Iran. J. Ichthyol. (June 2016), 4(2): 75–130
© 2017 Iranian Society of Ichthyology
P-ISSN: 2383-1561; E-ISSN: 2383-0964
Received: April 1, 2017
Accepted: May 29, 2017
doi: 10.7508/iji.2016.0
http://www.ijichthyol.org

Review of the Freshwater Mullets of Iran (Family Mugilidae)

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Abstract: The systematics, morphology, distribution, biology, economic importance and conservation of the freshwater mullets of Iran are described, the species are illustrated, and a bibliography on these fishes in Iran is provided. Two species are found in the Caspian Sea basin as exotics (*Chelon auratus, C. saliens*), two species in southern Iranian fresh waters as native species (*Mugil cephalus, Planiliza abu*) and two species in brackish waters of rivers (*Ellochelon vaigiensis, C. subviridis*).

Keywords: Biology, Morphology, Mugilidae, *Chelon*, *Ellochelon*, *Liza*, *Mugil*, *Planiliza*.

Citation: Coad, B.W. (2017). Review of the freshwater mullets of Iran (Family Mugilidae). Iranian Journal of Ichthyology 4 (2): 75-130.

Introduction

The freshwater ichthyofauna of Iran comprises a diverse set of families and species distributed in different basins (Fig. 1). 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, while the relevant section of that website is now closed down.

Family Mugilidae

The mullets or grey mullets are found world-wide in temperate to tropical coastal waters readily entering estuaries and even resident in freshwaters. There are about 20 genera and about 75 species (Nelson et al. 2016) but only three species are native to Iran in fresh and brackish waters and a further two species have been successfully introduced (the latter not mapped in Berra (2001) because they are exotics). The native species are placed in context with other Iranian fishes in Coad (1987, 1998) and Coad & Abdoli (1996). A number of species are recorded as entering the rivers of southern Iran from the Persian Gulf and Sea of Oman although identification is not always certain and only two are described here (*Ellochelon vaigiensis* and *Planiliza subviridis*). Examples of other Persian Gulf estuarine records include *Moolgarda seheli* (Forsskål, 1775) and *P. klunzingeri* (Day, 1888) in the Kol River, Hormozgan (Bagheri et al. 2010), and *M. buchanani* (Bleeker, 1853) generally in southern rivers (Nematzadeh et al. 2013), and doubtless other mullet species may be found in estuaries (see Fischer & Bianchi (1984) and Kuronuma & Abe (1986) for Persian Gulf marine species in general). The three main species of Iran are *Chelon auratus* and *C. saliens* introduced to the Caspian Sea and *Planiliza abu* of southern Iranian fresh waters (see Esmaeili et al. 2017). These three species are commercially important.

Literature on the Iranian species has appeared under a variety of generic names. Fishes in the genera *Chelon*, *Ellochelon* and *Planiliza* were previously in the genus *Liza* Jordan & Swain, 1884. Molecular data has caused this re-assessment and can be found in such papers as Durand et al. (2012, 2012),

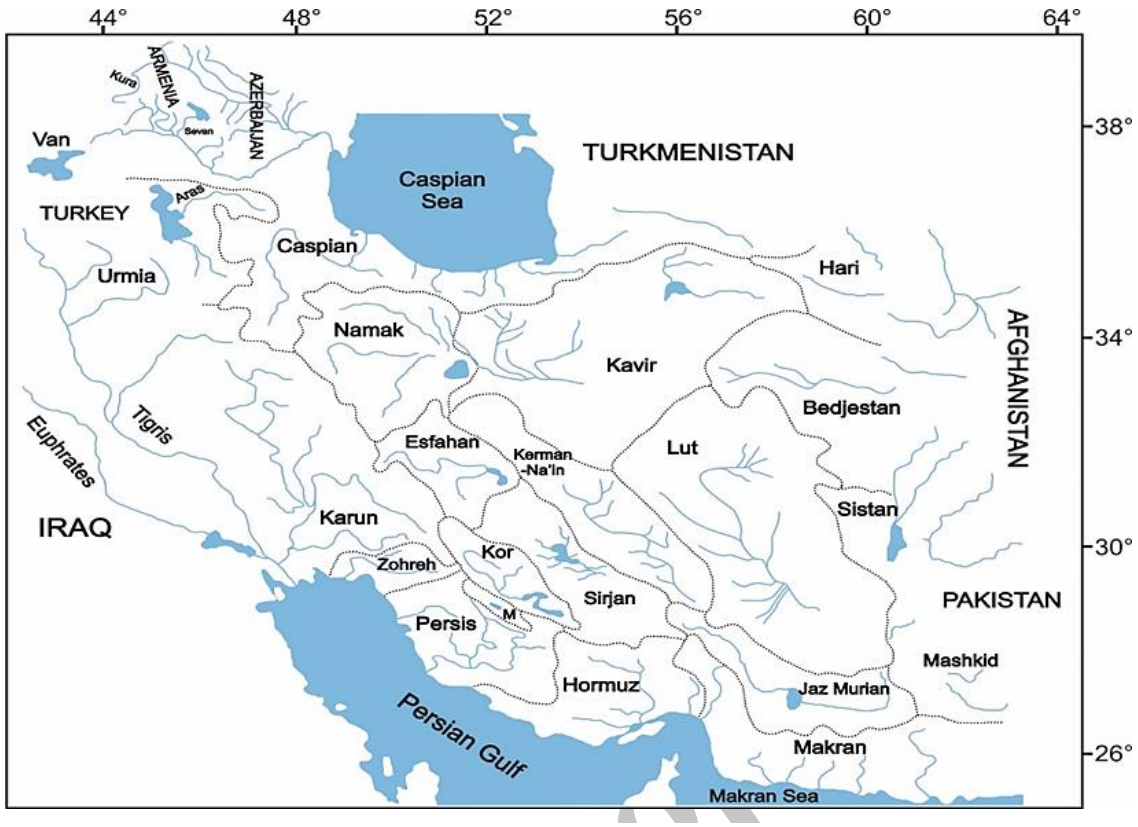

Fig.1. Map of Iran showing different basins, (M= Maharlu) (Esmaeili et al. 2017).

Nematzadeh et al. (2013) and Xia et al. (2016). Various authors have accepted, or not, these generic placements and a review of these opinions are beyond the scope of this paper. The "Catalog of Fishes" (Eschmeyer et al. 2016) should be referred to for varying opinions and a history of generic placement of species although *Liza* is retained there (downloaded 19 January 2017). Most of the literature cited below refers to the species discussed under the genus *Liza* (except for *Mugil cephalus*) but the genus name has been changed in this text for consistency.

This family is characterised by a compressed to subcylindrical body with a somewhat flattened head, moderate sized scales which may be cycloid but are ctenoid in most adults and extend onto the top and sides of the head, faint or no lateral line along the flank but pits or grooves on scales contain the sense organs, the eye may have an adipose or fatty eyelid forming a vertical, slit-like opening, vertebrae usually 24, rarely as high as 26, wide gill openings, gill rakers long and slender and increasing in number with growth, upper elements of the gill arch are specialised as a pharyngobranchial organ, 5-6 branchiostegal rays, a spiny and short first dorsal fin (4 spines), the second dorsal with 1 unbranched ray or spine and 6-10, usually 8, branched rays, anal fin with 2-3 spines and 8-12 branched rays, an abdominal pelvic fin with 1 spine and 5 soft rays, pelvic bones connected to the postcleithrum by a ligament, mouth transverse and small, teeth on jaws short, weak and flexible, the lower jaw may be toothless, the stomach wall is strongly muscled (gizzard-like), and the gut is very long and coiled. Maximum size is about 0.9m

Mullets are schooling fish which feed on microscopic algae and the minute animals associated with the algae. They grub, gulp or suck (hence "mugil") bottom deposits, spitting out some of the debris and extracting nutrient from the remainder. The long gill rakers filter the food, the strong gizzard-like stomach crushes it and the long intestine (about seven times body length) aids in digestion. Their

bottom feeding leaves long patches of disturbed sediment readily visible from a distance. Eggs, larvae and young mullet are pelagic. Adults are found in large schools in coastal waters or on tidal flats. These fishes are very important economically as food eaten fresh, smoked or canned, as bait, and as cultured fish in ponds. The flesh is oily and rich but has few bones. Mugilid species in Khuzestan are thought to be the intermediate hosts of Heterophyidae flukes found in humans and carnivores (Massoud et al. 1981). Barati (2009) found that the main prey in the early stages of chick development of the Great Cormorant, *Phalacrocorax carbo*, at Ramsar on the Caspian Sea was Mugilidae.

Soltani & Rahanandeh (2001) describe a case of gastric bloat in *Mugil capito* in the Caspian Sea. *Mugil capito* Cuvier, 1829 is a synonym of *Chelon ramada* (Risso, 1827), a species not known from the Caspian Sea. However, Nematzadeh et al. (2013) mention that samples of that species were imported from Egypt to the Gomishan Research Center in Gorgan where they were being maintained.

The total production of this family in 2013 was 698,293 tonnes, mainly (80.2%) capture fisheries but with 138,143t from aquaculture. Capture fisheries of *C. abu* were at 593t, *C. auratus* at 170t, *C. saliens* at 111t and *Mugil cephalus* at 133,514t (plus 12,245t from aquaculture for the latter). Iran's total for 2013 was 8,510t but 6,137t was for Persian Gulf marine species (*Moolgarda seheli* and *Planiliza klunzingeri*). Grey mullet roe is also consumed and the fish are used for bait by recreational and commercial fishers. Crosetti & Blaber (2016) give further details about capture methods and usage.

Studies have been carried out on culturing *M. cephalus* and *C. auratus* in brackish water, in inland pools and salt and freshwater culture ponds in the northern and central parts of Iran (Emadi 1993, Iranian Fisheries Research and Training Organization Newsletter 11: 6, 1996, Azari Takami et al. 1997; Yelghi et al. 2012). In April 1994, 20,000 *M. cephalus* fry weighing 0.5g were imported from Hong Kong as part of this programme (Iranian Fisheries Research and Training Organization Newsletter 4: 8, 1994). The general name for mullets in Farsi is kefal or kafal.

Pillay (1972) gave a bibliography on mullets, Thomson (1997) reviewed the taxonomy, giving further details of anatomy than summarised here, Ghasemzadeh & Ivantsoff (2004) gave an overview of mugilid systematics, Crosetti & Blaber (2016) summarised biology, ecology and culture, and Xia et al. (2016) provided a key to genera.

Genus *Chelon* Artedi, 1793

This genus is defined more by traits found in related genera but absent in *Chelon*. It is characterised by thin to moderately thick, terminal upper lip with or without papillae, the lower lip is directed forwards and is thin-edged, teeth are setiform, ciliiform or absent in the upper lip, ciliiform or absent in the lower lip, there is a symphysial knob to the lower jaw and the lower jaws meet at a 90º angle or more, the maxilla is bent down over the premaxilla and is either uniformly curved or is s-shaped, the maxilla end is visible when the mouth is closed, the anteroventral edge of the preorbital bone is serrate, weakly concave or kinked and ventrally it is broad and squarish, an adipose eyelid is present sometimes but is not well-developed being a narrow rim around the eye at all ages, the pharyngobranchial organ has two valves, pyloric caeca number 2-14, the intestine is 4-7 times standard length, the pelvic fin tip reaches the vertical from spines I-IV of the dorsal fin, scales are ctenoid, predorsal scales are uni- or multi-caniculate (= grooved), the pectoral axillary scale is weak or absent, and a neural postzygapophysis is short with a spine-like process gently curved and hook-like on the second vertebra (cf. *Planiliza*). Thomson (1997) and Xia et al. (2016) list further characters.

Members of this genus were formerly placed in the genus *Liza* Jordan and Swain, 1884. Some authors accept *Chelon* as the correct name, others retain *Liza*. For example, Ghasemzadeh (1998) stated that nomenclatural issues were complex and needed more work before *Chelon* could be accepted.

Molecular evidence from Durand et al. (2012, 2012) supports the synonymy of *Liza* with *Chelon* but no diagnostic morphological characters are apparent. A review of the situation can be found in Crosetti & Blaber (2016). Increasingly, the genus *Chelon* is used and is followed here.

Experiments have been carried out on fishing methods for these fishes in the Caspian Sea of Iran, comparing encircling gill nets with fixed gill nets and with purse seines (Annual Report 1992-93, Iranian Fisheries Research and Training Organization, Tehran, Annual Report 1993-94). In 1994-1995, the Caspian mullet catch was 4,145t, 85% of which was *C. auratus*. Catch per unit effort decreased by 50% over the preceding three years (Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran p. 37, 1996).

Azari Takami et al. (1997) successfully raised fry of *Chelon auratus* and *C. saliens* at Bafgh-Yazd in central Iran in earthen ponds supplied with brackish well water. Fry in the 3-10g range were cultivated for 100 days at 2200 fry/ha with pond fertilisation and with fertilisation and complementary feeding, giving 100g and 120g fish, respectively. Experiments with different stocking densities and mixes of the two species were also carried out. Second year *C. saliens* reached 165g and third year *C. auratus* reached 630g and sexual maturity.

Chelon auratus (Risso, 1810)
(Figs. 2-4)

Common names: Kefal-e auratus, mahi kefal-e talaee (= golden mullet fish), kefal-e zarin, kafal. [Gizili kefal in Azerbaijanian; gatykelle, singil, orsbalyk in Turkmenian; singil' in Russian; golden mullet, golden grey mullet, long-finned mullet].

Systematics: *Mugil Auratus* was originally described from Nice, France. No major relevant synonyms. Placed in the genus *Chelon* by Durand et al. (2012). Samadani & Gharahveysi (2010) compared samples from Babolsar and Fereydun Kenar using electrophoresis, genetics, morphometry and meristics and found significant differences. Ghodsi et al. (2011) examined fish from the Gomishan and Miankaleh regions in Golestan Province using microsatellite markers but found no conspicuous genetic variation. There was evidence of a genetic bottleneck in the populations. Ghodsi et al. (2013) subsequently examined fish from Babolsar and Chalus in Mazandaran and also found no conspicuous genetic variation. Kohestan-Ghaninejad et al. (2012) found differentiation between Iranian and Azerbaijani stocks based on morphometric and meristic characters. Kohestan-Eskandari et al. (2013) examined morphometric differences in fish from the Neka, Behshahr and Galogah populations in the southeastern Caspian Sea with the latter two populations showing low overlap but the Neka population showing high overlap with the other two. Limited dispersal and migration and high inbreeding were the probably the cause of morphologically distinct populations. Behrooz et al. (2014) examined fish from two localities in Mazandaran Province using microsatellite markers and found genetically distinct populations. Saeidi et al. (2014) used D-loop sequencing to compare fish from the Anzali and Gomishan areas and found high genetic differentiation between these Gilan and Golestan provinces' fishes, indicating different populations. Khayyami et al. (2014b) used 25 morphometric characters to compare fish from Gilan, Mazandaran and Golestan provinces and was able to assign all individuals to their locality. Gilan and Mazandaran samples showed overlap and were highly different from Golestan. Behruz et al. (2015) used 6 microsatellite markers to compare fish from the Anzali and Gomishan wetlands and found significant genetic differentiation.

Key characters: This species is distinguished from its relative in the Caspian Sea by each head and antero-dorsal flank scale having only one pit or groove (occasionally double), 6-11 pyloric caeca of about equal length or gradually becoming longer from ventral to dorsal, scales on the snout ending anteriorly as a single row of small scales, and the oral edge of the preorbital bone is moderately concave.

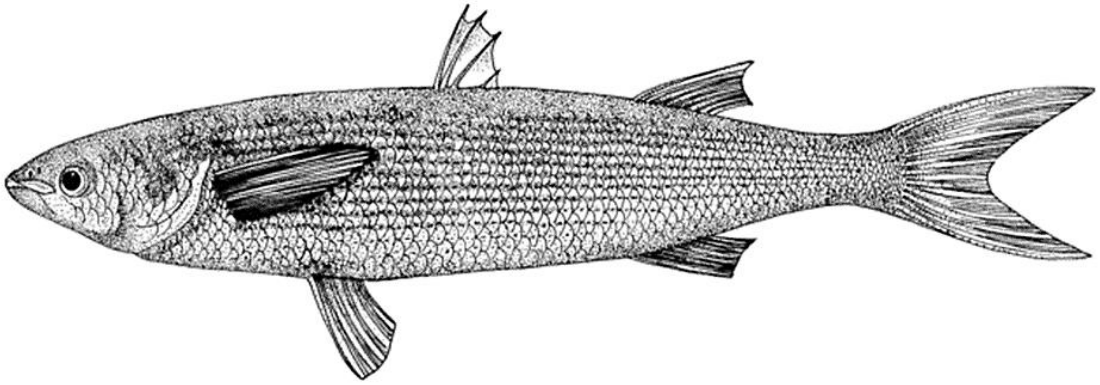

Fig.2. Line drawing of *Chelon auratus* by S. Laurie-Bourque.

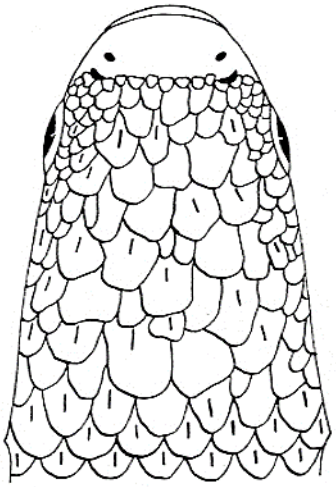

Fig.3. *Chelon auratus* dorsal head (after Movchan 1988).

The upper jaw reaches posteriorly to a level with the posterior nostril, the only species in the genus with this character. Young have two vertical dark lines at the origin of the caudal fin rays and a herring bone pattern on the flanks (Harrison in Miller 2003).

Morphology: The first dorsal fin has 4 strong spines, the last weakly developed compared to the first three. The second dorsal fin has 1-2 weak spines (more resembling unbranched rays than spines) and 6-9, usually 7 or 8 soft rays (the second unbranched ray or spine may be branched near the tip - the mode of 8 may include this ray in literature sources). The anal fin has 3 spines and 7-10, usually 9 branched soft rays. The pectoral fin has 2 unbranched rays and 13-17 branched rays and the pelvic fin has 1 spine and 5 branched rays. Scales number 40-49 in lateral series. There is no pectoral axillary scale. There is an elongate first dorsal fin axillary scale and a pelvic axillary scale. Scales have an almost vertical anterior margin with the anterior dorsal and ventral corners square to pointed. This margin is slightly indented where radii intersect it. The dorsal and ventral scale margins are parallel and the posterior margin is rounded. The focus is posterior and the posterior field has weak ctenii. Circuli are fine and numerous and radii are limited to the anterior field, numbering up to 13 in fish examined here but probably size dependent. The adipose membrane of the eye is rudimentary. The gill rakers are fine and numerous, apparently finer and more numerous than in *C. saliens*, exceeding 100 in the larger fish examined here. Raker number is probably size dependent. Rakers are slender, compressed and serrated medially. When appressed, a raker reaches the thirteenth raker below. The gut is elongate with several anterior and posterior loops after a muscular stomach. Khayyami et al. (2015b) gave details of the anatomy and histology of the stomach and pyloric caeca. The chromosome number is 2n=48 (Klinkhardt et al. 1995). The morphology of the saccular otolith was described by Bamshad et al. (2015).

