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Review of the pikes of Iran (Family Esocidae)

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Abstract: The systematics, morphology, distribution, biology, economic importance and conservation of the pike (*Esox lucius*) of Iran are described, the species is illustrated, and a bibliography on this fish in Iran is provided. There is one native species in the Caspian Sea basin, introduced elsewhere in Iran. The family is characterized by a flattened, elongate, duck-billed snout, dorsal and anal fins far back on the body near the tail, no adipose fin, teeth on the tongue and on the basibranchial bones behind the tongue are small, jaws have large teeth, branchiostegal rays 10-20, nasal bones are present, the swim bladder is connected to the gut by a duct, intermuscular bones are forked or Y-shaped, no fin spines, pelvic fins are abdominal, cycloid scales, the infraorbital sensory canal on the head has 8 or more pores, gill rakers are present as sharp denticles in patches, no pyloric caeca, the lateral line is complete, and the forked caudal fin has mostly 17 branched rays. *Esox lucius* is distinguished from other Iranian freshwater fish species by the broad and flat snout and position of the dorsal and anal fins being far back on the body. *Esox lucius* is distributed across northern Eurasia and northern North America. Iranian populations are at the southern edge of the range for this species.

Keywords: *Esox*, Biology, Morphology, Distribution.

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Introduction

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

Family Esocidae

The pikes, pickerels and muskellunge are found in fresh waters of the Northern Hemisphere. They are moderate to large-sized fishes, up to 1.4m. There are only 7 species in a single genus *Esox* (Eschmeyer & Fong 2016) with one species reported in Iran. Coad (1987, 1998) and Coad & Abdoli (1996) place the species in context with the Iranian ichthyofauna.

The family is characterized by a flattened, elongate, duck-billed snout, dorsal and anal fins far back on the body near the tail, no adipose fin, teeth on the tongue and on the basibranchial bones behind the tongue are small, jaws have large teeth, branchiostegal rays 10-20, nasal bones are present, the swim bladder is connected to the gut by a duct, intermuscular bones are forked or Y-shaped, no fin spines, pelvic fins are abdominal, cycloid scales, the infraorbital sensory canal on the head has 8 or more pores, gill rakers are present as sharp denticles in patches, no pyloric caeca, the lateral line is complete, and the forked caudal fin has mostly 17 branched

Fig.1. *Esox lucius*, female, 64cm and 3.5kg, from drainage canal near Abkenar, Anzali Wetland, courtesy of S. Nouripanah.

rays.

Pikes are predators on other fishes aided by the posterior dorsal and anal fins which facilitate rapid darts forward. They are important sport fishes, much sought after by anglers for their fighting ability, but are not very good eating because of the intermuscular bones.

Genus *Esox* Linnaeus, 1758

The characters of this genus have been outlined above under the family.

Esox lucius Linnaeus, 1758

(Figs. 1-4)

Common names: Ordak mahi (= duck fish from the snout shape), shok, shuk or shook (in Gilaki), shook chehkhab, chekab. [durnabaligi in Azerbaijan; shchuka in Russian; pike; northern pike].

Systematics: *Esox Lucius* was originally described from Europe. Nezami et al. (2007) compared fish from the Anzali and Amirkelayeh wetlands using meristic and morphometric characters and found significant differences, attributing these to environmental conditions. Tabarrok et al. (2015) also examined fish from these wetlands using microsatellite markers, finding two distinct populations and evidence of genetic bottlenecks. Javadian et al. (2013) found genetic differences between Mazandaran and Gilan samples but none of significance.

Key characters: The broad and flat snout and the dorsal and anal fins set far back on the body are distinctive.

Morphology: Coad et al. (1995) summarize morphology. Dorsal fin principal rays 15-19, about 6-10 unbranched and 13-18 branched, principal anal rays 12-16, about 4-8 unbranched and 10-15 branched, pectoral rays 11-17 and pelvic rays 7-13. The number of branched rays may be size-related as in smaller fish more anterior rays in the dorsal and anal fins are not branched. Lateral line scales 105-148, pored scales 42-56, but difficult to count accurately. Each scale on mid-flank is a rounded rectangle. The anterior margin is indented where 1-2 radii terminate. The radii split the scale so that the segments overlap. Circuli are very fine and the focus is posterior. Gill rakers are broad and spinulose, embedded in the arch skin with the tips of the spinules protruding. There are 9-11 pores on the lower jaws (usually 5 on each jaw). Vertebrae 56-65. The chromosome number is 2n=50 (Klinkhardt et al. 1995; Khoshkholgh et al. 2015). The gut is an elongate S-shape.

Boluki et al. (2015) examined anatomically and histologically the intestine and Sadeghinezhad et al. (2015) similarly the tongue, in relation to feeding habits.

Meristic values for Iranian specimens are:- dorsal fin branched rays 14(in 7 fish) or 15(9); anal fin branched rays 11(1), 12(8) or 13(7); pectoral fin branched rays 14(9), 15(5) or 16(1); pelvic fin branched rays 8(1), 9(7), 10(6), 12(1) or 13(1); pores on each lower jaw 5(22).

