater, possibly barley or barely, Y. Keivany, pers. comm., 25 September 2018), nazak or nazok (= slender), mahi-ye nazok-e jonoub (= southern slender fish), nazi (= cute, Y. Keivany, pers. comm., 25 September 2018); heif-e nan (= waste of bread, i.e., valueless) in Khuzestan; kapur puzeh dar (= longnose carp, Y. Keivany, pers. comm., 25 September 2018), siah deem in Behbahan; siah dom (= blacktail).

[Baloot muluki, pangki; zurri (= the harmful one) at Mosul (also used for *Alburnus sellal*, Oriental killifishes (Aphaniidae), *Gambusia* (Poeciliidae) and any small fishes or large fishes when young); terris or terris achmar meleki (meaning royal red terris) at Aleppo (= Haleb, Syria), all in Arabic; based on Heckel (1843b) for zurri and terris; Kababurun or Kababurun balığı in Turkish and Zul (local name in eastern Turkey) (Çiçek *et al.*, 2020; Kaya *et al.*, 2016); broad snout, king nase, Mesopotamian nase].

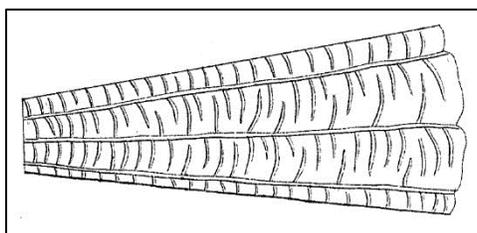
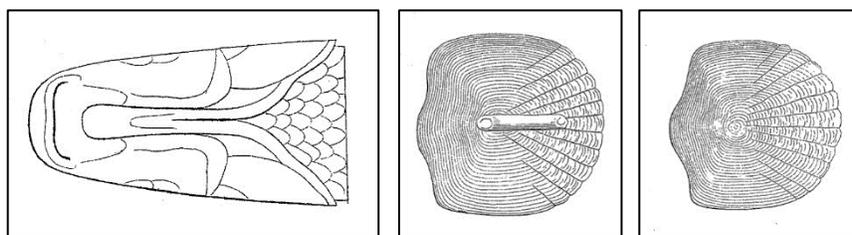
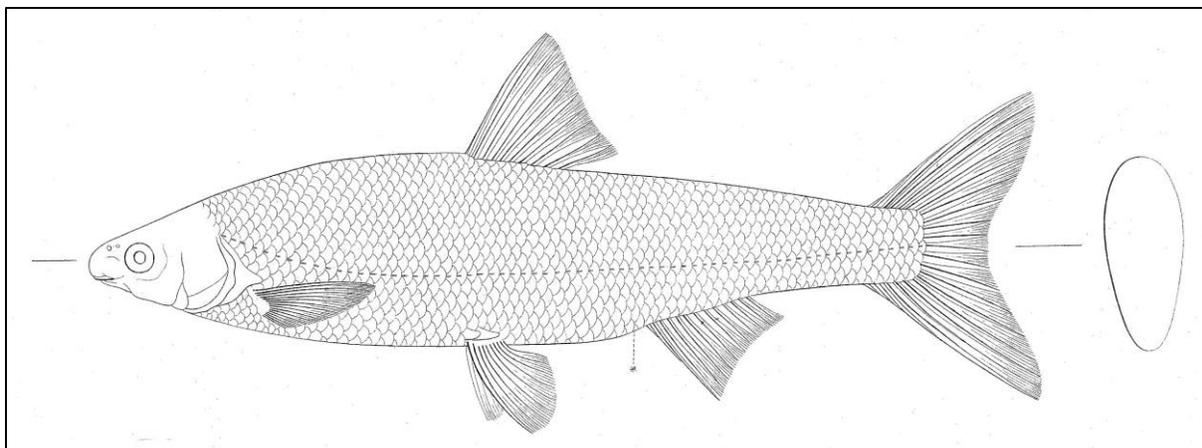
**Systematics.** *Chondrochilus regius* Heckel, 1843 was described from the "Orontes" (= Asi) (but see below) and "Tigris".

Banarescu (1960) regarded *C. regium* as only a race of a widespread species, *C. nasus* (Linnaeus, 1758). *C. nasus* has larger scales on average and 6-6 pharyngeal teeth (Berg, 1949); Heckel (1847c) found 47 *C. nasus* from the Danube River had 6-6 teeth, two had 6-7 and two had 5-6 while in 13 *C. regium* the count was 7-6 in 12 fish and 6-6 in one fish. Krupp (1985c) considered *C. regium* to be distinct while recognising the small degree of morphological variation between species in this genus. Data gathered for Iran show a wide range in scale and teeth counts (see below). Ladiges (1960) identified specimens from the same bodies of water in Turkey as members of both species. The earlier literature on the systematics of this genus remains confused (see Elvira (1988) for comments on Ladiges (1966) and Kuru (1981)). There may well be significant variation of a clinal nature, altitude and temperature may be important, and habitat types (lentic or lotic) may affect body form.

Yousefian *et al.* (2013) were able to separate populations in three headwater streams of the Gamasiab River basin by length and biological parameters using principal components analysis. Jouladeh Roudbar *et al.* (2014a, 2014b) found Iranian Tigris River basin populations could be separated on morphometry, compared to meristics, and attributed the differences to environmental and habitat conditions. Khalaji *et al.* (2015) found a high divergence in morphological characters in the Sefid-barg River, Kermanshah Province. Soghly and Hashemzadeh Segherloo (2015) barcoded fish from four localities in the Karun River basin and one in the Sirvan River basin and found the Karun samples to be monophyletic and distinct from the Sirvan samples.

Saadati (1977) referred to an unknown species of *Chondrostoma* from Kermanshah (CMNFI 2007-0113) here identified as *C. regium*.

Twelve syntypes of *Chondrochilus regium* are in the Naturhistorisches Museum Wien (seven fish as NMW 52532-52535 from the Quwayq (= Kueik) River near Aleppo and five fish as NMW 52536-52538 from the Tigris River near Mosul) (Elvira, 1988). Krupp (1985c) gave further details. All material was collected by Th. Kotschy in 1842 from the Quwayq and in 1843 from Mosul and the range in standard length for the fish from the Quwayq is 102-166 mm and from Mosul 119-241 mm. The Vienna catalogue listed only six fish but the card catalogue in 1997 listed NMW 52532 (2 fish), 52533 (2), 52534 (2), 52535 (1), 52536 (2), 52537 (1) and 52538 (2) as syntypes. The type locality "Orontes" (= Asi) in Heckel (1843b) seems to be an error.

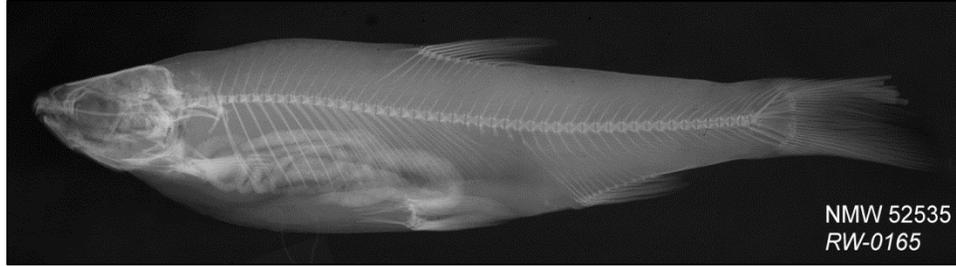


*Chondrochilus regius*,

body and cross-section, ventral head, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Chondrochilus regius*, syntype, NMW 52535, Naturhistorisches Museum, Wien.



*Chondrochilus regius*, syntype, NMW 52535, Naturhistorisches Museum, Wien.

**Key characters.** This species is found in the Esfahan, Persis and Tigris River basins. Dorsal fin branched rays 8-9 (8 in *orientale*), anal fin branched rays usually 9-11 (usually 9) and lateral line scales 50-73 (47-57).

**Morphology.** The body is elongate, oval and deepest at the dorsal fin origin. Large fish may develop a nuchal hump. The predorsal profile is convex. The caudal peduncle is compressed and relatively deep. The dorsal head profile is straight to a rounded snout. The snout overlaps the upper lip. The eye is in the anterior half of the head. The mouth is subterminal, has a well-developed keratinised edge and is straight to slightly arched. It extends back level with the nostril. Young fish have a more u-shaped mouth. Lips are moderately thick. The dorsal fin is emarginated in adults, slightly emarginate to rounded in young. The dorsal fin origin is anterior to the level of the pelvic fin origin. The depressed dorsal fin does not extend back as far as the anal fin origin level. The caudal fin is moderately forked with rounded to pointed tips. The anal fin margin is slightly concave to straight and the fin does not extend back to the caudal fin base. The pelvic fin is rounded and does not reach back to the anal opening but reaches the anal papilla. The pectoral fin is rounded and does not reach back to the pelvic fin origin.

Dorsal fin branched rays 8-11, mode 9 (note that Bogutskaya (1997) gave a mode of 10), anal fin branched rays 8-12, mode 11 (note that Bogutskaya (1997) gave modes of 11 or 12), pectoral fin branched rays 14-18, mostly 15-17, and pelvic fin branched rays 6-9, mostly 8. Lateral line scales 50-73, scales above the lateral line 9-13, and scales below the lateral line 5-6. Scale radii are few and restricted to the posterior field. The scale focus is near the anterior scale edge (Küçük *et al.*, 2017) but see figure above, and for general shape. Total gill rakers number 17-36 (ranges in single studies, presumably to a consistent technique, are 22-34, 24-31, 25-32, 25-34 and 25-36; but see my counts below). Counts for the whole arch on Iranian fish give a wide range of 18-34, highly correlated with size, larger fish having more (or more discernible) rakers than smaller fish ( $r = 0.5049$ ,  $p < 0.001$ ,  $n = 90$ ). Pharyngeal teeth are 5-5, 6-5, 6-6, 6-7, 7-5, 7-6 or 7-7, mode 6-6 or 7-6 but see below for Iranian fish. Total vertebrae number 42-49. A syntype shown above, NMW 52535, has 48 total vertebrae.

Moezi *et al.* (2019) described the osteology of fish from the Jarrahi, Karkheh and Karun rivers.

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(35), 9(46) or 10(1), anal fin branched rays 8(4), 9(45), 10(21), 11(9) or 12(3), and pelvic fin branched rays 7(3), 8(77) or 9(2). Lateral line scales 50(1), 51(5), 52(3), 53(12), 54(5), 55(6), 56(5), 57(4), 58(4), 59(8), 60(7), 61(6), 62(5), 63(3), 64(3), 65(1), 66(2), 67(1), 68(-) or 69(2). Total gill rakers 18(1), 19(2), 20(11), 21(7), 22(10), 23(1), 24(1), 25(3), 26(7), 27(6), 28(3), 29(3), 30(1), 31(4), 32(1) or 33(1). Pharyngeal teeth 5-5(15), 6-5(12), 6-6(13) or 7-6(3). Total vertebrae 42(1), 43(20), 44(17), 45(9), 46(14), 47(10), 48(9) or 49(2). Esmaeili *et al.* (2010) gave a diploid chromosome number of  $2n = 52$  with 21 pairs of sub-metacentric and five pairs of sub-

telocentric chromosomes from the Fahlian River in Fars. The arm number was 58. Other *Chondrostoma* species have  $2n = 50$ .

**Sexual dimorphism.** A specimen from CMNFI 2008-0102 with a low gill raker count (ca. 21) but a long snout (see comments above under *C. esmaeili*) had the following tuberculation. Small tubercles present over entire head including lower surface; dorsally these tubercles are interspersed with larger tubercles. Scales anterodorsally, on the anterior belly and on the caudal peduncle have a tubercle row lining the posterior scale margin and on the anterior exposed scale; belly scales often lack margin tubercles but have them scattered over the scale surface. All fins have tubercles on the rays. These are best developed on the pectoral fin where they form two rows anteriorly, becoming one row on the posterior rays.

**Colour.** The back is olive-brown with bluish tinges and the flanks and belly are silvery-white. The dorsal and caudal fins are greyish to brownish and the other fins hyaline to brownish. Some fish have bright orange fins, the pectorals paler, the pelvics and anal fins fringed by white. The dorsal and caudal fins have a black margin, wide on the caudal. These fin colours give them a flag-like effect (Heckel, 1843b). The caudal fin can be orange, distally black, with the extreme edge white in freshly dead fish.

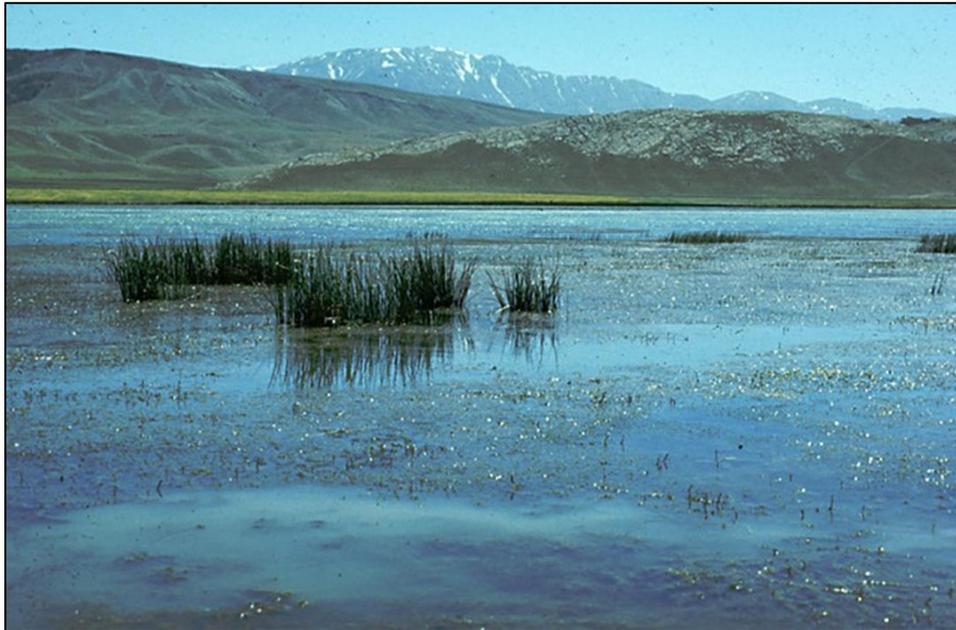
**Size.** Attains 40.0 cm and 1.0 kg.

**Distribution.** This species is found in the Tigris-Euphrates basin of Turkey, Syria, Iraq and Iran and in the Esfahan and Persis basins of Iran. Mohamed and Abood (2016) reported it for the first time from the Shatt al Arab, Iraq. In Iran it is found in the Esfahan basin in the Dimeh Spring, a tributary of the Zayandeh River, and the Zayandeh River and Dam; in the Persis basin in the Fahlian, Kheyraabad, Tang-e Shiv (Tang-e Shib) and Zohreh rivers; and in the Tigris River basin in the Ab-e Shalamzar (in the Khersan River basin), Ab-e Jahan Bin, Abloun, Agh Bolagh, Alvand, Aran, Armand, Arvand, Bazoft, Beheshtabad, Beshar, Bibi-Sayyedon, Dehno (= Deh Now), Dez, Dinorab, Dinvar, Diyala, Do Ab, Eivashan (= Eushan), Gahar, Gamasiab, Gangir, Garavand, Garus, Haramabad, Harud, Jagiran, Jarrahi, Kaaj, Kahman (as *C. orientalis*), Kahnak, Kalwi, Kangavar Kohneh, Karkheh, Karun, Kashkan, Kharchang, Khersan, Khorram (Khorramabad), Kiar, Kuhrang, Leleh, Mar Bor, Marun, Mehr Gerd, Nahr-e Shavor, Nokhor, Qareh Su, Qodarkabk, Ravansar, Razavar (= Raz Avar), Sarab, Sarab-e Maran, Sefid-barg, Sesar, Shalamzar, Shur, Silakhour, Simareh, Sirvan, Sulgan, Talkhab and Zard rivers, springs (sarabs) near Kermanshah, Sarab Nilofar, Javari Spring near Ravansar, in the Dez and Karkheh dams, the Hawr al Azim, the Choghakor (= Chagha Khur), Gandoman, Hashilan and Khondab wetlands, and the Bisheh-Dalan, Gamasiab, Haramabad and Pir Salman wetlands in Hamadan Province (Wossughi, 1978; Abdoli, 2000; Ghorbani Chafi, 2000; Fadaei Fard *et al.*, 2001; Eskandari *et al.*, 2007; Sadeghinejade Masouleh, 2008; Abbasi *et al.*, 2009; Biokani *et al.*, 2011; Kiani *et al.*, 2012; Biukani *et al.*, 2013; Raissy *et al.*, 2013; Dadashi *et al.*, 2014; Jouladeh Roudbar *et al.*, 2014a, 2015; Mahboobi Soofiani *et al.*, 2014; Marammazi *et al.*, 2014; Ramin *et al.*, 2014; Tabiee *et al.*, 2014; Zare *et al.*, 2014b; Abdolhahi, 2015; Esmaeili *et al.*, 2015; Khalaji *et al.*, 2015; Pirshaeb *et al.*, 2015; Soghly and Hashemzadeh Segherloo, 2015; Taghavi Niya and Velayatzadeh, 2015; Zamaniannejad *et al.*, 2015; Jouladeh-Roudbar *et al.*, 2016; Peykanheraty *et al.*, 2016; Taghiyan *et al.*, 2016; Keivany *et al.*, 2017; Mirzergar and Kuilvand, 2017; Pirali Khirabadi *et al.*, 2017; Beyraghdar Kashkooli *et al.*, 2018; Ebrahimi Dorche *et al.*, 2018; Keivany *et al.*, 2018a, 2018b; Nasri and Eagderi, 2018; Fatemi *et al.*, 2019; Golchin Manshadi *et al.*, 2019; Khamees *et al.*, 2019; Nasri, 2021).

**Zoogeography.** See above under the genus.

**Habitat.** This species is found in rivers, streams, pools, lakes, reservoirs and springs but

habitat requirements have not been studied in Iran in detail. Khalaji *et al.* (2015) noted that it is found at 21-30°C. Ünlü (2006) reported that this species prefers stone grounds and still waters in rivers and lakes in Turkey. Ghanbary *et al.* (2014) found Gamasiab River fish at 7.5-32°C. Mohammadi *et al.* (2019) found that higher water temperature and pH are stressful to this species and it lacks the physiological plasticity to cope with global warming and water acidification. Collection data included a temperature range of 14-29°C, pH 6.0-6.8, conductivity 0.2-1.75 mS, river width 1-75 m (and pool width 300 m), still to fast current, water depth 40-200 cm and deeper, clear and colourless, clear and brown-tinged, cloudy or muddy water, mud, clay, sand, gravel, pebble, stone, boulder or bedrock bottoms, encrusting, submergent such as *Myriophyllum*, emergent such as rushes, and floating vegetation, and a grassy, bushy or forested shore.



Habitat of *Chondrostoma regium* (and type locality of the aphaniid *Esmaeilius vladykovi*), CMNFI 1979-0247, Chahar Mahall and Bakhtiari, pool west of Boldaji (Chagha Khur Lake), 9 June 1977, Brian W. Coad.



Habitat of *Chondrostoma regium* (and *Alburnoides idignensis*, *Alburnus sellal*, *Barbus lacerta*, *Capoeta cf. shajariani* and *Garra rufa* among cyprinoids), CMNFI 2008-0175, Lorestan, Kahman River at Dow Ab-e Aleshtar, 3 December 2000, Brian W. Coad.



Habitat of *Chondrostoma regium*, Chahar Mahall and Bakhtiari, Behestabad River, Yazdan Keivany.

**Age and growth.** Yousefian *et al.* (2013) found fish up to 6 years old in headwater streams of the Gamasiab River basin. Ghanbary *et al.* (2014) examined 297 fish, 11.7-26.1cm

total length, from the Gamasiab River in the Bisotun region. Age range was 1-5 years, von Bertalanffy growth equations were  $L_t = 316[1 - e^{-0.25(t+0.577)}]$  in females and  $L_t = 306[1 - e^{-0.21(t+0.61)}]$  in males, and the length-weight relationship was  $W = 8 \times 10^{-6} L^{3.05}$  for males and  $W = 6 \times 10^{-5} L^{2.687}$  for females. Abbasi *et al.* (2019) gave a  $b$  value of 3.03 for 135 fish, 3.3-21.6 cm total length, from the Gamasiab River. Zare *et al.* (2014b) found a  $b$  value of 2.998 (isometric growth) for 95 fish in the Dez River and a condition factor of 0.69. Khalaji *et al.* (2015) found an age range of 2-4 years in fish from Sefid-barg River, Kermanshah Province. Valikhani *et al.* (2020) combined fish from the Shadegan Wetland and the Dez and Karkheh rivers and reported a  $b$  value of 2.65 (isometric growth) and a condition factor of 3.05 for 406 fish (3.4-13.5 cm total length).

Mahboobi Soofiani *et al.* (2014) examined a sample numbering 221 fish, 10.5-19.7 cm fork length, from the Dimeh Spring region in the Zayandeh River basin. The maximum age of females was 5 years and males 4 years. von Bertalanffy growth equations were  $L_t = 246[1 - e^{-0.206(t-0.034)}]$  and  $W_t = 163.29[1 - e^{-0.206(t-0.034)}]^{2.77}$  for females and  $L_t = 253.1[1 - e^{-0.206(t-0.175)}]$  and  $W_t = 188.25[1 - e^{-0.206(t-0.175)}]^{2.99}$  for males. Female:male ratio was 1.8:1. Growth was isometric for males and negative allometric for females. Weights and lengths were less than other populations, perhaps due to age structure, ecology or fishing gear used. Lake populations may attain a larger size than this riverine one. Beyraghdar Kashkooli *et al.* (2018) assessed age and growth for 63 fish from the upper Zayandeh River and found four age groups of 2 to 5 years with most fish aged 3 to 4 years, a length-weight relationship of  $W = 0.009SL^{3.21}$ , the most reliable von Bertalanffy growth model was scale-based (as opposed to otolith- and vertebra-based) and was  $L_t = 303(1 - e^{-0.11(t-0.34)})$ . Beyraghdar Kashkooli *et al.* (2019) demonstrated the relationship between otolith weight and age in Zayandeh River fish.

Keivany *et al.* (2015) gave a  $b$  value of 3.1 (positive allometric growth) for 335 fish, 3.32-23.1 cm total length, from the Beheshtabad River, in the Karun River basin. Keivany *et al.* (2018a, 2018b) also examined these 335 fish from the Beheshtabad River and found males to be 8.04-22.1 cm and 5.2-105.0 g, females were 7.84-23.15 cm and 8.7-155.0 g, males were in age classes 1<sup>+</sup>-5<sup>+</sup> and females 1<sup>+</sup>-6<sup>+</sup> with age class 3<sup>+</sup> dominant, the male:female sex ratio was 1:1.3 and was significantly different with females dominating in all age groups, the length-weight relationship for males, females and all individuals was as  $W = 0.0089L^{3.045}$ ,  $W = 0.0082L^{3.109}$  and  $W = 0.0107L^{3.0}$  respectively, indicating positive allometric growth pattern for the females and isometric growth for the males and all fish combined, the age-length and age-weight relationships in males and females were estimated as  $L_t = 26.23[1 - e^{-0.267(t+0.483)}]$ ,  $W_t = 160.77[1 - e^{-0.267(t+0.483)}]^{3.045}$  and  $L_t = 31.89[1 - e^{-0.148(t+2.067)}]$ ,  $W_t = 266.11[1 - e^{-0.148(t+2.067)}]^{3.109}$ , respectively, the growth performance index ( $\Phi'$ ) value was 3.84 in males and 2.18 in females, indicating a faster growth rate in males, and the mean condition factor was 1.02 for males and 1.14 for females and higher in spring than in fall.

Keivany *et al.* (2016) gave a  $b$  value for 335 fish, 5.95-23.15 cm total length, from the Bibi-Sayyeddan River, Semirom of 3.0864. Kiani *et al.* (2016) examined 471 fish, 5.5-21.5 cm total length, from the Bibi-Sayyeddan River and found a length-weight relationship of  $W = 0.007L^{3.088}$  for males,  $W = 0.007L^{3.086}$  for females and  $W = 0.007L^{3.079}$  for all fish, indicating positive allometric growth. Males were smaller than females perhaps due to halting of growth at maturity and higher male mortality. Age range was 1<sup>+</sup> to 4<sup>+</sup> years in males and 1<sup>+</sup> to 5<sup>+</sup> in females with some 0<sup>+</sup> fish undetermined as to sex. The 3<sup>+</sup> year class dominated in both sexes. The sex ratio was 1:2.3 with females dominant in all age groups and capture months. von Bertalanffy growth equations for length were  $L_t = 18.97[1 - e^{-0.279(t+0.58)}]$  in males and  $L_t = 23.85[1 - e^{-0.196(t+0.535)}]$  in females and for weight were  $W_t = 61.91[1 - e^{-0.279(t+0.58)}]$  in males and  $L_t =$

124.75[1-e<sup>-0.196(t+0.535)</sup>] in females. Growth parameters were  $L_{\infty} = 18.97$  cm,  $t_0 = -0.58$  year,  $K = 0.279$  year<sup>-1</sup> and  $\Phi' = 2.35$  in males and  $L_{\infty} = 23.87$  cm,  $t_0 = -0.535$  year,  $K = 0.196$  year<sup>-1</sup> and  $\Phi' = 2.23$  in females. Males showed a higher growth rate than females. Fish from the Bibi-Sayyedana River showed relatively slower growth than other populations.

Khalaf *et al.* (1986) studied 255 specimens of this species in the Diyala River, Iraq. Maximum age group was 7<sup>+</sup> years, males and females showed no difference in weight at the same length and samples from three adjacent areas showed no major differences in growth rates. Length-weight relationship was  $W = 0.0480L^{2.49}$ . Males matured at 15.0 cm and females at 19.0 cm in the Diyala River at Rustamiyah in Iraq (Allouse *et al.*, 1986). A population at Al Kadhmia north of Baghdad in the Tigris River had four age classes dominated by the 3-year age class, with all fish being sexually mature during the second year. Fish smaller than 15 cm for males and 17 cm for females were immature. The disparity in age structure with the Diyala River population was attributed to pollution in the Diyala (Daoud and Qasim, 1999). Jasim and Ahmed (2009) recorded this species as dominant in the catch at Mosul, Iraq.

Polat and Gümüş (1995) aged a population of this species in the Bafra Altınkaya Dam in Turkey using vertebrae, otoliths, scales, opercles and subopercles. Age reached 5, perhaps 6, years. Polat *et al.* (1999) found a similar age range in the Suat Uğurlu Dam, Turkey with annulus (hyaline ring) formation in October to February. Oymak (2000) examined growth characteristics of this species in the Atatürk Dam on the Turkish Euphrates River. Eight age groups were found and age-length and age-weight equations given for females and males were  $L_t = 38.67[1 - e^{-0.136126(t+3.073799)}]$ ,  $W_t = 527.52[1 - e^{-0.136126(t+3.073799)}]^{3.1986}$  and  $L_t = 35.01[1 - e^{-0.168137(t+2.754214)}]$ ,  $W_t = 724.73[1 - e^{-0.168137(t+2.754214)}]^{3.2779}$  respectively. The length-weight relationships were obtained as  $\text{Log } W = -5.4153 + 3.1986 \text{ Log } \text{FL}$  in females and  $\text{Log } W = -5.6212 + 3.2779 \text{ Log } \text{FL}$  in males. The condition factor was high in age group 7 and high in April and May, lowest in December and January. Gümüş *et al.* (2002) found deposition of hyaline rings was synchronous with decrease in food diversity in autumn in the Suat Uğurlu Dam, Turkey. Aydın *et al.* (2004) demonstrated a positive linear relationship between otolith length and fish length for this species in Keban Dam, Turkey. Serdar and Özcan (2018) examined 232 fish from 14 stations in the Qarasu River in eastern Anatolia, Turkey and found a  $b$  value of 2.77 (negative allometric growth) and a condition factor of 1.102.

**Food.** This species is omnivorous taking insect larvae, worms, eggs and fry of other fishes and algae in headwater streams of the Gamasiab River drainage (Yousefian *et al.*, 2013). Gut contents also included diatoms as well as large quantities of sand. However, Gümüş *et al.* (2002) examined diet in the Suat Uğurlu Dam, Turkey and found *Navicula*, *Cymbella* and *Synedra* were the most frequently consumed organisms. This species fed mostly on Bacillariophyta in this dam but also Chlorophyta, Cyanophyta, Xanthophyta, Euglenophyta and Rotifera. Diet varied with seasonable availability of food items. Keivany *et al.* (2018a) examined 335 fish from the Beheshtabad River and found the relative length of gut was 1.18 for all fish, indicating an herbivorous habit. The highest mean feeding intensity of males was in July and the lowest in March and April. In the female, the highest was in January and the lowest in June. The highest mean value of gut vacuity index of males and females was in the spring and the lowest in summer. About 55% of the studied stomachs were full. The highest number of empty stomachs was in May (80%) and the lowest in July (32%). Based on the mean gut vacuity index (48%), this fish is considered a medium feeding fish.

**Reproduction.** The Dimeh Spring population examined by Mahboobi Soofiani *et al.* (2014) matured in the second year of life with spawning during May and June. Mean absolute

and relative fecundity was 2,429 eggs and 78.1 eggs/g. Fish in the Bibi-Sayyedana River of the upper Tigris River basin near Semirum had a peak gonadosomatic index in March, declining sharply afterwards, indicating a short spring spawning period. Egg diameters reached 1.7 mm (Kiani *et al.*, 2012). Kiani *et al.* (2021) also examined fish from the Bibi-Sayyedana River and found a sex ratio of 1male:2.3females, age groups of the males and females were 1-4 and 1-5 years, the maximum total length and weight of males were 18.1 cm and 65 g and of females were 22.0 cm and 91 g. The minimum and maximum absolute fecundity were 600 and 6,500 eggs, the average egg diameter was 0.65 mm, the minimum and maximum egg diameters were 0.27 and 1.7 mm. The mean gonadosomatic index was 1.53 in males and 4.37 in females. This index showed significant differences in different months in both males and females and the maximum value in females was observed in March and was significantly different from that of other months. Based on gonadosomatic index values, egg diameter and histological studies, this species had a short spawning period during late March to early April. The ovary in this species is group synchronous. Fish examined by Ghanbary *et al.* (2014) in the Gamasiab River had mean gonadosomatic indices in females of 9.15 and in males 1.5, mean absolute fecundity was 9,440.98 eggs, and mean egg diameter was 1.05 mm (range 0.54-2.0 mm). Maximum condition factors were in April for males and March for females. The reproduction season was March to May. Keivany *et al.* (2018b) examined 335 fish from the Beheshtabad River and found a significant increase in oocyte diameter from April to June with a decrease in July and August corresponding to the gonadosomatic index. The highest gonadosomatic index for males was in April and for females in June. The spawning season was from late March to June.

Studies on the Diyala River population in Iraq found fish to be mature in December and by January females lacked eggs. Each female produced up to 6,900 eggs and number of eggs increased linearly with length (Allouse *et al.*, 1986). The breeding season at Al Kadhmia in the Tigris River near Baghdad was March-May (Daoud and Qasim, 1999). Al-Rudainy (2008) gave sexual maturity as 3 years, 25 cm total length and 250 g weight with spawning in February and March on gravel beds in shallow water with strong current for Iraq. Ünlü (2006) reported up to 13,280 eggs for fish in the Tigris River of Turkey. Beckman (1962) stated that this species probably spawns in May or June in Syria and Oymak (2000) found that condition factors were highest in April and May in the Atatürk Dam, Turkey.

**Parasites and predators.** Barzegar *et al.* (2004) examined this species for parasites in fish from the Beheshtabad River in Chahar Mahall and Bakhtiari Province and found *Lernaea cyprinacea*, *Dactylogyrus ergensi*, *Ichthyophthirius multifiliis* and *Myxobolus* sp. Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G.* sp. from the Dez and Karun rivers in *Chondrostoma nasus*, presumably this species. Barzegar *et al.* (2008) recorded the digenean eye parasites *Diplostomum spathaceum* and *Tylodelphys clavata* from this fish. Raissy *et al.* (2009) found the digenean eye parasite *Tylodelphys clavata* in fish from Choghakhor (= Chagha Khur) Lagoon. Raissy *et al.* (2013) recorded parasites from fish in the Kaaj River, an upper Karun River tributary, namely *Ichthyophthirius multifiliis* (Ciliophora) and *Rhabdochona* sp. (Nematoda). Keivany *et al.* (2017) examined 26 fish from the Beheshtabad River and found *Ichthyophthirius multifiliis*, *Philometra* sp. and *Trichodina* sp. Moumeni *et al.* (2020) recorded the zoonotic *Philometra* sp. from this species in Iran.

**Economic importance.** This species has been caught and used for food in Khuzestan and Kermanshah (Khalaji *et al.*, 2015). It sold for 100 rials/kg in 1978.

**Experimental studies.** Pirshaeb *et al.* (2015) found high levels of chromium and vanadium, exceeding international standards, in muscle tissue of fish from the Gharasou (=

Qareh Su) in Kermanshah from industrial and municipal wastewater. Peykanheraty *et al.* (2016) examined the histopathological effects of cadmium chloride on fish from a branch of the Zayandeh River, finding hyperplasia, clubbing and fusion of gills, and congestion, nuclear psychosis and necrosis of the liver, and intensity dependent on dose. Ghanbary *et al.* (2013) related total, fork and standard length to weight in male fish, useful in selecting fish with better total weight traits in breeding programmes. Mahboobi Soofiani *et al.* (2015) showed that higher temperatures led to an increase in maximum metabolic rate and aerobic scope whereas low temperatures led to a decrease. Mohammadi *et al.* (2018) found that an increase in water temperature (28-31°C) acted as a loading stressor while a decrease in temperature (3.5-6.5°C) acted as a limiting stressor.

**Conservation.** This species is relatively common and is not widely used as food; it may not need conservation. However, it is listed as endangered in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Iranian material:- CMNFI 1979-0245, 5, 35.3-47.1 mm standard length, Chahar Mahall and Bakhtiari, stream in Ab-e Shalamzar drainage (Khersan River basin) (32°08'N, 50°51'E); CMNFI 1979-0246, 4, 55.9-64.2 mm standard length, Chahar Mahall and Bakhtiari, stream 8 km west of Boldaji (31°57'30"N, 50°59'E); CMNFI 1979-0247A, 4, 57.2-65.3 mm standard length, Chahar Mahall and Bakhtiari, pool 3 km west of Boldaji (31°57'N, 51°01'E); CMNFI 1979-0248A, 2, 39.2-65.2 mm standard length, Chahar Mahall and Bakhtiari, stream 3 km east of Boldaji (31°55'N, 51°05'E); CMNFI 1979-0271, 11, 60.0-131.3 mm standard length, Lorestan, river in Kashkan River drainage (33°39'N, 48°32'30"E); CMNFI 1979-0272, 1, 58.5 mm standard length, Lorestan, river at Nokhor (ca. 33°40'-47'N, ca. 48°28'-45'E); CMNFI 1979-0273, 1, 59.5 mm standard length, Lorestan, Kashkan River drainage 5 km from Khorramabad (33°26'N, 48°19'E); CMNFI 1979-0275, 5, 31.4-42.4 mm standard length, Lorestan, Kashkan River 2 km from Ma'mulan (33°25'N, 47°58'E); CMNFI 1979-0279, 2, 61.8-134.0 mm standard length, Lorestan, Khorramabad River (33°37'N, 48°18'E); CMNFI 1979-0280, 1, 114.5 mm standard length, Lorestan, Kashkan River drainage (ca. 33°43'-47'N, 48°12'-15'E); CMNFI 1979-0283, 1, 137.0 mm standard length, Kermanshah, river in Qareh Su drainage (34°21'N, 47°07'E); CMNFI 1979-0286, 11, 77.4-100.4 mm standard length, Kermanshah, Ravansar River at Ravansar (34°43'N, 46°40'E); CMNFI 1979-0287, 22, 56.6-112.5 mm standard length, Kermanshah, Cheshmeh Javari 2 km from Ravansar (ca. 34°42'N, ca. 46°40'E); CMNFI 1979-0289, 1, 131.5 mm standard length, Kermanshah, river in Diyala River drainage (34°28'N, 45°52'E); CMNFI 1979-0368, 4, 54.0-84.5 mm standard length, Khuzestan, Karkheh River (32°24'30"N, 48°09'E); CMNFI 1979-0370, 6, 187.3-221.6 mm standard length, Khuzestan, Karkheh River (32°12'N, 48°14'30"E); CMNFI 1979-0382, 2, 37.7-62.5 mm standard length, Khuzestan, Karun River at Shushtar (32°03'N, 48°51'E); CMNFI 1979-0392, 1, 53.7 mm standard length, Khuzestan, Zard River (ca. 31°32'N, ca. 49°48'E); CMNFI 1979-0396, 2, 39.0-42.7 mm standard length, Khuzestan, Kheyabad River 20 km from Behbahan (30°32'N, 50°23'30"E); CMNFI 1979-0421, 5, 114.0-122.0 mm standard length, Kohgiluyeh and Bowyer Ahmad, stream in Khersan River drainage (30°24'N, 51°47'E); CMNFI 1991-0154, 1, 264.3 mm standard length, Khuzestan, Hawr al Azim (ca. 31°45'N, ca. 47°55'E); CMNFI 1993-0127, 1, 141.4 mm standard length, Kermanshah, Sarab-e Maran (34°44'N, 46°51'E); CMNFI 1993-0129, 1, 146.8 mm standard length, Kermanshah, Sarab Najibaran (34°00'-30'N, 47°00'-30'E); CMNFI 1993-0149, 1, 194.3 mm standard length, Khuzestan, Karun River (no other locality data); CMNFI 2007-0100, 2, 165.4-165.7 mm standard length, West Azarbayjan, Kalwi Chay near Piranshahr (ca. 36°44'N, ca. 45°10'E); CMNFI 2007-0111, 2, 183.3-191.7 mm standard length,

Kermanshah, Alvand River near Sar-e Pol-e Zahab (ca. 34°36'N, ca. 45°56'E); CMNFI 2007-0113, 2, 106.7-145.0 mm standard length, Kermanshah, Razavar (= Raz Avar) River, Qareh Su tributary (ca. 34°25'N, ca. 47°01'E); CMNFI 2007-0115, 3, 72.5-96.5 mm standard length, Kermanshah, Qareh Su basin north of Kermanshah (ca. 34°34'N, ca. 46°47'E); CMNFI 2007-0119, 17, 31.7-50.8 mm standard length, Kermanshah, Gamasiab River near Kangavar (ca. 34°31'N, ca. 48°03'E); CMNFI 2008-0102, 3, 166.8-185.6 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data); CMNFI 2008-0102, 2, 117.1-124.8 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data) (the prior two collections with the same catalogue number are separated here as they differ in certain characters (e.g., gill raker counts) and are probably from separate sarabs); CMNFI 2008-0132, 1, 189.4 mm standard length, Khuzestan, neighbourhood of Ahvaz (no other locality data); CMNFI 2008-0151, 1, 173.3 mm standard length, Kermanshah, Gamasiab River (34°10'44"N, 47°20'48"E); CMNFI 2008-0175, not kept, Lorestan, Kahman River at Dow Ab-e Aleshtar (33°47'N, 48°12'E); CMNFI 2008-0182, 1, 111.7 mm standard length, Chahar Mahall and Bakhtiari, Ab-e Bazoft Sofla (31°38'06"N, 50°28'30"E); CMNFI 2008-0184, 2, 81.2-82.2 mm standard length, Chahar Mahall and Bakhtiari, Armand River (31°37'N, 50°47'E); CMNFI 2008-0185, 2, 90.2-93.2 mm standard length, Chahar Mahall and Bakhtiari, Sulgan River (31°30'N, 50°50'E); CMNFI 2008-0191, 1, 64.6 mm standard length, Chahar Mahall and Bakhtiari, Ab-e Bazoft (31°38'06"N, 50°28'30"E); CMNFI 2008-0236, 1, 115.2 mm standard length, Kermanshah, Mereg River (35°25'N, 46°17'E); CMNFI 2008-0237, 1, 83.4 mm standard length, Kermanshah, Yavari Spring (34°28'N, 46°56'E); CMNFI 2008-0238, 1, 171.3 mm standard length, Kermanshah, Qareh Su (33°56'42"N, 47°28'40"E).

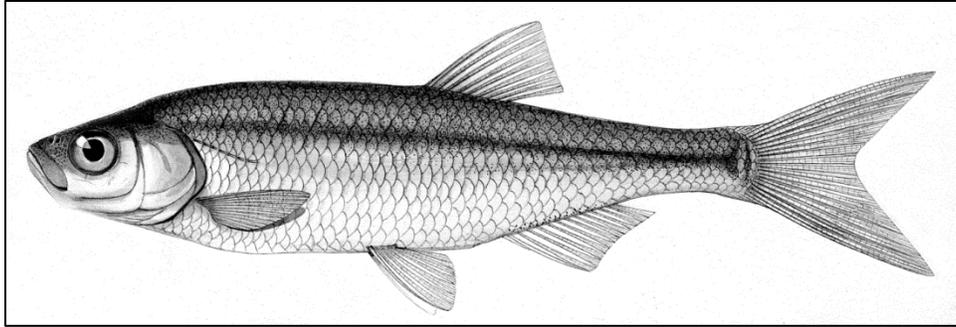
Comparative material:- BM(NH) 1931.8.12:1-3, 2, 136.0-172.2 mm standard length, Iraq, near Mosul (36°20'N, 43°08'E); BM(NH) 1971.4.2:6, 1, 147.7 mm standard length, Iraq, River Tigris near Mosul (36°20'N, 43°08'E); BM(NH) 1974.2.22:81-82, 1, 197.5 mm standard length, Iraq, Great Zab near Eski Kelek and near Bekhne Dam (no other locality data).

**Genus *Leucaspis***  
Heckel and Kner, 1857

The genus *Leucaspis* has a single species with a wide distribution in Europe and is also found in Iran. Schönhuth *et al.* (2018) noted that it was included in the *Alburnus* clade in their molecular analysis and the *Alburnus-Leucaspis* clade was the sister group to *Scardinus*.

The genus is characterised by a moderately compressed and elongate body, an incomplete lateral line on up to about 13 scales, moderately large, easily detached scales, short dorsal and somewhat longer anal fin, belly without a keel but somewhat compressed, terminal mouth with lower jaw entering the depression of the upper, pharyngeal teeth usually in two rows but counts variable, and gill rakers of moderate size and density.

***Leucaspis delineatus***  
(Heckel, 1843)



*Leucaspilus delineatus*, 8.5 cm total length, Russia, Lake Chukhloma in the basin of the Kostroma River, after Berg (1948-1949).



*Leucaspilus delineatus*, Gilan, Anzali Wetland, November 2009, Keyvan Abbasi.



*Leucaspilus delineatus*, Hoensbroek, The Netherlands (Alburnus alburnus cropped, CC BY-SA 3.0, Viridiflavus).

**Common names.** Mahi-ye riz-e noqrei or mahi-e-rize-noghreie (= small silvery fish).

[Gafgaz ustuzani in Azerbaijan; Kavkazskaya verkhovka or Caucasian verkhovka, ovsyanka, verkhovka in Russian; rain bleak, sunbleak, white aspe; belica; Moderlieschen in German].

**Systematics.** *Squalius delineatus* was originally described from Wien and Mähren, Austria. The Caspian Sea basin taxon was given by Berg (1948-1949) as *Leucaspilus 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 been applied as a subspecies by some authors (Arnold and Längert, 1995).

**Key characters.** The large, rounded papillae around the genital opening are distinctive in females, and for both sexes the combination of an incomplete lateral line with moderately large scales is key.

**Morphology.** The body is compressed and elongate, being deepest at the level of the pelvic fins. The predorsal profile is straight to slightly convex, with an incision at the head and body border, and falling slightly to the mouth tip. The caudal peduncle is compressed and shallow to moderate in depth. The belly is compressed in the mid-line between the pelvic fins and the vent but does not form a strong keel. The snout is pointed. The mouth is very oblique and superior. Lips are thin. The dorsal fin margin is straight to slightly emarginate. The dorsal fin origin is markedly posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back to the level of the mid-anal fin. The caudal fin is moderately forked with rounded or pointed lobes. The anal fin is emarginate and when depressed does not reach back to the caudal fin base. The pelvic fin is rounded and extends back to the anus and falls short of the anal fin origin. The pectoral fin is rounded and extends back almost to the pelvic fin origin or falls well short.

Dorsal fin with 2-3, usually 3, unbranched rays followed by 7-10 branched rays (usually 8 in Europe but counts of 7 and 8 are about equally frequent in the Caucasian populations according to Berg (1948-1949) but Abdurakhmanov (1962) gave a frequency of 94% for 8 rays and only 6% for 7 rays in fish from Azerbaijan), anal fin with 3-4, usually 3, unbranched rays followed by 9-17 branched rays (10-12 in the Caucasian “subspecies”), pectoral fin branched rays 11-16, and pelvic fin branched rays 7-8. Scales are caducous. Lateral series scales 36-53, lateral line incomplete with 0-13 pored scales anteriorly. Scales bear few anterior and posterior radii, have few circuli, a subcentral anterior focus and are a vertical oval in shape. Total gill rakers number 10-17 (rarely 20, usually 13-16), reaching the second raker below when appressed. Pharyngeal teeth are very variable and counts are 5-5, 5-4, 4-4, 4-5, 1,5-5, 5-5,1, 1,5-4, 5-4,1, 1,4-4, 4-4,1, 1,5-5,1, 1,5-5,2, 1,4-4,1, 1,4-5,1, 1,5-4,1, 1,5-4,2, 1,4-5,2, 2,5-4,1, 2,5-4,2, 2,5-5,2 and even 2,5-6,1. The frequency of various counts varies with locality, and even whether single row counts dominate over two-rowed counts (Arnold and Längert, 1995). Teeth are hooked at the tip and slightly to strongly serrated. The gut is an elongate s-shape. Total vertebrae number 36-40. The chromosome number is  $2n = 50$  (Klinkhardt *et al.*, 1995; Arai, 2011).

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(10) or 9(1), anal fin branched rays 10(4) or 11(7), pectoral fin branched rays 11(7), 12(3) or 13(1), pelvic fin branched rays 7(10) or 8(1), scales in lateral series 39(3), 40(5), 41(1), 43(1) or 45(1), total gill rakers 13 (4) or 14(7), and total vertebrae 36(1) or 37(9). One specimen showed fusions of abdominal vertebrae.

**Sexual dimorphism.** Females have a unique fold of skin in the shape of two, large, rounded papillae around the genital opening. The male is a little smaller than the female. Males develop prominent nuptial tubercles on the dorsal head surface, snout, on the lower jaw in three pairs and on the upper jaw in two pairs for a total of about 60 tubercles. Small tubercles line the rays of the anal, pectoral and pelvic fins with very few on the dorsal fin. The male genital opening is depressed.

**Colour.** The back is olive-green to brown and the flanks and belly silvery-white, or quite dark brown. A steel blue, silvery blue or bluish-green stripe begins at the rear third of the body and extends back, broadening, to the tail base. Fins are hyaline or slightly yellowish. The anal fin can be distally whitish and proximally as dark as the adjacent body. The peritoneum is light.

**Size.** Attains 12.0 cm total length although only up to 5.6 cm total length in the Caucasian form.

**Distribution.** This species is found in western and central Europe from the Rhine and north of the Alps east to northern drainages of the Black Sea and the western and northern drainages of the Caspian Sea. *Leucaspius delineatus caucasicus* is found in the north Caucasus including the Black Sea parts and in Transcaucasia. In the southern Caspian Sea basin, it is found in the lower reaches of the Kura River, Imeni Kirova Bay and the Lenkoran region of Azerbaijan (Kuliev, 1989). A single specimen from Iran was collected by Akbar Nasrollazadeh near Siah Darvishan (which is at 37°22'N, 49°26'E) in Gilan on 27 May 1993. In June 1996 over 50 specimens were caught in the Anzali Talab by K. Abbasi and A. Sarpanah of the Gilan Fisheries Research Centre (*Iranian Fisheries Research and Training Organization Newsletter*, 15:4, 1997). Also reported from the Anzali Talab by Abbasi *et al.* (1999, 2017) and present in the Pir Bazar, Pesikhan and Sefid rivers, Hendeh Khaleh swamp and the Amirkelayeh Wetland (Nasrollazadeh, 1999; K. Abbasi, pers. comm., 2001; Eagderi *et al.*, 2020).

**Zoogeography.** The Caspian shore of Iran has been surveyed in some detail during the 20th century and it is curious that this species was only discovered towards its end. It may simply have been confused with other small, silvery minnows although it should be noted that some of the surveys were carried out by Russian workers familiar with this species. It may be a recent introduction with other, commercial exotics, and therefore may not be from a Caucasian population.

**Habitat.** This species is found in rivers, streams, lakes, ponds, dams, lagoons and marshes, usually in still or slowly flowing water with vegetated shores in large schools. It can be found in fish ponds, ditches, gravel pits and quarries as well as natural habitats. Still water is required for reproduction. It is tolerant of a wide range of temperatures, pH and salinity depending on adaptation, e.g., temperature range of 3-32.8°C (Arnold and Längert, 1995). This small fish is found in large schools near the water surface. It may appear in small ponds without any apparent connection to other water bodies, hence the German name that has been interpreted as “Moderlieschen” or motherless. However, the German name may more correctly mean mud lover (G. H. Copp, *in litt.*, 16 June 2004).

**Age and growth.** Life span is about 4-6 years with growth fairly continuous over this period. Eagderi *et al.* (2020) examined 17 fish, 6.03-8.75 cm total length, from the Sefid River and found a *b* value of 3.35, positively allometric.

**Food.** Diet comprises plankton such as cladocerans, copepods and rotifers, benthic chironomids, flying insects which land on the water surface, and also some algae and detritus.

**Reproduction.** There is often a spawning migration against the water flow (up to 2-3 m/sec) to new waters. Eggs are laid in strings which are wound spirally around plants by the female, aided by the fold of skin around the genital opening. They may also be laid in a disc-shaped patch on any flat surface. Several spawnings occur over a few weeks in March to September in Europe. The eggs are guarded and fanned by the male who covers them with bacteriostatic dermal mucus. Up to 485 eggs are found in females and have diameters up to 0.5 mm in Azerbaijan, up to 3,500 eggs and 1.5 mm in Europe. Maximum egg production over two seasons is about 500-600 (Abdurakhmanov, 1962). Clutch sizes are about 50-350 eggs (Arnold and Längert, 1995). A minimum temperature of 18°C is required for reproduction.

**Parasites and predators.** Mirhashemi Nasab *et al.* (2017) found *Diplostomum spathaceum* in fish from the Anzali Wetland with prevalence (20.0%) and range (1-5 worms in a fish).

This fish is eaten by a wide variety of other fishes in Europe and numerous parasites are reported (Arnold and Längert, 1995).

**Economic importance.** The scales have been used in the production of artificial pearls as with *Alburnus alburnus* (a relative of *A. hohenackeri*). The abundant population in Lake Chukhloma, Russia was fished commercially (Berg, 1948-1949). It has also been used in aquaria and garden ponds and as bait by anglers.

**Experimental studies.** None.

**Conservation.** Lelek (1987) classified this species as rare to vulnerable in Europe. Kiabi *et al.* (1999) considered this species to be conservation dependent in the south Caspian Sea basin according to IUCN criteria. Criteria included few in numbers, habitat destruction, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Arnold and Längert (1995) summarised biology of European populations in detail.

Iranian material:- CMNFI 2008-0112, 1, 34.6 mm standard length, Gilan, swamp near Hendeh Khaleh (37°23'N, 49°28'E); CMNFI 2008-0239, 10, 31.2-37.5 mm standard length, Gilan, Anzali Talab (ca. 37°26'N, ca. 49°25'E).

### **Genus *Leuciscus***

Cuvier, 1816

The genus *Leuciscus s.l.* is not monophyletic based on allozyme data for a limited number of European taxa (Hänfling and Brandl, 2000). There may be about 17 species in the genus with two species reported from Iran. Many species formerly in this genus are now placed in *Squalius* Bonaparte, 1837.

The genus *Aspius* Agassiz, 1832, the asps, comprised two species found in Europe and Southwest Asia. Recent molecular studies by Perea *et al.* (2010) and Schönhuth *et al.* (2018) showed the two *Aspius* species are not clustered together and fall in *Leuciscus*. Much literature will, of course, be found under the earlier genus name. Pourshabanan *et al.* (2021) used two mitochondrial (CYTB and COX1) and one nuclear (RAG1) genomic markers in order to assess the taxonomic relationships between two Iranian species and confirmed their presence as distinct species with an interspecific genetic distance of 10.6%.

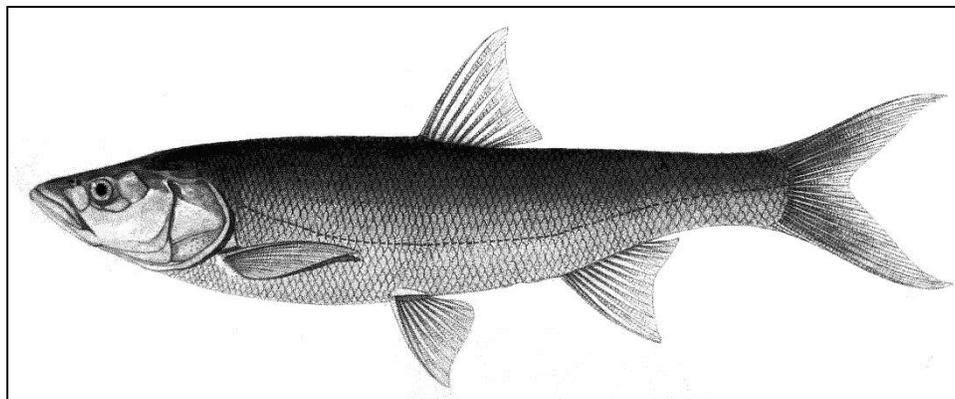
These are medium to large fishes with a somewhat compressed to elongate body, small to large scales, a complete lateral line, no barbels, mouth terminal, subterminal or superior, sometimes a large mouth with the lower jaw projecting and with a tubercle fitting into a notch in the upper jaw, thin lips with the lower one interrupted medially, a short dorsal fin without a thickened ray, a moderately long anal fin, long and hooked pharyngeal teeth in two rows (commonly 2 or 3,5-5, 3 or 2) usually with hooked tips and spoon-shaped crowns, short gut, no naked keel on the belly but a scaled keel in some, sometimes gill slits very wide such that the branchiostegal membranes attach under the posterior end of the eye, and short and relatively few gill rakers.

The following table summarises some key distinguishing characters of the Iranian species of *Leuciscus*.

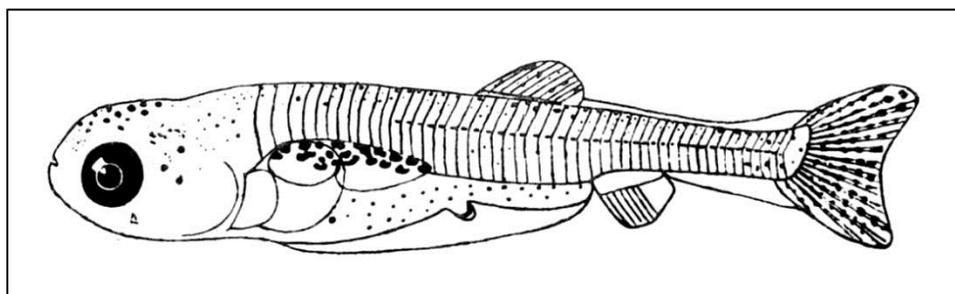
Species/Characters	Lateral line scales	Anal fin branched rays	Total gill rakers	Distribution
<i>L. aspius</i>	62-105	11-16 (mostly 12-13)	8-11 (mostly 8-9)	Caspian Sea
<i>L. vorax</i>	82-110	9-13	9-14	Tigris River

		(mostly 10-11)	(mostly 11-13)	
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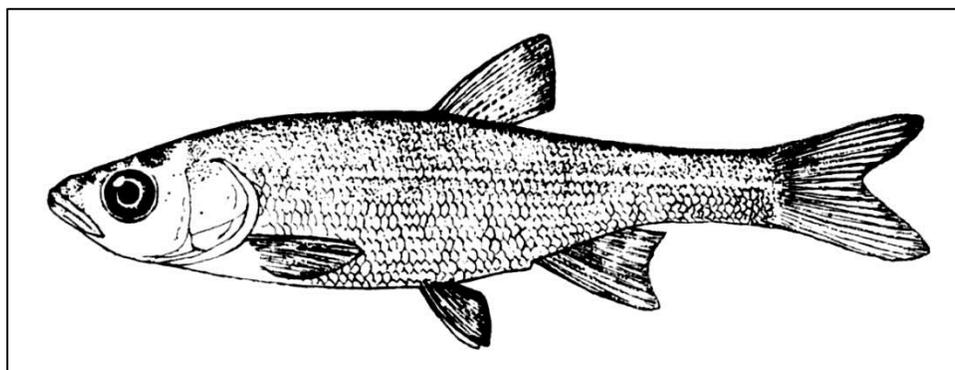
*Leuciscus aspius*  
(Linnaeus, 1758)



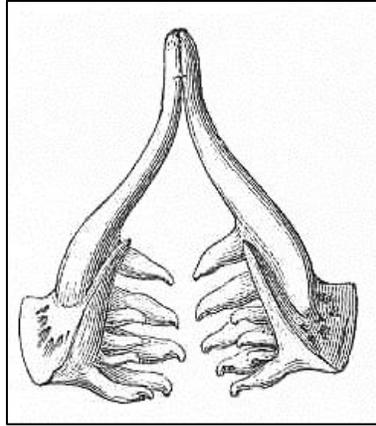
*Leuciscus aspius* 50.7 cm total length, ZISP 5205, Turkey, Lake Chaldyr-gel' (= Çıldır) in the former Kars Region (Aras River basin), after Berg (1948-1949).



*Leuciscus aspius* fry, 11.5 mm, age three weeks, Russia, Volga River delta, after Kazanskii (1925).



*Leuciscus aspius* fry, 41 mm, Kazakhstan, Ural River delta, after Berg (1932b).



*Leuciscus aspius*, pharyngeal teeth,  
after Seeley (1886).



*Leuciscus aspius*, Gilan, Anzali Shore, November 2010, Keyvan Abbasi.

**Common names.** Mash or mash mahi, khasham, mung fish (Amouei and Abdovali, 2014; mung being a bean and a translation of “mash”, sometimes seen also as pea).

[Hasam or khasham in Azerbaijan; Kocaağız balığı in Turkish (Kaya *et al.*, 2020); krasnogubyi zherekh or reddlip asp in Russian; asp, Caspian asp, European asp, South Caspian asp].

**Systematics.** *Cyprinus Aspius* was described originally from lakes of Sweden; the types are unknown (Eschmeyer *et al.*, 1996).

*Cyprinus Rapax* Leske, 1774 described from Leipzig, Germany, *Cyprinus taeniatus* Eichwald, 1831 described from the Kura River at Mingechaur, *Aspius erythrostomus* Kessler, 1877 (*sic*, sometimes spelt *erythrostomus* or *erithrostomus*) described in part from the Caspian Sea and Kura River, Azerbaijan and from the Aral Sea and lower part of the Amu Darya, Uzbekistan (all three with no types), and *Aspius transcaucasicus* Warpakhovskii, 1895 from the Lenkoran River and Lake Bussadagny, Azerbaijan, are synonyms. *Leuciscus aspius taeniatus* (Eichwald, 1831) is the subspecies found in the Caspian Sea.

Eschmeyer *et al.* (1996) gave *Aspius transcaucasicus* Warpakhovskii with the year 1896, although Berg (1948-1949) gave 1895; possibly the volume year is 1895 but the work did not appear until 1896. Warpakhovskii is a variant spelling in transliteration from the Russian and later in the *Catalog of Fishes* (downloaded 17 June 2019) it is spelled Warpachowski. Syntypes of this synonym are in the Zoological Institute, St. Petersburg under ZISP 10488 (2) and ZISP 10497-48 (*sic*, in Eschmeyer *et al.* (1996) but should read 10497-98 with five and two specimens respectively (Kottelat, 1997) and *Catalog of Fishes*, downloaded 31 March 2018).

Rezaei *et al.* (2012) examined fish from two fishing areas (Tonekabon and Sari) using meristics and morphometrics and found that the populations were distinct but with a relatively

high degree of overlap.

Poursaeid *et al.* (2014) described the karyology of hybrids with male *Rutilus frisii* (= *kutum*) ( $2n = 50$  and  $NF = 80$ ). Meknatkhah *et al.* (2016) recorded 16 morphometric and 6 meristic characters for this hybrid and found both intermediate and different characters in respect of the parents. Abbasi *et al.* (2021) analysed 101 specimens from the Aras River and the Astara, Anzali, Kiashahr and Langerud shores for 41 morphometric and nine meristic characters, finding significant differences in 27 morphometric characters which were more powerful in distinguishing populations than meristic characters. Upper caudal fin length and maximum body depth were effective characters in a principal components analysis.

The subspecies *L. a. taeniatus* may eventually be elevated to a species as has happened for other taxa in the Caspian Sea (see below for differences from the type subspecies). The limited material available to me did not permit a thorough analysis and fresh material would be needed for confirmatory DNA work.

**Key characters.** The subspecies of the southern Caspian Sea is distinguished from the type subspecies of Europe and the northern Caspian Sea since the former has higher lateral line scale counts of 67-90 as opposed to 64-76, lips are usually bright red, anal fin branched rays are usually 12 instead of 13 (but see Iranian fish below), and the height of the dorsal fin is usually shorter than the distance from the snout tip to the posterior edge of the preopercle (Berg, 1948-1949). Jaw characters and distribution serve to separate it from other leuciscids in Iran.

**Morphology.** The body is compressed and moderately deep. It is deepest between the end of the pectoral fin and the origin of the pelvic fin or over the end of the pectoral fin. The predorsal profile is convex. A nuchal hump may be present. The caudal peduncle is compressed and moderately deep. The head tapers and the snout is rounded to pointed. There is a groove across the head in front of the nostrils. The eye is positioned well into the anterior half of the head. The mouth is terminal and oblique and extends back level with the anterior eye margin. Lips are moderately thick. The lower jaw tip projects and fits into a notch in the upper jaw. Gill membranes are narrowly attached to the isthmus, almost under the posterior eye margin. The dorsal fin is slightly emarginate and its origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches level with the anterior anal fin or falls just short. The caudal fin is deeply forked with pointed lobes. The anal fin is markedly emarginate and does not extend back to the caudal fin base. The pelvic fin margin is round to straight or slightly emarginate and the fin does not extend back to the anal fin. The pectoral fin margin is straight or sickle-shaped and the fin does not extend back to the pelvic fin origin.

Dorsal fin unbranched rays 2-3, usually 3, branched rays 7-10, usually 8, anal fin unbranched rays 3-4, usually 3, and branched rays 11-16, usually 12-13, pectoral fin branched rays 14-18, and pelvic fin branched rays 7-9. Lateral line scales 62-105. There is a pelvic axillary scale and there is a scaled keel behind the pelvic fins. The scales have a central focus, fine circuli and few posterior and anterior radii. Total gill rakers number 8-11, very short and club-shaped, almost or not reaching half way to the raker below when appressed. Pharyngeal teeth are usually 3,5-5,3, sometimes 2,5-5,3 or with 6 teeth in the main row, teeth elongate, compressed and obviously hooked. The gut is an elongate s-shape. Total vertebrae number 47-51, mostly 50 (Berg, 1948-1949). The chromosome number is  $2n = 50-52$  (Klinkhardt *et al.*, 1995; Arai, 2011).

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(6), anal fin branched rays 13(6), pectoral fin branched rays 18(3), pelvic fin branched rays 8(3), lateral line scales 68(1) ..., 72(2), 73(1), 74(1) or 75(2), total gill rakers 8(1) or 9(2), pharyngeal teeth 3,5-5,3(3), and total vertebrae 50(2) or 51(1).

**Sexual dimorphism.** Mature males have the body covered in tubercles (Berg, 1948-1949). Abdurakhmanov (1962) noted greater head depth, lower caudal fin lobe length and pelvic fin length in males and greater body depth and pectoral to pelvic fin distance in females. Seven other morphometric characters differed between sexes in one population examined but not in another so sexual morphology is quite variable.

**Colour.** The overall colour is silvery with the back a blackish-olive or greenish-grey. The iris is silvery with a narrow golden circle around the pupil and a little grey pigment on the upper half. Lips are silvery with a little grey over the upper one. Both lips and iris are often bright red. The dorsal and caudal fins are grey with dark tips and the other fins are transparent without pigment or may also be grey. All fins may be tinged reddish or dark red. The peritoneum is silvery to brown.

**Size.** Reportedly attains 1.2 m and 20.0 kg, possibly over 30.0 kg (Machacek (1983-2012), downloaded 27 July 2012). The largest of 12,000 fish from the lower Kura River was 77.0 cm total length, males averaged 61.0 cm and females 64.0 cm. The average weight of 105,500 fish caught in 1927-1929 was 2.72 kg, females 2.93 kg (based on 1,500 fish), males 2.34 kg and the heaviest fish was 5.5 kg (Berg, 1948-1949).

**Distribution.** Found from the Rhine and north of the Alps in Europe to the drainages of the Black, Caspian and Aral seas including their southern shores.

In the Iranian Caspian Sea this species has been reported from Astara to Gorgan Bay including the Aras, Gorgan, Sari, Sefid, Shah, Shalman, Sheikan and Tonekabon rivers, the Aras Dam, and in the Iranian Caspian Sea such as at the Kiashahr and Langerud shores (Nedoshivin and Iljin, 1929; Derzhavin, 1934; Berg, 1948-1949; Abbasi *et al.*, 1999; Kiabi *et al.*, 1999; Abdoli, 2000; Masoumian *et al.*, 2002; Naderi Jolodar and Abdoli, 2004; Abdoli and Naderi, 2009; Rezaei *et al.*, 2012; Mouludi-Saleh *et al.*, 2021). Formerly reported from the Anzali Talab but no longer present (Holčík and Oláh, 1992) although reported from the Siahkeshim Protected Region of the Anzali Talab and Anzali Shore by Riazi (1996), Anzali Talab by Karimpour (1998) and the Anzali Shore by K. Abbasi (see photograph above) and the Siah Darvishan River, the Anzali Talab and its mouth (Abbasi *et al.*, 2007, 2017). A record of parasites from this fish caught in the Mahabad Dam of the Lake Urmia basin is either a misidentification or a transplant (Masoumian *et al.*, 2002).

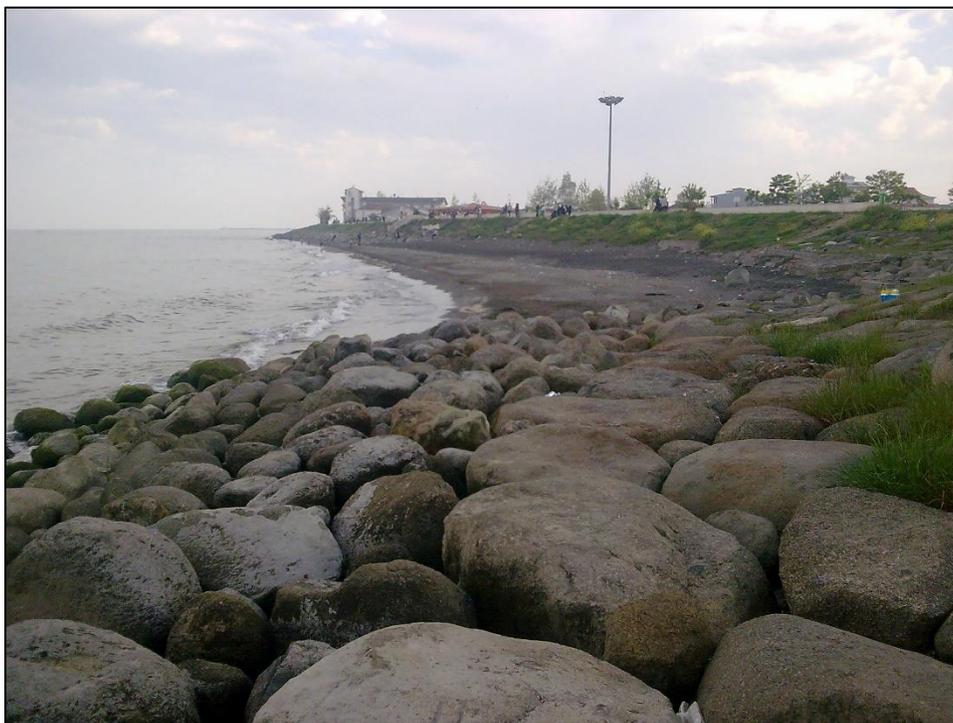
Also recorded from the Uzboi lakes, Karakum Canal and Kopetdag Reservoir in Turkmenistan (Shakirova and Sukhanova, 1994; Sal'nikov, 1995) and may eventually appear in the Tedzhen (= Hari) River basin in Iran.