Meristic values for Iranian specimens are:- first dorsal fin spines 4(30); second dorsal fin with 1(3) or 2(27) "spines" or unbranched rays and 6(1), 7(27), 8(1) or 9(1) branched rays; pectoral fin unbranched rays 2(30) and branched rays 15(7), 16(20) or 17(3);

Fig.4. *Chelon auratus* from the Anzali Shore, January 2012, courtesy of K. Abbasi.

pelvic fin branched rays 5(30); and lateral line scales 41(2), 42(4), 43(8), 44(3), 45(8), 46(4) or 47(1).

Sexual dimorphism: Unknown.

Colour: The body is a dusky grey to blue-grey with a silvery flank and belly. The back and upper flank have a series of dark to golden stripes. There is a golden blotch on the operculum. The peritoneum is dark brown to black. See also Key characters.

Size: Commercial catches in Iran during the 1950s weighed 0.3-0.8kg, sometimes as much as 1.5-1.8kg (Farid-Pak no date). Reaches 59.0cm and 2.5kg on the coast of Turkmenistan. The Fisheries Research Centre in Mazandaran caught an exceptional specimen of this species weighing 1.5kg and measuring 54.0cm long (Iranian Fisheries and Research Training Organization Newsletter 3, 1994). Norouzi & Bagheri Tavani (2016) found a maximum size of 58.0cm and 1,252g in the Anzali Talab or Wetland.

Distribution: Found in the Mediterranean and Black seas and from the British Isles south to South Africa. First reported from Iranian waters in 1933 by Shukolyukov (1937) and by Dmitriev (1946), this species and *C. saliens* became acclimated to the Caspian Sea over a period of 30-35 years and are regarded as naturalized from the latter half of the 1960s onward in Soviet waters (Marti 1940, 1941; Khoroshko 1982). It was first introduced to the Soviet Caspian Sea in 1930-1931 (Baltz 1991). Kaplin in Mandych (1995) indicates that these grey mullets entered from the Black Sea during a Caspian transgression but this is incorrect.

In Iran, this species is found in the lower reaches of rivers along the Caspian coast such as the Babol, Chabak, Chalus, Golshan, Gorgan, Hevigh, Karkan, Larim, Neka, Qareh Su, Rasteh, Sefid, Shafa, Shahrud, Sheikan, Tajan and Talar, the Anzali Talab and its outlets where numbers will probably increase with increasing salinity (Holčík & Oláh 1992), Gorgan Bay, the Gomishan Talab, and the whole Caspian Sea coast (Karimpour 1998; Abbasi et al. 1999; Kiabi et al. 1999; Abbasi 2006; Abdoli & Naderi 2009; Shayeghi et al. 2012; Hosseine et al. 2013; Behruz et al. 2015).

Zoogeography: This species is an exotic in Iran.

Habitat: This mullet inhabits the sea and enters the lower reaches of rivers, and is occasionally found in nearby lakes. Khodabandeh et al. (2009) found fry were able to change the number and size of gill chloride cells, indicating a high degree of adaptability to a wide range of salinity. Shahriari Moghadam et al. (2013) also found this adaptation and noted mortality occurred over a narrow range of salinity from 45 to 60p.p.t., being 100% in salinities higher than 60p.p.t.

It is recorded from depths of 5-700m (Caspian Sea Biodiversity Database, www.caspianenvironment.org). Eggs develop in the open sea, larvae migrate to the coast and young feed along the shore and in bays. It winters along the Iranian shore in

coastal waters, has a feeding migration in surface waters beginning in March to shallow areas of the middle Caspian and, by September-October, and mature fish migrate over deeper water (300-700m) of the middle and south Caspian to spawn. Feeding ceases at 6-8ºC and death occurs below 1.5ºC. The optimum temperature is 23-25ºC but young can be found in shallow water at 37.5ºC. It occurs from fresh water to salinities of 57‰ with mass mortalities recorded at 65‰ (Caspian Sea Biodiversity Database, www.caspianenvironment.org). Fazli et al. (2014) carried out 8 surveys in Iranian waters at 10-100m depths during 2008-2011 and found the mullet catch (both species) had a declining trend. The total catch fell from 3,064kg in spring 2008 to 93kg in winter 2011 with catch-per-unit-effort 63.8kg/0.5hr^{-1} to 2.9kg/0.5hr^{-1} respectively. Most mullets concentrated in depths <20m in all seasons and migrated to coastal zones during autumn to overwinter, and consequently the catch increased. Catch-per-unit-effort in summer at depths <20m was a maximum of 10.0kg/0.5hr^{-1} in the eastern coastal zone while in autumn the highest was 136.0kg/0.5 hr^{-1}.

Age and growth: Life span is up to 12 years in the Caspian Sea (Khoroshko 1982). Maturity is attained at 38-45cm and an age of 3-4 years for males and 5-6 years for females (RaLonde & Walczak 1972). Fish taken from commercial catches in Iran are mostly 3-7 years old, 30.2-49.1cm long and weigh 354-1,266g (Razivi et al. 1972). Fazli (1998) studied this species in the southeastern Caspian Sea of Iran and found that both scales and opercula could be used in ageing, although the latter were better. Maximum growth occurred at 3 years of age. The *b* value in the relation between length and weight was 3.019 and sex ratio was 1:1.3 with females dominating. Fazli et al. (2008) gave a length-weight relationship as $W=0.0118FL^{2.964}$ with an overall male:female ratio of 1:1.42 for 462 fish from Mazandaran, 22.1-51.9cm fork length. Fazli et al. (2008) examined 38,417 fish from Iran caught during 1991-2005. Length and weight ranged from 18 to 61cm and 50 to 2,500g and averaged 32.2cm and 41.6g respectively. Age ranged from 3 to 11 years with ages 4, 5, 6 and 7 years dominating in different years. The length-weight relationship was $W=0.0107L^{3.006}$ for the whole sample. Growth was rapid up to 3 years, increased slowly up to 5 years and then increased rapidly. Growth parameters were L_∞=62.7cm, K=0.15year^{-1} and t_0=-0.23year^{-1}. The instantaneous coefficient of natural mortality was estimated as 0.35year^{-1} and the instantaneous coefficient of fishing mortality varied over the 14-year period between 0.111 and 0.539 year^{-1}. The annual survival rate (S) was 0.486year^{-1} and the instantaneous coefficient of total mortality (Z) was 0.721year^{-1}. Biomass estimates were 13,527mt in 1991-1992, 23,992mt in 2002-2003 and 23,658mt in 2004-2005. It was concluded that the stock was not being over-fished. Ghaninejad et al. (2010) sampled fish from along the Iranian coast captured in 2007-2008. The overall male/female sex ratio at 1:1.22 differed significantly from 1:1 although only fish from Golestan were significantly different, size range was 19.0-50.2cm, mean 32.7cm, weight was 67g to 1,475g, mean 411g, age range was 2 to 10 years with mean age 4.42 years, age groups 3, 4 and 5 years constituted 62% of the age composition, and length of females at 50% maturity was estimated at 28.4cm. Ghaninejad et al. (2012) found a beach seine catch had an isometric *b* value of 3.01, age range was 4-8 years, mean 5.75 years, mean fork length was 310.1mm and mean weight was 310.3g. Moradinasab et al. (2012) give a *b* value of 2.8844 for 7,144 fish from beach seine fisheries of the southern Caspian Sea along with a mean condition factor of 1.071 and a relative weight of 1.74.

Food: This species is reported to enter the Anzali Talab to feed from January to March (Holčík & Oláh 1992), a result of the increasing salinity of this lagoon. Food items are small benthic invertebrates and detritus with some insects and plankton. Most stomach contents contain numerous sand grains. Adults scrape periphyton from rocks, silt and artificial structures. The predominant food items found by Ghadirnejad & Ryland (1996) from fish

taken in the southern Caspian Sea were bivalves, foraminiferans and calanoid copepods. Other food items were ostracods, eggs, nematodes, *Nereis* and cyclopoid copepods. Juveniles fed on ostracods and copepods while adults preferred bivalves, foraminaferans and *Nereis*. This fish consumed more foraminiferans than its relative and less copepods. Zandavar & Norouzi (2015) examined 20 fish from Bandar-e Torkeman and Gomishan and found the ctenophore *Mnemiopsis leidyi*, the bivalve molluscs *Mytilus* and *Cardium*, the amphipod *Gammarus* and Enteromorpha in the diet. The gastrosomatic index was higher in spring than in autumn. The relative length of the gut indicated that this species is an omnivore with a tendency to herbivory.

Reproduction: This mullet spawns in more northerly waters of the Caspian than its relative *C. saliens*. Spawning begins in the middle of July in the middle Caspian and ends in the south Caspian from the middle to the end of October. Intensive spawning in the middle Caspian takes place in August-September at 20-22°C and a transparency of 7-11m. Spawning depth is in the upper 0.5m. The main spawning areas are at least 50-60 miles (80-96km) from the coast (Avanesov 1972) and this prevents the spawning area being easily exploited. Fecundity exceeds 4.4 million eggs in the Caspian Sea (Khoroshko 1982); in Mazandaran Province average absolute fecundity reaches 772,350 eggs (Abdoli et al. 1996). The eggs are pelagic and have a diameter of 0.9mm. Gorgan Bay is believed to be a very important nursery and this is the major species caught by fishermen in winter (www.ramsar.org/ram_rpt_37e.htm, accessed 28 July 2000). Shabanipour (1995) and Shabanipour & Heidari (2004) carried out histomorphological studies on the ovary of this species in Iran. Fazli (1998) found populations in the southeastern Caspian Sea of Iran spawned in late August-November based on the gonadosomatic index, with most spawning in October. Spawning occurs when temperatures reach 20-22ºC, near the coast but 400-600m from beaches, and mainly at night. Males are ready to reproduce earlier than females. Absolute fecundity was 586,165 eggs. Fazli et al. (2008), again examining populations in the southeastern Caspian Sea, reported a reproductive season of October to December, a male:female ratio of 1:1.42, sexual maturity at 26.0cm fork length, mature gonads in 20% of fish at age 3, 63% at age 4, 88% at age 5 and 97% at age 6, individual absolute fecundity from 113,386 to 1.47 million eggs with a mean of 451,963. They concluded that the overlap between the fishing and spawning seasons required a delay of one month in the former to protect stocks. Heidari et al. (2009) studied late oogenesis in fish from Anzali. Recently spawned oocytes were lemon in colour and up to 0.8mm in diameter. Daryanabard et al. (2009) found this mullet in Mazandaran matured at 3.7 and 4.8 years for males and females respectively, and spawning began at the beginning of Mehr to Azar (last week of September to third week of December), and peak spawning was in the first half of Aban (last week of October to first week of November). Absolute fecundity was 740,259 eggs and length at which 50% of fish were mature was 26.6cm fork length. Length of maturity has decreased by 1.4cm and maturity occurred sooner than in the past. Ghaninejad et al. (2010) sampled fish from along the Iranian coast captured in 2007-2008. Peak spawning was in October off Gilan, but in November off Mazandaran and Golestan, and average absolute fecundity was 700,881 eggs with a range of 200,112 to 2,282,862 eggs, The male:female sex ratio was 1:1.22. The length of females at 50% maturity was 28.4cm. Khayyami et al. (2014b) noted peak spawning in Gilan was in October but for Mazandaran and Golestan it was in November. Most December spawning was in Golestan waters.

Parasites and predators: Mokhayer (1976) records the trematode *Saccocoelium obesum* from this species on the Iranian coast. This is a parasite of the intestine, with contamination rates of 90.4%, 88.6%, 81% and 34% for autumn, winter, spring and summer respectively. Gills carry *Microcotyle mugilis* at a rate of 2.0-2.3% and fish are also infected with Ancylodiscoides (*sic*) at a rate of 19.6%, 43%, 72%

and 43.3% for autumn, winter, spring and summer respectively (Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran p. 27-28, 1996, Annual Report 1993-94, Iranian Fisheries Research and Training Organization, Tehran p. 49-50, 1995). Naem et al. (2002) found species in the monogenean trematode genus *Ligophorus* on the gills of this species from the western branch of the Sefid River. Khodabandeh et al. (2007) found mortality in fry from the Iranian coast caused by *Myxobolus* sp. parasites on the gill epithelium.

At Ziba-kenar beach, Gilan in February 2004, this species showed erratic swimming and belly-up posture. A post-mortem showed gas accumulation and distension in the swimbladder, a yellowish liver, liquefaction of the gall bladder, excess micro-sand in the caecum and hyperaemia of the intestine. The cause is thought to be an infectious agent closely related to a betanovirus or nodavirus (Iranian Fisheries Research Organization Newsletter 38: 3, 2004, Saeedi et al. 2004, Zorriehzahra et al. 2005). Soltani et al. (2010) identified a betanodavirus from mass mortalities in 2006-2008. The fish showed necrosis and vacuolation of the brain, optic nerve and retina. Ghasemi et al. (2013) found *Betanodavirus* by histopathology and an indirect fluorescent antibody test in apparently healthy fish from market samples. Zorriehzahra et al. (2016) isolated and confirmed the presence of viral nervous necrosis caused by a *Betanodavirus* in moribund fish from the Iranian shore of the Caspian Sea. Zorriehzahra et al. (2014) found Mazandaran fish showing mortality, lethargy, abdominal distention, emaciation and abnormal swimming. Haematological and biochemical parameters were different from healthy fish and diseased fish weighed less. Macrocytic hypochromic anaemia, prolonged starvation and dystrophic chronic disease were affecting the mullet. This species is eaten by *Sander* spp., *Silurus glanis* and *Huso huso*.

Economic importance: This section contains information on *C. auratus* but also on that species and *C. saliens* combined in the Iranian Caspian Sea as they are sometimes not distinguished in fishery data. Daryanabard et al. (2009) found *C. auratus* comprised 95% of the mullet catch in Iranian waters over the previous decade.

Fazli (2014) examined the bony fish catch in the Iranian Caspian Sea for the period 1927-2013 and noted that in the early years the catch was dominated by *Rutilus rutilus* (= *caspicus*), *Rutilus frisii kutum* (= *kutum*), *Stizostedion* (= *Sander*) *lucioperca*, *Aspius* (= *Leuciscus*) *aspius*, *Silurus glanis* and shads but since 1956 the bulk of the catch is kutum and mullets. The change is attributed to destruction of spawning grounds and the artificial propagation of kutum. Fazli et al. (2014) found mullets had the highest catch frequency on 9 cruises during 2007-2011 in all seasons except summer, and were concentrated in depths <20m.

The catch in Iran for this species and *Chelon saliens* from 1956/1957 to 1961/1962 varied from 166,197 to 960,282kg (Vladykov 1964) and from 1965/66 to 1968/69 varied from 490 to 1,916 tonnes (Andersskog 1970). Vladykov (1964) and RaLonde & Walczak (1972) cite figures for the Bandar-e Anzali region for *C. auratus* from 1937/38 to 1961/62 of 14kg to about 113t and for 1969/70 a catch of 1,085t was recorded, while for the whole Northern Shilot (Fisheries Company) in the period 1965/66 to 1968/69 catches varied between 548t and 1,916t. Holčík & Oláh (1992) report a catch of only 3kg in the Anzali Talab in 1990. The Food and Agriculture Organization, Rome records the following catches for the 6 years from 1980 to 1985 for mullets in Iran, presumably from the Caspian Sea:- 150, 400, 1,500, 2,733, 2,135, and 2,200t, respectively. Moghim et al. (1994) give a total biomass of 2,400 tonnes for this species in the southern coastal area of the Caspian Sea with a maximum sustainable yield of 960 tonnes (figures for *C. saliens* are 7,000 tonnes and 2,900 tonnes respectively). Caspian Sea catches of this species in Iran for the year 1993-1994 was 22% of the bony fish catch with *Chelon saliens* comprising only 4% (the major part of the catch was sefid mahi,

Rutilus frisii (= *kutum*), at 62%)(Annual Report 1993-94, Iranian Fisheries Research and Training Organization, Tehran p. 83, 1995). Catches in former Soviet waters of the Caspian Sea are about three-quarters or more this species and one-quarter *C. saliens* (Khoroshko 1982). The main season for fishing in the Caspian Sea off Iran is from December to February, peaking in January (Farid-Pak no date). Abdoli et al. (1996) note that beach seiner cooperatives started fishing a month earlier than usual in 1993, coinciding with the spawning season in October. Annual catch variations occur in Iranian waters, this species having an abundance of 86.5% in 1994 decreasing to 38% in 1995 (Iranian Fisheries Research and Training Organization Newsletter 9: 5, 1995). The catch of this species declined from 76.9% to 41.2% of the total mullet catch from 1993-1994 to 1994-1995 through overfishing of juveniles (Iranian Fisheries Research and Training Organization Newsletter 11: 7, 1996). Abdolmalaki (2001) records a catch per unit effort for beach seining as 93kg in 1991, falling to 33kg in 1997 through overfishing. The mean length of the catch in Gilan decreased from 1991 to 1997 while in Mazandaran it increased. Fazli & Daryanabard (2012) examined catches for the period 1991-2011 in Iranian waters. Condition factor decreased from 1.16 to 1.01. The percentage of mature (fork length >28cm), optimum size (31.8-38.8cm) and mega–spawners (>38.8cm) were 58.6-88.4, mean 76.0%, 26.4-47.6, mean 36.1 and 6.8-29.0, mean 18.9% respectively. For conservation and revitalization of the stock the target would be for all fish spawn at once, net mesh size should be 33cm during the whole fishing season, no mega-spawners would be caught, the main catch focus would be on optimum length, and the start of the fishing season should be delayed to allow completion of spawning. Fazli et al. (2013) continued the above analysis and found biomass estimates increased from 13,527t in 1991-1992 to 20,100t in 2000-2001 and was lowest at 11,000t in 2007-2008. The acceptable biological catch was estimated at 2,200t in 2010 and the stock is vulnerable to environmental factors. Fazli & Ghaninejad (2004) give the year 2001 as that of the maximum mullet catch in their survey of the years 1993-2001, the catch increasing through this period. Catch per unit effort in each seine declined from 114kg in 1993 to 43kg in 1996, increasing to 66.4kg and 78.4kg in 2000 and 2001. For the years 2000 and 2001, *C. auratus* had a mean fork length of 32.7 and 32.3cm, a weight of 418.3 and 419.8g, and a K value of 0.61 and 0.93. They concluded that the harvest of this species is at a sustainable level. Heydatifard et al. (2002) stated that its catch is greater than that of other bony fishes (presumably excluding kilka) in the southern Caspian Sea. S.M.E.J. Zorriehzahra (pers. comm. 19 January 2011) noted a decline in catches from 6,442mt in 2002 to 2,400mt in 2010.