Sexual dimorphism: There is no obvious sexual dimorphism. Attempts have been made to sex pike by

Fig.2. *Esox lucius,* Anzali Wetland, June 2012, courtesy of K. Abbasi.

Fig.3. *Esox lucius,* Anzali Wetland, June 2012, courtesy of K. Abbasi.

characters of the urogenital region, but these are hampered by seasonal variations. Abdurakhmanov (1962) reports on fish from Azerbaijan where head length is greater in males while predorsal distance and interorbital width are greater in females.

Colour: The overall colour is dark with light spots, although there is variation over the vast range of this species in the details. The back and upper flank are dark green, olive-green or brownish, fading to a whitish belly. The flank has 7-9 rows of greenish, yellow to whitish blotches along it. Scales have a golden tip. The head sides have wavy, golden or yellow blotches and lines and the eyes are bright yellow to golden. The dorsal, anal and caudal fins are green, yellow, orange or pale red, blotched and barred irregularly with black. The pectoral and pelvic fins are dusky to orange. Young have 8-12, wavy, white or yellow bars which become the bean-shaped blotches in adults as they gradually break up. There is a gold to green stripe along the middle of the back in some fish but others are completely dark green. There is a stripe below the eye. The peritoneum is silvery.

Size: Attains 1.75m and about 48.0kg, possibly to 2.13m and 65.78kg, despite legends of pike up to 5.0m (Tsepkin 1986; Machacek (1983-2012), accessed 27 July 2012).

Distribution: Across northern Eurasia and northern North America. Iranian populations are at the southern edge of the range for this species. Found in the Caspian Sea basin, from the Anzali Mordab (=Wetland) and its drainage canals, tributaries and

Fig.4. *Esox lucius* catch, Anzali Wetland, June 2012, courtesy of K. Abbasi.

the Sia Keshim Protected Region to Gorgan Bay and its tributaries such as the Karasu, with other rivers including the Atrak, Babolrud, Chalus, Chamkhaleh, Golshan, Haraz, Harisak, Langarud, Safid, Shahrud, Shazdeh, Sheikan, Siahdarvishan, Siahrud, Tajan, Talar, Tonekabon, Lake Sama in the Alborz Mountains, the Lapu Lake, Boojagh Wetland and the Amirkelayeh Lagoon near Lahijan, and in Caspian Sea coastal waters (Derzhavin 1934; Berg 1936; Armantrout 1980; Petr 1987; Wossughi et al. 1991; Holčík & Oláh 1992; Molnár & Jalali 1992; Nejatsanatee 1994; Riazi 1996; Ramin1997; Karimpour 1998; Abbasi et al. 1999, 2007; Kiabi et al. 1999; Abdoli 2000; Jolodar & Abdoli 2004; Khara et al. 2004, 2011; Nezami & Khara 2004; Abdoli & Naderi 2009; Piri et al. 2009; Jamalzadfalah et al. 2011; Esmaeili et al. 2014; Fazli et al. 2014). However, Abdoli & Naderi (2009) do not report it from the Atrak River.

This species has been introduced to the Avan River, 7km from Alamut as early as 1956 (Niamir 2001), and to Valasht Lake near Marzanabad, Evan Lake northeast of Qazvin, the upper Karaj and middle Shur (Abhar stretch) rivers of the Namak Lake basin, Ghorigol Lake near Tabriz, the Talkheh River in the Lake Orumiyeh basin, Marivan Lake in Kordestan, and the Haft Barm Lakes west of Shiraz (Anonymous 1977; Petr 1987; Niamir 2001).

Zoogeography: This widely-distributed species reaches its southern range limit in Iran.

Habitat: Pike are solitary and are found in lakes and rivers where the water is still or flowing slowly as well as marshes and ponds. They are found only in the lower reaches of rivers along the Iranian shore

Fig.5. Habitat of *Esox lucius*, drainage canal near Abkenar, Anzali Wetland, courtesy of S. Nouripanah.

and do not penetrate upstream (Berg 1948-1949). Riazi (1996), for example, reports that this species is native (resident) to the Siah-Keshim Protected Region of the Anzali Mordab (=Wetland). O'Donovan (1882) reported that a small stream in the Atrak River drainage had many large pike lurking under bushes, stupefied by foul water, and that the Cossacks in his escort caught many of them by striking with the point of their sabres or simply whisked them out of the water by the tail. Large numbers of *Rutilus frisii* were seen here too and presumably the pike thrived on this food source. They are found in the more brackish areas of the Caspian Sea, at least in Kizlyar Bay of the north Caspian, at salinities up to 4‰ under the influence of fresh water from the Volga River. Here they are found in thickets of soft and rigid vegetation, as solitary predators but also feeding beyond the vegetation limit in the sea. They aggregate only in spring for spawning and in autumn prior to wintering on the bottom (Stolyarov & Abusheva 1997) (Fig. 5).