**Zoogeography.** The closest relative of this species lies to the south and indicates a connection between Euro-Mediterranean and/or Black-Caspian-Aral seas basins.

**Habitat.** This species is found in rivers, streams, lakes, canals, dams, marshes and brackish environments, usually in open areas. This species prefers running water (Berg, 1948-1949). Knipovich (1921) reported this species from depths of 14.6-16.5 m, and possibly deeper, in the Iranian Caspian Sea. Riazi (1996) stated that this species is native (resident) to the Siahkeshim Protected Region of the Anzali Talab. It was solitary, rarely in small groups as on the spawning migration. In the waters of Dagestan, asps began to migrate upriver in October, peaking at the end of November and the beginning of December. The Kura River run was from November to February, peaking in December at 6°C, with spawning in middle March and ending by the end of April. They overwintered in deep holes, emerging in early spring as rivers flooded and moved to the spawning grounds. These grounds included river channels, open lake areas with substantial flow and only rarely places weakly overgrown with very coarse submerged

vegetation such as reeds and rushes. After spawning the asps returned to the Caspian Sea (Shikhshabekov, 1979). Fry migrated to the sea from June until August at 3-4 months of age and 5-10 cm length (Berg, 1948-1949).

**Age and growth.** Fish taken from commercial catches in Iran were mostly 3-6 years old, 38.1-56.7 cm long and weigh 631-2,241 g (Razivi *et al.*, 1972) or 3-6 years and 33-63 cm total length (Holčík and Oláh, 1992). Growth was rapid in the latter report, fish reaching 1.0 kg during the fourth year of life. Maximum life span may be 15 years and Rezaei *et al.* (2012) reported fish up to 10<sup>+</sup> years in Iran. Amouei and Abdovali (2014) showed that weight and length of otoliths best correlated with age although they only examined fish ages 2 and 3 years. The *b* value was 3.15 indicating isometric growth based on 50 fish, 22-38 cm total length. Dejandian *et al.* (2017) examined 20 fish from Iran and found males attained 4<sup>+</sup> years and females 5<sup>+</sup> years and these were at stage 4 maturity. Mouludi-Saleh *et al.* (2020) examined 96 specimens from the Aras River and the Astara, Anzali and Kiashahr coasts of Gilan, and found *b* values ranged from 2.75 to 3.28 and condition factor from 0.85 to 0.95. Maximum and minimum *b* values were in the Astara and Kiashahr populations, respectively, and maximum and minimum condition factors were in the Astara and Anzali populations. Growth patterns were positively allometric except for the Kiashahr population. Mouludi-Saleh *et al.* (2021) examined 133 fish, 17.2-68.5 cm total length, from the Aras River and Gilan and Mazandaran coasts and recorded a *b* value of 3.07, isometric, and a condition factor of 0.91.



Gilan, Caspian Sea at Astara (Caspian Sea-Astara, CC BY-SA 3.0, Samaksasanian).

Life span in the Volga delta was 7-8 years with the bulk of the population mature at 6 years (Ali, 1974). In the waters of Dagestan life span was 8 years with maturity at 4 years. Mature males and females were 41-58 cm long and weighed 840-2,800 g (Shikhshabekov, 1979). Growth was more rapid in the Kura River of Azerbaijan than in other rivers in the former Soviet

Union.

**Food.** This species is a solitary predator on other fishes such as roaches (*Rutilus* spp.), gobies (Gobiidae) and silversides (Atherinidae), frogs and even ducklings. It may catch other fishes by plunging into shoals at the surface and may leap out of the water as a result. An Iranian specimen had the remains of a large crustacean in its gut. Abdoli (2000) reported *Scardinius erythrophthalmus*, *Atherina boyeri* (= *A. caspia*, Caspian silverside) and *Blicca bjoerkna* as food items in Iran. Surface insects are also eaten. Young feed on plankton initially but start to take the fry of fishes at 2-3 months. There is little feeding on the spawning migration.

**Reproduction.** The spawning season in Gilan is mid-February to late March at 10-13°C with an incubation period of 9-10 days (Hoseinie, 1995).

Spawning was non-intermittent and the period is short (10-15 days) in Dagestan (Shikhshabekov, 1979). Fecundity reached 483,500 eggs in the south Caspian Sea and maximum egg diameter in the Volga delta was 1.7 mm (Ali, 1974). In Hoseinie's (1995) study of artificial propagation of this species in Iran, large or swollen eggs numbered 117-277 per gramme, and egg diameters 2.0-2.2 mm. Absolute fecundity reached 264,248 eggs. Abdurakhmanov (1962) gave a maximum fecundity of 342,000 eggs and a maximum egg diameter of 2.4 mm for Azerbaijan populations. Females with ripe eggs were found between mid-April and mid-May at water temperatures of 4.0-12.2°C, optimally 9-11°C. Up to 20% of Volga asp females did not spawn annually. Eggs developed while between or adhering to stones on the river bed. Young migrated downriver from June to August at age 3-4 months and 5-10 cm length.

Berg (1948-1949) gave details of spawning in the Terek, Volga and Ural rivers of the Caspian Sea.

**Parasites and predators.** Molnár and Jalali (1992) recorded the monogenean *Dactylogyrus tuba* from this species in the Sefid River. Masoumian *et al.* (2005) reported the protozoan parasite *Chilodonella*, sp. from this species in the Aras Dam in West Azarbayjan. Masoumian *et al.* (2002) investigated parasites from this fish in the Aras and Mahabad dams (*sic* - see **Distribution**) in northwest Iran and found the protozoan *Myxobolus dispar*. Sattari *et al.* (2002, 2004, 2005) and Sattari (2004) recorded the presence of the nematode, *Eustrongylides excisus*. This parasite can damage muscles in commercial species and render them unsuitable for sale. Pazooki *et al.* (2007) recorded various parasites from localities in West Azarbayjan Province, including *Argulus foliaceus* from this species. Sattari *et al.* (2008) reported the nematode *Eustrongylides excisus* from fish along the southern Caspian Sea shore. Rasouli (2013) found the digenean *Diplostomum spathaceum* in fish from Caspian drainages in West Azarbayjan. This parasite causes secondary infections as the metacercariae penetrate the skin and eye, resulting in lesions, appetite loss, blurry vision and reduced feeding.

The Caspian seal, *Pusa caspica*, is a predator (Krylov, 1984).

**Economic importance.** This fish is taken in Iran as food but comprises only a small portion of the catch. Nevraev (1929) reported catches of 267 to 2,429 fish for the period 1914-1915 to 1917-1918 in the Anzali region. Holčík and Oláh (1992) recorded the catch in the Anzali region for 1969-1970 and 1970-1971 as 45.2 t and 36.1 t respectively, these being 84% and 69% of the total Iranian catch. In 1921-1930, the annual catch in the lower Kura River averaged 249,000 fish and in 1936 for Azerbaijan the catch weighed 8,100 centners and numbered 300,000 fish.

Falahatkar *et al.* (2015) examined growth of the aspikutum (*Leuciscus aspius* ♀ x *Rutilus frisii* (= *R. kutum*) ♂) in earthen ponds and concrete tanks, the former showing higher growth performance because of natural live food in addition to the commercial feed. Falahatkar *et al.*

(2019) determined the influence of stocking density in concrete tanks on this hybrid. Improved growth performance and changes in blood parameters showed that a density of 10 kg/cu m or more could be applied to rearing under commercial culture conditions.

Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use as food and in sport. The flesh is white and tasty but rather tough.

#### **Experimental studies.**

Abbaszadeh and Şişman (2021) determined the histopathologic effects of water pollution on this species. Hypertrophy, filament dilatation, lamellar epithelial liftings, thickening of filaments, especially curving, a decrease of the mean length, necrosis, fusion, and lifting in lamellae were observed in the gills. The main histopathological abnormalities in the liver were non-homogenous parenchyma, the proliferation of hepatopancreas, congestion, degeneration of the central vein, increasing melanomacrophage aggregates, and sinusoidal dilations. Changes in the kidney included the degeneration of renal tubules, increasing melanomacrophage aggregates, pyknotic nuclei and vacuolization in proximal and distal tubule epithelial cells, and lymphocyte infiltration in the renal parenchyma. The frequencies of the histological lesions were higher in the liver compared to other organs

Haghpast *et al.* (2014, 2020) examined the hybrid of the female of this species with the male of *Rutilus frisii* (= *R. kutum*) for the effects of differing protein and lipid levels in the diet. A diet with 35% protein and 15% lipid gave optimum growth in this hybrid, while no effects on biochemical and haematological parameters were achieved. Bagheri *et al.* (2015) found that this hybrid could be reared at a density of 10 kg/cu m or more without negative effects on growth performance and feeding and Falahatkar *et al.* (2019) determined the influence of stocking density in concrete tanks on this hybrid where improved growth performance and changes in blood parameters also showed that a density of 10 kg/cu m or more could be applied to rearing under commercial culture conditions. Falahatkar *et al.* (2015) examined growth of the hybrid or aspikutum in earthen ponds and concrete tanks, the former showing higher growth performance because of natural live food in addition to the commercial feed. Falahatkar *et al.* (2019) suggested increasing dietary fat levels in this hybrid up to 16% for better growth performance.

Falahatkar *et al.* (2010) studied induced spawning using ovaprim (a commercial spawning inducing agent) and carp pituitary extract. Falahatkar and Tolouei Gilani (2009, 2013) used laparoscopy for sex identification in aquaculture.

**Conservation.** Recruitment in this species is low in Iran because water is taken from the summer spawning streams for irrigation purposes. Spawning success is therefore limited. Larvae of spring spawners were lost when they entered irrigation channels and become stranded in fields (Razivi *et al.*, 1972). Holčík and Oláh (1992) considered the decline in this species to be due to indiscriminate catching of sexually immature fish and, in the Anzali Talab at least, environmental changes. The Pol-e Astaneh Fish Farm has studied propagation of this species (Keivany and Nasrollahzadeh, 1990) and Hoseinie (1995) demonstrated that artificial propagation was possible. It has also been raised to marketable size in ponds through artificial feeding with ground kilka (*Clupeonella* spp., Clupeidae) and a rice product (*Annual Bulletin 1993-94, Iranian Fisheries Research and Training Organization, Tehran*, pp. 81-82, 1995). The Shahid Beheshti hatchery on the Sefid River bred this species (Raymakers, 2002). The asp was bred in the Varvarinsk Hatchery in Azerbaijan and releases of up to 1.5 million yearlings were made into the Kura River, with plans for 8-10 million releases (Kosarev and Yablonskaya, 1994).

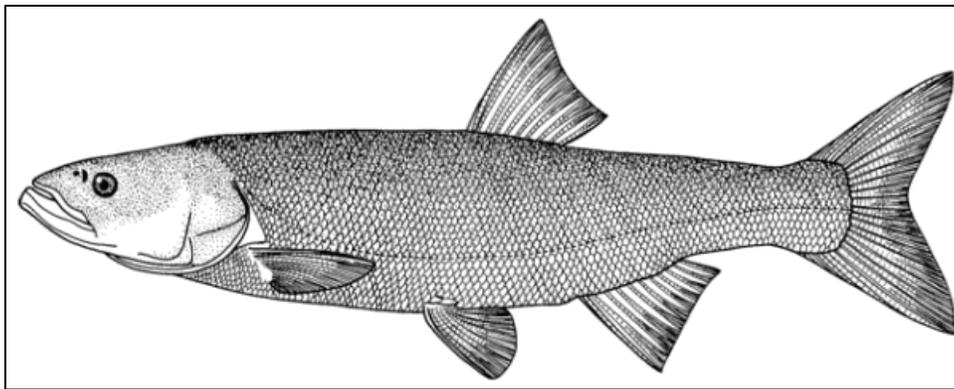
Lelek (1987) classified this species as vulnerable to endangered in Europe. Vulnerable in

Turkey (Fricke *et al.*, 2007). Kiabi *et al.* (1999) considered this species to be data deficient in the south Caspian Sea basin according to IUCN criteria. Criteria included commercial fishing, habitat destruction, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and absent outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Iranian material:- CMNFI 1970-0526, 2, 236.8-246.1 mm standard length, Gilan, Sefid River below Astaneh Bridge (37°19'N, 49°57'30"E); CMNFI 1980-0494, 1, 319.6 mm standard length, Iran, Caspian Sea basin (no other locality data); ZISP 3917, 1, 402.0 mm standard length, Gilan, Anzali (no other locality data).

Comparative material:- ZISP 3653, 2, 128.4-144.2 mm standard length, Uzbekistan, Kashkana-tau, Amu Darya delta (no other locality data); ZISP 3654, 2, 196.4-197.8 mm standard length, Uzbekistan, Kashkana-tau, Amu Darya delta (no other locality data); ZISP 3655, 2, 162.1-193.4 mm standard length, Uzbekistan, Kashkana-tau, Amu Darya delta (no other locality data); ZISP 3704, 1, 183.6 mm standard length, Uzbekistan, Amu Darya, Karakul (no other locality data); ZISP 13267, 1, 263.1 mm standard length, Kazakhstan, Kazalinsk (no other locality data).

*Leuciscus vorax*  
(Heckel, 1843)



*Leuciscus vorax*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Leuciscus vorax*, Khuzestan, Hawr al Azim, Asghar Mobaraki.



*Leuciscus vorax*, Iraq, P. Tiff.

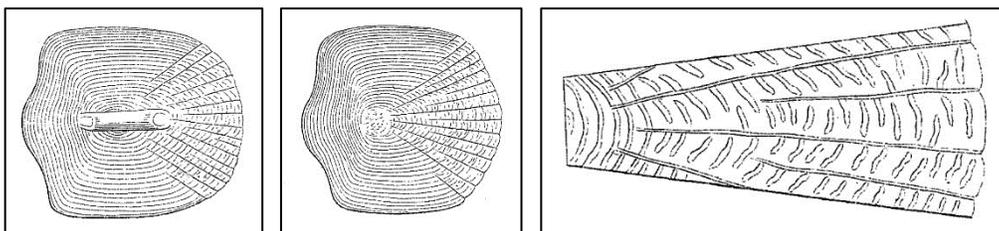
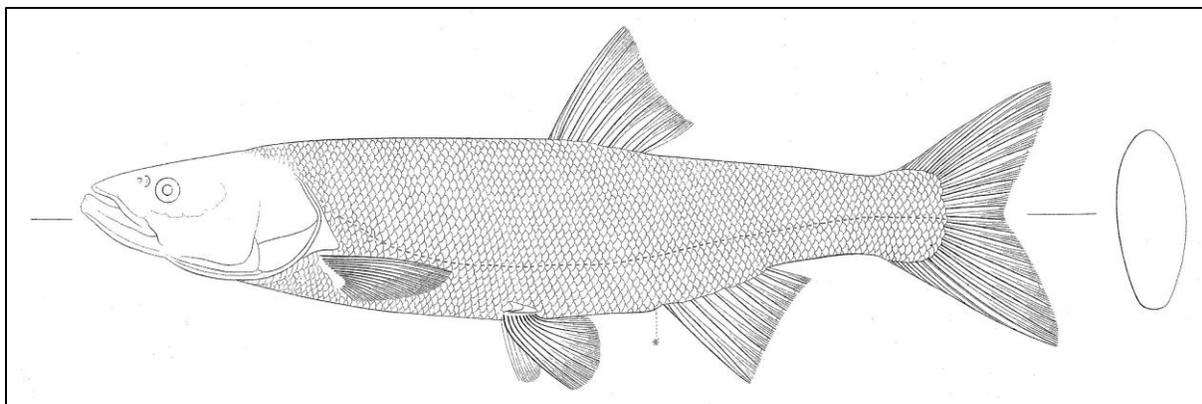


*Leuciscus vorax*, head, Khuzestan, Dez River, Brian W. Coad.

**Common names.** Shelej, shalaj, sholge, sholgeh (see below), mashmahi-ye jonoub (= southern pea fish (pea may not be the correct translation of “mash” but rather mung bean).

[Shilik, shillik, shillig, shiliq, shelej, shalaj, sholgeh (perhaps from shilig = a cucumber-shaped melon (Mikaili and Shayegh, 2011); abu elawi and bu aliawi (abu alawi = belonging to ali (Mikaili and Shayegh, 2011)); called “snake” by American soldiers in Iraq because of the name asp being familiar as the snake that killed Cleopatra; kaschschasch (= voracious) from Heckel (1843b), all in Arabic; Sis balığı in Turkish (Çiçek *et al.*, 2020); Mesopotamian asp, Tigris asp].

**Systematics.** The type locality for *Aspius vorax* is the “Tigris bei Mossul” according to Heckel (1843b). Krupp (1985c) reported, and I have examined, a specimen named as a syntype held in the Naturhistorisches Museum Wien under NMW 76776, 261.4 mm standard length. The catalogue in Vienna in 1997 listed NMW 76785 as a type and this specimen is also 261.4 mm standard length. Eschmeyer *et al.* (1996) listed a dried skin as a syntype under NMW 16527. The catalogue in Vienna listed four fish in spirits and two fish stuffed so there are presumably more types than the three mentioned here.



*Aspius vorax*,

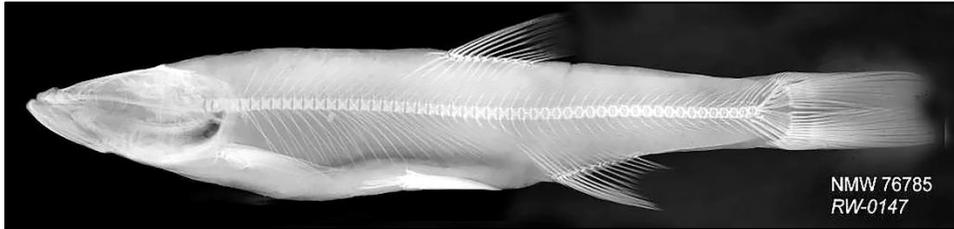
body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



*Aspius vorax*, syntype, NMW 16527, Naturhistorisches Museum, Wien.



*Aspius vorax*, syntype, NMW 76785, Naturhistorisches Museum, Wien.



*Aspius vorax*, syntype, NMW 76785, Naturhistorisches Museum, Wien.

Banister (1980) suggested that this species may be close to *Aspius* (= *Leuciscus*) *aspius*, perhaps a clinal variant, since the Caspian Sea basin subspecies, *L. a. taeniatus* has scale counts (67-90) intermediate between European populations of *L. aspius* (65-74) and *L. vorax* (93-105) (Banister's figures). However, this may be more apparent than real as there is considerable overlap and frequency distributions were not given. There was insufficient material on hand from Iran to investigate this character in more detail.

**Key characters.** Head and jaw characters coupled with distribution serve to identify this species.

**Morphology.** The body is compressed and moderately deep or shallow. It is deepest half way between the dorsal fin and the head. The predorsal profile is almost straight to somewhat convex especially near the head. A nuchal hump may be present. The caudal peduncle is compressed and moderately deep. The head is long and tapers anteriorly, being very pointed. The dorsal head profile may be concave or straight. The eye is well into the anterior half of the head. The mouth is oblique and elongate reaching back to the anterior half of the eye. The lower jaw projects and has a symphysis knob fitting into an upper jaw notch. The upper lip is thin and the lower lip is thick. The gill opening is large and extends forward to the posterior eye margin level. Fins are more falcate than in the line illustration when partially collapsed. The dorsal fin is emarginate and its origin is well posterior to the level of the pelvic fin origin. The depressed dorsal fin extends back almost level with the middle of the anal fin. The caudal fin is deeply forked with rounded to pointed tips, the lower lobe being longer. The anal fin is usually emarginate, sometimes markedly so, and it does not extend back to the caudal fin. The pelvic fin has a straight margin and the fin does not extend back to the anal fin. The pectoral fin is rounded and does not extend back to the pelvic fin.

Dorsal fin with 2-3 unbranched and 7-9, usually 8, branched rays. Al-Nasiri *et al.* (1975) gave a range of 8-11 (probably 7-10 using my system of counting) dorsal fin rays with a strong mode at 9 (i.e., 8) for 271 fish taken from the Basrah fish market from January to June. Anal fin with 2-3 unbranched and 9-13 branched rays. Al-Nasiri *et al.* (1975) gave a range of 10-13 (9-12, 10 modally but high frequencies at 11 too). Pectoral fin branched rays 16-18 (Al-Nasiri *et al.* (1975) gave 14-18, modally 16), and pelvic fin branched rays 8-9, usually 8. Lateral line scales

82-110, lateral line low on the flank anteriorly, rising to the midline of the caudal peduncle. There is a pelvic axillary scale. Scale shape is squarish with a rounded posterior margin and gently rounded dorsal and ventral margins. The anterior margin has a rounded centre with an indentation above and below, and rounded scale corners. Scales have a few radii on the posterior field only, a central focus and numerous, fine, concentric circuli. Pharyngeal teeth are 3,5-5,3 with variants 2,5-5,3 and 2,5-5,2, and are long, compressed and hooked at the tip. Total gill rakers number 9-14, some reaching the base of the adjacent raker when appressed but widely spaced and not developed anteriorly. Al-Nasiri *et al.* (1975) gave a range of 11-13 gill rakers with a strong mode at 12. The gut is an elongate s-shape. Total vertebrae number 51-53. Al-Nasiri *et al.* (1975) gave 37 as a count which cannot be reconciled with my counts. The syntype, NMW 76785, has 51 total vertebrae.

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(4), anal fin branched rays 10(1) or 11(3), pectoral fin branched rays 16(1) or 17(3), pelvic fin branched rays 8(4), lateral line scales 96(1), 97(-), 98(1), 99(-) or 100(1), total gill rakers 11(1), 12(2) or 13(1), pharyngeal teeth 3,5-5,3(3), and total vertebrae 51(3) or 53(1).

**Sexual dimorphism.** Unknown.

**Colour.** The back is greenish to blackish but overall colour is silvery-grey or silvery-white. Fins are said to be all pale yellow in live fish but are red or dark in some preserved and freshly-caught specimens. A photograph of one freshly caught specimen showed reddish pectoral, pelvic and anal fins, with the dorsal fin greenish, similar to the back and flanks. Another freshly caught specimen was overall silvery, with a brownish-green back, fins overall grey with some yellowish tinges. The peritoneum is black to brown.

**Size.** Reaches over 55.0 cm total length and 6.0 kg in Iraq (van den Eelaart, 1954; Herzog, 1967; Shafi and Jasim, 1982; Bartel *et al.*, 1986) and 1.5 m and 60.0 kg in the Euphrates (Gruvel, 1931; if identification is correct). The Suq al-Shouykh Marsh in April 2005 contained specimens larger than 65.0 cm ([www.iraqmarshes.org](http://www.iraqmarshes.org), downloaded 29 August 2005) and fish in Baghdad palace ponds were estimated to reach 36-40 inches (91-1.02 m) and 15-20 pounds (6.8-9.1 kg) (<http://members.cox.net/flybox/FishingUpdate.htm>, downloaded 9 January 2006). Hashemi *et al.* (2013) recorded a maximum total length of 40.5 cm and 0.6 kg for 188 fish from the Shadegan Marsh in Iran.

**Distribution.** This species is found in the Tigris-Euphrates and the Orontes (= Asi) River basins in the Middle East. In Iran it is recorded from the lower reaches of rivers in the Tigris River basin including the Arvand, Bahmanshir, Dez, Jarrahi, Kahnak, Karkheh, Karun, Qareh Su-Gamasiab-Simareh and Shate-Neisan rivers and also such marshes as the Hawr al Azim and Shadegan (Marammazi, 1995; Velayatzadeh and Abdollahi, 2011; Hashemi *et al.*, 2013; Khamees *et al.*, 2019).

**Zoogeography.** This is one of several species that has a sister taxon in the Euro-Mediterranean and/or Black-Caspian-Aral seas basin, indicating north-south connections in the past.

**Habitat.** This species is found in rivers, streams, lakes, dams, ponds and marshes. van den Eelaart (1954) studied this species in Iraq and found that it lived in rivers, lakes and marshes in both open and vegetated areas and remained in shallow water even in summer. It also occurred in smaller water bodies such as ponds. From spring to fall it was found mainly in marshes and lakes. The barrages at Hindiyah and Kut blocked the upstream migration of this species (Mahdi, 1962). Lakes at Camp Slayer in Baghdad contained this species and, in the shallows, the larger fish chased smaller fish and smaller species leaving v-shaped wakes with the tail fin exposed.

Smaller fish leapt out of the water to escape this predator

(<http://members.cox.net/flybox/FishingUpdate.htm>, downloaded 9 January 2006).

**Age and growth.** Hashemi *et al.* (2013) examined 188 fresh fish (11.5-40.5 cm total length) from the Shadegan Wetland or Marsh and found length-weight relationships were  $W = 0.06TL^{3.03}$  and  $W = 0.06TL^{3.02}$  for males and females respectively, showing no difference between sexes and positive allometry. A later study by Hashemi *et al.* (2016) on 456 fish, 11.5-47.5 cm total length, in Shadegan found negative allometric growth ( $b = 2.88$ ), length and weight at maturity were 26.6 cm and 162 g, production rate per biomass annually was 0.44, growth indices were  $L_{\infty} = 49.8$  cm, growth rate ( $K$ ) = 0.45/yr, and  $t_0 = -0.16$ , the species being medium vulnerable.

Shafi and Jasim (1982) made observations on the biology of this cyprinid in Habbaniyah Reservoir, Iraq. They reported 8 age groups with most rapid growth in summer months when water temperatures are above 25°C. Growth in weight was about 160.1 g per year to the fourth year of life and about 331.0 g per year afterwards. Condition factor was 0.74-1.18 with a mean of 1.0, stable values probably related to piscivory. The length-weight relationship was  $W = 0.0123TL^{3.0601}$ . The von Bertalanffy equation for growth was  $l_t = 91.0[1 - e^{-0.122(t-0.25)}]$ . Ali *et al.* (1986) found the condition factor to range from 0.05 to 1.09 (mean 0.73) and also gave the chemical composition and calorific value. This species had a higher fat content than *Barbus (= Carasobarbus) luteus* with which it was studied. Al-Dabical and Al-Daham (1995) studied growth in the first year of life in fish from the Shatt al Basrah Canal, Iraq and gave the length-weight relationship as  $\log_e W = -12.458 + 3.077 \log_e L$  and the growth equation as  $L_t = 104.118(1 - e^{-0.0121(t - 87.871)})$ . Epler *et al.* (2001) found the oldest age groups to be 5<sup>+</sup>, 6<sup>+</sup> and 7<sup>+</sup> in Iraqi lakes Razzazah, Habbaniyah and Tharthar respectively. The mean condition factor was 0.87, 0.88 and 0.76 respectively. The von Bertalanffy parameters were for Lake Tharthar  $L_{\infty}$  (cm) = 145.5,  $K = 0.0803$ ,  $t_0 = -0.3269$ ,  $W_{\infty}$  (g) = 32099 and  $n = 3.2249$ . These indicated rather uniform growth rates, as  $L_{\infty}$  is relatively high and  $K$  very low. Results were considered more reliable than an earlier study by Jasim (1980) which used inappropriate methods. Annual survival in Lake Tharthar for fish 2.6-5.5 years was 62.0% (Szczerbowski *et al.*, 2001). Productivity was low based on chemical and limnological studies, limiting fish production. Fish in the East Hammar Marsh, Iraq had dominant length groups 17-38 cm, a  $b$  value of 3.085 (positive allometric growth), a maximum age of 8 years,  $L_{\infty} = 65.0$  cm.  $K = 0.21$ , the sex ratio favoured females, and there was a short spawning season (Mohamed *et al.*, 2017). Al-Jubouri (2019) examined 495 fish, total length 10-54 cm, from the Al-Diwaniyah River, Iraq and found this species comprised 5.66% of the fish assemblage,  $W = 0.0069L^{3.0245}$ , the sex ratio differed significantly from 1:1 in favour of females, mean values of relative condition factor for small fish, males and females were 0.9, 0.95 and 1.05, respectively, eight age groups were recognized with lengths 14.3, 23.4, 31.0, 38.2, 42.9, 45.9, 48.7 and 51.5 cm, length group 17 cm dominated, and von Bertalanffy growth constants were  $L_{\infty} = 61$  cm,  $K = 0.226$  and  $t_0 = -0.195$ . The growth performance index ( $\Phi$ ) was 2.92. The total ( $Z$ ), natural ( $M$ ) and fishing ( $F$ ) mortality rates were assessed by applying the length cohort analysis and were 0.619, 0.255 and 0.364, respectively. The exploitation rate ( $E$ ) estimate was 0.588, exceeding the optimal level of exploitation ( $E = 0.5$ ), so this fish stock was overexploited. The following report was presumably based, at least in part, on this thesis. Mohamed and Al-Jubouri (2020c) examined 501 fish from the Al-Diwaniya River, Iraq and found this species constituted about 6.4% of the fish assemblage, there were 8 age groups, the total length of all individuals ranged from 10.2 to 55.5 cm, the length-weight relationship was calculated as  $W = 0.007L^{3.035}$  and growth was isometric, the mean value of the relative condition

factor was 0.98, von Bertalanffy growth parameters were  $L_{\infty} = 61.0$  cm,  $K = 0.227$  and  $t_0 = -0.196$  years, the growth performance index ( $\Phi$ ) was found to be 2.93, the overall male to female ratio was 1:1.51, and length at maturity was 29 cm for males and 31 cm for females.

**Food.** This fish is piscivorous, feeding almost entirely on fish when adult according to Iraqi studies (Shafi and Jasim, 1982), although aufwuchs may also be found in gut contents. It is mainly a mid-water and benthic feeder with limited predation on surface water organisms (Hussein and Al-Kanaani, 1991). The gill rakers are widely spaced, indicative of a piscivorous diet (Salman *et al.*, 1994) and, in a separate study, the gut was a short s-shape, about equal to fish standard length, also indicative of a piscivorous diet (Salman *et al.*, 1994). The mullet, *Liza* (= *Planiliza*) *abu* (abu mullet), is an important food fish (Al-Shamma'a and Jasim, 1993). There is a gradual shift from small- to large-sized fish prey as this species grows (Salman *et al.*, 1994). Frogs, molluscs and aquatic plants and algae were also found in stomach contents, with frogs being important to large fish in terms of prey volume. Plants may be accidental inclusions taken when seizing prey in weed beds. The fish eaten in descending order of importance were *Liza* (= *Planiliza*) *abu* (abu mullet), *Gambusia affinis* (*sic*, probably *G. holbrooki*, eastern mosquitofish), *Garra rufa* and *Cyprinus carpio*. The main crustacean eaten was *Metapenaeus affinis* along with decapods and amphipods.

Hussein *et al.* (1993) examined diet in the Garma Marshes, Iraq and found aquatic insects and crustaceans to be important in young fish in both summer and winter, with molluscs and fish less important. Even in large members of this species, fish were outranked by aquatic insects and in winter by crustaceans as well. Molluscs were a minor food. This species rejected certain molluscs while taking others, attributed to variations in shell thickness and attachment strength to substrates.

Hussein and Al-Kanaani (1989, 1991, 1994) examined the diet of this species in the Al-Hammar Marsh and found a gradually reduced feeding intensity towards the winter months, a highest fullness index in May and lowest in January, and a diet governed by food accessibility and availability. Crustaceans, fish and aquatic insects are the main food items in descending order of importance, with fish most important when using a percentage ranking index in large specimens and even in small ones by volume. Benthic molluscs were the third most important food for young fish after crustaceans and fish. In a study of the recovering Hammar Marsh, Iraq, diet was 80.0% fish and 20.0% insects, in the Hawr al Hawizeh 47.4% fish and 29.4% insects with shrimps, other crustaceans, algae, diatoms, plants and snails at less than 10% each, and in the Al Kaba'ish (= Chabaish) Marsh 73.0% fish and 16.8% insects with shrimps, other crustaceans, algae and plants at less than 10% each (Hussain *et al.*, 2006). Hussain and Ali (2006) examined feeding relationships among fishes in the Al-Hammar Marsh and found this species to be a carnivore, 41.9% of the diet being crustaceans, 10.0% insects and 34.1% fishes.

Epler *et al.* (2001) studied the diet of this species in Lake Tharthar, Iraq and found year-old fish to be eating oligochaetes, tendipedids and plant material with only fish in the diet of two- to seven-year-old specimens. Dietary coincidence with *Luciobarbus esocinus* was high in Lake Tharthar, 96.1%. Jubouri (2019) and Mohamed and Al-Jubouri (2020c) examining fish from the Al-Diwaniya River, Iraq found the feeding intensity and feeding activity were low during winter and high during summer. The species was a carnivore and fed mainly on fishes (49.5%), shrimps (24.9%), aquatic insects (9.5%), crustaceans (8.1%) and algae (8.0%). Large individuals fed mainly on fishes (58.1%), shrimps (24.3%), insects (10.9%) and crustaceans (6.6%).

**Reproduction.** Hashemi *et al.* (2016) found fish in Shadegan Marsh spawned in January and February.

van den Eelaart (1954) found this species in deep parts of Iraqi rivers in December-January, entering marshes and lakes in February to spawn at the end of February and the beginning of March. Spawning took place on gravel beds, the same as those used by *Barbus* (= *Luciobarbus*) *xanthopterus*, but also on plants. Shafi and Jasim (1982) recorded possible spawning in January at 10°C in Iraq with a fecundity up to 74,509 eggs, a mean of 1,157 eggs/g body weight and egg diameter of about 1.1 mm. Epler *et al.* (2001) studied reproduction in Iraqi lakes Tharthar and Habbaniyah and found males to achieve maturity in the third year of life at 44.2 cm and females in the fourth at 47.2 cm. Spawning occurred in February at 13-14°C. Fecundity was 92,000 eggs/kg body mass. Jubouri (2019) and Mohamed and Al-Jubouri (2020c) examining fish from the Al-Diwaniya River, Iraq found the maximum gonadosomatic index (9.37 for females and 4.4 for males) was in January then dropped dramatically for both sexes, suggesting that the species may spawn in February.

**Parasites and predators.** Jalali and Molnár (1990a) recorded the monogeneans *Dactylogyrus mokhayeri* and *D. pulcher* from this species in the Dez River. Moghainemi and Abbasi (1992) reported a wide range of parasites from this species in the Hawr al Azim in Khuzestan. Mortezaei *et al.* (2000) recorded an infection rate of 6.6% with the worm *Neoechinorhynchus tylosuri* in Khuzestan marshes. Farahnak (2000a, 2000b), Farahnak *et al.* (2002) and Moumeni *et al.* (2020) recorded *Contracaecum* sp. and *Anisakis* sp. from this fish in Khuzestan, both zoonotics. Barzegar *et al.* (2008) reported the digenean eye parasite *Diplostomum spathaceum* from this fish. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Argulus* sp., *Ergasilus* sp., *Ergasilus sieboldi*, *Lernaea* sp., *Lamproglena* sp. and *Lamproglena compacta* on this species.

It is eaten by *Silurus triostegus* (Mesopotamian catfish).

**Economic importance.** van den Eelaart (1954) gave the fishing season in Iraq for this species as December-February (peaking in January) and February and June-November (peaking in February and July-August). Sharma (1980) reported that this species was an important item at the Basrah, Iraq fish market, accounting for 68,948 kg from October 1975 to June 1977, although this is an order of magnitude less than for the three most important species.

Foreign soldiers in Iraq during 2005 regularly caught this species on angling gear using spoons and streamer flies, e.g., [www.carpecapio.com](http://www.carpecapio.com), downloaded 26 August 2005.

**Experimental studies.** Velayatzadeh and Abdollahi (2011) found concentrations of lead, cadmium and mercury in the Karun River at Ahvaz were lower than international limits for these heavy metals.



Khuzestan, Karun River at Ahvaz White Bridge  
(Iran – Ahvaz White bridge^ Karoon, CC BY 3.0, Alireza Javaheri).

Its potential for fish farming may be limited by its small gill area which makes it unfit to maintain gas exchange in oxygen-poor water (Salman *et al.*, 1994). Kassim *et al.* (1998) found locally-raised *Scenedesmus acutus* algal cultures at  $0.5 \times 10^6$  cell/ml with baker's yeast at 0.05 g/l to be the best formula for raising the rotifer *Brachionus calcyflorus* as live food for larvae in Iraq. Growth rate was, however, higher on an artificial diet of boiled eggs and soybean meal at 52% compared to 48%, in contrast to common carp.

**Conservation.** Few specimens have been caught in Iran and deposited in museums. This may reflect inadequate collection methods. It was commonly caught by American soldiers in Iraq in 2004 as evidenced by emailed photographs sent to me for identification and is an important food fish in Iraq. Detailed surveys using appropriate equipment are needed to assess its distribution and status in Iran. Vulnerable in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Scale counts were taken also from Banister (1980).

Type material:- *Aspius vorax* (NMW 76785).

Iranian material:- CMNFI 1991-0147, 1, 276.3 mm standard length, Khuzestan, Hawr al Azim, Albogorbeh Village (no other locality data); CMNFI 1991-0154, 1, 133.0 mm standard length, Khuzestan, Hawr al Azim (ca. 31°45'N, ca. 47°55'E); ZMH 2516, 1, 259.9 mm standard length, Kermanshah, Karasu-Gamasiab-Seymarreh (= Qareh Su-Gamasiab-Simareh, no further locality data); not kept, 3, 105.6-282.5 mm standard length, Khuzestan, Hawr al Azim and Dez River (no further locality data).

Comparative material:- BM(NH) 1920.3.3:127-146, 28, 69.8-284.7 mm standard length, Iraq, Basrah (30°30'N, 47°47'E); BM(NH) 1920.10.8:1, 1, 182.3 mm standard length, Iraq, Tigris River (no other locality data); BM(NH) 1931.12.21:11, 1, 250.2 mm standard length, Iraq, Mosul (36°20'N, 43°08'E); BM(NH) 1968.12.13:182, 1, 251.7 mm standard length, Syria, Cheria River,

tributary to the Orontes River (no other locality data); BM(NH) 1972.3.16:1, 1, 112.1 mm standard length, Iraq, Dokan Lake (no other locality data); BM(NH) 1973.5.21:189-190, 2, 166.2-192.0 mm standard length, Iraq, Shatt-al-Arab (no other locality data); CMNFI 1987-0117, 1, 200.8 mm standard length, Iraq, Hawr al Hammar (no other locality data); FMNH 51242, 1, 322.6 mm standard length, Iraq, Halfaya east of Amara (31°49'N, 47°26'E); NMW 90366, 1, 309.0 mm standard length, Turkey, Cermik on the Euphrates River (39°09'N, 39°27'E); NMW 90807, 1, 214.8 mm standard length, Turkey, Devegeçidi Çayı, Tigris River basin (no other locality data); NMW 91020, 1, 170.6 mm standard length, Iraq, Shatt-al-Arab, Basrah (30°30'N, 47°47'E).

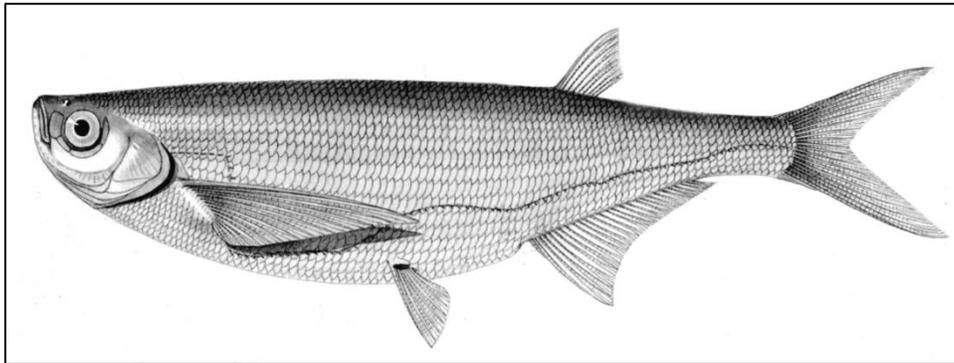
**Genus *Pelecus***

Agassiz, 1835

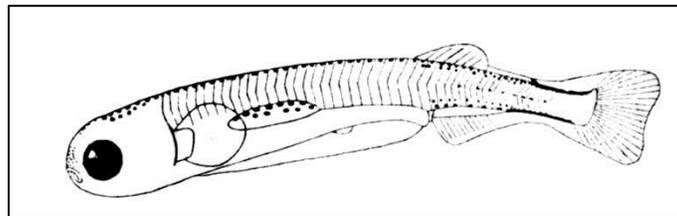
The sabre carp genus contains only a single species found from the Baltic to the Black, Caspian and Aral Sea basins including Iran. This genus is the sister group to other Old World Leuciscinae (Schönhuth *et al.*, 2018). The characters of the genus are the same as under the species.

***Pelecus cultratus***

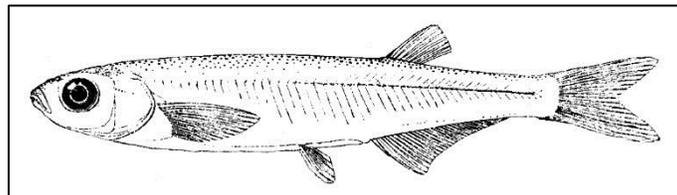
(Linnaeus, 1758)

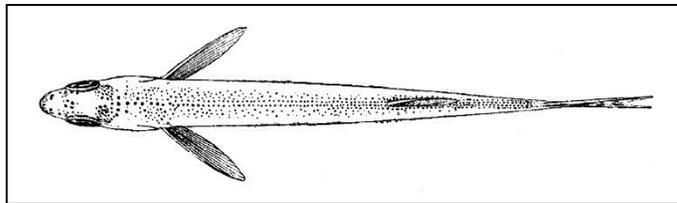


*Pelecus cultratus*, 27.3 cm total length, ZISP 13272, Uzbekistan, Aral Sea near the mouths of the Amu Darya, after Berg (1948-1949).

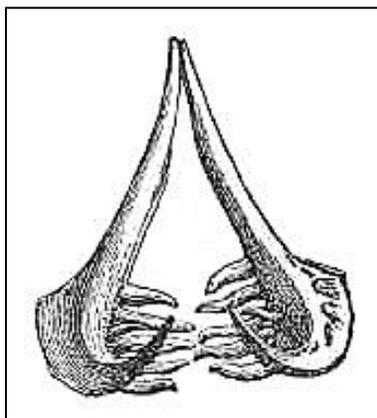


*Pelecus cultratus* fry, 14.2 mm, Russia, Volga River delta, after Kazanskii (1925).

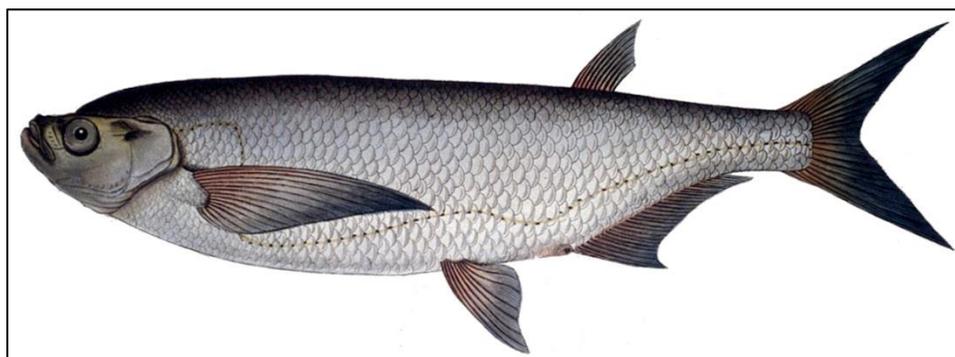




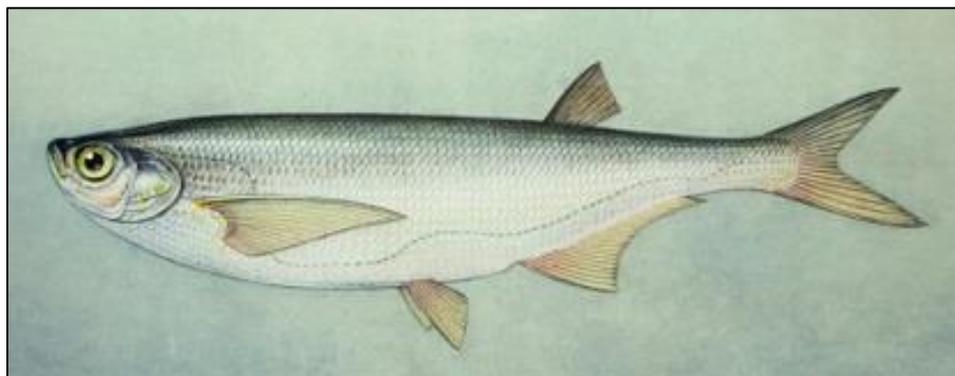
*Pelecus cultratus* young, 33 mm, lateral and dorsal views, Kazakhstan, Ural River delta, after Shukolyukov (1932).



*Pelecus cultratus*, pharyngeal teeth, after Seeley (1886).



*Pelecus cultratus*, after Bloch (1795-97).



*Pelecus cultratus*  
(CC0, NOAA Photo Library, N. N. Kondakov).

**Common names.** Shamshir mahi (= scimitar or sword fish), shamshir mahi ab-e shirin (= freshwater sword fish), kuli.

[Gilincbalig in Azerbaijan; chekhon' in Russian; razorfish, sabre carp, sabrefish, sichel, ziege].

**Systematics.** *Cyprinus cultratus* was originally described from the Helgeån River, Sweden. The holotype is in ZMUU Linn. Coll. 224 and is in poor condition.

*Pelecus cultratus kurensis* Smirnov, 1943 is the Kura River basin subspecies but Berg (1948-1949) considered that other populations over the range of this species had been insufficiently studied to validate this subspecies.

**Key characters.** This species is easily recognised by the scaleless keel extending from the throat to the anal fin and the decurved and wavy lateral line.

**Morphology.** The body is elongate and strongly depressed. The dorsal profile including the head is straight. The ventral profile of the head rises sharply. The snout ends as part of the straight dorsal profile. Lips are thin. The caudal peduncle is compressed and moderately deep. The mouth is almost vertical. The large eye is in the anterior half of the head. The lower jaw is hooked in older specimens and has a tubercle which fits into an upper jaw notch. The dorsal fin is far posterior, lying over the anterior anal fin, is very small and has a straight or slightly concave margin. The caudal fin is deeply forked with pointed tips. The lower lobe of the caudal fin is larger than the upper, with more rays and a stiffer ventralmost ray. The long anal fin is very emarginate and does not reach back to the base of the caudal fin. The pelvic fins are rounded and almost reach back to the anal fin. The elongate anal fin is deeply emarginate. The pectoral fins are long and curved, used for rapid manoeuvring when swimming normally and folded against the body when swimming rapidly. They reach back to or fall short of the pelvic fins. Gill openings are very wide with the branchiostegal membranes attached far forward, under the eye level. Muscles on the back extend forward to reach the anterior eye margin. Scales end over the eye anteriorly on the head.

Dorsal fin unbranched rays 2-3, usually 3, followed by 6-10, usually 7, branched rays, anal fin unbranched rays 2-3, usually 3, and branched rays 23-31, pectoral fin branched rays 13-17, and pelvic fin branched rays 6-8. Lateral line scales 88-120. Scale shape is a vertical oval with rounded margins, the posterior margin almost vertical and the anterior margin more rounded, or is squarish with a shallow posterior margin, straight to rounded dorsal and ventral margins, abrupt and rounded anterior corners, and the anterior margin coming to a central point and somewhat wavy. Scales have extremely fine circuli, a central to subcentral posterior focus and very few posterior radii. Total gill rakers number 15-26 (reaching the second or third raker below when appressed). Pharyngeal teeth are 2,5-5,2, are narrow and are very strongly hooked at the tip with obviously serrate edges. Variants include 2,5-4,2, 2,4-5,2 and 2,5-5,3. The gut is an elongate s-shape. Total vertebrae number 46-52. The chromosome number is  $2n = 50$  (Klinkhardt *et al.*, 1995; Arai, 2011).

**Sexual dimorphism.** Unknown.

**Colour.** The back is greenish and the flanks silvery to silvery-green. Fins are hyaline to grey, although the paired fins and the anal fin can be a bright yellow, and all fins can be quite dark.

**Size.** Reaches 65.0 cm and 2.0 kg, possibly 3.5 kg (Machacek (1983-2012), downloaded 27 July 2012) but most fish in the Volga-Caspian region are 80-180 g.

**Distribution.** This species is found in the drainages of the Baltic, Black, Caspian and Aral seas. In Iran, this species is reported as rare in the lower Sefid River (Derzhavin, 1934) and

is found in the Anzali Talab (Abbasi *et al.*, 1999; Kiabi *et al.*, 1999). Recorded by Abdoli (2000) from the middle to lower Sefid River, Anzali Talab and adjacent Caspian coast. Recorded from the Atrak River but not yet from its Iranian reach (Reshetnikov *et al.*, 1997). Also reported from the Karakum Canal and Kopetdag Reservoir of Turkmenistan (Shakirova and Sukhanova, 1994; Sal'nikov, 1995) and so may eventually be found in the Tedzhen (= Hari) River basin of Iran.

**Zoogeography.** A European and Western Asian species with its origins in a Danubian or Sarmatian fauna.

**Habitat.** This species is found in rivers, lakes, dams and brackish environments. This species lives primarily in the sea but is also anadromous and may live permanently in larger tributaries. Naderi Jolodar and Abdoli (2004) noted two forms in Iran, one resident in fresh water and a migratory form. Generally, it inhabits surface waters, aided by fin and mouth modifications for this mode of life (Adamicka, 1984). It migrates to the fresh water of large rivers to spawn. In the sea and larger rivers, it occurs in schools.

**Age and growth.** Sexual maturity in the Volga River was attained at 3-4 years and a minimum length of 20.0 cm in males, 4-5 years and 22.0 cm for females. The largest immature males were 24.0 cm long, females 25.0 cm and the maximum age of non-spawners of both sexes did not exceed 6 years. The spawning stock was mostly fish 4-10 years old. Males had a slightly smaller maximum size than females and life span was at least 16 years (Sil'chenko, 1976). Spawning took place first at age 2 in the Kura River of Azerbaijan. Growth was faster than in other populations, the Kura fish being the same size at age 2 as age 3 fish from the Don River of the Black Sea and age 4 fish of the Aral Sea.

**Food.** Food is taken by the vertical mouth from surface waters and includes insects and spiders. Young fish feed on zooplankton and even adults will do this if crustaceans are abundant. In the sea, various crustaceans are taken and these may be pursued near the bottom. Full grown *Pelecus* (50-60 cm) will capture fish such as *Clupeonella* (kilkas, Clupeidae), gobies (Gobiidae), Cyprinidae and even sticklebacks (Gasterosteidae) (Adamicka, 1984).

**Reproduction.** Spawning took place in the latter half of May in the Kyubyshev Reservoir of the Volga River at 13.5-14.1°C or as high as 18-22°C. Water depths were 2.0-3.5 m. The main spawning took place around sunset over a period of 24 days with a peak period of 10-12 days. Fecundity reached 71,400 eggs. Eggs sank to the bottom but swelled to an average diameter of 4.7 mm within an hour of fertilisation. Once swollen, any slight movement of the water suspended the eggs in the water column. Eggs developed pelagically in floodplains, main rivers, side channels, bays and lakes but all these diverse habitats had a high oxygen content through flowing water or wind mixing. In the Volga flow rates were 0.28-1.1 m/sec on a sand-gravel bottom. Spawning may also take place in brackish water where the eggs float. Spawning in the Kura River of Azerbaijan took place at the end of April and in May. The larvae are phototropic and active swimmers.

**Parasites and predators.** The Caspian seal, *Pusa caspica*, was reported as a predator on this species (Krylov, 1984).

**Economic importance.** Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use in textbooks and for food. The scales contain silvery crystals of guanine which are extracted and used to make *essence d'orient* for artificial pearls. In the period 1909-1913, the catch in the Volga-Caspian region was more than 14 million fish annually. The flesh is fatty and bony and so this species is best smoked.

**Experimental studies.** None.

**Conservation.** Lelek (1987) classified this species as intermediate to rare in Europe but

fairly common in the Caspian Sea basin. Kiabi *et al.* (1999) considered this species to be critically endangered in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, few in numbers, habitat destruction, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Meristic values are based partly on Wais (1995).

Iranian material:- None.

Comparative material:- CMNFI 1971-0825, 1, 232.0 mm standard length, Czechoslovakia, Lake Ozirna (no other locality data); CMNFI 1987-0220, 2, 96.9-105.7 mm standard length, Rumania, Lake Călărași (44°20'N, 27°20'E); ZISP 13273, 1, 182.6 mm standard length, Uzbekistan, Amu Darya, Petro-Alexandrovsk (= Turtkul) (no other locality data).

### **Genus *Rutilus***

Rafinesque, 1820

The roaches are found in Europe and Western Asia where there are about 15 species (Bogutskaya and Iliadou, 2006). Two to three species are found in Iran.

The genus is characterised by having pharyngeal teeth in one row, usually 6-5, more rarely 6-6 or 5-5, with conical crowns on the anterior teeth and posterior teeth slightly hooked and truncated, scales are large to moderate in size, numbering 33-68 and with numerous fine circuli and radii on all fields, few and short gill rakers (17 or less), short gut, usually a light peritoneum, few to moderate numbers of dorsal and anal fin rays (7-13), the dorsal fin commonly having 4-5 unbranched rays, abdomen behind the pelvic fins rounded or with a slight but scaled keel, and various osteological characters (Bogutskaya and Iliadou, 2006). Pourshabanan *et al.* (2017) confirmed the monophyly of this genus using data from an analysis of the cytochrome oxidase subunit I.

Levin *et al.* (2017) examined *Rutilus* taxa from the eastern part of the genus range using cytochrome *b* sequences. They found three major clades, *R. frisii* (which includes *R. kutum*), *R. rutilus sensu stricto*, and a group of six Ponto-Caspian taxa including *R. caspicus* (now *R. lacustris*) and *R. rutilus lacustris* of relevance to Iran. The Ponto-Caspian clade could be a single species, *R. lacustris* by priority of description. Levin *et al.* (2017) recommended using nuclear DNA and rigorous morphological examination to confirm this suggestion. Both *R. rutilus s.s.* and *R. lacustris* occur in the Caspian Sea basin although Levin *et al.* (2017) examined no material from Iran, their *R. rutilus* material being from the Volga and Ural River basins and some of their nominal *R. caspicus* (now becoming *R. lacustris*) being from the Caspian Sea of Azerbaijan and the Araks (= Aras) and Kura rivers. It remains to be determined whether *R. rutilus s.s.* occurs in Iran, presumably as a resident and non-migratory species of Caspian basin fresh waters. Jouladeh-Roudbar *et al.* (2020) also stated its presence in Iran needed confirmation. Data on Iranian *Rutilus*, appearing under the species names of *caspicus* and *rutilus*, are here treated under *R. lacustris* while recognising that resident populations may be that species too, or *R. rutilus* or indeed an undescribed taxon. Levin *et al.* (2017) noted the absence of phenotypic differentiation between under-yearlings of migrated and resident forms and that form-specific characters of the migrating fish previously identified as *R. caspicus* developed during their sea life. There was a lack of genetic divergence in cytochrome *b* from migrating and resident populations in the Caspian Sea basin, arguing for an ecological origin. This has not been tested thoroughly with Iranian populations.

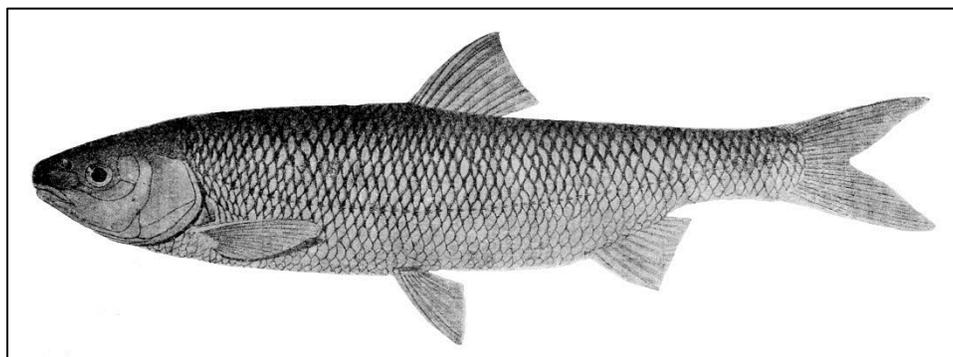
Chakmehdouz Gasemi and Behmanesh (2015) compared the two *Rutilus* species in the

south Caspian Sea of Iran (given as *Rutilus frisii kutum* and *R. r. caspicus*) using cytochrome *b* and found high genetic diversity and no distinct sister-clade. Eagderi *et al.* (2017) used osteology to compare fish from the Aras and Shalman rivers and Bandar-e Torkeman, finding differences in the Aras population from the other two may be due to phenotypic plasticity and, since similarities were observed between *R. rutilus* and *R. caspicus* (= *R. lacustris*) from the Kura (*sic*), it was proposed that they belong to the same species. *R. caspicus* from Torkeman may be a distinct taxon but this observation in particular needs additional evidence from DNA to be accepted.

The following table summarises some key distinguishing characters of the Iranian species of *Rutilus*.

Species/Characters	Lateral line scales	Gas bladder	Distribution
<i>R. kutum</i>	47-68 (mostly 55-58)	Elongate and conical, or pointed, posteriorly	Caspian Sea
<i>R. lacustris</i>	39-48 (mostly 41-47)	Rounded posteriorly	Caspian Sea

***Rutilus kutum***  
(Kamensky, 1901)



*Rutilus kutum*, western coast of the Caspian Sea, after Berg (1932b).



*Rutilus kutum*  
(CC0, NOAA Photo Library, N. N. Kondakov).



*Rutilus kutum*, Gilan, Pol-e Rud, February 2005, Keyvan Abbasi.



*Rutilus kutum*, Iran, Caspian Sea, Vadim D. Vladykov.



*Rutilus kutum*, Iran, southwest Caspian Sea, Gh. Moradinasab and M. Daliri.

**Common names.** Mahi sefid or sefid mahi (= white fish, and occasionally cause for confusion in translation from the Farsi to English with the whitefishes of the family Salmonidae, not native to Iran), sifid mahyi and asbalan mahi (in Gilaki meaning white fish and fish with eggs or caviar), mahi sefid daryacheh khazar or mahisephid-e-daryaye khazar (= Khazar or Caspian Sea white fish), talaji (in Mazanderani), kutum (from the Russian name).

[Kutum, ak-balyk (meaning white fish) or ziyad in Azerbaijan; akbalyk or kutum in Turkmenian; kutum in Russian; Caspian kutum, pearl roach, Southern Caspian roach].

**Systematics.** *Leuciscus Frisii* was originally described from the market in Odessa and the Danube, Dniester, South Bug, Dnieper and Don rivers, draining to the Black Sea. *Rutilus frisii kutum* (Kamensky, 1901) was the generally accepted Caspian Sea basin subspecies although J. Holčík (pers. comm., 1994) considered that this was not a good taxon (see also Holčík and Jedlička, 1994). It was originally described as *Leuciscus Frisii* var. *kutum* from the Caspian Sea, essentially in the southern part, spawning in the rivers and streams of Transcaucasia and Persia (Kura, Araxes, streams of the Lenkoran district) and in lesser numbers elsewhere. No types are known. The *Catalog of Fishes* (downloaded 4 August 2020) has Kamensky's plate 12 as an illustration of this taxon but this is *Leuciscus frisii*.

The subspecies *R. frisii kutum* was distinguished from the type subspecies from the Black Sea by having fewer lateral line scales (about 55-58 versus about 60-66), shallower body (depth equal to or less than head length versus exceeding head length), anal fin longer than high versus shorter than high, lower lobe of caudal fin usually shorter than head versus longer (young *R. f. kutum* have this lobe as long as head), and dorsal fin as high as long versus higher than long (young *R. f. kutum* have dorsal fin higher than long). Kotlík *et al.* (2008) discussed divergence and gene flow between Black and Caspian Sea populations, the majority of the migrations occurring during the Pleistocene (ca. 10,000-1,800,000 years ago). The refugial populations in the Black and Caspian seas have diverged despite periods of migrations between them. Naseka and Bogutskaya (2009) concurred with this conclusion.

*Leuciscus frisii caspius* Lönnberg, 1900 described "from the Volga delta" has priority over *Rutilus frisii kutum* which may be a nomen nudum as it is listed in Radde (1899) as "*Leuciscus Frisii* Nordm. var. *Kutum* Kam." without a description, the description only appearing in Kamensky (1899-1901). However, the name *caspius* has not been used while *kutum* appears widely in the literature as well as being the common Russian name of the fish, also used in Iran. Kottelat (1997) considered *kutum* to be a distinct species as did Bogutskaya and Iliadou (2006) and Fricke *et al.* (2007). Kuljanishvili *et al.* (2020) noted their unpublished molecular data (COI) failed to distinguish the Caspian *R. kutum* from the Black Sea *R. frisii* and treated *R. kutum* as a junior synonym of *R. frisii*. *R. kutum* is now widely used for the Caspian Sea populations and I have left it as such until published data become available.

*Leuciscus friesii* Kessler, 1870 from the Volga delta is presumably a misspelling.

Chakmehdouz Ghasemi *et al.* (2009) found the spring and autumn races of this species to be independent populations using microsatellite markers. Chakmehdouz Ghasemi *et al.* (2014) also used microsatellite markers to examine populations from the Anzali Talab and Shirud, two important spawning areas, finding the populations to be distinct. Kavan *et al.* (2009) investigated the population genetic structure of Iranian and Azerbaijani fish using microsatellite markers. Most of the variation was within rather than between locations.

Rezaei *et al.* (2010a) used microsatellite markers for fish from the Gorgan and Cheshmeh Kileh (= Tonekabon) rivers and found low genetic differentiation, which they attributed to mismanagement of the restocking programme. Rezaei *et al.* (2010b), however, used microsatellite

markers for fish from the Gorgan and Qareh Su rivers and found a high level of genetic variation and more than one population in these Golestan Province waters. Rezaei *et al.* (2011) studied populations from the Gharesou (= Qareh Su), Tajan and Goharbaran rivers using microsatellite markers and found weak genetic differentiation between populations and a large amount of total variation within populations. It was suspected that natural divergence between riverine populations had been reduced by offspring transfer in stocking operations. Rezaei *et al.* (2013) investigated the microsatellite diversity and population genetic structure of fish from the Tajan and Tonekabon regions finding evidence of a genetic bottleneck because of a reduction in population size. There was no obvious genetic differentiation between the populations and gene flow was high.

Rezvani Gilkolaei (2011) used microsatellite markers for 210 specimens of kutum from the Gorgan, Khoshk and Tonekabon rivers, the Anzali Lagoon or Talab and the Kura River mouth of Azerbaijan and found the average of expected and observed heterozygosity was 0.54 and 0.49, respectively. Significant deviations from Hardy-Weinberg expectations were observed in almost all locations and there were significant differences between locations. Rezvani Gilkolaei *et al.* (2012) used microsatellite markers to investigate the spring- and autumn-run fish in the Anzali Lagoon and spring-run fish from the Khoshk River. The latter showed lower allelic and genetic variation. There was no significant difference between the two runs in the Lagoon suggesting they originated from a common ancestor.

Abdolhay *et al.* (2010) found independent populations existed in the Lemir (= Lomir), Sefid, Shirud and Tajan rivers based on morphometric data. This had implications for the extensive stocking programmes for this species. Abdolhay (2011) and Abdolhay *et al.* (2012), however, used mitochondrial DNA and found low genetic variability with two main clusters, Shirud and Lamir (= Lomir) River populations and Tajan and Sefid River populations, the clustering not conforming with geography. And, Abdolhay *et al.* (2012), using microsatellite DNA found populations to cluster in three groups, Shirud, Lamir (= Lomir) and Tajan-Sefid, again attributing low genetic variability and high inbreeding to artificial fingerling production.

Shojaei Kavan (2010) used biometry and microsatellite techniques to compare Azerbaijan, Gorgan, Khoshk, Tonekabon, spring Anzali and autumn Anzali lagoon populations, finding the highest genetic distance between Gorgan and autumn Anzali populations and the lowest between Gorgan and Tonekabon ones. There were at least two populations in the Caspian Sea and more than one in the southern Caspian with implications for artificial reproduction and stock rebuilding. Kolangi Miandareh *et al.* (2015) found a low genetic distance between fish from the Gharesu (= Qareh Su), Goharbaran, Gorgan, Sefid and Tajan rivers using cytochrome *b*, and the most haplotypes were found in Gharesu and Gorgan River samples. Laloei *et al.* (2016) found genetic diversity using microsatellite DNA was significantly different between samples of Golestan and Gilan, Golestan and Sefid River, Golestan and Tajan, Mazandaran and Sefid River and Gilan and Tajan. Safari (2016) collected fish from the coastline at the Cheshmeh Kileh (= Tonekabon), Gharasou (= Qareh Su) and Sefid rivers to examine the population structure using microsatellite markers. The average genetic variation was lower than most other anadromous fish and, in spite of migrations between the Cheshmeh Kileh and Qareh Su, there were three different populations with implications for management and restocking. Kashiri *et al.* (2017, 2018) collected fish from the Gomishan Wetland, Gorgan Bay, and the Gorgan and Qareh Su rivers, used microsatellite marker analysis to compare wild and hatchery populations and found a somewhat lower genetic diversity in hatchery fish, and this again has relevance to stock management.



Mazandaran, Tonekabon River at Tonekabon  
(File 92 .... in Farsi, CC BY-SA 3.0, cropped, Mohammed Reza Shamsi).

Gorjian Arabi *et al.* (2010) analysed fish from the Shazdeh and Shirud using nine meristic characters and 26 morphometric characters. Principal components analysis showed both meristic and morphometric characters of females, but only meristic characters of males, overlapped. Kashefi *et al.* (2012) used meristic and morphometric characters to examine variation between non-reproductive and reproductive females in the southwest Caspian Sea. Meristic characters showed no difference but maximum body height, “post back” distance, dorsal fin height and upper caudal fin length discriminated between the two types. The first character could be indicative of eggs distorting the body profile. Ghojoghi *et al.* (2014) examined the morphometrics of fish from Bandar-e Torkeman, Mahmoudabad, Kellarabad, Bandar-e Kiashahr and the Talesh coasts, the populations clustering into three groups - Talesh (anterior position of caudal and anal fins), Kellarabad (elongate anal fin base), and the rest. Ghojoghi *et al.* (2018), examining fish morphometrically from the same localities as above, found the Kiashahr and Torkeman samples clustered together and concluded that kutum has a wide phenotypic plasticity potential.

Turkmen and Astara stocks could be discriminated using trace element content in otoliths (*Iranian Fisheries Research Organisation Newsletter*, 64:4, 2011). Tahami and Ghiasi (2013) compared serum markers and protein bioassay as well as morphometrics of fish from the Tajan and Shirud rivers finding significant differences in spring but not in autumn. Tahami (2014) found significant morphometric and blood serum (transferrin) differences between the two populations from the Shirud and Tajan rivers in spring, but not autumn.