TACIS (2002) demonstrates the growth in catches in the Caspian Sea basin of Iran as follows. The mullet catch was 390tonnes/year growing to 4,560t/y, and total catch was 7,440 t/y to 81,360 t/y. Nezami et al. (2000) gives the following figures for fish harvested from Caspian coastal provinces in Iran: Golestan Province:

Species/Year	**1997-98**	**1998-99**
Rutilus kutum	174,869kg	191,680kg
Rutilus caspicus	20,124kg	18.025kg
Mugilidae	43,016kg	229,487kg
Cyprinus carpio	229,734kg	260,890kg
Other	2,712kg	10,529kg
Total	470,455kg	710,611kg

This province demonstrates a great variation in mullet catch between years.

Mazandaran Province (1998):

Species	tonnes
Cultured fishes	12,363
Rutilus kutum	2,174
Mugilidae	1,533
Clupeonella (kilka)	31,583
Other bony fishes	374
Total	48,027

Gilan Province (1997):

Species	tonnes
Clupeonella (kilka)	36,077
All bony fishes	2,813
Acipenseridae (sturgeons)	264
Total	39,154

Table 1. Bony fish production in the Iranian Caspian Sea (tonnes) based on the Caspian Environment Programme (1998).

Year/Species	Kilka (*Clupeonella* spp.)	*Rutilus kutum*	Mugilidae	*Cyprinus carpio*	*Rutilus caspicus*
1973	1,013	2.63	927.3	93.5	22.5
1974	1,170	338.6	403.5	101.6	34.6
1975	1,286	695.7	963.4	84.4	29.5
1976	900	1,231.8	2,004.6	47.4	94.8
1977	1,261	530.6	1,297.9	40.1	18.6
1978	771	191.1	373.8	13	3.6
1979	836	84.1	352.4	69.6	11.9
1980	619	158.2	1,411.7	69.6	71.2
1981	1,341	252.1	408.3	129	217.4
1982	798	342.3	2,674.7	128.4	915.5
1983	621	277.9	1,637.7	160.2	108.6
1984	1,517	252.3	1,219.5	173.4	384.4
1985	1,828	174.5	1,402.9	16.4	200.5
1986	2,450	110.4	117.2	3.4	27.4
1987	4,389	162.7	109	19.5	6
1988	4,700	5,000	1,750	20	100
1989	7,902	6,500	2,380	-	130
1990	8,814	8,500	1,503	-	100
1991	13,817	12,000	2,500	-	120
1992	21,527	12,000	2,200	-	120
1993	28,730	12,727	5,135	-	714
1994	51,000	9,277	2,809	-	1,366
1995	41,000	8,435	5,014	-	1,178
1996	57,000	9,222	2,554	-	878

Unauthorised fishing in Gorgan Bay in the southeastern Caspian was estimated at 167,681kg in 2000-2001 (Kamran, 2006). Mullets (*Chelon auratus* and *C. saliens*) comprised 35.7% of the catch.

The biomass of fishes in the Iranian Caspian was estimated at 556,530t, 12.7% of the total for the sea, with a fish density of 50.6tonnes/nautical mile (the lowest values of any Caspian state) (Ivanov & Katunin 2001). The Caspian Environment Programme (1998) gave the bony fish production in the Iranian Caspian Sea (tonnes) in recent years (selected species) (Table 1). Abdolmalaki & Psuty (2007) give figures over a wide range of years for Iranian coastal catches in the southern Caspian Sea (Table 2).

The bony fish catches in the Iranian Caspian Sea waters for 1999-2000 were given by D. Ghaninejad (5th International Symposium on Sturgeon, Iranian Fisheries Research Organization, 9-13 May 2005, Ramsar). Beach seine cooperatives took 11,170t and the total catch, allowing for poaching, was estimated at 16,860t. The catch of *C. auratus* was estimated at 3,559t with about 22% undersized and the biomass estimated at 11,100t. Rabbaniha et al. (2015) found that mullets comprised 35% of the total bony fish catch in the Caspian Sea, and sometimes dominated. The catch near Bandar-e Anzali from 2003 to 2012 fluctuated with temperature - at a mean of 12.5ºC in 2006 the catch was 11,858.88 tons but in 2007 at 18.9ºC it was 6,925.82 tons (presumably metric tonnes).

Hosseini et al. (2004) determined the shelf life of this species on ice in Iran was 10 days. Mazandaran fish have an average fat composition of 9.25%, 72% being unsaturated. Omega-3 fatty acids constitute 18.7% of the total fatty acids with a significant ratio to omega-6 fatty acids of 1.97 (Hedayatifard et al. 2002). Akhondzadeh Basti et al. (2006) found the bacterial pathogens *Listeria monocytogenes* and *Staphylococcus aureus* in salted *C. auratus* and *Vibrio haemolyticus* in fresh and salted *C. auratus*. Hedayatifard & Yousefian (2009a, 2009b)

Table 2. Bony fish production in the Iranian Caspian Sea (tonnes) based on Abdolmalaki & Psuty (2007).

Catch and frequency (%)	1927-1936	1937-1946	1947-1956	1957-1966	1967-1976	1977-1986	1987-1996	1997-2003
Total recorded catch (t)	8,959	7,224	4,986	3,262	5,547	5,384	16,903	16,201
Sander lucioperca	29.7	1.7	1.0	0.2	0.4	0.1	0.1	0.2
Sturgeon meat + caviar	13.4	8.8	16.3	50.9	40.9	34.2	9.4	5.0
Cyprinus carpio	9.8	8.5	1.8	2.5	2.6	1.1	6.3	6.1
Rutilus kutum	12.2	43.0	24.9	25.8	17.8	19.8	53.2	45.4
Rutilus caspicus	20.7	25.5	18.8	0.7	0.8	2.3	5.8	6.1
Alosa spp.	1.9	6.2	14.7	2.9	0.3	0.2	3.2	3.9
Chelon auratus and *C. saliens*	0	1.8	20.9	15.8	36.1	42.2	19.7	28.9
Other species	12.3	4.5	1.6	1.2	1.1	0.2	2.5	4.4

determined the comparative fatty acid composition in filleted fish that were fresh or dry-salted and found this fish to be one of the best sources for omega-3 essential fatty acids compared to other fishes in the Caspian Sea basin. Hedayatifard & Nemati (2009) found salting was a good way to preserve fish roe and omega-3 and -6 essential fatty acids. Razavilar & Tavakoli (2006) studied the prevalence of human toxigenic *Clostridium botulinum* and the need for food safety control measures. Hosseini et al. (2013) assessed the risk of total mercury in fish from Mazandaran finding the average concentration was 0.137µg/g of fresh weight (0.432µg/g dry weight), less than guide values and not a threat to human health, a permitted consumption rate being 51g per day.

Ali et al. (2011) found the best shelf life of brined and vacuum-packaged fish stored for 90 days at 4ºC was 30 days. Ghelichpour et al. (2012) compared grilling, frying, steaming and microwaving fillets for physicochemical properties and colour. 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. Drip protein was 2.17% in 5% salt and TVB-N was 3.28mg/100g in 2% salt. Sahari et al. (2014) found losses of vitamins A, C, D and K during frozen storage (-24ºC) but vitamin E losses were not significant. Norouzi & Bagheri (2015) and Norouzi & Bagheri Tavani (2016) examined the fat, protein, moisture and ash in muscle tissue during sexual rest and ripeness for fish from 10 stations along the whole Iranian coast. A decrease in fat and protein and increase in moisture of muscles in fall was noted during sexual ripeness, presumably owing to gonad development, and restoration of fat and protein and moisture decrease in spring to the termination of spawning and appropriate feeding. Significant differences in protein content were noted (higher in eastern areas), the highest length and weight were in the Anzali Talab (maximum 58.0cm and 1,252g) and the lowest in the Gorgan River delta (maximum 48.0cm and 518g).

Contamination of this species in Iranian waters with Pb, Ni and Zn was examined by Fazeli et al. (2005). The highest contamination was in the southwest part of the Caspian followed by the south centre and the southeast. The highest concentrations observed were 17.51mg/kg for lead, 6.23mg/kg for nickel and 647.28mg/kg for zinc. Amini Ranjbar & Sotoudebnia (2005) assessed heavy metal (Zn, Cu, Pb and Cd) concentrations in fish from the Caspian Sea in Mazandaran and found higher than normal levels of Pb and Cd in muscle tissues. Shahriari Moghadam et al. (2006) experimented with fry from the Noor coast and found mass mortality at 350ppb of mercury with gill necrosis, kidney glomerulus capillary dilation and proximal tubule cell vacuolation. Pazooki et al. (2009) found the heavy

metals cadmium and chromium in fish from Bandar-e Anzali, more in the skin than in muscle and more in females than males, but not enough to constitute a health hazard. Ardalan et al. (2012) examined fish from Kiashahr, Gilan and found levels of cadmium, copper, lead and zinc were within an acceptable range and the fish were a high quality source of protein and fat for human consumption. Saghali et al. (2012) found fish from Gorgan Bay had high levels of cadmium and zinc and lower ones of chromium and zinc, but all were within acceptable limits although environmental levels were increasing. Shayeghi et al. (2012) examined fish from the Gorgan and Qarasu (= Qareh Su) rivers for the pesticides Diazinon and Azinphos Methyl and found levels higher than permitted levels, although the latter was only higher in summer in the Qareh Su. Shokrzadeh Lamuki et al. (2012) found the levels of the pesticides D.D.T. and D.D.A. in fish from four localities in Mazandaran were within standard permitted limits. Askary Sary & Velayatzadeh (2013) examined fish from the Tehran Sarcheshmeh market and found lead and zinc levels were above the acceptable limits for human consumption. Mashian Moradi & Golshani (2012) measured levels of the pesticides Diazinon, Malathion and Azinfos Methyl in fish from the estuaries of the Babol, Gorgan and Tajan rivers, finding the Babol fish were the most contaminated. Mashinchianmoradi & Pirouznezhad (2013) measured levels of chromium and tin in liver and muscle tissue of fish from the Babol, Gorgan and Tajan river estuaries finding liver concentrations higher than muscle, tin in liver from Gorgan fish had the highest concentration while the lowest concentration was in chromium from the Tajan River fish. Kardel et al. (2016) found that this species' liver, but not gills, accumulated higher concentrations of the heavy metals cadmium, lead and zinc than the cyprinid *Rutilus kutum* at the Babolsar coast. Higher concentrations were attributed to feeding behaviour, close to sediments where heavy metals accumulate. Levels were higher than acceptable international limits.

Conservation: The successful introduction of this species and *C. saliens* in the Caspian Sea has apparently led to a decline in various clupeid species (*Alosa*) and of *Sander marinum* (Baltz 1991). Beach seines with mesh sizes of 28mm, 33mm and 36mm caught non-standard fish as 43.3%, 35% and 2.2% of the total catch respectively. Seines with a cod end of at least 36mm are recommended for stock protection (Iranian Fisheries Research and Training Organization Newsletter 6: 8, 1994) (note the report names the fish as *Mugil cephalus* but the catch was probably a mix of *C. auratus* and *C. saliens*). Fazli & Daryanabard (2012) also give recommendations for stock protection noted above in Age and growth section. Studies on population structures mentioned above under Systematics section are aimed at sustainable use and management of stocks. Temperature, salinity and dissolved oxygen vary between these two areas in the spawning season, acting as barriers that can contribute to different spawning times, and to different populations.

The IUCN Redlist (IUCN 2015) lists this species as of Least Concern for its native habitat.

Sources: Distinguishing characters based on Trewavas & Ingham (1972). Sakri (1993) gives an account in Farsi on the spawning and catch of mullets in the Iranian Caspian.

Iranian material: CMNFI 1970-0509, 1, 124.2mm standard length, Gilan, Sefid River (37º24'N, 49º58'E); CMNFI 1970-0535, 1, 137.2mm standard length, Gilan, Shafa River (37º35'N, 49º09'E); CMNFI 1970-0543, 3, 33.5-38.5mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0543A, 4, 33.1-60.5mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0563, 19, 52.8-87.0mm standard length, Gilan, Caspian Sea, Kazian Beach (ca. 37º29'N, ca. 49º29'E); CMNFI 1970-0565, 4, 52.2-93.0mm standard length, Gilan, Sefid River estuary (ca. 37º28'N, ca. 49º54'E); CMNFI 1970-0581, 2, 147.7-151.5mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0587, 1, 78.9mm standard

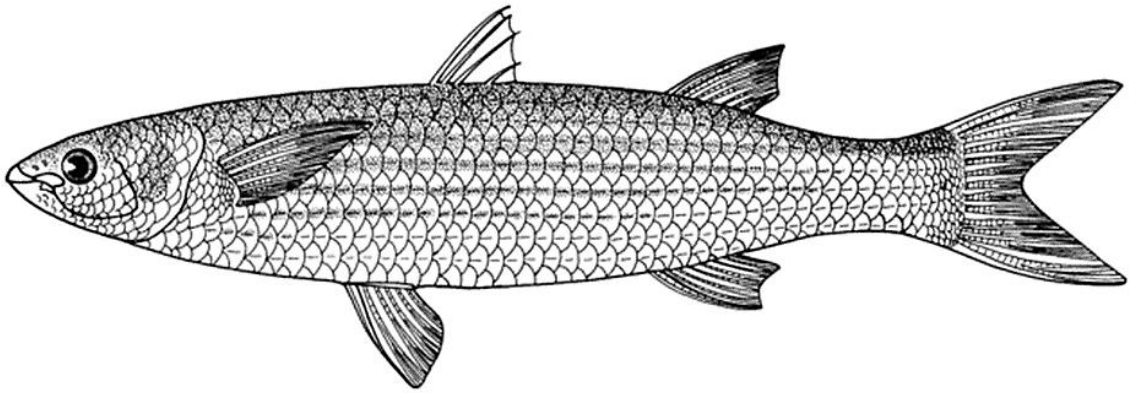

Fig.5. Line drawing of *Chelon saliens* by S. Laurie-Bourque.

length, Mazandaran, Babol River (36º43'N, 53º39'E); CMNFI 1971-0326A, 20, 30.0-46.0mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37º28'N, 49º27'E); CMNFI 1979-0430, 1, 42.0mm standard length, Mazandaran, river 1km east of Now Shahr (36º39'N, 51º31'E); CMNFI 1979-0470, 19, 29.4-57.4mm standard length, Mazandaran, stream 21km west of Alamdeh (36º35'N, 51º43'E); CMNFI 1979-0471, 3, 56.7-65.8mm standard length, Mazandaran, Caspian Sea 14km west of Alamdeh (36º35'N, 51º48'E); CMNFI 1979-0686, 2, 59.1-87.3mm standard length, Gilan, Sefid River near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1980-0117, 2, 99.7-114.5mm standard length, Gilan, Golshan River (37º26'N, 49º40'E); CMNFI 1980-0127, 6, 29.5-36.9mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1980-0146, 1, 135.7mm standard length, Mazandaran, Gorgan Talab at Ashuradeh-ye Kuchak(36º50'N, 53º56'E); CMNFI 1980-0149, 1, 38.4mm standard length, Gilan, Chabak River (37º21'N, 49º50'E).

Chelon saliens (Risso, 1810)
(Figs. 5-7)

Common names: Kefal-e saliens, kafal-e poozeh-barik, kafal. [Sivriburun kefal in Azerbaijanian; vitibutum or gatykelle in Turkmenian; ostronosik in Russian; sharpnose mullet, small mullet, grey mullet, leaping mullet, leaping grey mullet].

Systematics: *Mugil Saliens* was originally described from Nice, France. No major relevant synonyms. Placed in the genus *Chelon* by Durand et al. (2012). Rezvani Gilkolaie et al. (2012) used mtDNA to examine genetic diversity in coastal waters of Gilan and Golestan and determined there is one population.

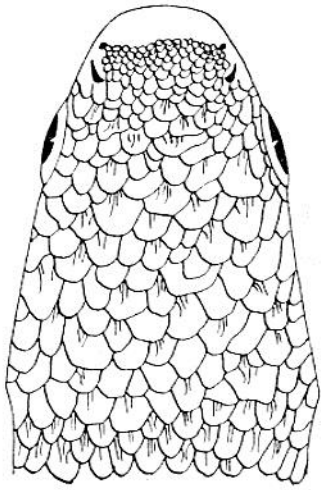

Fig.6. *Chelon saliens* dorsal head (after Movchan 1988).

Key characters: This species is distinguished from its relative in the Caspian Sea by each head and antero-dorsal flank scale having 2-7 or more grooves (mostly 2 grooves), pyloric caeca in two groups, 3-5 short and 3-4 long (total 6-9), scales on the snout ending anteriorly as numerous rows of small scales, and the oral edge of the preorbital bone is deeply notched. Young lack the vertical dark lines at the origin of the caudal fin rays and the herring bone flank pattern seen in *C. auratus* (Harrison in Miller 2003).

Fig.7. *Chelon saliens* from the Anzali Talab, October 2010, courtesy of K. Abbasi.

Morphology: The first dorsal fin has 4 spines, the last one weakly developed compared to the first three. The second dorsal fin has 1-3, usually 1or 2, spines (more resembling unbranched rays than true spines) and 6-9, usually 8 or 9 soft rays (the second unbranched ray or spine may be branched near the tip - modes of 8 or 9 in literature may include this ray). The anal fin has 3-4, usually 3, spines and 7-10, usually 9, soft rays. The pectoral fin has 2 unbranched rays and 14-17 branched rays and the pelvic fin has 1 spine and 5 branched rays. Scales number 42-50 in lateral series. There is no pectoral axillary scale. There is an elongate first dorsal fin axillary scale and a pelvic axillary scale. Scales have an almost vertical anterior margin with the anterior dorsal and ventral corners square to pointed. This margin is slightly indented where radii intersect it. The dorsal and ventral scale margins are parallel and the posterior margin is rounded. The focus is posterior and the posterior field has weak ctenii. Circuli are fine and numerous and radii are limited to the anterior field, numbering up to 10 in fish examined here but probably size dependent. Esmaeili et al. (2014) gave details of scale microstructure and scale size which can be used to distinguish species. The gill rakers are fine and numerous, but not as fine and numerous as in *C. auratus*, exceeding 70 in the larger fish examined here, and probably size dependent. When appressed, a raker reaches raker 6 or 7 below. Rakers have a serrated medial edge. Vertebrae 23-25. The gut is elongate with 2 posterior loops after a muscular stomach. The chromosome number is 2n=48 (Klinkhardt et al. 1995).