In fresh water, vegetation is heavy and the water warm but they usually retire to deeper, cooler water at the height of summer. Temperatures above about 30°C are usually fatal to pike. However pike are active in winter, as anglers can testify, and at this time can tolerate dissolved oxygen concentrations lower than 0.1mg/l. pH range is 5.0-9.5 although they have been recorded as spawning at 4.2-4.4 but embryos are then malformed (Mann 1996). Summer distribution is usually within 300m of shore and less than 4m deep. On windy days, pike retreat offshore in surface waters. Pike tolerate brackish water, up to about 7‰ for reproduction and 10‰ for feeding and growth. Reproduction requires living or dead vegetation (either aquatic or flooded terrestrial vegetation) in shallow, still waters protected from strong winds. Vegetation is also important for recruitment of young

pike. Pike deposit their faeces at specific locations far from their usual feeding area as the faeces contain alarm pheromones recognized, and avoided by, prey species.

Age and growth: Life span is up to about 26 years but is less than half this in fast-growing southern populations. Some aquarium fish have lived 75 years. Maturity, like growth, varies with latitude and habitat, and also with quality of food. Higher temperatures may inhibit growth. Males mature at 1-6 years (30-46cm) and females usually at 2-6 years, rarely at 1 year (31-63cm). Females grow larger, faster and live longer than males. Growth is best at 19-21°C and is very efficient.

Nezami Balouchi et al. (2005) examined this species in the Zibakenar-Kiashar Bojagh Lagoon on the Caspian coast of Iran. The 122 fish were 17.7-74.0cm long, average total length being 33.0cm, and weight was 38-1100g (average 307.3g). The age groups were 0-9 years. Nezami et al. (2004) examined this species in the Amirkelayeh Lagoon and found ages 1^+ to 6^+ years, average total length 44.8cm (range 15.6-63.0cm) and average weight 717.9g (24-1700g). Valipour (1998) investigated the pike in four areas of the Anzali Lagoon or Wetland and found relatively fast growth with fish above 2 years of age mature with an average length of 32.0cm. Abbasi et al. (2013) compared fish from the Anzali and Amirkelayeh wetlands and found age ranges to be the same (1^+ to 7^+ years), about 75% of fish were 3^+ to 4^+ years old, T_{max} was 23.08 and 21.43, respectively, total lengths and weights were 20.4-71.3cm and 100-2,635g and 19.2-73.6cm and 90-3,140g, *b* values were 2.782 and 2.856 (negative allometric growth), relative weight was 0.959 and 1.03 and differed significantly, the instantaneous growth coefficient was 0.51 and 0.54, von Bertalanffy growth parameters were L_∞=99.48, K=0.13yr- and t_0=-0.96yr and L_∞=101.12, K=0.14yr- and t_0=-1.0yr, growth performance index was 3.11 and 3.16 and weight at infinity was 8,343.87g and 9,177.79g. The results showed environmental conditions were more favourable in the Amirkelayeh Wetland. Moslemi-Aqdam et al. (2014d) studied 505 pike from the Anzali Wetland finding a b value in males of 3.1495, in females 3.1843 and for all fish 3.2137 indicating isometric growth. Mean relative condition factors were 1.003, 1.004 and 1.008 for males, females and all fish, respectively.

In the Kizlyar Bay of the north Caspian Sea, males mostly mature at age 2^+ with a body length of 36-40cm while females are 3^+ and 45-50cm. Some males are mature in the first year of life at 26-30cm and some females in the second year of life at 33-36cm. Maximum age is 11 years in this population (Stolyarov & Abusheva 1997). In Lake Aksehir, Turkey most males and females are mature at 2 years of age (Karabatak 1988). Altindağ et al. (1999) give growth features for a population in a Kesikköprü Dam lake, Turkey where females reached age 5 and males age 4 years.

Food: Food is initially zooplankton and aquatic insects but fish begin to predominate at 5.0cm after about 1 month's growth. Over 90% of the diet of adults is fish, but frogs, crayfish, mice, muskrats and ducklings are taken. Both sexes fast during spawning but females have rations 1.5-2.3 times as much as males in summer and winter. The daily ration was high from May to August with a June peak and very low in winter in North America, and a peak in mid-April to June in the northern Caspian Sea (Orlova & Popova 1976).

Pike have a highly mobile eye which enables them to spot prey in almost any direction and have sighting grooves along the snout to facilitate their judgment of depth and distance. Food is seized after a rapid dart from concealment. Cylindrical fish like perch are preferred over more deep-bodied species as being easier to swallow. The prey capture process can be summarized as follows: eye movements towards prey, turning of body towards prey, stalking, darting, capture, rotating prey head first in mouth, and swallowing. Prey is sucked into the mouth which is opened just as the pike reaches its prey. Prey size is usually about one-third to one-half the length of the

pike. Other fishes avoid the faeces of pike because they contain alarm pheromones but pike deposit faeces remote from their feeding areas.

