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Review Article

Review of the Silversides of Iran (Family Atherinidae)

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Abstract: The silversides are found in coastal areas of temperate to tropical seas and in fresh water. There are about 14 genera and 68 species with only one native species in the Caspian Sea basin, *Atherina caspia*. In this review, the systematics, morphology, distribution, biology, economic importance and conservation of the Caspian silverside of Iran are described, the species is illustrated, and a bibliography on this fish in Iran is provided.

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Introduction

The freshwater ichthyofauna of Iran comprises a diverse set of families and species. These form important elements of the aquatic ecosystem and a number of species are of commercial or other significance. The literature on these fishes is widely scattered, both in time and place. Summaries of the morphology and biology of these species were given in a website (www.briancoad.com) which is updated here for one family, while the relevant section of that website is now closed down. Other families will also being addressed in a similar fashion.

Family Carcharhinidae

The silversides or sand smelts are found in coastal areas of temperate to tropical seas and in fresh water. There are about 14 genera and 68 species (Nelson, 2006; Eschmeyer and Fong, 2011) with only one reported from the Caspian Sea and Iran. Coad (1987, 1998) and Coad and Abdoli (1996) place this species in context with the Iranian ichthyofauna. Most are small fishes with a maximum length of 60 cm.

These small, silvery fishes have a moderately elongate body, usually cycloid and moderately large scales, no lateral line but sometimes a pit on each scale, small teeth in the jaws and sometimes on the roof of the terminal, upwardly-directed mouth, wide gill openings with branchiostegal membranes free of the isthmus, 5-6 branchiostegal rays, gill rakers usually long and slender, two well-separated dorsal fins, the first with 3-10 unbranched but flexible rays, and the second with 1-2 unbranched and the rest branched rays, anal fin long, pectoral fins high on the flank, no pyloric caeca, egg membranes with filamentous outgrowths, back bluish to greenish with small melanophores but translucent, and a silvery stripe along the flank, often distinctively outlined with black.

Silversides can occur in vast schools in inshore waters and are an important item in the diet of other fishes. They have been used as bait but are too bony to be much used as food. Their food is plankton. Eggs are large and greenish. The sticky egg filaments entangle with plants, rocks or sand as anchors until hatching.

Genus *Atherina* Linnaeus, 1758

Members of this genus are found in fresh and brackish waters with a single representative in Iran. The record of *Atherina hepsetus* Linnaeus, 1758 in the Caspian Sea by Quignard and Pras in Whitehead

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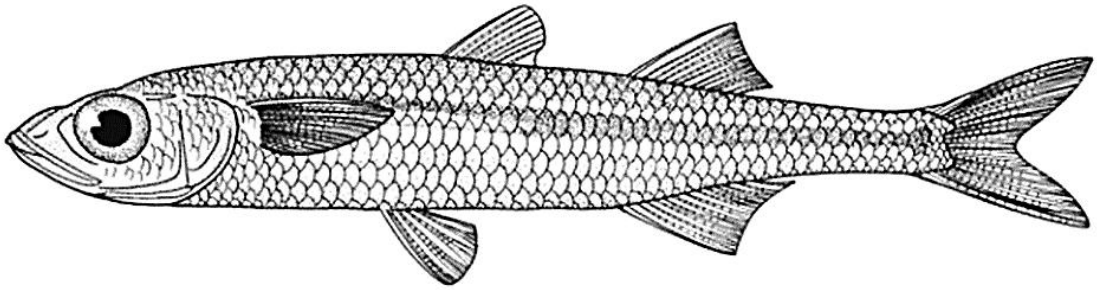

Figure 1. Line drawing of *Atherina caspia* by S. Laurie-Bourque.

et al. (1984-1986) is an error (Vasil'eva, 1994).

The body is compressed with a rounded belly, the mouth large and terminal, jaws large, reaching back to the anterior eye level or beyond, sides of the upper jaw are straight and premaxillaries protractile, the dentary bone has a high central portion, a preopercular notch is absent, rows of setiform teeth on the jaws, vomer and palatines, cycloid scales extending onto the head, short pectoral fins, vent nearer the pelvic fin origin than the anal fin, numerous gill rakers, 5-10 flexible rays in the first dorsal fin, and the second dorsal fin is similar in length to the anal fin with its origin above the anal fin.