Meristic values for Iranian specimens are:- first dorsal fin spines 4(30); second dorsal fin with 1(6), 2(22) or 3(2) "spines" or unbranched rays and 6(1), 7(20) or 8(9) branched rays; pectoral fin unbranched rays 2(30) and branched rays 14(2), 15(27) or 16(1); pelvic fin branched rays 5(30); lateral line scales 42(2), 44(6), 46(6), 47(8), 48(4) or 49(4).

Sexual dimorphism: Males are smaller than females.

Colour: The back is dark grey to blue-grey or grey-brown, the belly pale to silvery or yellowish, and the silvery-grey flanks have about 7 bluish stripes. There is a golden blotch on the operculum. The peritoneum is brown to black.

Size: Commercial catches in Iran during the 1950s weighed 0.3-0.8kg, sometimes as much as 1.5-1.8kg (Farid-Pak no date). Reaches 40.0cm.

Distribution: Found in the Mediterranean and Black seas and along the Atlantic coast to South Africa. First reported from Iranian waters by Dmitriev (1946), this species was introduced to the Soviet Caspian Sea in 1930-1931 (Baltz 1991). In Iran it is reported from the lower reaches of such rivers as the Babol, Chabak, Fereydun Kenar, Gharasu, Golshan, Gorgan, Haraz, Hevigh, Karkan, Larim, Masab, Pol-e Rud, Qareh Su, Rasteh, Sefid, Sardab, Shafa, Shahrud, Shesh Deh, Shirud, Siah, Tajan, Talar, the Anzali Talab, the Neka Dam, Gorgan Bay including the Miankaleh Wildlife Refuge, the Gomishan Wetland, the southeast Caspian Sea, southwest Caspian Sea and south-central Caspian Sea (Ramin 1997; Roshan Tabari 1997; Abbasi et al. 1999; Kiabi et al. 1999; Mostafavi & Abdoli 2003; Abbasi 2006; Banagar et al. 2008; Patimar 2008; Abdoli & Naderi

Fig.8. Habitat of *Chelon saliens*, Bandar-e Torkeman, southeast Caspian Sea, Brian W. Coad.

2009; Piri et al. 2009; Kalani et al. 2014).

Zoogeography: This species is an exotic in Iran.

Habitat: This is a pelagic species found mostly in inshore areas and entering lagoons and rivers. It is found in surface waters over depths of 5-700m at salinities of 4-13‰. It migrates to the southern Caspian in autumn when water temperatures fall (Caspian Sea Biodiversity Database, www.caspian environment.org). Generally it tolerates fluctuations of 5-27Cº and 11-28‰ although fry need time to adjust to lower salinities (Harrison in Miller 2003).

Age and growth: Life span is up to 10 years in the Caspian Sea (Khoroshko 1982). Males mature at 3 years and females at 4 years (Caspian Sea Biodiversity Database, www.caspianenvironment .org). The maximum growth rate in fish sampled between Babolsar and Bandar-e Torkeman in the Iranian Caspian was observed in fish age 3 years. The operculum gave better ages than scales (Fazli 2000). Patimar (2008) examined fish in Gorgan Bay and found maximum ages of 6+ for males and 7^{+} for females. Both sexes grew allometrically (b=2.478 for males, 2.545 for females) and rapidly during their first year of life, reaching more than 40% of their growth. Age and growth were in contrast to other populations in the southeast Caspian Sea. The von Bertalanffy growth functions were $L_t=30.415(1-e^{-0.275(t+0.645)})$ for males and $L_t=34.832(1-e^{-0.211(t+1.009)})$ for females. Males predominated at smaller sizes and females at larger sizes but see below. Fazli & Ghaninejad (2004) state that in the years 2000 and 2001, *C. saliens* had a mean fork length of 27.5 and 25.1cm, a weight of 224.7 and 179.1g, and a K value of 0.91 and 0.71. Aghli & Mohammadi (2011) found Gorgan Bay fish were 1-6 years old with most at age 3 (48.6%). Length range was 11-34cm with a maximum frequency at 19-20cm (about 25% of total catch), and weight range was 20-360g with a maximum frequency at 220g and the interval 180-240g was about 50% of total catch.

Food: Diet is very similar to that of *C. auratus*, comprising detritus, periphyton and small benthic organisms Stomach contents contain sand grains in Iranian fish. The predominant food items found by Ghadirnejad & Ryland (1996) from fish taken in the southern Caspian Sea were bivalves, foraminiferans and calanoid copoepods. Other food items were ostracods, eggs, nematodes, *Nereis* and cyclopoid

copepods. Juveniles fed on ostracods and copepods while adults preferred bivalves, foraminiferans and *Nereis*.

Reproduction: Spawning starts at the end of May and the beginning of June in the southern Caspian Sea and continues until the end of September and the beginning of October, most intensively between June and August off the Turkmenistan coast according to Avanesov (1972). Iranian fish spawned in July-August and males ripen earlier than females (Fazli 2000; Yousefian et al. 2003). Yousefian et al. (2003) gave details of oogenesis, detailing the stages in gonad development. Spawning occurs over depth ranges of 5-700m but most spawning in the southeastern Caspian is at 5-7m. Temperatures are between 17 and 29°C with the most intensive spawning when sea surface temperature is 25-29°C. Water transparency is 1-9m. The greatest aggregations of eggs are found 5-7 miles (8-11km) from shore in the eastern Caspian. Fecundity exceeds 2.1 million eggs in the Caspian Sea (Khoroshko 1982). Egg diameter is up to 0.8mm. Females predominate in Iranian samples examined by Fazli (2000) at a ratio of 1:3.14. Patimar's (2008) Gorgan Bay fish reproduced in May-July with an average fecundity reaching 389,790 eggs in 7^+ fish and relative fecundity 4,281 eggs/g. The low absolute fecundity contrasted with other populations in the southeast Caspian Sea. Ghaninejad (2011) found fish in markets illegally (May to September) and in legal commercial fisheries (October to April) off Gilan to have a significant 1:2.23 sex ratio (male:female), a peak spawning in July, an average absolute fecundity of 207,050 eggs (range 29,700-512,900 eggs), and length of females at 50% maturity was estimated at 23cm. Amiri et al. (2012) investigated the energy content of liver, muscle and ovary and its allocation during reproduction.

Parasites and predators: This species has a worm parasite in the intestine, *Saccocoelium obesum*, with contamination rates of 62%, 10.7%, 12% and 22.2% for autumn, winter, spring and summer respectively, lower than in *C. auratus*. Gills carry *Microcotyle mugilis* at a rate of 2.0-2.3% and fish are also infected with Ancylodiscoides (*sic*) at a rate of none, none, 1.6% and 4% for autumn, winter, spring and summer respectively, much lower than in *C. auratus* (Annual Report, 1994-1995, Iranian Fisheries Research and Training Organization, Tehran p. 27-28, 1996; Annual Report 1993-94, Iranian Fisheries Research and Training Organization, Tehran p. 49-50, 1995).

Zorriehzahra et al. (2014) and Ghiasi et al. (2016) note that the catch of mullets in the Caspian Sea has declined since 2002 through disease outbreaks, and that this has been attributed to a nodavirus. The catch of both mullet species was 6,446t in 2002 and 2,151t in 2012. Affected fish from the southern Caspian Sea showed skin darkening, belly-up at rest, lethargy, severe abdominal distension, abnormal swimming and hyperinflation of the swimbladder, and were significantly lower in length and weight than healthy fish. Massive vacuolation was seen in the brain, spinal cord, retina and optical nerve. A betanodavirus-like agent was identified from *Chelon saliens* (Ghiasi et al. 2016) and haematological and biochemical parameters were abnormal. Feeding of these fish was disturbed and mortality affected. Zorriehzahra et al. (2016) isolated and confirmed the presence of viral nervous necrosis caused by a *Betanodavirus* in moribund fish from the Iranian shore of the Caspian Sea.

Economic importance: The main season for fishing in the Caspian Sea off Iran is from December to February, peaking in January (Farid-Pak no date). Some catch information is summarised above under *C. auratus* which is 5-6 times more abundant in catches. However, a report on the 1994-1995 catch showed a severe reduction of 2,500 tonnes, as *C. saliens* replaced *C. auratus* as the main part of the catch. *C. auratus* declined from 76.9% of the mullet catch in 1993-1994 to 41.2% in 1994-1995, the cause being overfishing of juveniles (Iranian Fisheries Research and Training Organization Newsletter 11: 7, 1996). Moghim et al. (1994) give a total biomass of 7,000t for this species in the southern coastal area of the Caspian Sea with a maximum sustainable yield

of 2,900t (figures for *C. auratus* are 2,400 tonnes and 960 tonnes respectively). Annual catch variations occur in Iranian waters, this species having an abundance of 13.5% in 1994 increasing to 62% in 1995 (Iranian Fisheries Research and Training Organization Newsletter 9: 5, 1995). Abdolmalaki (2001) records a catch per unit effort for beach seining as 78kg in 1991, falling to 15kg in 1997 through overfishing. The mean length of the catch in Gilan and Mazandaran did not decrease from 1991 to 1997, the former in contrast to *C. auratus*. Aghli & Mohammadi (2011) examined the fishery in Gorgan Bay and found catch per unit effort (net, day) was 0.18kg, maximum amount of estimated catch was 15.1% (235.9kg) and estimated annual catch was 149,908kg and maximum catch was in Aban (October-November). Fazli & Ghaninejad (2004) give the year 2001 as that of the maximum mullet catch in their survey of the years 1993-2001, the catch increasing through this period. Catch per unit effort in each seine declined from 114kg in 1993 to 43kg in 1996, increasing to 66.4kg and 78.4kg in 2000 and 2001.

Kalani et al. (2014) examined levels of arsenic, cadmium, chromium, lead and nickel in muscle of fish from Gomishan Wetland. Levels were below harmful limits except for lead which exceeded international standards for human consumption. Weekly consumption of this fish would be risky for adult consumers.Some data on catches is given above under *C. auratus*.

Conservation: See above under *C. auratus*. Mercury levels at 0.0102-0.108mg/kg w.w. in this species from the Iranian shore were lower than the WHO guideline of 0.5mg/kg w.w. (Agah et al. 2007). Nasrollahzadeh Saravi et al. (2012) found 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, Nowshahr, Babolsar) affected by intensive shipping activities. The IUCN Redlist (IUCN 2015) lists this species as of Least Concern for its native habitat.

Sources: Distinguishing characters based on Trewavas & Ingham (1972).

Iranian material: CMNFI 1970-0507, 9, 23.6-46.8mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0508, 1, 50.6mm standard length, Gilan, Sefid River at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0509, 4, 31.9-66.8mm standard length, Gilan, Sefid River at Hasan Kiadeh(37º24'N, 49º58'E); CMNFI 1970-0510, 34, 38.1-72.8mm standard length, Gilan, Golshan River (37º26'N, 49º40'E); CMNFI 1970-0528, 16, 43.6-64.4mm standard length, Mazandaran, Tajan River estuary (36º49'N, 53º06'30"E); CMNFI 1970-0535, 1, 153.3mm standard length, Gilan, Shafa River (37º35'N, 49º09'E); CMNFI 1970-0539, 43, 25.1-102.0mm standard length, Gilan, Caspian Sea off Bandar-e Anzali (37º28'N, 49º27'E); CMNFI 1970-0543A, 2, 76.7-79.9mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0549, 1, 48.1mm standard length, Gilan, Qareh Su near Alb Imamzadeh (no other locality data); CMNFI 1970-0565, 3, 91.8-108.8mm standard length, Gilan, Sefid River estuary (ca. 37º28'N, ca. 49º54'E); CMNFI 1970-0577, 13, 22.1-38.8mm standard length, Gilan, Caspian Sea near Astara (ca. 38º26'N, ca. 48º53'E); CMNFI 1970-0581, 4, 41.0-71.0mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1970-0586, 8, 27.3-50.4mm standard length, Mazandaran, Gorgan Talab at Ashuradeh-ye Kuchak(36º50'N, 53º56'E); CMNFI 1970-0587, 165, 15.7-47.9mm standard length, Mazandaran, Babol River at Babol Sar (36º43'N, 52º39'E); CMNFI 1970-0590, 11, 28.6-54.0mm standard length, Mazandaran, Shesh Deh River near Babol Sar (ca. 36º43'N, ca.52º39'E; CMNFI 1979-0470, 17, 16.6-43.4mm standard length, Mazandaran, stream 21km west of Alamdeh (36º35'N, 51º43'E); CMNFI 1979-0471, 1, 59.1mm standard length, Mazandaran, Caspian Sea 14km west of Alamdeh (36º35'N, 51º48'E); CMNFI 1979-0477, 1, 16.7mm standard length, Mazandaran, Gorgan Talab at Bandar-e Torkeman (36º54'N,

54º02'30"E); CMNFI 1979-0788, 1, 22.7mm standard length, Mazandaran, Gorgan River at Khadje Nafas (37º00'N, 54º07'E); CMNFI 1980-0120, 9, 48.8-73.2mm standard length, Mazandaran, Babol River at Babol Sar (36º43'N, 52º39'E); CMNFI 1980-0126, 2, 217.5-244.2mm standard length, Gilan, Caspian Sea near Bandar-e Anzali (37º28'N, 49º27'E); CMNFI 1980-0127, 5, 22.8-52.8mm standard length, Gilan, Caspian Sea near Hasan Kiadeh (37º24'N, 49º58'E); CMNFI 1980-0129, 18, 28.3-64.2mm standard length, Mazandaran, Tajan River estuary (36º49'N, 53º06'30"E); CMNFI 1980-0136, 13, 35.9-76.8mm standard length, Mazandaran, Fereydun Kenar River estuary (36º41'N, 52º29'E); CMNFI 1980-0146, 2, 88.8-96.6mm standard length, Mazandaran, Gorgan Talab at Ashuradeh-ye Kuchak (36º50'N, 53º56'E); CMNFI 1980-0149, 10, 36.0-83.2mm standard length, Gilan, Chabak River (37º21'N, 49º50'E); CMNFI 1980-0157, 77, 25.7-50.1mm standard length, Mazandaran, Gorgan River estuary (36º59'N, 53º59'30"E); CMNFI 1993-0144, 2, 78.4-92.2mm standard length, Mazandaran, Neka Power Plant (36º51'48'N, 53º23'24"E).

Genus *Ellochelon* Whitley, 1930

This genus contains a single species so the characters of the species are those of the genus.

Ellochelon vaigiensis (Quoy and Gaimard, 1825) (Fig. 9)

Common names: None. [Massiyat or biah in Iraq; square-tail mullet, diamond-scaled mullet, diamond-scale grey mullet, brown-banded mullet].

Systematics: Originally described from Waigeo, Indonesia. Placed in the genus *Ellochelon* Whitley, 1930 in Randall (1995), previously in *Liza*.

Key characters: This species is uniquely characterised in this area of the northern Indian Ocean by the caudal fin being only slightly emarginate. All other local mullets have an obviously forked tail fin.

Morphology: The preorbital bone is notched anteriorly and is wide, filling the space between the eye and the upper lip. The head is broad and flattened on top, with head length 24-30% of standard length. The eye has adipose tissue around its margin. Lips are thin but the lower lip has a high symphysial knob. There are ciliate teeth on the lips, in 1-2 rows on the upper lip and one row on the lower lip. Larger fish lose the upper lip teeth at >250mm standard length and the lower lip teeth at ca. 100mm standard length. About half of the anal fin base lies anterior to the level of the second dorsal fin origin. The pectoral axillary scale is rudimentary or absent. The pectoral fin does not reach back on a level with the first dorsal fin origin. The second dorsal and anal fins are densely scaled. Pyloric caeca are more than 14. Hoda (1978) describes the larva in Iraq. Salehi et al. (2016) described the sagittal otolith morphology and its use in distinguishing this species from *Mugil cephalus* and *Planiliza klunzingeri* and *P. subviridis*.

First dorsal fin spines 4, second dorsal fin with 1 spine and 7-9 soft rays, anal fin with 3 spines and 7-9 soft rays, pectoral fin with 15-18 branched rays, lateral series scales 24-29, transverse scales (from first dorsal fin origin to pelvic fin origin) 9-11, and predorsal scales 15-16. Gill rakers 40-61.

Sexual dimorphism: Unknown.

Colour: The back is olive brown to pale olive, the flanks silvery and the belly white with yellowish tinges. Upper flank scales have characteristic brown blotches which appear to run together to form about 5-6 stripes. The iris has yellow patches. Fin margins are dusky to black but the body of each fin is yellowish. Young fish have black pectoral fins but in adults the lower half is yellow. The caudal, anal and pelvic fins are a bright yellow in young fish while the second dorsal fin is dark on its distal half.

Size: Reaches 63.0cm.

Distribution: This species is widespread in the tropical Indo-Pacific Ocean from Africa to Japan and Tahiti including the Persian Gulf. It also enters fresh waters. Reported from the Shatt al Arab, Iraq near Iranian Khuzestan by Al-Nasiri & Hoda (1976). A single specimen from Khuzestan, Iran may confirm

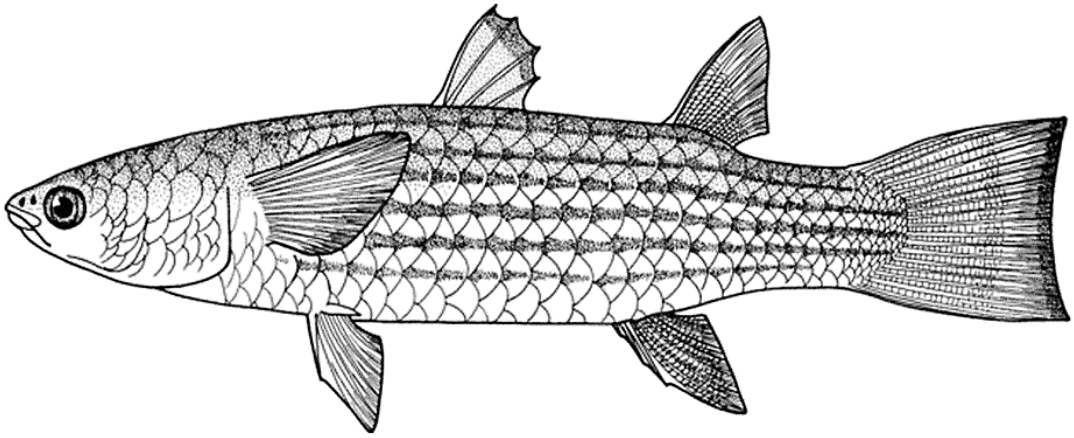

Fig.9. Line drawing of *Ellochelon vaigiensis* by S.Laurie-Bourque.

its presence in fresh water. Hashemi et al. (2015) reported it as an exotic in the Shadegan Wetland, but the meaning here is migrant from the sea. Akbari (1998) records it from coastal and estuarine waters in Hormozgan. Esmaeili et al. (2015) record it from the Persis basin. Other records from Iranian rivers draining to the Persian Gulf (e.g., Dez, Karun, Dalaki and Mand rivers) may be this species but could also be *P. subviridis*.