Valipour (1998) found feeding intensity and growth coefficient of this species in the Anzali Wetland decreased with age. Fish in the 0^+ age group fed mainly on zooplanktonic mysids while older fish took *Carassius auratus*, *Hemiculter leucisculus*, *Rhodeus amarus* and larvae of *Alburnus chalcoides*. Apparently, the pike is not restricting populations of commercial species in the lagoon but has an important role in controlling non-commercial exotics such as *Carassius auratus* and *Hemiculter leucisculus*. Abdoli (2000) lists *Gambusia holbrooki*, *Carassius auratus*, *Hemiculter leucisculus*, *Liza saliens*, *Atherina boyeri* (= *caspia*) and *Alburnus charusini* (= *Alburnus hohenackeri*) as food items for Iranian pike. Nezami et al. (2004) and Nezami Balouchi et al. (2005) examined this species in the Amirkelayeh Lagoon and found the diet to be 24% *Tinca tinca*, 16% *Proterorhinus marmoratus* (=nasalis), with *Esox lucius*, plecopterans, frogs and water beetles at 8%, and *Syngnathus caspius*, *Carassius auratus* and *Gammarus* at 4%. Diet varied with season, and age and sex of the pike. Nezami Balouchi et al. (2005) found fish from the Zibakenar-Kiashar Bojagh Lagoon fed on Odonata (14%), *Syngnathus caspius* (13.8%), and *Neogobius gorlap* (13.4%) as the most frequent items and Esox lucius and *Gambusia holbrooki* (each at 4.3%) as the lowest frequency items, and diet varied with age, season and sex. Ghane (2013) found the diet of 0-6 year old pike in the Anzali Wetland was 75% fish and 25% freshwater prawn (*Macrobrachium nipponense*), an exotic.

In the Kyzylagach or Imeni Kirova Bay of Azerbaijan, *Abramis brama*, *Cyprinus carpio*, *Rutilus rutilus* (presumably *R. caspicus*), *Rutilus frisii*, *Vimba vimba* (= *V. persa*), Mugilidae, and *Atherina boyeri* (=*caspia*) are taken (Kuliev 1989). Pike are cannibals when food is short. They compete with other piscivorous fishes, such as *Sander lucioperca* and *Perca fluviatilis*, for food. In the Kizlyar Bay of the north Caspian, the food of 2-month-old pike 3-4cm long is mainly *Rutilus rutilus* (presumably *R. caspicus*) fry, of pike 9-15cm long this species plus fry of *Cyprinus carpio* and *Scardinius erythrophthalmus*, and of adults mainly *Cyprinus carpio*, *Rutilus rutilus* (presumably *R. caspicus*) and *Clupeonella cultriventris* (= *caspia*) (during its spawning migration in April and May), *Scardinius erythrophthalmus*, *Tinca tinca*, *Blicca bjoerkna*, *Alburnus alburnus* (= *hohenackeri*), *Cobitis* sp., some gobies, frogs and crayfish. Sturgeon fry were once an important diet item but this declined with the decline in sturgeon numbers (Stolyarov & Abusheva 1997).

Reproduction: Samiei et al. (2013, 2015) using microsatellite markers found different reproductive populations in the Anzali Wetland, based on winter and spring spawning samples indicative of a genetic bottleneck. Moslemi-Aqdam et al. (2014) found pike from the Anzali Wetland had an absolute fecundity of 14,592 eggs and a relative fecundity of 26.05 eggs per gram. Khodadoust et al. (2015) detailed the histology of ovarian development and found a highest absolute fecundity of 13,609.5 eggs in autumn and a highest gonadosomatic index of 4.063 in the first half of winter. Moslemi-Aqdam et al. (2014a) found differences between males and females in gonadosomatic indices but not hepatosomatic indices in Anzali fish. Moslemi-Aqdam et al. (2014b) found a sex ratio of 1.06females:1male, for the period January to March, the gonadosomatic index was 0.088-3.83 for males and 0.252-14.708 for females and the hepatosomatic index was 0.719-2.982 and 0.747-2.783. Moslemi-Aqdam et al. (2014c) showed a reduction in gonadosomatic indices when fish entered a resting stage following spawning.

The spring spawning migration in Dagestan begins at ice melt and spawning takes place from mid-March to the beginning of April when water temperatures reach 5-7°C. One batch of eggs is laid over a period of 10-15 days (Shikhshabekov 1978). Spawning runs occur in the late evening and early night, several days before spawning occurs.

Spawning takes place during the day, often in mid-afternoon, in shallow bays or flooded fields just after ice melt, generally in late March to May. Water temperatures on the spawning run are as low as 1.1°C. Spawning itself takes place at temperatures several degrees warmer than this, up to 17.2°C. Each female is accompanied by 1-2 males as she swims over vegetation in the shallow water. Both sexes roll to bring their genital regions close together, vibrate and release 5-60 eggs and the sperm. Tail sweeps scatter the eggs. This 3-10 second process is repeated many times each day. Eggs are amber, up to 3.4mm in diameter after fertilization, adhesive and each female can produce up to 595,000, although usually much less.

