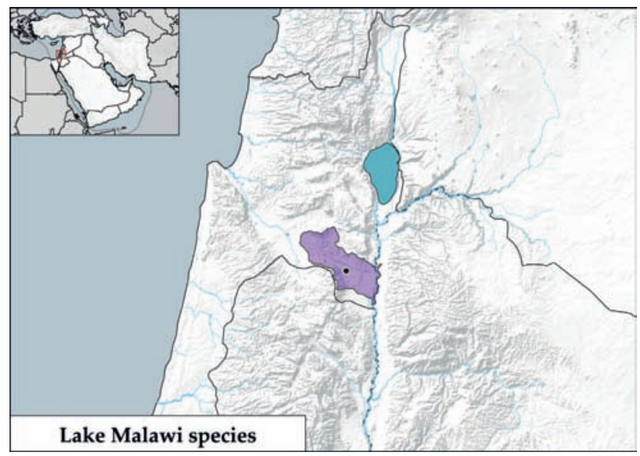
Family Cichlidae

Cichlids

A large family of mostly small freshwater fishes with approximately 1750 named (and several hundred unnamed) species distributed throughout tropical and temperate Africa, Madagascar, South and Central America, a few species are found in India, Sri Lanka, Iran, and the Levant. Some species have been introduced almost pan-tropically. Cichlids are immediately distinguishable from similar perch-like fishes by two lateral lines on the flank, with an anterior upper line and a posterior lower line. Eight species are native to West Asia, with seven being introduced. *Iranocichla* and *Tristramella* are endemic to West Asia, both having relationships to African genera and potentially representing the relics of a once much wider distribution of cichlids in the area. Cichlid fossils have been recorded from the Arabian Peninsula until the Pliocene, indicating a continuous distribution from the Levant through the Arabian Peninsula to Iran. Cichlids were "reintroduced" in Arabia in the modern era as non-native species for aquaculture and mosquito control. Cichlids are generally very sensitive to temperatures below 10°C, with mortality occurring if exposed for more than a few hours. This renders them susceptible to low winter temperatures, which restrict their distribution to warm springs in the northern part of West Asia. They represent a highly significant group for evolutionary studies and the pet trade, with numerous species being kept in aquaria, including in West Asian countries. Until now, *Amatitlania nigrofasciata* is the most widespread species released from aquaria. Other species, such as *Rubricatochromis guttatus*, an African species already found at several locations in Europe, are also expected to be found in West Asia in the future.



Lake Malawi cichlids introduced and established in Nahal Amal in Israel. From left: *Aulonocara* sp., *Dimidiochromis compressiceps*, *Labidochromis caeruleus*, *Chindongo elongatus.* © A. Spreinat.

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It is unknown how many cichlid species from East African Lake Malawi have established themselves in the warm springs of Nahal Amal in Bet She'an (Israel). At least *Aulonocara* hybrids, *Dimidiochromis compressiceps*, *Labidochromis caeruleus* and *Chindongo elongatus* have formed stable populations. *Aulonocara* are domesticated hybrids produced for the aquarium trade. Other species might have also been established, and more research is needed. Malawi cichlids are included in the identification key but do not have separate species chapters. Several other cichlids have been reported from West Asia but have yet to be established. More introduced cichlids will inevitably find their way from aquariums into the wild, especially in artificial waters in parks or private areas. To identify them, consulting specialist books on aquarium fish is necessary. **Further reading.** Trewavas 1983; Lévêque et al. 1992 (identification); Schwarzer et al. 2016 (molecular phylogeny).

Key to species of Cichlidae native and introduced to West Asia

1a - Anal with 8–10 spines.
……………..*Amatitlania nigrofasciata*
1b - Anal with 3 spines.
……………..2

2a - Scales ctenoid; yellow or orange ocelli on anal in adult male.
……………..3
2b - Scales cycloid; no ocelli on anal.
……………..7

3a - Lower jaw strongly projecting upper jaw, a continuous, bold-black midlateral stripe.
……………..*Dimidiochromis compressiceps*
3b - Upper jaw slightly projecting upper jaw or both jaws equally projecting.
……………..4

4a - Dorsal with a bold-black subdistal stripe on yellow background; flank yellow without bars or with very indistinctive bars.
……………..*Labidochromis caeruleus*
4b - Dorsal black, grey, yellowish, blue, red, marbled, often with whitish or yellow distal margin, without a bold-black subdistal stripe on yellow background; flank with indistinctive or bold bars or without bars.
……………..5