Zoogeography: A widely distributed marine species, this mullet also enters and is resident in fresh waters but is dependent on reproduction of marine populations to maintain the freshwater ones.

Habitat: This species is found in coastal waters over sand, in lagoons and mangroves and over reef flats and commonly enters fresh waters. Its biology in Iranian fresh waters is unknown. It apparently enters fresh water during the rainy season elsewhere in its range, ascending only to tidal limits.

Age and growth: Unknown.

Food: Food items are algae, diatoms, detritus, benthic polychaetes, molluscs and crustaceans which are ingested along with associated sand and mud.

Reproduction: Fry are known to occur along the sea coast and the eggs are pelagic and non-adhesive.

Parasites and predators: None reported from Iran.

Economic importance: This mullet is common in commercial catches along the west coast of India. It is caught in castnets, stakenets and beach seines.

Conservation: The IUCN Redlist (IUCN 2015) lists this species as of Least Concern.

Sources: Description based on literature sources, particularly Fischer & Bianchi (1984), Talwar & Kacker (1984) and Thomson (1997).

Genus *Mugil* Linnaeus, 1758

This genus is characterised by a strongly flattened head, a transverse mouth with the lateral cleft short, thin lips, lower jaw with a symphysial knob and lower jaws meeting at symphysis with an acute angle, the maxilla end is not visible when the mouth is closed, the anteroventral edge of the preorbital is serrate and straight and the ventral edge is slender and pointed, no true teeth in the jaws, a very well-developed adipose eyelid reaching to, or nearly to, the pupil, two pyloric caeca, pharyngobranchial organ with a single valve, no vomerine or palatine teeth, scales cycloid or feebly ctenoid, and pectoral axillary scale long and pointed. Thomson (1997) and Harrison in Miller (2003) give a wide range of generic characters but since only one species is found in Iranian waters, and that rarely, the species description suffices here.

Mugil cephalus Linnaeus, 1758

(Figs. 10-11)

Common names: Kefal or kafal, biah-e sarpahn (= flathead mullet), kafal-e khakestari. [Biah, biyah, biaha Ramadiyah, anubah or asfatiya in Arabic; striped mullet, loban, common, grey, jumping,

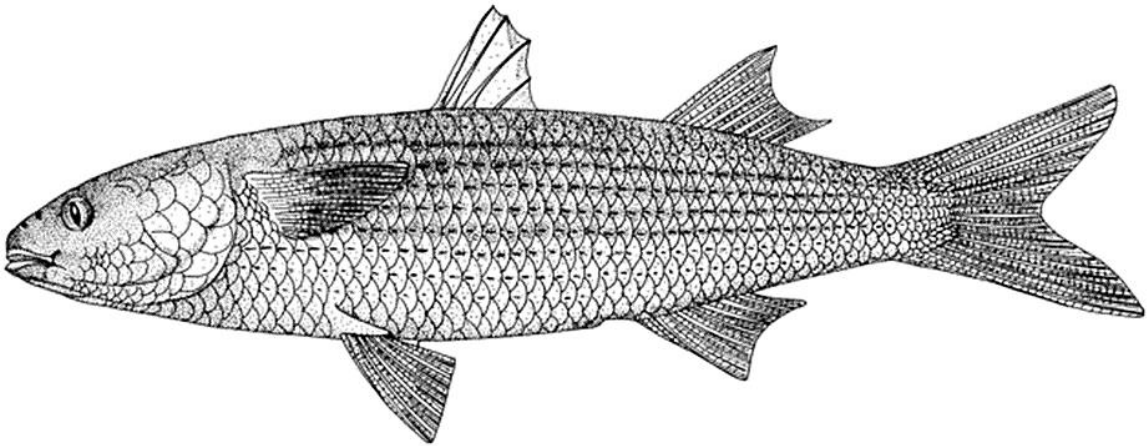

Fig.10. Line drawing of *Mugil cephalus* by Susan Laurie-Bourque.

Fig.11. *Mugil cephalus*, Cochin, India, courtesy of J. E. Randall.

flathead grey, sea, or river mullet; mighach, minghaj or karul in Pakistan].

Systematics: *Mugil Cephalus* was originally described from the Atlantic Ocean at the shores of Europe, entering rivers. No major relevant synonyms. Durand et al. (2012) and Durand & Borsa (2015) indicate, based on DNA, data that this wide-ranging species may include up to 14 species so the Iranian taxon may eventually bear a distinct name. Khayyami et al. (2015a) were able to separate fish from Bandar Abbas Port and neighboring Qeshm Island on morphometry (17 out of 25 characters significantly different).

Key characters: This species is distinguished from *Chelon* species by having only 2 pyloric caeca, the posterior end of the maxilla is straight rather than curved down behind the premaxilla and visible behind the corner of the closed mouth, adipose tissue on the eye reaches the pupil in adults, and the tip of the jaw end is on the line of the gape.

Morphology: There is a prominent adipose eyelid which leaves only a narrow slit over the pupil and extends twice as far behind the eye as in front of it. First dorsal fin with 4 spines, second dorsal fin with 1-2 spines and 6-9, usually 8 or 9, soft rays, anal fin with 3 spines and 7-9, usually 8, soft rays (below 5cm there are 2 spines and 9 soft rays), pectoral fin branched rays 14-17, and pelvic fin branched rays 5. Lateral series scales 36-46 with 3-5 on the caudal fin, transverse scale rows 14-15, predorsal scales 24-26 and cheek scales in 3-4 rows. Scales on the head extend forward to the tip of the snout. Scales are found on the caudal fin rays and at the bases of the anterior dorsal and anal fin rays. There is a pelvic axillary scale. Scales bear an anterior mid-margin notch, the anterior corners are very square and sharp,

upper and lower margins are parallel and the posterior margin is rounded. There are few radii (as few as 5) running from a subcentral posterior focus to the notch. Circuli are numerous and fine and the exposed scale surface is coarse. Gill rakers 24-80, long, fine and crowded, count increasing with growth of fish. Pyloric caeca number 2 and the gut is long with numerous loops, complexly coiled. Khayyami et al. (2015b) gave details of the anatomy and histology of the stomach and pyloric caeca. The chromosome number is 2n=48 (Klinkhardt et al. 1995). There is a distinct axillary scale at the pectoral fin, 33-36% of pectoral fin length. The pectoral fin reaches the tenth postopercular scale but not the level of the first dorsal fin origin; folded forward it reaches the eye but not the pupil. Salehi et al. (2016) described the sagittal otolith morphology and its use in distinguishing this species from *E. vaigiensis*, and *Planiliza klunzingeri* and *P. subviridis*. A single Iranian specimen has 4 first dorsal fin spines, 8 soft second dorsal fin rays, 8 anal fin soft rays, 15 pectoral fin branched rays, 5 branched pelvic fin rays, 43 scales in lateral series, and 24 total vertebrae.

Sexual dimorphism: Females grow larger and weigh more than males.

Colour: Back bluish-grey to olive-green or greyish-brown, flanks silvery and belly silvery to white. Each scale has a dark spot which line up to give the impression of 6-12 indistinct brownish or grey stripes. The upper rear corner of the operculum has a golden spot. There is dark purple blotch at the pectoral fin base. The dorsal and pectoral fins are a dark blue-grey while the anal and caudal fins are a yellowish-green. The dorsal and caudal fins have dusky margins. Young are bright, iridescent silver. Estuarine and freshwater fish may be duller overall than marine fish.

Size: Attains 1.2m and 7.0kg.

Distribution: Found world-wide between about 51°N and 42°S. Introduced into the Caspian Sea in 1902, it has not been observed there since and there appear to be no valid Caspian records for Iran (Dmitriev 1946; Baltz 1991). The introduction probably failed because the pelagic eggs were not buoyant at the low Caspian salinities (Baltz 1991) although Harrison in Miller (2003) notes spawning has been induced in fresh water. However, Kiabi et al. (1999) report it from the southeast Caspian Sea, Kalbassi et al. (2013) and Esmaeili et al. (2014) state the fish has a distribution in the Caspian Sea, and Moradinasab et al. (2015) note it as a by-catch of the Caspian Sea kilka fishery. The species is being cultured at Sari on the Iranian coast of the Caspian Sea (Iranian Fisheries Research Organization Newsletter 40, 41: 3, 2004, and see below). Jolodar & Abdoli (2004), Ghelichi et al. (2011) and Yelghi et al. (2012) report it from the Gomishan Wetland but only in farms there. According to Yelghi et al. (2012) the grey mullet fingerling were imported to Iran in 1997 from Hong Kong and, in coastal fish ponds of the northern part of Iran, were successfully cultured in order to obtain broodstocks and induce artificial reproduction

Reported from the Shatt al Arab, Iraq near Iranian Khuzestan by Al-Nasiri & Hoda (1975). Akbari (2002) records this species from creeks and coastal waters of Hormozgan. Esmaeili et al. (2015) record it from the Persis basin and also present in the Hormozgan basin. It enters rivers of southern Iran from the Persian Gulf and Sea of Oman, notably the Sarbaz River (Coad 1997) and as far east as Chabahar on the Pakistan border (Fereidouni et al. 2015).

Zoogeography: A widely distributed marine species, this mullet also enters and is resident in fresh waters but is dependent on reproduction of marine populations to maintain the freshwater ones.

Habitat: This mullet is found in surface waters of the sea and frequently ascends rivers. It is common in coastal and estuarine waters. Juveniles are found mainly in estuaries. It favours marine waters where the average monthly temperature is above 16°C and where the summer temperatures rise above 18°C. Temperature ranges of 5-37°C are tolerated. It can live in salinities up to 126‰. A salinity range of 15-36‰ is needed for embryonic development, optimally 26‰ or more. It is tolerant of low oxygen levels and can ventilate water in contact with the air

when conditions are hypoxic. This species lives in clear to turbid waters over sandy and muddy bottoms. It is a fast swimmer and may leap out of the water.

Age and growth: Age at maturity for both sexes varies with water temperatures, at 1 year in the warmest waters, such as Florida, and as late as 6-8 years in the Black Sea for example. Black Sea fish were 31-37cm long at maturity while in the Gulf of Mexico females were 25.8cm and males 24.0cm and larger. Life span lies between 11 and 21 years. Growth rate varies with locality and ceases in warm temperate waters during mid-winter. Khayyami et al. (2014a) found *b* values for Bandar Abbas Port and Qeshm Island to be 2.9118 and 2.9018, isometric growth.

Food: Diet is comprised of microscopic organic matter taken in with mouthfuls of sand. The sand probably helps grind up food in the gizzard-like stomach. The food items are diatoms, blue-green and green algae, foraminifers, small crustaceans and detritus, and sometimes plankton. Rarely, swarming marine worms are eaten rather than microscopic items, perhaps as an additional energy source prior to spawning. Juveniles eat invertebrates.

Reproduction: Spawning occurs only in the sea, in surface waters near the edge of the continental shelf over deep water after a migration from rivers for fish living in fresh water. In the Sea of Marmara, Turkey, this takes place in October and in southern India in October-May. Eggs and larvae drift with ocean currents until they are 20-30mm about 2-3 months after hatching. Fry make their way into estuaries and juveniles live in estuaries and lower reaches of rivers. Each female is attended by several males during spawning. The males nudge and press against the female's abdomen. The fish may quiver and cease swimming momentarily, sometimes rising to the surface. Fertilisation is external. Spawning occurs once yearly and some females only spawn in alternate years after first maturity. Fecundity is up to 4,800,000 non-adhesive, straw-coloured eggs and egg diameter reaches 1.08mm (some reports cite 7 million eggs). Hatching occurs in about 2 days. Ghelichi et al. (2011) give details of oocyte development in fish from Gomishan farms on the Caspian coast and show that from November fish are ready for hormonal induction.

Parasites and predators: Eslami & Anwar (1971) record the cestode *Caryophyllaeus fimbriceps* from this species on the Caspian coast of Iran. In the absence of valid records for this fish in Iranian Caspian waters, the host may have been another mullet species. Naseri et al. (2014) found fish from marine waters at Chabahar had *Photobacterium damselae* in the spleen, which causes bacterial septicaemia, and high mortality was observed within a week.

Economic importance: Fisheries take place around coasts world-wide as the mullet merge into migratory schools. Its wide distribution and size make it an important food fish, particularly in developing countries (Ghasemzadeh & Ivantsoff 2004). In Hormozgan, is caught in coastal waters by cast net and stake-net but only at 1.33% by weight and 0.19% by frequency compared to other edible fishes and with a frequency of 5% compared to other mugilids. It is not a significant species in Iranian fresh waters.

World-wide, it is sold fresh, frozen or salted and the roe is made into a type of caviar (Çelik et al. 2012). This species is also widely cultured, for example in Israel and India, with yields up to 2,434 fish per hectare. It has been reported as being ciguatoxic (intermittently poisonous through feeding on toxic food) (Bagnis et al. 1970) and as being ichthyoallyeinotoxic (hallucinogenic fish poisoning) (Halstead 1967-1970, 1978). The latter is a sporadic and mild form of poisoning. This species is rare in Iranian freshwaters and unlikely to be health hazard there (Coad 1979).

Fingerlings from Taiwan, Egypt and Hong Kong have been cultured in enclosed ponds in Mazandaran and the area of the Gomishan Wetland (A. Matinfar, pers. comm. 1995; Annual Report 1993-94; Iranian Fisheries Research and Training Organization, Tehran p. 43-44, 1995; Annual Report, 1994-1995; Iranian Fisheries Research and Training

Organization, Tehran p. 31, 1996; Annual Report, 1995-1996; Iranian Fisheries Research and Training Organization, Tehran p. 39, 42, 1997; Iranian Fisheries Research and Training Organization Newsletter, Tehran 18: 5, 1997; Iranian Fisheries Research Organization Newsletter 40&41: 3, 2004; Iranian Fisheries Research Organization Newsletter 53: 3, 2008; Mir Hashemi Rostami et al. 2016). 20,000 fingerlings, weighing about 0.5g, were imported to the Caspian Sea Ecology Research Center in Sari in 1993, for example. Fry were cultured for 21 days on plankton grown by manuring ponds with wheat and rice bran and soya. Growth in salt water averaged 235g and 28.4cm in the first year and 544g and 40cm in the second year. Growth in fresh water averaged 216g and 28.5cm in the first year and 668g and 38cm in the second year.

Experiments on the mass production of *Nannochloropsis oculata* algae used in the culture of rotifers and *Mugil cephalus* larvae have been carried out in Golestan Province (Iranian Fisheries Research Organization Newsletter 37: 3, 2003). Mirhashemi Rostami et al. (2008) have examined mortality factors in fry from 9 year old broodstock in Iran, Yousefian et al. (2009) gonad development and hormonal induction in brood stock at Gomishan Fish Farm, and Mir Hashemi Rostami et al. (2016) the effects on length and weight of rearing densities at Gomishan. Vazirzadeh & Ezhdehakoshpour (2014) gave different hormonal treatments to wild-caught mullet from Chabahar involving carp pituitary extract and sGnRHa (gonadotropin-releasing hormone analogue) and found all were effective in induction of oocyte maturation.

Hosseini Aghuzbeni & Hajirezaee (2015) and Hosseini Aghuzbeni et al. (2017) studied co-culturing of this mullet with western white shrimp (*Litopenaeus vannamei*) in earthen ponds at Gwadar on the Sea of Oman. The studies showed the mullet had a positive effect on control of *Vibrio* bacteria of the shrimp and improved shrimp growth by reduction of organic matter and improvement of water quality.

Sharifpour et al. (2003), Ghelichi et al. (2004), Yeganeh et al. (2005), Mirhashemi Rostamy et al. (2006) and Tehrani (2006) give further details on culturing this mullet in Iran. Peak spawning was mid- to late January with the best time for artificial breeding using hormones being December. Up to 2.6 million eggs could be produced from a female with fertilisation varying from 10 to 95% and hatching rate between 0.008 and 88.9%. Ghelichi & Jorjani (2004) state that this species is expected to play an important future role in fish culture in Iran. They studied induced spawning in this species and found 17-α hydroxyprogesterone to be effective. Ghalichi (2003) and Ghelichi et al. (2004) examined the efficacy of hypophysial (carp pituitary), LRH-A2 and HCG hormones on plasma steroid levels and oocyte maturation in captive, mature, female mullet. Histological details of oocyte development were given and cortisol levels were used to measure handling level and stress effect on brooders. The steroid 17-α hydroxyprogesterone was found to be one of the maturation-inducing substances for this fish. Ghelichi et al. (2007) studied oocyte maturation after stimulation with hormones and also found 17-α hydroxyprogesterone to be the most effective steroid in final maturation. Mohammadshahali et al. (2014) have used ultrasonography to sex fish on Gomishan farms. Accuracy was 100% and the procedure took 30 seconds per fish.

Akbary et al. (2015) and Fereidouni et al. (2015) found that a diet with 3% garlic extract (*Allium sativum*) can improve growth, feed performance, carcass quality, general health and enzyme activity in larvae raised in aquaculture. Kakoolaki et al. (2016) found that diets supplemented with 100 and 200mg/kg of *Camellia sinensis* (tea plant) leaf extract significantly enhanced the immune system and reduced mortality of fingerlings challenged with *Photobacterium damselae*, which causes potentially fatal pasteurellosis or photobacteriosis.

Mohamadi et al. (2014) demonstrated experimentally that low salinities are stressful for juvenile grey mullets. Presumably only adults enter fresh water easily.

This species is also studied experimentally, e.g. Jahanbakhshi (2016) found the LC_{50} 96h for potassium dichromate, used as an oxidising agent in industry, was 83.07p.p.m.and this fish could be used as a model in ecotoxicological studies.