In the Kizlyar Bay of the north Caspian Sea, the oldest females produce 365,000 eggs (Stolyarov & Abusheva 1997). Eggs hatch 12-14 days later and the fry attach to vegetation by an adhesive head gland until the yolk sac is absorbed 6-10 days later. The Kizlyar Bay population begins to spawn in late February or early March, sometimes under ice or immediately after ice melt at 4-6°C. Eggs are laid at depths of about 0.5m and may dry out during water surges caused by northwestern winds although the increase in sea level has lessened this. Eggs adhere to vegetation but fall off after 2-3 days but do not die because of the low water temperatures and favourable oxygen conditions. Eggs hatch in 7-18 days depending on water temperature.

Parasites and predators: Eslami et al. (1972) found helminths in 78.9% of 109 pike examined from Iran, a very high rate of infestation. The species encountered were *Triaenophorus crassus*, *Raphidascaris acus* and *Contracaecum osculatum baicalensis*. This latter parasite can infest man if fish is eaten smoked, salted or fried at temperatures below 50°C. Mokhayer (1976) records the digenetic trematode *Rhipidocotyle illense*, the nematode larva *Eustrongylides excisus*, and the acanthocephalan *Acanthocephalus lucii*. Molnár & Jalali (1992) report the monogenean *Tetraonchus monenteron* from pike in Lake Sama in the Alborz Mountains. Naem et al. (2002) found the monogenean trematode *Tetraonchus monenteron* on the gills of this species from the western branch of the Safid River. Sattari et al. (2002) and Sattari (2004) records the presence of the nematode, *Eustrongylides excisus*. This parasite can damage muscles in commercial species and render them unsuitable for sale. Barzegar et al. (2008) record the digenean eye parasite *Diplostomum spathaceum* from Iranian pike. Miar et al. (2008) examined fish in Valasht Lake and the Chalus River, Mazandaran and found the metazoans Rhaphidascaris acus and *Tetraonchus monenteron*. Barzegar & Jalali (2009) reviewed crustacean parasites in Iran and found *Lernaea* sp. on this species. Jamalzad Fallah et al. (2014) examined fish from commercial sources and found the parasites *Eustrongylides excisus*, *Tetraonchus monenteron*, *Diplostomum spathaceum*, *Corynosoma strumosum* and *Rhipidocotyle illense* and noted changes in haematological parameters in the pike.

Khara et al. (2004) looked at pike from the Amirkelayeh Lagoon or Wetland in Gilan and recorded *Raphidascaris acus*, *Camallanus lacustris*, *Eustrongylides excisus*, *Triaenophorus crassus*, *Trichodina* sp., *Tetraonchus monenteron*, *Diplostomum spatheceum*, *Lernaea* sp., *Argulus* sp. and *Piscicola* sp. and attributed the diversity to its piscivorous diet. Khara et al. (2006a) also record the eye fluke *Diplostomum spathaceum* for this fish in this wetland.

Khara et al. (2007) examined fish from the Chamkhaleh River and recorded *Raphidascaris acus*, *Camallanus lacustris*, *Diplostomum spathaceum*, *Tetraonchus monenteron*, *Triaenophorus crassus*, *Corynosoma strumosum* and *Lernaea* sp.

Khara et al. (2006b) record the nematode *Raphidascaris acus* from this species in the Boojagh Wetland of the Gilan coast. Khara et al. (2008) found the eye parasite *Diplostomum spathaceum* in fish from this wetland. Tatina et al. (2009) examined 39 pike from the wetland finding *Raphidascaris acus*, *Diplostomum spathaceum* and *Tetraonchus monenteron*. Khara et al. (2011) also list the

monogenean *Tetraonchus monenteron*, the digenean *Diplostomum spathaceum* and the nematode *Raphidascaris acus* from this wetland.

Ataee & Eslami (1999, www.mondialvet 99.com, accessed 31 May 2000) report *Asymphylodora tinca* from the gastro-intestinal tract of fish from the Anzali Wetland. Sattari et al. (2004; 2007) record the nematodes *Camallanus lacustris*, *Raphidascaris acus* and *Eustrongylides excisus*, the digeneans *Rhipidocotyle illense* and *Diplostomum spathaceum* and the monogenean *Tetraonchus monenteron* in this species from the wetland. Khara et al. (2007) found *Raphidascaris acus*, *Triaenophorus crassus*, *Tetraonchus monenteron* and *Eustrongylides excisus* in fish from the wetland although the letter two species were found in only one fish each. Jamalzadfalah et al. (2011) found 10 parasite species in fish from the wetland namely *Argulus foliaceus* and *Lernaea cyprinacea* (Crustacea), *Eustrongylides excisus* and *Raphidascaris acus* (Nematoda), *Tetraonchus monenteron* and *Dactylogyrus* sp. (Monogenea), *Diplostomum spathaceum* (Digenea), *Trichodina* sp. (Ciliata), *Corynosoma strumosum* (Acanthocephala), and *Rhipidocotyle illense* (Platyhelminthes). Jamalzad Fallah et al. (2012a, 2012b, 2014, 2014, 2015) inspected 120 pike from the wetland at various stations finding the crustaceans *Lernaea cyprinaceus* and *Argulus foliaceus* and the ciliate *Trichodina* sp. on the skin, the digenean *Dactylogyrus* sp. and the monogenean *Tetraonchus monenteron* on the gills, the digenean *Diplostomum spathaceum* on the eye, and the nematodes *Eustrongylides excisus* and *Raphidascaris acus*, the platyhelminth *Rhipidocotyle illense* and the acanthocephalan *Corynosoma strumosum* in the gut. Details of diversity and intensity of infection were given and the haematological parameter mean cell volume was significantly different between infected and uninfected fish.