Atherina caspia Eichwald, 1831

(Figs. 1-2)

Common names: Shisheh mahi (= glass fish), gol azin mahi (= flower decoration fish), atrinka (from the Russian). [aterinka or xazar aterini in Azerbaijan; kaspi aterinasy in Turkmenian; Kaspiiskaya aterinka or Caspian silverside in Russian; Caspian silverside, Caspian sand smelt, big-scale sand smelt].

Systematics: Formerly called *Atherina mochon pontica* natio *caspia* Eichwald, 1831 or *Atherina mochon caspia* in Caspian Sea literature.

Atherina mochon Cuvier, 1829 was described originally from Ivasa and *Atherina presbyter pontica* Eichwald, 1831 from near Odessa, Ukraine. The Caspian Sea taxon was also known as *Atherina boyeri* Risso, 1810. *Atherina boyeri* was originally described from the sea shore and lower course of rivers in the Département du Var, France. Reshetnikov et al. (1997) give the date for this species as 1826.

Atherina presbyter var. *caspia* Eichwald, 1831 described from "in Caspii maris littore australiore, sinu balchanensi" (i.e., southern shore of the Caspian Sea, Balkhan Bay) was considered a synonym of *Atherina boyeri*. Naseka and Bogutskaya (2009) consider *caspia* to be a full species and this is followed by Esmaeili et al. (2014).

Syntypes of *A. boyeri* are in the Muséum national d'Histoire naturelle, Paris under MNHN A-4342 (2) and MNHN B-860 (1) (Eschmeyer's "Catalog of Fishes", downloaded 29 August 2007). No types are known for *Atherina presbyter* var. *caspia*.

Bamber and Henderson (1985) demonstrated how the morphology of *Atherina presbyter* around Britain varies according to temperature and salinity during embryonic development. Isolation of populations results in local selection and random genetic drift and thus recognisable morphologies but these were not recognised as distinct. Kottelat (1997) reviewed literature reports of variation in this species in the Mediterranean and Black seas and neighbouring fresh waters and concludes that lacustrine populations should be called *A. boyeri* while marine populations are *A. mochon*. The status of Caspian populations was not commented on. These studies showed how variable these related silversides are and why the definition and limitation of species has been varied.

The silverside in the Caspian Sea was referred to as *Atherina boyeri caspia* by Savenkova and Asanov (1991) and by Vasil'eva (1994, 1996) and this seemed a reasonable step as the population is isolated from other populations in the Atlantic Ocean and Mediterranean Sea. The subspecies was

Figure 2. *Atherina caspia*, Anzali Shore, December 2009, courtesy of K. Abbasi.

characterised by a reduced number of infraorbital bones (3 bones in Caspian Sea fish as opposed to 4 in Black Sea fish; apparently infraorbital bones 2 and 3 fuse), a reduced number of gill rakers (generally 19-27 as opposed to 27-37), and the form of the maxilla (the inferior margin in Caspian Sea fish is always smooth while in the Black Sea and Sea of Azov a "wing" is usually developed). However, Kiener and Spillman (1972) allocated Caspian populations to this subspecies on the basis of larger size, hardly an adequate criterion. Vasil'eva (1994) makes the allocation based on a reduced number of gill rakers, reduction of the number of bones around the eye to three (preorbital, infraorbital and postorbital) and a smooth lower margin to the maxilla without a wing protuberance.

Dobrovolov and Ivanova (1999) studied two non-enzymatic proteins and 11 enzymes for putative *Atherina boyeri* and *A. mochon pontica*. They concluded that these are distinct species and indeed the Black Sea fish are a distinct species, *A. pontica*. They diverged 2.316 MYA. These authors did not examine Caspian Sea material. Miller in Miller (2003) followed a conservative approach, regarding the various named and wide-ranging populations as representing a single polymorphic species.

Key characters: The two dorsal fins, cycloid scales, pectoral fin high on the flank and the vent remote from the anal fin are characteristic.