Conservation: The IUCN Redlist (IUCN 2015) lists this species as of Least Concern.

Sources: Thomson (1963) and Whitfield et al. (2012) gave synopses of the biology of this species and the above account is based mostly on these works. Some distinguishing characters are based on Trewavas & Ingham (1972).

Iranian material: OSU 4281, 1, 234.3mm standard length, Baluchestan, Kalani, Sarbaz River (25°17'N, 61°24'E).

Genus *Planiliza* Whitley, 1945

All Indo-Pacific species formerly placed in the genera *Chelon* and *Liza* are in this genus. Apparently, no diagnostic morphological traits were identified from 68 examined and the genus is defined based on DNA evidence (Crosetti & Blaber 2016). Xia et al. (2016) gave an osteological character, a neural postzygapophysis very long, curved and dull-tipped on the second vertebra. Iranian *Planiliza* also have an adipose eyelid not limited to the rim around the eye in contrast to related genera (*Chelon* for example).

Planiliza abu (Heckel, 1843)

(Figs. 12-14)

Common names: Biah, biah zury, zuri, kafal, shochy; do'kelki in Khuzestan (= with two sails, presumably referring to the two dorsal fins), derbak. [Maid, khishni, hishni, abu-khraiza, hosoon, hashsoun, abu-khraiza, or abu sukkanejn (= father of two anchors in allusion to the toothed suborbital bone according to Heckel (1843) or from sukkanayn (= dual and steering wheel or handle bars) hence two steering or dorsal fins (Mikaili & Shayegh 2011)), all in Arabic with further explanations of Arabic names in this work; minghaj in Pakistan; abu mullet, freshwater mullet].

Systematics: *Mugil pseudotelestes* Pietschmann, 1912, described from the "Schatt el Arab bei Basra (Aschar)" (Ashar is at 30°31'N, 47°50'E), is probably a synonym (Coad 1991) based on the original description. *Mugil hishni* Misra in Hora & Misra, 1943 described from "Rivers and Hors, Iraq" (hors or hawrs are marshes) is also a synonym based on the description, an opinion concurred in with Ingham (no date) and Özdilek (2003). Thomson (1997) considers *hishni* to be a synonym and possibly *pseudotelestes* although he considers the description of this species insufficiently detailed. *Mugil abu zarudnyi* Berg, 1949 was described from "Ser-i-pul, 30km from Malamir, between Deh-i-dez and Malamir, region of the Bakhtiars and Lurs, upper course of the Karun R., south-western Ian, 17 III 1904, N. Zarudnyi". Thomson (1997) considers this subspecies to be of doubtful validity given the variability of this species. Different stocks exist in the Tigris, Euphrates and Orontes rivers as evidenced by morphology (Turan et al. 2004). Khayyami et al. (2014c) examined the morphometry of fish from the Karun River (fresh), Arvand River estuary (brackish) and Mousa Creek (saline) and found a high degree of overlap between the first two localities while these two were highly different from the third.

Randall (1995) places this species in the genus *Chelon*; Thomson (1997) does not.

Material of *Mugil abu*, housed in the Naturhistorisches Museum Wien, is under NMW 9224-9230 (7 fish) and 67868 (2) and are syntypes. The type locality is the "Tigris bei Mossul" according to Heckel (1843b) and the catalogue lists 4 specimens. *Mugil* (*Liza*) *abu zarudnyi* Berg, 1949 was described from Iranian tributaries of the Tigris River basin. The 5 syntypes of *zarudnyi* are in the Zoological Institute, St. Petersburg (ZISP 24336), and measure 69.1-80.7mm standard length. The date in the catalogue is 4.II.1904 (old style). The holotype of *M. hishni* is in the Zoological Survey of India, Calcutta under ZSI F13626/1 with 1 paratype under ZSI F13627/1 (Menon & Yazdani 1968, Eschmeyer et al. 2016).

Key characters: The high lateral scale count, long

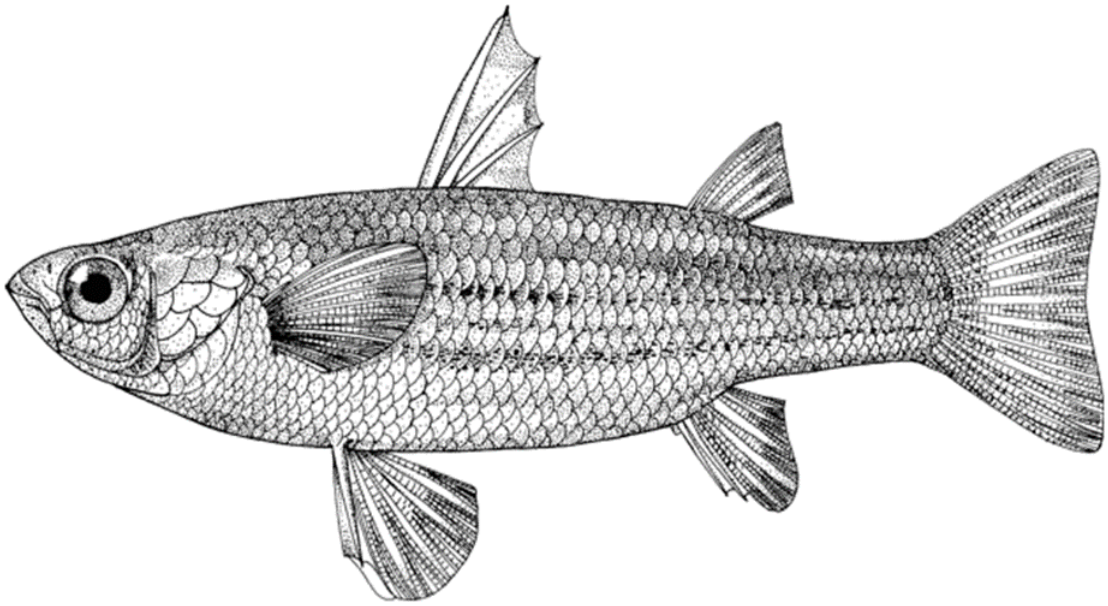

Fig.12. Line drawing of *Planiliza abu* by S. Laurie-Bourque (after *P.a. Zarudnyi* from Berg (1949)).

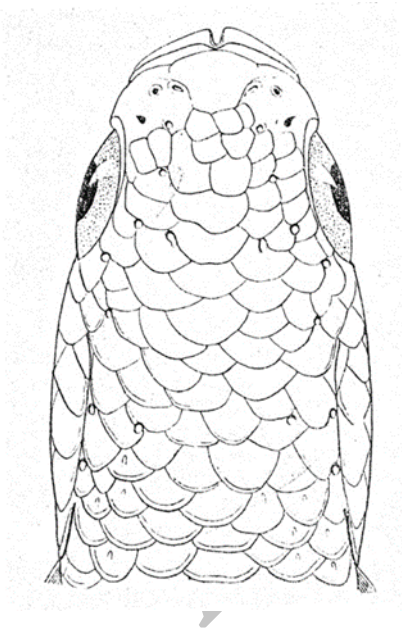

Fig.13. Line drawing of *Planiliza abu*, dorsal view of head (after *P.a. Zarudnyi* from Berg (1949)).

pectoral fins reaching almost level with the first dorsal fin origin when folded back (note fin tips often frayed, especially in preserved material, so not as apparent), short pectoral axillary scale, thin lips, 3 anal fin spines and 8 branched rays, relatively strong spines in the first dorsal and anal fins, and peg-like or setiform teeth (not tricuspid) in the upper jaw only, distinguish this species.

Morphology: The eye has fatty tissue covering as far as part of the iris. Lips are thin and the lower lip has a pronounced knob. Peg-like teeth are obviously present only on the upper lip, the lower lip having scattered ciliate teeth. The end of the maxilla has an s-shaped bend and its tip is exposed. The anterior edge of the denticulate preorbital is angular, bending down at the corner of the mouth. The pectoral axillary scale is weakly developed. Occasional antero-dorsal scales have double canals. Pectoral fin length is 75-78% of head length and this fin extends back to a level almost at the first dorsal fin origin. First dorsal fin spines 3-4, usually 4, second dorsal fin soft rays 5-10, usually 8 after 1-2 spines, anal fin spines 3 followed by 5-10, usually 8 soft rays, pectoral fin branched rays 13-17 and pelvic fin branched rays 5-6, usually 5. Vertebrae 21-25. Fusions and minor vertebral anomalies were described by Al-Hassan (1987) and Al-Hassan & Na'ama (1986) from Iraqi fish. Lateral scales 39-53, usually 44-50. Scales are strongly ctenoid on the exposed part and the fish feels rough to touch when rubbed from tail to head. The embedded part of the scale has fine circuli. The focus is very posterior. Scale shape is rectangular with the anterior margin vertical or somewhat wavy. The anterior upper and lower corners are square or even

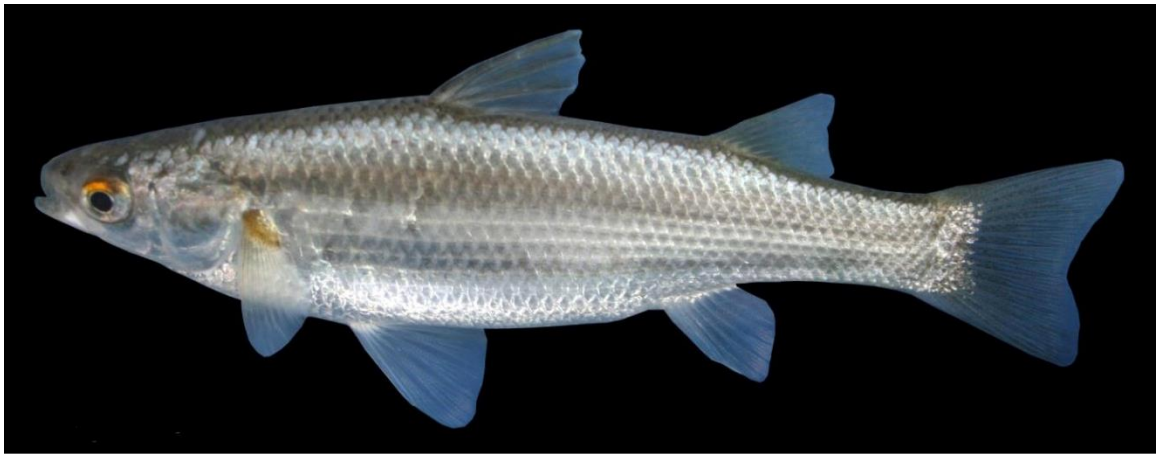

Fig.14. *Planiliza abu* from Lake Maharlu, courtesy of H.R. Esmaeili.

pointed. The dorsal and ventral scale margins are straight and the posterior margin is rounded. There are a few radii (as few as 4) from the focus to the anterior margin and, where these intersect the margin, it may be slightly indented to form a wavy edge. Esmaeili et al. (2014) gave details of scale microstructure and scale size which can be used to distinguish species. There are 4 pyloric caeca and the gut is elongate and coiled. Khayyami et al. (2015b) gave details of the anatomy and histology of the stomach and pyloric caeca. Gill rakers are shorter than the gill filaments and number 44-55. They bear teeth on the internal edge. Islam & Al-Nasiri (1978) give morphometric characters. Hoda (1978) describes the larva (as *Mugil hishni*) in Iraq. The chromosome number is 2n=48 (Deĝer et al. 2013).

Al-Hassan (1984) showed differences in counts of vertebrae and dorsal fin rays between fish from Basrah, Iraq and the Karkheh River in Iran. Turan et al. (2004) also noted differences in morphometric data for stocks from the Orontes (= Asi), Tigris and Euphrates rivers of Turkey, attributing this to phenotypic adaptation as the stocks were genetically homogenous. Thomson (1997) notes that this is the most variable species in the family. Jawad (2004) studied asymmetry in this species from the Shatt al Arab at Basrah and suggested pollution could be a cause. Jawad & Öktener (2007) record lordosis (axial spinal curvature) in this species in the Atatürk Dam Lake, Turkey. Jawad et al. (2010) describe a specimen from Karkheh River branch near Susangerd with a malformed caudal fin. Ramezani Rad et al. (2015) described the neurocranium as more delicate than in other mugilids.

The nominal subspecies *zarudnyi* has 3-4 first dorsal fin spines, 1-2 spines and 5-7 soft rays in the second dorsal fin, the anal fin has 3 spines and 5-9 soft rays, usually 9, and scales in lateral series 41-46. The larger scales distinguish it from the typical form at Mosul in Iraq (Berg 1949). My observations on the types show 4(4) first dorsal fin spines, 1(2) or 2(2) second dorsal fin spines and 7(3) or 8(1) soft rays, 7(1), 8(1) or 9(2) anal fin soft rays, 5(4) pelvic fin rays, 13(1) or 14(3) branched pectoral fin rays, and 39(1), 43(1), 44(1) or 45(1) scales in lateral series. One specimen is unusual in having a mix of abnormally low counts and normal counts: 3 first dorsal fin spines, 5 second dorsal fin soft rays, 5 anal fin soft rays, 5 pelvic fin rays, 15 pectoral fin rays, and 43 lateral series scales.

Meristic values for Iranian specimens, excluding the above: first dorsal fin spines 4(36); second dorsal fin soft rays 7(4), 8(31) or 9(1); anal fin soft rays 8(28) or 9(8); pectoral fin branched rays 13(1), 14(17), 15(13) or 16(4); pelvic fin branched rays 5(35) or 6(1); lateral series scales 44(5), 45(5), 46(5), 47(8), 48(2), 49(4), 50(1) or 51(1).

Sexual dimorphism: Unknown.

Colour: The back is a light brown, greyish, greenish-grey or olive-green with the flanks and belly silvery

or yellowish-silver. There may be an indistinct silvery stripe or 2 grey stripes along the flank. Generally the upper flank is dark, the lower flank pale, and the two clearly demarcated. The upper part of the lower flank may bear alternating light and dark stripes but these are sometimes poorly expressed. The second dorsal and caudal fins are dusky to brownish and lower fins are yellowish-white to hyaline. The caudal fin may have a dark border. Scale margins are covered in small black spots. The top of the eye is lime-green and reddish-brown just below but still silvery around the pupil generally. Young fish have a reddish colour at the base of the pelvic, anal and caudal fins and have an evident mid-lateral stripe against a pale body.

Size: Attains 26.2m total length and 209g. Hashemi et al. (2011) reported the largest of 382 fish from Shadegan Wetland was 26.2cm total length and 209g while Hashemi et al. (2014) found the largest of 630 fish was 25.0cm total length and 141g.

Distribution: Found in the Tigris-Euphrates and Orontes (= Asi) (Özdilek 2003) river basins, and in Pakistan. In Iran, found in the Tigris River basin in rivers and marshes such as the Abjahanbin, Arvand, Bahmanshir, Dez, Jarrahi, Kahnak, Karkeh, Karun and Zard rivers, Dez Dam Lake, the Dasht-e Azadegan west of Ahvaz, Hawr-al-Azim or Hoveyzeh Marsh and Shadegan Wetland, in lower reaches of rivers and creeks draining to the Persian Gulf such as the Helleh, Mond and Zohreh in the Gulf or Persis basin, and the Jalabi, Mehran and Shour rivers of the Hormoz basin (Najafpour 1997; Eskandari et al. 2007; Chelemal et al. 2009; Jawad et al. 2010; Hashemi et al. 2011; Maghtouie et al. 2011; Papahn et al. 2013; Khoshnood 2014; Zare et al. 2014; Esmaeili et al. 2015; Pazira et al. 2016; Keivany & Zamani-Faradonbe 2017).

It is also recorded from Parishan (= Famur) Lake in 1977 (see below CMNFI 1979-0240) but it was not captured in a 1995 survey. Teimori et al. (2010) record it in the lake as a translocation but it may be native given the earlier records. Found in Kamfirouz Lake as a translocation (Teimori et al. 2010) and also recorded from Kaftar Lake and the Band-e Amir, all in the Kor River basin. Sayyadzadeh et al. (2016) record it as native to the Kor River basin. Records from the Barm-e Shur and Pol-e Berengie near Shiraz in the Lake Maharlu basin are probably an introduction too as this species was not caught there in the 1970s by me (Gh. Izadi, pers. comm. 2001, Esmaeili et al. 2014).

Abdoli (2000) maps this species in the lower Hasan Langi, Kul, Gowdar and Mehran rivers at the Straits of Hormoz in the Hormoz basin, the lower Mand River and the lower Zohreh (= Hendijan) rivers in the Gulf basin, the Arvand, lower Karun, lower Karkheh and the Simarreh rivers in the Tigris River basin. It is also reported from the upper Karun River as *M. a. zarudnyi*.

Zoogeography: As a freshwater member of a genus with many species in the sea, its origins lie with these marine relatives.

Habitat: This mullet is a freshwater species found in rivers, streams, channels, canals and drains, lakes, reservoirs and ponds, on fish farms of Iraq and neighbouring countries, occasionally entering estuaries. It usually occurs in schools. Epler et al. (2001) found it to be the dominant species of fish in lakes Habbaniyah, Tharthar and Razzazah, Iraq, comprising 72% of all fish collected. This was one of the most abundant species in the recovering marshes of southern Iraq in 2005-2006 (at almost 36% of 16,199 fishes collected) (Hussain et al. 2006) and in the marshes in the 1980's (Hussain & Ali 2006). Nasir & Na'ama (1988) and Hussain & Naama (1989) reported it from the Khawr az Zubayr in a marine environment, probably a consequence of human-induced environmental changes. It is the most abundant species in autumn in the Karun River, Iran, comprising 44.2% of the catch (Mokhayer 1981).

van den Eelaart (1954), reporting on Iraqi populations, found this mullet in the surface waters and submerged vegetation of lakes and marshes, preferably where there is a gentle water flow. In December-January it enters rivers and deeper waters, especially in very cold winters. Ahmad et al. (1983,

1985) have shown this species can withstand abrupt increases of temperature up to 30°C and salinity up to 10‰ for 24 hours under experimental conditions. Mortality in water at 15‰ is low. Salinities up to 30‰ and temperatures up to 35°C are tolerated, presumably if increases are gradual. Ahmed et al. (2002) stated that it prefers salinities not exceeding 2‰ (later 5.6‰) but can survive abrupt transfer to 15‰. S. Cowton (pers. comm. 23 August 2005) has observed schools of this species gaping at the surface in the artificial lake around Al Faw Palace in Baghdad, presumably in response to high temperatures and low oxygen. It is often the dominant species left in small pools when marshes dry up, as in the Shadegan Wetland of Iran observed by me. Hashemi et al. (2015) reported it as the fourth most abundant fish in Shadegan at 12.04% of 26 species found there (Fig. 15).