Sattari et al. (2004, 2005) surveyed this species in the Anzali, Amirkelayeh and Boojagh wetlands, recording *Raphidascaris acus*, *Eustrongyloides excisus* and *Camallanus lacustris*. Sadrinejad et al. (2014) compared pike from the Chamkhaleh River and the Anzali and Amirkelayah wetlands finding *Eustrongylides excisus*, *Raphidascaris acus* and *Triaenophrus crassus* in the intestine, *Tetraonchus monenteron* on the gill and *Diplostomum spathaceum* in the eye, with the Anzali fish having more parasites, attributed to the more rapid eutrophication of this wetland.

Young pike are eaten by various other fishes, including adult pike, birds and even, when young, large aquatic insects. Barati et al. (2008) document this species in the diet of chicks of the pygmy cormorant in the Sia Keshim Protected Region.

Economic importance: Nevraev (1929) reports a catch for the 1901-1902 to 1913-1914 period in the Anzali region was 1150 to 20,529 fish. Holčík & Oláh (1992) report a catch of 5836kg in the Anzali Wetland in 1990, at 7.8% of the catch the fourth most important fish there, while annual reported catches from 1932-1964 varied from none to 98 tonnes. However it is not a favoured food fish in Iran (Vladykov 1964). Paighambari et al. (2014) found that red fyke nets caught more pike in the Anzali Wetland and so could be used to reduce by-catch. Samiee et al. (2013) showed the dominant fatty acids in liver and muscle tissues of pike form Anzali are docosohexaenoic acid and palmitic acid, omega-3 fatty acids essential in the human diet and also suitable as raw material in the processing industry.

Hedayatifard et al. (2011) examined the effects of salting on fatty acids and flesh quality of pike stored at 4°C for 90 days; finding salting not only conserved fish and reduced bacterial activity but preserved fatty acids. Velayatzadeh et al. (2012) investigated levels of drip, drip protein and total volatile base nitrogen (TVB-N) as measures of spoilage of fish kept refrigerated at -18°C with various salt levels, the lowest drip being in this species without salt of four species examined. Hajisafarali et al. (2015) found that fillets of pike stored at -20°C for 6 months showed some changes in quality and nutritional value but the changes were

within the acceptable range.

Pourang (1995) describe heavy metal concentrations (lead, chromium, copper, cadmium, zinc, manganese and nickel) in fish of the Anzali Wetland. Levels in *Esox lucius* were below recommended levels for human consumption (Annual Report, 1995-1996, Iranian Fisheries Research and Training Organization, Tehran p. 46-47, 1997). Nadim (1977) found the mercury levels in Caspian Sea fish were 0.36mg/kg in *E. lucius*. As the acceptable limit was 0.5mg/kg, mercury contamination in fish was not considered a problem. Mercury concentrations in fish and fishermen's hair were studied from the Caspian shore by Zolfaghari et al. (2008). The mean hair mercury concentration was below the WHO threshold level and there was a weak correlation between number of fish meals per month and mercury levels. Levels in *E. lucius* exceeded US EPA guidelines. Nozari et al. (2011) examined 58 pike from the Anzali Wetland for mercury and found differences between muscle and liver tissues but not sexes. Molazadeh & Nozari (2014) however found age and sex affected mercury concentrations, the highest mercury concentration was in the spleen of fish from the wetland and levels were within acceptable limits for human consumption.

Imanpour Namin et al. (2011) examined the heavy metals in fish from the Anzali Wetland and found cadmium, copper and zinc were below the maximum allowed by international standards but lead concentrations exceeded them and fish were unsafe for human consumption. Mansouri et al. (2013) also found lead concentrations in fish from the Anzali Wetland exceeded acceptable standards for human consumption although cadmium and chromium did not. Chromium levels were higher than in other species studied but these were cyprinid fishes, not a predator like the pike. Salamat et al. (2015) again found lead levels in the wetland fish above the permissible limit although tin and zinc were not. Panahandae et al. (2013) and Salamat et al. (2016) however found lead levels (and cadmium, chromium, tin and zinc) in the wetland were lower than the allowable limit or the potential hazard of consumption posed no risk for consumers. Zamani-Ahmadmahmoodi et al. (2013) found Anzali Wetland fish had positive correlations of length and weight and muscle cadmium and lead but a negative correlation with weight. Higher metal concentrations were found in fish from the southeast of the wetland where boat traffic and agricultural activity contribute to pollution. Ahmadi et al. (2015) found nickel levels in the western parts of the Anzali Wetland exceeded permissible limits and consumption of this fish was a health threat to vulnerable groups. Zamani-Ahmadmahmoodi et al (2014) found Anzali Wetland fish had a poor relationship between mercury concentration and sediment levels and levels were low compared to reports from elsewhere.