Berenjkar *et al.* (2016) identified and sequenced the two copies of the growth hormone (GH-1 and GH-2) that are found in fish as a result of duplication during evolution. These sequences could be used to reconstruct phylogenetic relationships, study different allelic forms more precisely, and establish relationships between these loci and important economic traits.

Pourang *et al.* (2018) sampled fish from areas adjacent to the estuaries of the Gorgan Sefid and Tajan rivers and, using elemental fingerprinting of strontium in otoliths and potassium in scales, concluded that the Gorgan and Tajan specimens were from the same population.

Abbasi *et al.* (2020) sampled fish from beach seines for the shape indices of their sagittal otoliths and found four distinct spatial groups 1) Gomishan, 2) Khajeh Nafas-Miyankaleh-Sari-Babolsar, 3) Nowshahr-Tonekabon-Roodsar, and 4) Bandar-e Anzali-Astara.

A hybrid of this species and *Ctenopharyngodon idella* has been bred at the Astaneh Ashrafie Fisheries Research Station (Sefidrud Research Station) and named “Samur” (*Iranian Fisheries Research and Training Organization Newsletter, Tehran*, 11:6, 1996, 18:6, 1997; Khara *et al.*, 2002; Nouruz Fashkhami *et al.*, 2002). Gynogenesis may have occurred. Artificial hybrids with *Rutilus rutilus* (possibly including *R. lacustris*) and *Abramis brama* have been bred in Iran (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 39-40, 1996).

**Key characters.** This species is distinguished from the related *Rutilus rutilus* and *R. lacustris* by the higher scale count (usually >50) and the posterior part of the gas bladder being elongate and conical or pointed rather than rounded.

**Morphology.** The body is compressed and is moderately deep, being deepest between the end of the pectoral fin and the origin of the pelvic fin. The predorsal profile is almost straight, being slightly convex. The caudal peduncle is compressed and moderately deep. The head tapers to a rounded snout. The eye is at the beginning of the anterior half of the head. The mouth is oblique and extends back to the rear of the nostril level or almost to the eye. Lips are of moderate thickness. The dorsal fin margin is slightly to moderately emarginate. The dorsal fin origin is just posterior to, or over, the level of the pelvic fin origin. The depressed dorsal fin does not reach back to the level of the anal fin origin. The caudal fin is moderately to deeply forked with pointed tips. The anal fin margin is straight to slightly emarginate. The pelvic fin is rounded and does not extend back to the anal fin origin. The pectoral fin is rounded and does not extend back to the pelvic fin origin.

Dorsal fin with 3 unbranched and 8-10, usually 9, branched rays, anal fin with 3 unbranched and 9-12, usually 10, branched rays, pectoral fin branched rays 16-19, and pelvic branched rays 8-9. Lateral line scales 47-68, mostly 55-58. Scales are regularly arranged over the body. A pelvic axillary scale is present. Scales are oval in shape (but specimens examined were small). The posterior scale margin is rounded to crenulate and the anterior margin is wavy to crenulate or with a central protrusion but scale margins vary greatly between individual scales. The ventral margin is more rounded than the dorsal margin. The anterior scale corners are abrupt but rounded. Esmaeili and Gholami (2011) gave details of scale morphology using scanning electron microscopy, indicating that fine structures are of taxonomic import. Scales have numerous circuli, numerous posterior radii, few but distinctively crowded anterior radii (more than in *Rutilus rutilus* and *R. lacustris*) and an almost central focus which is broken up into a network of lines. Total gill rakers number 7-12 and are very short, hardly reaching the one below when appressed. Pharyngeal teeth are usually 6-5, with crowns rounded above a slender stalk, posterior teeth with a weakly hooked tip, and the posteriormost tooth margin may be serrated. The gut is an elongate s-shape. Total vertebrae number 40-44. Chromosome number  $2n = 50$  (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, p. 43, 1996; Klinkhardt *et al.*, 1995; Noruz Fashkhani and Khosroshahi, 1995; Arai, 2011).

Adibmoradi and Sheibani (2002) carried out a histological study of the brain of this species and concluded, in part, that vision was sharp and the fish were good chasers of food. Naserizadeh *et al.* (2013) documented abnormal specimens from the Cheshmeh Kileh (= Tonekabon) River. Khoshnood (2015) described the histological structure of the visual system in larvae and fingerlings. Farhang and Eagderi (2019) described the ontogeny of the caudal skeleton. Mazaheri Kouhanestani *et al.* (2020) gave a description of the larval stage from southeastern waters of the Caspian Sea. Shabanipour and Abbasi (2020) followed the ontogeny of the eye from pre-hatch to the end of the larval stage. Vakili *et al.* (2020) described the

morphological characteristics of otoliths of fish from Fereydun Kenar.

Meristic values for Iranian specimens are:- dorsal fin branched rays 8(1), 9(58) or 10(1), anal fin branched rays 9(24), 10(35), 11(-) or 12(1), pectoral fin branched rays 16(15), 17(30), 18(14) or 19(1), pelvic fin branched rays 8(49) or 9(11), lateral line scales 47(1), 48(-), 49(1), 50(1), 51(1), 52(7), 53(8), 54(6), 55(5), 56(11), 57(7), 58(7) or 59(5), total gill rakers 8(1), 9(21), 10(25) or 11(13), pharyngeal teeth 6-5(23), 5-5(1) or 5-4(1), and total vertebrae 40(1), 41(7), 42(34), 43(3) or 44(2).

**Sexual dimorphism.** Females are larger than males. The breeding tubercles are evident in males and may develop as early as the end of summer before the spring spawning season in the following year. Large tubercles are found on the top of the head above the eye level, behind the eye, between the eye and the mouth and on the snout as well as on upper flank scales (see photographs above). Tubercles are white in contrast to the dark head. Imanpour and Shirmohammadli (2008) found that fish from the Gorgan River showed correlations between increase in number of tubercles and total length, sperm volume, and gonad weight but not with sperm motility, spermatocrit, sperm density and gonadosomatic index. Tekeh and Imanpour (2009) in their spermatology study examined fish with more than 135 tubercles on the head. Pourkazemi and Razikazemi (2011) tried to differentiate sex using a PCR-RAPD technique but failed either due to these fish not having sex chromosomes or the sex genes are on different autosomal chromosomes.

**Colour.** Small specimens up to a year old are silvery on the flanks and belly and the back is steel-grey to pale brown or pale olive. In adults, back scales are circled with black and there is a strong contrast between the back and flank. The anterior part of each flank scale, particularly those of the lateral line, is darkly pigmented. Lateral line scales may have two dots, one above and one below the opening as in some *Alburnoides* spp. but not as pronounced. The sides of the head are silvery with some yellow and darker pigment, the latter particularly in front of the eye. Adults are a bright silvery on the flank. The belly is pearly-white. The iris is silvery, with some spots, and with a marked dark spot above. The dorsal and caudal fins have some grey and a faint orange tint while the pectoral, pelvic and anal fins are colourless to lightly pigmented with black. The pectoral fin may be orange.

**Size.** Attains 68.0 cm total length, fork length 63.5 cm and 4.3 kg (*Iranian Fisheries Research Organization Newsletter, Tehran*, 65:2, 2011). An earlier reported gave 66.0 cm body length and 4.065 kg in Iran (Farid-Pak, 1968). Ouseley (1819-1823) ate one almost 3 feet long (ca. 90 cm). In Iran during the 1950s, catches were 36.0-67.0 cm long (Farid-Pak, No date). Rabazanov *et al.* (2017, 2019) gave maximum sizes of 71.0 cm and 5.0 kg and for commercial catches typically 1.0-1.7 kg.

**Distribution.** This species is found in drainages of the Caspian Sea. It is absent from the northeastern Caspian Sea and the northern eastern coast and is found only sporadically in the mouths of the Volga and Ural rivers. In periods of high abundance, it enters these rivers. In Iran, it is found along the whole Caspian coast, entering almost all the rivers to spawn including the Aras, Asbuchin, Astara, Atrak, Babol, Behambar, Chaf, Chalus, Chalvand, Chamkhaleh, Chobas, Dinachal (= Denya Chal), Goharbaran, Golshan, Gorgan, Haraz, Harisak, Haviq, Jef, Kargan, Kazem, Kelarabad, Khalehsara, Khazar Abad, Khoshk, Kiarud, Larim, Lomir, Mahmoudabad, Masoleh, Masuleh-Rukhan, Mirud, Molahadi, Nahang, Nawarud, Nesa, Pir Bazar, Polrud (= Pol-e Rud), Qareh Su, Rasteh, Sardab, Sari, Sefid, Shafa, Shah, Shalman, Shazdeh, Sheikan, Shesh Deh, Shirud, Siah Darvishan, Sorkh, Sowsar, Tajan, Talar, Tirom, Tonekabon and Valiabad rivers, the Anzali and Astara talabs, Boojagh Kiashahr, Gomishan and Miankaleh wetlands, at

Bandar-e Kiashahr, Bandar-e Torkeman, Nowshahr, Gorgan Bay, the Mojgol Sibli area of Astara, off Goharbaran, and in the southeast, southwest and south-central Caspian Sea (Nedoshivin and Iljin, 1929; Kozhin, 1957; Holčík and Oláh, 1992; Riazi, 1996; Karimpour, 1998; Oryan *et al.*, 1998; Abbasi *et al.*, 1999, 2007, 2017, 2020; Kiabi *et al.*, 1999; Abdoli, 2000; Nazari, 2002; Najar Lashgari *et al.*, 2007; Banagar *et al.*, 2008; Lasheidani *et al.*, 2008; Khara *et al.*, 2008; Najafipour *et al.*, 2008; Abdoli and Naderi, 2009; Piri *et al.*, 2009; Shafiei Sabet *et al.*, 2009a; Gorjian Arabi *et al.*, 2010; Nikoo *et al.*, 2010, 2012; Esmaeili and Gholami, 2011; Abdolhay *et al.*, 2012; Einollahi *et al.*, 2012; Hosseinzadeh Safari *et al.*, 2012; Keivany *et al.*, 2012; Rashidi *et al.*, 2012; Rezvani Gilkolaei *et al.*, 2012; Naserizadeh *et al.*, 2013; Farzadfar *et al.*, 2014; Hassanpour *et al.*, 2014; Bagheri *et al.*, 2015; Kolangi Miandareh *et al.*, 2015; Rowshan Tabari *et al.*, 2015; Moradi Chafi *et al.*, 2016, 2017; Afraei Bandpei *et al.*, 2017; Naderi Jolodar *et al.*, 2017; Pourasdi *et al.*, 2017; Kouhestan Eskandari *et al.*, 2018; Shahnazari *et al.*, 2020; Abbasi *et al.*, 2021).

Hoseini *et al.* (2015) recorded it from the fishing stations Jahan Nama, Shahid Beheshti, Karegar, Azadegan, Azadi Larim, Azadi, Koliver, Karfon, Shahed, Fereydun Kenar, Bishe Kola and Khoram Mahmoodabad, listed from east to west along the Caspian shore in Mazandaran.

It has been introduced to Khandaghlo Dam Reservoir in Zanzan Province in 2003, whether accidentally or deliberately is not known (Abdolmalaki *et al.*, 2017) and also introduced to the Gheshlagh (= Qeshlaq) Dam in the Tigris River basin of Kordestan Province (Bahrami Kamangar *et al.*, 2012a; Zadmajid *et al.*, 2017).

It is also found in Valasht Lake, Mazandaran (landlocked and introduced about 1850 to provide food for the royal family which had a summer residence there) where it possibly hybridises with native *Alburnus chalcoides* (Armantrout, 1980).



Mazandaran, Valasht Lake  
(CC BY 3.0, Alirzea Javaheri).

Taheri *et al.* (2014) noted that this species is reared in earthen ponds in Qom Province. von den Driesch and Dockner (2002) recorded it as faunal remains in an excavation at the Great Mosque in medieval Siraf on the Persian Gulf coast. This may well be a misidentification but, if not, indicates that a fondness for this species has a long history considering that a preserved fish or its remains had to be transported all the way from the Caspian Sea.

**Zoogeography.** A species with its origins in a Danubian or Sarmatian fauna.

**Habitat.** This species is found in rivers, streams, dams, marshes and brackish environments. Some fish were reported at depths of 36.6-53.0 m in the Iranian Caspian Sea (Knipovich, 1921). It has been caught at 31-32°C in the Sefid River estuary on 9 July 1962 (CMNFI 1970-0565, CMNFI 1980-0908). It is migratory, spawning in rivers in March-April and returning to the Caspian Sea. Fish may spend 1 or 2 years in fresh water after hatching (Holčík and Oláh, 1992) and this affected growth, 1-year fish growing more quickly than those spending 2 years in fresh water, maturing earlier and having a shorter lifespan. Growth in the Anzali Talab was slower than it was 20 years prior to the report of Holčík and Oláh (1992), probably owing to a higher population density and more competition for food resources. Rezavi (1997) found three populations in Iran, one autumn and two spring populations. However, today the autumn run comprises only about 1% of the run as re-stocking is of the spring run (Rezvani Gilkolaei *et al.*, 2012). Iljin (1927) recorded schools of fish entering the Anzali Bay (= Talab) as numbering in the several tens of thousands. On one fishing ground next to the Djifrud in February 1914, 12,000 fish were taken simultaneously. However, while the majority of fish migrated into lowland rivers not far from the sea to spawn among bulrushes and cattails, some migrated far upstream into the mountains of Tavalesh (= Talesh) and Gilan where spawning conditions were very different. These fish may well overwinter in the river (Derzhavin, 1934). Such fish reached altitudes of about 1,000 m before environmental changes inhibited the migration. Young fish migrated downstream, the migration ending in August, and in Azerbaijan entered the sea within 20-50 days. Holčík (1994, 1995) stated that Iranian young from the Anzali Talab never entered the sea but remained in fresh or brackish water for 1-2 years. Riazi (1996) reported that this species migrated into the Siahkeshim Protected Region of the Anzali Talab.

Yousefian (2011d) investigated the spawning migration in the Shirud, the most important river for wild production in Iran. The number of migrants was related to water temperature (see below), weather (clouds increased catch, wind from sea to land increased catch), the delta of the river (storms changing river direction decreased catch), water level (higher increased catch), turbidity (higher decreased catch), and sea wave conditions (waves increased catch). There was an early run when water temperatures increased slightly but quickly at the end of winter and a late run which held in sea areas near the river mouth for several weeks before migrating upriver. Migrating fish were caught at 7.0-19.5°C from early March to late May, with most taken at 10-14°C. About 30,000 males and 10,000 females migrated in 2003. Artificially propagated females made up 58.4% of the catch. Fish were 3-8 years old, males were 33.9 cm and 617.6 g on average and females were 39.6 cm and 975.5 g. Kouhi-Dehkordi and Bani (2017) sampled 4,567 adult fish ascending the Khoshk River between March and May 2012. Melatonin levels were measured in a hundred migratory spawners collected during the day and night. More fish entered the river at night. Melatonin levels decreased to the minimum level during peak days of migration, suggesting variations in melatonin levels could help to harmonize the daily rhythm in kutum migration.

Kohestan-Eskandari *et al.* (2014) caught 504 reproductive adults from four localities along the southern Caspian Sea and examined their morphometry. Each sample site represented

an independent population despite artificial stocking programmes over the last 30 years mixing broodstocks. The results confirmed the success of homeward migration, the high grouping of fish suggesting that almost all populations returned to their birthplace river to breed, which resulted in high inbreeding.

Haghi Vayghan *et al.* (2013) used habitat suitability index modeling to determine that depth and substrate structure were the most important environmental variables for kutum to select its habitats and chlorophyll *a*, photosynthetically active radiation and sea surface temperature were the most critical parameters for near real-time prediction of habitat. Haghi Vayghan *et al.* (2016) modeled habitat preferences using classification trees and found the effect of different seasons, sea depth and photosynthetically active radiation were the main predictors affecting habitat preferences in the southern Caspian Sea. Ashtab *et al.* (2018) also used habitat species modelling and found depth and chlorophyll *a* were the most important environmental variables and the most suitable habitat was the southwestern Caspian Sea.

Fazli *et al.* (2014) investigated spatial and temporal distribution of this fish in bottom trawls from 10 to 100 m. The maximum catch and catch-per-unit-effort were 79.0 kg and 1.41 kg/0.5 h in spring. In spring and summer, most fish were in depths less than 20 m. The average catch-per-unit-effort was 94.0 kg/0.5 h in 20-50 m depths in autumn and 128.3 kg/0.5 h in depths greater than 50 m in winter. Bagheri *et al.* (2015) ranked rivers on physicochemistry at the time of release of cultured juveniles and found the Gorgan, Sefid and Tajan rivers were the most polluted and the Cheshmeh Kileh (= Tonekabon), Khalehsara and Khoshk were the best rivers. Bagheri *et al.* (2016) examined environmental factors of estuarine spawning sites and found no significant relationships between environmental changes over the period 1992-2012 and recruitment of kutum. Fazli *et al.* (2018) found that this species predominated, along with *Liza aurata* (= *Chelon auratus*, golden mullet), in the commercial beach seine fishery in the eastern part of the Caspian Sea at 73.05% and 24.67% respectively.

Abbasi *et al.* (2015) found that 1-2 g hatchery fingerlings, released in the Sefid River near Minoabad village about 2 km from the river mouth, almost all moved downriver to the mouth in 6 hours and the sea shore in 24 hours. Most migrated to the sea in the first month of release but some stayed in the river for 105 days, Fish were capable of osmoregulation allowing sea entry within a day. Moradi Chafi *et al.* (2017) examined larval production in two rivers in Gilan, finding in the Khalehsara River an estimated 7,250,000 larvae with an average body weight of 0.006 g and total length of 10.33 mm at first sampling and 1.38 g and 52.6 mm respectively at final sampling (April 13 to July 20, 2016). In the Khoshk River an estimated 3,050,000 larvae were 0.007 g and 11.32 mm at first sampling and 0.540 g and 38.09 mm respectively at final sampling. A decrease and increase in the estimated number of fry in the Khoshk and Khalehsara, respectively, was found compared to the previous year. In general, an estimated 10,300,000 fry were present in the rivers in 2016 and showed an increase of 5% over the previous year.

Afraei Bandpei *et al.* (2017) examined the complex relationship between this species and such biological parameters as phytoplankton, zooplankton and macrobenthos densities and the fish catch ratio of *Cyprinus carpio*, which was similar where this could be due to equal reproduction behaviours, feeding periods and anadromy.

Shahlapour *et al.* (2018) found juveniles of this species were dominant in the Farahbad region (68.1% relative abundance) and were dominant in the Miankaleh region but this was due to artificial breeding and release of juveniles. Naderi Jolodar *et al.* (2019) found this species comprised 73.05% of the total catch at Goharbaran, Mazandaran with *Liza aurata* (= *Chelon*

*auratus*, golden mullet) at 24.67%. Yahyaei *et al.* (2021) studied catches along the Miankaleh Peninsula from 1965 to 1993 comprising 8,914 specimens. The temperature factor, especially the increase in maximum temperature, had the most effect on the frequency of kutum.

Gerami (2016) recommended more studies on movement ethology of this species as an aid to making recruitment more successful.

**Age and growth.** Azari Takami *et al.* (1990) described the biology of this species in Iran. Males normally matured between their third and fourth year, sometimes earlier, females during their fourth year. Life span was at least 9 years in Dagestan (Shikhshabekov, 1979) and 8 years in Iran (Holčík and Oláh, 1992; Aghili and Mohammadi, 2012) and maximally about 12 years (Afraei Bandpei *et al.*, 2010). Mohaghegh *et al.* (2014) aged Iranian fish using the sagittal otolith, finding fish 1<sup>+</sup> to 4<sup>+</sup> years. Spawners were 3-8 years old and the principal age groups were 4-5 years for males and 5-6 years for females in the Anzali Talab (Holčík and Oláh, 1992; Holčík, 1995), older than the 3-4 years of fish reported in 1970-1971. However, recently males were maturing at age 2 and females at age 4 with most spawners at age 3 and 4 years respectively (Holčík and Oláh, 1992). In Gorgan Bay 75% of the catch was 2-4 years old with four-year-olds at 31% weighing 790 g and length 38.7 cm on average (Aghili and Mohammadi, 2012). The average size of mature females (700 g) has decreased (Bartley and Rana, 1998b). Males grew faster than females until about the third year of life and then more slowly. Males were smaller and had a shorter life span than females (Holčík and Oláh, 1992). An annual increase in length of 17% over the first 4 years was observed in tagged fish, decreasing to 4.7% annually in subsequent years (for weight the figures were 61.2% and 25.7%). Male:female sex ratios in spring were 3.08:1 and in autumn 0.78:1 (*Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran*, p. 55, 1997).

A series of studies on this species, apparently sampling in somewhat different areas or from different commercial fish catches gave several growth parameters as follows, listed chronologically by author(s) and publication dates.

Abdolmalaki and Ghaninejad (2007a) examined the commercial catch in 2003-2004 and found mean fork length was 36.7 cm (range 21-69 cm) and mean age was 3.82 years (range 1-8 years). Age groups 3-5 years comprised 87% of the total catch age composition. von Bertalanffy growth parameters were  $L_{\infty} = 70.1$  cm,  $K = 0.138/\text{year}$ ,  $t_0 = -1.557$  years, total mortality = 1.1/year, natural mortality 0.28/year and fishing mortality 0.83/year. Abdolmalaki *et al.* (2007) sampling the commercial catch found the total catch of kutum, including poaching, was 6,612.5 t or 43.3% of all commercial bony fishes in the 2004-2005 season. Mean fork length was 38.2 cm, age range was 1-8 years and mean age was 4.2 years. Age groups 3-5 years made up 85.5% of the age composition. von Bertalanffy growth parameters were  $L_{\infty} = 60.7$ ,  $K = 0.15/\text{year}$ , and  $t_0 = -1.75$  years. Instantaneous total mortality coefficient (Z) was estimated at 0.88/year, instantaneous natural mortality coefficient (M) was 0.31/year, and annual fishing mortality coefficient (F) was 0.52/year. Growth rate decreased in comparison to previous years probably due to non-selective artificial breeding over more than 20 years.

Najar Lashgari *et al.* (2007) found males migrating to the Khoshk River were 3<sup>+</sup> to 6<sup>+</sup> years old with an average weight of 122.5 g and an average standard length of 506.8 cm.

Patimar *et al.* (2007) examined fish migrating to the Tonekabon River and found males in age groups 3<sup>+</sup> to 6<sup>+</sup> and females in 4<sup>+</sup> to 7<sup>+</sup>, age groups 3<sup>+</sup> dominated in males and 7<sup>+</sup> in females, sex ratio was 1:1.33 in favour of males, condition factor was highest in 6<sup>+</sup> males and in 7<sup>+</sup> females, growth was positive allometric for females and negative allometric for males, and von Bertalanffy growth parameters were  $L_{\infty} = 130.62$  cm,  $K = 0.06/\text{year}$  and  $t_0 = -0.21$  for females

and  $L_{\infty} = 79.87$  cm,  $K = 0.11/\text{year}$  and  $t_0 = -0.38$  for males.

Afraei Bandpei *et al.* (2008) surveyed biological characteristics in samples from Iranian coastal waters. Average fish size was 11.73 cm fork length, range 8.9-29.0 cm, average weight was 22.74 g and range 8.8-321.2 g. Females were larger than males (12.27 cm and 32.26 g on average compared to 11.03 cm and 17.07 g). The male:female sex ratio was 1.3:1. Overall condition factor was 1.23. Afraei Bandpei *et al.* (2010) also recorded features of fish from Iranian coastal waters but found a range in size of 21 to 58 cm and 148 to 2,450 g, average fish size was 39.0 cm fork length and 830.3 g for females and 38.2 cm and 719.1 g for males, sex ratio was 0.65:1 in favour of females, and condition factor varied from 1.2 to 1.3. The von Bertalanffy growth parameters were  $L_{\infty} = 63.00$ ,  $K = 0.21/\text{year}$ ,  $t_0 = -0.88$  years for both sexes,  $L_{\infty} = 62.03$ ,  $K = 0.21/\text{year}$ ,  $t_0 = -0.80$  years for females, and  $L_{\infty} = 54.52$ ,  $K = 0.27/\text{year}$ ,  $t_0 = -0.75$  years, and the growth performance index was 2.89 for both sexes. Life span was 9 years in females and 8 years in males with a mean age of 3.99 years overall and four-year-old fish dominating in the sample. The length-weight relationship value  $b$  was 3.02 indicating growth was isometric. Growth was seen to be rapid in this southern Caspian Sea population, attributed to warm temperatures, available food resources and the brackish water environment. Historically, there has been a decrease in size of fish over three decades as length and weight used to be 67 cm and 7 kg. Afraei Bandpei *et al.* (2010), in another study, investigated the population dynamics in Iranian fish during the fishing season October to April, and found the von Bertalanffy growth parameters to be  $L_{\infty} = 59.85$  cm fork length (FL),  $K = 0.27/\text{year}$ ,  $C = 0.25$ , WP (winter point) = 0.40, instantaneous total mortality coefficient ( $Z$ ) was estimated at 1.28/year, instantaneous natural mortality coefficient ( $M$ ) was 0.46/year, instantaneous fishing mortality coefficient ( $F$ ) was 0.82/year, current exploitation rate ( $E$ ) was 0.64, mean length at first capture ( $L_c$ ) was 36.8 cm FL, maximum exploitation rate ( $E_{\max}$ ) was 0.76, and the current exploitation rate ( $E$ ) was less than  $E_{\max}$ . The highest growth oscillation occurred in December and was attributed to active feeding before wintering and migration to deeper waters. These figures indicated that the fish population was moderately exploited and agreed in general with other studies in the Caspian Sea. Variations in growth performance could be due to food availability, ecological conditions, geographical changes and genetic variability. A further analysis (Afraei Bandpei *et al.*, 2011), also from October 2006 to April 2007 on fish from the beach seine fisheries, found von Bertalanffy parameters were  $L_{\infty} = 67.5$  cm,  $K = 0.21/\text{year}$  (0.18 in one place in text) and  $t_0 = -0.10$ . The oldest females were 9 years old and the oldest males 7 years old. The highest frequency (52.6% for males and 35.5% for females) occurred at 4 years old. Mean fork length for males was 39 cm and for females 40 cm. Afraei Bandpei *et al.* (2013) found fish in Mazandaran waters of the Caspian Sea lived to 8 years and highest condition factors were in April at 1.29 and lowest in September at 1.16.

Daliri *et al.* (2010) sampled beach seine fisheries in Gilan from 2001-2010 and found catch-per-unit-effort had minimum and maximum values of 39.33 kg/n and 155.74 kg/n respectively.

Hoseini *et al.* (2010) sampled beach seine catches from Sari to Mahmodabad in Mazandaran finding most fish were age 4 years and growth parameters were  $L_{\infty} = 58$  cm,  $K = 0.24/\text{year}$  and  $t_0 = 0.016/\text{year}$ .

Fazli (2011) examined the fish catch in 2006-2010. Kutum, golden grey mullet (golden mullet, *Chelon auratus*) and common carp predominated the composition of bony fishes, representing 61.3, 29.6 and 7.6% of the total catch. The average fork length of kutum was 38.4 cm and weight was 784.5 g. The value of  $b$  in the length-weight relationship was 3.02 indicating

isometric growth. The maximum age was 12 years. The sex ratio showed that females were dominant. The von Bertalanffy growth equation was  $L_t = 62.9 (1 - e^{-(0.19(t+1.0)})}$ .

Abedi *et al.* (2012) examined broodstock from the Tajan and Shirud rivers and juveniles from the Caspian Sea. Higher condition factors were noted for male compared to female broodstocks and female juveniles had a higher condition factor than males. von Bertalanffy growth parameters were  $L_t = 50.11(1 - e^{-0.48(t+1.814)})$  for broodstock from the Tajan,  $L_t = 40.67(1 - e^{-2.27(t-18.84)})$  for broodstock from the Shirud and  $L_t = 48.36(1 - e^{-0.537(t+0.913)})$  for juveniles. Males from the Shirud showed a negative allometric growth pattern, females from the Shirud and broodstock males from the Tajan showed isometric growth, broodstock females from the Tajan and juveniles of both sexes showed positive allometric growth.

Gheshlaghi *et al.* (2012) examined fish from the Beach Seine Cooperative along the Iranian shore and found a maximum fork length of 69 cm, weight 2,370 g, a life span of 14.25 years, a length-weight relationship of  $W = 0.004L^{3.258}$ ,  $L_\infty = 70.45$  cm,  $K = 0.2/\text{year}$ ,  $t_0 = -0.75$  years, total mortality = 0.92/year, natural mortality 0.36/year and fishing mortality 0.56/year. The exploitation rate was 0.6. The current yield per recruit was estimated as  $YPR_{\max} = 287.535$ , meaning that if fishing mortality increased from 0.56/year to 0.7/year, the yield would only raise by 1.2%. Most kutum were caught before reaching the length of maturity. Maintaining the harvest at the current level would avoid overharvesting and allow a sustainable yield.

Gorjian Arabi *et al.* (2012) examined 100 males and 100 females from the Tajan River in March-May 2011 and found total lengths were 37.1-54.7 cm and weights 400-1,658.66 g, there were 5 age groups with most in age 3<sup>+</sup> and least in age 1<sup>+</sup> years in females and 2<sup>+</sup> and 6<sup>+</sup> in males, the instantaneous growth rate in 3<sup>+</sup>-4<sup>+</sup> fish was much lower than younger age groups, the length-weight relationship was positively allometric for males ( $W = 0.0000005xL^{3.47}$ ) and negatively allometric for females ( $W = 0.00005xL^{2.73}$ ).

Keivany *et al.* (2012) studied predominately females in the Gorgan River estuary. There were six age groups up to 8<sup>+</sup> years with the 5<sup>+</sup> and 6<sup>+</sup> age groups dominant at about 75% of the catch. The male:female sex ratio was 1:1.5, significantly different. Growth was isometric ( $b = 2.93$ ). The mean condition factor was 1.5 and was not correlated with age. This eastern population had a lower  $b$  value, a lower ratio of male:female, higher mean egg diameter and a lower absolute and relative fecundity (see below) compared to data on western populations, of import for fishing, stocking, and management.

Moradinasab *et al.* (2012) gave a  $b$  value of 2.9077 for 4,870 fish (20.5-62.5 cm total length) from beach seine fisheries of the southern Caspian Sea along with a mean condition factor of 1.017 and a relative weight of 0.929. Growth in this species had decreased in recent years, attributed to artificial breeding and restocking as well as overfishing and elimination of larger individuals.

Fazli *et al.* (2013) provided estimates of yield-per-recruit and spawning biomass-per-recruit under various harvest strategies for stock management purposes. The paper also proposed a method for estimating acceptable biological catch that accounted for differences in quality and quantity of data on this species. The current yield-per-recruit (with  $F$  (fishing mortality) = 0.61/yr and  $t_c = 3.2$  yr) was 218.3 g per recruit which indicated that the fishery was operating below the maximum yield-per-recruit at 236.9 g when  $t_c = 3.5$  yr. The yield-per-recruit was highest at  $F_{\max}$  and  $F_{0.1}$  when  $t_c = 4$  yr (244.8 g and 214.2 g respectively). The  $F_{30\%}$  value was 0.85/yr at  $t_c = 4$  yr with the spawning biomass-per-recruit of 338.3 g. The  $F_{\text{current}}$  (0.61/yr at current  $t_c$  is 3.2 yr) was higher than the corresponding reference points,  $F_{0.1}$  (0.47/yr) and  $F_{30\%}$  (0.46/yr). The acceptable biological catch was estimated at 7,850 mt in 2009-2010.

Mohammad Nejad Shamoushaki *et al.* (2013) analysed the catch from 1999 to 2008 in Golestan Province from 20 active seine cooperatives. The catch in the west (Miankaleh) was more significant than in the east (Gomishan), Catches declined over the period studied and the catch ratio was carp>mullet>kutum>roach at 39.23, 33.76, 26.54 and 0.47%.

Karimzadeh *et al.* (2014) examined samples from gillnet cooperatives in Tonekabon in the southwest Caspian Sea and found age groups 1-7 years with the 4-year age group the most frequent (51.1%) and the 1-year age group the least frequent (0.8%), and males were commoner than females.

Alaei Borujeni *et al.* (2015) found that the estimated maximum sustainable yield for the period 1989-2007 was higher than the reported yield by beach seine cooperatives. By controlling illegal fishing, beach seining could be raised at least 61%, maintaining sustainability. Alaei Borujeni *et al.* (2015) showed that the recruitment enhancement programme in place since 1982 had positive effects on profitability and a reduction in fishing mortality caused a consequent increase of the net present value from the fishing activity.

Kouhestan Eskandari *et al.* (2018) compared six models for back calculation (estimating growth in years preceding capture from fish lengths at previous ages derived from scale or otolith annuli), namely scale proportional hypothesis, body proportional hypothesis, nonlinear scale proportional hypothesis, nonlinear body proportional hypothesis, the Morita Matsuishi model and the Fraser Lee model. The Fraser Lee model was preferred for both males and females.

Daryanabard *et al.* (2019) collected data from fishing cooperatives in Gilan, Mazandaran and Golestan provinces. Mean fork length and total weight were 37.4 cm and 729.8 g, age range was 2 to 11 years with fish 3 to 4 years old comprising 73.4%, mean length of 3-year-old fish was 33.8 cm and of 4-year-old fish 39.0 cm, the  $b$  value in the length-weight relationship was 2.99,  $L_{\infty}$  was 61.4 cm,  $K$  was 0.21/year,  $t_0$  was -0.54, mortality parameters  $Z$ ,  $M$  and  $F$  were 0.76, 0.36 and 0.36 respectively, and the biomass was estimated at 27,437.7 tons.

Fazli *et al.* (2019) examined fish from the eastern coasts of the Caspian Sea (Goharbaran region) using three fishing methods, small mesh size beach seine, gillnet and commercial beach seine, during January 2014 to July 2014. The results showed that the slope ( $b$  value) of the length-weight relation was 3.0003 indicating isometric growth. Small and large fish were caught in the small mesh size beach seine and the commercial beach seine, respectively. The average length and weight were significantly different among three fishing methods. The average condition factor of small mesh size beach seine, gillnet and commercial beach seine were calculated as 1.30, 1.38 and 1.29 and  $K_{rel}$  was recorded as 1.30, 1.37 and 1.29, respectively. For both variables, there were significant differences among three fishing methods. Also, the averages for condition factor and relative condition factor were significantly different among the different length classes and seasons. Based on the average relative condition factor, it was concluded that this fish had good feeding and growth conditions in the Goharbaran region.

Forouhar Vajargah *et al.* (2020a) reported negative allometric growth for fish from Sari and Bandar-e Torkeman ( $b = 2.56$  for 42 fish, 34.2-43 cm total length, and 2.72 for 44 fish, 35.2-41.5 cm) and positive allometric growth for fish from Anzali, Kiashahr and Astara stations ( $b = 3.03$  for 44 fish, 16.5-51.0 cm, 3.1 for 44 fish, 29.0-50.0 cm, and 3.07 for 44 fish, 30.0-48.0 cm). Fish from Anzali had the maximum condition factor (1.152) and those from Astara the lowest (0.107), presumably from unsuitable nutrient conditions and pollution at the latter. Forouhar Vajargah *et al.* (2020b) examined 112 fish, 16.5-51.0 cm total length, from beach seines on the south Caspian Sea shore. The mean gonadosomatic and hepatosomatic indices for

the whole population were 4.67 and 7.86, respectively. The length-weight relationship in males, females and total population were  $W = 0.821L^{2.4278}$ ,  $W = 0.01L^{3.0025}$  and  $W = 0.041L^{2.6224}$ , respectively. A negative allometric growth pattern was shown for males and the whole population, whereas females followed an isometric growth pattern. The mean condition factor was 1.10 in males, 1.01 in females and 1.07 in the whole population. Differences between males and females in condition factor were not statistically significant.

Shahifar *et al.* (2020) studied growth and mortality parameters based on 700 samples collected from commercial beach seining in Gilan and Mazandaran provinces during the 2017-2018 fishing season. Females were dominant in both populations. Size frequency distributions showed significant variation among and between sexes. Different length-weight relationships were observed, positive allometric in Mazandaran ( $b = 3.03$  and  $3.15$  for males and females) and negative allometric in Gilan ( $b = 2.66$  and  $2.95$  for males and females). There were significant differences in growth parameters between sexes, females were of much greater asymptotic length than males, while the male fish had a higher growth rate and attained a smaller theoretical  $L_{\infty}$  size than females ( $L_{\infty} = 60.74$  cm fork length for males and  $69.12$  for females from Gilan and  $52.77$  for males and  $69.12$  for females from Mazandaran). The theoretical maximum length ( $L_{\infty}$ ) was larger than the maximum one recorded during sampling. Based on the Bhattacharya method, the Caspian kutum from Gilan fishing grounds was more diverse, and included nine cohorts, while the population from Mazandaran Province showed only six cohorts. The linearised catch curve based on age composition data showed that total mortality rates ( $Z$ ) were 1.32/year and 0.63/year for males and females of Gilan, and that of males in Mazandaran was 1.04/year and of females 0.86/year. The natural mortality rates ( $M$ ) were 0.48/year for males and 0.26/year for females in Gilan, and 0.26/year and 0.45/year for males and females in Mazandaran. The exploitation ratio ( $E$ ) was found to be higher than 0.5 for both sexes from Gilan, and was lower than the expected optimum level of exploitation in males and females caught in Mazandaran. Caspian kutum suffered greater fishing pressure in Gilan and fishing pressure was relatively low in Mazandaran. The relatively high degree of variability found in some growth parameters could represent either adaptations to local selective pressures (both fishery and environmental) or ecophenotypic variations. The estimated Caspian kutum population parameters indicated a trend toward its being a k-strategist species based on a high maximum theoretical length, a low growth rate, a long lifespan and a low natural mortality. This suggested that regulation strategies developed for fishery management should be based on the different growth patterns.

**Food.** Juveniles in the Anzali Talab of Iran fed mostly on phytoplankton in contrast to the zooplankton reported for Azerbaijan fish (Holčík, 1995). This was a consequence of the poor productivity of this lagoon. Fingerlings in the Sefid River estuary fed on 52 genera of phytoplankton, 15 groups (*sic*) of zooplankton and 10 groups of benthic animals (Abbasi *et al.*, 2016). *Nitzschia*, *Navicula* and *Synedra* were abundant phytoplankton foods, Rotatoria, Rhizopoda and Cladocera were zooplankton foods, and chironomid larvae were benthic food. There were seasonal and spatial (river or sea) differences in food quantity and quality, with zooplankton and benthos the main food items. Small Iranian specimens from the Caspian Sea had bivalve shell remains, plant remains and in one case a worm, in guts of fish seen by me. In general, adults fed on molluscs, insect larvae and crustaceans.

Oryan *et al.* (1998) stated that the bivalve *Cardium* was the main food of this species on the eastern and western coasts of Bandar-e Anzali. Crabs and the barnacle *Balanus* were also important. The hepatosomatic index was highest in February and March, the prespawning period.

Seyfabadi *et al.* (2005) compared diet with mullets (*Liza* (= *Chelon*) spp.) on the

Mazandaran coast and found feeding priority was barnacles, bivalves and sand crabs for kutum and foraminifers, ostracods, bivalves and gastropods for mullets, and there was no feeding competition.

Afraei Bandpei *et al.* (2008) found diet in the southern Caspian Sea was the mussel *Mytilaster* (48.46%), Gastropoda (31.84%), the bivalve *Cerastoderma* (19.65%) and *Balanus* (0.05%). Afraei Bandpei *et al.* (2009) sampled fish from the commercial catch caught from October to April and found the diet was dominated by bivalves (59%) with *Cerastoderma lamarcki* the dominant prey (57%). Other foods were cirripeds (21%), gastropods (13%), malacostracans (3%), fish eggs (2%), amphipods (1%), and filamentous algae (1%). Fish fed on a wider variety of food groups in November compared to other months and the lowest feeding activity was in January and April, the latter being the peak of the spawning season. Afraei Bandpei *et al.* (2013) found fish in Mazandaran waters of the Caspian Sea fed on *Cerastoderma lamarcki* as the main prey, *Theodoxus* sp. (snail), and *Balanus improvisus* as subordinate prey, and *Rhithropanopeus harrisi* (crab), *Hypanis* sp., *Neogobius* sp., algae, scales and fish eggs as random prey. Fingerlings (<10 cm) fed on *Exuviaella cordata* (= *Prorocentrum cordatum*, a dinoflagellate) and *Nitzschia distance* (*sic*, a diatom) and nematodes. Carnivory started at one year of age on mysids.

Fazli (2011) recorded the main prey item of mature fish in the southern Caspian Sea was *Cerastoderma lamarcki* while Gastropoda and *Balanus* were subordinate. Crabs, the bivalve *Hypanis*, fish (*Neogobius* sp.) algae, eggs and scales were random prey items. Planktonic groups comprised juvenile food including *Exuviaella*, *Nitzschia*, *Oscillatoria*, *Synedra*, Nematoda, *Navicolla* (*sic*, presumably *Navicula*), *Diatoma* and *Rhoicosphenia*. Based on the important species index, *Cerastoderma lamarcki* and *Balanus* were dominant species in the food.

Naderi Jolodar *et al.* (2013) also found *Cerastoderma* was the main food (by weight) with *Balanus* the main food by frequency. Feeding intensity was higher in males and in length groups smaller than 30 cm, and lower in the spawning season and winter. Bivalves had a pivotal role in feeding but had decreased in recent years.

Abdolmalaki *et al.* (2017) found the introduced population in Khandaghlo Dam Reservoir in Zanzan fed on the shrimp *Macrobrachium nipponense*.

Naderi Jolodar *et al.* (2019) found fish at Goharbaran, Mazandaran fed on bivalves predominately, especially *Cerastoderma*, while gastropods, crabs, fish eggs and filamentous algae were rare. The reduction in bivalve stocks was such that there was not enough food for kutum stocks.

The hybrid with *Ctenopharyngodon idella* fed principally on macrophytes with phytoplankton as a secondary food in ponds in Gilan (Khara *et al.*, 2002).

Zarbalieva (1987) provided data on feeding of this species in the Caspian Sea off Azerbaijan. Fish concentrated on a sandy-shell rock bottom and remain there for most of the year to feed. The crab *Rhithropanopeus harrisi* dominated in the diet, 67.9-93.7% by weight. Molluscs, mainly *Cerastoderma lamarckii*, comprised 30% by weight of the food of fish 30-40 cm long. Fish larger than 40 cm seldom took molluscs but occasionally *Clupeonella* spp. (kilka, Clupeidae). Molluscs used to be the main diet item of this fish. Stocks of kutum declined between 1991 and 2006 with a decline in kilka stocks themselves affected by competition for food with the invasive ctenophore *Mnemiopsis leidyi*. However, the decline in kutum catches seemed to be more related to overfishing than the ctenophore invasion (Roohi *et al.*, 2010). Pourang *et al.* (2016) noted a sharp increase in kutum stocks between 2001 and 2006, attributed to adaptation to new conditions in relation to the invasive ctenophore.

**Reproduction.** Fish spawned annually according to an Iranian study by Azari Takami *et al.* (1990) and probably returned to their river of birth. Temperatures, and probably river flow, were the factors determining the entrance of fish into the rivers on the spawning migration. Male fish ran before females. Yousefian and Mosavi (2008) gave March to May as the spawning season. Aminian Fatideh *et al.* (2008, 2008) determined stages of sexual maturity of migrating fish, 87% achieving stage 5 in April and 94% stage 5 in June. Shafiei Sabet *et al.* (2009a) studied developmental changes in the ovaries of fish in the Bandar-e Kiashahr area of the southwest Caspian Sea. The gonadosomatic index began to increase in March, peaked in April and then decreased sharply in early May. Development was synchronous. The main migration (99%) in the Anzali Talab began in February and lasted 3 months at 8-10°C with a much smaller run (only about 1%) in November-December. The talab is now overgrown with reeds or has a silty, vegetated bottom and is no longer a spawning site (Holčík and Oláh, 1992), an economic and poetic loss. Holčík and Oláh (1992) translated Iljin (1927) on Anzali Talab mahi sefid “During this time the reeds rustle as if of wind as the fish rubs pushing their flanks to the reed stalks or pushing forward among reeds standing in rows”. Each female was flanked by two males at spawning in shallow water. Sometimes the backs of the fish protruded from the water. Females sharply rubbed their lower abdomen and pectoral area on the gravel bottom, males and females convulsed, and eggs were shed and fertilised. Eggs are adhesive and hatch in 20 days at 10-14°C. The migration into the Dinachal (probably Denya Chal) River occurred on 1 November in 1975, when sexually immature fish were caught. By 11 February, five spawners were caught and the peak migration occurred on 26 March when 3,845 fish were caught at a water temperature of 10.5°C. The migration was continuous until 11 May. Water temperatures between 28 March and 23 April in 1976 and 1977 varied between 9.1°C and 13.5°C when peak migrations occurred in the Havyg (probably Haviq) River. Here, the spring form of this species started to migrate at 6°C and the optimum water temperature appeared to be between 11 and 13°C. Khaval (1998) reported a spawning migration into the Sefid River despite construction, sand removal and pollution. The migration peaked in the second half of March at a water temperature of 11°C. Golshahi and Moradnezhad (2009) captured migrating fish in the Goharbaran River, Mazandaran from 14 March to 21 April 2008. The temperature range at this time was 11-18°C. The male:female sex ratio was unequal at 1.82:1. Absolute and relative fecundities were 40,550 and 40,714 eggs (*sic*). Dehkordi and Bani (2016) counted 4,563 adults ascending the Khoshk River between 13 March and 9 May 2012. They found that more fish entered the river at night and that melatonin levels helped, as a secondary factor, in harmonizing the day-night rhythm of the migration. Melatonin is a hormone that regulates sleep and wakefulness.

Embryonic development in glass incubators at 14-16°C was described by Parivar *et al.* (1993). Cleavage and gastrulation began within 24-30 hours, hatching at 216 hours (10 days after fertilisation) and resorption of yolk was complete at day 16. Some males and females were injured through contact with the gravel stream bed. Embryonic development took 10-15 days at 8-16°C and 5-6 days at 20°C (Aslaanparviz, 1994). Young fish go down to the sea in summer according to some works although Holčík and Oláh (1992) believed that they stayed in fresh water or brackish river mouths for 1-2 years before entering the sea.

Abdurakhmanov (1962) gave a fecundity of 290,000 eggs for fish in Azerbaijan, higher than Iranian reports below. Farid-Pak (1968) examined 888 fish from the Murdab Bay (= Anzali Talab) where sexually mature females were 38-68 (68 in abstract, 66 in conclusions), mean 51.25 cm long, weighed 840-4,065, mean 2,181 g, weight of roe in stage 4 was 100-755, mean 360.7 g, absolute fertility was 36,200-198,560, mean 106,805 eggs, relative fertility was 22,300-

79,400, mean 49,200 eggs/g, and maximum egg diameter was 2.0 mm. There were two spawning migrations, winter and spring, and so two forms or stocks of this species (Azari Takami *et al.*, 1990). There may be three stocks based on electrophoretic studies of blood proteins associated with the two spawning migrations (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, p. 41, 1996). The winter form entered rivers with emergent or submerged aquatic plants at the end of autumn or the beginning of winter. Eggs were deposited on these plants. The principal rivers were the Nahang Roga, Pir Bazar Roga, Sowsar Roga, and Anzali Roga (all draining the Anzali Talab) but the stock had declined with overfishing and destruction of the habitat. The Sefid River was listed as the main spawning ground by the Caspian Sea Biodiversity Database ([www.caspianenvironment.org](http://www.caspianenvironment.org)). The spring form entered rivers at the end of winter or the beginning of spring and spawned on gravel or sand. Adults returned downstream after spawning, in the early morning. The run occurred both by day and night but increasing water clarity near the end of the spawning season limited runs to the night.

Yousefian and Mosavi (2008) found a spawning temperature range of 5 to 21°C centred on 11°C. Fertilisation rate in four rivers was 75-92% and hatchability was high. Rivers with high turbidity had low hatchability because of egg damage. Further details of natural and artificial reproduction were given by these two authors.

Afraei Bandpei *et al.* (2011), for beach seine fishes, found reproduction occurred in March-April with the highest gonadosomatic index for males at 6.52 and for females at 17.0 in April. Fifty-percent of female fish were mature at a fork length of 37.78 cm. Absolute fecundity ranged from 15,723 eggs for a three-year-old to 130,737 eggs for an eight-year-old with a mean of 60,435 eggs. Males matured at age 2, females at age 3 years, with most spawners at age 3 years for males and age 4 years for females. A reduction in length at first maturity and a lower number of eggs was noted compared to other studies, perhaps due to sampling methodology.

Fazli (2011) recorded the spawning migration started in March in the southern Caspian Sea. The gonadosomatic index value peaked in March and April. Absolute fecundity was 64 400 eggs. Length at maturity (Lm50%) was 39.07 cm.

Khara *et al.* (2011) examined 90 females caught from the Shirud in February-May and found average values for total length of 43.26cm, weight 832.08 g, age 4.41 years, egg diameter 1.85 mm, egg number 294.49, absolute fecundity 41,370, relative fecundity 52 and fertilisation 93.55%. Khara *et al.* (2012) also reported on migrants to the Shirud River and found maximum average egg diameter (1.86 mm), number of eggs in each gramme of body weight (309.12), relative fecundity (56.21) and fertilisation rate (95.82%) was found from 5 to 20 April at 15.95°C, while maximum average of ovary weight (201.0 g) and absolute fecundity (49,987.18 eggs) was found from 6 to 20 March at 17.74°C.

Keivany *et al.* (2012), in their Gorgan River estuary population, found an absolute fecundity up to 115,177 eggs in an eight-year-old fish. Absolute and relative fecundities were 70,300 and 51/g eggs. Fecundity was highly and positively correlated with fork length, body weight, ovary weight and age. Egg diameters reached 251 µm. Gonadosomatic indices peaked in the last week of April.

Moradi Chafi *et al.* (2016) sampled rivers in Gilan from 29 April to 29 June 2015 and found an estimated 4,165,000 larvae in the Khale-Sara River with an average body weight 5.2 mg and total length 9.8 mm at first sampling and 51.8 mg and 17.9 mm by late May, and an estimated 5,640,000 larvae in the Khoshk River with an average body weight of 7.4 mg and total length 11.0 mm at first sampling and 509.8 mg and 35.7 mm by late June.

Bavand Savadkouhi and Khara (2017) investigated age-dependent (three- to six-year-old

fish) changes in reproductive efficiency in the Shirud, Mazandaran Province. No differences were found in sperm characteristics between age groups. Female characteristics showed change with the highest fertilisation rate (87%) and survival rate (91%) when four-year-old males were crossed with four-year-old females. Egg diameters ranged on average from 1.48 to 1.63 mm, absolute fecundity from 25,838.7 to 62,656.8 eggs and relative fecundity from 52.2 to 59.2 eggs/g. Ghomi *et al.* (2017) also examined fish from the Shirud and found that there was a significant negative correlation between the total length and weight of females and the number of larvae produced in a gramme. Total length and weight of adult males and females had no significant relationship with other reproductive parameters such as egg weight and size, fertilisation rate and larvae weight, so that such parameters were independent of broodstock size. Ghomi *et al.* (2017) examined the relationship between physico-chemical parameters and reproductive parameters in Shirud fish and found sea water salinity and egg weight were negatively correlated, river salinity was correlated with egg weight and fertilisation rate, and electrical conductivity and total dissolved solids were correlated with egg weight.

Zadmajid *et al.* (2017) examined 20 male fish from the Gheshlagh (= Qeshlaq) Dam, an introduced population in the Tigris River basin. The fish averaged 2.1 years of age, various sperm and seminal plasma parameters were recorded, the mean gonadosomatic index was 5.71 and there were no adverse effects on male reproductive characteristics in these transplanted fish.

Kousha *et al.* (2007) examined some aspects of reproductive endocrinology in this species, specifically on sex steroid-binding protein in plasma. Najafipour *et al.* (2008) examined 17- $\alpha$ -hydroxy progesterone hormone levels, egg diameters and liver weight in fish caught at sea and in the Chaland River near Astara. These factors were used to indicate physiological indices of reproduction, hormone levels and egg diameters increasing in fish caught in the river, while liver weight decreased. Egg diameters increased from 1.55 to 2.14 mm. Shafiei Sabet *et al.* (2009b) studied gonad steroid levels in fish from the Sefid River and found estradiol and testosterone reached their highest levels in April and were closely correlated to ovarian development and the gonadosomatic index. Heidari *et al.* (2009) gave microscopic details of oocyte development. Shafiei Sabet *et al.* (2010b, 2011b, 2011c) described ovarian follicle ultrastructure and the rhythm of gonad development in fish from Bandar-e Kiashahr, showing that the gonadosomatic index began to increase in March, was highest in April and decreased sharply in early May. Gonad development was synchronous. Darvish Bastami *et al.* (2013) found that the fatty acid composition of the ovule showed greater similarity to saltwater fish rather than species in fresh water despite this fish being a freshwater spawner. In addition, there were direct relationships between fatty acid composition and egg size, egg number and weight of larvae. Imanpour *et al.* (2013) examined ionic ratio variations in milt from fish captured in the second half of March, the migration season. Broodstock migrating to the Shirud had better semen quality than fish from the Tajan and Gorgan rivers. Abdollahi and Imanpur (2014) examined fish from the Tajan River and found egg diameters of 1.92-2.25 mm and a surface to volume ratio of 2.66-3.07 mm<sup>-1</sup>. Hydrated eggs were 2.41-2.78 mm and 2.162.48 mm<sup>-1</sup>. Diameter values were minimum at the end of the migratory time and maximum at its initiation, and the reverse for surface to volume ratio. Shafiei Sabet *et al.* (2016) collected fish from the Sefid River estuary and studied variations in plasma sex steroid hormones in females. A resting stage extended from June to February with the lowest levels of hormones and a peak reproduction activity phase in March and May. Progesterone was highest in March-April, testosterone in March-April and 17  $\beta$  estradiolin February-May. Curiously, the baseline level of 17  $\beta$  estradiol during the resting stage was high compared with other teleost fishes and the gonadosomatic index was also high. This

suggested either non-migratory populations in the Caspian Sea or populations which migrate to adjacent wetlands in autumn for spawning.

**Parasites and predators.** Mokhayer (1976b) recorded the digenetic trematodes *Aspidogaster limacoides* and *Asymphylogora macracetabulum* from kutum. Eslami and Kohneshahri (1978) reported various helminths from this species in Iranian waters. These were the monogenean *Diplozoon paradoxum*, the aspidogastreaean *Aspidogaster limacoides*, the digenean *Asymphylogora kubanicum* and larvae of the nematode *Anisakis* sp. This fish therefore was potentially a source for human infection with *Anisakis*. Mokhayer (1989) reported metacercariae of the eye fluke, *Diplostomum spathaceum* from this species in Iran, which could cause complete blindness and death in commercially important species. Jalali and Molnár (1990a) recorded the monogeneans *Dactylogyrus frisii* from this species in the Khosk (probably Khoshk) River and *D. rarissimus* and two monogenean species, *Dactylogyrus* spp., from the Sefid River. Jalali and Molnár (1990b) recorded the monogeneans *Dactylogyrus frisii* and *D. rarissimus* at fish farms in Iran. Molnár and Jalali (1992) reported the monogeneans *Dactylogyrus suecicus*, *D. haplogonus* and *D. turaliensis* from this species in the Sefid River and Gussev *et al.* (1993b) also recorded *D. haplogonus* from Sefid River fish. Masoumian and Pazooki (1998) surveyed myxosporeans in this species in Gilan and Mazandaran provinces, finding *Myxobolus bramae*. Safari and Khandagi (1999) recorded *Clostridium botulinum* from 2.2% of fresh and smoked samples in Mazandaran Province.

Shamsi and Jalali (2001b, 2001c) detailed monogenean parasites for Sefid River and Caspian Sea samples, including six species of *Dactylogyrus*. Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G. prostaе* and *G. sp.* in fish from the Sefid River. Amini (2006) recorded *Gyrodactylus* sp., nematodes, *Diplostomum* sp., *Trichodina* sp., *Aeromonas* sp. and *Hydrophila* sp. in fingerlings from hatcheries in Iran. The latter two parasites caused a heavy mortality in the Shahid Rajaei hatchery ponds. Khara *et al.* (2008) found the eye parasite *Diplostomum spathaceum* in this fish from Boojagh Kiashahr Wetland in Gilan. Barzegar *et al.* (2008) also recorded this digenean, *Diplostomum spathaceum*. Sattari *et al.* (2008) reported the trematodes *Asymphylogora tincae* and *Aspidogaster limacoides* and the nematode *Raphidascaris acus* from fish along the southern Caspian Sea shore. Khara *et al.* (2009) found migratory fish from the Shirud had *Paradiplozoon chazarikum*, *Dactylogyrus* sp. (Monogenea), *Diplostomum spathaceum*, *Asymphylogora macracebelum*, *A. kubanicum* (Digenea), *Raphidascaris acus* (Nematoda) and *Aspidogaster limicoides* (Trematoda). Taati *et al.* (2009) examined fingerlings from aquaculture ponds in Gilan and found the monogeneans *Dactylogyrus* spp., metacercaria of the digenean *Diplostomum spathaceum*, the cestode *Bothriocephalus gowkongensis*, the nematode *Camallanus lacustris*, and the crustacean *Argulus foliaceus*.

Besmel *et al.* (2010) examined migratory fish from the Babolsar River finding *Asymphylogora kubanicum* and *Aspidogaster limacoides* (Digenea), and *Dactylogyrus* sp. and *Paradiplozoon chazarikum* (Monogenea) with age and sex differences in infestation. Khara *et al.* (2011) studied the prevalence of infection in migratory fish in the Tajan River and its effect on haematological parameters. Parasites were *Paradiplozoon chazarikum*, *Dactylogyrus* sp., *Diplostomum spathaceum* and *Asymphylogora kubanicum* but there was no relationship between parasites and blood parameters. Rahanandeh (2010) and Rahanandeh *et al.* (2011) examined fish from the southwest Caspian Sea and recorded *Ichthyophthirius multifiliis*, *Chilodonella hexastica*, *C. piscicola*, *Trichodina* sp. (protozoans), *Paradiplozoon chazarikum*, *Dactylogyrus frisii*, *D. nybelini*, *D. rarissimus*, *D. turaliensis* (monogeneans), *Diplostomum spathaceum*, *Aspidogaster*

*limacoides*, *Asymphylogora kubanicum* (trematodes), *Bothriocephalus gowkongensis* (cestode), *Raphidascaris acus*, *Dioctophyma renale*, *Eustrongylides excisus* (nematodes) and *Lernaea cyprinacea* (crustacean). Rahanandeh *et al.* (2016) found damage to gut tissues by the digenetic trematode *Aspidogaster limacoides* in fish caught by Iranian beach seines, including hyperaemia, haemorrhage, inflammation, cellular degeneration, mucosal damage, tissue adhesion and displacement, hyperplasia, and necrosis.

Ghiasi *et al.* (2012) found a relationship between chemical and physical water factors and the incidence of aquatic and saprophytic fungi on eggs in hatcheries. *Saprolegnia* spp. were the only aquatic fungi found while saprophytic species belonged to the genera *Fusarium*, *Penicillium*, *Aspergillus*, *Moucor*, *Pscilomyces* and *Alternaria*. Zamani *et al.* (2013) found that apparently healthy fingerlings may harbour spring viraemia of carp, a *Rhabdovirus carpio* infection, also called swimbladder inflammation, and a major threat to both native and farmed fish populations. Ghasemi *et al.* (2014), Zamani *et al.* (2014) and Omidvar *et al.* (2016) experimentally infected fingerlings and fry with spring viraemia of carp virus and found it to be highly pathogenic with a mortality rate of 75-85% and haematological and immunological effects. Immersion was the best route of transmission with the highest mortality in fingerlings and intraperitoneal injection in fry. Also, the viral genome was detected in apparently healthy tissues showing this fish could be a vector of the virus. Taheri *et al.* (2014) identified intestinal bacterial flora from farm pond fish in Qom Province as *Klebsiella* spp., *Bacillus licheniformis* (a probiotic candidate), *Bacillus* spp., *Aeromonas* spp. (dominant), *Streptococcus* spp., *Pseudomonas* spp., *Vibrio* spp., *Erysipelothrix* spp. and *Citrobacter* spp. Zorriehzahra (2014) studied viral nervous necrosis in golden grey mullet in the Caspian Sea as this is a major constraint on aquaculture and has the potential for transmission to kutum. Asgharnia *et al.* (2017) recorded the parasites on fingerlings being released into the Sefid River and found the trematodes *Diplostomum spathaceum*, *Posthodiplostomum* sp., *Ichthyophthirius multifiliis*, *Trichodina* sp. *Dactylogyrus* sp. and *Gyrodactylus* sp. with the highest prevalence amount, mean intensity, mean frequency and parasite number range in *Dactylogyrus*. Rezvani *et al.* (2017) identified the monogenean *Octomacrum europaeum* from the gills of this species. Vahedi and Pazooki (2017) captured 33 fish, 20.0-40.5 cm, from Sari, Mazandaran and investigated monogeniasis. Mean infection intensity and frequency of Dactylogyridae and Diplozoidae families of parasites were respectively 118, 100% and 4.53, 78.78%. Gills showed filament demolition and adhesion of gill lamellae, epithelial cell hypertrophy and hyperplasia of gill blades, separation of the epithelium from the basement membrane of the blades, aneurysm and clubbing. The total number of chloride cells decreased but there was no change in their size.

Tavassoli and Moghir (2002) described a squamous cell carcinoma in the oral cavity of this species, the first record for the Caspian Sea.

**Economic importance.** Sefid mahi or kutum is the most popular food fish in Iran as well as being important in Russia, Azerbaijan and Turkmenistan. This is also reflected in the literature on this species (e.g., the word “kutum” is mentioned well over 1,000 times in these two volumes on Carps and Minnows). An overview of its exploitation is given by Rabazanov *et al.* (2017, 2019) who covered fisheries in countries in addition to Iran in the Caspian Sea and gave recommendations for management actions. Rabazanov *et al.* (2019) also summarised catches in Iran and noted that in recent years these were stable and were associated with stocking programmes.

It is the freshwater fish with the highest economic value in Iran (Azari Takami *et al.* (1990) and Afraei Bandpei *et al.* (2008) recorded 10,773 fishermen making a living from its

capture). More than 70% of bony fish caught in the coastal Caspian Sea of Iran were this fish (Yousefian and Mosavi, 2008) or 78% and 76.6% of the income (Afraei Bandpei *et al.*, 2011). Afraei Bandpei (2014) analysed the bony fish, beach seine, catch along the Iranian shore of the Caspian Sea for 2008-2009 and found cooperatives took 13,000 metric tonnes of which kutum accounted for 10,138 mt. Kutum contributed 76.6% of sales of bony fish with an estimated income of US\$30,415,998. Fishermen's income from kutum was 74% for Gilan, 85.8% for Mazandaran and 26% for Golestan. The average break-even catch was more in the Mazandaran zone. The annual value of the catch in Iran from 2004 to 2008 varied from \$34 million to \$50 million and comprised most of the total annual export value (\$49-88 million) of fishery products from Iran between 1997 and 2008 (Rabazanov *et al.*, 2019). Fazli and Daryanabard (2017) found it comprised 66.24% of 123 beach seine catches in 2009-2012 along the whole Caspian coast, followed by mullets (Mugilidae), carp (at 1.31%) and shads (Clupeidae). The average annual catch from 1991 to 2001 was about 9,600 t (Afraei Bandpei *et al.*, 2010). The catch in 2006 and 2007 was 16,117.5 t (Heidari *et al.*, 2009). Fishing was banned from May through September in the southern Caspian Sea (Afraei Bandpei *et al.*, 2011). Kutum and mullets (Mugilidae) comprised more than 98% of the total catch in the Iranian Caspian Sea (Fazli *et al.*, 2014). Kutum were mostly caught in autumn and winter in depths less than 20 m in the central region.

It may be available out of season as mahi qachaq or bootleg fish, an indication of its popularity. About 35% of all Iranian catches were estimated to be illegal (Rabazanov *et al.*, 2019). Batmanglij (1999) noted that this fish may be baked and served with herbed rice. A stuffing consisted of garlic, parsley, tarragon, scallions, coriander, mint, ground walnuts, barberries, raisins, lime juice, salt and pepper, sautéed in butter (he also incorrectly referred to mahi-e sefid as striped bass). In 1996, a news report stated that "In the port city of Anzali, one small white fish sells for \$10" ([www.iran-e-azad.org/english/boi/03400201.96](http://www.iran-e-azad.org/english/boi/03400201.96)). In Rasht, 60% of the inhabitants consumed no other fish and "86% of ladies in Rasht can only cook one kind of seafood" (Khairkhan, 1994). Ouseley (1819-1823) reported that this species "seemed most abundant, and was found in all the great rivers of this country near the sea; for several days it had furnished the principal dish of my dinners and often of my breakfasts". Holmes (1845) recorded catches with cast-nets in the Anzali Talab over 175 years ago which were even then worth £1,400-1,500. O'Donovan (1882) reported that a small stream in the Atrak River drainage was so crowded with this species that individuals could only move by floundering and jumping over one another, and the horses in crossing the stream, trod them to death by scores. Lönnberg (1900a) reported an annual catch of some millions in Persian waters.

It was caught in rivers and lagoons and by large, mechanically hauled beach nets in the Caspian Sea. Sea nets can be 1,500 m long and 18 m deep. The fishing season began in October and reached a maximum between 20 February and 10 March, ready for the "Now Ruz" or New Year celebrations when many Iranians ate this fish with rice (Emadi, 1979). Gill nets were also used (Aghili and Mohammadi, 2012).

The roe of this species was also eaten, salted or unsalted (the fish are called asbalan mahi and the roe shur-e asbal in Gilaki, the local dialect of Gilan). Whole female fish were soaked for one year in a mixture of salt and madder in special clay jars. The jars were traditionally buried in the ground and hermetically sealed but a modern technique has the roe removed from the fish after 20 days. Esmailzadeh *et al.* (2004) studied the nutrient composition and marinade qualities of this fish and compared them to those for grass carp (*Ctenopharyngodon idella*), the latter being preferable according to the organoleptic properties. The marinades could be stored for 6 months at 10°C. Alipour *et al.* (2009) studied the effects of different brine concentrations and

temperatures in traditional smoking of this fish, finding a brine concentration of 26% gave the better quality and taste. Sahari *et al.* (2014) examined vitamin loss during storage of frozen fish, some vitamins showing significant loss and others not - this species had the highest vitamin A content of five species studied, for example. Mahjoorian *et al.* (2018) incorporated 1% clove essential oil with gelatin from fish scales to make a biodegradable, edible packaging film, which had the best physical, mechanical and antimicrobial properties. Mahjoorian *et al.* (2020) optimised the extraction of gelatin, which has many applications in the food, pharmaceutical and cosmetic industries, from scales, by-products of fish cleaning. Fish oil was prepared from kutum abdominal waste mechanically using heat and centrifugation (Babakhani, 2021). The oil contained 15% polyunsaturated fatty acids. The ratio of n3 to n6 fatty acids and the total amount of eicosanoic and docosahexaenoic fatty acids were 4.88 and 9.68, respectively. The results showed that the oil maintained good quality in terms of fatty acids and lack of microbes and could be used as a raw material for omega 3 oils.

The average weight of fish caught in the Anzali Talab in the early years of this century was 2 kg, the catch in the 1914-1915 season was 47,000 fish and in 1913-1915 123,000 fish. On 26 February 1914 a single haul in the sea near Anzali took 41,045 fish (Iljin, 1927; Berg, 1948-1949). Iljin (1927) estimated a yearly catch in Anzali Bay (= Talab) to be 3-4 million fish, a figure conflicting with these other reports.