Age and growth: Hashemi (2010) and Hashemi et al. (2010a, 2010b) give a length at maturity (L_M) of 6.7cm, production per biomass (P/B) of 0.72, L_∞ of 289mm, K of 0.36yr^{-1} and t_0 of -0.35yr^{-1} for fish from the Shadegan Wetland in Khuzestan. Production in this wetland was 5.63kg/ha/yr for 2008-2009 (Hashemi et al. 2011) or 8.67kg/ha/yr for 2010-2011 (Hashemi & Ansary (2012). Zare et al. (2014) found fish from the Karkheh River at Andimeshk had a mean total length of 182.6mm, a mean weight of 74.2g, a *b*-value indicating negative allometric growth, and a condition factor of 0.78 consistent with previous studies. Keivany & Zamani-Faradonbe (2017) gave a *b* value of 2.72 for fish from the Zohreh River.

Al-Nasiri & Islam (1978) studied the age and growth of this species from commercial catches in the Shatt al Arab, Iraq. Specimens were aged by examining the otoliths and three age groups determined with 0^+ fish being 8.9-10.9cm, 1^+ fish being 9.9-14.8cm and 2^+ fish being 13.6-18.2cm total length. Length-otolith formulae were given. Al-Yamour et al. (1988) examined a population of this species in the Al-Daoodi Drain, Baghdad and found an age span up to 7 years using scales to age fish.

Fig.15. Habitat of *Planiliza abu*, Lake Famur, Brian W. Coad.

Older age groups (5 and 6 years) grow more slowly than Diyala River fish, perhaps because of higher salinity in the Drain and the enriched conditions in the Diyala River due to sewage. The length-weight relationship was $W=0.034\ L^{2.6}$, for males $W=0.062\ L^{2.396}$, and for females $W=0.031\ L^{2.642}$. The condition factor was 6.308 for males and 3.155 for females. Khalaf et al. (1986) studied a population in the Diyala River, Iraq which was polluted with sewage from the Rustamiyah treatment plant. Khishni is the second dominant species from December to March after the cyprinid *Chondrostoma regium* and in August the dominant species in catches. Fish were heavier and in better condition in the more polluted areas, but probably not as good for human consumption! Growth declines after age group 5 with few fish in

Fig.16. Habitat of *Planiliza abu*, Karun River at Ahvaz, Khuzestan, Brian W. Coad.

age group 6. Length-weight relationships were W=-3.39 $L^{2.64}$ for males and W=-2.96 $L^{2.50}$ for females. Mhaisen & Yousif (1989) examined a population of this species in Mehaijeran Creek, a side branch of the Shatt al Arab south of Basrah, Iraq. Only 3 age groups (0^+ to 2^+) were reported since the creek water level is affected by the tide and older fish tend to move into the deeper waters of the adjacent Shatt al Arab. Growth is faster in the creek than in other Iraqi locations. The length-weight relationship was logW=2.794logTL-1.64840 for males and logW= 3.337logTL-2.25728 for females. Mhaisen & Al-Jaffery (1989) report 6 age groups for fish from Babylon Fish Farm west of Hilla, Iraq with a total length-weight relationship logW=2.96057logL-11.19599 (and for standard length logW=2.87574 logSL-10.24769). Fish were in good condition as they were taking food meant for cultured carp. The relative condition factor was 0.98-1.04, similar to values obtained by other authors. The von Bertalanffy growth equation was TL_t=409.6 {1 - exp [-0.06314 (t-3.13868)]}. Epler et al. (2001) found the oldest age groups to be 4^+ in Iraqi lakes Habbaniyah and Razzazah and 5^+ in Lake Tharthar. The mean condition factor was 0.97, 1.05 and 1.09 in lakes Habbaniyah, Tharthar and Razzazah respectively. Syzpuła et al. (2001), studying age and growth in the lakes Habbaniyah, Tharthar and Razzazah in 1981 and 1982, found this species grew fastest in Lake Tharthar. A decrease in length growth was noted in the second year of life and a decrease in body mass in the last years of life. Mohamed (2014) assessed stock in three restored marshes in southern Iraq, East Hammar, Huwazah (=Al-Huwaizeh) and Chabaish. Respectively, relative abundance was 35.9, 37.1 and 62.0% of total catches, *b* values were 2.899, 2.91 and 2.662, mean relative condition factor was 1.0, 1.02 and 0.98, and growth and mortality parameters were L_∞=23.2cm, K=0.37, Z=2.125, M=0.903 and F=1.222, L_∞=21.1cm, K=0.44, Z=1.688, M=1.055 and F=0.632 and L_∞=20.0cm, K=0.41, Z=2.297, M=1.006 and F=1.291. The Huwazah (close to the Iranian border) was unexploited (E=0.375) while the other two were overexploited (E=0.575 East Hammar and 0.562 Chabaish).

The effect of starvation over 35 days on the proximate chemical composition of this species was studied by Yesser et al. (1999). They found a sharp decline in lipid content (4.38 to 0.98%), a slight drop in protein and an increase in both moisture and ash. Both condition factor and viscera somatic index declined gradually, 1.2 to 0.83 and 10.18 to 3.63%

respectively. Body weight fell by 30.59%. Lipid reserves in muscle were therefore an important form of energy storage.

Ünlü et al. (2000) report age groups of 1^+ to 4^+ in the Turkish Tigris River. Hussain et al. (1987) found condition factor to range from 1.12 to 1.64 for different length groups for Karkheh River fish from Iran near the Iraq border and Hawr al Hawizah.

Food: Hussain et al. (1987) examined the food of khishni in the Karkheh River, Khuzestan, where it is the dominant species in terms of numbers caught, by two orders of magnitude. However capture techniques would affect this assessment. Food was similar to that reported from Iraqi fish. Phytoplankton is the most important food for fish 3.0-3.9cm long, followed by organic detritus, while in larger fish this order is reversed. Silt is an important content of the gut in all fishes studied. Eighteen species of Bacillariophyceae, 6 Chlorophyceae and 4 Cyanophyceae species were recorded from gut analyses. Abdoli (2000) reports *Daphnia*, Hemiptera, *Navicula, Nitzschia, Amphora* and *Cymbella* species for Iranian specimens.

Al-Nasiri et al. (1977) studied the feeding ecology of this species in the Shatt al Arab, Iraq. Aquatic plant parts and phytoplankton are food items but the vast bulk of material is sand grains and organic detritus, the former presumably ingested while searching for detrital food. Phytoplankton is made up of diatoms (50%), green algae (36%) and blue-green algae (14%), with diatoms the most abundant numerically. Plant parts are fragments of *Vallisneria* leaves and, rarely, leaves and stems of *Potamogeton* and *Polygonum*. Islam et al. (1981) reported on the seasonal patterns of feeding in Rashdiyah Reservoir, Baghdad. However it should be noted that only 10 fish were examined for each month. Aquatic plant parts, organic debris and phytoplankton are dominant foods followed by zooplankton and aquatic insects. The diet is diverse, 48 species of Chlorophyceae, 60 species of Bacillariophyceae, 9 species of Myxophyceae and 3 of Euglenophyceae. Heavy feeding occurs in late winter, spring and fall with peaks in April and November. Empty stomachs are more common in summer. Islam & Khalaf (1983) studied diel feeding patterns in the same reservoir and found peaks at 0600 and 2100 hours. Naama & Muhsen (1986) studied the feeding periodicity of this species in the Hawr al Hammar, Iraq and found the main food to be algae, mixed with incidental sand grains. There is a single feeding peak each day at 1730 hours and feeding stops at 0200 hours. This species is a day feeder. In another study of the recovering Hawr al Hammar, diet was 76.49% algae and 20.3% diatoms with amounts of crustaceans and plants being less than 10% each, in the Hawr al Hawizah 74.3% algae and 22.5% diatoms, with amounts of plants and crustaceans being less than 10% each, and in the Al Kaba'ish (= Chabaish) Marsh 75.8% algae and 20.0% diatoms with plants and crustaceans at less than 10% each (Hussain et al. 2006). Ahmad & Hussain (1982) examined the food of young fish near Basrah, Iraq and found organic detritus to be an important food followed by phytoplankton. The smallest fish were consuming eggs in large quantities. Al-Shamma'a & Jasim (1993) studied feeding in the Hawr al Hammar in Iraq during the flood period and reported small quantities of adult insects, chironomid larvae, trichopteran larvae, other insect larvae, molluscs and worms, while copepods, cladocerans, and rotifers were important foods. This variation from the diet studies reported above may be due to the flood not allowing diatoms and algae to settle out and become available as food. Typical foods and gut contents such as organic detritus, algae, diatoms, plant tissues and sand grains were also present. Sand grains may help in trituration of food and therefore are not an accidental inclusion. Al-Shamma'a et al. (1995) examined fish from the Tigris River at Za'faraniyah and found phytoplankton ranked first in the diet followed by detritus. Debris comprised more than 37% of stomach contents on the points method. Epler et al. (1996) found detritus to be the main food in three Iraqi lakes. Epler et al. (2001) found detritus to be 83.7% of the diet in Lake Tharthar, mineral parts

(presumably sand) 12.7% and plants 3.6%. In Lake Habbaniyah detritus was 73.0%, mineral parts 16.5% and plants 8.4%. In Lake Razzazah, detritus was 84.4%, mineral parts 14.7% and plants 0.9%. Detritus was the principal food year round with no seasonal variations. Hussain & Ali (2006) examined feeding relationships among fishes in the Hawr al Hammar and found this species to be a herbivore, 39.6% of the diet being plants and algae, with 18% detritus.

Reproduction: Marammazi (1994) considered it likely that this species spawns twice each year in the Zohreh River, Iran draining to the northern Persian Gulf. Chelemal Dezfoul Nejad (2007) detailed sexual maturation in Khuzestan fish. Spawning occurred in April. The sex ratio was 1:2.7 in favour of females. Egg diameter reached 472.19μ and absolute fecundity was 30,805-431,247, mean 111,275 eggs. Chelemal et al. (2009) studied reproduction in fish from Dasht-e Azadegan west of Ahvaz. Females predominated over males (2.7:1) and maximum gonadosomatic indices were found in March for both sexes with a minimum in August, suggesting spawning in April with a spawning season extending from February to June. Details were given on histological development of the ovaries with spawning females having eggs 470.3μ in diameter.

van den Eelaart (1954) gave the spawning season in Iraq as end of February to mid-March. In the Al-Daoodi Drain at Baghdad and the Hawr al Hammar of southern Iraq spawning starts in March and continued through May (Al-Yamour et al. 1988). Mean number of eggs reaches 59,793, increasing with size and weight. In the study by Khalaf et al. (1986), all age group 1 fish were mature and females outnumbered males in age groups 2 to 6 although this may be due to sampling bias. Ünlü et al. (2000) reported maturity at age 1 in the Turkish Tigris River based on gonad development, with no spawning in the period August to February. Mhaisen & Yousif (1988) examined a population of khishni in Mehaijeran Creek, a side branch of the Shatt al Arab south of Basrah. Fish are ripe from January to March and females partly spent in April and spent in May. The fish spawned once. All males and females were mature at 16cm in the creek while females mature at 13cm in the Hawr al Hammar. Some males matured at 10.5cm and some females at 10.6cm in the creek. Naama et al. (1986) studied reproduction in the Hawr al Hammar and found a prolonged breeding period from November to April during which two batches of eggs could be shed. Maturity is attained at the end of the first year of life for both sexes when they are about 10cm total length, with all males mature at 16cm and all females at 13cm. Egg diameter is up to 0.75mm. Epler et al. (1996) recorded a relative fecundity of 359,873 to 756,118 eggs for fish of age groups 1^+ to 3^+ from three lakes in Iraq. Mature eggs were found from January to May in one lake and from November to March in another, maturity being two months earlier in saltier water. Daoud et al. (1998) examined reproductive biology in fish from the Tigris River at Al-Khadhmia north of Baghdad. They found a sex ratio of 1:1.45 (male:female), significantly different from 1:1, a breeding season from December to March, sexual maturity in all fish longer than 10cm total length, smallest mature male 10.4cm, smallest mature female 10.6cm, absolute fecundity 12,033-63,836 eggs and relative fecundity 1,237 eggs/g. Epler et al. (2001) studied reproduction in lakes Tharthar and Habbaniyah and found both sexes to achieve maturity in the first year of life at 14.2cm. Spawning occurred in May and fecundity was 652-791,000 eggs/kg body mass. Eggs are shed on, and adhere to, vegetation. Mohamed et al. (2013) found eggs up to 19,480/10sq m in April and larvae up to 15,800/10sq m in March from conical nets and on aquatic plants in the northern part of the Shatt al Arab, Iraq, a spawning and nursery ground.

Rashid (1994) gives details of the histological changes in the ovaries for fish from the Qarmat Ali canal, along with several indices. The gonadosomatic index showed no significant change from October to December but increased from 3.03 in December to 9.43 in January and 16.4 in February, decreasing subsequently suggesting a gradual spawning took

place in March and into April. The hepatosomatic index showed a significant increase in February to 3.34 and a significant decrease in March to 1.32, suggesting the liver was involved in vitellogenin synthesis necessary to oocyte development. The somatic index increased from 0.65 in October to 1.15 in December as the fish lay down reserves, decreasing to 0.53 in February and rising throughout March and April.

Parasites and predators: Bykhovski (1949) reports a new species of monogenetic trematode, *Ancyrocephalus fluviatilis*, from this species in the Karkheh River, Iran. Mokhayer (1981) reports a high infestation rate with larvae of the nematode *Contracaecum* in Karun River fish. This has health consequences for humans if fish are eaten raw, or are inadequately salted, smoked or cooked. There has been no report yet of this parasite from humans in Iran.

Moghainemi & Abbasi (1992) recorded a wide range of parasites from this species in the Hawr al-Azim in Khuzestan. Mortezaei et al. (2000) reported the worm *Neoechinorhynchus tylosuri* in 54.8% of fish examined from Khuzestan marshes. Farahnak (2000) and Farahnak et al. (2002) recorded Anisakidae from this species in Khuzestan. Barzegar et al. (2008) recorded the digenean eye parasites *Diplostomum spathaceum* and *Tylodelphys clavata* from this fish. Barzegar & Jalali (2009) reviewed crustacean parasites in Iran and found *Caligus lacustris*, *Lamproglena* sp. and *Ergasilus* sp. on this species. Golchin Manshadi et al. (2012) reported the protozoan *Trichodina puytoraci* from the skin and gills of this fish in Parishan Lake.

Economic importance: It appears in stores as a regular food fish in Ahvaz, Khuzestan, and is an important food fish in southern Iraq (Al-Nasiri & Islam 1978) with 212,850kg marketed at Basrah from October 1975 to June 1977 (Sharma 1980). It forms about 29% of the total annual catches of freshwater fishes in southern Iraq and about 7.4% of the total annual catch for the whole country despite its small individual size (Mhaisen & Yousif 1989; Mhaisen & Al-Jaffery 1989). Its caloric value is 162.42Kcal/ 100g (Mahdi et al. 2005). Salim (1962) recorded this species jumping into boats in Iraq when attracted by lights. It is important on fish farms in Iraq where it competes for food with cultured carp (Al-Shamma'a & Jasim 1993) and Mhaisen & Al-Jaffery (1989) believed it could be farmed successfully because of its high growth rate. It is taken also in the subsistence fisheries of the Indus River in Pakistan. van den Eelaart (1954) gave the fishing season for this species as December-January (peaking in January) in rivers, and December-March (January) for lakes and marshes in Iraq.

Balasem et al. (2002) showed this species to be more sensitive to pollution than other Iraqi species tested, namely *Barbus* (= *Carasobarbus*) *luteus*, *Cyprinus carpio*, *Carassius carassius* (sic, probably *C. auratus*) and *Gambusia affinis* (sic, probably *G. holbrooki*). The LC_{50} of *P. abu* to copper after 72 hours exposure was 0.4ppm, while the other species showed no mortality at this level. *P. abu* was also more sensitive to arsenic than these species and also *Barbus* (= *Mesopotamichthys*) *sharpeyi*, *Barbus* (= *Luciobarbus*) *xanthopterus*, *Barbus* (= *Arabibarbus*) *grypus* and *Ctenopharyngodon idella* (Ali et al. 1999). Wahab (1999) also tested the toxicity of four organophosphate insecticides to young fish, namely Dursban, Superacid, Malathion and Nogos with LC_{50} at 0.102, 0.125, 0.875 and 1.2 5mg/L respectively. Salinity has a significant effect on the toxicity. This mullet has also been used to assess the impact of gas oil from oil spills in the Shatt al Arab on ionic regulation, on the chloride cells and on the gills (Faddagh et al. 2004). It was found to be sensitive to this form of pollution and suitable as an indicator species.

Velayatzadeh et al. (2010) found the heavy metals copper and zinc in muscle tissues of fish from the Karun, Bahmanshir and Dez rivers. Beheshti et al. (2011) examined fish from the Dez River for copper, iron, zinc and manganese and found iron and manganese to be present at contaminating levels according to international standards. Maghtouie et al.

(2011) examined fish for mercury levels from the Arvand River and found no health threat for consumption by humans. Askary Sary et al. (2012) investigated levels of cadmium, copper, iron, mercury, lead, manganese and zinc in fish from the Bahmanshir and Karkheh rivers and found the former had higher levels than the latter except for iron and only lead had levels higher than international standards. Askary Sary & Beheshti (2012) showed that fish from the Karun and Karkheh rivers had levels of cadmium, iron, lead and mercury higher than international standards, iron concentration was highest, and levels were higher in Karun River fish for cadmium, iron and mercury. Ghorbani Ranjbary et al. (2013) found Karun River fish had higher lead than mercury and cadmium concentration, concentrations were higher in gills, and lower than in *Barbus* (= *Arabibarbus*) *grypus*. Koshafar & Velayatzadeh (2015) examined the concentration of the heavy metals arsenic, cadmium, cobalt, copper, iron, lead, nickel, vanadium and zinc in muscle tissue of fish from the Bahmanshir River. The highest concentration was zinc at 12.985mg/kg and the lowest nickel at 0.011mg/kg.

Conservation: Mhaisen & Yousif (1988) recommend banning fishing from mid-January to mid-May during the spawning season and instituting an increase in fishing net mesh size to 23.2mm. The IUCN Redlist (IUCN 2015) lists this species as of Least Concern.

Sources: Type material: *Liza abu zarudnyi (*ZISP 24336).