Rahimibashar & Alipoor (2012) found juveniles exposed to mercury chloride in the laboratory had a LC_{50} 96h of 0.078 and for LC_{50} 24h 0.092mg Hg/l, bioaccumulation values during 24h in muscle, kidney and gill were 1.93, 18.6 and 28.2mg Hg/l, respectively and exposure values during 96h were 3.8, 19.5 and 30.6mg Hg/l, respectively.

Södergren et al. (1978) reported on pollution with organochlorines in *E. lucius* from the wetland and found this predatory fish to have accumulated the DDT metabolite p,p'-DDE, suggesting that this occurred over considerable time and was not a recent event. DDT did not appear to be incorporated in the pelagic food chain, although it has been used for agriculture and vector control problems. Most DDT probably attaches to clay and soil particles and settles out on the wetland bottom. The levels of PCBs (polychlorinated biphenyls, a persistent organic pollutant) in the Anzali Wetland have been studied by Teimouri et al. (2011, 2011) and Sakizadeh et al. (2012). Concentrations were 24.36ng/g (dried weight) in skin and 14.36ng/g in muscle, less than some but more than other allowable international limits. Salimi et al. (2013) analyzed PAHs (polycyclic aromatic hydrocarbons, carcinogenic organic compounds) in the wetland and found them to be within acceptable limits for human

consumption.

Khodadoust et al. (2013, 2015) documented levels of sex steroid hormones in pike from the Anzali Wetland as important indicators of reproductive biology for management and preservation of stocks. Jamalzad Fallah et al. (2012b, 2013) and Khodadoust (2015) similarly documented blood biochemical parameters from the wetland stock.

Khaval et al. (2010) found that pike controlled coarse fish in carp culture ponds, reducing unwanted fishes by 79.3% and 74.3% at a pike density of 200 and 500 individuals per hectare. Pike fed mainly on frog juveniles but reduced such unwanted fish as *Carassius auratus*, *Hemiculter leucisculus*, *Alburnus alburnus* (=*hohenackeri*) and *Pseudorasbora parva* by 94.0, 88.9, 62.4 and 56.82%, respectively. The cultured *Cyprinus carpio* in pike treated ponds increased in weight by 220% and all cultured fish production by about 17.9%.

Forsman et al. (2015) document changes in the study of this species from physiology and disease to ecology and evolution. The species can be exploited as a model for studying phenotypic and genetic variation in individuals, populations and species as well as community processes.

There is some opportunity for sport fishing for this species in the Anzali Wetland and potentially in various lakes around the country where it has been introduced (Anonymous 1977). Anglers catch this species in rivers along the Caspian shore such as in the Shazdeh River at Babol-sar (Noorbakhsh 1993).

It is an important sport and commercial fish in other parts of its range. The catch in Turkey in 1981 was 796 tonnes and for the inland waters of the former U.S.S.R. in 1975 it was 16,101 tonnes. Stolyarov & Abusheva (1997) report a commercial stock of 2500t with a recommended catch of 800-850t in Kizlyar Bay in the north Caspian in the early 1990s.

The eggs or roe of this species are very poisonous as fresh extracts injected intravenously into rabbits have caused respiratory distress, convulsion and death within one hour (Halstead 1967-1970). Despite this, the eggs have been used as a caviar substitute according to Adeli & Namdar (2015).

Conservation: Raat (1988) gives details of conditions which should exist to facilitate pike reproduction and growth, including such factors as vegetation, water levels, eutrophication, pollution, prey availability, intra- and inter-specific interactions, fishery, stocking, concentration of dissolved solids, pH levels, and temperature regimes. Vladykov (1964) noted a fish kill in the Anzali Wetland on 11 June 1962 where water chestnut (*Trappa natans*) had caused an oxygen deficiency in the shallow water.

Gilan Fisheries Research Station has cultured pike in earthen ponds. Pike caught in autumn and in winter were injected with gonadotropic hormone from carp (4-7mg/kg). Eggs were stripped after 48-72 hours and incubated for 10 days at 8-11°C and 7-8 days at 10-15°C. Absorption of the larval yolk sac took approximately twice as long as the incubation period.

Ramin (1999) reports on a project involving artificial spawning and raising of fry in earthen ponds. Spawning temperatures were 8-15°C from 4 February to 20 March. Males and females were a minimum of 3 years old and a maximum of 5 and 6 years respectively and weighed 0.75-4.0kg. Eggs composed 10-20% of body weight, incubation lasted 120 degree days and yolk sac absorption 160-180 degree days. The rate of fertilization was 45-85% and swelled eggs were 2.5-3.5mm. Absolute fecundity was 22,400-112,000. Survival from larvae to fingerlings in chicken manure enriched ponds was 20-22% over 50 days with growth to 7.4g and 8.5cm on average. Khaval et al. (2014) found the best dosage of the synthetic hormone Ovaprim to induce spawning was 10-20µg/kg body weight.