Nevraev (1929) gave catches for various fishing regions in Iran in the early twentieth century. For the period 1901-1902 to 1913-1914 the catch in the Astara region was 0 to 29,053 individuals, for 1901-1902 to 1917-1918 the catch in the Anzali region was 2,565 to 124,195 individuals, in the Sefid River region from 1904-1905 to 1917-1918 the catch was 100 to 31,799 individuals, and in Astrabad (= Gorgan) region from 1900-1901 to 1912-1913 the catch was 4,000 to 323,500 individuals. The total catch for Iran in the 1914-1915 season was 443,000 fish. The catch in Iran from 1956/1957 to 1961/1962 varied from 197,884 kg to 2,066,580 kg (Vladykov, 1964), from 1965/66 to 1968/69 it varied between 159 and 1,252 tonnes (Andersskog, 1970), from 1963/64 to 1968/69 it varied between 121.3 and 1,252 t (RaLonde and Walczak, 1970b, 1972), from 1987 to 1991 it varied between 3,500 t and 8,855 t (Holčík and Oláh, 1992), and between 1989 and 1998 it varied between 11,792 kg and 14,336 kg (Caspian Environmental Programme, 2001a) - catch figures are at variance with each other. Holčík and Oláh (1992) reported a catch of 3,107 kg in the Anzali Talab for 1990 and for 1932-1964 a range of 95.1-3,488.9 t. They were also caught in rogas and inflowing rivers of the talab in late winter and early spring.

Moghim *et al.* (1994) estimated that coastal areas of the southern Caspian Sea had a total biomass of 24,000 t with a maximum sustainable yield of 7,000 t. In 1993-1994, the total catch of this species, including the illegal catch, was 11,175 t with the total stock estimated at 25,400 t and a maximum sustainable yield of 9,300 t. More than 25% of the catch was young fish indicative of non-standard methods being used (*Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran*, pp. 19-20, 1997). In 1994-1995, the biomass of this species in Iran was 241,000 t (*sic*, probably 24,000 t) and the maximum sustainable yield was 9,000 t (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, p. 37, 1996). About 62% of the bony fish catch in the Caspian Sea of Iran in 1993-1994 was this species with *Liza aurata* (= *Chelon auratus*, golden mullet) second at 22% (*Annual Bulletin 1993-94, Iranian Fisheries Research and Training Organization, Tehran*, p. 83, 1995). The catch from beach seine cooperatives along the Iranian coast was 8,477 t in in 2004-2005, a 2,500 t decrease over the previous year, and 45.5% of the total bony fish catch. Catch per unit

effort was 93.3 kg/set. The biomass of this species in Iranian coastal waters for 2003-2004 was estimated at about 25,000 t (Abdolmalaki, 2006a; Abdolmalaki and Ghaninezhad, 2007a). Kalantarian *et al.* (2017) found that the beach seine fishery at Salmanshahr, Mazandaran caught 58.17 kg per seine haul and this was the most abundant species caught at 48.31%.

Bartley and Rana (1998a, 1998b) commented that the fishery collapsed in 1980 but had risen from 500 tonnes in 1981 to around 10,000 t in 1996 after restocking from around 400,000 fingerlings/year in 1981 to around 142 million/year in 1997. Rana and Bartley (1998) noted that 7 million 1 g fingerlings were released into the Caspian Sea in 1997 which contradicted their earlier report. There was only a state-supported stocking programme but ERM-Lahmeyer International GmbH, DHI Water & Environment and GOPA Consultants (2001a) noted that this fish was being successfully managed in Iran while it had been fished almost to extinction in waters off Dagestan and Azerbaijan. Since 2000 releases have exceeded 200 million fish annually and three strategies are used: 1) spot planting with release of larvae and fingerlings at the same time, 2) scatter planting with release of fry at several sites in the same region, and 3) trickle planting with release of fingerlings in the same region over a period of time (Rabazanov *et al.*, 2019). Market price was high at about U.S. \$5.00/kg, five times the price for silver carp. Export prices were higher, 700 g of smoked mahi sefid cost £21.00 in 2004 ([www.superhormuz.com](http://www.superhormuz.com), downloaded 19 January 2004). However, this species was difficult to culture beyond the 40-50 g stage and growth was slower than common carp.

The conflicting ranges seen in Andersskog and RaLonde and Walczak above are typical of the wide variations in reports; figures can only be taken as general guides for many Iranian fisheries. Abdolmalaki (2006b) stated that fluctuations were due to destruction of spawning grounds, overfishing and release of fingerlings. The mean catch sizes were 3,110 tonnes in 1937-1947, 990 t in 1967-1977 and 8,505 t in 1987-1997. A minimum catch of 121 t was taken in 1964 and a maximum of 11,175 t in 1994. Catch-per-unit-effort also showed high variation. The calculated stock biomass was 1,300 t in 1971 and between 18,489 and 25,400 t between 1990 and 2000. The mean biomass in the past 10 years was 22,750 t, a 17-fold increase over the year 1971. The catch in the previous 10 years was 35-46% of the annual stock. A decrease in stock size during 1998-1999 was attributed to an exploitation rate being more than maximum sustainable yield, a decreased mean weight of released fingerlings and a lowered return rate. Mohammad Nejad Shamoushaki *et al.* (2013) reported a decline in fishing cooperative catches of 22.5% from 2009 to 2011.

Catches in the Bandar-e Anzali area have been as high as 5,480 t in 1939-1940 but fell to 85 t in 1961-1962 (Vladykov, 1964; RaLonde and Walczak, 1972) but have risen again as indicated above. This was attributed to the massive stocking effort with 170 million fingerlings released in Iran in 1991, about a quarter in the Anzali Talab (Holčík and Oláh, 1992). The Sari hatchery produced 400 million “white fish” over the previous 10 years (*Tehran Times*, 30 May 1998). Sea ranching increased the yearly catch to 8,500 t in 1991, the highest recorded catch in the past being 5,850 t in 1940 (Emadi, 1993a). Natural stocks in the past were very high. Migrating fish were so dense at the talab mouth that they were caught in buckets and jumping fish literally fell into boats.

Salehi (2003b) analysed the economics of production of fingerlings in Iran. The cost of labour was 50%, feed and fertiliser 20%, maintenance 10%, and harvesting, handling and releasing 6%. The average cost per fingerlings was 37 rials in 2001 (rising to 123 rials in 2003 (Salehi, 2008a)). As the average rate of fingerling return was 8.3% and the average weight and age of commercially caught fish was 815 g and 3.7 years, it was expected that 19,257,494

individuals weighing 16,000 t would be harvested over the Iranian year 2004-2005. The value would be an estimated 345 billion rials at the 2001 price (8,050 rials to a U.S. dollar in 2001; \$42.86 million). Salehi (2008a) estimated the wholesale price of the catch as 505 billion rials in 2004 and reviewed the comparative economics of fingerling production for 2001-2003.

Fazli *et al.* (2012) examined changes in biomass and condition index in relation to stock enhancement during 1991-2011 in the Iranian Caspian Sea. Length and weight ranged from 18 to 70 cm fork length and 75 to 5,750 g, higher for females except in 1998-1999. Age ranged from 2 to 9 years with ages 3 and 4 the largest groups at 25.8% and 28.5%. The condition factor declined in both sexes from 1.48 in 1991-1992 to 1.29 in 2010-2011 for females and from 1.4 to 1.2 in males. The annual survival rate was estimated to be 0.25/year. The instantaneous coefficient of natural mortality was 0.39/year and the instantaneous coefficient of fishing mortality varied over the 20 years between 0.2/year and 1.04/year (0.2 to 0.42/year when the first two years were omitted due to poor computation). The exploitation ratio was 0.34 to 0.73. Biomass estimates increased from 34,700 mt in 1991-1992 to 40,900 mt in 1993-1994, declined to 28,800 mt in 2001-2002, increased to 56,900 mt in 2006-2007, and declined again to 42,600 mt in 2010-2011. The total number of kutum fingerlings released increased from 110 million in 1991 to 400 million in 2010-2011. There was a significant positive correlation between fingerling release and recruitment while condition factor was adversely affected. Recent data showed biomass and catches were not benefiting much from increased efforts at fingerling release.

Experimental culture of triploid mahi sefid has been carried out at the Gilan Fisheries Research Centre (*Iranian Fisheries Research and Training Organization Newsletter*, 2:2, 1993) to increase fish weight for exploitation but apparently was unsuccessful although the techniques worked with grass carp, *Ctenopharyngodon idella* (*Annual Bulletin 1993-94, Iranian Fisheries Research and Training Organization, Tehran*, pp. 70-71, 1995). In addition, monoculture and polyculture of this species has been investigated, the latter with grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*) (*Iranian Fisheries Research and Training Organization Annual Report, 1992-93; Danesh Khoshasi, 1997*). From an average initial weight of 7 g, monocultured fish weighed 158 or 177 g on average at the end of each of two one-year periods, polycultured fish weighed 158 or 168 g, and maximum weight attained was 250 or 300 g (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, p. 38, 1996). Danesh Khoshasi (1997) gave figures of 177 g for mono-cultured fish after 6 months in ponds, polycultured fish weighed 185 g (with a maximum of 300 g) while stocking with 7 g fish gave 168 g and 192 g for mono- and polyculture fish respectively (maximum weight 250 g) (these two reports on the same experiment have confusing figures). The fish were fed on pellets especially made for this species, nitrate and phosphate fertiliser and cow and chicken manure were added to the ponds, and water temperature was 15.0-27.64°C. Growth in Iranian fish farms was up to 1.5 g in 8 weeks after a hatching rate of 75% (Aslaanparviz, 1994).

Moradinasab *et al.* (2015) noted the presence of kutum in the kilka by-catch (*Clupeonella* spp., Clupeidae) on the Bandar-e Anzali fishing grounds although it, along with five other species, only comprised 0.2% of the kilka catch.

Elmi *et al.* (2018) converted waste fish scales from this species into a magnetic hydroxyapatite bionanocomposite for the removal of heavy metals from groundwater. Karimzadeh (2018) extracted glycosaminoglycan from fish scales (a fishery waste) of *R. frisii kutum* (= *R. kutum*) and showed it had valuable anticoagulant properties compared to synthetic anticoagulant compounds such as heparin. Naderi Gharahgheshlagh *et al.* (2020) isolated and

characterised collagen from the skin of kutum and Naderi Gharehgheshlagh *et al.* (2021) used it and chitosan from shell waste of shrimp for in vivo second-degree burn wound healing in rats, finding a 1:1 ratio could significantly restore burn wounds compared to silver sulfadiazine ointment.

**Experimental studies.** This species has been studied extensively in Iran as the most popular food fish and is second only to *Cyprinus carpio* in the number of studies. Some sections below are separated by year groups to show the growth in studies. Certain topics may appear in different sections as they are studied in combination, e.g., stress may be a study on its own or may be combined with a study on feeding, growth, survival, etc. These studies are not replicated in each section and readers should search other sections for this additional information.

*Pollution:-*

Tehranifard *et al.* (2002, 2007) reported on the effects of anionic detergents and the pesticide diazinon on the LC<sub>50</sub>, both separately and in combination, in fingerlings. The LC<sub>50</sub> 96 h for diazinon was 0.34 mg/l, for liquid and powder detergents values were 4.69 and 12.24 mg/l, and for mixtures of diazinon and liquid detergent and diazinon and powder detergent were 7.27 and 0.9 mg/l. Shariati *et al.* (2004) recorded the toxicity and LC<sub>50</sub> 96 h of phenol and 1-naphthol as 21.5928 and 2.1544 mg/l. Gharaei *et al.* (2006) and Gharaei and Esmaili-Sari (2008) studied the acute LC<sub>50</sub> 96 h (0.086 mg/l) and bioconcentration (96 h exposure 2.8, 16.8 and 26.65 mg/l in tissue, kidney and gill respectively) of mercuric chloride in juveniles. Choobkar (2007) examined the survival and growth of larvae and fry exposed to the pesticide trichlorfon, finding it not harmful if the proper concentrations were used and stocking was delayed so that the pesticide degraded. Farokhrous Lashydany (2007) measured the effects of the herbicide butachlor on sexually mature fish, finding a decrease in testosterone and sperm production and an increase in abnormal sperm. Foroughi *et al.* (2007) determined mercury content, which varied between tissues, was not significantly different between sexes and was lower than permissible limits in fish from the south-central Caspian Sea. The mean concentration of mercury in muscle, liver and skin tissues was 849.9, 670.9 and 493.7 ng/g, respectively. Gholami *et al.* (2007, 2010) found that the permissible limits for pollutants in fry were 0.021 mg/l for cadmium, 0.4 mg/l for copper, 1.16 for the anionic surfactant used in LAS detergent (linear alkylbenzene sulfonate), 0.004 mg/l for a mixture of cadmium and LAS, and 0.009 for a mixture of copper and LAS. Gholami and Falahi (2008) showed that copper and cadmium transmission in the food chain was significant individually and when mixed with LAS detergent. Vaezzadeh *et al.* (2008) found the levels of the pesticide heptachlor in fish from Hashtpar and dieldrin in fish from Kiashahr could have a health risk to consumers. Mohammadnezhad Shamoushaki *et al.* (2009) determined the LC<sub>50</sub> 96 h for the insecticide endosulfan was 0.002 mg/l, above the maximum allowable concentration at 0.0002 mg/l.

Elsagh (2010) recorded levels of the heavy metals zinc (mean 32.4 mg/g), cadmium (1.205), iron (90.716) and copper (9.455) in fish from the Caspian Sea. Farokhruz Lasheydani *et al.* (2010) studied the deleterious effect of the herbicide butachlor, used to control weeds in rice fields, on haematological parameters. Mohammad Nejad Shamoushaki (2010) found that the pesticide diazinon adversely affected various haematological and immunological parameters as well as various tissues although there was no effect on weight and length. Mohammad Nejad Shamoushaki *et al.* (2010) determined the lethal concentration (LC<sub>50</sub> 96 h) of the herbicide roundup (glyphosate) used in agriculture was 5,189 mg/l. Elsagh (2011) found Iranian fish fillets with cadmium and lead levels above accepted limits for human consumption. Eslami *et al.* (2011) measured trace element levels in various tissues of fish from the Tajan River where

nearly all non-essential metals (cadmium, lead, nickel) were higher than official limits in the edible muscle, for example. Hosseinie *et al.* (2011) carried out a risk assessment for mercury in Mazandaran and found consumption of kutum was not a threat to consumer health. Mohammad Nejad Shamoushaki *et al.* (2011a, 2011b) studied the effect of sublethal concentrations of the pesticide diazinon on haematological and hormonal parameters of male brood stocks, finding the  $LC_{50}$  96 h was 0.4 mg/l, various aspects of blood and hormones were adversely affected, there was no effect on average weight and body length and on average weight of the heart and brain but there was a decrease in gonad weight and gonad index as well as atrophy, fibrosis and necrosis in the testis, vascular congestion, changes in heart structure, and vascular congestion and oedema in the brain. Sharifpour *et al.* (2011) examined experimentally the effects of the water-soluble fraction of crude oil on gill tissue of juveniles, finding an  $LC_{50}$  96 h at 33.95 p.p.m. and serious damage to the gill affecting homeostasis. Einollahi *et al.* (2012) measured polycyclic aromatic hydrocarbons in adipose tissue and the liver from fish at the Nowshahr oil jetty. Elsagh (2012) found levels of cobalt, copper and zinc were higher than acceptable limits at 0.3, 9.45 and 29.97  $\mu\text{g/g}$  dry weight, respectively, while manganese at 0.2  $\mu\text{g/g}$  was not. Fadakar Masouleh *et al.* (2012) found that the injurious effects of mercury on the testis and spermatozoan motility had a direct relationship with time of exposure and concentration of the toxin. Fekri *et al.* (2012) studied the effects of the pesticide diazinon on haematological fluctuations and stress factors, cortisol and glucose being increased for example. Mohammadnezhad Shamoushaki *et al.* (2012) studied the pesticide diazinon in male breeders, finding an  $LC_{50}$  96 h of 0.4 mg/l, effects on body weight and length and on spleen weight, and deleterious effects on various body organs such as necrosis, inflammation, bleeding and hypertension, among others. Mohammad Nejad Shamoushaki *et al.* (2012) also recorded various changes in haematology and biochemistry of male broodstocks exposed to long-term, low-level concentrations of the organophosphate diazinon. Monsefrad *et al.* (2012, 2012) found the concentration of heavy metals was influenced by reproductive status (and the fish sampled were safe for human consumption), and found interactions between metals in fish tissues influenced accumulation of toxic metals. Nasrollahzadeh Saravi *et al.* (2012) discovered high levels of polyaromatic hydrocarbons in edible tissue, higher than corresponding sediment concentrations, with the highest levels in samples from the Caspian Sea ports (Anzali, Babol Sar, Nowshahr) affected by intensive shipping activities. Sadat Naeemi (2012) showed that linear alkylbenzene sulfonate (widely used in detergents and found in Iranian Caspian Sea wastewater) had deleterious effects on the gills, kidney and liver, particularly the former. Shokrzadeh Lamuki *et al.* (2012) evaluated pesticide residues in fish from four major fishing centres (Babol Sar, Chalus, Khazarabad and Miankaleh) and found mean D.D.T. values ranged from 0.018 to 0.029 mg/kg and D.D.A. from 0.019 to 0.031 mg/kg. Askary Sary and Velayatzadeh (2013) showed fish from Sarcheshmeh Market, Tehran had levels of lead and zinc in liver and muscle above acceptable limits. Mohamadian *et al.* (2013) studied the effect of mercury chloride on embryonic development, finding an  $LC_{50}$  96 h of 102.91 p.p.b., and increasing mortality, growth reduction and abnormalities with increasing concentrations of the chemical. Naeemi *et al.* (2013, 2013) found severe histopathological changes of the gill, liver and kidney of fish exposed to sublethal concentrations of the synthetic anionic surfactant used for cleaning, linear alkylbenzene sulfonate. Azimi *et al.* (2014) found juveniles were resistant to nitrite poisoning and changes in liver tissue could be used as a biomarker of nitrite pollution. Hassanpour *et al.* (2014) determined levels of heavy metals (cadmium, copper, lead, zinc) in fish from the Miankaleh International Wetland where cadmium and lead levels exceeded international standards. Khoshnood *et al.* (2014) studied the toxicity of

atrazine, an herbicide, on fry where the ion composition was affected and major damage to the gill epithelium was observed, but there was no effect on growth parameters. Shahbazi *et al.* (2014) measured an LC<sub>50</sub> 96 h of the insecticide malathion at 0.86 mg/l for 3 g fish in experimental conditions, highly toxic, also showing significant decreases in haematocrit with increasing malathion concentrations, and with symptoms being irregular eye protrusion and irregular swimming movements. Shirdel and Kalbassi (2014) assessed the sensitivity of juveniles to acute toxicity of nonylphenol, a toxic microbial degradation product of a compound used in surfactants, paints, emulsifiers, lubricants, pesticides and detergents, the LC<sub>50</sub> 96 h being 1,262.36 µg/l or moderately toxic. Soltani *et al.* (2014) found concentrations of heavy metals (cadmium, copper, lead) in edible tissue of fish from Babol Sar and Tonekabon were safe for consumers.

Hoseini *et al.* (2015) found higher levels of lead and cadmium in liver over muscle tissue in Mazandaran samples, of lead over cadmium, and differing with some station sites particularly those near industrial waste regions but below hazardous health levels. Khoshnood *et al.* (2015) studied the histopathological effects of the herbicide atrazine on gills of fingerlings, which caused a wide range of damage, presumably affecting respiration and ion regulation, and proved to be highly toxic even at a sublethal concentration (12.47 mg/l). Khoshnood *et al.* (2015b) found the LC<sub>50</sub> of atrazine for fry was 18.53 p.p.m. and atrazine affected ion composition of the body even at sublethal concentrations but had no effects on growth. Nejatkhah Manavi and Kiadehy (2015) examined levels of the pesticide lindane in muscles of fish from Astara, Bandar Anzali, Bandar-e Torkeman, Chalus, Fereydun Kenar, Hashtpar Khazarabad Sari and Kiashahr, finding Chalus to be the most polluted and a declining trend in pesticide amount in recent years. Shahbazi *et al.* (2015) found that the insecticide cypermethrin had increased toxicity to fry and more deaths occurred with increased temperatures. Shamloufar *et al.* (2015) determined an LC<sub>50</sub> 96 h of juveniles exposed to the insecticide sevin of 3.0654 mg/l, and it was moderately toxic, causing abnormal swimming, blocked respiration and loss of colour, hyperplasia, oedema, inflammation, and damage to gills, liver, spleen and kidney. Sinkakarimi *et al.* (2015) examined fish from the southeastern coast of the Caspian Sea and found mean concentrations of cadmium and lead over the previous five years exceeded various national and international standards. However, adults could consume 0.21 and 0.75 kg/day of fish in terms of cadmium and lead content and children 0.05 and 0.26 kg/day without any health risk. Dadar *et al.* (2016) studied the bioaccumulation in edible muscles of the heavy metals arsenic, cadmium, cobalt, copper, lead, manganese, mercury and zinc in male and female fish from the Noor and Babol Sar coastal regions of the Caspian Sea, and found accumulation of zinc in Babol Sar fish varied with sex and arsenic and mercury with sex at Noor (higher in females), and levels were not a consumption threat.



Mazandaran, Caspian Sea at Noor  
(Iran - Mazandaran - Nour - Caspian Sea – panoramio, CC BY 3.0, Alireza Javaheri).

Golshani (2016) found that toxin accumulation in fish from five estuaries on the Caspian Sea of Iran was strongly controlled by habitat and feeding habits. The herbivorous carp had the middle level toxin concentration, less than the detritivore *Liza aurata* (= *Chelon auratus*, golden mullet) and more than the carnivore *Rutilus kutum*. The acetylcholinesterase enzyme activity was gradually inhibited with increase in organophosphorus pesticide concentration. Hosseini *et al.* (2016) assessed heavy metals content of muscle in fish from the south-central Caspian Sea finding the estimated daily intake of all metals was below international levels and therefore there was no risk for consumption in moderation. Kardel *et al.* (2016) studied heavy metal (cadmium, lead, zinc) accumulation in fish from the Babol Sar coast, finding less in liver tissue than in *Liza aurata* (= *Chelon auratus*, golden mullet) but no difference for gill tissue. Levels in both tissues were higher than acceptable limits (compare above). Pourkhabbaz *et al.* (2016) found LC<sub>50</sub> 96 h values for copper sulphate and mercury chloride on fingerlings were 1.47 mg/l and 0.28 mg/l respectively, mortality decreased with time, and most deaths were in the first 24 hours. Shokrzadeh *et al.* (2016) found diazinon levels in fish from the central coast of the Caspian Sea were acceptable for human consumption. Farahbakhsh *et al.* (2017) studied the amount of copper, nickel and zinc in muscle tissue, and nickel was higher than international standards, but the potential risk and hazard indicators indicated there was not much danger to consumers. Heshmati *et al.* (2017) compared wild and farmed fish for toxic and trace elements (arsenic, cadmium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium and zinc) in muscle tissue of fish from the southwest Caspian Sea, finding arsenic to be below the detection limit, iron was the highest concentration in both wild and farmed fish, cadmium, lead, mercury and manganese were higher in wild fish, others showed no difference between wild and farmed fish, and the estimated daily intake for humans was acceptable, and hazard quotient values showed no health risk to consumers. Moradi *et al.* (2017) measured the amount of the hydrocarbon benzo[a]anthracene in fish from the Anzali Wetland, finding no significant differences between

sample areas and levels lower than international health standards (20 µg/kg dry matter). Salehi Borban *et al.* (2017) examined fish from the Mahmoudabad area and found levels of arsenic, cadmium, copper, iron, lead and mercury in muscle and fish oil were near or below harmful levels and did not pose a health problem for consumers. Sinka Karimi *et al.* (2017) carried out a review and meta-analysis of lead concentrations in fish from the southeastern coast of the Caspian Sea and found a great difference between the various studies in terms of the reported effect factor. Current consumption led to no serious health risk and 0.23 kg/day for adults and 0.048 kg/day for children without effect. Farhangi (2018) found that for fingerlings under stable conditions and aeration the lethal concentrations of nickel and iron were 40mg/l and 155 mg/l respectively and the sublethal concentrations were 19.35 mg/l and 124.52 mg/l. Higher concentrations of these metals showed convulsions, open operculum and various types of gill damage. Pourang *et al.* (2018) sampled fish from areas adjacent to the estuaries of the Gorgan, Sefid and Tajan rivers and applied elemental fingerprinting to seven soft and hard tissues (liver and muscle, dorsal spine, eye lens, otolith, scale and vertebra). There were no significant relationships between the elements and such biological characteristics as weight and length. The levels of copper, iron, manganese and zinc in muscle were far below the recommended limits for human consumption. Seifzadeh *et al.* (2018) found bioaccumulation of the pesticides aldrin, diazinon and endrin in muscle tissues of fish from the Anzali Wetland were lower than international detection limits and so consumers were not at risk. Sharifi *et al.* (2018) showed that fish from the southern Caspian Sea coast were safe to consume in respect of cadmium levels (mean 0.38 µg/g wet weight in muscle). Alijani Ardeshir *et al.* (2019) measured the genetic toxicity of fipronil insecticide on the liver and found increasing damage to DNA with dosage, reducing the survival rate of fingerling and larva, and possibly expanding gastrointestinal cancer in humans in the northern provinces of Iran. Fathabad *et al.* (2019) recorded heavy metal concentrations in fish from the Rasht Fish Market, finding the highest concentrations in this species among four examined for arsenic, lead, mercury, nickel and tin although all were at acceptable levels for human consumption. Forouhar Vajargah and Hedayati (2019) found the LC<sub>50</sub> 96 h of the pesticide butachlor was 0.258 mg/l and was more toxic for this species compared to *Cyprinus carpio*. Heidari *et al.* (2019) showed fluctuations in metabolic enzymes indicated a change in the physiological state of fish under nanoparticle stress (copper oxide and silver nanocolloid) that could threaten fry health. Sattari *et al.* (2019) investigated element concentrations in fish from five fishing regions in the southern Caspian Sea and found the highest concentrations of calcium and manganese in muscle tissue, aluminium, barium, cadmium, cobalt, iron, potassium, sodium, sulphur, tin, tungsten and zinc in kidney tissue, arsenic, lead, nickel and rubidium in gonad tissue, antimony, chromium, lithium, magnesium, phosphorus, silicon, strontium, thorium and titanium in skin tissue, and copper and uranium in liver tissue. Zakeri *et al.* (2019) found 66.6% of fish from Babolsar, Bandar Anzali, Chamkhaleh, Gomishan, Mahmoudabad and Tonekabon had microplastics in their guts, potentially transferable to humans.

Seifzadeh (2020) found that zinc had the highest concentration in muscle tissue followed by copper and cadmium in fish from the northern and southern Anzali Wetland. Various correlations were noted between length, weight, age and gender, e.g., positive correlation of copper with weight in the southern wetland and negative with age in the northern wetland. Metal levels rendered fish suitable for human consumption. Esmaeilbeigi *et al.* (2021) showed fingerlings exposed to the oil pollutant benzo [ $\alpha$ ] pyrene generally had DNA damage increased in the liver and gill cells as well as the frequency of micro- and bi-nucleated erythrocytes in a

time and concentration-dependent pattern. In addition, the liver and gill tissues displayed several histopathological lesions. Malvandi (2021) collected fish at four best-selling stations, Bandar-e Torkeman, Bander Anzali, Fereydun Kenar and Chalus, with mean mercury concentrations being 49.4, 132.6, 103.6, and 107.6 µg/g, respectively. Mercury in the muscle tissue increased from east to west. The mercury concentrations at all stations were below the permissible international levels for this heavy metal, suggesting no or low potential health risk. Taghizadeh Rahmat Abadi *et al.* (2021) recorded microplastics from fish samples, 33.0-48.5 cm fork length, sold for human consumption in Bandar-e Torkeman. On average, 11.4 microplastic items per fish (0.015 items per 1 g fish wet weight) were found in stomachs at an individual detection rate of 80%. It was recommended that the potential effect of microplastics on the trophic food web, particularly for human consumption and health, should be urgently investigated.

#### *Diet:-*

Novirian *et al.* (2007) carried out experimental studies on different lipid levels in food fed to cultured fry, a level of 12% increasing growth levels.

Talebi Haghighi *et al.* (2010) evaluated the effects of different levels of the synbiotic biomin imbo on fry. Positive effects on final weight, weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio, feed efficiency and daily feed intake were found. Food conversion ratio showed a significant decrease and no difference in condition factor was observed. The synbiotic reduced feed cost and increased profit. Aftabgard *et al.* (2011) measured the effect of the prebiotic immunoster on growth (slightly better), survival (no change), blood cell density (increased), and body composition (protein, fibre and carbohydrate increased) of fingerlings. Enayat Gholampoor *et al.* (2011) found the highest rates of daily growth, specific growth and weight gain were at salinities of 2 and 4 p.p.t., lowest at 10 p.p.t., while food conversion ratio and condition factor along with various blood parameters and body composition showed no change. Jafari *et al.* (2011) showed a diet of *Artemia* nauplii with egg yolk increased growth and survival and gave a better body composition for larvae. Manafi Havigh *et al.* (2011) found replacing 30% of fish meal with soybean meal did not reduce growth and survival and was therefore optimal economically. Shahkar *et al.* (2011) found that larval growth varied with mixtures of proteins and frequency of feeding. Falahatkar *et al.* (2012) studied starter diets for larvae including *Gammarus* dry powder, shrimp dry powder, egg yolk dry powder and newly-hatched brine shrimp (*Artemia* nauplii). The latter was the best but the most suitable and inexpensive was egg yolk powder which gave high growth performance and survival rates. Mahmoodi *et al.* (2012) determined the growth needs of fry in protein being 30% and in fat 14%. Aftabgard *et al.* (2013) examined the immunoster prebiotic in the diet of fingerlings, showing little effect on growth performance but a significant immunostimulant effect on leucocytes and increasing the number of lymphocytes. Akrami *et al.* (2013) found that fry fed supplements of 5 g/kg mannan oligosaccharide had improved growth performance, survival and salinity stress resistance. Akrami *et al.* (2013, 2013) determined the effect of the dietary prebiotic mannan oligosaccharide with  $\beta$ -1, 3-glucan on growth, survival and body composition of fry, showing no influence and therefore this mixture was not appropriate for supplementation. Fathi (2013) fed fry with *Daphnia magna* enriched with essential fatty acids finding enhanced growth but no significant difference in survival rate with other treatments. Goli *et al.* (2013) found that food pellets containing various taste substances affected feeding behaviour; citric acid or sucrose, for example, increased consumption of pellets and the number of pellets consumed in relation to grasps, but not calcium and sodium chloride, and the effect of concentration change on retention time of pellets after the first grasp(s) was significant with all taste substances. Haghjou Jahromi

*et al.* (2013) showed how growth and survival was higher in larvae fed with *Artemia urmiana* nauplii enriched with vitamin C. *Artemia urmiana* is found in the Urmia salt lake. Hassantabar *et al.* (2013) investigated the growth rate, survival and activity of digestive enzymes ( $\alpha$ -amylase and alkaline phosphatase) in larvae fed *Artemia* nauplii. Stocking in high density decreased growth efficiency but there was no considerable effect on survival rate of larvae. A significant increase in activity of amylase was found from 23 to 30 days and the highest amylase activity was found at 30 days after hatching. The high content of glycogen and carbohydrates in live food may have stimulated synthesis and secretion of amylase. An early peak of activity in alkaline phosphatase activity was observed at day 8 after hatching, indicating the maturation process in the intestines of kutum larvae. Karimzadeh *et al.* (2013) used dietary immunogen, a prebiotic, which improved nutrient efficiency and larval performance through growth stimulation by beneficial bacteria. Mirzaei *et al.* (2013) found that feed with different levels of highly unsaturated fatty acids had significant effects on growth, haematocrit and blood biochemical parameters. Roufchaie *et al.* (2013) found that fingerlings fed hoplite (a dietary supplement containing glucan) showed growth promotion and modulation of intestinal microbiota. Ghomi *et al.* (2014) studied the combination effect of the probiotic primalac and vitamin C on growth performance of juveniles, finding it better than controls, and recommending 0.3% probiotic and 200 mg/kg vitamin C in the diet. Hoseinifar *et al.* (2014) used dietary xylo-oligosaccharide for fry which had beneficial effects on mucosal immunity but none on growth performance or diet utilisation. Mahdavi *et al.* (2014) investigated the use of supplementary fennel essential oil (*Foeniculum vulgare*) in the diet of fry finding no significant effect on growth but 100 mg/kg promoted the immune system by increasing white and red blood cells. Mohammadzadeh *et al.* (2014) observed that increasing carbohydrate levels in juvenile diets from 15 to 35% led to an efficient protein ratio and optimal growth although there was no clear correlation between fish growth and thyroid hormones. Nekoubin *et al.* (2014) found the food additive L-carnitine, an amino acid, did not have a significant effect on growth but did on carcass quality. Rostandeh *et al.* (2014) studied the effect of the bactocell microbial probiotic on growth, survival and immunological factors in fry, finding no effect on growth but no mortality while blood and immunological parameters showed significant increases. Rufchaei and Hoseinifar (2014) found low levels of the dietary yeast glucan improved growth performance, body protein levels and survival rate of fry, stimulated the immune response, and modulated intestinal microbiota.

Adel *et al.* (2015, 2015) showed how *Mentha piperita* (peppermint) extract at a level of 3.0% in the diet of fry improved growth performance, survival rate, and increased the main haematological and immune humoral (both mucosal and systemic) parameters. Imanpoor and Roohi (2015) found that a supplement of 0.1% primalac, a probiotic, had a positive effect on growth performance and blood chemical parameters of fry but not survival and tolerance to salinity stress. Imanpoor and Roohi (2015) showed that the herbal supplement sangrovit could improve growth rate, feed utilisation and blood biochemical parameters of fry, although survival, condition factor and resistance to salinity stress were unaffected. Kamali Najafabad *et al.* (2015, 2016a, 2016b) showed that chitosan added to the diet of fingerlings at 1-2 g/kg increased survival rate, resistance to thermal stress and the height of intestinal villi, and improved feed conversion ratio and nonspecific defense mechanisms. Keramat Amirkolaie (2015) found the administration of 1 g/kg of the prebiotic immunogen in the diet improved nutrient efficiency and performance of fry through growth stimulation of beneficial intestinal bacteria. Khodabakhsh and Ghobadi (2015) studied the effects of replacing fish oil with sunflower and colza (colza or rapeseed) oil in the diet of juveniles, finding no differences such that fish oil could be replaced

by these vegetable oils. Mahmoodi *et al.* (2015) found a diet of 35% protein and 14% lipid improved growth and they detailed biochemical changes in the fish. Amirisendesi *et al.* (2017) investigated the use of different levels of canola meal in the diet of fingerlings as a cheaper food than fish meal. AnvariFar *et al.* (2017a, 2017b) used different levels of dietary nucleotides supplementation in fry diet. This supplementation could strengthen the immune system, increase the level of absorption in the intestine, and increase the effectiveness of growth and osmotic stress response. Mortality was significantly different in these studies and cortisol levels were affected. Barari *et al.* (2017) studied the effects of the prebiotic immunowall (a yeast extract rich in  $\beta$ -glucans and mannan oligosaccharides promoting gut microflora) in the diet of juveniles, finding higher survival and increases in growth factors and body composition. Barari *et al.* (2017) also found weight gain, specific growth rate, growth rate, feed conversion ratio and body weight index for fish administered 0.15% immunowall showed statistically significant differences over a control. Barari *et al.* (2017) also found weight gain, specific growth rate, growth rate, feed conversion ratio and body weight index for fish administered 0.15% primalac (a prebiotic additive) showed statistically significant differences. Bazarganpour *et al.* (2017) found that combo multi-enzyme, at levels of 1.5 and 2.0 g/kg in the diet, caused an increase in blood parameters and specific and non-specific factors in fingerlings. Jabbari *et al.* (2017) found that dietary betaine given to fingerlings had no effect on growth performance, feeding parameters, body composition, survival rate and resistance to stress. Karimzadeh and Zahmatkesh (2017) studied the effect of different dietary zinc levels on pyruvate kinase activity and electrophoretic pattern of muscle tissues in juveniles, finding that a 200 mg/kg level did not affect intensity of separated protein bands and pyruvate kinase activity of muscle. Mahdavi *et al.* (2017) found that fennel (*Foeniculum vulgare*) essential oil at 100 mg/kg in the diet of fry could improve the immune system by promoting biochemical parameters and also increased stress resistance. Mohammadzadeh *et al.* (2017) evaluated the effects of dietary carbohydrate levels on growth performance and digestive enzyme activities in juveniles, finding that increasing levels from 15% to 35% had positive effects on growth while enzyme activities increased from 15% to 35% in some but decreased above 25% in others. Soltani (2017) found that the application of combined dietary fructo-oligosaccharide with probiotic *Pediococcus acidilactici* and *Lactococcus lactis* was useful in early rearing of fry in terms of growth, for example. Rafiee *et al.* (2018) showed that dietary dried lettuce at rates between 8-10% could be used to replace fish meal, wheat and oats. Sayahan *et al.* (2018) used sesame meal instead of fish meal at different levels in the diet of young and found negative effects on growth parameters but not blood factors. Zamatkesh and Karimzadeh (2018) found juveniles fed a diet with 44% protein and 50 mg/kg zinc gave a better growth and body composition. AnvariFar *et al.* (2019) demonstrated that dietary nucleotides exerted a positive effect on the growth performance of fry and showed lower stress-induced apoptosis and cortisol elevation. Safavi *et al.* (2019) gave the synbiotic biomin imbo to fingerlings and found improved growth, feed efficiency and carcass composition as well as a stimulus for the non-specific defense system. Taati *et al.* (2019) found wheat gluten was not optimal for the kutum fry diet and cannot be substituted for fish meal.

Farabi *et al.* (2020) added salt to the diet of freshwater juveniles to improve survival during migration to brackish water. Karimzadeh *et al.* (2020) showed that fingerlings fed on nucleotides (Hilyses and Augic<sup>15</sup>) showed an improved growth performance and salinity resistance, and evidently required a larger nucleotide diet at early life stages to control stress related parameters such as cortisol and glucose. Rufchaei *et al.* (2020) found that adding *Pontogammarus maeotica* extract to the juvenile diet had no significant effect on growth

performance but did increase immunity.

*Aquaculture:-*

Imanpour *et al.* (2006) showed larvae reared under red light had better growth and survival.

Ataimehr *et al.* (2010) detailed the varied effects of different ions, osmolarity and water concentration on body tissues, gill chloride cells and mortality of different-sized juveniles and found, for example, mortality increased with salinity but decreased with increase in weight. Mohagheghi Samarin (2010) found stripping eggs should occur within 168°C-hours after ovulation as a complete loss of viability occurred at 672°C-hours, *in vivo* storage was more effective than *in vitro*, and successful *in vitro* storage could be used at least within 8 hours at 4-12°C. Shabani and Darvish Bastami (2010) compared the levels of ionic and non-ionic factors in blood of fish emigrating from the Tajan River, which regulated pH and influenced growth and reproduction. Fallahi (2010) showed that using slurry in aquaculture ponds was effective in promoting the growth of zooplankton which was the food of the fish larval stage. Imanpoor *et al.* (2011) examined 80 migratory, sexually-mature females and recorded sodium, potassium, magnesium, calcium, total protein, cholesterol and glucose in eggs, finding various correlations, and these factors could be effective in broodstock selection programmes and larval growth in aquaculture. Yousefian (2011c) found a positive correlation between fertilisation rate and egg size (larger eggs offered a larger target to sperm) and a negative correlation between fertilisation rate and fecundity (egg size decreased with increase in number of eggs), egg size therefore being important in aquaculture. Khosravi Bakhtiarvandi *et al.* (2012) investigated changes in growth and amino acid composition during larval development from one to 50 days after hatching. Farabi *et al.* (2013) showed that salinity and turbidity stress caused physiological changes in gill and kidney tissue of juveniles, and had direct effects on weight and survival. Goli *et al.* (2013) tested the behaviour of fingerlings exposed to various taste materials (calcium chloride, citric acid, sodium chloride and glucose), useful in feed preparation. Hosseinzadeh Sahafi (2009, 2013) and Hosseinzadeh Sahafi *et al.* (2012) tagged 10,450 and 15,930 fingerlings (respectively, the former probably part of the latter) released into the Khoshk River estuary and treated them with the synthetic amine-based odorant morpholine to enhance imprinting of natural river odours and promote homing behaviour, finding treatment at the active fry stage at 0.5-1.0% had the best homing rate, and recapture rate was greater at 6.7% in the treatment period than in a previous five-year period without treatment at 5%. Mohammad Nejad Shamoushak *et al.* (2013) found that the best stocking density for cultured fry was 350,000/hectare. Vahid Farabi *et al.* (2013) studied the effect of salinity and turbidity on survival and changes in gill tissues of juveniles, the gills showing shortening and thickening although survival rate was acceptable. Alijanpour *et al.* (2014) found orange eggs had a higher carotenoid content than green ones and larger fish had more carotenoid content, but fertilisation rate was not affected by carotenoid content. Alijanpour *et al.* (2015) studied egg colours (yellow, orange or green), carotenoid content (highly pigmented eggs had more and this may affect variability of the eggs) and fertilisation rate in migratory fish from the Shirud and Tajan rivers, finding that Shirud fish had less carotenoid, orange and yellow eggs had more carotenoid than green ones, larger fish had more carotenoid, and fertilisation of orange and yellow eggs was somewhat associated with carotenoid content. Bani *et al.* (2014) showed the effects of salinity on levels of cortisol, glucose and sex steroids of fish from the Khoshk River - females from the river matured in March but those held at a salinity <0.5 p.p.t and 8-13 p.p.t. did not ovulate while both wild and captive males spermiated. Farzadfar *et al.* (2014) described the morpho-histology of the male gonad in fish from the Jef River.

Ghahremanzadeh *et al.* (2014) made a cytological comparison of fish from the Caspian Sea (8.49 p.p.t. salinity, 12.4°C) and the Khoshk River (0.18 p.p.t., 18°C), brackish water fish having higher Na<sup>+</sup>, Cl<sup>-</sup>, K<sup>+</sup> and Mg<sup>2+</sup> ions and osmotic pressure, and larger average size and number of chloride cells. Gheisvandi *et al.* (2014) found how water temperature affected food transit time and digestive enzyme activity in larvae. Gheisvandi *et al.* (2014) showed significant differences in growth and intestine morphology in juveniles exposed to different salinities either abruptly or gradually. Khosravi Bakhtiarvandi *et al.* (2014) studied ontogenetic changes in lipids, fatty acids and body composition from the fertilised egg to larvae 50 days post-hatching, used in order to increase quality and survival by providing the correct nutritional requirements. Sayyad Bourani *et al.* (2014) examined chloride cell frequency and distribution in the gills as well as ions and osmotic pressure of larvae exposed to water of Caspian Sea salinity.

Gheisvandi *et al.* (2015) found noticeable effects on the activity of digestive enzymes in larvae reared with gradual and abrupt salinity changes. Khoshnood *et al.* (2015a) described the structure and ultrastructure of gill chloride cells used in ion transport and thus facilitating migration between salty and fresh environments. Mohseni *et al.* (2015) measured changes in ion, hormone and biochemical factors in fingerlings released into the Tajan River estuary, the normal stocking procedure, with results showing osmoregulatory disorder and failure in salinity adaptation. Ahmadian *et al.* (2016) found that fingerlings could be grown well at 5‰ salinity and 24°C, although salinity and temperature did not affect survival. Ghanei Tehrani *et al.* (2015) and Ghanei Tehrani (2016) gave physical, chemical and biological properties and pesticide load of the Tagan (= Tajan) and Surkh or Sorkh rivers and found the latter had better conditions for release of fingerlings. Laloei (2016) used the luciferase gene as a genetic marker for detection of this species. Mohiseni *et al.* (2016) examined the effects of fasting on body electrolytes during migration to the sea of juveniles, finding a disruptive effect on success in seawater adaptation. Mohiseni *et al.* (2016) studied feed deprivation on chloride cell development, important in salinity adaptation for this migratory fish, and found a disruptive effect with decreases in gill Na<sup>+</sup>, K<sup>+</sup>, ATPase activity, and chloride cell diameter, perimeter and area. Rezamand *et al.* (2016) found *b* values of 2.609-3.196 in the length-weight equation for 50 cultured juveniles, showing a range of ecological conditions. Sayyad Bourani (2016) determined the suitable size for releasing cultured fish by evaluation of the osmotic regulation ability. Overall, the results of measuring ions and osmotic pressure on the tenth day of treatment, the osmotic potential of juveniles of 2.5, 5, 10 and 20 g in Caspian Sea water and all groups except the 0.5 g in water of 7 p.p.t., were confirmed. But in the case of unfavorable conditions for the release in estuaries, fish with a weight 1 to 3 g could be released directly to a beach (where the salinity was 7 g/l) and fishes with a weight from 10 to 20 g could be released to the sea. Valipour (2016) studied the effect of rearing density on growth and survival of fingerlings and recommended 25 kutum/sq m in Caspian Sea water. Zakir *et al.* (2016) studied the relationship between lysozyme activity and migration between fresh and brackish water, finding activity greater in skin mucus than in the blood and greater in brackish than fresh water. Hadifar *et al.* (2017) cultured skin cells from fin tissue for use in virology, toxicology and immunology research. Nikghorban *et al.* (2017, 2019) cultured kidney cells, of use in studying oncology, cellular physiology, gene expression, and viral diseases and toxic compounds which readily affect kidney tissues. Omidvar *et al.* (2017) studied fingerlings in aquaculture to determine the natural amounts of white blood liver enzymes and found also that the liver was the target organ of the spring viremia of carp (*Rhabdovirus carpio*). Rahpayma *et al.* (2017) cultured spleen cells as a preliminary to studying diseases and environmental pollutants. Samarin *et al.* (2017) determined survival rates of stripped eggs stored

in ovarian fluid at low temperatures (4 and 7°C) and found they should be fertilised within 8-12 hours after stripping to give a viability rate above 50%. Fadakar Masouleh *et al.* (2018) studied osmoregulation in juveniles suddenly entering waters of 6 and 11 p.p.t., concluding that indicators reached a desirable point at seven days and release of hatchery fish into the Caspian Sea, where salinity was higher, was preferable as estuarine pollutants would be avoided. Khoshkhal *et al.* (2018) identified *Lactobacillus* species in the gut using DNA where these bacteria produced antimicrobial compounds, enhanced the immune response and increased nutrient availability. Valipour and Maghsoodieh Kohan (2018) studied stocking density in concrete ponds on growth and survival of fingerlings in Caspian Sea water and found a density of 455 g/sq m was the most suitable.

Bani *et al.* (2020) studied the spawning migration of five-year-old reproductive and non-reproductive female kutum using the trace elements barium, calcium and strontium in their otoliths as a means of differentiation. Small differences in the concentration of strontium and significant differences in the barium:calcium ratio were found and the latter could be the result of fish migration towards the coastal zones over the reproductive season and feeding of non-reproductive individuals in estuarine areas. Shakoori *et al.* (2021) investigated the abundance of microbenthos (*sic*, macrobenthos) as natural food in the ponds of the Shahid Rajaie Center, Mazandaran and found that the percentage of macrobenthos in pond 1 was Lumbricidae (81.3%), Chironomidae (8.8%), Tubificidae (6.8%) and Baetidae (2.9%) and in pond 2 was Lumbricidae (79.9%), Chironomidae (14.8%) and Tubificidae (5.2%). Lumbricidae and Chironomidae, which are resistant families, had the highest presence in both ponds. These earthen ponds had good potential for aquaculture and could provide part of the live food needed by juveniles from natural production.

#### *Chemical composition and food safety:-*

Ershad Langroudi (2004) studied the durability and levels of polycyclic aromatic hydrocarbons in relation to the lipid content of smoked common carp, finding less than in *Hypophthalmichthys molitrix* and in the clupeid *Alosa caspia* (Caspian shad). Hosseini *et al.* (2005) recorded changes in condition and appearance of fish stored on ice for 1-20 days, showing gradual deterioration in quality with appearance excellent to good until the fourth day and good to acceptable until the tenth day. Razavilar and Tavakoli (2006) studied the prevalence of the human toxigenic bacterium *Clostridium botulinum* and the need for food safety control measures. Jalili (2007) documented protein changes and fatty acid deterioration as influenced by cold storage time. Babazadeh *et al.* (2008, 2008) reported on the changes in chemical, organoleptic and nutritional factors in fish stored at -18°C for up to 120 days, 80 days being ideal. Ghanbari *et al.* (2009) investigated production of a bacteriocin or antibacterial from intestinal bacteria of this fish species. This bacteriocin had potential for use as a biopreservative for food. Hedayatifard and Nemati (2009) salted roe which acted to conserve it, and also by decreasing the fat content helped to preserve omega-3 and omega-6 fatty acids. Hosseini *et al.* (2009) found a lower temperature (-18°C) reduced spoilage and total volatile base nitrogen was the best indicator for quality control rather than microbial indicators. Safari *et al.* (2009) recorded the lipid and protein composition of muscle in different maturity stages from January to April but found no significant differences.

Babakhani *et al.* (2010) studied the effect of cooking methods on the proximate composition and fatty acid profile of raw, baked and fried fish with baked fish the most valuable dish for human consumption requirements. Ghomi *et al.* (2010) found no significant effect of photoperiod on gut bacterial load in juveniles. Mirshekari *et al.* (2010, 2011) measured the effect

of the bacteriocin nisin Z and sodium benzoate which improved shelf life of vacuum-packed fillets at 4°C. Rohollah Javadian (2010) determined the effect of different thawing methods (in a refrigerator, water, air or microwave) on quality, finding the lowest adverse chemical and biochemical values, as well as microbial growth, in water-thawed samples. Velayatzadeh *et al.* (2012) examined levels of drip, drip protein and total volatile base nitrogen (TVB-N) as measures of spoilage of fish kept refrigerated at -18°C with various salt levels, the highest drip and drip protein being in 5% salt in this species among four examined. Anvari *et al.* (2013) concluded that gutting of kutum before cold smoking was recommended as pre-treatment for storage at room temperatures as there was less bacterial spoilage and oxidation. Khorramgah and Rezaei (2013) examined various chemical and sensory properties of frozen fish and found an acceptable quality over six month's storage. Rabiei *et al.* (2013) found ajowan oil (from the herb carom or *Trachyspermum ammi*) significantly reduced bacterial growth (*Listeria monocytogenes*), more so in fish broth medium than fillets. Rezaei *et al.* (2014) identified and extracted polycyclic aromatic hydrocarbons from smoked fish and found acceptable levels of them and of the bacterial community, and fatty acid levels were suitable.

Kaseb and Kalbassi (2015a, 2015b) studied the toxicity of colloidal silver nanoparticles and their effects in allowing an increase in skin bacterial flora. Pourashouri *et al.* (2015) described chemical and microbiological changes that occurred when roe was salted (protein and moisture content were less than raw roe, for example), but salted roe had inhibitory effects on bacterial and yeast growth. Raoofi *et al.* (2015) recorded changes in chemical and microbiology of fish stored in ice for up to 16 days where beach-seined fish were of better quality than gill-netted fish. Hedayatifard and Pourmolaei (2016) showed that smoked fish from northern Iranian markets had acceptable chemical indices, nutritional values and microbial communities, and valuable fatty acids were preserved. Mirshekari *et al.* (2016) found that the simultaneous use of nisin Z and sodium benzoate could increase the shelf life of vacuum-packed fillets stored at 4°C by their antimicrobial and antioxidant properties. Motallebi *et al.* (2017) found that salted roe coated with chitosan and natamycin at 10 mg/kg increased shelf life. Zand *et al.* (2017) examined the use of modified atmosphere packaging (gas mixtures, carbon dioxide, nitrogen and oxygen, and vacuum) and multi-layer flexible films on the pH and therefore shelf-life of smoked fish. Amini Khahan *et al.* (2018, 2019) compared quality and shelf life, and sensory and appearance changes, between gill-netted fish caught alive and dead in the net, finding quality and shelf life, colour hue, hardness and chewiness, texture, appearance of gills, and sensory evaluation were significantly different and live fish were preferable. Mehdipour *et al.* (2018) found that the heavy metal content (cadmium, chromium, lead) in this species decreased with various cooking methods such as boiling, grilling and microwaving. Hasebi *et al.* (2019) extracted and purified trypsin from the intestine and found it more kinetically effective than commercial trypsin.

Naderi Gharagheshlagh *et al.* (2020) isolated acid-soluble collagen from the skin of this species for commercial use as other sources, such as bovine and pig skin and chicken waste, had religious and biological contaminant restrictions in Iran.

#### *Disinfection and healing:-*

Farokhroz *et al.* (2013, 2014) examined the effects of formalin and copper sulphate, used to treat parasitic and bacterial infections in aquaculture, on skin and gill tissues, finding increasing damage with increasing dosage. Nodeh and Hoseini (2013) investigated the toxicity of potassium permanganate, used as a biocide and disinfectant in aquaculture, the LC<sub>50</sub> 96 h being 3.204 for 1 g fish and 3.46 for 3 g fish, kutum being susceptible to permanganate toxicity.

### *Hormones and immunology:-*

Heidari *et al.* (2010) found the steroid hormones estradiol-17 $\beta$  and testosterone were functionally important during the vitellogenic stage of oocyte development while progestogens were probably associated with the maturational phase of ovarian growth. Ahmadinejad *et al.* (2013) assessed the effects of the hormone LHRH-A2 alone and in combination with the dopamine antagonist pimozide on spawning and reproductive quality indicators in broodstock, finding the combination economical and useful in the field. Ahmadnezhad *et al.* (2013) assessed changes in gonad development and sex steroid hormones in broodfish after induction with various hormone treatments (LHRH-A2 alone and in combination with dopamine antagonists pimozide and chlorpromazine), showing variations in both with each treatment.

Koohilai *et al.* (2015) evaluated the effects dopamine antagonists and adrenergic agonists and antagonists on plasma levels of 17 $\beta$ -estradiol and 17 $\alpha$ -hydroxyprogesterone finding an inverse relationship between the dopaminergic and adrenergic systems. Bani *et al.* (2016) found sexually mature female fish held in saline conditions showed suppressed steroid hormones resulting in failure of gonad development while male fish adapted well and showed synchronicity in steroid hormone variations with wild fish, resulting in testicular development. Sudagar *et al.* (2016) compared ovaprim, ovafact and pituitary extract on artificial reproduction of female brood stocks, finding the former was best on the basis of ovulation rate, availability and lower cost. Heidari and Farzadfar (2017) found lysozyme levels in the head kidney, spleen and liver tissues of male and female fish declined from October to March coinciding with the lowest sea surface temperature rather than gonadal growth, increasing in April and May. Koohilai *et al.* (2017) evaluated the effects of third generation dopaminergic and adrenergic agonist and antagonist pharmaceutical compounds with GnRH $\alpha$  (gonadotropin releasing hormone stimulating follicle release) and ovaprim on 17 $\beta$ -estradiol and 17 $\alpha$ -hydroxyprogesterone levels in plasma, the dopaminergic system inhibiting reproduction while the adrenergic system stimulated it. Koohilai *et al.* (2017) evaluated a range catecholaminergic pharmaceuticals in various combinations for ovulation and spawning induction, finding ovaprim (a commercial spawning inducing agent) treatment had the highest mean value of ovulation success, ovulation index, fertilisation success, relative fecundity and number of eggs. Mohammadrezaei *et al.* (2017) showed that the natural phytoestrogens genistein and  $\beta$ -sitosterol reduced reproduction performance in the long term, disrupting the function of the endocrine system. Mohammadrezaei (2018) and Mohammadrezaei *et al.* (2018) noted that vitellogenin gene expression could be used as an indicator to determine the altering effect of estrogenic plant compounds. The effects of genistein and  $\beta$ -sitosterol were examined and it was found that gene expression was higher in the liver of fish exposed to genistein at 500 ng/l than a control or  $\beta$ -sitosterol. Steroid biosynthesis was altered and enzyme activity disturbed such that the population structure and reproduction performance could be reduced over time. Hadifar *et al.* (2019) produced a possible permanent cell line from caudal fin tissue of this fish. Tolouei Nia *et al.* (2019) carried out a basic study on the biochemical characteristics and activity of lysozyme, an antimicrobial enzyme of the immune system, and found some phenomena such as water hardness and warming could exert negative effects on the innate immunity of the fish.

Ghorbankhah and Bani (2020) noted that females display different egg colours (green and orange) during the spawning season, mostly due to the presence of carotenoid pigments and there was a positive influence of this egg carotenoid on post- fertilisation stages, such as elevating the innate immune parameters in larvae. Sarpanah *et al.* (2020) found cortisol treatment with subsequent ovaprim injection decreased plasma sex steroids and increased oocyte cortisol

content in wild confined broodstocks subjected to short-term confinement stress but had no effect on oocyte histological characteristics. Valipour and Heidari (2021a) studied the effect of different concentrations of kisspeptin (5, 20, 50 and 100  $\mu\text{g}/\text{kg}$  of body weight) that stimulates the production and secretion of GnRH in the hypothalamus of the brain and is required for normal maturation and reproduction. The reproductive hormones 17- $\alpha$ -20- $\beta$ -dihydroxy-4-pregn-3-one (DHP) and 17- $\beta$ -estradiol (E2) were measured eight hours after injection. The secretion of reproductive hormones changed significantly at different concentrations of kisspeptin.

#### *Spermatology:-*

Takeh *et al.* (2008) studied the ratio of ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ ) on semen biological characteristics (and therefore selection of suitable quality sperm in aquaculture), the ratios variously affecting sperm duration, haematocrit, total protein and glucose, and each other. Takeh *et al.* (2009) compared spermatological and biochemical parameters of semen at different broodstock migration times, some varying significantly (e.g., sperm movement duration, spermatozoa motility and  $\text{K}^+$ ) while others did not. Tekeh and Imanpour (2009) examined males with less than 110 head tubercles, 110-135 tubercles and more than 135 tubercles for various seminal characteristics finding, for example, correlations with sperm duration, spermatozoa motility and  $\text{K}^+$  of seminal plasma but not other characteristics, some evidently changing during maturation and others remaining constant.

Bavand Savadkoshi *et al.* (2012) examined age (2-6 years) and efficiency factors (sperm characters, fertilisation and hatching rates) for artificial propagation of spawning males in the Shirud, finding four-year-olds were economically the best choice. Esfandyari *et al.* (2012) found sperm motility varied among males and in different ovarian fluids, some males thereby having faster sperm overall. Gharache and Paighambari (2012) showed fish caught in gill nets had better spermatocrit levels than those taken by beach seine, but no difference in semen volume and sperm movement. Fadakar Masouleh (2014) noted how low levels of kraft liquor from the wood and paper industry affected testicular development and sperm quality. Fallah Shamsi and Khara (2015a) studied spermatological characteristics in 3- and 4-year-old fish from the Sefid River and found osmolality, mobility percentage and duration and compaction were positively correlated with fertilisation percentage and hatching rate in artificial propagation. Fallah Shamsi *et al.* (2015) examined fish at the Shahid Ansari Bony Fishes Propagation Center and found a significant correlation between osmolality, mobility percentage, mobility duration and compaction of sperm with parameters of artificial propagation efficiency such as fertilisation percentage and hatching rate. Binaii (2016) and Binaii *et al.* (2016) evaluated sperm quality before and after cryopreservation showing a significant decrease in motility although those samples diluted with glycerol were motile while those in ethylene glycol were immotile. Golpour *et al.* (2016) found that ovarian fluid significantly influenced sperm motility (duration) and percent motility (progressive forward motile sperm), although the full mechanism was still unknown. Rajabi Islami *et al.* (2017) found that fork length and body height could be used as indices of sperm density and spermatocrit while weight had no correlation in 3-4-year-old males. Tehranifard *et al.* (2018) detailed changes in blood, immunity, ions and testicular tissue in relation to age in winter and spring in the Chaf and Chamkhaleh rivers of Gilan. Hormone levels were consistent with testis development, reaching the highest level for progesterone in May in 4-5-year-olds, for example. Akbari Nargesi *et al.* (2021) found chilled storage of semen up to 48 hours can facilitate the management of artificial insemination in hatcheries.

#### *Haematology:-*

Afkhami *et al.* (2011, 2014) surveyed ionic and metabolic factors of blood serum, of use in reproduction and farming management of this species. Shafiei Sabet *et al.* (2011d) examined blood ionic and metabolic indices in mature and maturing females, useful in enhancing breeding, culturing and restocking. Darvish Bastami *et al.* (2012) studied ionic ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{2+}$  and  $\text{Ca}^{2+}$ ) and metabolite (cholesterol, total protein, glucose) factors of blood serum during the spawning migration, useful in improving the management of reproduction and cultivation. Khara *et al.* (2012) examined broodstock migrating into the Tajan River and found no differences in a wide range of blood parameters except for neu (neutrophils presumably) between age groups and mon (presumably monocytes) between sexes. Firouzbakhsh *et al.* (2013) compared blood factors in male and female broodstocks from the Tajan and Shirud rivers, results suggesting male and female variations in these factors should be taken into account when used to assess sex, age and spawning.

Azarin *et al.* (2015) examined the effects of different levels of iron and the probiotic BioPlus-2b on fry blood parameters, finding 7 mg/kg of iron in feed and  $1.6 \times 10^9$  probiotics continuous flow culture resulted in the highest amount of red blood cells, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin and lymphocytes.

*Stress:-*

Nikoo *et al.* (2012) recorded blood parameters of adults in relation to sex, size and maturity as monitors of stress and pathological changes. Nikoo and Falahatkar (2012) examined physiological responses in wild broodstock subjected to physiological stress (crowding) during transport. Behrouzi *et al.* (2014) found that heavier juveniles better survived a range of salinity in a laboratory setting although kidney tissues were affected under salinity stress. Gharache *et al.* (2014) measured blood and biochemical parameters which differed with stress of capture methods such as beach seines and the more stressful gill nets.

Ghiasvand *et al.* (2017) found that fry fed 1% garlic powder (*Allium sativum*) had the highest survival index after 48 hours exposed to salinity stress (15 p.p.t.) as well as improved growth performance and body composition. Ahamdi *et al.* (2019) showed that fish caught in gill nets were acutely and lethally stressed, especially at higher temperatures, and fish perished after 18 hours entanglement. Sarpanah (2019) investigated the effect of captivity stress in fibreglass tanks on reproduction and found a reduction in hormone levels.

*Anaesthesia:-*

Babaeinezhad *et al.* (2013) compared stress levels when the anaesthetics clove extract, lidocaine and sodium bicarbonate were used with male fish, finding that a combination of clove extract and lidocaine had less stressful effects than other treatments. Babaiinezhad and Bahrekazemi (2019) showed that sodium bicarbonate was not a suitable anaesthetic for brood stock because of irreversible stressful effects while lidocaine, and then clove extract, were recommended as suitable especially for females.

**Conservation.** Azari Takami *et al.* (1990) listed the following reasons for a decline in the commercial catch of this species:- a) regression of the Caspian Sea which decreased the surface area of the Anzali Lagoon and increased the growth rate of aquatic vegetation, b) mechanisation of farming and a consequent increased demand for irrigation water leading to reduced river flows during the spawning migration, c) use of fertilisers and pesticides in rivers draining into the Anzali Talab (and pesticides and herbicides such as diazinon, malathion, machete and saturn had a highly toxic effect on fingerlings of this species (Piri *et al.*, 1999) and the herbicide butachlor reduced sperm volume and increased abnormal sperm (Lasheidani *et al.*, 2008)), for example among others), d) pumping of river water for irrigation causing mass mortalities of fry, e)

industrial development increasing the pollution load, and f) excessive catches of adults to the extent that all spawners in a river were taken. Emadi (1979) and Rabazanov *et al.* (2019) added such factors as road construction and the removal of sand and gravel from banks and river beds, habitat degradation, erosion caused by felling trees and shrubs along river banks and in the mountains construction of bridges and dams and raising of their substructures which formed barriers to migration, illegal fishing, and climatic changes. Illegal fishing and non-standard nets threatened the stocks while fingerling release (120-140 million) and improvement of natural spawning areas through rises in water level contributed to stock increases (*Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran*, pp. 19-20, 1997). Three million fingerlings weighing 3-5 g were released into the Anzali Lagoon or Talab (*Iranian Fisheries Research Organization Newsletter*, 49:4, 2006). Poaching was rampant, even on the spawning grounds, and was also a significant factor in decline of this species (RaLonde and Walczak, 1972). Yahyaei *et al.* (2019) noted that Miankaleh, Golestan beach seines caught fish below standardised sizes.

In the 1970s, rivers were rented to fishermen to exploit to an unlimited degree such that all spawning fish were taken and there was no recruitment for four years (Carl Bond Archives, Oregon State University, Corvallis).

The catch declined from 5,854 t in 1918 to 172 t in 1937. Actual catches were about 20-30% larger because of local sale and consumption (Emadi, 1979). RaLonde and Walczak (1970b) noted a decline from 1,556 t in 1957 to 162.1 t in 1967 so the catch did not decline evenly. Aminian Fatideh and Shafiei Sabet (2011) noted that the beach seine size of fish was 55 cm 80 years before but was 37 cm in 2007. Emadi (1979) also pointed out that intensive sea fishing and fishing in rivers hindered spawning of the winter form, and led to a situation where only the spring form spawned. Leasing of rivers to fishermen was discontinued in an attempt to alleviate the decline in this species. The migration distance up rivers decreased from about 25 km to about 8 km in recent years because of water abstraction and dams for agriculture (Bartley and Rana, 1998b). However, Yousefian and Mosavi (2008) reported that artificial stocking had increased catches from 1,000 t in 1981 to 10,000 t in 2002. Chakmehdouz Ghasemi *et al.* (2009) reported a catch of 17,000 t in 2008. Aghili and Mohammadi (2012) found a catch per unit effort using research nets was 0.17 kg/net/day in Gorgan Bay. Poursadi *et al.* (2017) documented a reduction in catches in the Gilan rivers Chaland, Lamir (= Lomir), Hawiq (= Haviq), Nawarud (= Navrud or Nav) and Khalehsara from a total number of male and female fish caught in 1386 (21 March 2007-19 March 2008) at 22,130 along with 1,031 kg of eggs, to 7,052 males and females and 494 kg of eggs in 1395 (2016-2017), and 2,814 males and females and 141 kg of eggs in 1396 (2017-2018). Problems affecting numbers of fish were given as uncontrolled harvesting of sand, deepening of the river bed, increasing water salinity due to sea invasion, deformation of the spawning sites, the effects of fine particles and sediments on the respiration of fish and food insects, and the effect of zinc pollution.

A further problem was the restocking programme only took spring-run fish; the fall-run stock may no longer exist (but see below). Valipour and Khanipour (2015) stated the autumn (or fall) form was near extinction. In addition, stocks from various rivers were mixed and may result in outbreeding depression, the loss of adaptations to specific rivers in terms of migration patterns, spawning time, behaviour and other factors (Bartley and Rana, 1998b). Chakmehdouz Ghasemi *et al.* (2009) noted that the spring run comprised over 98% of the catch and that the autumn run stock has declined from deterioration of spawning grounds, overfishing and other factors.

Fazli *et al.* (2013) examined changes in mature females for the periods 1948-1950, 1974 and 2007 in Iranian waters. The average fork length decreased from 54.1 to 44.7 to 43.9 cm (or 40.0 in the text) and average weight from 2,181 to 1,295 to 1,210 g. However, the average condition factor had remained fairly constant between 1.35 and 1.38. Potential fecundity declined from 106,800 to 74,600 to 64,400 eggs. The reduction in fecundity was a consequence of a shift to smaller fish size. Artificial propagation was extensive and this resulted in smaller fish maturing earlier and ovulating sooner than larger fish.

Karimzadeh *et al.* (2014) examined samples from gillnet cooperatives in Tonekabon in the southwest Caspian Sea where this species comprised 69% of the total catch. The catch per unit effort was 220 kg and showed a remarkable increase over the past decade but qualitative changes in stocks were observed such as length, weight and age.

Measures to combat loss of this valued fish included a ban on fishing in the Anzali Talab and its tributary rivers (catches here were up to 1,000 t per year (Emadi, 1979)), effective control of illegal fishing and artificial spawning experiments (although the latter were insufficient to replace stocks). For several years starting in 1925, artificial breeding raised larvae for release in the 10 most important rivers. In 1976-1977, fingerlings were raised to increase the stock in the Caspian Sea. Over 5 million fry were produced by the Havyg (Haviq) Hatchery alone in 1977. Mesh size of nets used to catch this species were apparently not harmful to younger fish as these had a chance to escape from the wings, with a wider mesh, before the bag net, with a smaller mesh, came into play (Afraei Bandpei *et al.*, 2010).