5a - Snout roundish; head below eye dark-grey to bluish-black; flank with 4–8 dark-grey to bluish-black bars in male, less pronounced or absent behind dorsal base.
……………..*Chindongo elongatus*
5b - Snout pointed; head below eye same colour as above eye, with blue iridescent shine or with a bold bar between eye and corner of mouth; flank with indistinctive dark-grey or brown-black bars.
……………..6

6a - Flank without stripe or horizontally elongated blotches; no bar between eye and corner of mouth; flank with bold dark-grey or brown bars in female and juveniles.
……………..*Aulonocara* sp.
6b - Flank with a short stripe between opercle and about middle of spined part of dorsal, continued as 1–2 blotches on lateral midline behind spined part of dorsal; bold bar between eye and corner of mouth; flank with indistinctive dark-grey or brown bars.
……………..*Haplochromis flaviijosephi*

7a - No scales on chest, belly, and isthmus in front of pelvic origin; nuptial male dark-grey or black with many white spots or short vermiculation on flank.
……………..8

7b - Chest, belly, and isthmus in front of pelvic covered by small scales; nuptial male pale-grey or pinkish white without white spots or vermiculation on flank.
………………9

8a - Chest and lower part of head black in nuptial male; black blotch on last spinous part of dorsal distinct; no or very few white spots on caudal.
………………*Iranocichla hormuzensis*
8b - Chest and lower part of head bright orange in nuptial male; black blotch on last spinous part of dorsal pale-grey or invisible; white spots forming wavy bars or stripes on caudal.
………………*Iranocichla persa*

9a - 8–14 gill rakers on lower part of first branchial arch.
………………10
9b - 18–27 gill rakers on lower part of first branchial arch.
………………12

10a - Chest red or red and black in adults (rarely absent), red colour restricted to lateral chest in juveniles; lower jaw not projecting; 8–11 gill rakers on lower part of first branchial arch.
………………*Coptodon zillii*
10b - Chest not red; lower jaw projecting; 10–14 gill rakers on lower part of first branchial arch.
………………11

11a - Lower jaw slightly projecting; outer teeth bicuspid, inner teeth tricuspid (Fig. 66).
………………*Tristramella simonis*
11b - Lower jaw very strongly projecting; teeth conical, unicuspid (Fig. 66).
………………*Tristramella sacra*

12a - Flank scales without dark-grey scale pockets in preserved individuals, isolated black scales pockets or fields of black scale pockets in some individuals; anterior processes of lower pharyngeal bone not or very slightly projecting beyond anterior margin of toothed pads; without red or orange colour in life; caudal almost without pattern.
………………*Sarotherodon galilaeus*
12b - All flank scales with dark-grey scale pockets in preserved individuals, dark-grey scales pockets never organised in fields; anterior processes of lower pharyngeal bone clearly projecting beyond anterior margin of toothed pads, tips of dorsal rays and orange caudal in life adult male (*O. aureus*, *O. mossambicus*) or caudal with regular bars (*O. niloticus*); caudal with strong pattern.
………………13

13a - Caudal with regular vertical bars in individuals larger than 80 mm SL; tip of membrane between dorsal spines grey to black.
………………*Oreochromis niloticus*
13b - Caudal with tessellate or marbled pattern or few irregularly shaped bars, without regular vertical bars in individuals larger than 80 mm SL; tip of membrane between dorsal spines pink to red.
………………14

14a - Nuptial male bright blueish or grey with whitish lower part of head and orange dorsal- and caudal margins; snout in male larger than 200 mm SL not duck-bill-like elongated.
………………*Oreochromis aureus*
14b - Nuptial male black or dark-grey with whitish lower part of head and orange or red dorsal- and caudal margins; snout in male larger than 200 mm SL duck-bill-like elongated.
………………*Oreochromis mossambicus*