Morphology: First dorsal fin spines 5-10, second dorsal fin with 1-2 spines and 8-15 soft rays, anal fin with 1-2 spines and 9-18 soft rays, pectoral branched rays 10-17, usually 12-15, pelvic fin with 1 spine 5-7, usually 5, branched rays, lateral series scales 37-53 (possibly to 61, see Vasil'eva (1994)), total gill rakers 19-29 in the Caspian Sea, spinulose on the interior surface, and long and reaching about 7 rakers along the arch when appressed, and vertebrae 39-52. Note narrower ranges for all preceding meristic characters for Iranian material given below. The anus is 4-5 scales in advance of the anal fin. Scales are higher than broad, with slight indentations on the otherwise straight dorsal and ventral margins, a rounded posterior margin, and a wavy to rounded anterior margin with a protuberant central point. There are no radii. Circuli are restricted to the anterior third of the scale with a central and vertical roughened area posterior to the circuli, presumably made up of fragmented circuli. The focus is central. The lower jaw symphysis fits into a notch in the upper jaws. The haemal arches of the anterior 4-7 caudal vertebrae are expanded around the gas bladder. The gut is s-shaped. The chromosome number is 2n=48 (Klinkhardt et al., 1995).

Meristic values for Iranian specimens are: first dorsal fin spines 8(28), 9(5) or 10(1); second dorsal fin soft rays 11(10), 12(21), 13(2) or 14(1), anal fin soft rays 13(7), 14(15), 15(9) or 16(3), pectoral fin branched rays 12(1), 13(12), 14(14) or 15(6), pelvic fin branched rays 5 (34), caudal fin branched rays 13(1), 15(30), 16(2) or 17(1), lateral series scales 50(1), 51(10), 52(5), 53(3), 54(8), 55(3), 56(3) or 57(1), predorsal scales 17(1), 18(2), 19(12), 20(8), 21(3), 22(3), 23(1), 24(3) or 26(1), caudal peduncle scales 12(31), 13(2) or 14(1), transverse scales from anal fin antero-dorsally 10(2), 11(6), 12(23) or 13(3), total gill rakers 24(3), 25(4), 26(14), 27(8), 28(4) or 29(1), and total vertebrae 45(1), 46(19), 47(7) or

48(7).

Sexual dimorphism: Females tend to be larger than males and there are some differences in morphometrics and meristics (Ghoorbanalidoost et al., 2003).

Colour: General colour is given in the family account. The lateral band is strongly developed and bright in Caspian Sea specimens. The belly is white, fins are pale to translucent grey. Lagoon specimens are brownish or grey-brown on the back. The peritoneum is brown to black, eggs being encased in a black peritoneum while the abdomen wall is a light brown.

Size: Reaches 11.8 cm and 17.6 g in the Atrak River (Savenkova and Asanaov, 1991), to 14.5 cm standard length in the Caspian Sea basin generally (Henderson and Bamber, 1987). Kiener and Spillman (1972) found a maximum of 15.4 cm in their Caspian Sea sample and Patimar et al. (2009) found 12.8 cm total length for their sample of 2256 fish in the Gomishan Wetland.

Distribution: Found in the Caspian Sea and the Uzboi Valley of Turkmenistan. In Iran, it is reported along the whole Caspian Sea coast, and from the Safid, Tajan, Tonekabon, Havigh, Karkan, Chalus, Farahabad, Langarud, Siahrud, Sheikan, Shafa, Talar and Atrak rivers, Gomishan Lagoon or Wetland, Boojagh Wetland, Anzali Lagoon and the Sowsar Roga outlet of the lagoon seasonally, the Caspian Sea at Bandar Anzali breakwater and beach, Hasan Kiadeh, Kazian Beach and west of Chalus, Gorgan Bay, Alma-Gol, Adji-Gol and Ala-Gol (Savenkova and Asanov, 1991; Holčík and Oláh, 1992; Roshan Tabari, 1997; Karimpour, 1998; Abbasi et al., 1999; Kiabi et al., 1999; Afraie and Lalooie, 2000; Khara et al., 2004; Abbasi, 2006; Patimar, 2008b; Abdoli and Naderi, 2009; Patimar et al., 2009; Esmaeili et al., 2014).

Zoogeography: This species probably entered the Caspian Sea from the Black Sea during Khvalyn transgression (10-70,000 years B.P.) via the Kumo-Manych Depression (Kosarev and Yablonskaya, 1994). Berg (1948-1949) contends that it entered the Caspian from the Black Sea in post-glacial times while most other Caspian fishes are relicts of earlier transgressions or migrants from northern waters.