Emadi (1979) recorded releases of 28-44 million fingerlings and 250 million larvae “in recent years”. A farm in the Siah Kal region of Gilan Province near Rasht was expected to produce 40 million white fish “roe”, presumably fry, in 1985 (*Kayhan International*, 20 May 1984). The Dr. Beheshti Hatchery near Rasht expected to release more than 60 million fingerlings in the Iranian year 1993-1994 (*Abzeeyan*, Tehran, 4(5):VI, 1993). This hatchery had a peak production for the period 1973-1993 of over 140 million fingerlings in 1989, rising from the low period of 1973-1982 with less than 10 million fingerlings, and with subsequent decreases to about 50 million fingerlings in 1993 (*Abzeeyan*, Tehran, 5(3 & 4):IX-X, 1994). The number of fingerlings released from 1986 to 1991 climbed from 38 million to 170 million (Holčík and Oláh, 1992). Krasznai (1987) also referred to propagation of this species at Sad-e Sangar (Dr. Beheshti) and Siah Kal Fish Farms near Rasht in Gilan. Emadi (1993a) gave fingerling production at government hatcheries as follows:- 25.3 million in 1983, 28.3 million in 1984, 38.0 million in 1985, 51.7 million in 1986, 72.0 million in 1987, 84.3 million in 1988, 140.2 million in 1989, 156.3 million in 1990, 110.0 million in 1991, and 145.0 million in 1992. The Shahid Rajaei Hatchery in Sari released 358 million fingerlings, possibly in a single year (*Abzeeyan*, Tehran, 4(7):VII, 1993), although 70 million were reported as released annually to Mazandaran rivers in 1995 (*Abzeeyan*, Tehran, 6(8):III, 1995) and production of 70 million kutum fingerlings annually was reported in 2001 (*Iranian Fisheries Research Organization Newsletter*, 28:3, 2001). In 1997, 142 million fingerlings were produced for restocking (Bartley and Rana, 1998b). In 1999-2000, 150 million juveniles were released into the Caspian Sea (*Iranian Fisheries Research Organization Newsletter*, 23:4, 2000). From October to March 2000, 80 million juveniles raised in the Shahid Ansari aquaculture and breeding centre in Gilan were released into the Caspian Sea and neighbouring water bodies (*Iranian Fisheries Research Organization Newsletter*, 26:2, 2001). Billard and Cosson (2002) cited a mean of 100 million alevins released per year, reaching 140 million in some years, and gave a brief overview of production facilities. Amini (2006) reported release of fingerlings into the Larim, Goharbaran, Shirud, Tonekabon,

Sardab, Mirud, Babol, Asbuchin and Sorkh rivers in 2000-2001 numbering 53.7 million and 62.5 million. Fork length was 36.7 mm and 43.3 mm and condition factor 1.13 and 1.2 respectively by year. In 2006, a report had more than 150 million juveniles being released into the Caspian Sea every year ([www.iranfisheries.net](http://www.iranfisheries.net), downloaded 28 July 2006). Sources obviously conflicted on exact numbers, nevertheless marked variations in production were evident over short periods. The South Caspian Fisheries of Azerbaijan also released larvae in Soviet waters, more than 150 million in 1983 for example (Zarbalieva, 1987). Abdolhay *et al.* (2011) gave figures for fingerlings released in Iran as 225 million in 2002, 155 million in 2003, 179 million in 2004, 229 million in 2005, 174 million in 2006, 262 million in 2007, and 187.1 million in 2008. The catch in the years 2002 to 2008 was 6,417 t, 8,984 t, 7,036 t, 9,631 t, 16,117 t, 17,196 t and 14,835 t respectively. Fazli and Daryanabard (2020) assessed the desirable levels of the kutum for stock enhancement with two scenarios using fingerlings released (FR) and recruitments (R) density-dependence and macrobenthic production (P). In the years 1989-2018, the FR increased from 72 million in 1989 to 400 million in 2009 and then declined to 176 million in 2018. In contrast, the R with a lag of two years declined from 44.53 million in 1991 to 25.77 million in 1998, increased to 65.07 million in 2005, and then collapsed to 25.01 million in 2018. Based on FR-R relationships of Ricker and segment regression models, the lowest level of FR, which resulted in the highest R (39 million), was about 200 and 150 million fingerlings, respectively. Based on the P/biomass ratio of macrobenthic species, the annual production was 241.6 thousand mt. The desired number of fingerlings concerning stock enhancement should be lower than 150 million to prevent overcompensation in the Iranian waters of the Caspian Sea. Karami Rad *et al.* (2021) reviewed the release of over 5.6 billion juveniles for the three decades 1970-1980-1990 with a catch of over 305 thousand tons.

The Inland Water Aquaculture Research centre in Anzali has artificially propagated the autumn or fall-run stock ([www.iranfisheries.net](http://www.iranfisheries.net), downloaded 28 July 2006). Three million fish were released in July 2006, probably at 3-4 g with more to be released at a heavier weight. Valipour (2010) and Valipour and Khanipour (2015) caught brooders of the fall form from the entrance to the Nahang Roga in the Anzali Wetland and held them in floating cages there and in earthen ponds at the Sefidrud Fisheries Research Station. There were no significant differences between the two maintenance statuses in maturation period and other reproductive characteristics. The male:female ratio was 1:1.4, minimum and maximum weight was 1,450 g and 3,100 g, brooders injected with carp pituitary extract showed absolute, practical and relative fecundities of 88,565, 73,805 and 48,670 eggs, incubation lasted 7-10 days at 14-16°C, larvae were introduced to earthen ponds at 3 million/ha and were cultured for 3-4 months, and 1.8 million fingerlings at 1-2 g were released into the Anzali Wetland.

Azari Takami *et al.* (1990), Woynarovich (1985) and Bartley and Rana (1998b) detailed the technique for artificial spawning, incubation and raising of fingerling mahi sefid or kutum. Adults were caught as they entered rivers on the spawning migration by blocking the river with wooden tripods interlaced with twigs as screens and using a meshed net. The Shaeed Ansari Fish Farm (of Shilat, the Iranian Fisheries Company) took fish from five main rivers, forming a brood stock of 10,000 females and 20,000 males (Bartley and Rana, 1998b). Almost 100% of migrating fish were caught. Ripe fish were stripped and the eggs fertilised with sperm. Eggs from two females were pooled and mixed with milt from two males. The adhesive layer was washed away with water and continuous stirring. Once the eggs were completely separated from each other they were placed in incubator jars. Eggs may be placed in net-bottomed trays in the river for two days before being sent to a hatchery. Egg development took a minimum of seven days but larval

development only took 1-2 days. Larvae were fed with a mixture of milk and eggs until they were five days old and then put in the earthen rearing ponds. In the Shaeed Ansari Fish Farm, fingerlings were released in a river mouth at 1 g and most entered the Caspian Sea within three days (Bartley and Rana, 1998b). Fingerlings were grown in ponds to a weight of 2-3 g and then released in the Sefid River which carried them down to the sea (Petr, 1987). Production of 1-2 g fingerlings attained 3 tonnes per hectare in fish farms (Emadi, 1993a). Farabi *et al.* (2007) studied brood stocks and fingerlings in the Shirud, Tonekabon, Tajan and Goharbaran rivers from March 2004 to March 2005. The mean length, weight and condition factor for broodstock females and males were 43.75 and 36.5 cm, 1,189.5 and 678.13 g and 1.42 and 1.38 respectively. Eggs collected over a 62-day period weighed 4,931 kg, mostly at the end of March and beginning of April. Percentage of survival of eggs in the four rivers listed above was 94.5, 95.1, 87.7 and 96.9 respectively. Newly hatched larvae averaged a total length of  $6\pm 2$  mm and a weight of  $2\pm 0.2$  g. The number of fish produced at less than 1g was 16,942,454 representing 19.9% of the total released in Mazandaran in 2004. Fish in the 1.0-1.5 g weight class, suitable for release, numbered 62,905,247. Parasites of fry were *Diplostomum*, *Dactylogyrus*, *Butriocephalus*, nematodes, *Trichodina* and *Epistelis*.

Haghi Vayghan *et al.* (2013) used habitat suitability index modeling to describe the relationship between abundance and ecological variables, both remotely sensed and field data. A geometric mean model explained the relationship when the variables depth, benthos biomass, photosynthetically active radiation and sea surface temperature were used. Depth and substrate were the most important field data for kutum to select its habitats and chlorophyll *a*, photosynthetically active radiation and sea surface temperature were the most critical remotely sensed data for near real-time prediction of the habitat.

The hybrid with grass carp reached an average weight of 100 g and a length of 22 cm after 5 months in the first report cited above under **Systematics** and 6.7 g and 9.17 cm after 4 months in the second report. Larvae were fed live food twice a day and hybrids larger than fingerling size ate grass. The hybrid phenotype resembled the sefid mahi but was an herbivore. It was expected that this hybrid would be used as a new culturable “species”.

Masompour *et al.* (2018) found this species in ghost nets in the Caspian Sea between Babolsar and Sorkh Rud over 200 sq km of Mazandaran coastline. A total of 515 gillnet panels were removed with an estimated total length of 30.9 km and an average mesh size of 80 mm. It was the second most caught species in fall of 12 recorded at 15 fish and the second of 10 recorded in winter at 171 fish. *Alosa caspia* was the most often caught species at 51 fish in fall and 187 in winter. Higher catch rates in winter were attributed to migrations from the northern to the southern Caspian Sea and in shallower water to illegal fishing and loss of nets there.

A fine of 1,500 rials was imposed specifically for illegal angling of this species (Anonymous, 1977-1978).

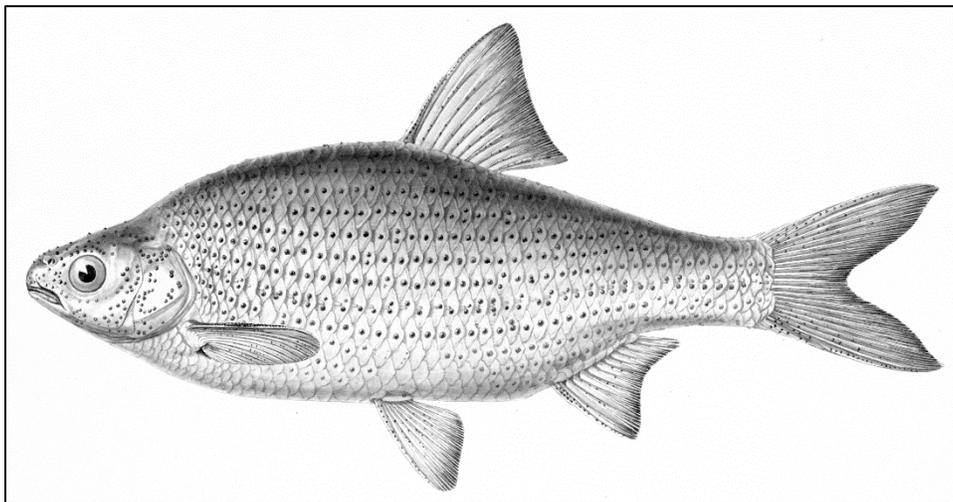
Robins *et al.* (1991) listed this species (as *Rutilus frisii* and presumably including this taxon) as important to North Americans. Importance was based on its use in aquaculture and as food. Kiabi *et al.* (1999) considered this species to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included commercial fishing, sport fishing, abundant in numbers, habitat destruction, widespread range (75% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. The 2000 IUCN Red List listed this species as DD (Data Deficient) but was later listed as of Least Concern. Coad (2000), using 18 criteria, found this species to be one of the top four threatened species of freshwater fishes in Iran. *Mnemiopsis leidyi*, the invasive ctenophore, reduced the biomass of this fish in Iranian

waters (Fazli *et al.*, 2015).

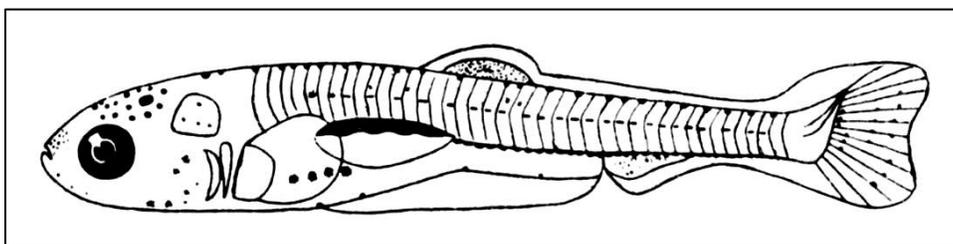
**Sources.** Iranian material:- CMNFI 1970-0506, 4, not kept, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0509, 1, not kept, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0510, 1, 49.3 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0512, 3, 44.2-53.2 mm standard length, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0513, 9, 51.1-66.1 mm standard length, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0514, 4, 53.5-66.5 mm standard length, Gilan, Shafa River estuary (37°55'N, 49°09'E); CMNFI 1970-0516, 27, 42.3-61.0 mm standard length, Gilan, Lomir River (38°14'N, 48°52'30"); CMNFI 1970-0518, 9, 43.4-60.7 mm standard length, Gilan, Haviq River estuary (38°10'N, 48°54'E); CMNFI 1970-0519, 9, 42.8-52.4 mm standard length, Gilan, Chelvand River (ca. 38°18'N, ca. 48°52'E); CMNFI 1970-0520, 19, 46.7-73.9 mm standard length, Gilan, Astara River (ca. 38°25'N, ca. 48°52'E); CMNFI 1970-0521, 1, 52.1 mm standard length, Gilan, Sefid River near Lulaman (no other locality data); CMNFI 1970-0522, 2, 49.7-67.9 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0526, 4, not kept, Gilan, Sefid River below Astaneh Bridge (37°19'N, 49°57'30"E); CMNFI 1970-0544, not kept, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0563, 24, 40.8-58.1 mm standard length, Gilan Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0565, 3, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1970-0568, 1, not kept, Gilan, Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0587, 1, 57.4 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0590, 1, not kept, Mazandaran, Shesh Deh River near Babol Sar (ca. 36°43'N, ca. 52°39'E); CMNFI 1979-0088, 1, 104.3 mm standard length, Gilan, Sefid River (no other locality data); CMNFI 1979-0265, 3, 39.2-45.0 mm standard length, Gilan, head of Anzali Talab at Abkenar (37°28'N, 49°20'E); CMNFI 1979-0470, 8, 30.2-38.9 mm standard length, Mazandaran, stream 21 km west of Alamdeh (36°35'N, 51°43'E); CMNFI 1979-0471, 1, 106.0 mm standard length, Mazandaran, Caspian Sea 14 km west of Alamdeh (36°35'N, 51°48'E); CMNFI 1979-0473, 1, 46.5 mm standard length, Mazandaran, Babol River (36°38'N, 52°38'E); CMNFI 1979-0494, 1, 36.1 mm standard length, Mazandaran, Talar River tributary (36°21'N, 52°51'30"E); CMNFI 1979-0685, 6, 45.2-50.5 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0686, 30, 42.8-52.2 mm standard length, Gilan, Sefid River above ferry (37°24'N, 49°58'E); CMNFI 1979-0696, 39, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1980-0116, 4, 50.8-58.8 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0132, 2, 45.6-48.7 mm standard length, Gilan, Sefid River at Kisom (37°12'N, 49°54'E); CMNFI 1980-0135, 8, 45.7-54.5 mm standard length, Iran. Caspian Sea basin (no other locality data); CMNFI 1980-0138, 4, 45.7-48.7 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1980-0140, 1, not kept, Gilan, Astara Talab close to sea (ca. 38°26'N, ca. 48°53'E); CMNFI 1980-0159, 1, 117.0 mm standard length, Gilan, Caspian Sea at Kazian Bridge (37°28'30"N, 49°28'E); CMNFI 1980-0160, 1, 88.5 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1980-0908, 24, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1993-0140, 2, 64.5-71.5 mm standard length, Mazandaran, Tirom River, Ramsar (36°51'48"N, 50°48'E); CMNFI 2008-0114, 2, 39.7-42.0 mm standard length, Gilan, Talebabad Anzali (37°26'N, 49°34'E).

Comparative material:- BM(NH) 1879.11.14:31-32, 2, 410.0-430.0 mm standard length, Russia, Astrakhan (ca. 46°24'N, ca. 48°05'E).

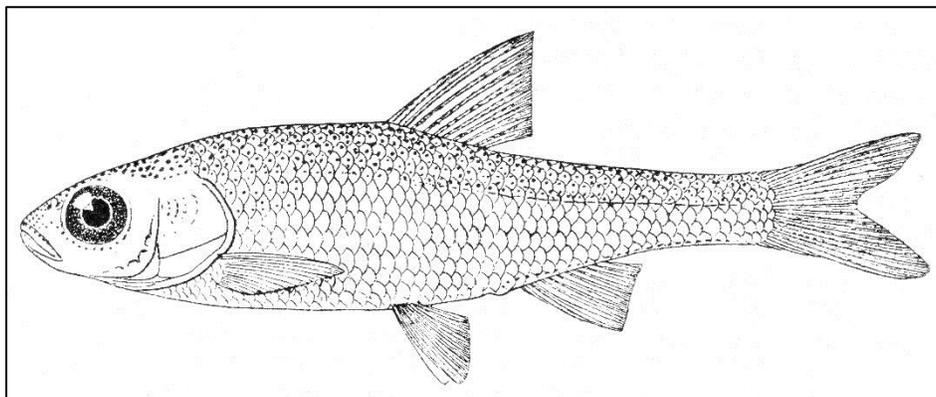
***Rutilus lacustris***  
(Pallas, 1814)



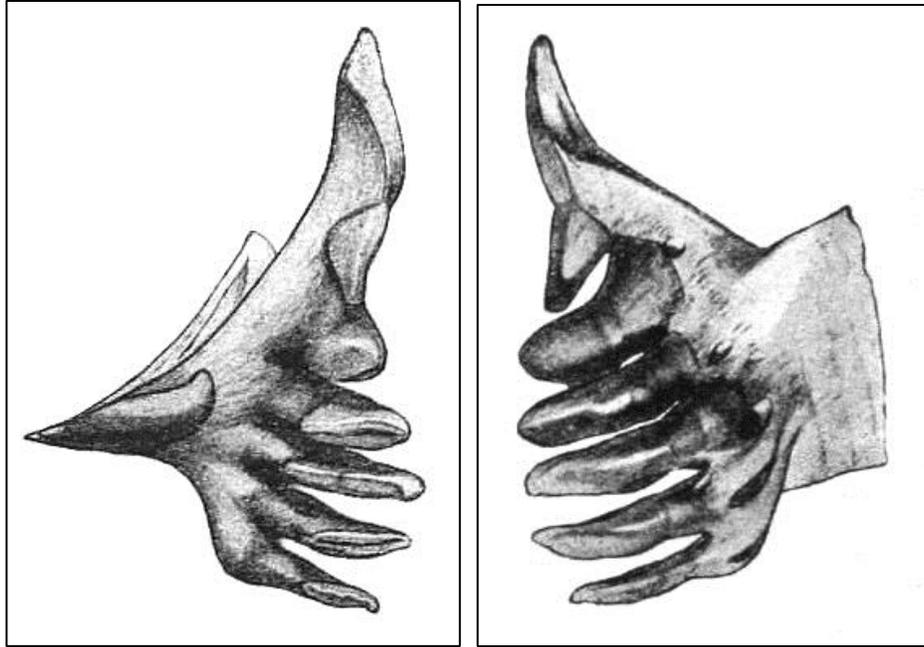
*Rutilus lacustris* (as *R. rutilus caspicus*) with tubercles, 30+ cm total length, western coast of the Caspian Sea, after Berg (1948-1949).



*Rutilus lacustris* (as *R. rutilus caspicus*) fry, 9 mm, age two weeks, Russia, Volga River delta, after Kazanskii (1915).



*Rutilus lacustris* (as *R. rutilus caspicus*), young, 24 mm total length, Kazakhstan, delta of the Ural River, after Shukolyukov (1932).



*Rutilus lacustris* (as *R. rutilus caspicus*), left pharyngeal arch, inner view on left, outer view on right, after Berg (1916).



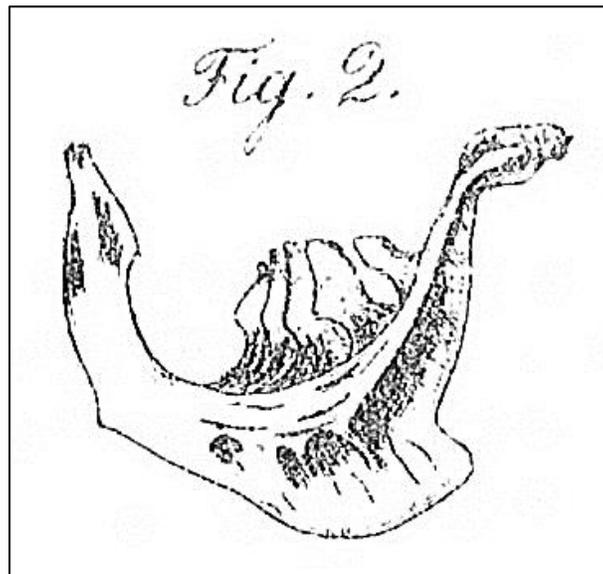
*Rutilus lacustris*, Iran, Keyvan Abbasi.

**Common names.** Kolme, kollme, kolme, koolme or kalam (meaning unknown), mahi kolme, kolme Gorgan, talaji or telagi (in Gilaki and Mazandarani, meaning unknown), latter three used for fish identified as *R. r. caspicus* natio *knipowitschi*), mahi cheshm qermez (= redeye fish), kolme Kura or kolme Anzali for fish identified as *R. r. caspicus* natio *kurensis*, kolme Gorgan or kolme Turkmenistan for fish identified as *R. r. caspicus* natio *knipowitschi*.

[Kulma, kyumen, Kur kulmasi and xazar kulmasi in Azerbaijan; kasli akcapagy in Turkmenian; vobla, Astrabadskaya vobla or Astrabad vobla, Astrakhanskaya vobla or Astrakhan vobla, Kurinskaya vobla or Kura vobla, severo-kaspiiskaya vobla or North Caspian vobla, Turkmenskaya vobla or Turkmenian vobla, Sibirskaya plotva or Siberian roach, soroga, chebak, and serushka for *R. r. fluviatilis*, all in Russian, roach being the English equivalent of vobla; river whitefish, whitefish (whitefish usually refers to salmonids not native to Iran)].

**Systematics.** *Cyprinus Rutilus* Linnaeus, 1758 was originally described from lakes in

Europe, the type being from Sweden and this was the name, as *Rutilus rutilus*, long used for the species in Iran. A discussion of the taxa present in Iran and their names is given under the genus above. Earlier studies centre around fish named as *R. rutilus*, *R. rutilus caspicus* and *R. caspicus* but these are all subsumed under *R. lacustris* here when referring to Iranian fish. *Cyprinus lacustris* Pallas, 1814 was originally described from Siberia, Russia and *Leuciscus rutilus* var. *caspicus* Yakovlev, 1870 was described from the Volga River delta and types are unknown for both (*Catalog of Fishes*, downloaded 11 September 2017).



*Leuciscus rutilus* var. *caspicus*, pharyngeal arch, after Yakovlev (1870) which does not illustrate a whole fish.

Bogutskaya and Naseka (2004) and Kottelat and Freyhof (2007) recognised *Rutilus caspicus* (Yakovlev, 1870) as the semi-anadromous species in the Caspian Sea with *R. rutilus* in rivers and lakes. The presence of a resident *R. rutilus* (or even a distinct taxon) and a semi-migratory *R. caspicus* (now referred to *R. lacustris* after Levin *et al.* (2017)) needs to be resolved for Iranian populations. Most Iranian populations are close to the Caspian Sea and are actually or potentially semi-migratory and so are treated here as that species. Data on them cannot be easily differentiated as the resident and the semi-migratory species, if indeed the former exists. Pourshabanan *et al.* (2021) using molecular techniques mentioned in a brief abstract that only two *Rutilus* species occurred in the Caspian Sea basin of Iran, presumably *R. kutum* and *R. lacustris*.

Studies below in the various sections for Iranian fish may reference *R. rutilus*, *R. r. caspicus* or *R. caspicus* as the use of *R. lacustris* for this taxon is recent, but this is not listed for each study. Often there is no clear separation or indication in these studies between resident and migratory populations.

Curiously, nominal *R. caspicus* and *R. frisii* showed low genetic divergence in a study by Ketmaier *et al.* (2008), a study using DNA but sample sizes were low.

Holčík and Skořepa (1971) revised the roach, *R. rutilus*, and found no reason to maintain subspecies, of which they listed 12. *Rutilus rutilus caspicus* (Yakovlev, 1870) (North Caspian or Astrakhan vobla) was the subspecies found in the Caspian Sea basin with natio *knipowitschi*

Pravdin, 1927 (Astrabad or Turkmenian vobla) in Gorgan (= Astrabad) and Gasan-kuli bays and the Gorgan, Atrak and Qareh Su rivers and natio *kurensis* Berg, 1932 (Kura vobla) in Kyzylagach Bay, the Kura River, Astara and rarely the Anzali Talab. The Kura vobla was said to differ from the Astrabad vobla by a greater body depth, smaller eye and more rapid growth. *R. r. caspicus* was distinguished from other subspecies by having modally 9 dorsal fin branched rays, darker fins, more inferior mouth, higher dorsal and anal fins, longer pectoral and pelvic fins, a deeper head, and larger eyes (see Berg (1948-1949) for more details). *R. r. caspicus* was originally described as *Leuciscus rutilus* var. *caspicus* from the Volga River delta, Russia. Eschmeyer *et al.* (1996) listed *Leuciscus rutilus* var. *wobla* Grimm, 1896 described from the North Caspian Sea and mouths of rivers (Volga, Ural, Emba, Terek, Kura, Astara) entering the Caspian Sea. This is presumably a synonym of *Rutilus rutilus* (as was) judging from the subspecific name which is the Russian word for this species (wobla = vobla or roach). Kottelat (1997) listed it as a nomen nudum.

Holčík and Skořepa (1971) recognized the Caspian Sea populations as the morph or morpha *migratorius*, perhaps a first step towards differentiation and speciation. Mironovskii and Kas'yanov (1986, 1987) however, retained *Rutilus rutilus caspicus* (= *R. lacustris*) as a distinct subspecies in the Caspian Sea based on a multivariate analysis of 12 meristic and seven morphometric characters. Mironovskii (1991, 1992) also demonstrated differences between Turkmen and Azerbaijan samples. Kuliyeu (1984) considered these variations to be responses to different and changing conditions of the environment.

Naddafi *et al.* (2002) demonstrated differences in meristic (anal fin rays, predorsal scale number and total body vertebrae of 12 characters studied) and morphometric characters (7 measurements of 28 studied) for fish from the Anzali Wetland and the Gorgan River estuary of Iran. Patimar *et al.* (2005) found morphological differences between fish from the Gomishan Wetland and those from the Aj-gol and Alma-gol (= Ulmogol) wetlands in southeast Iran, and between the latter two wetlands. Inter- and intra-population variation was higher in the Gomishan fish. Keyvanshokoo and Kalbassi (2006, 2009) however, found the value of Nei's genetic distance ( $d = 0.04$ ) to be small between these two populations using DNA. The populations had similar levels of polymorphism. Keyvanshokoo *et al.* (2007) compared populations in the Anzali Wetland and Gorgan Bay using microsatellite markers and found differences between both populations were not significantly different for average number of alleles per locus nor for observed heterozygosities. Parafkandeh Haghighi and Rezvani (2005) and Parafkandeh Haghighi (2006) used the trace element content in otoliths to demonstrate the presence of two different populations in the southern Caspian Sea, the Anzali-Kura and the Gorgan-Turkmen, as noted above on meristic and morphometric values. Rezvani *et al.* (2006) used mitochondrial DNA to compare Anzali and Turkmen roach and found the former to be more genetically variable, attributing this to there being more rivers, and therefore more spawning populations, in that area. Kashiri *et al.* (2010) found high diversity within populations of the Golestan coast using microsatellite loci. Kashiri *et al.* (2012) found low genetic differentiation between populations from the Gharesou (= Qareh Su) and Gomishan regions in Iran using microsatellite loci. Most variation is within populations but they could be separated. Kashiri *et al.* (2012) compared microsatellite loci from fish in the Anzali and Gomishan wetlands and found populations were probably separated. Reyhani *et al.* (2010) used microsatellite markers and found higher heterozygosity in Anzali Wetland fish compared to those from Gorgan Bay. However, gene flow was high and population differentiation was non-significant. Rezvani Gilkolaei (2011) used microsatellite markers for 90 fish from the Anzali Lagoon and Gorgan

Bay, and the Volga River of Azerbaijan. The average of expected and observed heterozygosity was 0.5 and 0.7, respectively. There were no significant differences between Iranian locations but there were between Iranian and Azerbaijan populations.

Ghojoghi *et al.* (2014a) found differences in morphometry between Aras River, Anzali Wetland fish and Bandar-e Torkeman populations and suggested they be considered as distinct stocks. Ghojoghi and Eagderi (2014) compared Turkmenian (Gomishan Wetland) and Kura (Talesh region) populations morphometrically and found the sexes and the populations to differ. The Kura population had a bigger head, longer anal fin and a deeper body, attributed to environmental factors. Ghojoghi (2015) found differences in the caudal skeleton of fish from the Aras River, Anzali Wetland and the Gomishan Wetland.

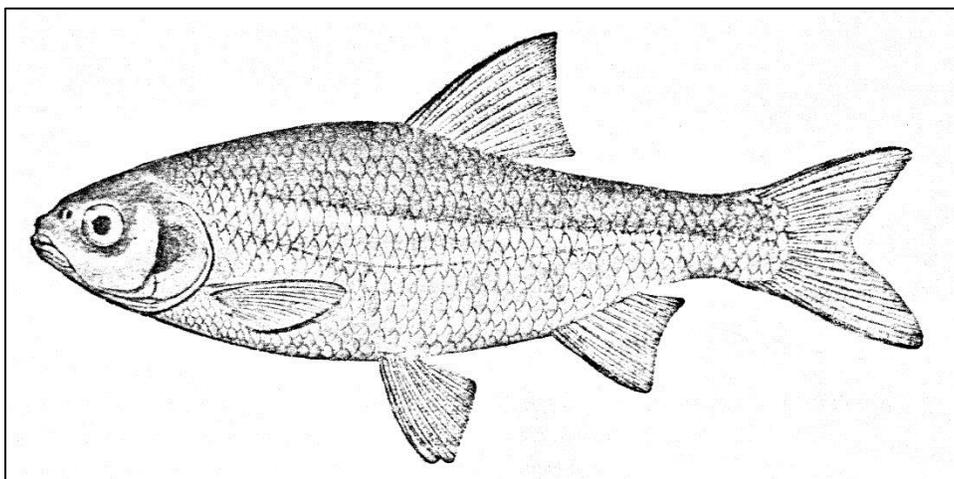
Sharifi *et al.* (2016) and Behmanesh *et al.* (2017) analysed cytochrome *b* and found that the population in the Aras Lake was genetically differentiated from south Caspian Sea populations (Astara and Bandar-e Torkeman) and these latter two areas represent a single panmictic population. Laloei *et al.* (2016) using microsatellite DNA found genetic divergence was significantly different between samples of Golestan and Gilan, Gilan and Mazandaran and Gilan with Gorgan Bay.

Jabeleh (2020) used microsatellite markers to compare wild broodstock, farmed and hybrids from three populations and found the genetic distances between the wild, farmed and mixed offspring populations were 0.459, 0.298 and 0.684, respectively. The results of molecular variance analysis revealed that genetic diversity within the individual was 90 percent, while among them it was three percent. The  $F_{st}$  value was 0.032 indicating the low genetic differentiation between the three populations which could be explained by the low number of alleles in the three populations. Furthermore, the natural migration ( $N_m$ ) between two stations was 7.394. Cluster analysis based on genetic distance showed that the breeding and hybrid populations are in a separate branch from the wild population.

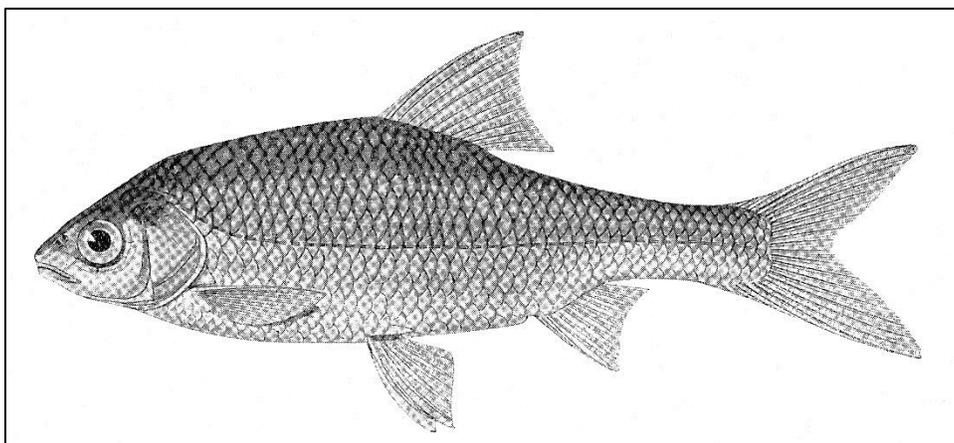
Hashemzadeh Segherloo *et al.* (2021) genotyped 7,984 single nucleotide polymorphisms and sequenced the mitochondrial C oxidase subunit I gene of 37 *R. lacustris* and *R. frisii* (= *R. kutum*) from the southeast and southwest Caspian Sea and the Aras River. The first two populations were closely related but highly differentiated from the Aras River population. Three hybrids were found with mtDNA from *Abramis brama* or *R. frisii* (= *R. kutum*) and nuclear DNA from *R. lacustris*.

Three “types” of *Rutilus rutilus caspicus* (= *R. lacustris*) have been reported from Iran (Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran, pp. 54-55, 1997). One type lived in the Anzali Talab and was relatively small, the second was larger and migrated between Anzali and the Kura River of Azerbaijan and the largest migrated between the northern and southern coasts of the Caspian Sea.

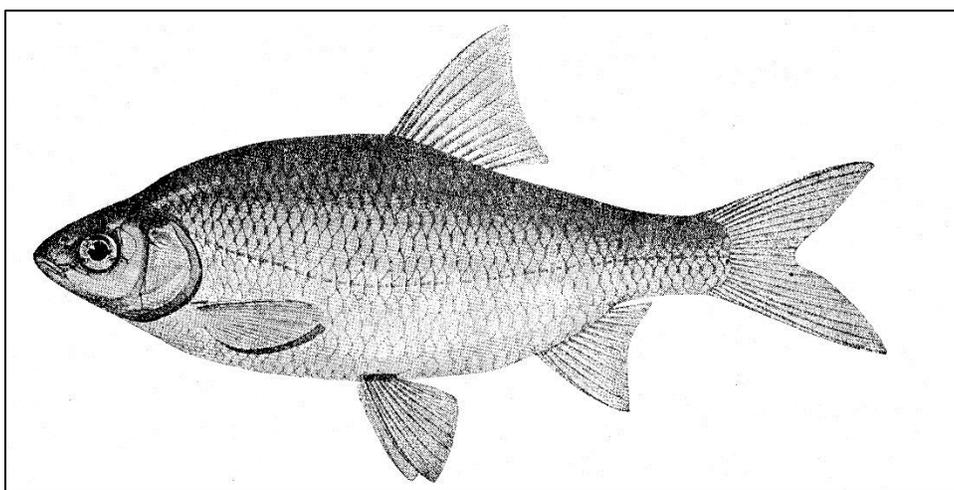
*Rutilus rutilus schelkovnikovi* Derzhavin, 1926 (syntypes many, whereabouts unknown, *Catalog of Fishes*, downloaded 11 June 2021) was described from the Karasu which falls into the Aras River 5 km above the mouth of the Zanga River (Razdan River), Echmiadzin District, Armenia. *Rutilus rutilus uzboicus* Berg, 1932 from lakes in the Uzboi River Valley (with the type from Lake Yaskhan) in Turkmenistan north of the Iranian border has seven possible syntypes under ZISP 2312. The former is included in *R. lacustris* by Levin *et al.* (2017) and the latter too is presumed to be a synonym (given as a synonym of *R. rutilus* in the *Catalog of Fishes*, downloaded 15 May 2018). *Leuciscus rutilus* var. *fluviatilis* Jakovlev, 1870 described from the delta of the Volga River was not addressed by Levin *et al.* (2017) and is given as a synonym of *R. rutilus* in the *Catalog of Fishes* (downloaded 15 May 2018).



*Rutilus rutilus schelkovnikovi*, syntype, after Derzhavin (1926).



*Rutilus rutilus uzboicus*, holotype, 18.4 cm total length,  
Turkmenistan, Lake Yashkan along the Uzboi, after Berg (1932).



*Leuciscus rutilus* var. *fluviatilis* (= *R. r. fluviatilis*), 18.6 cm total length,  
Russia, Volga River delta, after Berg (1932).

Hybrids with *Blicca bjoerkna* were reported from the Aras River basin in Armenia, which is shared with Iran. Artificial hybrids with *Rutilus frisii kutum* (= *R. kutum*) and *Abramis brama* have been bred in Iran (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 39-40, 1996).

**Key characters.** This species is distinguished from the related *Rutilus kutum* by the lower scale count (< 50) and the posterior part of the gas bladder being rounded rather than pointed.

**Morphology.** The body is relatively deep and rounded and is somewhat compressed but can be quite thick. It is deepest at a level behind the end of the pectoral fin. A nuchal hump may develop. The predorsal profile is strongly convex. The caudal peduncle is compressed and moderately deep. The head tapers as part of the dorsal profile to a rounded snout. The eye lies well into the anterior half of the head. The mouth is gently oblique and is terminal to slightly subterminal. Lips are thick. The mouth extends back level with the anterior eye margin. There is a groove in front of the nostrils across the head. The dorsal fin is emarginate and the fin origin lies over or posterior to the pelvic fin origin level. The depressed dorsal reaches back almost to, or level with, the anal fin origin. The caudal fin is moderately to deeply forked with pointed to rounded tips. The anal fin is emarginate and does not extend back to the caudal fin base. The pelvic fin is rounded and does not extend back to the anal fin origin. The pectoral fin has a straight to rounded margin and does not extend back to the pelvic fin origin.

Dwarf and large forms are recognised in Dagestan by Shikhshabekov (1969) with different life histories, and distinct spawning stocks are known from the north Caspian Sea.

Dorsal fin unbranched rays 2-5, branched rays 8-12, usually 9 or 10 in the Caspian Sea, anal fin unbranched rays 2-4, branched rays 8-12, mostly 9-10, pectoral fin branched rays 14-18, and pelvic fin branched rays 7-9. Lateral line scales 39-48, mostly 42-47. There is a pelvic axillary scale and a scaled keel behind the pelvic fins. Scales have a squarish shape with a wavy anterior margin and a finely crenulated posterior margin. Dorsal and ventral margins are slightly rounded and the anterior corners are abrupt but rounded. Scales have very numerous fine circuli around a central focus. Radii may be found on all fields but fish often lack radii on lateral fields. Radii on anterior and posterior fields are widely spaced. Usually there are very few anterior and posterior radii (e.g., in a fish 150.7 mm standard length there are 2 anterior and 4 posterior radii; but counts are quite variable, at least 7-14 radii total). Total gill rakers number 9-17, usually 10-14, short and stubby and reaching the adjacent raker when appressed. Pharyngeal teeth are 6-5 or 5-5, rarely 6-6, 4-5, 5-4 or 5-6 with the grinding surface slightly folded to form a long, hollow crown for the largest teeth. There is a rounded and hooked tip to teeth 1-4. The tooth margin in the posteriormost two teeth is serrated. The anteriormost two teeth are rounded. Teeth are more serrated and hooked in smaller fish. The gut is s-shaped with a small anterior loop. Total vertebrae number 37-43. Lake populations generally have more vertebrae than river populations and the number of vertebrae is genetically fixed, generally following the maternal genotype (Izyumov and Kas'yanov, 1995). The chromosome number for *R. rutilus caspicus* (= *R. lacustris*) is  $2n = 50$  (Klinkhardt *et al.*, 1995; Arai, 2011).

Ghojoghi *et al.* (2014b) described the osteology of this species from Turkmen Harbour specimens and Hasanpour *et al.* (2015, 2016) described the developmental osteology of the vertebral column and the paired, dorsal and anal fins of fish from Sijval Restocking Center, Bandar-e Torkeman. Zakeri Nasab *et al.* (2018) described the morphology and histology of the gut and accessory glands. Mazaheri Kouhanestani *et al.* (2020) gave a description of the larval stage from southeastern waters of the Caspian Sea. Eagderi *et al.* (2021) outlined the

development of the eye during early ontogeny.

Meristic values for Iranian specimens are:- dorsal fin branched rays 9(22) or 10(18), anal fin branched rays 9(16), 10(23) or 11(1), pectoral fin branched rays 14(1), 15(4), 16(22), 17(12) or 18(1), pelvic fin branched rays 7(4), 8(33) or 9(3), lateral line scales 40(1), 41(4), 42(16), 43(11), 44(5) or 45(3), total gill rakers 11(4), 12(15), 13(18) or 14(3), pharyngeal teeth 6-5(22), 6-6(1), 6-4(1) or 5-5(1), and total vertebrae 37(1), 38(-), 39(2), 40(9), 41(64) or 42(19).

**Sexual dimorphism.** Tuberculation of mature fish is figured above in a line drawing. In four males caught on 26 April 1962 (150.7-170.3 mm standard length, CMNFI 1980-0905), moderate-sized tubercles were evenly distributed over the top and sides of the head, with fewer tubercles on the undersurface. Scales bore one strong tubercle in the exposed mid-scale, anterior and dorsal scales had smaller tubercles on the scale margin and belly scales had minute tubercles on the margin and exposed scale base. Fine tubercles followed the branching fin rays in single file on all fins, both dorsally and ventrally on the pectoral and pelvic fins, and in 1-2 rows on the last unbranched ray of each fin. Some fish had some scales with 1-3 tubercles, usually 2, one above the other. When there were three tubercles these were variably arranged, e.g., in an L-shape or a reversed L. Females also bore tubercles on the head and scales but these were less well-developed and were not present on fins.

Ghojoghi *et al.* (2014a) found dimorphism in morphometry within Aras River and Anzali Wetland fish, but not Bandar-e Torkeman fish, with females having a deeper body and lower anterior position of the snout and, for Aras fish, a smaller female head.

**Colour.** Overall colour is silvery. The back is grey and the sides of the head golden. The belly is pearly-white. The iris is silvery with a black spot above the pupil, some gold on the upper part, and may be orange to red. Pectoral, pelvic and anal fins are light grey with a darker band on the edge. The middle of the pelvic and anal fins may be transparent, orange to pink, or red. The peritoneum is silvery with moderately dispersed but evident melanophores.

**Size.** Attains 56.0 cm and 3.13 kg. Larger fish may be hybrids with *Rutilus kutum*. In Iran during the 1950s, catches were 16-35 cm long (Farid-Pak, No date).

**Distribution.** Found from drainages of the Aegean Sea and Atlantic Ocean to the Black-Azov, Caspian and Aral seas, inland waters of Central Asia, and the Arctic Ocean as *R. lacustris*. For the taxon *R. rutilus*, should it be present in Iran, the distribution is from the British Isles and France eastwards to the Volga River basin and the Caspian and White Sea drainages, north of the Alps.

Abdoli (2000) and Abdoli and Naderi (2009) have natio *knipowitschi* (see above for taxonomy) in Gorgan Bay and the neighbouring Caspian coast and in the Atrak, Gorgan and Qareh Su rivers, and natio *kurensis* in the lower Sefid River, Anzali Talab and neighbouring Caspian coast to Astara and the middle Aras River.

This species is found in the Aras, Astara, Atrak, Babol, Behambar, Fereydun Kenar, Ghorichay, Ghotor, Goharbaran, Golshan, Gorgan, Haraz, Langarud, Larim, Nahang, Pir Bazar, Qareh Su, Rasteh, Sefid, Shafa, Shah, Shalman, Shesh Deh, Siah, Siah Darvishan, Tajan, Talar and Zangbar rivers, Ajigol, Alma-gol (= Ulmogol), Amirkelayeh, Boojagh Kiashahr, Gomishan and Miankaleh wetlands, the Anzali Talab and its mouth and tributaries, the Siahkeshim Protected Region, the Astara Talab, Gorgan Bay, Lake Amirkelayeh, the Alborz and Aras dams, and along the whole Caspian Sea coast (Nedoshivin and Iljin, 1929; Berg, 1948-1949; Kozhin, 1957; *Iranian Fisheries Research and Training Organization Newsletter*, 9:5, 1995; Riazi, 1996; Karimpour, 1998; Abbasi *et al.*, 1999, 2017; Kiabi *et al.*, 1999; Youssefi *et al.*, 2005; Khara *et al.*, 2006a, 2008; Masoumian, 2007; Banagar *et al.*, 2008; Piri *et al.*, 2009; Tatina *et al.*, 2009;

Alipour *et al.*, 2015; Levin *et al.*, 2017; Nouroozikoh *et al.*, 2017). Rasouli *et al.* (2011) reported it from Marmisho Lake, west of Urmia.

Tavakol *et al.* (2015) recorded *Rutilus rutilus (sic)* in the Mahabad Dam of the Lake Urmia basin which could be a misidentification or an introduction.

*Rutilus rutilus aralensis* Berg, 1916 (Levin *et al.* (2017) placed this taxon in their *R. lacustris*) is reported from the Karakum Canal and Kopetdag Reservoir in Turkmenistan (Shakirov and Sukhanova, 1994; Sal'nikov, 1995) and may eventually be found in the Tedzhen (= Hari) River basin of Iran.

**Zoogeography.** This species is a member of the Ponto-Caspian clade as defined by Levin *et al.* (2017) with a wide European and Asian distribution. Their molecular data indicated an intricate phylogeographic history with multiple refugia within the Ponto-Caspian region.

**Habitat.** Berg (1948-1949) gave an extensive account of the biology of this species in the North Caspian Sea and Volga River and there have been numerous studies since not reviewed here. This is a eurytopic species, living in rivers, streams, lakes, dams, lagoons, ponds, marshes and fresher parts of seas. It occurs in schools close to vegetation in fresh waters.

It gathered in front of the Volga River delta in the north of the Caspian Sea in large shoals in autumn when water levels decreased. At water temperatures of 5°C they descended to the sea floor and “lie in winter sleep” (Holčík and Skořepa, 1971). It is not known if this occurs off the warmer Iranian shore. Generally, the vobla lives in the sea itself and migrates to rivers for spawning. Although most spawning took place in fresh water, some occurred at a salinity of 6.5‰. This species was the most tolerant of the semi-anadromous fishes, the lethal salinity level being 15-16‰. In the north Caspian Sea, this fish was found mostly shallower than 7.5 m but Knipovich (1921) reported this species at 36.6-53.0 m in the Iranian Caspian Sea.

A mass migration of the Kura vobla (*natio kurensis*) into the Anzali Talab occurred between 21 and 28 February 1915, only to disappear after 4 April. Riazi (1996) reported that this species migrated into the Siahkeshim Protected Region of the Anzali Talab. Males migrated into the Anzali and Gomishan wetlands of Iran earlier than females and the larger fish entered first (Naddafi *et al.*, 2005).

*Natio knipowitschi* lives in the sea in Gorgan and Gasan-kuli bays and enters rivers there. Savenkova (1985) reported as many as 2,000 million juveniles descending the Atrak River in May and June in high productivity years and as few as 83 million in low productivity years. The sea in July and August was as warm as 28-30°C off the Iran-Turkmenistan border and the juvenile fish from the Atrak descended to 11-12 m. They fed in the sea at depths of 4.0-8.5 m and wintered in Iranian waters (Savenkova, 1985). Savenkova (1994) gave further details of movements in relation to temperature, e.g., when waters cooled to 8-12°C off Turkmenistan, young fish moved to warmer Iranian waters to overwinter. It has been caught at 32°C in the Sefid River estuary in marine water on 9 July 1962 (CMNFI 1970-0565). ERM-Lahmeyer International GmbH, DHI Water & Environment and GOPA Consultants (2001a) reported that the Gomishan Lagoon at 37°11'N, 53°57'E is an important staging area for this species.



Habitat of *Rutilus lacustris*, CMNFI 1979-0477, Golestan, Bandar-e Torkeman, 5 July 1978, Brian W. Coad.

**Age and growth.** Generally, growth is a function of type of feeding (a diet favouring molluscs gave higher growth than herbivory) and temperature. High growth rate was shown by semi-migratory fish but was also shared by some populations resident in lakes and rivers. Kas'yanov *et al.* (1995) reviewed the complex relationships of environmental factors affecting growth in this species.

A life span up to 19 years has been reported although most fish were 10 years or less. Growth was fastest in the second and third years of life when most fish matured sexually (Strubalina and Chernyavskiy, 1992).

Some fish matured at 1 year of age and a length of 9-11 cm in the Atrak River population (Petr, 1987). Growth in the Atrak population juveniles was heavily dependent on temperature regimes in the sea, the timing of descent to it, and stock abundance. Fish which descended earlier because of low flow and had a longer feeding season, found a favourable, warm regime and few competitors would have faster growth (Savenkova, 1994).

Young-of-the-year Turkmen fish reached 4.9-5.8 cm in July while in the northern Caspian they only attained 3.3-4.1 cm, although the latter had a higher condition factor, possibly because of higher benthic biomass and heterogeneity (Savenkova, 1994). The dwarf form in Dagestan was 11 cm and 31 g at 3 years of age while the large form was 20.3 cm and 130 g. Both were sexually mature (Shikhshabekov, 1969).

The commercial catch in Iran during 1971/72 was 3-6 years old, 20.4-26.0 cm long and weighed 146-300 g (Razivi *et al.*, 1972). The average weight in 1995 was 200-300 g (Abzeeyan, Tehran, 5(9):V, 1995).

In Gorgan Bay, the age composition was from 1<sup>+</sup> to 6<sup>+</sup> with age group 3<sup>+</sup> and 4<sup>+</sup> each accounting for about 30% (Berg, 1948-1949). Growth rate for all south Caspian populations was higher than the north Caspian populations, two-year-olds being the same length as three-year-

olds. Average weight was 247 g with larger fish at 30 cm weighing 583 g. Numerous fish entered Gorgan Bay in mid-January in the early years of this century and by the end of that month ascended all the tributary rivers, in particular the Qareh Su (= Karasu).

Growth rate in the Anzali Talab was higher than in the Gomishan Wetland of the southeastern Caspian Sea, limited by higher salinity in the latter (Naddafi *et al.*, 2002a, 2002b, 2005; Paghe *et al.*, 2005). The population density was higher in Gomishan as Anzali suffers more from pollution, overfishing, illegal fishing and other human impacts. Mean condition factors for the Gomishan population were 1.84 for males and 2.09 for females while in the Anzali population these were 2.03 and 2.2 respectively. The most abundant age groups in the commercial fishery of both areas were 3<sup>+</sup>, 4<sup>+</sup> and 5<sup>+</sup>. Maximum age at Gomishan was 8<sup>+</sup> years. Growth was rapid in the first year with a sharp decline in the second year and a steady, less rapid decline in subsequent years. Females were longer than males at in each age class. Sex ratios did not differ significantly from 1:1. The Anzali population had longer body lengths than fish from other studies, perhaps due to a longer growing season and higher water temperatures in the south Caspian Sea, better food supply and genetic factors.

Sedaghat and Hoseini (2012a) found southern Caspian Sea fish to have an age to 6 years with two-year-olds most frequent. The length-weight relationship showed positive allometric growth and was  $W = 0.0065FL^{3.30}$ . Abbasi *et al.* (2017) examined 232 fish from Gilan coasts in 2011-2013 and found fork lengths 105-230 (mean 159.5) mm, body weight 17.2-201.2 (mean 65.0) g and age 1-4 years, condition factor was 1.11, growth was positive allometric, and females constituted 60.3% of all fish. Overfishing was noted as a problem requiring stock management.

Mohammad Nejad Shamoushaki *et al.* (2013) analysed the catch from 1999 to 2008 in Golestan Province from 20 active seine cooperatives. The catch in the west (Miankaleh) was not significantly different from that in the east (Gomishan). Catches declined over the period studied and the catch ratio was carp>mullet>kutum>roach at 39.23, 33.76, 26.54 and 0.47%.

Bandani (2016) examined samples caught in beach seines in Iranian waters. The fork length and total weight ranged from 12.5 to 29.5 cm and 29.0 to 293 g and 10.5 to 23 cm and 17.2 to 21.0 g in Golestan and Gilan Provinces, respectively. The *b* value of the length-weight relationship ranged 3.02 to 3.25 and 3.28 to 3.75 for females and males, in Golestan and Gilan Provinces, respectively. The age composition of the catch was from 1 to 4 years in both provinces. Average growth in length was described with the von Bertalanffy growth model,  $L(t) = 30.94(1 - \exp(0.42(t-0.18)))$  and  $L(t) = 20.49(1 - \exp(0.53(t-1)))$ , respectively by province. Bandani (2016) examined samples taken from beach seine catches and at fish markets. The age composition was 1 to 4 years and most of the catch was in the length range of 18 to 20 cm. Growth parameters were  $L_{\infty} = 32.39$  cm and  $K = 1.24$ /year, total mortality, natural mortality rate, fishing mortality and growth performance index were 1.09/year, 0.26/year, 0.4 and 2.54, respectively. The biomass and maximum sustainable yield were estimated at 368.9 t and 32.7 t. Bandani *et al.* (2018) gave growth and mortality parameters for the southern Caspian Sea but there is confusion in values between Farsi and English abstracts.

Taghavi Jolodar and Amiri Sahebi (2016) examined 160 fish from Sari and Torkeman ports and reported the mean age, body weight and fork length for Sari and Torkeman were 2.8 and 2.4 years, 117.67 and 76.73 g, and 18.56 and 16.5 cm. There was a significant correlation between age, weight and length. The male:female sex ratio was 1:1.5 in Sari and 1.7:1 in Torkeman fish, significantly different. Mean condition factors were 1.24 in Sari and 1.12 in Torkeman fish.

Dordi Tatr *et al.* (2018) and Tatar *et al.* (2018) examined 246 fish from cooperative beach

seines in the southeastern Caspian Sea and found fork lengths 14.5-32.1 cm, weights 70.7-437.0 g, an age range of 3-10 years, the von Bertalanffy equation was  $L_t = 41.8[1 - e^{-0.12(t+0.766)}]$ , the length-weight relationship was isometric,  $W = 0.0208FL^{2.9184}$  for females and  $W = 0.0138FL^{3.0244}$  for males, total mortality (Z), natural and fishing coefficients (M, F) and exploitation rate (E) were 1.239, 0.324, 0.916/year and 0.74 respectively, fish biomass was 417 kg, maximum sustainable yield was 215 kg and the ration of cooperative companies was 28 kg. The stocks were severely exposed to overfishing and conservation is needed.

Rahnama *et al.* (2019) studied 384 specimens from coastal waters of Golestan Province caught by gillnet and beach seine from April 2015 to March 2016. The smallest and largest fish were at 14 and 26 cm and the minimum and maximum weights were 28 and 246 g. The  $b$  value for males and females was 3.012 and 3.205 respectively.  $W_\infty$  was estimated about 216.466 g in males and 259.77 g in females. The natural and fishing mortality rates in both males and females were 1.13, 0.401 and 0.84, 0.673 per year. The utilization factor was  $\Phi' = 0.26$  and 0.43 in males and females. The growth performance index was estimated at 2.57 for males and 2.48 for females. The age groups were from one to four years old, the most frequent being one to two plus years old.

Kor *et al.* (2020) reported on broodstocks collected from the Gorgan River estuary over five years from 2014 to 2018 during February-March for semi-natural propagation. Total length and weight of the broodstocks ranged from 21.0 to 32.5 cm and from 45.6 to 423.5 g, respectively. The largest mean value of lengths and weights were observed in 2014, and the smallest in 2018. The age of broodstocks ranged between 3<sup>+</sup> and 9<sup>+</sup> years. The abundance of ages and sexes differed between years. Females had positive allometry in all years, while males ranged from 2.65 to 3.05, indicating mainly negative allometric growth. Different instantaneous growth rates were observed over the five years, indicating the presence of strong and/or weak ages and/or cohorts in the populations. The condition factors of females were larger than that of males in all periods. The results showed that  $L_\infty$  of males ranged from 26.49 to 38.53 cm, and that of females from 32.45 to 41.97 cm, the K-coefficient ranged between 0.12 and 0.24/year for males and between 0.11 to 0.21/year for females, and  $t_0$  of males ranged from -0.21 to -0.34 (year), and that of females from -0.39 to -0.99 (year).

Jableh *et al.* (2016) compared 587 wild, farmed and mixed populations of fingerlings from a fish farm and found  $b$  values of 2.58, 2.505 and 2.45 respectively and condition factors of 0.9, 0.832 and 0.842 respectively. Growth parameters of wild fish were better than farmed and mixed populations.

**Food.** The young feed first on phytoplankton and then switch to zooplankton and benthic insect larvae with growth. Adults eat benthic animals and plants with molluscs an important diet item where present as in the southern Caspian Sea. A mollusc diet occasioned significant wear on the pharyngeal teeth (Holčík and Skořepa, 1971). Moharamifard *et al.* (2015) found nereids and gammarids were important diet items on the Mazandaran coast. There has been a long-term variation in the diet of roach in the Caspian Sea, molluscs declining and being replaced by crustaceans and plants (Strubalina and Chernyavskiy, 1992). There was little feeding during spawning in rivers. Young-of-the-year in the Atrak delta fed on the polychaete worm *Nereis* (up to 89.5%) and with growth the mollusc *Cerastoderma lamarckii* (up to 70.8%), and to a lesser extent the exotic mollusc *Abra ovata* (5.2%) since this abundant species was partially buried and was not readily available. Polychaetes and molluscs had high biomasses in the silty sediments of around 30-50 g/sq m. Sometimes protozoans and crustaceans figured prominently in the summer diet but diet varied considerably between months and years (Savenkova, 1994). Abbasi *et al.*

(2017) examined 232 fish from Gilan coasts and calculated a coefficient of vacuity of 30.6%, a relative length of gut 0.96 and an intensity of fullness 199.0. There were more than 15 food items with polychaete worms and mollusks dominant. Bandani (2016) for Golestan and Gilan fish found that gastropods, polychaetes, worms and molluscs dominated. Shrimps, fishes, insects, zooplankton and clams were scarce prey.

**Reproduction.** A spawning migration runs up rivers in the Caspian Sea basin in spring, the larger fish first. The main spawning rivers in Iran are the Qareh Su, Goharbaran, Larim, Siah-Darvishan and Shafa rivers (*Iranian Fisheries Research and Training Organization Newsletter*, 9:5, 1995). Spawning grounds are mostly flooded meadows that warm up easily (Caspian Sea Biodiversity Database, [www.caspianenvironment.org](http://www.caspianenvironment.org)). Immature fish only migrated in autumn after their gonads had matured, spending the summer in deeper water. The fish return to the sea after spawning in the same sequence as the upriver migration. Young remain in the river until early summer when they too go down to the sea. However, some populations of this species were exclusively freshwater and did not migrate.

Spawning is continuous and takes about 5-6 hours. Fecundity reaches about 202,000 eggs and egg diameters 1.6 mm. In the Volga delta, this species spawned in the same areas as *Abramis brama*. However, it spawned earlier at temperatures of 7-16°C on last year's dead vegetation while the bream spawned later at 15-23°C on new growth. Spawning can occur on stony bottoms in the absence of vegetation. Spawning is a noisy process which can be heard from some distance. Each female is accompanied by 2-3 males who push on her belly, sometimes lifting her part way out of the water, as they swim in circles. With many fish engaged in this process, the water foams. The fish gradually approach the shore where the eggs are shed in water only 5-20 cm deep as the female is squeezed by two males. Other males take part in the process, as many as 10 at a time. Incubation takes four days at 17-20°C. Young actively move downstream once they reach 20-25 mm.

The breeding migration in the Atrak River started in January-February and continued until April, the fish traveling 70-80 km upriver (Petr, 1987). Nümann (1969) stated that the spawning migration took place from November to December in Iranian waters. The migration in the Atrak peaked at 10-12°C and lasted 20-25 days. Spawning peaked at 15-18°C in March on the lower Atrak floodplains (in 1908 spawning in the lower Atrak was observed in mid-April). In the absence of flooding, no spawning occurred. After spawning, females migrated back to the sea first. In the Qareh Su of Gorgan Bay, spawning took place 20-25 km upriver from the mouth in 1907 and 1908. It started in mid-February, peaked in the second half of February and the first half of March, and ended between 20 and 30 March. Males with running milt first appeared between 14 and 20 February in 1915 and ripe females a week later. Mass spawning took place at the beginning of March (Nedoshivin and Iljin, 1929).

Adeli Mosabbab and Piri (2005) reported spawning in Iranian rivers from the end of March to the middle of April, beginning at 10°C. A large female, 60 cm long, 3.24 kg and 7 years old contained 124,712 eggs but some large females may have over 250,000 eggs.

Fecundity in the Gomishan Wetland (4,262-98,804 eggs) was significantly higher than in the Anzali Talab (6,035-32,141) for a given body size. Egg diameters ranged from 0.9 to 1.45 mm and were not significantly different between the two wetlands. The peaks for the gonadosomatic index (GSI) curves were early March for males and mid-March to early April for females. The GSI was higher in Gomishan (Naddafi *et al.*, 2005). Akhoundian *et al.* (2016) gave details of ovarian development of fish from the Qareh Su River near Bandar-e Torkeman and also found a spawning period from late March or early April till the end of April based on

gonadosomatic indices. This species was found to be an iteroparous synchronous spawner. Bandani (2016) for Golestan and Gilan fish noted there was one spawning peak and fecundity variations were high and ranged from 7,260 to 231,965 eggs.

Başkurt *et al.* (2015) compared a Turkish population of *R. rutilus* with *R. rutilus caspicus* (*sic*) (= *R. lacustris*) noting the slow growth rates in the Anzali and Gomishan wetlands and fast growth in the Caspian Sea, ruling out taxon-specific differences in growth rates. However, these may well be different taxa in Iran.

Abbasi *et al.* (2017) examined 232 fish from Gilan coasts and found length at maturity in 50% of males and females was 151 and 155 mm fork length respectively, and spawning took place in March and April. Akhoundian and Movahedinia (2017) studied histomorphometric indices in oocytes and found seven stages of gonadal development, the first phase starting in October and vitellogenesis and maturation of oocytes continuing from February to April. This species has group synchronous gonads and spawning occurs after a reproductive migration to the southeast rivers of the Caspian Sea.

**Parasites and predators.** Mokhayer (1976b) recorded the cestode larva *Diagramma*. Jalali and Molnár (1990a) reported the monogenean *Dactylogyryrus turaliensis* from this species in the Sefid River. Masoumian *et al.* (2002) recorded parasites from fish captured from the coast of the southeast Caspian Sea as *Anisakis* larvae, *Aspidogaster limacoides*, *Bothriocephalus gowkongensis*, *Dactylogyryrus turaliensis* and *Diplostomum spathaceum*. Youssefi *et al.* (2005) found the plerocercoid larvae of *Ligula intestinalis* in fish from the Aras Dam. A toxin produced by this parasite could cause infertility and weight loss in the fish and could be harmful to humans. Khara *et al.* (2006a) recorded the eye fluke *Diplostomum spathaceum* for this fish in the Amirkelayeh Wetland in Gilan, having the highest infection rate in seven species examined and . Masoumian (2007) reported the parasite *Diplozoon megan* from fish in the Aras, Ghotor and Zangbar rivers in West Azarbayjan. Barzegar *et al.* (2008) recorded the digenean eye parasite *Diplostomum spathaceum*. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea* sp. on this species.

Khara *et al.* (2006b) recorded the cestode *Caryophyllaeus fimbriceps* from fish in the Boojagh Wetland of the Gilan coast and Khara *et al.* (2008) found the eye parasite *Diplostomum spathaceum* in fish from Boojagh. Tatina *et al.* (2009) found fish from the Boojagh Wetland contained *Caryophyllaeus fimbriceps*, *Diplostomum spathaceum*, *Piscicola* sp. and *Lernaea* sp. Khara *et al.* (2011) also listed the digenean *Diplostomum spathaceum*, the cestode *Caryophyllaeus fimbriceps* (but see Barčák *et al.* (2017) who indicated this needs confirmation), the crustacean *Lernaea cyprinacea* and the leech *Piscicola* sp. Boojagh fish.

Rasouli *et al.* (2011) found the crustacean *Argulus foliaceus* on fish from Marmisho Lake west of Urmia. Rasouli (2013) reported the digenean *Diplostomum spathaceum* in fish from Caspian drainages in West Azarbayjan. This parasite causes secondary infections as the metacercariae penetrate the skin and eye, lesions, appetite loss, blurry vision and reduced feeding. Tavakol *et al.* (2015) reviewed the acanthocephalan fauna of Iran and noted *Pallisentis cholodkowskyi* from *Rutilus rutilus* (possibly *R. lacustris*) in Mahabad Dam (*sic*). Nouroozikoh *et al.* (2017, 2017) surveyed infestation of fish with *Eustrongylides excisus* and *Ligula intestinalis* in Alborz Dam in Mazandaran, finding a high prevalence for these economically important parasites.

The main predator of this species in the north Caspian Sea is *Sander lucioperca* (pike-perch), accounting for 65% of its food. *Silurus glanis* (European catfish) and *Esox lucius* (northern pike) and various birds such as the pelican are also important predators (Kushnarenko,

1978). Khaleghizadeh and Sehhatisabet (2006) noted that great grebes (*Podiceps cristatus*) and pygmy cormorant (*Phalacrocorax* (= *Microcarbo*) *pygmaeus*) ate this species in Gilan. The Caspian seal, *Pusa caspica*, was a significant predator on this species (Krylov, 1984). On the spawning grounds, this fish could be picked up by hand and fell easy prey to birds and other predators. Ashoori *et al.* (2017a) recorded this species as an occasional item in the diet of young black-crowned night herons (*Nycticorax nycticorax*) in the Anzali Wetland.

**Economic importance.** This species is one of the most important commercial species in the Caspian Sea with a catch in the north Caspian and lower reaches of rivers in 1930 being 2,591,000 centners (15,000,000,000 fish) or 45.5% of the total catch of fishes in the Caspian Sea or nearly 20% of the whole Soviet fish catch. Archaeological studies on the eastern Caspian shore in the former Soviet Union have shown this species to have been fished for 5,000 years ago (Tsepkin, 1986). It is a significant food for the sturgeon *Huso huso* (Keyvanshokoo and Kalbassi, 2006).

The main fishing season in Iran is February and March (Farid-Pak, No date). Nevraev (1929) gave catches for various fishing regions in Iran in the early twentieth century. For the Anzali region from 1914-1915 to 1917-1918 the catch was 6,000 to 244,800 individuals (the catch declining steadily over this period), and in the Astrabad (= Gorgan) region from 1909-1910 to 1912-1913 the catch was 8,348,800 to 21,790,000 individuals. The catch in Iran from 1956/1957 to 1961/1962 varied from 2,989 kg to 1,092,719 kg (Vladykov, 1964), from 1965/66 to 1968/69 it varied from 32 to 74 tonnes (36, 74, 32 and 35 t respectively) (Andersskog, 1970) and from 1963 to 1967 from 2.4 to 47.0 t (23.1, 2.4, 3.7, 30.7, 47.0 t respectively) (RaLonde and Walczak, 1970b). Vladykov (1964) reported catches from the Anzali region for the period 1933/1934 to 1961/1962 to vary from 57 to 716,974 kg, with none reported in some years. Holčík and Oláh (1992) reported an annual catch in the Anzali Talab from 1932-1964 of 0.8-449.7 t. The total catch in 1989 (or 1990) was only 26 t but increased to 120 t in 1995 because of the rising Caspian Sea level which provided more spawning grounds (*Abzeeyan*, Tehran, 5(9):V, 1995; *Iranian Fisheries Research and Training Organization Newsletter*, 9:5, 1995). Conflicting values from reports where they overlap are typical of fisheries statistics from Iran which can only be taken as general trends rather than absolute values. The Food and Agriculture Organization, Rome gave the catch for *Rutilus* spp., presumably this species, for the years 1980-1985 as 0, 0, 0, 121, 347, and 350 t respectively. The catch in Gorgan Bay 20-30 years ago according to Petr (1987) was about 4,000 tonnes per year but was negligible at the time of this report. In the 1914-1915 fishing season in Gorgan (= Astrabad) Bay, 24.2 million fish were taken, of which 21.9 million were taken in the Qareh Su. Petr (1987) cited catches of 830 t in 1978 for the southeastern Caspian Sea and for 1979 only 120 t, probably including Soviet catches. Recruitment fell when the Atrak River, a major spawning ground, failed to flood adequately.