Pike from the Anzali Wetland have been cultured with Chinese carps and were found to be mature in less than a year (Iranian Fisheries Research Organization Newsletter 56:2, 2008).

Tabarrok et al. (2015) found distinction between

populations (see above) and this was considered important for resource management of the species in Iran.

Kiabi et al. (1999) consider this species to be conservation dependent in the south Caspian Sea basin according to IUCN criteria. Criteria include commercial fishing, sport fishing, medium numbers, habitat destruction, medium range (25-75% of water bodies), present in other water bodies in Iran, and present outside the Caspian Sea basin. Mostafavi (2007) lists it as conservation dependent in the Talar River, Mazandaran. The IUCN (2015) list it as Least Concern. Populations in Turkey are Endangered (Fricke et al. 2007).

Sources: Crossman & Casselman (1987) give a bibliography and Raat (1988), Craig (1996) and Zarkami (2012) give synopses of biological data and habitat modeling on this extensively studied species. General biology and characters are based on world-wide data. Sohrabi (1996) gives an account of this species in Farsi. Further details on collections examined can be found in the museum catalogues.

Iranian material: CMNFI 1970-0510, 1, 250.3mm standard length, Gilan, Golshan River (37°26'N, 49°40'E); CMNFI 1970-0535A, 1, 329.6mm standard length, Gilan, Pir Bazar Roga (37°21'N, 49°33'E); CMNFI 1970-0542, 1, 39.0mm standard length, Gilan, Old Safid River estuary (37°23'N, 50°11'E); CMNFI 1970-0543A, 1. 136.2mm standard length, Gilan, Caspian Sea at Hasan Kiadeh (37°24'N, 49°58'E); CMNFI 1970-0553, 1, 136.7mm standard length, Gilan, Sosar Roga (37°27'N, 49°30'E); CMNFI 1970-0579, 9, 71.9-111.2mm standard length, Gilan, Old Safid River estuary (37°23'N, 50°11'E); CMNFI 1971-0343, 3, 63.8-74.7mm standard length, Gilan, Langarud at Chamkhaleh (37°13'N, 50°16'E); CMNFI 1979-0685, 1, 149.2mm standard length, Gilan, Safid River around Mohsenabad below Dehcha (no other locality data); CMNFI 1980-0123, 2, 126.3-209.3mm standard length, Gilan, Safid River around Dehcha above Mohsenabad (no other locality data); CMNFI 1980-0138, 2, 148.2-164.3mm standard length, Gilan, Safid River estuary (ca. 37°28'N, ca. 49°54'E); CMNFI 1993-0147, 1, 106.0mm standard length, Iran (no other locality data).

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مقاله مروری

مروری بر اردک ماهی های ایران (خانواده اردک 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 اردک ماهی *Esox lucius* شرح داده شده، تصاویری از آن ارائه گردیده و فهرستی از منابع موجود درباره این گونه لیست شده است. تنها یک گونه ی بومی در حوضه‌ی دریای خزر وجود دارد که به نقاط دیگر ایران معرفی شده است. این خانواده با خصوصیات زیر شناخته می‌شوند: پوزه‌ی پهن، دراز و نوک اردکی شکل؛ باله‌های پشتی و مخرجی در انتهای بدن نزدیک دم؛ فقدان باله‌ی چربی؛ دندان‌های کوچک روی زبان و استخوان های بازی برانشیال پشت زبان، دندان‌های بزرگ و روی آرواره‌ها؛ شعاع‌های برانکیوستگال ۱۰ تا ۲۰ عدد؛ وجود استخوان‌های بینی؛ اتصال کیسه‌ی شنا به روده توسط یک مجرا؛ شکل استخوان‌های بین ماهیچه‌ای، چنگالی یا Y شکل؛ فاقد خار باله؛ باله‌های لگنی در موقعیت شکمی؛ فلس‌های دایره‌ای؛ کانال‌های حسی زیر حدقه‌ای روی سر دارای هشت منفذ یا بیش‌تر؛ دسته‌های خارهای آبششی به‌صورت دندانه‌های تیز؛ فقدان سکوم‌های پیلوری؛ خط جانبی کامل؛ باله‌ی دمی چنگالی دارای ۱۷ شعاع نرم. *Esox Lucius* از دیگر گونه‌های ماهی‌های آب شیرین ایران با ویژگی‌هایی چون پوزه‌ی پهن و تخت و موقعیت انتهایی باله‌های پشتی و مخرجی متمایز می‌شود. *Esox Lucius* در اوراسیای شمالی و شمال آمریکای شمالی پراکنش دارد. جمعیت‌های ایرانی آن در حاشیه‌ی جنوبی محدوده‌ی پراکنش گونه وجود دارند.

کلمات کلیدی: *Esox*، زیست‌شناسی، ریخت‌شناسی، پراکنش.