Habitat: The Caspian silverside is a schooling fish found at depths exceeding 100 m but is concentrated at 10-20 m. Salinity tolerance is high, up to 77‰ (Miller in Miller, 2003), up to 60‰ in the Atrak River (Savenkova and Asanov, 1991). Reproduction can occur up to 42‰ while preferred levels are 3-12‰. A wide temperature range is tolerated, 0-31ºC (Miller in Miller, 2003). It is also found in lagoons and river mouths, and enters rivers to spawn, against currents up to 1.2 m/sec. It is the dominant species in the Gomishan Wetland in spring, summer and autumn (Patimar et al., 2009). Holčík and Oláh (1992) report its apparent recent occurrence in the Anzali Lagoon in response to increased salinity there. It is also known from fresh water in Lenkoran. It can rapidly adjust its life history to a range of environments, from fresh water to coastal water.

Age and growth: Maturity is attained in the first year and life span varies from 1 to 5 years, 4-5 years usually in the Caspian Sea basin (Henderson and Bamber, 1987). Ghoorbanalidoost et al. (2003) found populations in the south Caspian Sea to be 73.82 mm long on average and 3.15 g in weight, with age groups 1-3 years, average 1.7 years, total length and length-weight relationship $W=0.00000615L^{3.02}$ and a sex ratio of male:female=0.47:0.53. Heydarnejad (2009) gave the length-weight relationship for an Iranian sample as $W=0.0326TL^{3.033}$. Patimar (1995) and Patimar et al. (2009) found 2256 fish from the Gomishan Wetland had a 4-year life cycle (to age 4^{+} years). Length-weight relationships were $W=0.0053TL^{3.0181}$ for males and $W=0.0050TL^{3.063}$ for females, both allometrically positive. The von Bertalanffy equation was $Lt=155.17[1-exp-0.28(t+0.738)]$ for males and $Lt=162.77[1-exp-0.27(t+0.727)]$ for females. The sex ratio was male:female 1:1.3 and females dominated in the older age classes. Amri Sahebi et al. (2015) examined 191 fish from the southeast coast of the Caspian Sea and found an average fork length of 7.7 cm, weight 3.64 g and age 2 years.

Food: Savenkova and Asanov (1991) report plankton, eggs and juvenile fishes to be food items in the Atrak River of Turkmenistan. Some populations also eat benthic organisms such as amphipods, worms and molluscs. Some Iranian specimens contained encysted cladocerans and beetles in their guts. It has a trophic plasticity, adapting to whatever conditions obtain (Miller in Miller, 2003). Amri Sahebi et al. (2015) examined this fish in the southeast coastal waters of the Caspian Sea, finding it to be an opportunistic and carnivorous fish and a relatively voracious feeder. Benthic *Gammarus* and the zooplankton *Daphnia* were favoured foods and various other cladocerans along with copepods, ostracods, nematodes and dipterans were taken.

Reproduction: Spawning in this species is intermittent and occurs along the coast from May to July, peaking in mid-May to mid-June (Savenkova and Asanov, 1991) or from April to August (Henderson and Bamber, 1987). Preserved Iranian fish samples have relatively large eggs from April to September, e.g., 1.4 mm on 27 April, 1.6 mm on 14 May. Savenkova and Asanov (1991) also studied the annual spawning migration into the Atrak River (lower reaches in Turkmenistan, upper reaches shared with Iran). Fish are caught in a fish ladder 18-19 km from the sea and in the river. The first schools appear in the Atrek mouth as early as mid-February at water temperatures of 8-10°C but the mass migration takes place in mid to late March and the first half of April at 14-22°C. Spawning occurs in March, April and May but most intensively in April at flood water temperatures of 13.7-23.0°C. There is a larger migration in high-water years. Sex ratio is about 1:1. A female may be able to spawn 5-6 times in one season so that egg numbers and diameters vary within each individual for different generations of eggs. Egg deposition in the Caspian Sea is associated with the alga *Cladophora* to which the eggs are attached or entangled by long filaments (up to 15) and this plant is present in the Atrak. Egg diameters may reach up to 2.0 mm and the light yellow eggs number up to 5500 (Caspian Sea Biodiversity Database, www.caspianenvironment.org) presumably total seasonal fecundity. Only one gonad develops. Larvae are pelagic but may school close to shore. Patimar et al. (2009) for their Gomishan study found the reproductive season was March-July, peaking in March. Average absolute and relative fecundities were 2976 eggs and 784 eggs g^{-1} of body weight respectively (874 in the abstract). Maximum fecundity was 10,188 eggs for a 4^{+} fish. Mean oocyte diameter was 0.68 mm.