The dwarf form in Dagestan was of no commercial value and may have arisen with changing environmental conditions (Shikhshabekov, 1969).

Adeli and Namdar (2015) suggested the eggs of this species (as *Leuciscus rutilus*) as a substitute for sturgeon caviar.

**Experimental studies.** There have been relatively few experimental studies on this species in Iran compared to its congener. These are summarised by headings although not all study areas have been covered in publications. The species name used in most of these papers (*q.v.*) is *Rutilus rutilus*, *Rutilus rutilus caspicus*, *Rutilus caspicus* or even *Rutilus rutilus caspicus knipowitschi*, all assumed here to be *R. lacustris* (as noted in **Systematics** above).

*Pollution:-*

Anan *et al.* (2005) measured concentrations of 13 trace elements (Ag, Cd, Cr, Co, Cu, Hg, Mn, Mo, Pb, Se, Tl, V and Zn) in muscle of bony fishes collected from coastal areas of the Caspian Sea (Kazakhstan, Azerbaijan, Turkmenistan and Iran). Caspian roach were collected from five stations in Iranian coastal waters and the concentrations of Ag, Cd, Co, Mo and Tl were higher in fishes from western stations than those from eastern stations, whereas the opposite trend was observed for Hg, indicating that local sources of trace metal pollution may be present in the Iranian coastal areas of the Caspian Sea. Gerve'ei *et al.* (2008) determined that aluminium sulphate had an LC<sub>50</sub> 96h of 0.725 mg/l and caused gill tissue lesions. Mohammadzadeh Shamoushaki *et al.* (2009) showed the LC<sub>50</sub> 96 h for the insecticide endosulfan was 0.00053 mg/l, above the maximum allowable concentration at 0.000053 mg/l.

Abasi and Mohammadzadeh Baran (2010) exposed 5.0 cm long fish to mercury chloride at graded sublethal concentrations (10, 30, 50 µg Hg/l) and observed histopathological changes, such as telangiectasis (capillary dilation) and degeneration, in the ovary. Keramati *et al.* (2010) studied the effect of the agricultural organophosphate diazinon on enzyme activity. Mohammad Nejad Shamoushaki *et al.* (2010) found the lethal concentration (LC<sub>50</sub> 96 h) of the herbicide roundup (glyphosate) used in agriculture was 7,728 mg/l. Mohammadzadeh *et al.* (2011) examined the effects of lead on liver and gill tissues finding various damage which increased with dosage. Sheikh *et al.* (2011) found an LC<sub>50</sub> 96 h of 7.88 mg/l for diazinon which was classified as a toxic pesticide for this species of fish. Deformities, irregular behaviour and changes in haematocrit were observed. Gharedaashi *et al.* (2012) showed that copper was more toxic to fingerlings than lead. Hoseini and Nodeh (2012) found levels of copper and mercury in fry were less than in Caspian Sea water. Khosravi Katuli *et al.* (2012, 2012) examined the negative effects of the pesticide diazinon on gill histology and osmoregulation. Gill tissues were damaged and osmoregulatory capacity was reduced in both river and sea environments, and this may adversely affect later migratory capacity. Alipour *et al.* (2013) measured heavy metals (cadmium, chromium, lead, nickel) in pelagic fish from the Miankaleh Wetland finding levels lower than in the benthic goby *Neogobius gorlap* and liver and gill tissue had higher levels than muscle. Sharifian *et al.* (2013) found sublethal concentrations of nanosilver caused gill tissue damage to fingerlings and this damage could be used as an indicator of environmental contamination. Farokhi (2014) examined the deleterious effects of the insecticide malathion on haematological and biochemical parameters and on DNA. The LC<sub>50</sub> value was 6.5 p.p.m. Farokhi *et al.* (2014) studied the effect of increased and prolonged exposure to the insecticide malathion and found a reduction in such haematological parameters as red and white blood cell counts and haematocrit and haemoglobin levels. Hedayati *et al.* (2014) found the LC<sub>50</sub> 96 h for manganese was 300 mg/l and all concentrations (60-300 mg/l) showed decreased plasma alternative complement and lysozyme activity, significant increases were found in whole body superoxide dismutase, catalase and malondialdehyde, and there was a lower tolerance to saltwater. Mohamadzadeh and Gamili (2014) found lead affected gill and liver tissues of fingerlings, at 0.1 mg/l minimum tissue damage was observed, but with increasing time in 0.2 and 0.4 mg/l maximum tissue injuries were found. Soltani *et al.* (2014) demonstrated that concentrations of heavy metals (cadmium, copper, lead) in edible tissue of fish from Babol Sar and Tonekabon were safe for consumers.

Mazandarani *et al.* (2015, 2016) examined susceptibility to sublethal exposure to ammonia, which accumulates in earthen ponds used in aquaculture, finding 0.2 mg/l did not lead to mortality but was harmful for growth and haematological indices, and 0.162 mg/l was the maximum sublethal concentration for fingerlings. Raeisi *et al.* (2015) determined that cadmium

and lead heavy metals were highly toxic in muscle with lead showing higher toxicity in terms of nutritional parameters and antioxidant enzyme activity. Alipour *et al.* (2016) determined the levels of arsenic, copper, iron and zinc in fish from the Miankaleh Wetland, where liver levels were higher than in gill and muscle tissues, iron was higher than other metals, and arsenic levels were above the permissible limit for human consumption. Farokhi *et al.* (2016, 2016) found a wide range of liver and gill tissue damage and effects on enzymes in fish exposed to the insecticide malathion, the damage increasing with time and higher concentrations. The LC<sub>50</sub> was 6.5 p.p.m. Hedayati (2016) found cadmium was toxic to this species with an LC<sub>50</sub> of 5.26 p.p.m., lower than in silver carp, *Hypophthalmichthys molitrix*, at 6.58 p.p.m. Hedayati *et al.* (2016) showed that increasing sub-lethal levels of the insecticide diazinon caused increasing gill tissue lesions and Hedayati *et al.* (2016) measured the LC<sub>50</sub> 96 h of diazinon at 1.71 mg/l, less resistant than silver carp at 3.93 mg/l. Hedayati *et al.* (2016) found that lead had negative effects on blood biochemistry, immune factors and such biochemical factors as glucose and cortisol, and could result in death. Khosravi Katuli (2016) noted the presence of azinophos methyl and diazinon in the Gorgan and Qareh Su rivers of Golestan and found experimentally that sub-lethal concentrations matching those in the wild led to adverse effects on a wide range of haematological parameters. Pourkhabbaz *et al.* (2016) found LC<sub>50</sub> 96 h values for copper sulphate on fingerlings were 2.25 mg/l and mortality decreased with time and most deaths were in the first 24 hours. Daneshian *et al.* (2017) found that the LC<sub>50</sub> 96 h was 20.01 and 31.39 mg/l for arsenic and cadmium respectively, considered as moderate sensitivity. Forouhar Vajargah and Hedayati (2017) found an LC<sub>50</sub> 96 h of 0.342 p.p.m. for butachlor in fingerlings (and 0.76 p.p.m. in *Sander lucioperca* (pike-perch)). These findings suggested that this herbicide is moderately toxic and moderately irritating with clinical symptoms including protrusion of the eyes and irregular swimming. The roach was more sensitive than the pikeperch. Oveysi *et al.* (2017) analysed the vitellogenin gene structure during exposure to the endocrine disruptor pesticide atrazine. Vitellogenin expression is used to assess exposure to endocrine disruptors in the environment. Aghamirkarimi *et al.* (2018) showed that copper nanoparticles could cause a decrease in antioxidant enzyme activity, cause severe damage to liver tissue, and result in death. Bahrani *et al.* (2018) calculated the acute toxicity of the chemicals pretilachlor and paracin to be 43.22 mg/l and 222.2 mg/l, respectively, in juveniles. Karimzadeh *et al.* (2018) investigated the toxic effects of zinc oxide nanoparticles on the oxidative stress enzymes in brain tissue over seven days and found an induction of free radical and oxidative stress. Khosravikatuli *et al.* (2018) exposed juveniles to sub-lethal levels of diazinon for 14 days and found the activated antioxidant condition returned to its natural state after a recovery period of 10 days. Mohammad Nejad Shamoushaki and Shahkar (2018) determined the LC<sub>50</sub> 96 h for the insecticides chlorpyrifos and diazinon was 0.016 and 12.81 mg/l in fingerlings. Mohammadzadeh Baran *et al.* (2018) found that methyl tert-butyl ether, an octane booster used to increase oxygen levels in gasoline and a pollutant, caused extensive and varied tissue damage to gills, kidneys and liver and could eventually cause death. Mohammadzadeh Baran *et al.* (2019a) showed that methyl tert-butyl ether degraded the DNA of blood cells. Mohammadzadeh Baran *et al.* (2019b) examined the effects of methyl tert-butyl ether on enzyme activity. The antioxidant enzymes superoxide dismutase and catalase showed increased activity with increase in the octane booster levels, acting as a defense mechanism. Zolfaghari (2018) found mercury concentrations in muscle tissue of fish from the Anzali Wetland were lower than World Health Organization limits. Tajari *et al.* (2019) found that exposure to sublethal doses of the insecticide endosulfan stimulated the non-specific immune system.

Zahmatkesh *et al.* (2020) investigated the dietary use selenium nanoparticles (1 mg/kg) and chitosan oligosaccharide (600 mg/kg) against malathion-induced blood haematological and biochemical alterations, finding positive effects. Etefaghdoost and Alaf Noveirian (2020b) measured the concentration of eleven heavy elements (As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn) in muscle tissue of 25 Caspian roach caught from the Siah Darvishan River, Gilan and found all except five heavy elements were below the standard approved by international organisations (FAO/WHO). The five were, in  $\mu\text{g/g}$  dry weight, nickel ( $0.584 \pm 0.026$ ), arsenic ( $0.764 \pm 0.027$ ), cadmium ( $0.296 \pm 0.024$ ), lead ( $0.817 \pm 0.011$ ) and manganese ( $1.665 \pm 0.166$ ). Hosseinzade *et al.* (2021) reported on the effects of diazinon on the olfactory epithelium and genes related to olfactory signal transduction. Exposure included a significant decrease in the number of olfactory receptor cells, while goblet cells increased. In addition, Gprotein  $\alpha$  was significantly upregulated, whereas calmodulin-dependent kinase II  $\alpha$  was significantly downregulated after seven days as compared to a control group. These results indicated that diazinon can impair olfactory function through an effect on the olfactory epithelium and olfactory signal transduction pathways.

*Diet:-*

Golshahi *et al.* (2009) found exposure to red light for 24 hours/day showed maximum growth in larvae and various other photoperiods showed no significant differences in survival rate.

Pouralimotlagh *et al.* (2010) investigated the replacement of fish oil by sunflower and soybean oil as dietary lipid sources and found these had no significant growth performance and health impacts. Akrami *et al.* (2011) investigated the effect of dietary mannan oligosaccharide on fry and found a positive correlation between growth performance, survival and supplementation level but none for salinity stress survival and body composition. A supplementation level of 2.0 g/kg was recommended for fry diets. Abolfathi *et al.* (2012) demonstrated compensatory growth dependent on duration of food deprivation, this knowledge allowing exploitation for increased growth rate and feeding efficiency in aquaculture. Kordi *et al.* (2012) studied diet supplementation of juveniles with L-carnitine, an amino acid compound, finding it had no effect on growth performance but it affected carcass chemical quality. Mohammad Nejad Shamoushaki (2012) found that an increase in feeding frequency did not affect growth and survival in young cultured fish. Mohammad Nejad Shamoushaki and Mazini (2012a) used probiotic bakery yeast (*Saccharomyces cerevisiae*) to introduce beneficial microflora to the digestive tract and give better growth; feeding in black tanks was more effective for growth too. Soleimani *et al.* (2012) found that fry fed a diet supplemented with prebiotic oligofructose had better growth condition including final weight, specific growth rate and condition factor compared to controls, and also higher resistance to salinity stress and higher survival. Soleimani *et al.* (2012) showed that dietary supplementation with the prebiotic fructo-oligosaccharide improved the innate immune response, stress resistance, digestive enzyme activities and growth performance of fry. Taheri and Aliasghari (2012) found that elongating a starvation period in fry resulted in a decrease in the compensation growth mechanism. Ahmadvand *et al.* (2013) looked at various levels of phosphorus in the diet of larvae in respect to growth and carcass composition, determining that growth performance measures were not enough and bone mineralisation also needed to be determined. Ahmadvand *et al.* (2013b) studied hatchery larvae fed a diet with a low phosphorus content, noting skeletal deformations with kyphosis being the most frequent abnormality. Fatahi and Hoseini (2013) investigated the use of tryptophan and betaine in diets, the latter having no effect while 0.25% tryptophan reduced mortality in fish exposed to copper pollution. Hoseinifar

*et al.* (2013) showed that fry fed galacto-oligosaccharide had improved growth performance, stress resistance, and modulation of intestinal microbiota by increasing lactic acid bacteria. Ahmadifar *et al.* (2014) found that fish oil could be completely replaced with alternative vegetable oils (soybean and sunflower) without seriously affecting growth performance and health of juveniles in aquaculture. Ahmadivand *et al.* (2014) detailed skeletal disorders in larvae, finding the highest incidence in fish with diets low in phosphorus. Akrami *et al.* (2014) fed betafin (extract of sugar beet molasses) to juvenile as a food attractant on growth, survival, body composition and resistance to stress, but there was no significant difference in most parameters and it was not recommended. Roosta *et al.* (2014) determined that fry fed vitamin C showed beneficial effects on the skin mucus immune parameters and on growth performance. Tajdar Nasrabadi and Akrami (2014) showed that 5g/kg of mannan oligosaccharide supplement in the juvenile diet improved growth performance and survival, allowing for cost compared with fructo-oligosaccharide.

Fatahi (2015) examined the effects of different levels of betaine and tryptophan on growth and resistance to salinity stress in juveniles. Tryptophan did not reduce food consumption meaningfully. Increased food consumption as a result of betaine did not show a significant effect on growth rate. At 12 p.p.t. no mortality occurred. At 20 p.p.t. 100% mortality occurred within six hours while with treatment 100% mortality occurred after 24 hours. At 16 p.p.t. the lowest mortality (16.66%) occurred with treatments containing 1% betaine and 0.5% tryptophan while the highest mortality (59.98%) occurred in the control group. Hoseinifar *et al.* (2015) carried out experimental studies on fry fed extract of the scud *Pontogammarus maeoticus*, finding better growth, immune response and resistance to salinity challenges. Roosta *et al.* (2015) found an increase in mucus immunity by means of disease decrease was obtained with vitamin C as an immune stimulant. Salmanian Ghahderijani *et al.* (2015) showed that dietary garlic supplements positively affected skin mucus immune parameters and growth parameters of fry. Shamloofar *et al.* (2015) evaluated the efficiency of the immune stimulant immunogen in young fish but found no advantage in growth and survival. Chitsaz *et al.* (2016) showed that the addition of the synbiotic biomin imbo to the diet of juveniles enhanced growth performance and feed efficiency, increased resistance to salinity stress and survival rate, stimulated beneficial intestinal flora, and immune responses were significantly higher. Ghorbani (2016) evaluated the effects of different dietary levels of protein (30, 35, 40 and 45%), fat (8, 12, 16 and 20%) and total energy (3,500, 4,000, 4,500 and 5,000 kcal/kg) on growth of fingerlings and found 30% protein, 16% fat and total energy 5,000 kcal/kg was suitable. Rufchaie *et al.* (2017) found that dietary administration of *Pontogammarus maeoticus* extract to fingerlings increased immune responses, salinity stress resistance, feed intake and growth performance. Rufchaie *et al.* (2018) evaluated gammarid extracts in the diet of fingerlings and found an increase in feed acceptability, and in various growth parameters and resistance against salinity stress because of suitable amino acid and fatty acid profiles. Rufchaie *et al.* (2017, 2017, 2019) investigated the use of dietary earthworm (*Eisenia fetida*) extracts on the growth performance, immune response and salinity stress resistance of fry and fingerlings and found it to be beneficial. Ghorbani *et al.* (2018) evaluated dietary energy levels (3,500-5,000 kcal/kg and 45% protein) on juveniles and found no effect on weight gain, specific growth rate, obesity coefficient, shelf life, feed conversion ratio and protein efficiency coefficient. Rastegari *et al.* (2018) studied the effect of different levels of peppermint (*Mentha piperita*) powder on growth and immune skin parameters of juveniles, finding gains in body weight and specific growth rate while feed conversion ratio decreased, and skin mucus protein levels and alkaline phosphatase and lysozyme activity

increased. Ghorbani *et al.* (2019) found the highest growth performance in fingerlings when fed a diet with 16% fat. Tarkhani *et al.* (2019) isolated host-associated probiotic lactic acid bacteria from the intestine of adult Caspian roach and compared efficacy with a commercially available probiotic strain (*Pediococcus acidilactici*) on the growth and feed utilisation, digestive enzymes and systemic and mucosal immune system of roach fingerlings. The host-associated probiotic lactic acid bacteria resulted in better immune competence and growth performance, and the aquaculture sector should probably focus on the development of probiotics isolated from cultured species instead of using terrestrial probiotics with greatly different requirements and environmental conditions.

Khanmohammadi Otaghsara *et al.* (2020) investigated the probiotic effects of isolated lactic acid bacteria (*Lactobacillus acidophilus*, *L. brevis* and *L. plantarum*) from kutum guts on *Escherichia coli* and *Pseudomonas aeruginosa*. The most inhibitory effect belonged to *L. acidophilus* on both *E. coli* and *P. aeruginosa*, *L. plantarum* had a moderate inhibitory effect on *P. aeruginosa* and *L. brevis* had no effect on both bacteria. Paknejad *et al.* (2020) concluded that dietary mint powder increased the growth and non-specific immunity of fish. Tarkhani *et al.* (2020) found beneficial effects of dietary supplementation with *Enterococcus faecium* strain CGMCC1.2136 isolated from adult roach on growth performance, proximate body composition, serum innate immune parameters and digestive enzymes activity in fingerlings.

#### *Aquaculture:-*

Malakpour Kolbadinejad *et al.* (2010) examined gradual salinity increase on osmoregulatory functions, conditions which mimicked stocking of hatchery-reared fish. The fish adapted to a wide range of salinities although survival rate at 15‰ was less than the control group. Malakpour Kolbadinezhad *et al.* (2012) found that juveniles used for re-stocking could adapt to a salinity increase after an initial non-lethal iono-osmotic perturbation. Mohammadnejad Shamoushaki *et al.* (2012) found maximum weight and length was better in fingerlings fed in black tanks. Mohammad Nejad Shamoushaki and Mazini (2012b) found the best temperature for growth and survival of fingerlings was 30°C from a studied 26-32°C range. Ahmadvand *et al.* (2013a) studied the stress of stocking density for larvae by examining growth and haematological parameters. Growth performance decreased with increasing density but haematological parameters were unchanged. Optimum stocking density was one larva per litre. Piri (2013) investigated the cultivation of fingerlings in earthen ponds with fresh or brackish water at 10,000, 15,000 or 20,000 fish per hectare, finding generally similar results with some differences in length, weight and condition factor. Egderly *et al.* (2014a, 2014b) gave some details of allometric growth and morphological development up to 80 days post-hatching, an understanding of which is necessary for aquaculture management.

Behzadi Mackvandi *et al.* (2015) used image analysis to record measurements on live fish and thus reduce loss from disease and death when fish were measured manually. The developmental osteological study of Hasanpour *et al.* (2015, 2016) could be used as an early indicator of non-optimal rearing conditions in hatcheries. Monajjemi (2015) found that the best conditions for rearing juvenile roach were 20-24°C temperatures and feeding 2-4 times/day. Shahkar *et al.* (2015) found that growth performance in juveniles could be stimulated by using 24L and 18L:6D photoperiods without any significant stress response as measured by haematological parameters. Yaghoubi *et al.* (2015) detailed the histological development of the digestive tract from hatching to fingerling size. Bisheh *et al.* (2017) evaluated the ponds at the Sijaval Cultivation Center (or Bony Fish Farm or Bony Fish Reproduction Center, in Bandar-e Torkeman), where juveniles were cultured for release into the Gorgan River and the

physicochemical conditions were found to be suitable. Ermakov *et al.* (2017) gave test systems using mtDNA to identify rapidly *R. lacustris* and *R. rutilus* (in Russia). Imanpour *et al.* (2018) showed that stocking density affected the growth (weight gain, feed conversion rate, specific growth rate) of juveniles but increasing the feeding frequency did not. The lowest levels of haematocrit were observed in a density of 10 fish/aquarium at two times/day feeding frequency.

Akhoundian *et al.* (2020) exposed mature females to varying photoperiod and temperature regimes and found photoperiod played a more important role in ovarian development than temperature. Earliest spawning occurred in fish exposed to 16L/8D and 20°C and even fish at 14°C matured and spawned earlier with longer day-length. Jebeleh *et al.* (2020) evaluated the diet of juveniles in earthen ponds at the Syjaval Bony Fish Farm over a four-month period from March to June. The highest and the lowest condition factors (K) were 1.196 and 0.633, respectively, while the highest dominance index was reported as 42.14 for Gastropoda and the lowest was 2.4 for aquatic insects. Gastropoda and crayfish were the major prey items, and organisms such as aquatic insects and bivalves were minor foods.

#### *Chemical composition and food safety:-*

Moeini and Daneshnuran (2001) and Moini *et al.* (2005) investigated the production of marinades using this fish and various recipes, examining their chemical composition over time and their comparative tastes. Chari Aliabad *et al.* (2019) applied four cooking methods (deep frying, baking, steaming and microwaving) to fillets and recommended baking for increased fatty acid levels and steaming for reduction in heavy metals.

#### *Disinfection and healing:-*

Ghelichpour and Eagderi (2012) found that formalin treatment (used to combat parasites and disinfect equipment in cultured fish) reduced saltwater tolerance in this species (fish are released in estuaries because of low water flow in the upper river and salt intrusion may give salinities >10‰). Hoseini *et al.* (2013) studied formalin toxicity finding recommendations in the literature for dosages of this disinfectant and therapeutic agent were not valid for fingerlings of this species, which was more susceptible. Hoseini and Nodeh (2013) found the LC<sub>50</sub> 96 h for fingerlings exposed to formalin was 49 p.p.m. Farhangi *et al.* (2014) studied the effect of copper sulphate on this species as it is used as a disinfectant and algicide. The lethal concentration was 0.4 mg/l. High concentrations of this heavy metal caused convulsions, oedema, hyperemia, haemorrhages and kidney lesions. Ghelichpour *et al.* (2016) studied gill histopathology of fingerlings treated with potassium permanganate and formalin finding no difference in gill damage in short-bath treatments but more in long-bath formalin treatments. Sahraei *et al.* (2017) examined the effects of black powder seeds (*Nigella sativa* or fennel flower) in the diet of young fish, finding a positive effect on the antibacterial activity in the fish mucus.

#### *Spermatology:-*

Imanpour *et al.* (2009) examined the relationship between fish size and various spermatological parameters. Sperm volume did not increase with body length although gonadal weight did. Spermatocrit, sperm motility, sperm density, gonadosomatic index and haematocrit were not influenced by fish body size but sperm density decreased significantly with increasing gonadal weight.

Golpour and Imanpour (2010) studied relationships between seminal and blood plasma composition during the reproductive season, as part of improving artificial fertilisation. Golpour *et al.* (2011, 2013) found fish caught in March had better spermatological and biochemical characteristics than those caught in February and April. Golpour *et al.* (2014) showed that broodstock migrating in the middle of the spawning season had better semen quality than at other

times. Halimi *et al.* (2014) recorded quantitative characteristics and chemical composition of sperm in this species for use in artificial fertilisation.

*Anaesthesia:-*

Jahanbakhshi *et al.* (2014) showed that fish should be anaesthetised at higher doses of 2-phenoxyethanol, a glycol ether, for reduced stress as shown by blood parameters.

**Conservation.** Holčík and Oláh (1992) reported a catch of only 5 kg in the Anzali Talab for 1990, indicative of decline. This species has been cultured at Sad-e Sangar Fish Farm near Rasht (3 million larvae a year), at Astara and at Anzali on the Caspian among other localities (Mokhayer, 1972). In 1999-2000, 30 million juveniles were released into the Caspian Sea (*Iranian Fisheries Research Organization Newsletter*, 23:4, 2000). Adeli Mosabbab and Piri (2005) recorded the release of fry into the Gorgan River of the southeast Caspian Sea as 16,663 million in 2000, 19,119 in 2001, 12,263 million in 2002, 11,931 in 2003 and 10,413 in 2004, the decrease being due to a fall in capture of brood fish. Noroozi *et al.* (2006) detailed capture of brood stock from the Gorgan River estuary for release into 2 ha earthen ponds enriched with manure and fertiliser. The optimum temperature for spawning brood stocks was 12-17°C, found in mid-March to late April. Pine branches were placed in the ponds as spawning sites. Ponds were stocked with 700 females averaging 150 g and 350 males averaging 100 g. Eggs hatched on the sixth day. Larvae were fed on natural zooplankton (*Rotatoria* and *Daphnia*) and artificial food.

Savenkova (1990) listed several reasons for reductions in catches in the Atrak River stock of Turkmenistan on the border with Iran and commented on the marketing of this species in southwestern Turkmenistan. These included ineffective fish passes, poor marketing strategies, and the low quality of fish reaching the spawning grounds. The Atrak River population could be conserved by regulating the discharge so that the spawning grounds flooded at the appropriate time (Petr, 1987). Beach seines with mesh sizes of 28 mm, 33 mm and 36 mm caught fish of ages 2.8 years, 2.9 years and 3.3 years respectively. These data indicated that 58.3%, 50.5% and 3.6% of the total catch were non-standard respectively. Seines with a cod end of at least 36 mm were recommended for stock protection (*Iranian Fisheries Research and Training Organization Newsletter*, 6:8, 1994). Catches were increasing with the rise of the Caspian Sea water level as noted above, indicating how natural events beyond human control could have a significant effect on stocks.

Hashemzadeh Segherloo *et al.* (2020) recommended in their population genomics study that the Aras River and sea-run *R. lacustris* of Iran be treated as two separate conservation units and the southeastern and southwestern Caspian Sea populations should be viewed as two potentially separate management units.

Listed as of Least Concern by the IUCN under *Rutilus caspicus* (downloaded 25 February 2019). Golpour and Imanpour (2010) considered this species to be threatened in Iran from overfishing and deterioration of spawning grounds. Robins *et al.* (1991) listed this species (under *Rutilus rutilus*) as important to North Americans. Importance was based on its use in aquaculture and as food, in sport and in textbooks and because it has been introduced outside its natural range. Everard (2006) is one book of many describing the biology and importance of the roach (as *Rutilus rutilus*).

**Sources.** Wossugh-Zamani (1991c) and Akbari-Pasand (1996) gave accounts of this species in Farsi.

Iranian material:- CMNFI 1970-0507, 3, not kept, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0509, 3, 73.4-82.9 mm standard length, Gilan, Sefid River at

Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0510, 4, 58.6-83.8 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0531, 14, 65.5-115.8 mm standard length, Mazandaran, Larim River talab (36°46'N, 52°56'E); CMNFI 1970-0532, 1, 74.9 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0543A, 1, 119.4 mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0548, 1, not kept, Golestan, Qareh Su (no other locality data); CMNFI 1970-0549, 1, 109.7 mm standard length, Golestan, Qareh Su near Alm Imamzadeh (no other locality data); CMNFI 1970-0563, 5, 40.3-112.2 mm standard length, Gilan Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0565, 2, 42.4-45.8 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1970-0581, 1, not kept, Gilan, Caspian Sea near Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0583, 6, 35.7-84.9 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0590, 1, not kept, Mazandaran, Shesh Deh River near Babol Sar (ca. 36°43'N, ca. 52°39'E); CMNFI 1979-0431, 1, 157.0 mm standard length, Mazandaran, bazaar at Now Shahr (no other locality data); CMNFI 1979-0476, 23, 25.4-32.3 mm standard length, Golestan, Qareh Su near Kord Kuy (36°51'N, 54°05'E); CMNFI 1979-0477, 15, 26.5-39.7 mm standard length, Golestan, Khalij-e Gorgan at Bandar-e Shah (= Bandar-e Torkeman) (36°54'N, 54°02'30"E); CMNFI 1979-0685, 1, 45.6 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0689, 1, not kept, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1979-0788, 2, 64.9-66.6 mm standard length, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0117, 1, 92.2 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0120, 1, 54.2 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1980-0126, 4, 162.2-178.3 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1980-0131, 1, 43.0, Iran, Caspian Sea basin (no other locality data); CMNFI 1980-0136, 4, 72.1-109.7 mm standard length, Mazandaran, Fereydun Kenar River estuary (36°41'N, 52°29'E); CMNFI 1980-0139, 1, not kept, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0140, 9, not kept, Gilan, Astara Talab close to sea (ca. 38°26'N, ca. 48°53'E); CMNFI 1980-0148, 1, 85.4 mm standard length, Gilan, Pir Bazar Roga River (37°21'N, 49°33'E); CMNFI 1980-0157, 2, 73.1-132.0 mm standard length, Golestan, Gorgan River estuary (36°59'N, 53°59'30"E); CMNFI 1980-0905, 9, 98.5-203.0 mm standard length, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E).

**Genus *Scardinius***  
Bonaparte, 1837

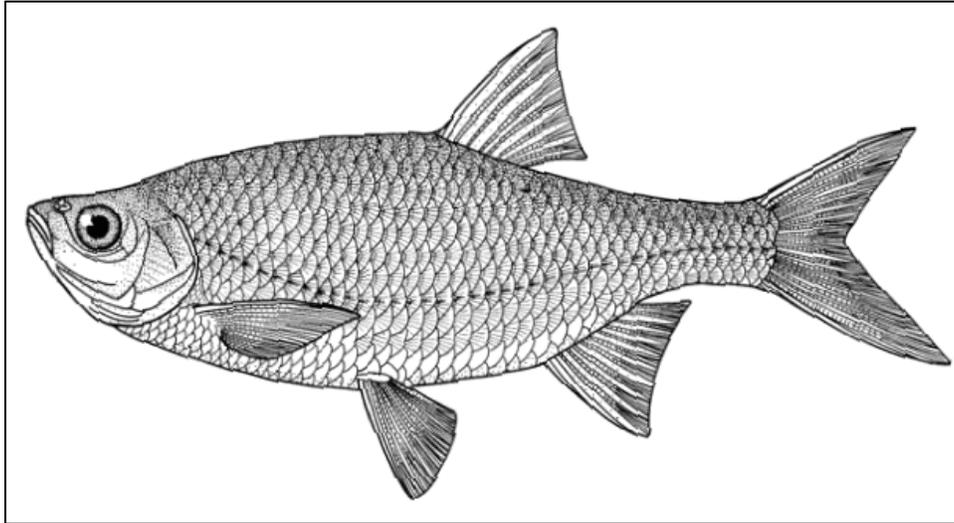
The genus contains perhaps 10 species and is found from the British Isles and the Iberian Peninsula throughout Europe to the Caspian and Aral Sea basins, with one species in Iran.

Howes (1981) placed this genus in *Rutilus* Rafinesque, 1820 on osteological grounds. Bogutskaya (1988) disagreed. *Scardinius* is usually separated from *Rutilus* by having two, as opposed to one, rows of pharyngeal teeth and a ventral keel on the body. Howes (1981) considered pharyngeal teeth to be of only species importance and the keel is variously developed in *Rutilus*.

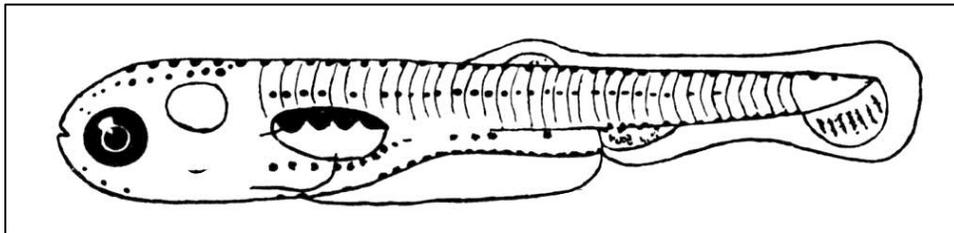
The genus is characterised by a pharyngeal tooth count of 3,5-5,3 with major row crowns laterally compressed and bearing 5-8 serrations, scales moderate in size in a complete lateral line, few, short gill rakers, a keel on the belly behind the pelvic fins covered with scales, a short gut

and light peritoneum, dorsal and anal fins of moderate length, dorsal fin origin well behind the origin of the pelvic fins, and a terminal and oblique mouth.

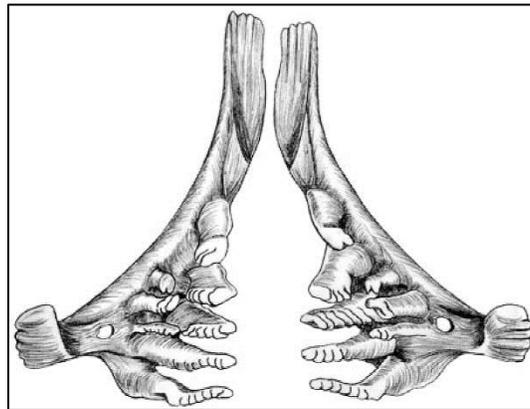
*Scardinius erythrophthalmus*  
(Linnaeus, 1758)



*Scardinius erythrophthalmus*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Scardinius erythrophthalmus* fry, 7 mm, age two weeks, Russia, Volga River delta, after Kazanskii (1915).



*Scardinius erythrophthalmus*, pharyngeal teeth  
(CC0, U.S. Geological Survey).



*Scardinius erythrophthalmus*, aquarium specimen  
(Rotfeder Rudd, CC BY 2.0, rotated, cropped, background cleaned, Olaf Nies).



*Scardinius erythrophthalmus*  
(CC BY-SA 2.5, U. S. Geological Survey, Noel Burkhead).



*Scardinius erythrophthalmus*, Ukraine, Southern Bug River  
(*Scardinius erythrophthalmus* 2009 G1, CC0, rotated, George Chernilevsky).

**Common names.** Sorkh par, sorkh-e par or sorkh pareh (= red fin), mahi sorkh baleh (= red fin fish), mahi chesm ghermez (= red eye fish), redfish or scorpionfish (after Akbari Nargesi *et al.*, 2018).

[Giziluzkac in Azerbaijan; Kizilkanat in Turkish (Çiçek *et al.*, 2020); krasnoperka in Russian; rudd, pearl roach, redeye, redfin].

**Systematics.** See above under the genus. *Cyprinus Erythrophthalmus* was originally described from northern Europe. No types are known. This species is widely known to spawn with other cyprinid fishes making hybrids a common occurrence. Some Iranian material appears to be hybrids of this species and another, unknown parental species but this has not been investigated.

**Key characters.** This species is often confused with *Rutilus rutilus* and *R. lacustris* but can be distinguished by the posterior position of the dorsal fin (in relation to the pelvic fins), the belly keel, the upturned mouth, and the serrated pharyngeal teeth in two rows.

**Morphology.** The body is compressed and deep, although some young fish have a shallower body. The body is deepest over the pelvic fin origin or just in front of the dorsal fin. The back rises steeply behind the occiput and is compressed before the dorsal fin. The head is small, markedly shorter than body depth, and may be straight or concave dorsally. The chin can be oblique to almost vertical. The caudal peduncle is compressed and relatively deep. The snout ends abruptly. The mouth is terminal and oblique with its upper tip level with the upper third of the eye. Lips are thin. The eye is in the anterior half of the head and close to the snout. The dorsal fin is truncate or slightly emarginate and its origin is well behind the level of the pelvic fin origin. The depressed dorsal fin reaches back to a level above the mid-anal fin. The caudal fin is moderately to deeply forked with pointed lobes, the lower lobe often longer and more rounded. The anal fin is slightly emarginate or sub-truncate. The depressed anal fin does not reach back to the caudal fin base. The pelvic fin is rounded and almost reaches back to the anal fin origin or falls well short. The pectoral fin is rounded and falls short of, or almost reaches back to, the pelvic fin.

Dorsal fin with 2-4 unbranched and 7-10, usually 8 branched rays, anal fin with 3-4 unbranched followed by 9-13, usually 11, branched rays (Abdurakhmanov (1962) initially gave 8-9 anal fin branched rays for Azerbaijan fish but this may be a misprint as a subsequent table listed 9-11 rays), pectoral fin branched rays 13-16, and pelvic fin branched rays 7-9. Lateral line scales 36-45. The lateral line is decurved, nearer the abdomen than the back. There is a pelvic axillary scale. There is a strongly-developed, scaled keel between the vent and the pelvic fin base. Scales are squarish in shape, with sharp dorsal and ventral anterior corners, a wavy anterior margin, central focus, fine circuli which are coarser on the posterior field, and very few anterior and posterior radii (e.g., 2 anterior and 3 posterior primary radii reaching the focus from the margin). The scale margin is indented where radii terminate and the thick posterior radii are visible on the flank. Total gill rakers number 6-16 and are short and widely spaced, touching the adjacent one when appressed. Pharyngeal teeth are mostly 3,5-5,3 with variants 3,5-5,2, 3,5-5,1, 3,5-4,3, 2,5-5,3 and 2,5-5,2, narrow and elongate, slightly hooked and with about 5-8 strong serrations on each tooth. The gut is s-shaped with an anterior loop. Total vertebrae number 37-42. The chromosome number is  $2n = 48-50$  (Klinkhardt *et al.*, 1995; Arai, 2011).

A single Iranian specimen had the following meristics:- dorsal fin branched rays 8, anal fin branched rays 10, pectoral fin branched rays 16, pelvic fin branched rays 8, lateral line scales 37, total gill rakers 10, pharyngeal teeth 3,5-5,3, and total vertebrae 39.

**Sexual dimorphism.** Males develop breeding tubercles on the head and body.

**Colour.** The back is blue-black to greenish- or olive-brown, the flanks are brassy and the belly silvery-white. Upper flank scales have dark bases. The tips of the caudal, anal and pelvic fins are a bright, blood red in the spawning season and the dorsal fin is black proximally and red distally. The iris is yellow to orange, or gold, with a red spot at the top. The peritoneum is silvery with scattered melanophores. Young are much less brightly coloured than adults.

**Size.** Attains 62.0 cm and 3.01 kg (Machacek (1983-2012), downloaded 27 July 2012).

**Distribution.** Found from the British Isles and north of the Pyrenees east to the Caspian and Aral Sea basins. It is recorded from the Lenkoran in Azerbaijan and, in Iran, from the Aras, Babol, Haraz, Pesikhan, Pir Bazar, Rasteh, Sefid and Sheikan rivers, the Anzali Talab, the Boojagh Wetland and a swamp near Hendeh Khaleh (Derzhavin, 1934; Holčík and Oláh, 1992; Karimpour, 1998; Abbasi *et al.*, 1999, 2017, 2018; Abdoli, 2000; Naderi Jolodar and Abdoli, 2004; K. Abbasi, pers. comm., 21 February 2005; Patimar *et al.*, 2010; Nikgoo *et al.*, 2018).

**Zoogeography.** This species is part of a European and West Asian fauna whose origins may lie in a Danubian or Sarmatian fauna.

**Habitat.** This species is found in rivers, streams, lakes, dams, lagoons, ponds and marshes. Rudd can favour heavily overgrown areas (Shikhshabekov, 1979) and are generally found in shallow warm lakes or slow-moving rivers. They are usually inhabitants of midwater or near the surface but they overwinter in deep water. They are regarded as fairly hardy and are adapted to eutrophic, and presumably therefore, polluted waters. In Iranian waters its density was highest in the Anzali Talab (K. Abbasi, pers. comm., 21 February 2005) and the population there was stunted through poor habitat quality (Patimar *et al.*, 2010).

Hatton *et al.* (2018) listed various mean parameters for this species such as the upper incipient lethal temperature (35.8°C), critical thermal maximum (33.5°C), critical thermal minimum (2°C), optimal growth temperature (21°C), final temperature preferendum (18.5°C), optimal spawning temperature (18°C) and optimal egg development temperature (21.8°C).

**Age and growth.** Nasri Tajan and Taati (2010) examined 181 fish from the Anzali Wetland finding age groups 0<sup>+</sup> to 2<sup>+</sup> years, with average fork length 133.99 mm and average weight 46.02 g, a significant difference in fork length between sexes, and fork length-total weight relationship  $W = 0.0000087FL^{3.145}$ , in males  $W = 0.00000979FL^{3.119}$ , and in females  $W = 0.00000655FL^{3.205}$ . Patimar *et al.* (2010) studied the stunted population in the Anzali Lagoon or Wetland and found maximum total length was 14.6 cm and maximum weight was 46.93 g. Males reached 4<sup>+</sup> years and females 5<sup>+</sup> years with 92.5% of fish age 2<sup>+</sup> to 3<sup>+</sup> years. Females were longer and heavier than males. Growth was isometric. There was no significant difference in condition coefficients between sexes and no temporal differences when considered separately for each date of sampling. The condition coefficient was highest in early May for males and mid-May for females and was lowest in early June for both sexes. Females dominated in older age classes and males in the younger. Moradinasab *et al.* (2012) found 141 Anzali Wetland fish, 6.4-17.7 cm total length, to have a *b* value in the length-weight relationship of 3.3613, positively allometric, a relative condition factor of 1.0 and a Fulton's condition factor of 1.4. Moradinasab *et al.* (2012) continued their study of Anzali Wetland fish and found an age range of 2<sup>+</sup> to 7<sup>+</sup> years for males and 3<sup>+</sup> to 7<sup>+</sup> years for females and 81.41% of age composition was in age groups 4-5<sup>+</sup> years. Total catch composition was 53.09% female, 42.59% male and 4.32% juvenile. The male:female sex ratio was 1:1.25, not significantly different. Growth was positively allometric with *b* values of 3.23 for males and 3.39 for females. Values respectively for males and females were relative weight ( $W_r$ ) 1.007 and 1.095, instantaneous growth coefficient (*G*) 0.39 and 0.45, growth performance index ( $\phi$ ) 1.79 and 1.85, and growth performance ( $W_\infty$ ) 193.27 and 217.59. von Bertalanffy growth parameters were  $L_\infty = 217.92$  mm,  $K = 0.128$  year<sup>-1</sup> and  $t_0 = -1.07$  for males and  $L_c = 232.4$  mm,  $K = 0.132$  year<sup>-1</sup> and  $t_0 = -1.29$  for females. These values and an adequate relative weight showed that biological conditions were suitable for this species in the Anzali Wetland in contrast to Patimar *et al.* (2010). Abbasi *et al.* (2018) found fish in their diet study in the Anzali Wetland to be 0<sup>+</sup> to 7 years old (and see below under **Reproduction**). Akbari Nargesi

*et al.* (2018) sampled the western Anzali Wetland and found, based on 127 fish, that 58.5% of fish were females and 7.41% were males.

Catches in the Anzali Wetland were higher using a red fyke net, compared to blue and black (Paighambari *et al.*, 2014).

Sexual maturity was attained at 3-4 years in Dagestan at lengths of 17-29 cm and 80-530 g. A stunted form was found in rice paddies at an age of 2 years, 7.5-11.0 cm and 10-23 g (Shikhshabekov, 1979). Elsewhere life span is at least 17 years.

**Food.** Food is aquatic macrophytes as well as insect larvae, crustaceans, molluscs and more rarely fish eggs and fry. The young feed on zooplankton. Abbasi *et al.* (2018) examined diet in the Anzali Wetland and found fish to have an average gut length of 0.85, a feeding intensity of 224.9 and a coefficient of gut vacuity of 14.8%. There were 21 genera of phytoplankton from four phyla in the gut, of which *Nitzschia*, *Cyclotella* and *Scenedesmus* with an abundance of 26.0, 17.2 and 10.6% of total cell numbers were dominant, respectively, but only one type of zooplankton (*Philodina*, Rotatoria) with a low volume. Individuals fed on 13 types of benthic and aerial animals and two types of fish fry, of which Ostracoda, *Dreissena*, Hemiptera and the exotic prawn, *Macrobrachium nipponense*, were dominant with an abundance of 26.7, 19.1, 13.0 and 8.5% of their total weight, respectively. The fish also consumed seven aquatic plants, of which digested plants, *Spirogyra*, *Potamogeton* and *Ceratophyllum* were abundant with 42.9, 26.3, 14.7 and 13.7% of eaten plant volume. The results showed this species is an euryphagous and omnivorous fish in the Anzali Wetland.

**Reproduction.** The Iranian study of Patimar *et al.* (2010) found a reproductive period of mid-April to late May and showed that the gonadosomatic index peaked in mid-May for both sexes and then decreased sharply. Egg diameters reached 1.23 mm, maximum fecundity reached 59,620 eggs and relative fecundity 1,737.69 eggs/g. Akbari Nargesi *et al.* (2018) sampled the western Anzali Wetland and found the mean gonadosomatic index was 1.8 and 0.6 for males and females. MoradiChafi *et al.* (2018) examined 54 fish from the Anzali Wetland aged 2-7 years, total length 5.45-17.2 cm, mean 14.0 cm, with 4-5-year-old fish dominant. Absolute fecundity was 403-56,967 eggs, mean 18,510 eggs, and relative fecundity was 130-1,045, mean 401.0 eggs/g body weight.

Spawning took place at water temperatures of at least 18-20°C in June-July in Dagestan. Each female could be accompanied by two males, one on each side. Two batches of eggs may be spawned in this period (Shikhshabekov, 1979). In the Volga Delta, spawning took place from April until the end of June. Eggs attached to water plants. The young remained attached to vegetation until the yolk-sac was absorbed. Fecundity was up to 232,000 eggs with a diameter of 1.5 mm. Hatching took three days at 20-22°C.

**Parasites and predators.** Masoumian and Pazooki (1998) surveyed myxosporeans in this species in Gilan and Mazandaran provinces, finding *Myxobolus pfeifferi*. Sattari *et al.* (2004) recorded the nematode *Raphidascaris acus* larvae from this species in Gilan and Khara *et al.* (2006b, 2011) recorded this nematode in fish from the Boojagh Wetland of the Caspian coast. Daghigh Roohi (2016) recorded a *Dactylogyrus* sp. from fish in the Anzali Wetland. Mirhashemi Nasab *et al.* (2017) found *Diplostomum spathaceum* in fish from the Anzali Wetland with prevalence (46.66%) and range (one worm in a fish). Nikgoo *et al.* (2018) found fish from the Anzali Wetland hosted the nematodes *Agamospirura* sp., *Camallanus lacustris*, *Contracaecum squalii*, *Cosmocephalus obvelatus*, *Goezia* sp., *Hysterothylacium fabri*, *Molnaria intestinalis*, *Paraquimperia tenerrima*, *Rhabdochona denudata*, *Raphidascaris acus* and *Spiroxys contortus*, found in 92% of specimens with the highest and lowest rate of infection in summer and winter

respectively.

The Caspian seal, *Pusa caspica*, is a predator on this species (Krylov, 1984). Ashoori *et al.* (2017a) recorded this species as an occasional item in the diet of young black-crowned night herons (*Nycticorax nycticorax*) in the Anzali Wetland.

**Economic importance.** Holčík and Oláh (1992) reported a catch of 98 kg in the Anzali Talab in 1990.

Robins *et al.* (1991) listed this species as important to North Americans. Importance was based on its use in aquaria and aquaculture, as food, in sport and in textbooks and because it has been introduced outside its natural range.

**Experimental studies.** None.

**Conservation.** Lelek (1987) classified this species as vulnerable in Europe. Kiabi *et al.* (1999) considered this species to be conservation dependent in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, medium numbers, habitat destruction, limited range (less than 25% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. Near threatened in Turkey (Fricke *et al.*, 2007). Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Iranian material:- CMNFI 2008-0110, 1, 103.7 mm standard length, Gilan, swamp near Hendeh Khaleh (37°23'N, 49°28'E).

### **Genus *Squalius*** Bonaparte, 1837

There may be about 50 species in the chub genus *Squalius* found from England to Southwest Asia with 5 named species reported from Iran with perhaps others undescribed. The members of this genus were formerly placed in the dace genus *Leuciscus* Cuvier, 1816. The genus *Leuciscus* is not monophyletic based on allozyme data for a limited number of European taxa (Hänfling and Brandl, 2000). Schönhuth *et al.* (2018) noted that *Squalius* is the sister group to *Petroleuciscus* Bogutskaya, 2002

It has been suggested that species formerly considered to belong to the subgenus *Squalius* should be simply regarded as part of a *Leuciscus cephalus* complex characterised by serrated pharyngeal teeth in two rows (2,5-5,2) and an almost straight or convex anal fin margin. This complex would include *L. cephalus* (now several species), *L. gaderanus* and *L. lepidus* among Iranian species (Bogutskaya, 1994). Bogutskaya (2002), however, placed *L. persidis* and *L. ulanus* in a new genus *Petroleuciscus*, and placed *L. cephalus* (and by implication other *Squalius*) and *L. lepidus* in the genus *Squalius*, and this latter placement is followed here. Perea *et al.* (2010) found *Squalius* to have a Mediterranean group, an Euroasiatic group (central-east Europe, Asia and north of the Mediterranean area) and a Paratethys group (Black Sea and Anatolia).

Bogutskaya (2002) gave the characters of *Squalius* as numerous total vertebrae (commonly more than 40, up to 48), an increased number of sensory cephalic pores (up to 12-20 in the supraorbital canal) in most species, often fused and very expanded fourth and fifth infraorbitals, and a depressed neurocranium with a reduced interorbital septum. Other characters are a somewhat compressed body, moderate to large scales, a complete lateral line, no barbels, mouth terminal or subterminal, usually no notch in the upper jaw accommodating a tubercle on the lower jaw, thin lips with the lower one interrupted medially, a short dorsal fin without a thickened ray, a moderately long anal fin, long and hooked pharyngeal teeth in two rows (2,5-

4,2, 2,5-5,2 or 3,5-5,3 modally) usually with hooked tips and spoon-shaped crowns, short gut, no keel on the belly, and short and relatively few gill rakers.

Fishes in northern and western Iran, apart from the distinctive long-snouted chub *S. lepidus*, were formerly recognised in the literature as the wide-ranging European-Southwest Asian short-snouted chub *Leuciscus cephalus* with a subspecies *L. c. orientalis* (Nordmann, 1840) found in Southwest Asia, and later as *Squalius cephalus* or *Squalius orientalis*. This taxon is now divided into *S. berak* (Tigris River basin), *S. namak* (Namak Lake basin) and *S. turcicus* (Caspian Sea and Lake Urmia basins) (Esmaeili *et al.*, 2016; Khaefi *et al.*, 2016). *Squalius orientalis* Heckel, 1847 described from the Kueik River near Aleppo, Syria was possibly not intended by Heckel as an original species description; otherwise it is a homonym of *Leuciscus orientalis* Nordmann 1840 (*Catalog of Fishes*, downloaded 21 January 2021).

Chubs are fairly large cyprinids of economic and sporting importance in Southwest Asia, although not used as extensively as their relatives in Europe.

The following table summarises some key distinguishing characters of the Iranian species of *Squalius*.

Species/ Characters	Modal dorsal fin branched rays	Mouth	Lower jaw symphysis knob	Posterior tip flank scale	Anal, pelvic, caudal fins	Distribution
<i>S. berak</i>	8	Subterminal, terminal or lower jaw projects slightly	Absent	No bold blotch or bold blotch present	Hyaline or with a grey or yellow hue	Tigris River
<i>S. latus</i>	7	Lower jaw projects slightly	Present	No bold blotch	Orange to reddish	Hari River
<i>S. lepidus</i>	8-9	Elongate and pointed head with a projecting lower jaw	Present	No bold blotch	Reddish	Tigris River
<i>S. namak</i>	8-9	Subterminal or lower jaw projects slightly	Wide and thick	Bold grey or brown, roundish or crescent- shaped blotch	Orange to reddish	Dasht-e Kavir, Namak Lake
<i>S. turcicus</i>	8-9	Terminal to slightly or markedly subterminal;	Small	No bold blotch	Orange	Caspian Sea, Lake Urmia

***Squalius berak***  
Heckel, 1843



*Squalius berak*, 137.0 mm standard length, ZM-CBSU J1740, West Azarbayjan, Little Zab River between Piranshahr and Sardasht. Hamid Reza Esmaili.

**Common names.** Mahi-ye sefid rudkhanehi or mahi-e-sephid-e-roodkhaneie (= white river fish) in Khuzestan, aroos or arus mahi (= bride fish).

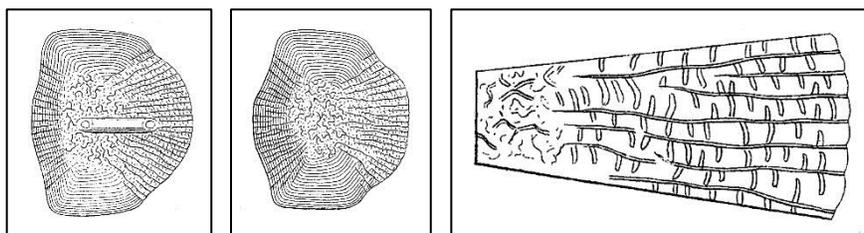
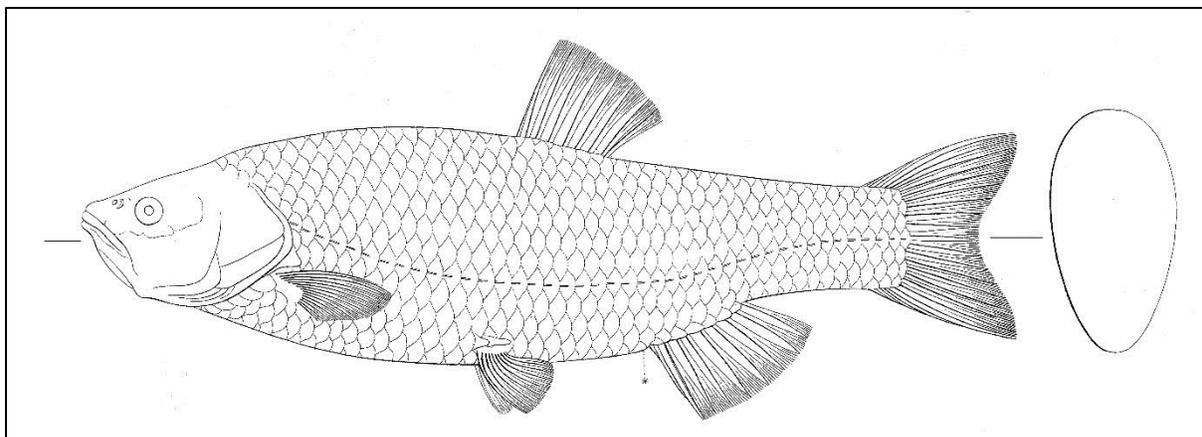
[Berak (meaning breast perhaps in allusion to the broad and fleshy chin (Heckel, 1843b)), baeaan, barayan, bir-aan siphaloos, at Aleppo, all in Arabic; Mesopotamian chub; riverine whitefish (Darvishi *et al.*, 2018)].

**Systematics.** *Squalius berak* is now recognised as a distinct species (Doadrio and Carmona, 2006; Turan *et al.*, 2009; Bogutskaya and Zupančič, 2010; *Catalog of Fishes*, downloaded 15 May 2018). It was originally described from Aleppo, Syria. The taxon appeared as a name only and was spelled *Berag* on p. 1041 of Heckel (1843b).

*Squalius cephalopsis* Heckel, 1843 described from “Aleppo” and *Squalius orientalis* Heckel, 1847 described from “Flusse Kueik bei Aleppo” (the latter possibly not meant by Heckel to be an original species description) are presumably synonyms, as used for Iranian Tigris River basin fish, of *Squalius berak*.

Six syntypes of *Squalius berak* are in the Naturhistorisches Museum Wien under NMW 48915 and three syntypes are in the Senckenberg Museum Frankfurt under SMF 469, formerly in NMW, and three syntypes of *Squalius cephalopsis* are under NMW 49438 and two other syntypes are under NMW 49440 (Eschmeyer *et al.*, 1996). The Vienna catalogue listed six specimens as *Squalius berak* and two specimens as *Squalius cephalopsis* but the Vienna card index in 1997 agrees with Eschmeyer *et al.* (1996) for the NMW specimens.

Older works cited below, for example in **Distribution**, appeared under the names *Leuciscus cephalus* or *L. c. orientalis*.



*Squalius berak*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line (regenerated), and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



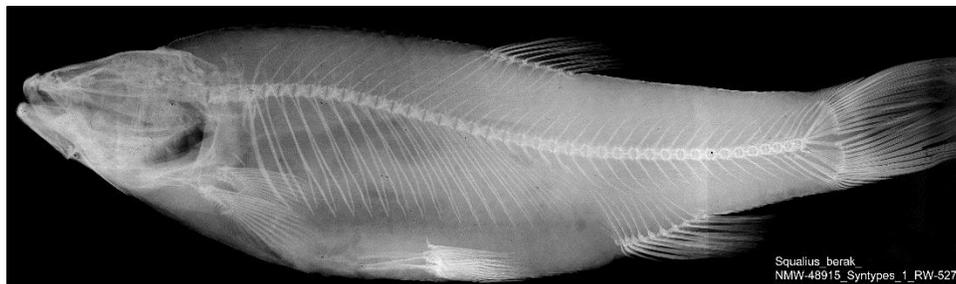
*Squalius berak*, syntypes, NMW 48915, Naturhistorisches Museum, Wien.



*Squalius berak*, syntypes, NMW 48915, Naturhistorisches Museum, Wien



*Squalius berak*, syntype, NMW 48915, Naturhistorisches Museum, Wien.



*Squalius berak*, syntype, NMW 48915, Naturhistorisches Museum, Wien.

**Key characters.** This species is distinguished by the upper lip projecting beyond the lower lip (although this varies with some having the lower lip projecting or lips equal), no knob on the lower jaw synthesis, head blunt and deep, pelvic, anal and caudal fin rays hyaline, grey or yellow, the posterior tip of the flank scales without a bold blotch (present in some), and distribution in the Tigris River basin.

**Morphology.** The body is rounded and moderately deep, being deepest in front of the pelvic fin origin. The predorsal profile is gently convex and a nuchal hump is present in some fish. The dorsal head profile is concave or straight. The abdomen between the anus and the

posterior pelvic fin base is compressed. The caudal peduncle is compressed and deep. The snout tip is slightly pointed. The eye is positioned well into the anterior half of the head. The mouth is oblique, terminal, or the upper lip projects, or usually slightly subterminal or lips equal, and the mouth extends back to a level between the nostril and the eye. Lips are moderately thick and the upper lip is thickest at its centre. Fin rays are thin and not fleshy (Turan *et al.*, 2017). The dorsal fin margin is straight. The dorsal fin origin lies posterior to the level of the pelvic fin origin. The depressed dorsal fin extends back level with the anal fin origin. The caudal fin is shallowly forked and has pointed tips. The anal fin margin is straight, emarginate or slightly rounded. The anal fin does not extend back to the caudal fin base. The pelvic fin is rounded and does not extend back to the anal fin origin. The pectoral fin is rounded and does not extend back to the pelvic fin origin.

Dorsal fin unbranched rays 3, branched rays 7-8, usually 8, anal fin unbranched rays 3, branched rays 7-9, usually 8 or 9, pectoral fin branched rays 14-19, and pelvic fin branched rays 7-10, usually 9. Total lateral line scales 40-46, scales above lateral line 8, scales below lateral line 3-4, scales around caudal peduncle 15-17, mode 16, and predorsal scales 18-21. Scale shape is squarish with a gently rounded posterior margin, straight to gently rounded dorsal and ventral margins and a protruding central part to the anterior margin with shallow indentations above and below. The anterior margin may be wavy. The anterior scale corners are abrupt but gently rounded. The focus is almost central and may be broken up into irregular lines. Radii are moderate to numerous on the anterior and posterior fields. Circuli are fine and numerous. Total gill rakers number 7-13, mode 9, anterior rakers being stubby, and the longest raker touching the one below when appressed. Pharyngeal teeth number 2,5-5,2, presumably with variants as seen under *S. turcicus*, and teeth are hooked at the tip and strongly serrated below it. The fifth tooth may be reduced to a nub. Total vertebrae number 40-43. Four of the six syntypes of *S. berak*, NMW 48915, have 41(3) or 42(1) vertebrae (the remaining two too faint to count). Poria *et al.* (2014) gave details of meristic and morphometric characters of fish from Shohaday-e Songhor Dam in Kermanshah Province.

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(1) or 8(12), anal fin branched rays 7(1), 8(4) or 9(8), pectoral fin branched rays 14(1), 15(1), 16(3), 17(4), 18(-) or 19(1), pelvic fin branched rays 7(1), 8(3) or 9(9), lateral line scales 40(1), 41(3), 42(2), 43(3), 44(3), 45(-) or 46(1), total gill rakers 7(1), 8(2), 9(6), 10(2), 11(1), 12(-) or 13(1), and total vertebrae 41(6), 42(1) or 43(1), including 4 syntypes.

**Sexual dimorphism.** Unknown.

**Colour.** Esmaeili *et al.* (2016) described live fish as having a head and body silvery brown, darker on the back, and the belly white. There is a faint dark flank stripe. The posterior scale margins on the flank have a few grey pigments but the tip lacks any strong pigmentation. Anal fin rays are orange in live fish, greyish in preservative (Turan *et al.*, 2017). Scale pockets are well-pigmented above the lateral line, with a bold, brown or black, crescent-shaped, vertically elongated or roundish anterior scale mark on scales below the lateral line. A few, very small spots may be on the mid-scale. Free margins of scales above the lateral line are pale. The pectoral, pelvic, anal and caudal fin rays are orange, and caudal fin rays have some black pigments. Dorsal fin membranes are hyaline with dark-grey rays. Preserved fish have the head and body pale brown, darker on the back, and can be quite dark. The pigment is lighter below the lateral line. Dorsal and caudal fins have blackish rays and hyaline membranes and the pectoral, pelvic and anal fin rays are whitish and the membranes yellowish. The peritoneum is black.

**Size.** Reaches 37.5 cm total length (Sadeghinejad Masouleh and Radkhah, 2018).

**Distribution.** This species is found in the Quwayq, Euphrates and Tigris River basins (Turan *et al.*, 2017) with earlier records under *Leuciscus* (or *Squalius*) *cephalus* and *L. c. orientalis*. In the Tigris River basin in Iran in the Ab-barik, Ab-e Bazoft, Ab-e Jahan Bin, Armand, Arvand, Avachar, Avar, Badin Abad, Baneh, Boen, Chameshk, Chamzarivar, Choman, Dez, Dinorab, Dinvar, Gahar, Gamasiab, Gangir, Gaveh, Haramabad, Jahanbin, Kalwi, Kangavar Kohneh, Karkheh, Karun, Kashkan, Khersan, Khorram (Khorramabad), Kiar, Little Zab (or Zab-e Kuchek), Marun, Qareh Su, Qaveh, Qeshlaq, Razavar (= Raz Avar), Simareh, Sirvan, Sulgan, Zanoschay and Zemkan rivers, sarabs in Kermanshah, in the Shohadaye Songhor Dam in Kermanshah and the Qeshlaq Dam, Kordestan, Lake Zaribar, and the Agh-Gol, Gamasiab and Haramabad wetlands in Hamadan Province (Barzegar and Jalali Jafari, 2006; Biokani *et al.*, 2011; Bahrami Kamangar *et al.*, 2012a; Bozorgnia *et al.*, 2012; Sedaghat *et al.*, 2012; Biukani *et al.*, 2013; Dadashi *et al.*, 2014; Pooria *et al.*, 2014; Ramin *et al.*, 2014; Reyahi-Khoram *et al.*, 2014; Alizadeh Marzenaki *et al.*, 2016; Khaefi *et al.*, 2016; Darvishi *et al.*, 2018; Maleki *et al.*, 2018; Mouludi-Saleh and Keivany, 2018b; Sadeghinejad Masouleh and Radkhah, 2018; Hasankhani *et al.*, 2019; Eagderi *et al.*, 2020; Nasri, 2021).

**Zoogeography.** See under the genus above and under *S. turcicus* below.

**Habitat.** This species is found in rivers, streams, lakes, dams and springs. Esmaeili *et al.* (2016) stated that it is found in small to medium streams mostly in mountain and hilly areas as shown below.



Habitat of *Squalius berak*, West Azarbaijan, Little Zab tributary, Hamid Reza Esmaeili.

**Age and growth.** Sedaghat *et al.* (2012) examined 60 fish identified as *Squalius cephalus*, 13.8-29.5 cm total length, from the Gamasiab River, Hamadan and found ages 1 to 4 years, with the 1-year age group most frequent (45.16%) and the 4-year age group least frequent (12.9%), maximum size was 29.5 cm and weight was 271.1 g, mean condition factor was 875 g/cm, and length-weight relationship showed positive allometric growth ( $W = 0.006TL^{3.97}$ ). Pooria *et al.* (2014) found 113 fish identified as *S. cephalus*, 16.7-25.4 cm total length, from the Shohadaye Songhor or Shahda Dam in Kermanshah Province had a mean condition factor of 1.65 for males and 1.63 for females, not significantly different, the age range was 2 to 6 years, the male:female

sex ratio was 1:0.24, length-weight relationships were  $W = 7e-06L^{3.112}$ ,  $4e-05L^{2.83}$  and  $9e-06L^{3.08}$  for males, females and the population, and fish in the dam attained higher lengths compared to fish of the same age range in other waters, possibly because of better environmental and food supply conditions. Poria *et al.* (2014) reported age groups 2<sup>+</sup> to 5<sup>+</sup> years for this dam. Mouludi-Saleh and Keivany (2018b) examined 23 fish, 2.7-7.2 cm total length, from the Abbarik River and found a *b* value of 3.14. Sadeghinejad Masouleh and Radkhah (2018) examined 62 fish, 11.2-37.5 cm total length, from the Kashkan River and found growth was positively allometric. Hoseinpour *et al.* (2019) studied the effect of wastewater on 280 fish identified as *S. cephalus* from the Gheshlagh (= Qeshlaq) River. The upstream, high water quality locality had a male:female sex ratio of 1:1.86 while the downstream, polluted locality had 1:0.61, both significantly different from the expected 1:1 ratio. Age was 0<sup>+</sup> to 5<sup>+</sup> in both localities. Downstream fish were larger and heavier than upstream fish. In the von Bertalanffy growth equation, for the whole river, the average asymptotic length was 28.2 cm for males and 35.5 cm for females, and overall condition factor was 1.53 for males and 1.5 for females, being significantly larger in most age classes in upstream fish. Differences between the two localities were attributed to wastewater input. Eagderi *et al.* (2020) examined 64 fish, 5.42-19.02 cm total length, from the Baneh, Choman, Gaveh and Khersan rivers and found a *b* value of 3.14, positively allometric. Zare-Shahraki *et al.* (2020) measured 25 fish, 9.0-17.0 cm total length, from the Karun River system and recorded a *b* value of 3.25.