Iranian material: CMNFI 1979-0240, 3, 57.1-70.7mm standard length, Fars, Lake Famur (ca. 29º31'N, ca. 51º50'E); CMNFI 1979-0304, 12, 21.5-50.0mm standard length, Fars, Lake Famur (ca. 29º31'N, ca. 51º50'E); CMNFI 1979-0352, 5, 11.4-22.6mm standard length, Khuzestan, marsh 57km east of Abadan (30º33'30"N, 48º48'E); CMNFI 1979-0353, 3, 15.7-18.3mm standard length, Khuzestan, Karun River (30º22'30"N, 48º17'E); CMNFI 1979-0354, 6, 18.4-25.2mm standard length, Khuzestan, Karun River tributary (30º31'N, 48º19'E); CMNFI 1979-0355, 3, 16.7-29.4mm standard length, Khuzestan, Karun River tributary (30º35'N, 48º22'E); CMNFI 1979-0360, 12, 17.7-35.8mm standard length, Khuzestan, canal branch of Karkheh River (31º40'N, 48º35'E); CMNFI 1982-0369, 11, 39.3-57.9mm standard length, Khuzestan, Karkheh River (no other locality data); CMNFI 1993-0149, 2, 106.0-142.2mm standard length, Khuzestan, Karun River (no other locality data); CMNFI 2008-0166, 1, not kept, Khuzestan, Shadegan Wetland at Rogbeh (30º42'N, 48º34'E); CMNFI 2008-0253, 4, 110.8-153.3mm standard length, Fars, Barm-e Shur stream (29º27'31"N, 52º41'21"E); ZSM 25387, 4, 56.6-90.9mm standard length, Khuzestan, Karun River at Ahvaz (31º19'N, 48º42'E); ZSM 25700, 6, 41.0-57.4mm standard length, Khuzestan, fish pond near Ahvaz (no other locality data); uncatalogued 1, 169.8mm standard length, Khuzestan (no other locality data).

Comparative material: BM(NH) 1971.4.2:1, 1, 130.2mm standard length, Iraq, pond 25km from Mosul (no other locality data); BM(NH) 1973.5.21:179-184, 6, 41.4-51.4mm standard length, Iraq, Tigris River at Jadriyah, Baghdad (no other locality data); BM(NH) 1974.2.22:10-13, 4, 107.3-119.5mm standard length, Iraq, Najab Bazar (no other locality data).

Planiliza subviridis (Valenciennes, 1836)
(Figs. 17-18)

Common names: Biah or biah arabi at Bushehr, garriz at Bandar Abbas; meid or maid (for small specimens); kefal posht sabz. [Biag, meid or maid, biah akhtar, beyah akhtar in Arabic; greenback mullet, greenback grey mullet, silver mullet].

Systematics: Originally described from Malabar, India. Synonyms are *Mugil dussumieri* Valenciennes in Cuvier & Valenciennes, 1836 and *Mugil jerdoni* Day, 1876 (not of *E. vaigiensis* as in Jouladeh-Roudbar et al. (2015)). Placed in the genus *Chelon* in Randall (1995) and in the genus *Planiliza* in Jouladeh-Roudbar et al. (2015), Durand & Borsa (2015), Crosetti & Blaber (2016) and Xia et al.

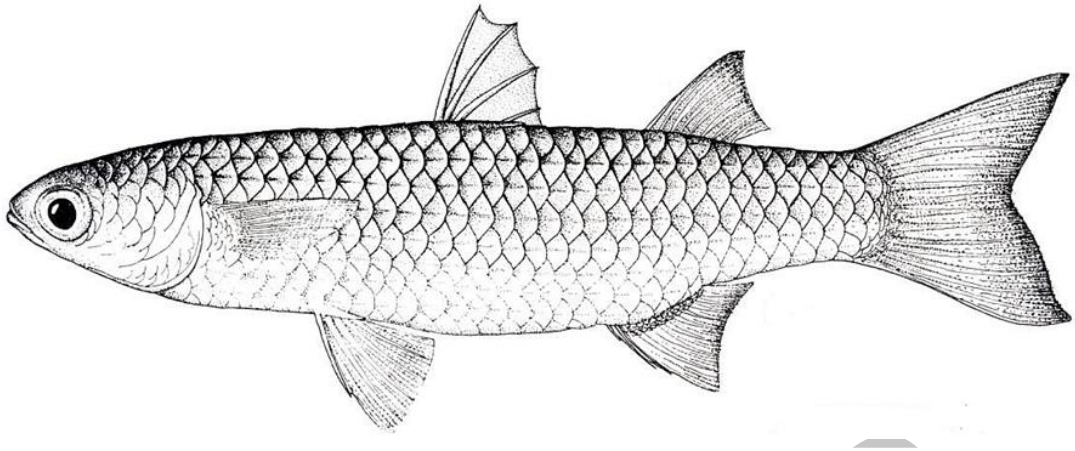

Fig.17. Line drawing of *Planiliza subviridis* after Coad (2010).

Fig.18. *Planiliza subviridis*, courtesy of J. E. Randall.

(2016).

Al-Hassan & Madhi (1989) studied enzyme polymorphisms in populations from the Shatt al Arab, Khawr az Zubayr and Kuwait but found no evidence of sub-population differentiation. A single stock is found in the northern Persian Gulf.

Key characters: The preorbital bone does not occupy the whole space between the eye and upper lip as in all other mullets.

Morphology: The head is wide and flattened with head length 23-27% of standard length. There is a well-developed adipose eyelid, covering about half of the iris, but this is absent in young fish. The lower lip has a weak to marked symphysial knob (authors differ) and both lips are thin. The upper jaw extends back on a level with the anterior nostril to the anterior eye rim. Upper jaw teeth are in several rows and ciliiform lower jaw teeth in one row. The preorbital bone is strongly notched anteriorly and only occupies three-quarters of the space between the eye and upper lip. Scales are regularly arranged and are dense on the second dorsal and anal fins. The second dorsal fin origin lies over the anterior half of the anal fin base. The pectoral axillary scale is rudimentary or absent. The pectoral fin does not reach back on a level with the first dorsal fin origin and is 74-76% of head length. The first dorsal fin has 4 spines, the second dorsal fin has 1 spine and 8-9, usually 8, soft rays and the anal fin has 3 spines and 8-9, usually 9, soft rays. Scales in lateral series 27-32. Transverse scales 10-11, usually 11. Pyloric caeca 4-5.

Ahmed & Hussain (2003) described the larvae of this species from Khawr az Zubayr and the Shatt al Arab estuary. Salehi et al. (2016) described the

sagittal otolith morphology and its use in distinguishing this species from *Ellochelon vaigiensis*, *Mugil cephalus* and *Planiliza klunzingeri*.

Sexual dimorphism: Sayari & Rahmani (2014) examined fish from the coastal area of Bandar Abbas and found morphometric and meristic characters overlapped in the two sexes.

Colour: The back is dark to light green or greyish-green, the flanks silvery to white and the belly white. There may be 3-7 blackish stripes along the flank but these may not always be obvious. Pectoral fin yellowish, sometimes with a blue spot at fin origin. The caudal fin is bluish and has a black margin, other fins are hyaline.

Size: Attains 39.5cm total length and 270g (Al-Hassan & Al-Seyab 1992).

Distribution: Found in the Persian Gulf and eastwards to India, China, Japan, northern Australia and Polynesia. Reported from the Shatt al Arab and Hawr al Hammar, Iraq near Iranian Khuzestan by Al-Hassan et al. (1989), Al-Hassan & Al-Seyab (1992) and Hussain et al. (1997, 2001). Records of *Liza dussumieri* from the Tigris River at Amara and Baghdad, the Euphrates River and the Shatt al Arab by Kennedy (1937), Khalaf (1961), Mahdi (1962), Al-Nasiri & Hoda (1976) and Hussain et al. (1989), if correctly identified, are referred to this species (Thomson & Luther in Fischer & Bianchi 1984).

Recorded from the lower Mand River in Bushehr Province at 28°14'N, 51°51'E, 28°11'N, 51°32'E and 28°07'N, 51°24'E by M. Rabbaniha (pers. comm. 1995) and from Khuzestan in the Zohreh and Bahmanshir rivers and the Shadegan Wetland by Najafpour (1997). Hashemi et al. (2015) reported it as an exotic in the Shadegan Wetland, but the meaning here is migrant from the sea. Records from Iran could be *E. vaigiensis* (*q.v.*). No specimens have been examined by me to confirm these anecdotal and literature records.

Zoogeography: A widely distributed marine species, this mullet also enters and is resident in fresh waters but is dependent on reproduction of marine populations to maintain the freshwater ones.

Habitat: This species lives in the sea, particularly in coastal waters, lagoons and estuaries, but regularly enters fresh water. Its biology in Iranian fresh waters is unknown. At a freshwater station on the Shatt al Basrah Canal, Iraq with salinities up to 3.5‰, Al-Daham & Yousif (1990) found this species to be dominant, comprising 59.6% by number and 40.0% by weight. Eggs of this species and *P. klunzingeri* were most abundant in the inner part of the Shatt al Arab estuary in February with larvae most abundant in February and April. The temperature range for several sites was 12.5-22ºC and salinity 32-38‰. Temperature is the most important factor influencing spawning (Ahmed & Hussain 2000). This was one of the more abundant species in the recovering Hawr al Hammar of southern Iraq in 2005-2006 and in the marshes in the 1980's (Hussain & Ali 2006).

Age and growth: Shadi et al. (2011) gave a length-weight relationship for fish from the northern Persian Gulf off Khuzestan with *a* (intercept)=0.017 and *b* (slope)=2.819 for fish 7.2-16.5cm total length, mean 11.5cm. In the Shatt al Basrah Canal of southern Iraq, populations of this species are comprised of age groups 1 to 6 but most fish are in age groups 1 and 2 (Al-Daham & Wahab 1991). Age 2 dominated from February to April and age 1 from June to January. Females are slightly longer in each age group and have a longer life span than males. The oldest females are age 6 and 303mm and the oldest males age 4 and 251mm. Males are less numerous than females with a sex ratio 1.0:1.4. Maturity is attained at age 1 and the smallest mature male is 137mm and the smallest mature female is 142mm. Ali et al. (1999) examined the stock of this species in Khawr Abdullah and found the infinity length (L_∞) to be 34.3cm total length (TL), the growth coefficient (K) 0.31, annual total mortality (Z) 1.06, natural mortality (M) 0.70 and fishing mortality (F) 0.366. The exploitation rate (E) was 0.34 indicating that the stock was slightly exploited during September 1989-August 1990. The length-weight relationship was $W=0.0000208\ L^{2.985}$. Mohamed et al. (1998) found, for fish from the northwest Persian Gulf, a length-weight relationship

Table 3. The growth parmeters of *Planiliza subviridis* in various studies (After Ali et al. (1999)).

Author	sex	L_∞	K	1	2	3	4	5	6
Wahab (1986)	♂	29.4	0.39	14.6	19.3	22.1	24.0	-	-
(Shatt al Basrah)	♀	40.2	0.151	15.5	20.5	23.0	25.2	27.3	29.0
Al-Hisnawi (1990)	♂	25.2	0.474	11.4	16.55	19.84	21.85	-	-
(Khawr az Zubayr)	♀	48.9	0.141	11.35	16.78	20.92	24.31	27.82	30.5
Mohamed et al. (1998) (Northwest Arabian Gulf)	♂ + ♀	30.8	0.225	9.4	13.6	17.0	19.7	21.9	23.7
Ali et al. (1999) (Khawr Abdullah)	♂ + ♀	34.3	0.31	8.9	15.5	20.37	23.97	26.65	28.64

of $W=1.34x10^{-5}\ L^{2.961}$, condition factor ranged from 0.98 to 1.21 and the growth model was $L_t=308\ (1-e^{-0.225\ (t\ +\ 0.618)})$.

Ali et al. (1999) summarise annual growth of this species from their own and other studies, attributing differences to differing methodologies (Table 3). Mohamed et al. (2013) carried out a stock assessment of this species in the East Hammar Marsh in Iraq from January 2009 to May 2010 based on 4,470 specimens. Total lengths ranged from 8.7 to 29.2cm, the length-weight relationship was $W=0.0145L^{2.9337}$, growth and mortality parameters were L_∞=33.66cm, K=0.27, Z=1.2, M=0.69 and F=0.51. The exploitation rate at 0.43 was below the optimum level. Two recruitment peaks were recorded, in April (28.63%) and in June (71.37%). The maximum yield per recruitment was achieved at E_{max}=0.59.

Muhsin (1988) determined protein, lipid and ash content of fish taken monthly from the marine Khawr az Zubayr and found fluctuations to follow the reproductive cycle. Lipid content of the liver increased in winter and of the carcass in winter and spring, the pre-spawning period, along with increases in the gonadosomatic and hepatosomatic indices. The latter indices peaked in March and decreased sharply until June. Total protein decreased during winter and spring from the carcass and in spring from liver and ovaries as they were used for energy and to support maturation of the ovaries. In Malaysia, maturity is attained at 95-115mm for males and 105-115mm for females (Chan & Chua 1980).

Food: Food items are algae, diatoms and detritus extracted from ingested mud and sand. Al-Hassan & Madhi (1987) include higher plants as part of the diet and Al-Hassan & Al-Seyab (1992) copepods for Iraqi waters. Mohamed et al. (1998) found this species to be a detritivore in the northwest Persian Gulf. Hussain & Ali (2006) examined feeding relationships among fishes in the Hawr al Hammar, Iraq and found this species to be a herbivore, 75.2% of the diet being plants and algae. In another study of the recovering Hawr al Hammar, diet was 80.84% algae and 15.66% diatoms with amounts of crustaceans and plants being less than 10% each (Hussain et al. 2006).

In Malaysian estuaries and coastal areas, Chan & Chua (1979) found this species to feed only on zooplankton when less than 12mm standard length, becoming bottom feeding at 16-20mm on zooplankton, diatoms and detritus and by 24mm zooplankton was absent but filamentous algae was added where available. The proportion of the various food items varied with the locality.

Reproduction: Spawning occurs in the sea, with all eggs released at once in a Malaysian population (Chan & Chua 1980). Al-Daham & Wahab (1991) were unable to locate eggs and larvae in fresh waters of Iraq. They believe that adults leave the Shatt al Basrah Canal to spawn in the sea. However, Al-Hassan & Madhi (1987) give a reproductive season of February through April in the Shatt al Arab, Iraq and Ahmed & Hussain (2003) give March to June in the offshore area near the mouth of the Khawr az Zubayr and Shatt al Arab. Muhsin (1988) determined April-June to be the spawning season, with mature ova released in May, in the Khawr az Zubayr (see above). Male and female gonads are best developed in February to March and spawning is deduced to have occurred from March to May, possibly offshore

in the Persian Gulf. In Malaysia, spawning can occur from June to November and in the off-season (Chan & Chua 1980). In Iraq, fry 27-40mm in length are captured from April to June in fresh water. The adult mullet return to fresh water after spawning. Fecundity was 133,224-295,065 eggs for fish 182-243mm total length, this being higher than in Malaysia at 40,000-145,000. Fecundity is somewhat lower than in other mullets but may be attributed to year round spawning at some localities (Chan & Chua 1980). Al-Hassan & Madhi (1987) give a fecundity of 549,278 eggs with egg diameter up to 0.65mm and Al-Hassan & Al-Seyab (1992) give 580-590,000 eggs for their large specimen from Hawr al Hammar.

Rasta et al. (2015) examined fish from Bushehr and found a female:male sex ratio of 1.6:1, spawning occurred from February to late April with a mean total fecundity of 80,000 eggs, a mean gonadosomatic index of 2.44, and maximum gonadosomatic indices from January to April.

Parasites and predators: Behrouzirad et al. (2013) found great cormorants at culture ponds in Shushtar, Khuzestan ate this fish at 4.41% compared to 70.78% for common carp for example.

Economic importance: This species forms part of coastal fisheries in shallow waters and is caught with a variety of nets, particularly seines, stationary traps, gill nets and cast nets. It forms a substantial part of brackish water fisheries in southern Iraq, being the most abundant species in estuaries, and economically the most important mullet (Al-Daham & Wahab 1991). Ali et al. (1999) gave a catch of 35t in Khawr Abdullah, Iraq, almost 6% of the marine catch. Mohamed et al. (1998) gave a value of 3.4% of the commercial catch for this species with catch rates in the northwest Persian Gulf of 0.15kg/h in June to 0.75kg/h in October. This species is potentially important in fish culture as it is herbivorous. Consequently ponds can be fertilised inexpensively and plant food supplements such as rice bran and peanut meal can be given. Chan & Chua (1979) recommend that fish for stocking should be at least 30mm standard length as their bottom feeding habit is then most suitable for pond culture.

The proximate chemical composition measured in fish from the Basrah fish market was moisture 76.16%, protein 16.82%, fat 5.1% and ash 1.82% and the general condition was a maximum of 1.78 (Ali et al. 2004). It is characterised as a fatty fish according to a lipid content 9-14% by wet weight of muscle in autumn (Hantoush et al. 1999).

Conservation: Population numbers and trends are unknown so conservation requirements cannot be ascertained.

Sources: Description based on literature sources, particularly Blegvad & Løppenthin (1944), Fischer & Bianchi (1984), Talwar & Kacker (1984) and Thomson (1997).

Acknowledgments

I am indebted to the Department of Biology, Shiraz University and the Canadian Museum of Nature, Ottawa for funding of research. Numerous colleagues and co-authors assisted in developing the website on Iranian fishes, providing specimens, data and photographs and are listed at www.briancoad.com.

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Iran. J. Ichthyol. (June 2017), 4(1): 75–130

P-ISSN: 2383-1561; E-ISSN: 2383-0964
http://www.ijichthyol.org

مروری بر کفال ماهی های ایران (خانواده کفال ماهیان)

برایان کد

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

چکیده: در این مقاله مروری، سیستماتیک، ریخت‌شناسی، پراکنش، زیست‌شناسی، اهمیت اقتصادی و حفاظت کفال ماهیان ایران شرح داده شده، تصاویری از آن ارائه گردیده و فهرستی از منابع موجود درباره این گونه‌ها لیست شده است. دو گونه ی بیگانه (*Chelon auratus*, *C. saliens*) در حوضه ی دریای خزر ، دو گونه بومی(*Mugil cephalus*, *Planiliza abu*) در آب‌های شیرین جنوب ایران و دو گونه (*Ellochelon vaigiensis*, *C. subviridis*) در آب‌های لب شور رودخانه‌های جنوب ایران یافت می‌شوند.

کلمات‌کلیدی: زیست‌شناسی، ریخت‌شناسی، پراکنش، کفال ماهیان، *Chelon, Ellochelon, Liza, Mugil, Planiliza*.