Parasites and predators: The Caspian seal, *Pusa caspica*, is a predator on this species (Krylov, 1984) as are the larger fishes such as *Stenodus leucichthys* and *Alosa saposchnikowii* (Lönnberg, 1900) and the sturgeons *Acipenser persicus* and *A. stellat*us (Haddadi Moghadam et al., 2009).

Economic importance: This species is food for a number of other fishes including such economic species as sturgeons, Sander and the predacious shads. It has been caught as a by-catch in kilka seine nets and used in fishmeal production. In Europe, the related *A. boyeri* has been sold fresh or canned, and in Turkey has been investigated as a food in the form of fish chips (Izci et al., 2011).

Conservation: Kiabi et al. (1999) consider this species to be of least concern in the south Caspian Sea basin according to IUCN criteria. Criteria include abundance in numbers, widespread range (75% of water bodies), absent in other water bodies in Iran, and present outside the Caspian Sea basin. The IUCN (2014) has not assessed this species.

Sources: Further details on collections examined can be found in the museum catalogues.

Iranian material: CMNFI 1970-0507, 11, 22.2-56.3 mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0509, 5, 49.5-101.7 mm standard length, Gilan, pond at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0543A, 7, 52.9-83.1 mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0563, 18, 39.8-112.5 mm standard length, Gilan, Kazian Beach (ca. 37º29'N, ca. 49º29'E); CMNFI 1970-0581, 5, 47.6-54.8 mm standard length, Caspian Sea near Hasan Kiadeh

(37º24'N, 49º58'E); CMNFI 1970-0586, 7, 33.4-84.9 mm standard length, Mazandaran, Gorgan Mordab at Ashuradeh-ye Kuchak (36º50'N, 53º56'E); CMNFI 1971-0343, 2, 65.9-72.5 mm standard length, Gilan, Langarud at Chamkhaleh (37º13'N, 50º16'E); CMNFI 1979-0081, 3, 74.1-77.3 mm standard length, Mazandaran, Caspian Sea, 3 km west of Chalus (36º41'N, 51º24'E); CMNFI 1980-0127, 6, 39.7-44.4 mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1980-0146, 4, 92.1-103.6 mm standard length, Mazandaran, Gorgan Mordab at Ashuradeh-ye Kuchak (36º50'N, 53º56'E); and CMNFI 1980-0160, 2, 49.2-73.8 mm standard length, Iran, Caspian Sea basin (no other locality data); CMNFI 1993-0144, 1, 75.3 mm standard length, Mazandaran, Neka Power Plant (36º51'48"N, 53º23'24"E); CMNFI 2008-0105, 1, 87.6 mm standard length, Gilan, Bandar Anzali breakwater (37º26'N, 49º29'E).

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چکیده فارسی

مروری بر گل آذین ماهیان ایران (خانواده Atherinidae)

برایان کد
موزه تاریخ طبیعی کانادا، اتاوا، انتاریو، K1P 6P4، کانادا.

چکیده:
گل‌آذین ماهیان در نواحی ساحلی دریاهای معتدله تا گرمسیری و آبهای شیرین یافت می‌شوند. حدود ۱۴ جنس و ۶۸ گونه در این خانواده وجود دارد که تنها یک گونه بومی بنام *Atherina caspia* در دریای خزر یافت می‌شود. در این مقاله مروری، سیستماتیک، ریخت‌شناسی، پراکنش، زیست‌شناسی، اهمیت اقتصادی و حفاظت گونه گل آذین خزری ایران توصیف شده و به تصویر کشیده می‌شود. همچنین یک فهرست منابع در مورد این ماهی در ایران ارائه می‌گردد.
کلمات کلیدی: *Atherina*، زیست‌شناسی، ریخت‌شناسی، دریای خزر.