Life span is 7 years in the Savur stream in the Tigris River basin of southeast Anatolia (Ünlü and Balcı, 1993a, 1993b), and over 8 years in the Euphrates River in Turkey (Özdemir and Şen, 1986) for fish identified as *L. c. orientalis*.

**Food.** Presumably similar to other chubs.

**Reproduction.** Ünlü and Balcı (1993a, 1993b) found spawning to take place from May to late June in southeast Anatolia in the Savur Stream, a tributary of the Tigris River. Fecundity reached 20,140 eggs and egg diameter 1.5 mm. Equations for the relationship between fecundity (F) and length (FL), weight (W) and ovary weight (GW) were given as  $F = 0.0458FL^{2.3680}$ ,  $F = 270.96W^{0.7912}$  and  $F = 1888.86GW^{0.8163}$ .

Iraqi fish attained sexual maturity in 3 years at 20 cm length and 700 g weight, spawning in March and April and depositing eggs in shallow water on gravel (Al-Rudainy, 2008).

**Parasites and predators.** Daghig Roohi *et al.* (2015) recorded the first report of *Pomphorhynchus laevis*, an acanthocephalan, from fish identified as *Squalius cephalus* in the Gamasiab River. Maleki *et al.* (2018) reported metacercariae of the trematode *Clinostomum complanatum* from fish identified as *S. cephalus* in the Qeshlaq River basin.

**Economic importance.** Listed as economically important in the Turkish Euphrates River as *L. cephalus orientalis* (Özdemir and Şen, 1986).

**Experimental studies.** None.

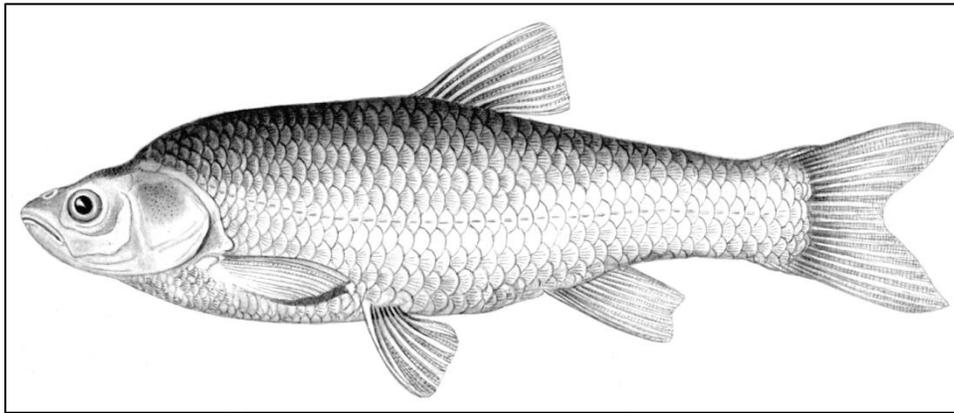
**Conservation.** Listed as of Least Concern by the IUCN (downloaded 15 February 2019).

**Sources.** Iranian material:- CMNFI 1979-0276, 1, 59.7 mm standard length, Lorestan, Chameshk River (ca. 33°19'N, ca. 47°53'30"E); CMNFI 2007-0099, 3, 34.7-35.5 mm standard length, West Azarbayjan, Kalwi Chay west of Mahabad (ca. 36°35'N, ca. 45°25'E); CMNFI 2007-0109, 1, 101.1 mm standard length, Kordestan, Qeshlaq River basin (ca. 35°16'N, ca. 47°01'E); CMNFI 2007-0113, 1, 99.5 mm standard length, Kermanshah, Qareh Su River tributary (ca. 34°25'N, ca. 47°01'E); CMNFI 2008-0102, 2, 179.4-266.0 mm standard length, Kermanshah, sarabs near Kermanshah (no other locality data); CMNFI 2008-0132, 1, 207.5 mm standard length, Khuzestan, neighbourhood of Ahvaz (no other locality data); CMNFI 2008-

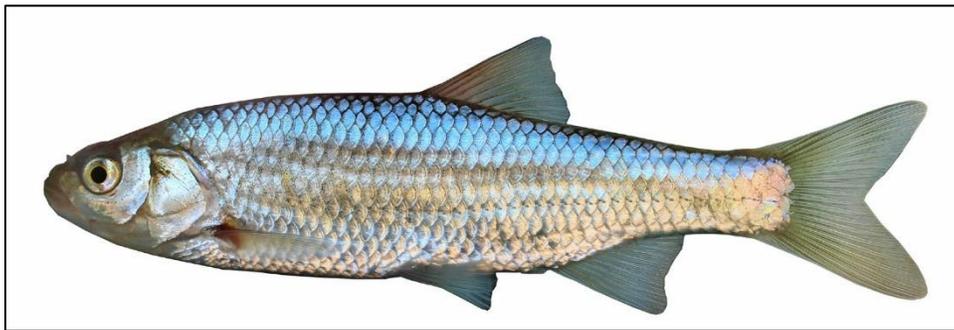
0182, 1, 51.5 mm standard length, Chahar Mahall and Bakhtiari, Ab-e Bazoft Sofla (31°38'06"N, 50°28'30"E); CMNFI 2008-0185, 2, 51.4-71.6 mm standard length, Chahar Mahall and Bakhtiari, Sulgan River (31°30'N, 50°50'E); CMNFI 2008-0191, 1, 53.4 mm standard length, Chahar Mahall and Bakhtiari, Ab-e Bazoft (31°38'06"N, 50°28'30"E).

Comparative material:- BM(NH) 1974.2.22:71-72, 2, 68.0-93.1 mm standard length, Iraq, Baghdad (33°21'N, 44°25'E); BM(NH) 1974.2.22:74, 1, 152.1 mm standard length, Iraq, Greater Zab near Aski Kalak (ca. 36°16'N, 43°39'E); BM(NH) 1974.2.22:75, 1, 154.0 mm standard length, Iraq, Qizilja River, Lesser Zab (no other locality data).

*Squalius latus*  
Keyserling, 1861



*Squalius latus*, 16.7 cm total length, Turkmenistan, Murghab River, after Berg (1948-1949).



*Squalius latus*, Razavi Khorasan, Hari River, after Jouladeh-Roudbar *et al.* (2020).

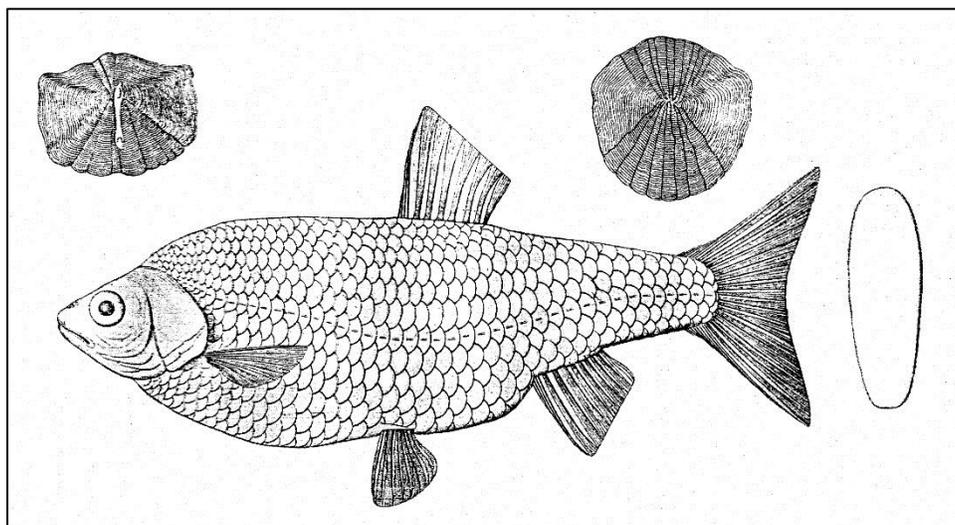
**Common names.** Aroos or arus mahi-e Harirud (= Hari River bride fish).

[Zakaspiiskii elets or Transcaspian dace in Russian; eastern asp, Hari asp, Murgab dace].

**Systematics.** *Squalius latus* was described from the “Fluss. Heri-Rud bei Herat” (now in Afghanistan, then in Persia). No types were kept.

*Squalius transcaspensis* Berg, 1898 from “Habitat in flum. Tedschent, prope Aschabat in provincia Transcaspica” is a synonym. The type locality is presumably the Tedzhen River in Turkmenistan (not Iran as given in Eschmeyer *et al.* (1996)) although Ashkhabad is not on the Tedzhen River. Many syntypes are in the Zoological Museum of Moscow State University (MMSU or ZMMU) according to Eschmeyer *et al.* (1996) but not found in 2002 (*Catalog of Fishes*, downloaded 7 September 2018). Possibly a subspecies of *Squalius lehmanni* (Brandt,

1852) according to Nikol'skii (1938) and Svetovidova (1967) or of *Leuciscus leuciscus* (Linnaeus, 1758) according to V. V. Kafanova (cited in Bogutskaya, 1994). Bogutskaya (1994) considered *S. latus* to be distinct. Jouladeh-Roudbar *et al.* (2020) re-affirmed its place in the genus *Squalius* based on unpublished molecular and morphological data as it had previously been under *Leuciscus*.



*Squalius latus*, after Keyserling (1861).

**Key characters.** This species is distinguished by a dorsal fin branched ray count modally 7 and distribution in the Hari River basin.

**Morphology.** The body is rounded and can be fairly deep. The body is deepest in front of the dorsal fin over the pectoral fin level. The predorsal profile is convex. A nuchal hump is present in larger fish. The mouth is oblique, terminal and extends back to the level of the nostrils or the anterior eye margin. The lower jaw can protrude slightly. The rear of the eye is at the beginning of the anterior half of the head. The dorsal fin margin is straight to slightly convex. The dorsal fin origin is behind the level of the pelvic fin origin. The depressed dorsal fin extends back to a level just behind the origin of the anal fin. The caudal fin is moderately forked with pointed lobes. The anal fin margin is straight to slightly concave. The anal fin does not reach back to the caudal fin. The pelvic fin is rounded and does not reach back to the anal fin origin. The pectoral fin is rounded and almost reaches back to the pelvic fin origin in some fish.

Dorsal fin unbranched rays 3 and branched rays 7-9, usually 7, anal fin unbranched rays 3 and branched rays 7-10, pectoral fin branched rays 13-16, and pelvic fin branched rays 7-10, usually 8. Lateral line scales 39-47. A pelvic axillary scale is present. Scales are rounded to squarish. Flank scales have a rounded posterior margin, less rounded dorsal and ventral margins, and a gently rounded anterior margin with some small indentations. Scales bear a moderate number of anterior and posterior radii, have numerous circuli and a sub-central anterior focus. Total gill rakers number 8-11 and reach the raker below when appressed. Pharyngeal teeth are usually 2,5-5,2, with variants 2,5-5,1, 1,5-5,1, 3,4-4,2, 3,5-5,2 or 2,5-4,2 and have narrow cutting edges on each side of a shallow groove below a hooked tip and, in larger fish, some teeth are serrated below the tip. Total vertebrae number 39-41.

Meristic values for fish from the Tedzhen (= Hari) River, part of which is the Iran-Afghanistan border are:- dorsal fin branched rays 7(12), anal fin branched rays 7(1), 8(6) or 9(5),

pectoral fin branched rays 15(6) or 16(6), pelvic fin branched rays 7(1) or 8(11), lateral line scales 39(1), 40(1), 41(2), 42(2), 43(1), 44(2), 45(1), 46(1) or 47(1), total gill rakers 8(2), 9(1), 10(5) or 11(4), pharyngeal teeth 2,5-5,2(3), and total vertebrae 39(4), 40(6) or 41(3) (includes data from x-rays of ZISP 18361 (x-rays only seen) and ZISP 11047).

**Sexual dimorphism.** Unknown.

**Colour.** The back and upper flank are reddish-brown or with a bluish sheen, the flanks yellowish and the belly silver. The dorsal and caudal fins are yellowish-brown and the other fins are reddish. The base of all fins becomes bright orange during spawning.

**Size.** Reaches 26.7 cm.

**Distribution.** This species is found in the Tedzhen River (= Hari River in Iran) and the Murgab River to the east in Afghanistan and Turkmenistan. Eagderi *et al.* (2020) is a recent Iranian record.

**Zoogeography.** This species is part of a complex of species found from Western Europe to Siberia. Its origins may lie in a Ponto-Caspian-Aralian refugium, becoming isolated and speciating in the eastern part of this area.

**Habitat.** This species is found in rivers but details of habitat are unknown.

**Age and growth.** Eagderi *et al.* (2020) examined 12 fish, 7.45-16.25 cm total length, from the Hari River and found a *b* value of 3.11, positively allometric.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported from Iran.

**Economic importance.** None.

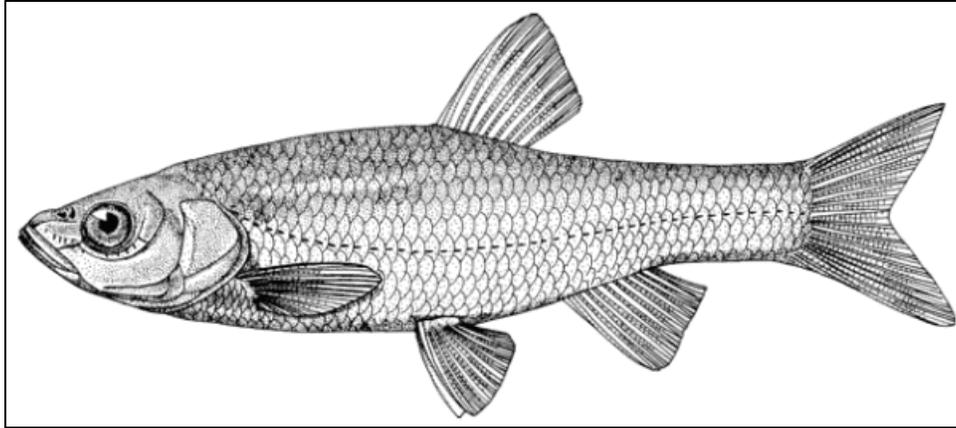
**Experimental studies.** None.

**Conservation.** Numbers and habitat requirements are unknown and so a conservation assessment cannot be made. Mousavi-Sabet *et al.* (2018) noted there have been no new records for many years, probably since the collection of the type specimens, and no records from Iranian waters (but see Eagderi *et al.*, 2020). Jouladeh-Roudbar *et al.* (2020) listed it as Data Deficient.

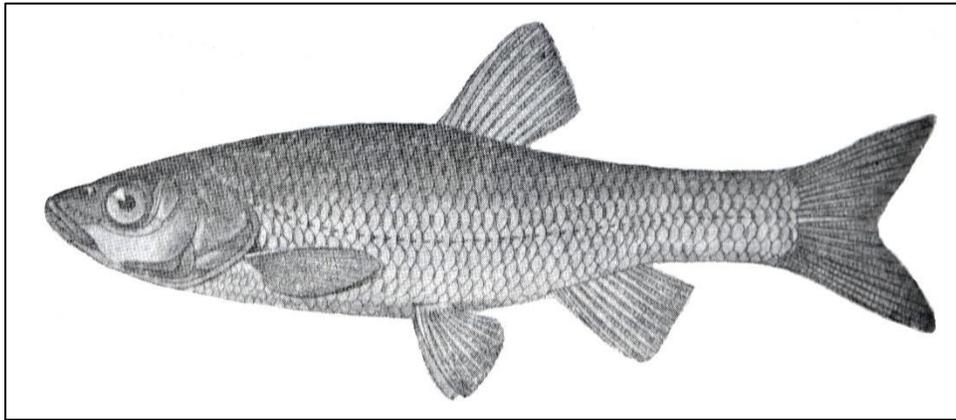
**Sources.** Iranian material:- None.

Comparative material:- ZISP 10357a, 1, 63.2 mm standard length, Turkmenistan or Afghanistan, Tedzhen River (no other locality data); ZISP 10359, 4, 93.4-130.5 mm standard length, Turkmenistan or Afghanistan, Tedzhen River (no other locality data); ZISP 10360, 6, 58.4-122.0 mm standard length, Turkmenistan or Afghanistan, Tedzhen River (no other locality data); ZISP 10419, 1, 107.6 mm standard length, Turkmenistan, Iolotan near Merv (37°18'N, 62°21'E); ZISP 11047, 1, 133.2 mm standard length, Turkmenistan, Tedzhen River (no other locality data).

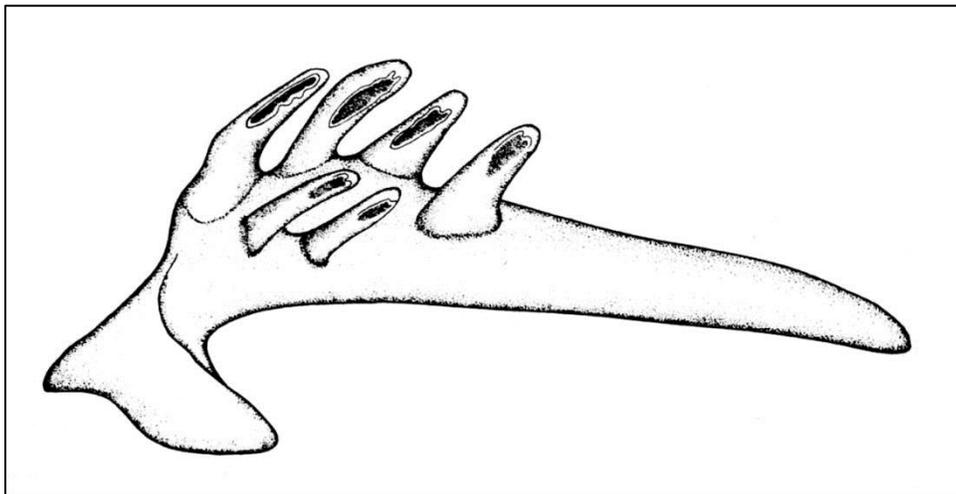
*Squalius lepidus*  
Heckel, 1843



*Squalius lepidus*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Squalius lepidus*, 13.2 cm total length, ZISP 24055, Iraq, Mendeli, after Berg (1949).



*Squalius lepidus*, pharyngeal teeth, Freidhelm Krupp.



*Squalius lepidus*, Iran, Gamasiab River, May 2008, Keyvan Abbasi.



*Squalius lepidus*, Kordestan, Gaveh River (above) and Kermanshah, Dinvar River (below), after Jouladeh-Roudbar *et al.* (2020).

**Common names.** Kavar or kawar (= probably from kahvar (like wheat straw), Y. Keivany, pers. comm., 25 September 2018), aroos or arus mahi (= bride fish).

[Bara'an or bir-aan abiadh in Arabic; Akbalık in Turkish (Kaya *et al.*, 2016); long-snouted chub, Mesopotamian pike chub, Tigris dace].

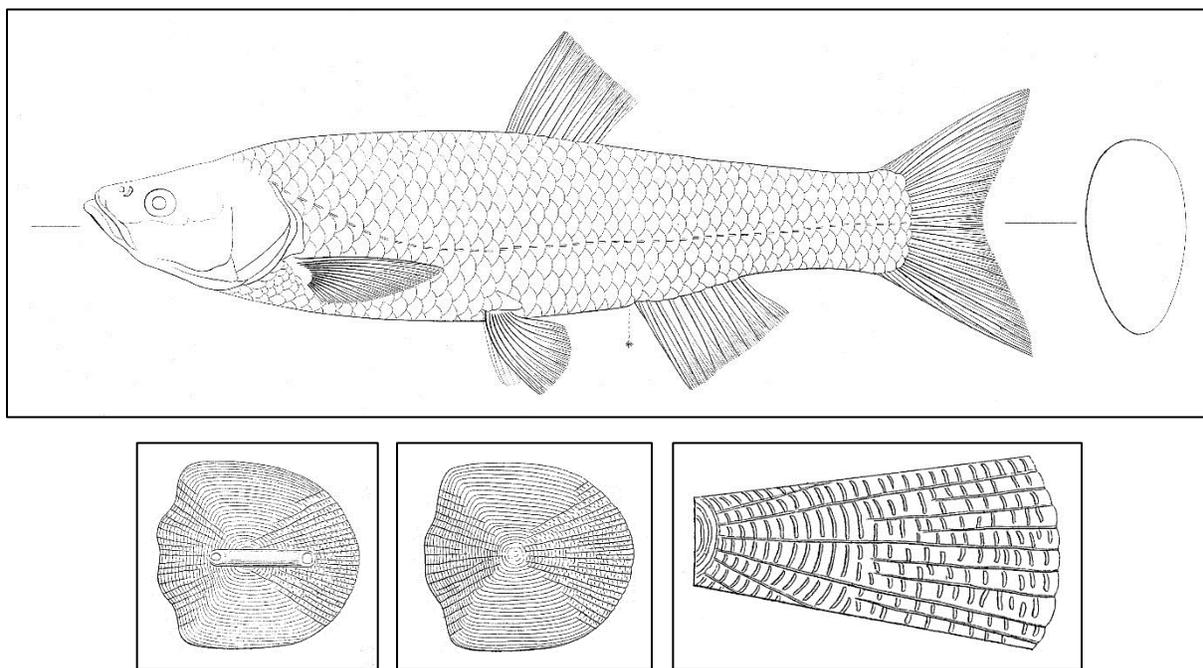
**Systematics.** *Squalius lepidus* was originally described from the "Tigris bei Mossul" (Heckel, 1843b).

*Alburnus doriae* De Filippi, 1865 and *Alburnus maculatus* Keyserling, 1861 are synonyms according to Coad (1982c, 1985) but these are errors. Note also that *Alburnus maculatus* Kessler, 1859 from the Salghir River at Simferopol, Crimea, Ukraine preoccupies *Alburnus maculatus* Keyserling, 1861 and is a distinct species of *Alburnoides* (Bogutskaya and Coad, 2009).

The syntypes of *Squalius lepidus* are in the Naturhistorisches Museum Wien according to Krupp (1985c) under NMW 49342, 2 specimens, 228.3-240.2 mm standard length as measured by me and NMW 49343, 2, 82.4-107.3 mm standard length, collected by Th. Kotschy in 1843. Bogutskaya (1994), however, listed a lectotype (237.0 mm standard length) and five paralectotypes under NMW 49342, two paralectotypes under NMW 49343, and one paralectotype under SMF 847 (the paralectotypes measure 90.8-233.8 mm standard length).

Eschmeyer *et al.* (1996) also listed one syntype under NMW 49344 and this specimen (166.5 mm standard length) appears in the 1997 Vienna card catalogue as a syntype along with the other four fish mentioned by Krupp (1985c). One syntype is in the Senckenberg Museum Frankfurt (SMF 847, formerly NMW) (F. Krupp, pers. comm., 1985). The catalogue in Vienna listed six fish in spirits and one fish stuffed.

Jouladeh-Roudbar *et al.* (2020) suggested it could be a hybrid between *Alburnus* and *Squalius* species based on morphological features and its rarity. Molecular work is needed to clarify this suggestion.

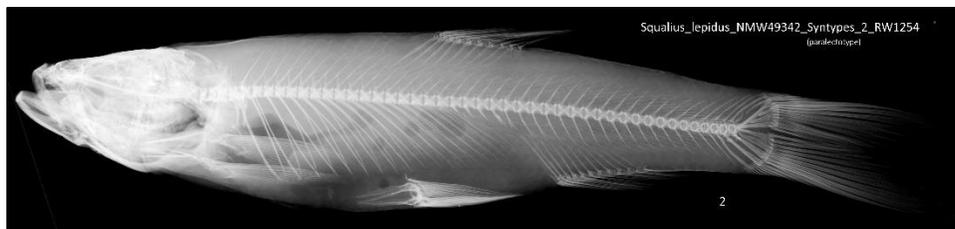


*Squalius lepidus*,

body and cross-section, lateral line scale, flank scale from between the dorsal fin and lateral line, and detail of flank scale, Naturhistorisches Museum, Wien, after J. J. Heckel.



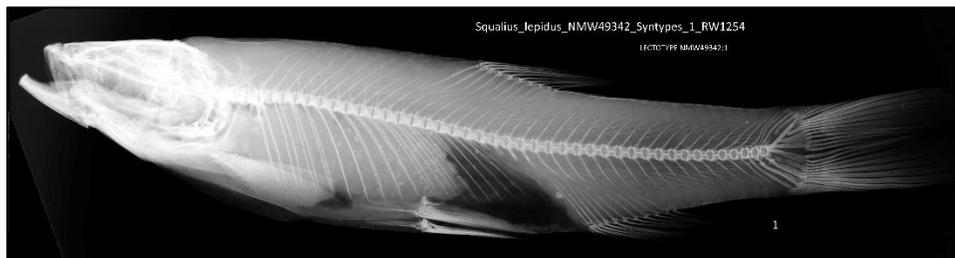
*Squalius lepidus*, lectotype, NMW 49342, Naturhistorisches Museum Wien.



*Squalius lepidus*, lectotype, NMW 49342, Naturhistorisches Museum Wien.



*Squalius lepidus*, paralectotype, NMW 49342, Naturhistorisches Museum Wien.



*Squalius lepidus*, paralectotype, NMW 49342, Naturhistorisches Museum Wien.



*Squalius lepidus*, paralectotypes, NMW 49343, Naturhistorisches Museum Wien.



*Squalius lepidus*, paralectotypes, NMW 49343, Naturhistorisches Museum Wien.

**Key characters.** This species is distinguished by the elongate and pointed head with a projecting lower jaw, an adaptation for piscivory which develops early and is not evident in other *Squalius* even when these feed on fish as adults.

**Morphology.** The body is compressed and moderately deep. The predorsal profile is slightly to moderately convex. A nuchal hump may develop. The caudal peduncle is compressed and moderately to quite deep. The projecting lower jaw fits into a notch in the upper jaw. The mouth is oblique and extends back level with the nostril or the anterior eye margin. The dorsal fin margin is rounded and the fin origin is slightly posterior to the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the anterior or mid-anal fin. The caudal fin is moderately to shallowly forked with rounded lobes. The anal fin margin is straight and the fin does not reach back to the caudal fin base. The pelvic fin is rounded and does not reach back to the anal fin origin. The pectoral fin is rounded and does not reach back to the pelvic fin origin.

Dorsal fin unbranched rays 3-4, branched rays 7-10, usually 8 (Krupp, 1985c; Khaefi *et al.*, 2016) or 9 (Bogutskaya, 1994) (8 in four syntypes, 9 in one), anal fin unbranched rays 3, branched rays 8-11, usually 9 (9 in three syntypes, 10 in two), pectoral fin branched rays 14-18,

and pelvic fin branched rays 7-8, usually 8. Lateral line scales 42-55. A pelvic axillary scale is present. The scale is squarish with a rounded posterior margin, gently rounded dorsal and ventral margins, and a posterior margin with a rounded central part flanked by dorsal and ventral indentations and strong but rounded dorsal and ventral corners. The focus is almost central, slightly subcentral anterior. Circuli are fine and numerous. Scales have few to many radii on the anterior and posterior fields. Total gill rakers number 7-13, reaching the one below when appressed (near junction of upper and lower arches) and sometimes curled. Pharyngeal teeth are 2,5-5,2 or 2,5-4,2, strongly hooked and serrated. Total vertebrae number 42-46. The lectotype and paralectotype, NMW 49342, have 45 total vertebrae and the paralectotypes, NMW 49343, have 44 and 45 total vertebrae.

**Sexual dimorphism.** Unknown.

**Colour.** The back and upper flank are brown to bluish-brown or blackish, the flanks generally silvery, and the belly silvery-yellow. The upper flank, head and fins may be sprinkled with black spots. Flank scales have a spot at their base. All fins can be pale with rays pigmented, the caudal fin being overall darkest. Fins are reddish in some fish, with the pectoral and anal fins the brightest. The dorsal fin may have a black margin. The caudal fin is blue-grey or reddish and its margin is yellowish to blackish.

**Size.** Reaches 54.2 cm (Karabatak, 1997).

**Distribution.** This species is found in the Quwayq and Tigris-Euphrates basins. Records from the Tigris River basin in Iran are the Armand, Bazoft, Beheshtabad, Beshar, Boen, Chamesk, Chamzarivar, Dez, Dinorab, Dinvar, Gamasiab, Gaveh, Jarrahi, Karkheh, Karun, Kashkan, Khersan, Little Zab, Marakeh, Marun, Qareh Su, Qeshlaq, Simareh, Sirvan and Zemkan rivers, Lake Zaribar in Kordestan, the Haramabad Wetland in Hamadan, and the Qeshlaq Dam in Kordestan (Wossughi, 1978; Abdoli, 2000; Abbasi *et al.*, 2009; Bahrami Kamangar *et al.*, 2012a; Khaefi *et al.*, 2016; Taghiyan *et al.*, 2016; Pirali Khirabadi *et al.*, 2017; Fatemi *et al.*, 2019; Jouladeh-Roudbar *et al.*, 2020; K. Abbasi photograph, see above). Also recorded from Mendeli on the Iran-Iraq border (Berg, 1949). Abdoli (2000) recorded this species from the Qom, Shur and Zayandeh rivers probably in error. Soofiani *et al.* (2011) recorded this species from the Dimeh Spring in the Zayandeh River - their largest specimen was 16.3 cm (*cf.* maximum size above) and identification needs verification. Also recorded from the headwaters of the Karun River as *Squalius cf. lepidus* (Zamaniannejad *et al.*, 2015). A record from a canal near Gaz a few miles from Esfahan is also probably an error (Keyserling, 1861).



Kohgiluyeh and Bowyer Ahmad, Khersan River near Cheshmeh Nesai-ye Banestan (river in Kohkiluyeh and Boyer-Ahmad.... in Farsi, CC BY 3.0, Seyed Mahmoud Javadi).

**Zoogeography.** Durand *et al.* (2000) using cytochrome *b* suggested that this species is fully introgressed with mtDNA of *Leuciscus cephalus* (= *S. cephalus* and presumably what is now recognised as *S. berak*) and so question the taxonomic validity of this species. Morphological data contradicts this conclusion. Durand *et al.* (2000) concluded that their data did indicate that “*L. lepidus* and *L. cephalus* might have had different dispersion histories over the same geographical range” and that “*L. lepidus* introgression by the chub (*L. cephalus*) is ancient, explaining the complete sorting of the *lepidus* lineage”. However, Özuluğ and Freyhof (2011) speculated that this taxon is not the sister species of all other chubs in the Euro-Asiatic lineage but just easier to recognise. Khaefi *et al.* (2016) noted occasional hybridisation with *S. berak* which might lead to false identifications.

**Habitat.** This species is found in rivers, lakes and dams. Özuluğ and Freyhof (2011) found it to be restricted to main rivers while other, related species are found in tributaries. Khaefi *et al.* (2016) found it to be widespread in larger rivers and streams in lowland habitats. It occurred syntopically with *S. berak* in the Tabon River of the Little Zab River basin of Iraqi Kurdistan

**Age and growth.** Soofiani *et al.* (2011) for their 415 Zayandeh River fish (see identity comment above) found maximum age was 4<sup>+</sup> years, male:female sex ratio was 1:3, and von Bertalanffy growth parameters were  $k = 0.162$ ,  $LY = 232$  mm,  $t_0 = -0.427$  years for females and  $k = 0.136$ ,  $LY = 217$  mm,  $t_0 = -0.847$  years for males. The length-weight relationship was  $W = 0.00005L^{2.827}$  for males and  $W = 0.00005L^{2.855}$  for females, indicating negative allometric growth for both sexes. Hasankhani *et al.* (2014) found a *b* value of 2.78 for 62 fish, 4.3-15.4 cm total length, from the Sirvan River.

Çolak (1983) studied the age of this species in the Keban Dam, Turkey and found a maximum age of 8 years, that females grew faster and were longer than males, and growth was rapid until 5 years of age when it fell by almost half in each succeeding year. von Bertalanffy formulae, sexes combined, for two years were  $L_t = 87.92 (1 - e^{-0.112(t+1.464)})$  and  $L_t = 65.64 (1 - e^{-0.214(t+0.878)})$ .

**Food.** Plant remains and fish scales have been found in gut contents. Fish appeared to be the main diet item even in young from about 10 cm in length (Bogutskaya, 1994) although Al-Rudainy (2008) cited fish fry and aquatic insects for Iraqi fish, presumably smaller ones.

**Reproduction.** Soofiani *et al.* (2011) for their Zayandeh River fish (identity uncertain) found minimum, maximum and mean fecundity to be 1,161, 12,953 and 4,279 eggs and relative fecundity was 148.4 eggs/g body weight. Gonadosomatic values indicated spawning in May-June.

Ünlü (2006) gave age at first maturity as 2-3 years in the Turkish Tigris River with spawning over sand, stone and gravel. Al-Rudainy (2008) cited sexual maturity at 3-4 years, 30 cm length and 3 kg weight in Iraq with spawning in March and April with eggs deposited in shallow water on gravel beds.

**Parasites and predators.** Williams *et al.* (1980) reported the digenean helminth *Allocreadium isoporum* from this species in the Zayandeh River at Esfahan but the fish species was most probably misidentified. Barzegar *et al.* (2008) recorded the digenean eye parasite *Diplostomum spathaceum* from this fish.

**Economic importance.** None.

**Experimental studies.** None.

**Conservation.** Listed as of Least Concern by the IUCN (downloaded 25 February 2019).

**Sources.** Some counts were taken from Bogutskaya (1994).

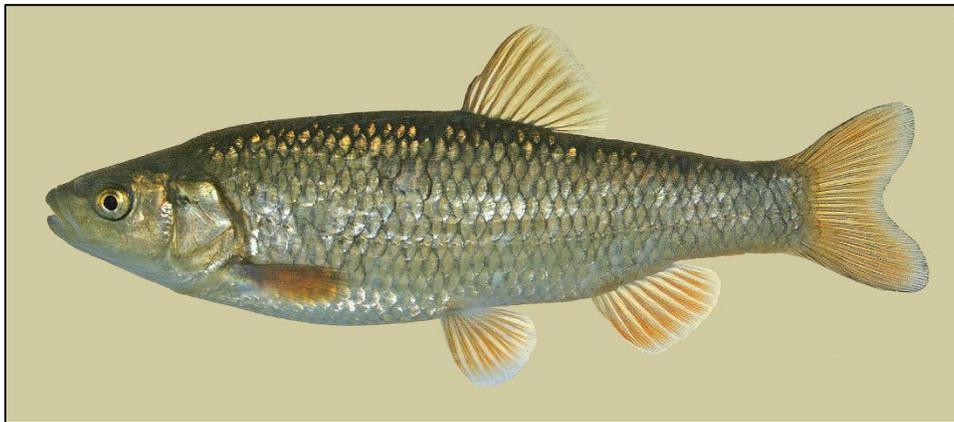
Type material:- *Squalius lepidus* (NMW 49342, NMW 49343 and NMW 49344).

Iranian material:- None.

Comparative material:- NMW 91149, 11, 69.6-115.9 mm standard length, Syria, Euphrates River at Jarabulus (36°49'N, 38°01'E); NMW 91620, 2, 91.6-95.6 mm standard length, Syria, Euphrates River at Jarabulus (36°49'N, 38°01'E); NMW 94441, 1, 175.7 mm standard length, Turkey, Palu, Murat River (38°42'N, 39°57'E).

### *Squalius namak*

Khaefi, Esmaili, Sayyadzadeh, Geiger and Freyhof, 2016



*Squalius namak*, ZM-CBSU G1001, paratype, 189.0 mm standard length, Markazi, Bolagh Spring, Hamid Reza Esmaili.

**Common names.** Mahi sefid (= white fish - in central Iran), mahi sefid-e Namak (= Namak white fish), aroos or arus mahi Namak (= Namak bride fish).

[Namak Lake Chub].

**Systematics.** The holotype is under ZM-CBSU (Zoological Museum of Shiraz University, Collection of Biology Department, Shiraz) G121, 136 mm standard length, Iran, Markazi Province, spring Bolagh (Cheshmeh Bolagh) at Shazand, east of Anjirak, 34°00'38"N 49°50'51"E. Paratypes are from Markazi Province, ZM-CBSU G1001, 2, 155-189 mm standard length, ZM-CBSU G111, 10, 170-202 mm standard length, ZM-CBSU E769, 28, 57-188 mm standard length, ZM-CBSU G433, 5, 144-168 mm standard length and FSJF (Fischsammlung J. Freyhof, Berlin) 3521, 5, 105-146 mm SL, all same data as the holotype, and ZM-CBSU D871, 22, 37-110 mm standard length and FSJF 3522, 5, 57-122 mm standard length, Poledoab River at Shazand, 34°02'36"N 49°21'09"E. The species is named for the Namak Lake basin.

Mouludi-Saleh and Keivany (2018a) compared the three chub species from the Caspian Sea and Lake Urmia, Namak Lake and Tigris River basins based on 709 specimens and using 14 meristic and 19 morphometric characters. Significant differences in 11 meristic and 15 morphometric characters were found, the major differences being related to the position of the pectoral fin and head and body depth, but in general the populations highly overlapped.

Mouludi Saleh *et al.* (2017) examined fish from three rivers (Ginercheh, Jaj and Qom) in the Namak Lake basin and found significant differences in morphometry (such as head and body depths, anal fin position, caudal fin length and width) attributed to variation in water flow and level of feeding. Mouludi-Saleh and Keivany (2018c) examined fish morphometrically from the Khaznagh and Qareh Chay rivers and found the latter had a greater body depth and smaller head length and the former had a more inferior mouth, a longer snout and a shallower caudal peduncle. The inferior mouth may indicate bottom feeding and the shallower body a faster water habitat. Mouludi Saleh *et al.* (2018) compared the biometry of fish from Ghinercheh, Jaj, Khaznagh, Qareh Chay and Qom rivers using 14 meristic and 19 distance characters. The Khaznagh, Qareh Chay and Qom populations were separable morphometrically but meristic characters overlapped. Mouludi-Saleh and Eagderi (2021) compared this species with *S. turcicus* morphometrically and found the latter has a deeper body, longer caudal peduncle and a ventral snout position.

**Key characters.** This species is distinguished by having a wide and thick symphyial knob on the lower jaw, the upper lip clearly projecting beyond the lower lip, a deep and blunt head, a convex posterior anal fin margin, a bold, dark-grey or brown, roundish or crescent-shaped blotch at the posterior tip of each flank scale, orange caudal, anal and pelvic fin rays in life, distribution in the Dasht-e Kavir and Namak Lake basins, and mtDNA COI barcode data.

**Morphology.** The body is elongated, compressed and moderately deep. It is deepest in front of the dorsal fin between the end of the pectoral fin and the origin of the pelvic fin. The predorsal profile is slightly convex and a slight to well-developed nuchal hump is present. The upper head profile is concave or straight and the interorbital area is concave. The caudal peduncle is compressed and deep. The belly between the posterior pelvic fin bases and the anus is compressed. The snout is rounded to pointed. The rear margin of the eye is in the anterior half of the head. The mouth is oblique and terminal or subterminal or the lower lip may project slightly. The mouth extends back level with the anterior eye margin. The upper lip is thick at its mid-point. The uppermost point of the mouth cleft is between the level of the lower margin of the pupil and the lower margin of the eye. The lower jaw-quadrant junction is at about a vertical through the anterior margin of the eye. The lower jaw has a very wide and thick symphyial knob. The dorsal fin origin is well behind the level of the pelvic fin origin. The depressed dorsal fin reaches back level with the anterior anal fin. The dorsal fin margin is rounded to straight. The caudal fin is shallowly forked with rounded lobes. The anal fin margin is straight to rounded and

does not reach back to the caudal fin base. The pelvic fin is rounded and does not reach back to the anal fin origin. The pectoral fin is rounded and does not reach back to the pelvic fin origin.

The following counts are from Khaefi *et al.* (2016):- dorsal fin unbranched rays 3-4, mode 3, branched rays 7-10, mode 8-9 (in text; 7-9, mode 8 in table), anal fin unbranched rays 3-4, mode 3, branched rays 7-10, mode 8 (in text; 6-9, mode 8 in table), pectoral fin branched rays 15-18, usually 16-17, pelvic fin branched rays 9-11, mode 9. Lateral line scales 39-43 (in text; 40-45 total in table presumably including scales on caudal peduncle; Jouladeh-Roudbar *et al.* (2020) gave 39-46), scales between dorsal fin and lateral line 6-8, mode 7 (in text; 7-9, mode 8 in table), scales between pelvic fin and lateral line 3-4, mode 3 (in text; 4-5, mode 4 in table), scales around caudal peduncle 14-18, mode 16, and predorsal scales 19-24 (in text; 18-23 in table). A pelvic fin axillary scale is well-developed. Scale shape is squarish. Scales have a shallowly rounded posterior margin, gently rounded dorsal and ventral margins, and an anterior margin with a central protrusion with an indentation above and below. The anterior scale corners are abrupt but rounded. There are numerous fine circuli, a subcentral and slightly anterior focus, and few anterior and posterior radii. Total gill rakers number 9-12, mode 10. Pharyngeal teeth number 2,5-5,2, presumably with variants as seen under *S. turcicus*, and teeth are hooked at the tip and strongly serrated below it. Total vertebrae number 40-42 (Jouladeh-Roudbar *et al.*, 2020).

Meristic values are:- dorsal fin branched rays 7(2) or 8(4), anal fin branched rays 7(1), 8(28) or 9(18), pectoral fin branched rays 15(2), 16(11), 17(30) or 18(4), pelvic fin branched rays 6(1), 7(-), 8(42) or 9(3), lateral line scales 41(13), 42(19), 43(11), 44(3), 45(-) or 46(1), total gill rakers 7(1), 8(3), 9(25) or 10(17), and total vertebrae 40(5), 41(13) or 42(12).

**Sexual dimorphism.** A specimen 97.2 mm standard length (CMNFI 2008-0228) had small tubercles closely spaced on the top and sides of the head, one to two rows on the unbranched pectoral fin ray and weakly on the branched rays, but this was a small fish where tuberculation was probably incompletely developed.

**Colour.** Khaefi *et al.* (2016) described live fish as having the head and body silvery brown, darker on the back, and the belly white. A faint black bar runs from the uppermost part of the gill opening to the pectoral fin base. Each flank scale margin has dark brown or black pigments forming a reticulate pattern. Scale pockets are poorly pigmented above the lateral line, with a bold, brown or black, crescent-shaped, vertically elongated or roundish anterior scale mark on scales below the lateral line. Free margins of scales above the lateral line are pale brown or grey, each with a bold, brown or black, crescent-shaped, vertically elongated or roundish blotch on the posterior tip. The pectoral, pelvic, anal and caudal fin rays are orange, the caudal fin rays with black pigments. Dorsal fin membranes are hyaline with dark-grey rays. Preserved fish have a pale brown head and body, darker on the back. Dorsal and caudal fins have blackish rays and hyaline membranes. The pectoral, pelvic and anal fins have whitish rays and yellowish membranes. The peritoneum is black.

**Size.** Attains 18.9 cm standard length (Khaefi *et al.*, 2016).

**Distribution.** This species is found in the Dasht-e Kavir and Namak Lake basins. In the Dasht-e Kavir basin in the Hableh and Nam rivers; and in the Namak Lake basin in the Ab Chay, Abhar, Abshineh-Simineh, Alichay, Bahador Beyg, Bar, Damagh-Tasranmix, Fordaghan, Ghinercheh, Jaj, Kaleh, Karaj, Khar, Khaznagh, Khenejin, Khomeigan, Mazlaghan (= Mazdaqan), Pol-e Doab, Qareh Chay, Qom, Ravan, Saleh Abad, Sharra, Shur, Siah and Suzan rivers, the Bolagh, Emarat and Eskan springs in the Pol-e Doab River drainage, and the Emamzadeh Abdollah Spring in the Qom River drainage (Touraji and Vosoughi, 2006; Abbasi, 2009; Mirzaei *et al.*, 2010; Khaefi *et al.*, 2016; Mouludi Saleh *et al.*, 2017, 2018; Mouludi-Saleh

and Keivany, 2018b, 2018c; Eagderi *et al.*, 2020).

**Zoogeography.** See above under the genus.

**Habitat.** This species is found in rivers and springs. Collection data included a temperature range of 17.8-26°C, pH 6.0-6.5, conductivity 1.3-3.7 mS, river width 0.5-12 m, slow to fast current, depth 70-100 cm, mud, sand, gravel or pebble bottoms, encrusting vegetation, and a grassy shore.

**Age and growth.** Mouludi-Saleh and Keivany (2018b) examined 132 fish, 2.4-15.1 cm total length, from the Ghare-Chi (= Qareh Chay), Ghinercheh (*sic*), Jaj, Khaznagh and Qom rivers of the Namak Lake basin and found a *b* value of 3.25. Eagderi *et al.* (2020) examined 49 fish, 8.21-16.6 cm total length, from the Ghareh-Chai (= Qareh Chay), Mazlaghan-Chay (= Mazdaqan Chay) and Nam rivers and found a *b* value of 3.09, positively allometric.

**Food.** Unknown.

**Reproduction.** Unknown.

**Parasites and predators.** None reported.

**Economic importance.** None.

**Experimental studies.** None reported.

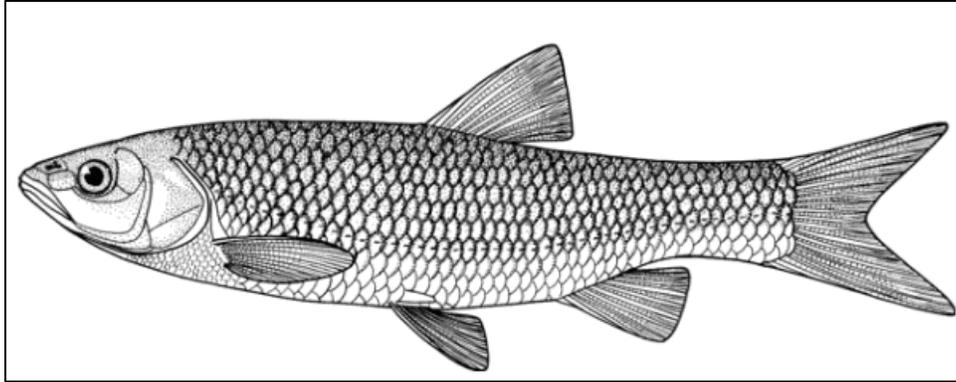
**Conservation.** This species is found in a basin with large population centres and agriculture and so would be under threats similar to related species elsewhere and to other species in this basin. Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern because populations are widespread and there are no major threats.

**Sources.** Khaefi *et al.* (2016).

Iranian material:- CMNFI 1979-0253, 33, 46.4-100.4 mm standard length, Qom, river in Qareh Chay drainage (34°52'N, 50°49'E); CMNFI 1979-0255, 2, 90.7-90.8 mm standard length, Markazi, Bar River drainage 2 km west of Shahabiyeh (33°51'30"N, 50°23'E); CMNFI 1979-0462, 12, 50.7-104.5 mm standard length, Markazi, Mazdaqan River (35°06'30"N, 49°40'30"E); CMNFI 1979-0465, 13, 54.7-70.5 mm standard length, Markazi, Qom River (34°18'30"N, 50°32'E); CMNFI 1980-0156, 1, 54.2 mm standard length, Alborz, Karaj River below village (35°47'N, 50°58'E); CMNFI 1993-0154, 1, 94.8 mm standard length, Markazi, Sharra River near Far (34°03'N, 49°20'E); CMNFI 1993-0158, 1, 88.5 mm standard length, Markazi, Sharra River at Taht-e Mahall (34°01'N, 49°22'E); CMNFI 2007-0074, 17, 24.3-125.5 mm standard length, Markazi, Qareh Chay 32 km west of Arak (34°03'N, 49°21'E); CMNFI 2007-0077, 1, 49.0 mm standard length, Markazi, Qom River (ca. 34°18'N, 50°32'E); CMNFI 2007-0078, 2, 90.4-108.6 mm standard length, Markazi, Qom River (ca. 34°18'N, ca. 50°32'E); CMNFI 2007-0120, 25, 31.1-47.4 mm standard length, Hamadan, Ab Chay near Hamadan (ca. 34°49'N, ca. 48°29'E); CMNFI 2007-0122, 1, 46.7 mm standard length, Qazvin, Khar River basin south of Takestan (ca. 35°56'N, ca. 49°30'E); CMNFI 2008-0152, 2, 89.2-117.6 mm standard length, Namak Lake basin (no other locality data); CMNFI 2008-0228, 2, 85.9-97.2 mm standard length, Markazi, Qom River (no other locality data).

*Squalius turcicus*

De Filippi, 1865



*Squalius turcicus*

Susan Laurie-Bourque @ Canadian Museum of Nature.



*Squalius turcicus*, Gilan, Lakan River, Anzali Talab basin, 0.35 kg, caught on blood worm and released, Sarang Nouripanah.



*Squalius turcicus*, Gilan, Lakan River, Anzali Talab basin, female, 40 cm, 0.9 kg, Sarang Nouripanah.



*Squalius turcicus*, Zanjan, Golabar Reservoir, November 2011, Keyvan Abbasi.

**Common names.** Mahi sefid (= white fish), kuli (= general term for any small fish), Sefid roodkhaneyi (= Sefid River fish), aroos, arus or ‘rus mahi (= bride fish, Y. Keivany, pers. comm., 25 September 2018).

[Enlibas or gafgaz enlibasi, nour enlibasi for natio *kaznakovi*, all in Azerbaijan; tepug in Armenia; Kura tatlı su kefali in Turkish (Kaya *et al.*, 2020); Kavkazskii golavl’ or Caucasian chub in Russian; Transcaucasian chub].

**Systematics.** Iranian populations were usually recognised as *Leuciscus cephalus orientalis* (Nordmann, 1840) in past literature. The nominal Iranian subspecies, *L. cephalus orientalis*, differs from the European subspecies, *L. c. cephalus*, by having a more elongate body, a dark stripe behind the operculum and on average fewer scales and anal fin branched rays according to Berg (1948-1949, 1949). Bianco and Banarescu (1982) pointed out that there had been no critical revision of the *cephalus* subspecies and that differences were slight. Recognition of subspecies is disputable according to Reshetnikov *et al.* (1997). However, *S. orientalis* was recognised as a species by Turan *et al.* (2009), Bogutskaya and Zupančič (2010) and Esmaili *et al.* (2014), and others, and was used as the name for the fishes found in the Caspian Sea basin of Iran. *Cyprinus cephalus* Linnaeus, 1758 was originally described from northern Europe. *Leuciscus orientalis* Nordmann, 1840 was originally described from Abkhazia, Georgia.

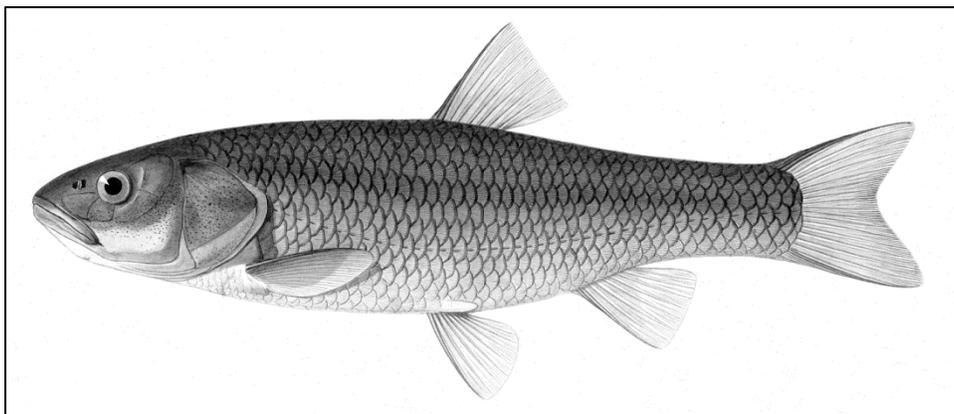
Doadrio and Carmona (2006), Özuluğ and Freyhof (2011), Turan *et al.* (2013, 2017), Keivany *et al.* (2016), Khaefi *et al.* (2016), Abbasi *et al.* (2017), Eagderi and Moradi (2017), Esmaili *et al.* (2017) and Mouludi-Saleh *et al.* (2018) considered fish in the Caspian Sea and Lake Urmia basins of Iran to be *S. turcicus*. However, Çiçek and Sungur Birekcikligil (2016) did not record *S. turcicus* from localities near Iran in their collections in the Turkish Kura-Aras River basin. Fish from the Lake Urmia basin are distinct from Kura River (and presumably Caspian Sea basin fish here referred to *S. turcicus*) and are more closely related to Tigris River basin fish according to N. Bogutskaya (*in litt.*, 9 November 2015). Recent molecular studies cited above disagree. It is distinguished from *S. orientalis* (Nordmann, 1840) of the Black Sea basin by the absence of orange pigments on the anal fin rays of live specimens having a few brownish pigments, narrow scale pockets almost entirely covered by the preceding scales rather than broad scale pockets, a black bar behind the opercle absent or very slightly distinct, and the absence of a hump at the nape especially in fish larger than 20.0 cm standard length (Turan *et al.*, 2013). However, colour photographs of Iranian fish show orange anal fins and a black bar behind the opercle indicating that further work is needed on the distinction of these fishes although the name *turcicus* may still apply to Caspian and Urmia fish.

*Squalius turcicus* De Filippi, 1865 described from “Dell’ Arasse presso Erzerum” (Aras River near Erzerum in Turkey) and *Squalius agdamicus* Kamensky, 1901 from near Agdam in

the Kura River basin were formerly synonyms of *S. cephalus* but are now recognised as distinct species (*Catalog of Fishes*, downloaded 23 May 2018). The recognition of the above taxa as distinct restricts the distribution of *S. cephalus* and *S. orientalis* to areas outside Iran

Several natio and varieties within what was *Leuciscus* or *Squalius cephalus* have been described from Iran or contiguous drainages and are listed as follows. They have not been used in the literature, are not available being infrasubspecific, but the names may reoccur. *Leuciscus cephalus orientalis* natio *kaznakovi* Berg, 1912 was described from Lake Nour near Vandam, Nukha District, Azerbaijan (in the Tur'yan-chai basin of the Kura River basin but not connected to it). *Squalius turcicus* var. *platycephala* Kamensky, 1897 was described from Lake Taparavani (= Lake Paravani at 41°26'N, 43°48'E) and the Kyrchbulach River in the upper Kura River basin, Georgia. *Leuciscus cephalus orientalis* natio *aralychensis* Barach, 1934 was described in Latin from "Turcia, Aralych. fl. Kara-su", and in Russian "Reka Kara-su u vblizi Aralykha podnoshchiya Ararata" (= Kara-su River at the foot of Ararat in the vicinity of Aralykha). *Leuciscus cephalus orientalis* natio *zangicus* Barach, 1934 was described in Russian from "R. Zanga v Armenii" (i.e., at Erivan). *Leuciscus cephalus orientalis* natio *ardebilicus* Barach, 1934 was described in Latin from "Ardebil, fl. Balyk-tchai in systemate fl. Arax. inf." and in Russian "R. Balyk-chaya, vblizi Ardebilya v Persii" (i.e., Balyk River or Balyk-chai) in the upper Aras River basin of Iran near Ardabil.

There are no extant types of *S. orientalis*. The syntypes of *Cyprinus cephalus* are in the Naturhistoriska Riksmuseet, Stockholm under NRM 51 (1 fish) and in the Zoologiska Museet, Uppsala Universitet, Uppsala under ZMUU Linnaeus Collection 213 (1) (Eschmeyer *et al.*, 1996; *Catalog of Fishes*, downloaded 15 May 2018). Three syntypes of *Squalius orientalis* Heckel, 1847, 111-146 mm standard length from Aleppo are in the Naturhistorisches Museum Wien under NMW 49438 (Krupp, 1985c). Two more fish from Aleppo are under NMW 49440 and measure 130.0-168.3 mm standard length and may be syntypes. Types of *Squalius agdamicus* and *S. turcicus* have not been located. Natio *ardebilicus* syntypes are in the Georgian State Museum, Zoological Section, Tbilisi under ZMT 136h, natio *aralychensis* syntypes are under ZMT 22-11 (10), natio *kaznakovi* syntypes are in the Zoological Institute, St. Petersburg under ZISP 12089 (5), syntypes of natio *zangicus* are in the Natural History Museum, Armenia (17) and no types of natio *platycephala* were found in the Zoological Institute, St. Petersburg (Eschmeyer *et al.*, 1996; *Catalog of Fishes* (downloaded 15 November 2015)).



*Leuciscus cephalus orientalis* natio *kaznakovi*, syntype, ca. 25.6 cm total length, ZISP 12089, Azerbaijan, lake near Vandam (= Lake Nour), Kura River basin, after Berg (1948-1949).

Özuluğ and Freyhof (2011) noted, following Berg (1948-1949), that the western lineage of *Squalius cephalus* has modally 8 anal fin branched rays while the eastern lineage has 9 and gave their own counts to confirm this. Their material did not extend east to Iran where counts given below show a mode of 8 (57.7%) with high counts of 9 (42.3%) excluding three counts of 7 branched rays. Anal ray counts do not appear to be a useful character.

Dadashpour Ahangari *et al.* (2010) compared 36 fish from the Gamasiab River (presumably *S. berak*) in the Tigris River basin and 31 from the Talar River in the Caspian Sea basin, finding significant differences in characters but no population distinction using principal components analysis. Gorjian Arabi *et al.* (2011) surveyed morphological diversity of 123 male and 115 female fish from the Tuji head branch of the Talar River, Mazandaran for eight meristic and 26 morphometric characters, finding no significant differences between sexes. Babazadeh and Vatandoust (2013) examined 167 fish from the Shahid Rajaei Dam and the Tajar River below it for 27 morphometric and nine meristic characters but found populations were not separable despite a low level of overlap. However, Babazadeh and Shapoori (2017) compared the same localities and characters and reported significant differences. Alizadeh *et al.* (2015) examined morphometric and meristic characters of fish from the Dogh, Sefid and Siah rivers in the southern Caspian Sea basin finding sexual dimorphism in all populations (pupil diameter, postdorsal distance, length of anal fin base, interorbital distance and head width), and all populations separated significantly with such characters as caudal peduncle width, pectoral fin base, eye diameter, interorbital distance, pupil diameter and anal fin base length. Mouludi Saleh *et al.* (2018) examined 264 fish from the Babol, Haraz, Neka, Noor and Tajar rivers using 13 landmarks finding Babol and Haraz populations grouped apart from the others, the major differences in body shape being related to head and body depth and position of the anal and pectoral fins. Mouludi Saleh *et al.* (2018) digitised populations from the Aras, Atrak, Ghar Chai, Kheyr, Sefid and Tajar rivers using 14 landmarks and found significant morphometric differences between them. Mouludi Saleh and Keivany (2019) compared fish morphometrically from the Chalak, Divandarreh, Kasma, Noor, Palangab, Qezel Owzan, Sefid, Shafa, Talvar, Tonekabon, Zalkie and Zarin rivers in the southwest Caspian Sea and found significant differences between populations related to head and body depth and the position of the anal, dorsal and pectoral fins. These differences were adaptations to various habitats. Mouludi-Saleh *et al.* (2020) examined 102 specimens from the Aras, Atrak, Ghareh-Su (= Qareh Su), Kheyr, Sefid and Tajar rivers using 14 homologous landmarks. Significant differences were found in body shape for the six populations in particular related to the snout, base of the dorsal and anal fins, body depth and pectoral fin position. The Kheyr population stood alone and showed a longer snout and caudal peduncle. The Tajar and Atrak populations had a higher and lower body depth. The Aras and Atrak populations possessed a shorter anal fin base and a shallower body depth. Both Aras and Atrak specimens had a shorter dorsal fin base. The Qareh Su population had a deeper caudal peduncle. These differences were attributed to phenotypic plasticity to the environment. A deeper body shape is advantageous in rapid turning and maneuvering in tight quarters, such as area with aquatic plants, as seen in the Tajar River. A lower body depth with a fusiform body shape, as seen in the Aras and Atrak populations, could decrease drag in the current, hence reducing energy consumption to maintain position and also this could be useful for constantly moving and searching out prey.

**Key characters.** This species is distinguished from its relatives by having modally 8 dorsal fin branched rays, the knob on the lower jaw symphysis is small, the posterior tip of flank scales lacks a bold blotch, the mouth is terminal (or slightly to markedly subterminal), the tip of

the upper lip is level with the tip of the lower lip, caudal, anal and pelvic fin rays are orange in life, and distribution is in the Caspian Sea and Lake Urmia basins.

**Morphology.** The body is compressed and moderately deep. The dorsal profile of the body is straight to arched while the ventral profile is convex. The caudal peduncle is compressed and moderately deep. The snout is pointed to slightly rounded and, in males, the chin is indistinct. The eye is well into the anterior half of the head. The mouth is oblique and extends back level with the anterior eye margin. Lips are moderately thick, the upper lip thickest at the middle. The dorsal fin margin is straight or slightly convex. The dorsal fin origin lies posterior to a level with pelvic fin origin (but see natio *kaznakovi* drawing above). The caudal fin is shallowly forked with rounded tips. The anal fin margin is convex to straight and the fin does not reach back to the caudal fin base. The pelvic fin is rounded and does not extend back to the anal fin. The pectoral fin is rounded and does not extend back to the pelvic fin. Fin rays are thin (Turan *et al.*, 2017).

Dorsal fin unbranched rays 2-3, usually 3, branched rays 6-10, usually 8, anal fin unbranched rays 3, branched rays 7-10, usually 8 or 9, pectoral fin branched rays 14-19, and pelvic fin branched rays 6-9, usually 8. Lateral line scales 38-48. There is a prominent pelvic axillary scale. Scale shape is squarish. The anterior scale margin is wavy, sometimes irregular and in others with a small central protuberance and indentations above and below. Scales have few to moderate numbers of radii on the anterior and posterior fields. The focus is central to subcentral anterior and circuli are fine. On the posterior field, circuli break up into tubercles and are coarser than on other fields. Total gill rakers number 7-12, and are short, touching the adjacent raker when appressed. Pharyngeal teeth are 2,5-5,2, with variants 2,5-4,2, 2,4-4,2, 2,5-5,1, 1,5-5,2, 1,5-5,1, 2,5-5,3, 2,6-5,2, or even 1,5-5,1,2 and 1,2,5-5,2,2. Teeth are very narrow, strongly hooked at the tip and with strong rounded serrations below so that there is no obvious flat surface. The gut is an elongate s-shape. Total vertebrae number 40-46, usually 41-42. Total vertebrae number 47-49 according to Jouladeh-Roudbar *et al.* (2020) at variance with my counts. Chromosome number is  $2n = 50$  (Al-Sabti, 1986; Klinkhardt *et al.*, 1995; Arai, 2011; Kiliç and Şişman, 2016 - for fish identified as *S. cephalus*). Jalali (2015) and Vatandoust *et al.* (2016) described the osteology of this species in the Caspian Sea and Lake Urmia basins.

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(3), 8(103) or 9(1), anal fin branched rays 7(3), 8(60) or 9(44), pectoral fin branched rays 14(3), 15(13), 16(39), 17(46), 18(5) or 19(1), pelvic fin branched rays 6(1), 7(1), 8(100) or 9(5), lateral line scales 40(2), 41(20), 42(45), 43(30), 44(9), 45(-) or 46(1), total gill rakers 7(2), 8(14), 9(58), 10(31) or 11(2), and total vertebrae 40(6), 41(29), 42(45) or 43(6).

Khaefi *et al.* (2016) and Mouludi-Saleh *et al.* (2018) summarised meristic characters for fish from Caspian Sea Iranian rivers as follows: dorsal fin branched rays 6-10, mode 8, anal fin branched rays 7-10, mode 8, pectoral fin branched rays 14-17, pelvic fin branched rays 8-9 (in a table, 7-9 in the text of Mouludi-Saleh *et al.* (2018)), lateral line scales 41-47, scales above lateral line 7-10, mode 8, scales below lateral line 3-5, mode 4, predorsal scales 16-23 and scales around caudal peduncle 14-16 (in a table, 12-16 in the text of Mouludi-Saleh *et al.* (2018)). The population from the Divandarreh River was identified as a separate group based on cluster analysis (in the abstract, Kasma River in the text and a table) but generally meristic characters cannot separate populations although six major clusters were recognised. My counts agree with those of Turan *et al.* (2013) for fish from the Aras and Kura rivers in Turkey.

**Sexual dimorphism.** Abdurakhmanov (1962) reported that head length, eye diameter, caudal peduncle length, dorsal and anal fin heights, pectoral and pelvic fin lengths and lower

caudal fin lobe length are all greater in males while postorbital length, interorbital width, head depth and pectoral-pelvic fin distance are greater in females. See also above under **Systematics**.

**Colour.** Overall colour is silvery to grey. Scales of the lateral line and upper back have a strong dark pigmentation along the posterior margin and a distinct dark spot anteriorly but no bold blotch at the posterior scale tip. Scales may have some gold in their centre. The back is dark brown or reddish-brown to blue-grey and the belly and lower head are pearly-white to a silvery yellow. The operculum is a strong copper-yellow colour and the opercular opening is dark, nearly black. The iris is silvery and has very little gold, or is golden with a lot of dark grey pigment. There may be an upper spot of dark grey on the iris. The dorsal and anal fins are grey and may have some pink or orange. The dorsal fin is blackish distally. The pectoral fin has a little pale grey pigment and there may be a yellow or yellow-pink spot at its upper base with this colour extending onto the first 2-3 rays. The pelvic and anal fins are pink to red-pink or orange with somewhat colourless posterior margins, especially in spawning males. The caudal fin is dark or a pale pink to dirty reddish with some dark pigmentation to the posterior margin. The peritoneum is dark brown in preserved fish.

**Size.** Possibly as long as 85.0 cm although 45.0 cm is a more likely maximum (Berg, 1948-1949; Machacek (1983-2012), downloaded 27 July 2012) and a weight of 6-8 kg, possibly 10.0 kg (Machacek (1983-2012), downloaded 27 July 2012), although these figures included *S. cephalus*. Reaches 43.0 cm total length in the Madar Su of Golestan National Park (A. Abdoli, pers. comm., 1995). Reaches 39.2 cm and 870 g in Taham Dam in northern Iran (*Iranian Fisheries Research Organization Newsletter*, 54 & 55:4, 2008). Attains 39.0 cm fork length in Çıldır Lake, Aras River basin, Turkey (Yerli *et al.*, 1999).

**Distribution.** This species is found in the Caspian Sea and Lake Urmia basins. Records for the Caspian Sea basin are the Ahar, Alamut, Aras, Atrak, Avachar, Azar, Babol, Balekhlu, Chalak, Chalus, Chapak, Chay, Cheshmeh Kileh, Divandarreh, Dogh, Garm, Gaveh, Ghar Chai, Ghorichay (= Quri Chay), Gorgan, Haraz, Harisak, Haviq, Kasma, Kelarud, Keselian (= Kaslian), Khair (= Kheyr), Kiarud, Lakan, Madar Su, Neka, Noor, Palangab, Pir Bazar, Polrud (= Pol-e Rud), Qareh Su, Qezel Owzan, Qonbad, Ramian, Rasteh, Sardab, Sefid, Shafa, Shah, Shalman, Shirabad, Shirud, Shur, Siah, Siah Darvishan, Tajan, Talar, Taleghan (= Taleqan), Talvar, Tilabad, Tonekabon, Tuji, Valam, Yasalegh, Zalkie, Zanjan, Zarin, Zarrin Gol, Zav and Zonuz rivers, Chay Almas Spring in Ardabil Province, the Anzali Wetland, the Alborz, Sattarkhan and Shahid Rajaei dams, the Golabar and Taham dams in Zanjan Province, and the Nazdik, Sefid and Zir dams on the Sefid River; and for the Lake Urmia basin the Aji (= Talkheh), Baranduz, Bitas, Chamalton, Hasanlu, Koter, Mahabad, Mardogh, Qader, Roseh, Saqqez, Serudan, Simineh and Zarrineh rivers, and in the Cheragveis, Hasanlu and Mahabad dams (Günther, 1899; Berg, 1949; Wossughi, 1978; Bianco and Banarescu, 1982; Holčík and Oláh, 1992; *Abzeeyan*, Tehran, 5(5):III, 1994; Abbasi *et al.*, 1999, 2005, 2007, 2009, 2014; Roshan Tabari, 1997; Shamsi *et al.*, 1997; Kiabi *et al.*, 1999; Abdoli, 2000; Mirhasheminasab and Pazooki, 2003; Aghili *et al.*, 2008; Abdoli and Naderi, 2009; Hajirostamloo, 2009; Piri *et al.*, 2009; Mirzajani, 2010; Gorjian Arabi *et al.*, 2011, 2012; Mirzajani *et al.*, 2012; Babazadeh and Vatandoust, 2013; Rahmani *et al.*, 2013; Abdoli *et al.*, 2014; Gholizadeh *et al.*, 2014; Hosseinifard *et al.*, 2014; Moradi and Eagderi, 2014; Rekabi *et al.*, 2014; Jafarzadeh *et al.*, 2015; Khaefi *et al.*, 2016; Taghiyan *et al.*, 2016; Vatandoust *et al.*, 2016; Babaei, 2017; Eagderi and Moradi, 2017; Taheri Mirghaed *et al.*, 2017, 2018; Mouludi-Saleh and Keivany, 2018b; Mouludi Saleh *et al.*, 2018, 2018, 2020; Fathi and Ahmadifard, 2019; Eagderi *et al.*, 2020; Jouladeh-Roudbar *et al.*, 2020; Mouludi-Saleh *et al.*, 2020; Shahnazari *et al.*, 2020; Aazami and Alavi

Yeganeh, 2021; Seyfi *et al.*, 2021).

**Zoogeography.** Durand *et al.* (1999), working on the cytochrome *b* of European populations, found that a lineage from a Ponto-Caspian refugium recolonised the Baltic area in the Holocene after glaciation. Durand *et al.* (2000), again examining cytochrome *b*, considered that *S. cephalus* (presumably including *S. orientalis* and other taxa formerly called subspecies or synonyms) may have originated from Mesopotamia and, in the late Pliocene, used the large inland lake of Anatolia existing at that time for dispersion. Uplift of the Anatolian Plateau, climatic changes and river isolation was probably the main vicariant event leading to a quick radiation in these chubs.

**Habitat.** This species is found in rivers, streams, lakes, dams, lagoons and marshes. Collection data included a temperature range of 11.5-29°C, pH 6.0, conductivity 0.75-1.95 mS, river width 2-100 m, still to fast current, depth 50-100 cm, muddy water, mud, clay, sand, gravel or pebble bottoms, encrusting, emergent and submergent (such as *Potamogeton*) vegetation, and a grassy or forested shore. In the Caspian Sea basin, it is found mainly in upstream waters according to Naderi Jolodar and Abdoli (2004).



Habitat of *Squalius turcicus*, Gilan, Lakan River, Anzali Talab basin, Sarang Nouripناه.



Habitat of *Squalius turcicus*, CMNFI 1979-0482, Golestan, river between Minudasht and Dowlatabad, 6 July 1978, Brian W. Coad.

**Age and growth.** The weight class 150-450 g dominated in Taham Dam in Iran (*Iranian Fisheries Research Organization Newsletter*, 54 & 55:4, 2008). Ashja Ardalan *et al.* (2011) examined 441 fish from the Babol River and found the average total length was 165.6 mm, with an average maximum in May (190.6 mm) and an average minimum in October (137.5 mm), average fork length and weight for males was 139.72 mm and 43.18 g, these values for females being 152.88 mm and 57.32 g, fish reached age 4<sup>+</sup> with most in age group 2 and the minimum in age group 4<sup>+</sup>. The gonadosomatic index for males was 1.47 and for females 2.95 and the hepatosomatic index was 0.73 for males and 1.08 for females. Biniiaz *et al.* (2011) in contrast found 7 age groups in 251 fish above and below the Alborz Dam on the Babol River. Above the dam, the average of total length and body weight for males was 120.44 mm and 23.23 g, for females 148.33 mm and 39.91 g, and below the dam, for males was 117.08 mm and 22.15 g and for females 131.47 mm and 31.9 g, and the sex ratio of female:male, above and below the dam was 1:1 and 1:1.69, respectively. Gorjian Arabi *et al.* (2012) examined 298 fish from the Tuji tributary of the Talar River in Mazandaran finding fish from 0<sup>+</sup> to 4<sup>+</sup> years, positive allometric growth for males and females and negative isometric growth for immature fish, fastest growth in age groups 2<sup>+</sup> and 3<sup>+</sup> (average instantaneous growth rate 1.1, compared to 0.89 for 3<sup>+</sup> and 4<sup>+</sup> age groups), highest condition factor 1.58 for females and lowest 1.17 for immature fish, and an equal sex ratio. Alizadeh *et al.* (2014) compared 958 fish from Gilan, Golestan and Mazandaran and found a total length of 22-33 cm, weight 138.62-347.7 g, males age 0<sup>+</sup> to 5<sup>+</sup> and females age 0<sup>+</sup> to 6<sup>+</sup>, von Bertalanffy parameters different between males and females in each area and between the same sexes of different areas, the largest L<sub>∞</sub> was in Gilan (38.97 cm for females), growth was positively allometric (except for males in Golestan), the highest condition factor was for males in early June, and females had the highest growth rate. Esmaeili *et al.* (2014) gave a *b* value for 16 fish from the Caspian Sea, 8.37-11.6 cm total length, as 3.17. Rekabi *et al.* (2014) found no significant differences between condition factors of 46 and 24 fish from the Siah and Tajar rivers (averages 1.39 and 0.49) and growth was isometric and positive allometric

respectively. Aazami *et al.* (2015b) gave a  $b$  value of 3.09 for 642 fish, 5.73-21.18 cm total length, from the Tajan River. Amouii *et al.* (2016) found females were between 1 and 5 years old in the Sefid River based on 150 females, 8.5-32.0 cm total length. Seifi *et al.* (2017a, 2017b) found 591 fish in the Shahid Rajaei Dam in Sari during four seasons in 2015-2016 had mean total length for males and females as 161.36 and 170.75 cm and mean body weight for males and females as 54.18 and 63.61 g, the length-weight relationship for males was  $3.056W = 0.01L$  and for females was  $3.0025W = 0.0113L$ , indicating isometric growth, and back calculations determined for all age groups 1 to 4 years old did not show a significant difference between methods. Mouludi-Saleh and Keivany (2018b) examined 542 fish, 2.0-18.1 cm total length, from the Babol, Chalak, Divandarreh, Haraz, Kasma, Neka, Noor, Palangab, Qezel Owzan, Sefid, Shafa, Tajan, Talvar, Tonekabon, Zalkie and Zarin rivers and found a  $b$  value of 3.37. Eagderi *et al.* (2020) examined 86 fish, 3.8-15.62 cm total length, from the Balekhlou, Kheyr, Sefid, Siah, Tajan and Talar rivers and found a  $b$  value of 3.17, positively allometric. Seyfi *et al.* (2021) studied the population dynamics of 591 fish identified as *Squalius cephalus* from the Shahid Rajaei Dam in Mazandaran sampled at three stations in four seasons. The most frequent catch was in autumn (303 fish) and the lowest catch was in winter (43 fish). Both sexes had age groups  $0^+$  to  $5^+$  with two-year-olds prevailing in both sexes. The male:female sex ratio was 1:1.06, not significantly different. Fish were 10.2 to 26.5 cm in length and 11.59 to 241.86 g in weight with females longer and heavier than males. The length-weight relationships were  $W = 0.000001L^{3.05}$  for females,  $W = 0.000009L^{3.01}$  for males and  $W = 0.000001L^{3.01}$  for the population, all positively allometric. The von Bertalanffy growth equation for males was  $L_t = 27.04(1 - e^{-0.23(t+2.03)})$  and for females was  $L_t = 31.4(1 - e^{-0.22(t+1.31)})$ . The condition factor was almost equal in both sexes but was significantly different in age groups from  $0^+$  to  $3^+$ . Many dynamic parameters were better in the dam than in the river, 15 years after the dam was constructed.

Öztaş (1988, 1989), Öztaş and Solak (1988) and Türkmen *et al.* (1999) studied the chub in the Aras River of Turkey and found its condition factor to be higher in summer and autumn and to vary between age groups. Life span there was over 8 years (Ünlü and Balcı, 1993a, 1993b). In the Aras, females grew faster than males and there were more sexually mature females in the older age groups. Sexual maturity was attained at age 2-3 in males and ages 3-4 for females. Mean condition factor for Aras males was 1.326 and for females 1.333.

**Food.** Food items included mayfly and caddisfly larvae, other small organisms such as molluscs, and crayfishes, small fishes and frogs. Large fish fed mainly on other fish. Reputedly even fruit fallen in the water will be eaten. Trout eggs and fry were also eaten. Guts of Iranian specimens contained a wide variety of organisms including ants (presumably taken at the water surface), aquatic insects such as chironomids among others, crustaceans, filamentous algae, higher plant fragments, scales of cyprinids and the remains of a *Paracobitis malapterura*. Abdoli (2000) reported Ephemeroptera, Chironomidae and Trichoptera. In Taham Dam algae, higher plants, bivalves and insects were found (*Iranian Fisheries Research Organization Newsletter*, 54 & 55:4, 2008). Seyfi *et al.* (2021) in their Shahid Rajaei Dam study found relative gut length indicated a tendency to carnivorous feeding and the vacuity index showed males were relatively edacious and females were edacious or voracious. Based on the index of fullness in both sexes and different ages, feeding conditions were not appropriate.

**Reproduction.** Spawning in Iran appears to take place in spring judging from egg development. Around 40% of the fish in Taham Dam in Iran spawned in early June and around 30% did not spawn at all (*Iranian Fisheries Research Organization Newsletter*, 54 & 55:4, 2008). Ashja Ardalan *et al.* (2010) examined fish from the Babol River and found mean egg

diameter was 69.83  $\mu\text{m}$  in May, mean absolute fecundity was 8,038, average gonadosomatic index was 1.47 for males and 2.95 for females, and condition factor was 1.12 for males and 1.17 for females. Spawning occurred once from mid-May to late June. Biniiaz *et al.* (2011) found reproduction in fish above and below the Alborz Dam on the Babol River was similar. The female:male sex ratio was 1:1 and 1:1.69 above and below the dam, egg diameter was a mean of 0.94 mm and 0.75 mm respectively, absolute fecundity was a mean of 6,417 and 5,111 respectively, the gonadosomatic index was 2.52 for males and 4.66 for females above the dam and 3.7 and 4.09 below, the hepatosomatic index was 1.18 for males and 1.25 for females above the dam and 0.66 and 1.03 below. Ashja Ardalan *et al.* (2011) also examined fish from the Babol River and found batch spawning was from mid-May to late June. Amouii *et al.* (2016) found that the mean gonadosomatic index for Sefid River fish peaked between April and May. Seyfi *et al.* (2021) in their Shahid Rajaei Dam study found an absolute and relative fecundity of 4,478.2 eggs and 54.1 eggs/g and the average egg diameter was 0.86 mm.

Öztaş (1989) examined reproduction of this species in a stream tributary to the Aras River in Turkey. Spawning began at the end of May although most fish spawned in June. Water temperatures at this time were 12-18°C. Fecundity was up to 61,808 eggs and maximum egg diameter was 1.39 mm. Türkmen *et al.* (1999) found spawning between May and July in the Aras River proper with fecundity up to 17,187 eggs. In Azerbaijan, Abdurakhmanov (1962) gave spawning temperatures as 12-21°C, maximum fecundity as 118,000 eggs, and maximum egg diameter as 1.8 mm.

**Parasites and predators.** Ergens and Gusev (1965) reported the monogenean helminth *Dactylogyrus prostrae* in this species from Bandar-e Shah (= Bandar-e Torkeman) on the Caspian Sea coast. The monogeneans *Diplozoon paradoxum* and *D. megan* were recorded from this species in the Tajan River, Mazandaran (*Iranian Fisheries Research and Training Organization Newsletter*, 6:7, 1994). Shamsi *et al.* (1997) and Moumeni *et al.* (2020) reported *Clinostomum complanatum*, a parasite causing laryngo-pharyngitis in humans, from this species in the Shirud. Masoumian and Pazooki (1998) surveyed myxosporeans in this species in Gilan and Mazandaran provinces, finding *Myxobolus minutus* and *M. muelleri*.

Mirhasheminab and Pazooki (2003) listed *Ergasilus peregrinus*, *Tracheliastes polycolpus* and *Lernaea cyprinacea* from this species in Mahabad Dam, the latter being the most dangerous parasite. Jalali *et al.* (2005) summarised the occurrence of *Gyrodactylus* species in Iran and recorded *G. sp.* from fish in the Sefid River. Pazooki *et al.* (2005) recorded *Lamprolegna compacta*, *Ergasilus peregrinus* and *Lernaea cyprinacea* from this species in waterbodies of Zanzan Province. Miar *et al.* (2008) examined fish in Valasht Lake and the Chalus River, Mazandaran and found the protozoan *Chilodonella hexastica*. Barzegar and Jalali (2009) reviewed crustacean parasites in Iran and found *Ergasilus peregrinus*, *Ergasilus sp.*, *Lamprolegna compacta*, *Lernaea sp.*, *Tracheliastes longicollis* and *Tracheliastes polycolpus* on this species. *Ligula intestinalis* was recorded from fish in Sattarkhan Dam in East Azarbayjan (Hajirostamloo, 2009).

Rasouli (2013) found the digenean *Diplostomum spathaceum* in fish from Caspian drainages in West Azarbayjan. This parasite causes secondary infections as the metacercariae penetrate the skin and eye, lesions, appetite loss, blurry vision and reduced feeding. Hosseinfard *et al.* (2014) recorded various nematodes from this fish (as *L. cephalus*) in the Garmrud at Amol, Mazandaran. Shokrolahi *et al.* (2014) recorded *Bothriocephalus gowkongensis* (cestode), *Paradiplozoon sp.* (monogenean), *Ichthyophthirius sp.* (protozoan), *Dactylogyrus sp.* and *Rhabdocona sp.* (nematodes) from fish in the Alborz Dam on the Babol River identified as

*Leuciscus cephalus*. Other parasites were mentioned but not assigned specifically to this species. Hosseini Fard *et al.* (2017) recorded *Ichthyophthirius multifiliis*, *Paradiplozoon* sp., *Myxobolus* sp., *Dactylogyrus lenkorani*, *Gyrodactylus protate* (*sic*, presumably *prostae*) and *Bothriocephalus* sp. in fish from the Chalus River. Taheri Mirghaed *et al.* (2017) recorded parasites from fish in the Alborz Dam and Babol River in Mazandaran, namely *Myxobolus minutus* (dam and river) (Myxozoa), *Dactylogyrus chalcalburni* (river) and *D. vistulae* (dam and river), *Paradiplozoon homoion* (dam and river) (Monogenea), *Allocreadium isoproum* (river) and *Bothriocephalus opsariichthydis* (dam and river) and *Ligula intestinalis* (dam) (Digenea), and *Rhabdocona denudata* (river) (Nematoda). Barzegar *et al.* (2018) reported the monogenean *Gyrodactylus ophiocephali* from fish identified as *S. cephalus* from the Tajan River in Mazandaran. Taheri Mirghaed *et al.* (2018) reported the protozoans *Ichthyophthirius multifiliis* and *Trichodina* sp., the myxozoan *Myxobolus muelleri* and the monogeneans *Dactylogyrus vistulae*, *Gyrodactylus mutabilis* and *Paradiplozoon* sp. from the Siah River, the Haraz River (except *Ichthyophthirius multifiliis*), and the Neka River (except *Myxobolus muelleri*). Moeini Jazani *et al.* (2019) also examined fish from the Siah River identified as *Squalius cephalus* and found two protozoan species from the gills namely *Ichthyophthirius multifiliis* with the highest numbers in summer and *Trichodina* sp. with the highest numbers in spring, one myxozoan species from the intestine namely *Myxobolus muelleri* with the highest numbers in winter, and three monogenean species namely *Dactylogyrus vistulae* and *Diplozoon paradoxum* from the gills with highest numbers in autumn and summer respectively, and *Gyrodactylus mutabilis* from the gills and the skin with the highest numbers in summer.

**Economic importance.** Robins *et al.* (1991) listed this species (as *Squalius cephalus*) as important to North Americans. Importance was based on its use in textbooks and for sport.

**Experimental studies.** Banagar *et al.* (2013) found copper levels in liver tissue of fish identified as *Squalius cephalus* from the Tajan River were higher than the standard limits set by the World Health Organization. Golmohammadi *et al.* (2013) found a greater zinc accumulation in liver over muscle tissue in fish identified as *Squalius cephalus* from the Tajan River, and levels exceeded the acceptable standard set by the U.K. Ministry of Agriculture Fisheries and Food but lower than other standards.

**Conservation.** Kiabi *et al.* (1999) considered this species (as *Leuciscus cephalus*) to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria included sport fishing, medium numbers, habitat destruction, widespread range (75% of water bodies), present in other water bodies in Iran, and present outside the Caspian Sea basin. Listed as of Least Concern by the IUCN (2015).

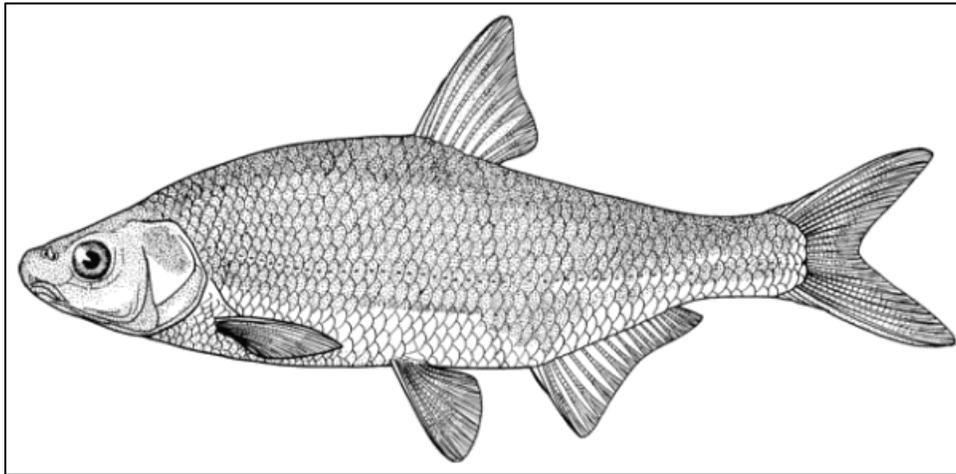
**Sources.** Iranian material:- CMNFI 1970-0506, 6, 42.5-116.3 mm standard length, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0511, 2, not kept, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0512, 1, not kept, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0525, 1, 129.8 mm standard length, Gilan, Sefid River near Mohsenabad (ca. 37°22'N, ca. 49°57'E); CMNFI 1970-0532, 1, 44.1 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0536, 3, 89.0-223.0 mm standard length, Gilan, Siah River estuary near Rudbar (36°53'N, 49°32'E); CMNFI 1970-0537, 8, not kept, Gilan, Shah River above Manjil Dam (36°44'N, 49°24'E); CMNFI 1970-0538, 7, 40.8-137.2 mm standard length, Gilan, Qezel Owzan River above Manjil Dam (36°44'N, 49°24'E); CMNFI 1970-0542, 2, not kept, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0545, 1, 51.5 mm standard length, Gilan, Sefid River from Emamzadeh Hashem to Lulaman (no other locality data); CMNFI 1970-0546, 3, 52.8-60.7 mm standard length, Gilan, Sefid River canal (no

other locality data); CMNFI 1970-0559, 1, 81.7 mm standard length, West Azarbayjan, Baranduz Chay (ca. 37°25'N, ca. 45°10'E); CMNFI 1970-0576, 2, 40.1-62.4 mm standard length, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0583, 6, 41.4-123.8 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0587, 1, not kept, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0589, 1, 142.0 mm standard length, Gilan, Sefid River opposite Kisom (37°12'N, 49°54'E); CMNFI 1979-0430, 3, 49.7-94.8 mm standard length, Mazandaran, river 1 km east of Now Shahr (36°39'N, 51°31'E); CMNFI 1979-0452, 3, 51.7-57.1 mm standard length, East Azarbayjan, Qezel Owzan River 6 km from Mianeh (37°23'N, 47°45'E); CMNFI 1979-0453, 7, 46.7-60.2 mm standard length, Zanzan, Zanzan River (37°06'N, 47°56'E); CMNFI 1979-0469, 6, 86.0-127.5 mm standard length, Mazandaran, river 36 km west of Alamdeh (36°37'30"N, 51°35'E); CMNFI 1979-0473, 4, 31.8-85.6 mm standard length, Mazandaran, Babol River (36°38'N, 52°38'E); CMNFI 1979-0474, 6, 71.3-80.6 mm standard length, Mazandaran, Tajan River (36°34'N, 53°05'E); CMNFI 1979-0475, 2, 34.4-36.6 mm standard length, Golestan, stream on road to Gorgan (36°46'N, 54°00'E); CMNFI 1979-0482, 2, 112.2-160.1 mm standard length, Golestan, river between Minudasht and Dowlatabad (37°19'30"N, 55°31'E); CMNFI 1979-0493, 7, 85.2-114.5 mm standard length, Mazandaran, stream in Tajan River drainage (36°19'N, 53°23'E); CMNFI 1979-0494, 12, 9.1-92.6 mm standard length, Mazandaran, Talar River tributary (36°21'N, 52°51'30"E); CMNFI 1979-0685, 1, 45.0 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0686, 1, 42.8 mm standard length, Gilan, Sefid River above ferry (37°24'N, 49°58'E); CMNFI 1979-0692, 3, 24.0-94.3 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1979-0695, 2, 47.8-77.4 mm standard length, Gilan, Sefid River at Manjil Bridge (36°46'N, 49°24'E); CMNFI 1980-0120, 2, 41.8-118.1 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1980-0132, 4, 40.1-50.4 mm standard length, Gilan, Sefid River at Kisom (37°12'N, 49°54'E); CMNFI 1980-0155, 1, 56.3 mm standard length, Ardabil, Qareh Su near Ardabil (ca. 38°15'N, ca. 48°18'E); CMNFI 1980-0490, 1, 43.6 mm standard length, Caspian Sea basin (no other locality data); CMNFI 1980-0494, 1, 192.5 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 2007-0082, 1, 35.0 mm standard length, Zanzan, Zanzan River near Zanzan (ca. 36°36'N, ca. 48°32'E); CMNFI 2007-0084, 1, 157.1 mm standard length, East Azarbayjan, Talkheh River basin west of Sarab (ca. 37°56'N, ca. 47°19'E); CMNFI 2007-0092, 5, 90.3-145.7 mm standard length, West Azarbayjan, Zilber Chay (38°42'N, 45°16'E); CMNFI 2007-0098, 5, 116.8-198.1 mm standard length, West Azarbayjan, river south of Mahabad (ca. 36°42'N, ca. 45°41'E); CMNFI 2007-0101, 1, 162.0 mm standard length, West Azarbayjan, Simineh River (ca. 36°54'N, ca. 46°07'E); CMNFI 2007-0103, 2, 36.5-39.4 mm standard length, Kordestan, Zarrineh River basin north of Saqqez (ca. 36°18'N, ca. 46°16'E); CMNFI 2007-0105, 1, 96.9 mm standard length, Kordestan, Zarrineh River basin (ca. 36°06'N, ca. 46°20'E); CMNFI 2007-0106, 1, 80.6 mm standard length, Kordestan, Qezel Owzan River basin near Divan Darreh (ca. 35°52'N, ca. 47°05'E); CMNFI 2008-0086, 1, 154.2 mm standard length, Ardabil, Qareh Su basin near Nir (ca. 38°02'N, ca. 48°00'E); CMNFI 2008-0118, 1, 88.1 mm standard length, Mazandaran, Babol River (no other locality data); CMNFI 2008-0137, 1, 72.0 mm standard length, West Azarbayjan, Zarrineh River (37°05'N, 45°44'E); CMNFI 1980-0149, 4, not kept, Gilan, Chapak River (37°21'N, 49°50'E); CMNFI 2008-0158, 1, 123.3 mm standard length, Lake Urmia basin (no other locality data).

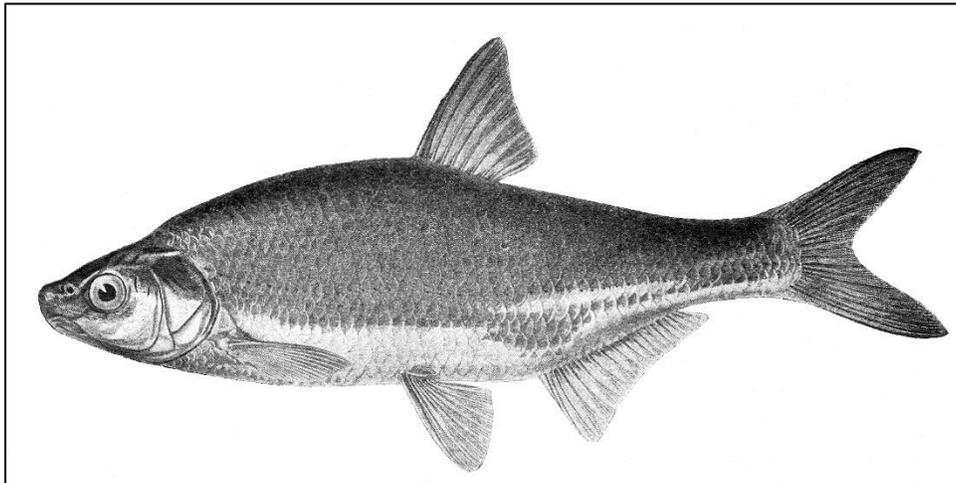
**Genus *Vimba***  
Fitzinger, 1873

This genus is found in the basins of the Baltic, Aegean, Black and Caspian seas and has five species. It is characterised by a compressed, moderately deep body with an inferior, crescentic mouth, a scaleless keel between the pelvic and anal fins, a scaleless groove in front of the dorsal fin and an evident keel behind it, pharyngeal teeth in a single row, short dorsal and long anal fin, gill rakers short, and scales moderate in size. Bogutskaya (1986) using skull morphology reaffirmed the generic separation of *Vimba* Fitzinger, 1873 from *Abramis* Cuvier, 1816 although Howes (1981) considered it to be a synonym.

*Vimba persa*  
(Pallas, 1814)



*Vimba persa*  
Susan Laurie-Bourque @ Canadian Museum of Nature.



*Vimba persa*, 26.0 cm total length, ZISP 9790, Russia, Volga River near Astrakhan,  
after Berg (1948-1949).



*Vimba persa*, CMNFI 1979-0435, Gilan, stream west of Ramsar, 4 June 1978, Brian W. Coad.



*Vimba persa*, Gilan, Sefid River, April 1999, Keyvan Abbasi.

**Common names.** Siah kuli, siahkooli or siyah koli (= black fish), cooli, couli, coli, kooli or kuli (= kuli and variants are a general term for any small fish), mahi siah kuli (= black fish).

[Garasol in Azerbaijan; chernospinka, Kaspiiskii rybets or Caspian vimba, both in Russian; Caspian vimba, Persian vimba, southern white-eye, vimba; gypsy king fish (after Sohrabi *et al.* (2013)].

**Systematics.** *Cyprinus persa* Gmelin, 1774 is a nomen nudum - see Kottelat (1997) - and was later made available by Pallas. It was described originally from “Persa; in lacubus ad Cyrum”, i.e., the southern coast of the Caspian Sea in lakes of the Kura River system in what is now Azerbaijan. No types are known. It is distinguished by larger scales and usually fewer anal rays from *V. vimba* (Linnaeus, 1758) which it was formerly synonymised with or recognised as a subspecies of. *Cyprinus Vimba* was originally described from lakes of Sweden. No types are known. Hänfling *et al.* (2009) found phylogenetically distinct mtDNA sequences for Caspian Sea basin samples, the Caspian clade having diverged from a western or Pontic clade 1-2 MYA at the beginning of the Pleistocene. Caspian populations could then rank as a separate species or subspecies although they considered further work involving western Caucasian populations was needed to support one conclusion over the other. Naseka and Bogutskaya (2009) recognised *V. persa* as a species.

Rahmani and Abdoli (2008) compared populations from the Gorgan River, Shirud and Anzali Lagoon and found morphometric and meristic differences between them. Nejati Javaroni *et al.* (2009) examined fish from the coast of Astara, Bandar-e Torkeman and Tonekabon, using meristic and morphometric characters, and found them not to be completely distinct but possibly from different populations which migrated to these areas. Mohamadian *et al.* (2011, 2011, 2012)

used microsatellite markers on fish from the Anzali Lagoon, Babol River, Gorgan River and Havigh (= Haviq) River and showed significant population structuring, with enormous diversity in the past. Abbasi *et al.* (2013) examined 124 fish from Talesh, Anzali Beach, Kishash (*sic*, possibly Kiashahr), the Chalus coast and Langarud and Tonekabon rivers using 24 morphometric characters and found high phenotypic variation between populations, and the Anzali Beach population was completely isolated from other areas, while samples from the Langarud were very close to samples of west Mazandaran (Chalus coast and Tonekabon River), for example. Vatandoust *et al.* (2014) examined fish from Astara, Bandar-e Anzali, Bandar-e Torkeman, Tonekabon and Sari and using 25 morphometric and 10 meristic characters. They were able to assign 98.3% of individuals to locality on morphometrics and 55.4% on meristics. Population differentiation should therefore be considered in restocking programmes. Rahmani and Kamali Pashakolai (2017) examined 135 fish from the Gorgan and Valiabad rivers and the Larim and Mahmoudabad coastal waters using 27 morphometric and 10 meristic characters and found the populations were not entirely separable.

A hybrid with *Alburnus chalcoides* was reported from the Sefid River (Petrov, 1926) and inheritance of microsatellite markers in this hybrid was investigated by Rouholahi *et al.* (2012).

**Key characters.** The snout projects over the lower jaw and, in large fish, is quite bulbous, there is a keel on the belly and on the back, and fin ray counts are distinctive.

**Morphology.** The body is compressed and deep, being deepest at the dorsal fin origin. The predorsal profile is convex and a nuchal hump is often present. The caudal peduncle is compressed and moderately deep. The snout is very to moderately rounded and projects over an oblique mouth. The mouth extends back to a level between the nostril and the eye or to under the nostril. The rear of the eye is at the beginning of the anterior half of the head. The dorsal fin is emarginate and its origin is posterior to the level of the pelvic fin origin. The depressed dorsal fin extends back over the beginning of the anterior third of the anal fin. The caudal fin is moderately to deeply forked with rounded tips. The anal fin is emarginate near its origin and then becomes lower and straight or emarginate. The pelvic fin is rounded and may almost reach back to the anus. The pectoral fin is rounded and does not extend back to the pelvic fin.

Dorsal fin with 2-3 unbranched rays (always 2 in the former subspecies *persa* (Berg, 1948-1949) but the first unbranched ray of 3 is minute and visible in x-rays in Iranian specimens) and 7-9, usually 8, branched rays, anal fin with 3 unbranched and 12-22 branched rays (16-18 in *persa* after Berg (1948-1949) but see below), pectoral fin branched rays 11-18, and pelvic fin branched rays 7-10. Lateral line scales 47-55. The lateral line runs below the midline of the caudal peduncle. Predorsal scales are small and crowded. A pelvic axillary scale is present. The naked ventral keel begins 0-3 scales behind the pelvic fin bases. Scales at the anal fin base form a sheath. The anterior scale margin is wavy and the posterior margin is crenulate. There is a central focus, numerous fine circuli and few anterior and posterior radii. Total gill rakers number 12-20, small and reaching the raker below when appressed. Pharyngeal teeth are usually 5-5, with the largest teeth having long and narrow, flat to slightly concave crowns, and tips recurved or very slightly hooked. The gut is s-shaped. Total vertebrae number 38-45. The chromosome number is  $2n = 50$  (Klinkhardt *et al.*, 1995; Arai, 2011) or  $2n = 52$  (Reshetnikov, 2002). Pourkazemi *et al.* (2010) found hatchery fish in Iran had  $2n = 50$  (74.7%),  $2n = 48$  (14.7%) or  $2n = 49$  (4.7%).

Jalali *et al.* (2019, 2020) described the ontogenic development of the digestive tract and accessory glands in larval and juvenile fish (identified as *Vimba vimba*), useful in identifying limiting factors in breeding larvae.

Meristic values for Iranian specimens are:- dorsal fin branched rays 7(1) or 8(39), anal fin branched rays 16(3), 17(13), 18(18) or 19(6), pectoral fin branched rays 14(8), 15(22), 16(7) or 17(3), pelvic fin branched rays 8(10) or 9(30), lateral line scales 47(1), 48(4), 49(7), 50(10), 51(14), 52(1), 53(1), 54(1) or 55(1), total gill rakers 15(1), 16(2), 17(12), 18(14), 19(9) or 20(2), pharyngeal teeth 5-5(15), 5-4(4) or 4-5(1), and total vertebrae 41(3), 42(9), 43(24) or 44(3). Abbasi *et al.* (2004) found 149 Sefid River fish to have mean values of 50.83 lateral line scales, dorsal fin branched rays 7.96 and anal fin branched rays 17.58.

**Sexual dimorphism.** Females are slightly larger than males of the same age and differ morphometrically on account of the eggs distorting body shape. The males become black on the back, reddish on the belly, their fins become red and the tips of the dorsal and caudal fins become dark, and they develop minute tubercles on the body during the spawning season (Kuliev, 1988; Abbasi *et al.*, 2004). Females may also develop tubercles but to a lesser extent. Sefid River fish showed differences in two meristic and 16 morphometric characters, especially body depth and lengths of dorsal, pectoral, pelvic and anal fins (Abbasi *et al.*, 2004) and sexes from the Anzali Lagoon differed in 12 morphometric characters, especially body height and dorsal and anal fin lengths (Hosseini *et al.*, 2012).

Iranian specimens have small tubercles lining the scale margins and larger tubercles over the whole head but particularly on the dorsal surface and upper sides. Fin rays bear small tubercles in files following the branching of the rays. The pelvic fin has weakly developed tubercles on its ventral surface as well as dorsally. The pectoral and pelvic fin unbranched rays bear several rows of tubercles.

**Colour.** The back is a reddish-brown to grey-blue, flanks are silvery and the belly yellowish. Paired fins are red at the base, pink distally. The anal fin base is red while other fins are grey to hyaline. Spawning fish develop black stripes along the dorsal and ventral body.

**Size.** Reaches 60.0 cm and 3.0 kg as *Vimba vimba*. *V. persa* is apparently smaller, to 30.5 cm (Rahmani *et al.* 2011).

**Distribution.** In Iran it is recorded from the whole Caspian Sea basin including the Astara, Babol, Chapak, Chelondchay, Chelvand, Fereydun Kenar, Gholab Ghir, Golshan, Gorgan, Haraz, Haviq, Iz Deh, Kargan, Khoshk, Kiarud, Langarud, Larim, Masuleh-Rukhan, Nahang, Nerissi, Pir Bazar, Polrud (= Pol-e Rud), Qareh Su, Qezel Owzan, Rasteh, Sardab, Sari, Sefid, Shafa, Shah, Shalman, Sheikhan, Shesh Deh, Shirud, Siah, Siah Darvishan, Sorkh, Tajan, Tonekabon and Valiabad rivers, the Fereydun Kenar International Wetland, the Manjil Dam on the Sefid River, the Babol River Dam, Voshmgir Dam on the Gorgan River, the Astara and Anzali talabs, Anzali, Astara and Kiashahr beaches, the Chalus coast, Gorgan Bay, the Anzali and Bandar-e Torkeman coasts, and the southeast, southwest and south-central Caspian Sea (Kozhin, 1957; Nümann, 1966; Holčík and Oláh, 1992; Riazi, 1996; Karimpour, 1998; Abbasi *et al.*, 1999, 2007, 2017; Kiabi *et al.*, 1999; Abdoli, 2000; Banagar *et al.*, 2008; Rahmani and Abdoli, 2008; Abdoli and Naderi, 2009; Nejati Javaromi *et al.*, 2009; Piri *et al.*, 2009; Nikoo *et al.*, 2010; Ahmadpour *et al.*, 2012; Abbasi *et al.*, 2013; Sohrabi *et al.*, 2013; Rahmani and Kamali Pashakolai, 2017; Sattari *et al.*, 2020; Abbasi *et al.*, 2021). It has also been introduced to Sistan.

**Zoogeography.** This species reaches its most south-easterly occurrence in Iran. Its relationships lie with European taxa (see *Abramis*).

**Habitat.** This species is found in rivers, streams, lakes, dams, lagoons, marshes and brackish environments. Caspian vimba have a sparse distribution in the sea and are not fished there commercially. It is more common in Gilan than Mazandaran and Golestan coastal waters

(Naderi Jolodar and Abdoli, 2004). The semi-migratory form enters fresh water or brackish water only for reproduction in spring. After spawning, it migrates to river mouths to feed until the next reproductive season (Kuliev, 1988). Riazi (1996) reported that this species is native (resident) to the Siahkeshim Protected Region of the Anzali Talab. S. Bazari Moghaddam ([www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp](http://www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp), downloaded 17 January 2005) recorded a migration into the Sefid River in spring for reproduction. Feeding continued on this migration. Knipovich (1921) reported this species from depths of 36.6-53.0 m in the Iranian Caspian Sea. It has been caught at 31-32°C in the Sefid River estuary on 9 July 1962 (CMNFI 1970-0565, CMNFI 1980-0908). In fresh water it occurs in schools in the lower reaches of rivers, in deep water over stone and gravel bottoms. It may also occur in lakes over mud bottoms.

Shahlapour *et al.* (2018) found only a low abundance of juveniles of this species in the eastern Caspian Sea, attributed to destruction of riverine habitats and illegal fishing of adults.



Habitat of *Vimba persa*, CMNFI 1979-0435, Gilan, stream west of Ramsar, 4 June 1978, Brian W. Coad.

**Age and growth.** Four-year-olds predominated in the spawning population in Kyzylagach or Imeni Kirova Bay, Azerbaijan. Most spawning females were 16-23 cm (46%) and males 13-19 (42%). Large fish spawned first and the number of smaller fish spawning increased towards the end of the reproductive season (Kuliev, 1988; Shikhshabekov, 1979).

Most fish on the spawning migration into the Anzali Talab were 170-250 mm and ages 3-4 years (Holčik and Oláh, 1992). Maturity was attained in the second or third year of life, males maturing at age 2 in the Anzali region. In the Sefid River migrating fish were 2-4 years old, predominately three-year-old fish (S. Bazari Moghaddam, [www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp](http://www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp), downloaded 17 January 2005). Fish on the spawning migration of the Sefid River had a fork length of 116-208 mm and a weight of 21.1-116.1 g in males and 122-222 mm and 23.1-170.0 g in females. Spawning males were 2-6 years old and females 3-7 years (Abbasi *et al.*, 2005).

Chaichi (2010, 2011) found fish from coastal waters of Mazandaran had a male:female sex ratio of 1:1.35, significantly different from the 1:1 ratio, growth was isometric

for females and positively allometric for males, and von Bertalanffy growth and mortality parameters were growth coefficient ( $K$ ) = 0.28 per year for both sexes (0.3 for males, 0.33 for females), theoretical maximum length ( $L_{\infty}$ ) = 26.1 cm, hypothetical age for length at age  $t = 0$  ( $t_0$ ) = -0.65 per year for both sexes (-0.51 for males, -0.23 for females), the growth performance index ( $\Phi'$ ) = 2.28, instantaneous coefficient of total mortality ( $Z$ ) = 0.98-1.07 per year (different values in different papers here and below where two are given, other values the same in all), instantaneous coefficient of natural mortality ( $M$ ) = 0.58-0.59 per year, instantaneous coefficient of fishing mortality ( $F$ ) = 0.39-0.49 per year, exploitation coefficient ( $E$ ) was 0.4-0.46, showing the population was highly exploited and not sustainable as a fishery, total biomass was 1,336 t, and maximum sustainable yield (MSY) was 528.8 t. The oldest fish was 5 years.

Hosseini Kenari *et al.* (2010, 2011) analysed fish from the Kiashahr region in the southwest Caspian Sea and found three age groups  $1^+$  to  $3^+$  years, most fish being  $2^+$  years (84.8%), with a female:male sex ratio of 1:1.38, and a condition factor of 0.98 in males and 1.04 in females. Maximum life span was about 15 years.

Patimar and Safari (2010) found a maximum age of 5 years for fish in the Gorgan Bay-Miankaleh Wildlife Refuge of the southeastern Caspian Sea. The von Bertalanffy growth functions were  $L_t = 32.565(1 - e^{-0.184(t+0.530)})$  for males and  $L_t = 32.95(1 - e^{-0.179(t+0.529)})$  for females with a balanced sex ratio but males predominating in smaller age classes and females in larger ones. Rahmani *et al.* (2011) examined fish from the Gorgan River, found a maximum age of 7 years with the most abundant age class  $6^+$  years in 1999 and  $3^+$  years in 2000. Growth was allometric. von Bertalanffy growth parameters of  $L_{\infty} = 41.65$  cm and  $K = 0.13$  yr<sup>-1</sup> for females in 1999 and  $L_{\infty} = 29.52$  cm and  $K = 0.27$  yr<sup>-1</sup> in 2000, higher than in males where  $L_{\infty} = 34.1$  cm and  $K = 0.19$  yr<sup>-1</sup> in 1999 and  $L_{\infty} = 24.74$  cm and  $K = 0.32$  yr<sup>-1</sup> in 2000. Rahmani *et al.* (2011) compared fish from the Gorgan River with those from Mahmoudabad and found a sex ratio of males to females of 67% to 33% for the Gorgan River and 57% to 43% for Mahmoudabad, there was no significant differences for average length and weight, growth patterns were negative allometric and isometric (*cf.* above in another co-authored study), and asymptotic length was higher in males than females in both populations but growth rates were relatively higher in females.

Taridashti *et al.* (2013) examined fish from the Gilan coast for length-weight relationships, females being  $W = 0.0085FL^{3.1619}$  and males  $W = 0.0126FL^{3.9865}$ , weight increasing isometrically with length for both sexes, but for all fish  $W = 0.0331FL^{2.6432}$  indicating negative allometric growth. Taridashti *et al.* (2017) examined 811 fish from three fisheries in the southwestern Caspian Sea at Bandar Anzali, Kiashahr and Talesh. Females had a fork length range of 8-24 cm and males 8-20.3 cm. The age range was  $0^+$  to  $7^+$  years with females more frequent than males at  $4^+$  and  $5^+$  years. The oldest female was  $7^+$  years and the oldest male  $5^+$  years. Growth rate was relatively high at about 0.29/year for females and 0.32/year for males. The overall male:female sex ratio was balanced at 1:0.92 and growth was isometric for both sexes. The von Bertalanffy parameters were  $L_{\infty} = 24.53$  cm,  $k = 0.28$ /year and  $t_0 = -0.53$  for females and  $L_{\infty} = 23.34$  cm,  $k = 0.33$ /year and  $t_0 = -0.29$  for males, and  $k$  and  $t_0$  were significantly different between sexes. The growth performance index ( $\phi'$ ) was 2.25 and 2.26 for males and females. The length-weight relationships were  $W = 0.0116TL^{3.023}$  for males and  $W = 0.0114TL^{3.0307}$  for females, isometric for both sexes. Condition factor for males did not vary monthly but increased considerably for females in June and October coinciding with the spawning season and the beginning of vitellogenesis. The coefficient of total mortality ( $Z$ ) was 1.27/year, the instantaneous coefficient of natural mortality ( $M$ ) was 0.46/year, instantaneous

coefficient of fishing mortality (F) was 0.8/year, and exploitation coefficient (E) was 0.63/year. F and Z rates were higher for males. Males grew faster, reached larger sizes and lived for a shorter time than females. The authors noted differences in growth parameters and age range between different regions in the Caspian Sea although comparison with populations outside the Caspian referred to another species, *Vimba vimba*. The population was experiencing significant legal and illegal exploitation pressure.

Karimi *et al.* (2021a) sampled fish from the Kiashahr coast from March 2016 to April 2017. The means of total length and total weight were 17.87 cm and 60.1 g. The relationship between length and weight was highly correlated in both sexes and equations were  $W = 0.25L^{2.95}$  for males and  $W = 0.21L^{2.82}$  for female, both showing negative allometric growth. The somatic conditions were 1.35 in males and 1.38 in females.

**Food.** Diet is aquatic insects, crustaceans, snails, worms and algae on muddy bottoms. Iranian specimens had zebra mussels and insect remains. S. Bazari Moghaddam ([www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp](http://www.meeresschule.com/cgi-bin/abstracts/gastbuch.asp), downloaded 17 January 2005) reported oligochaetes, chironomids and Odonata in fish from the Sefid River. Chaichi (2010) found fish from coastal waters of Mazandaran were mesophagous and fed on arthropods, worms, plants, detritus and fishes in descending order.

**Reproduction.** Fish entered the Anzali Talab of Iran in mid-January at a water temperature of 8-9°C, peaking from 21 April-10 May at 19-21°C (Holčík and Oláh, 1992). Khaval (1998) reported a spawning migration into the Sefid River despite construction, sand removal and pollution. Fish from the Shafa River estuary in Iran caught on 10 April 1962 (CMNFI 1980-0121) had highly developed eggs measuring 1.3 mm. Fecundity generally is up to 89,200 eggs per female, increasing with age and body size. Spawning is non-intermittent, in contrast to related Black Sea vimbas. Eggs are deposited on gravel or stones where there is a current of 0.6-0.9 m/second. Concrete structures and flooded fields may be used as long as there is some current (Holčík and Oláh, 1992). The eggs may form a layer up to 10 cm thick. Initially attached to plants or stones, the eggs are later washed down between the plants or stones. Other fishes eat these eggs and mortality is high. Some fish deposited eggs in sandy shallows of bays or on the roots of reeds and bulrushes. The young migrated to the coastal zone of the Caspian Sea for the summer, moving to greater depths as winter approached. At temperatures of 17-22°C, eggs incubated for 70-77 hours (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 37-38, 1996).

Abbasi *et al.* (2005) found that the Sefid River population started the spawning migration in March and this continued until July, peaking in mid-April to late May. Gonad weight for females increased with distance from the estuary. Spawning occurred from late May to late June, peaking in May at 18-29°C water temperatures. Eggs were shed on pebble and gravel grounds 25-75 km from the estuary. The Disaam tributary was the major spawning site. Chaichi (2010) and Chaichi *et al.* (2011) examined fish from the coastal waters of Mazandaran and found advanced maturity stages in April-May with the highest gonadosomatic index for females in May and the lowest in July, and for males May and October respectively. The average absolute and relative fecundities were 17,198 and 171.85 eggs respectively. Maximum egg production was 34,636 eggs. Hosseini Kenari *et al.* (2010) found Kiashahr region fish to have a maximum absolute fecundity of 13,589 eggs and a maximum relative fecundity of 152 eggs. The gonadosomatic index was highest in May for males and in June for females. Patimar and Safari (2010) found Gorgan Bay-Miankaleh Wildlife Refuge fish to spawn in late April to late May based on the gonadosomatic indices, which were highest in early May for males and in late April

for females (*sic*, compare above). Absolute fecundity reached 36,141 eggs and maximum egg diameter 1.7 mm. Rahmani *et al.* (2011) found Gorgan River fish to have a maximum fecundity of 21,491 eggs, with a mean absolute fecundity of 15,157 eggs in 2009 and 9,852 in 2000, significantly different. The highest gonadosomatic indices for both sexes were at the end of April, with no differences between the two sample years. The mass migration into the river was in the first half of April at a water temperature of 22-23°C (compare above for the Anzali Talab). Rahmani *et al.* (2011) compared fish from the Gorgan River with those from Mahmoudabad and found mean absolute fecundity to be 11,970 and 6,728 eggs respectively, there being significant differences in this and in average egg diameter and condition factor.

Tari *et al.* (2015) examined fish from the fisheries stations of Talesh, Anzali and Kiashahr in the southwest Caspian Sea over a two-year period. Gonadosomatic index peaks were found in June 2012 and May 2013, oocyte development was synchronous, absolute fecundity was 5,873-35,421 eggs, sex ratio was essentially 1:1, size at first maturity (50% mature) for females was 120 mm fork length and all were mature at 180 mm, and the species was a total spawner with variable spawning depending on environmental conditions. Rostamnezhad *et al.* (2019) compared the reproductive ability and histological properties of fish from the Anzali Wetland and the Sefid River, finding significant differences in terms of gonad weight, liver weight, hepatosomatic index, fecundity and relative fecundity, but not length. Reproduction began and ended earlier in the wetland.

Nikoo *et al.* (2010) measured serum sex steroids during spawning in the Valiabad River and concluded that this fish may be a multiple spawner.

Karimi *et al.* (2021b) noted that this species lived mainly in brackish waters and migrated in to rivers for spawning. It was a total spawner and spawning occurred from April to June in water with a temperature of 16 to 20°C.

Kuliev (1988) and Shikhshabekov (1979) studied reproduction in the Kyzylagach Bay of the southwestern Caspian Sea and the waters of Dagestan respectively. The spawning migration began in March or April at 10-13°C and spawning took place at the end of April at 16-20°C, continuing until the end of May or into June.

**Parasites and predators.** Jalali and Molnár (1990a) recorded the monogeneans *Dactylogyrus cornoides* and *D. haplogonus* from this species in the Sefid River. Sattari *et al.* (2007) recorded the cestodes *Caryophyllaeus laticeps* and *Caryophyllaeus fimbriceps*, the digenean *Diplostomum spathaceum* and the monogenean *Dactylogyrus extensus* in fish from the Anzali Wetland. Barzegar *et al.* (2018) reported the monogeneans *Gyrodactylus katharineri*, *G. mutabilitas* and *G. vimbi* from fish identified as *V. vimba* from the Tonekabon and Talar, Talar and Shirud, and Tonekabon rivers, Mazandaran, respectively.

**Economic importance.** The vimba catch over the whole Caspian Sea basin was less than 100 tonnes per year in the 1980s (Kuliev, 1988). The catch in Dagestan in 1934 was 1,319 centners or 1,265,000 fish (Berg, 1948-1949). The catch by local fishermen in the Anzali Talab region in 1990-1991 was 823 kg or about 8,400 fish (Holčík and Oláh, 1992). They were caught in rogas and inflowing rivers of the talab in late winter and early spring. In 1994-1995, the population of this species was noted as declining in recent years (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, pp. 37-38, 1996). Chaichi *et al.* (2011) gave a maximum catch in recent years of 474 t in 2009-2010 for Iranian waters and was as low as 9 t in 2005-2006 (Taridashti *et al.*, 2017). It is also a sport fishery species in Iran (Rahmani *et al.*, 2011). This species is harvested by local people for food (Taridashti *et al.*, 2017). Mohamadian *et al.* (2011, 2011, 2012, 2012) differentiated populations genetically along

the Iranian coast and noted that this has significance in conservation and restocking programmes.

Robins *et al.* (1991) listed related species as important to North Americans. Importance was based on its use as food and in aquaculture.

**Experimental studies.** Shokrzadeh Lamuki *et al.* (2012) evaluated pesticide residues in fish from four major fishing centres (Babol Sar, Chalus, Khazarabad and Miankaleh) and found mean D.D.T. and D.D.A. values both ranged from 0.016 to 0.019 mg/kg. Mansouri Chorehi *et al.* (2013) found Caspian vimba from the Sefid River were highly sensitive to the pesticide diazinon, used in Iranian agriculture, with an LC<sub>50</sub> 96 h of 0.08 mg/l. Farahbakhsh *et al.* (2017) studied the amount of copper, nickel and zinc in muscle tissue and nickel was higher than international standards, but the potential risk and hazard indicators indicated there was not much danger to consumers. Etefaghdoost and Noveirian (2019) measured the levels of arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium and zinc in muscle tissue of fish from the Siah Darvishan River and the levels of all except arsenic, lead and manganese were lower than the international standard threshold. Solgi *et al.* (2019) found iron to have the highest metal content in fish from Manjil Dam, the lowest and highest levels of copper, iron and zinc were in muscle and gill tissues, respectively, and copper and zinc levels were lower than international standards while iron was low to high depending on the standard used. Sattari *et al.* (2020) determined the levels of 36 elements in liver and muscle tissue of fish from the southwestern Caspian Sea and the relationship with growth indices (length and weight, condition factor and hepatosomatic index). The highest element concentration reported in muscle and liver belonged to phosphorus. The average concentrations of metals in both tissues were in the order of selenium, potassium, sodium and calcium respectively. Many elements were below detection limits.

Jalali *et al.* (2018) measured mouth size in larval and juvenile fish. They found that with the onset of exogenous feeding, larvae were probably able to ingest and digest 110 µm pellet food eight days after hatching. Formulated diets therefore could only be used 20 days after hatching until the end of the larval rearing period. Cultured fish were released into the Caspian Sea 60 days after hatching.

Catches in the Anzali Wetland were higher using a blue fyke net, compared to red and black (Paighambari *et al.*, 2014).

Norousta and Mousavi-Sabet (2013) examined haematological parameters, in mature and immature fish from the mouth of the Sefid River, finding differences between the life stages in total erythrocyte count (lower in mature fish), total white blood cell count and neutrophil (higher in mature) and rate of clot time (lower in mature). The species also had higher mean values for haematocrit and haemoglobin concentration, similar values for total erythrocyte count, and low percent of heterophils in relation to other cyprinoid species. Sohrabi *et al.* (2013) examined haematological parameters of this species migrating for reproduction in May in the Khoshk River. These parameters are important in managing proposed artificial reproduction of a species, and for assessing health and environmental disturbances.

**Conservation.** Weirs are a problem for this species in Iran as they block the spawning migration, the fish massing below the obstruction, and causing re-absorption of eggs and sperm (Holčík and Oláh, 1992). Reportedly less than 5% of migratory fish can reproduce naturally and the rest are caught (Karimi *et al.*, 2021b). Aquaculture of this species has been investigated in Iran (see above); it could be bred semi-artificially using methods similar to that for *Rutilus* species (*Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran*, p. 38, 1996).

Kiabi *et al.* (1999) considered this species to be near threatened in the south Caspian Sea basin according to IUCN criteria. Criteria included commercial fishing, sport fishing, abundant in numbers, habitat destruction, widespread range (75% of water bodies), absent in other water bodies in Iran, and absent outside the Caspian Sea basin. Mostafavi (2007) listed it as near threatened in the Talar River, Mazandaran. Taridashti *et al.* (2017) reported many catches were illegal and made during the spawning season in rivers. Jouladeh-Roudbar *et al.* (2020) listed it as of Least Concern because of its widespread distribution and no known major threat.

**Sources.** Iranian material:- CMNFI 1970-0509, 1, not kept, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0510, 3, 29.1-43.7 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0511, 2, not kept, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1970-0512, 1, not kept, Gilan, Shalman River (37°08'N, 50°15'E); CMNFI 1970-0519, 6, 21.4-28.6 mm standard length, Gilan, Chelvand River (ca. 38°18'N, ca. 48°52'E); CMNFI 1970-0521, 3, not kept, Gilan, Sefid River near Lulaman (no other locality data); CMNFI 1970-0522, 2, 25.9-26.8 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1970-0526, 4, 45.1-60.5 mm standard length, Gilan, Sefid River below Astaneh Bridge (37°19'N, 49°57'30"E); CMNFI 1970-0528, 47, not kept, Mazandaran, Tajan River estuary (36°49'N, 53°06'30"E); CMNFI 1970-0531, 8, 44.4-70.5 mm standard length, Mazandaran, Larim River talab (36°46'N, 52°56'E); CMNFI 1970-0532, 7, 36.8-48.9 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0536, 3, not kept, Gilan, Siah River estuary near Rudbar (36°53'N, 49°32'E); CMNFI 1970-0537, 13, not kept, Gilan, Shah River above Manjil Dam (36°44'N, 49°24'E); CMNFI 1970-0538, 2, 32.8-33.5 mm standard length, Gilan, Qezel Owzan River above Manjil Dam (ca. 36°44'N, ca. 49°24'E); CMNFI 1970-0542, 5, not kept, Gilan, Old Sefid River estuary (37°23'N, 50°11'E); CMNFI 1970-0543, 46, 34.7-50.4 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0543A, 9, 38.9-87.4 mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0544, 1, 162.2 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1970-0548, 2, not kept, Golestan, Qareh Su (no other locality data); CMNFI 1970-0549, 1, 43.1 mm standard length, Golestan, Qareh Su near Alm Imamzadeh (no other locality data); CMNFI 1970-0563, 17, 40.9-73.1 mm standard length, Gilan, Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0565, 3, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1970-0568, 1, not kept, Gilan, Caspian Sea at Kazian Beach (ca. 37°29'N, ca. 49°29'E); CMNFI 1970-0583, 50, not kept, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0585, 11, 21.5-42.5 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1970-0587, 1, 38.1 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1970-0589, 1, not kept, Gilan, Sefid River opposite Kisom (37°12'N, 49°54'E); CMNFI 1970-0590, 7, not kept, Mazandaran, Shesh Deh River near Babol Sar (ca. 36°43'N, ca. 52°39'E); CMNFI 1971-0343, 1, 57.8 mm standard length, Gilan, Langarud at Chamkhaleh (37°13'N, 50°16'E); CMNFI 1979-0430, 1, 36.1 mm standard length, Mazandaran, river 1 km east of Now Shahr (36°39'N, 51°31'E); CMNFI 1979-0431, 1, 145.0 mm standard length, Mazandaran, bazaar at Now Shahr (no other locality data); CMNFI 1979-0435, 1, 141.1 mm standard length, Gilan, stream west of Ramsar (36°57'N, 50°37'E); CMNFI 1979-0436, 5, 115.1-156.5 mm standard length, Gilan, stream 26 km west of Ramsar (37°02'30"N, 50°27'E); CMNFI 1979-0437, 1, 155.2 mm standard length, Gilan, Sefid River, 2 km west of Astaneh (37°16'30"N, 49°56'E); CMNFI 1979-0438, 2, 139.5-152.6 mm standard length, Gilan, Gholab Ghir River (37°27'N, 49°37'E); CMNFI 1979-0446, 1, 33.8 mm standard length, Gilan, Astara River (38°26'30"N, 48°51'E); CMNFI 1979-

0685, 5, 27.8-56.4 mm standard length, Gilan, Sefid River (ca. 37°22'N, ca. 49°57'E); CMNFI 1979-0686, 2, not kept, Gilan, Sefid River above ferry (37°24'N, 49°58'E); CMNFI 1979-0689, 11, not kept, Gilan, Sefid River at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1979-0696, 13, not kept, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1979-0788, 2, 28.5-50.7 mm standard length, Golestan, Gorgan River at Khadje Nafas (37°00'N, 54°07'E); CMNFI 1980-0116, 1, 36.1 mm standard length, Gilan, Sefid River at Astaneh Bridge (37°16'30"N, 49°56'E); CMNFI 1980-0117, 1, 33.9 mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0120, 7, 47.5-63.7 mm standard length, Mazandaran, Babol River at Babol Sar (36°43'N, 52°39'E); CMNFI 1980-0121, 3, 139.5-152.2 mm standard length, Gilan, Shafa River estuary (37°35'N, 49°09'E); CMNFI 1980-0122, 4, 35.3-45.1 mm standard length, Mazandaran, Nerissi River (36°38'N, 52°16'E); CMNFI 1980-0123, 2, 34.1-37.0 mm standard length, Gilan, Sefid River around Dakha (ca. 37°22'N, ca. 49°57'E); CMNFI 1980-0126, 1, 170.8 mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37°28'N, 49°27'E); CMNFI 1980-0127, 2, 180.3-182.1 mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1980-0129, 1, 51.9 mm standard length, Mazandaran, Tajan River (36°49'N, 53°06'30"E); CMNFI 1980-0130, 4, 22.7-33.9 mm standard length, Mazandaran, Iz Deh near Shilat Post (36°36'N, 52°07'E); CMNFI 1980-0131, 5, 26.2-34.4, Iran Caspian Sea basin (no other locality data); CMNFI 1980-0135, 1, 56.2 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1980-0136, 3, not kept, Mazandaran, Fereyduh Kenar River estuary (36°41'N, 52°29'E); CMNFI 1980-0138, 10, 28.1-105.0 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1980-0139, 3, not kept, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1980-0140, 10, not kept, Gilan, Astara Talab close to sea (ca. 38°26'N, ca. 48°53'E); CMNFI 1980-0142, 1, 180.1 mm standard length, Gilan, Nahang Roga River (37°28'N, 49°28'E); CMNFI 1980-0144, 53, not kept, Mazandaran, Sorkh River (36°40'N, 52°25'E); CMNFI 1980-0149, 2, 36.6-37.8 mm standard length, Gilan, Chapak River (37°21'N, 49°50'E); CMNFI 1980-0160, 3, 49.6-73.4 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1980-0908, 4, 87.8-135.7 mm standard length, Gilan, Sefid River estuary (ca. 37°28'N, ca. 49°54'E).

## Bibliography

This section contains all the papers and books referred to in the text and also attempts to be a bibliography on cyprinoid fishes of Iran and their environment.

The suborder Cyprinoidei encompasses a number of families, of which seven are found in Iran, and these were formerly subfamilies of the family Cyprinidae. The Bibliography includes papers and books on the seven families although five of the families (indicated by an asterisk below) are published separately as papers (see Coad (2018b, 2018c, 2019b, 2019c, 2020)). A few important works on the five families that appeared after they were published are also included here but the bibliographies on these five families are only up-to-date as of their publication.

Family **Cyprinidae** Rafinesque, 1815 (carps)

\*Family **Danionidae** Bleeker, 1863 (danionids)

\*Family **Xenocyprididae** Günther, 1868 (East Asian minnows)

\*Family **Tincidae** Jordan, 1878 (tenches)

\*Family **Acheilognathidae** Bleeker, 1863 (bitterlings)

\*Family **Gobionidae** Bleeker, 1863 (gobionids)

Family **Leuciscidae** Bonaparte, 1835 (minnows)

Some works listed here may not be cited in the text, as they duplicate other papers, mention cyprinids only in passing, or are abstracts or titles from conference papers with little content, some of which were replaced by full papers later, but are cited here for completeness. Some few citations may have only the doi (digital object identifier) as the paper had not appeared in a volume and issue when this book was finished or a paper version could not be located. A few articles appeared online but seemingly were never formally published. Some articles may be marked as “in press” being online versions not yet published with volume and page numbers or doi. These and the doi citations were updated when possible; others can easily be updated by an online search. Most websites are cited in the text, with some in the Bibliography, as sources of information although the web address may no longer be functional. Newspaper articles are cited by name of the newspaper and the date. Newspapers and other news outlets have websites and can be searched although some appear to have been hacked or replaced, e.g., [www.netiran.com](http://www.netiran.com), but are still cited as the original source. A more extensive bibliography on Iranian freshwater fishes generally can be found at [www.briancoad.com](http://www.briancoad.com).

The Scientific Information Database or SID, Tehran ([www.sid.ir/](http://www.sid.ir/)) appears in Farsi and English, and lists publications in Iranian journals, with abstracts in English and Farsi. Papers generally in the current work may be in languages other than English and this is mentioned (or implied by the translated title) where known although some Iranian-based papers have only been seen as an English abstract (refer to SID). Most Iranian papers in Farsi have an English abstract.

Aquatic Commons (<http://aquaticcommons.org/>) covers natural marine, estuarine/brackish and fresh water environments including papers in Farsi from Iran with English abstracts. Note that some works are cited as having a single author (the lead or principal author) while others have numerous authors (the team working on the project, sometimes over 20 individuals - apologies for not always including all team members). Either one is easy to locate.

Older classical works are now readily available on-line at, for example, the Biodiversity Heritage Library ([www.biodiversitylibrary.org](http://www.biodiversitylibrary.org)), or can simply be googled for other sources.

Many Iranian-based journals and their papers along with M.Sc. and Ph.D. theses are, naturally, in Farsi but this is not always noted in the absence of the full paper, only an English abstract having been seen. Some journals have an English name in an English abstract, which is followed here, but a direct Farsi translation may differ. Some abstracts in English of Farsi papers only give the senior author's name and not the other authors of the paper. This could not always be checked so apologies to anyone inadvertently omitted.

Some Iranian journals have titles that are the same as distinct journals published in English in other countries. The difference is evident when "In Farsi" is added at the end of the citation.

The names of one journal have changed over time - "Iranian Journal of Fisheries Sciences", "Iranian Fisheries Scientific Journal", "Iranian Fisheries Journal", "Iranian Fisheries Scientific Bulletin" and "Iranian Fisheries Bulletin", was published in Farsi with English abstracts. It now appears as the "Iranian Scientific Fisheries Journal" in Iranian abstracting journals and websites but references may appear here under the older, original journal names. The "Iranian Journal of Fisheries Sciences" (starting in January 1999 with volume 1(1)) is published in English with Farsi abstracts. The Iranian Fisheries Research Organization (formerly Iranian Fisheries Research and Training Organization) publishes these journals and has a website with lists of publications.

Some papers have been reprinted under the journal title "New Technologies in Aquaculture Development (Journal of Fisheries)" (at volume 14 in 2020) and appeared earlier and were cited here under "Journal of Fisheries". These have not been repeated here. Not all papers are repeated and pagination as well as year differs in some. Both versions appeared in Farsi with an English abstract. On-line searches for the articles by title or author may appear in either version. There is also another "Journal of Fisheries" appearing in Farsi (at volume 73 in 2020) and the "New Technologies..." version is presumably to avoid confusion.

Note that Iranian surnames may be compound, comprised of two components, with either the first or second component often ending in the -i suffix, or both ending in that suffix (the second in the latter case usually referring to a geographic location, e.g., Langarudi). The names may be separated, hyphenated or joined and generally appear in this sequence in the Bibliography. Such names may be cited with both (a recent innovation), or only one, of these components in papers and inadvertently herein - authors may then appear in three, relatively adjacent, places in the Bibliography. Names are also transliterated in various ways by authors themselves and by journals, e.g., Langarudi, Langrudi, Langaroodi, Langaroudi, Langroodi, Langroudi; and sometimes with a different initial letter, or a quite different spelling. The names are generally left as seen in the paper or abstract to facilitate searches of the original paper. Letters of the alphabet in Farsi include some transliterated as two letters in English (e.g., gh, kh, sh, zh) so first names of authors may have this double abbreviation, or not. And first names may be compound. The first name Gholamreza, for example, could appear as the initials G. R., Gh. R., Gh. or G. Some explanation of Persian name structure is given by Megerdooian (2008).

Major spelling errors or other faults in citations are indicated by "(sic)" meaning thus; minor ones are generally ignored especially in translation from Farsi in abstracts. Titles translated into English do not always agree fully with the original language but are generally consistent, and different sources vary in their translations. Some translated titles are given as originally cited for ease of retrieval even though the grammar and spelling are incorrect. Almost all scientific names are italicised in the original, occasionally some are underlined and rarely some are in quotes or not italicised. Some may not have been italicised in the original but are

here for emphasis as the original work was not seen.

Papers and books in Farsi are cited in English for ease of access by those readers unfamiliar with Farsi. This also avoids mistakes in writing and orthography and, as Farsi reads from right to left, in layout.

Some Iranian journals give volume, issue and sequential publication number. The latter is variably included here. Some volumes may give both or only the latter within that journal. The Iranian year runs from March to March so papers in Farsi without the Iranian month indicated may bear an incorrect English year when transposed. This would only be of significance for taxonomic reasons and this applies to none of the papers in Farsi. Papers may now appear on-line in the year before paper publication - the latter year is followed here (see Zareian *et al.* (2018) as an example). Some journals have issues appearing on-line as early as July but dated in the next year. Unless nomenclatorial issues are involved, the date appearing on the paper is used. Increasingly, journals use a unique article number (an abbreviated form of an article's digital object identifier) instead of the page range in the citation. And rarely a unique article number is given rather than pages.

The growth in literature on Iranian freshwater fishes, or literature of relevance to that fauna, can be summarised by number of publications by decadal interval years as follows:- 1954 (4), 1964 (9), 1974 (22), 1984 (40), 1994 (70), 2004 (124) and 2014 (497), for example. Over the five-year period 2013-2017 an average of 450 publications per year appeared.

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**Tamam shud.**



Sunset over Bam Citadel, Kerman, Brian W. Coad.