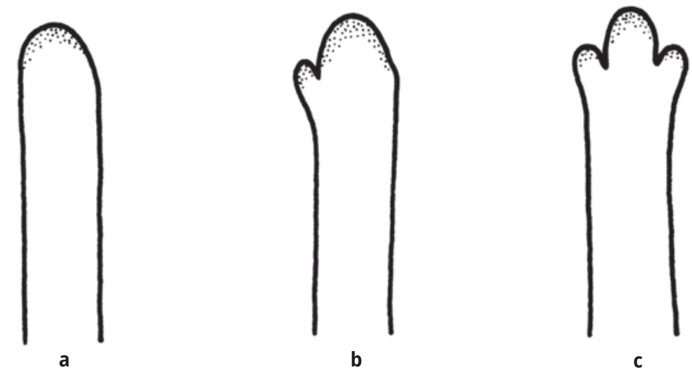


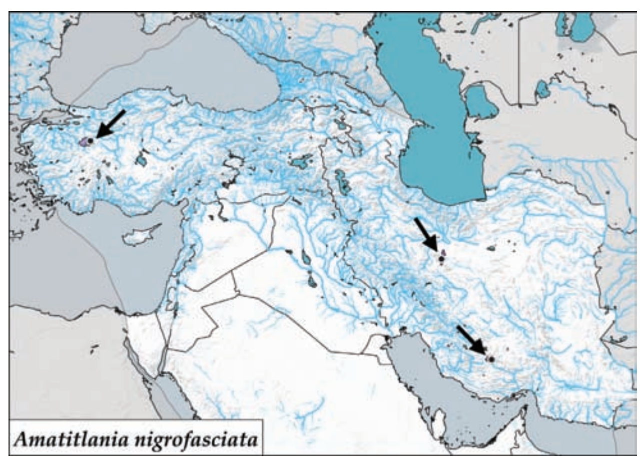
Figure 66. Jaw teeth in Cichlidae: **a,** unicuspid; **b,** bicuspid; **c,** tricuspid (from Kottelat & Freyhof 2007, after Trewavas 1983).

Rubricatochromis guttatus is an invasive species expected to be found in West Asia in the near future.

Amatitlania nigrofasciata; Fossa Calda, Italy; female; ~45 mm SL.

Amatitlania nigrofasciata; Fossa Calda, Italy; male, ~70 mm SL.

Amatitlania nigrofasciata
Common name. Convict cichlid.
Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ○ 8–10 anal spines / ● 8–9 black bars on grey flank (albinotic individuals occur in non-native populations). Size up to 150 mm SL.
Distribution. Türkiye: a hot spring in upper Sakarya drainage. Iran: Golabi spring near Darab in Fars prov., and Soleymaniyeh spring in Namak Lake basin. Was established in Israel but seems to have disappeared. Native to Central America: Pacific slope, from Río Sucio, El Salvador to Río Suchiate, Guatemala; Atlantic slope, from Río Patuca, Honduras to Río Jutiapa, Guatemala. Introduced in Austria, Hungary, Italy, Australia, Japan, Philippines, Puerto Rico, the USA, Hawaii and likely elsewhere.
Habitat. A wide range of streams and springs.
Biology. Forms pairs; both sexes territorial. Females lay eggs on exposed hard surfaces such as stones or wood. Larvae and young guarded by parents. Male guard outer and female inner circle around young. Incubation of eggs, larvae, and free-swimming juveniles in the wild lasts 4–6 weeks and occurs only once a season for most females. An opportunistic feeder, feeding on detritus and plant material and preying on small aquatic animals. Frequently used in behavioural studies.
Conservation status. Non-native; released from aquaria.
Further reading. Wisenden 1995 (reproduction); Schmitter-Soto 2007 (native distribution); Esmaeili et al. 2013b (Iran); Mousavi-Sabet & Eagderi 2016a (record in Lake Namak).



Coptodon
Coptodon comprises approximately 35 species, which are primarily distributed in West Africa. Many species have relatively small distribution ranges in tropical rainforests. Some species are found in coastal lagoons and may forage in marine habitats. The concept of a widespread coastal species (*C. guineensis*) has recently been rejected, and the number of *Coptodon* species may be grossly underestimated. Two crater lakes in Cameroon host endemic species flocks: Lake Bermin with 11 species and Lake Ejagham with four species. *Coptodon* are macroherbivores and, if available, feed on plants. They graze submerged vegetation and, during high water levels, migrate into forests and

other terrestrial ecosystems to feed on flooded plants. It is common to observe them leaping out of the water to bite pieces from overhanging leaves. As some *Coptodon* species are particularly abundant, their grazing structures freshwater ecosystems. They may also play an important role in the dispersal of seeds. Many species grow to a large size and are of importance in both subsistence and commercial fisheries. **Further reading.** Stiassny et al. 1992 (Bermin); Dunz & Schliewen 2010 (Ejagham); Dunz & Schliewen 2013 (generic concept); Kide et al. 2016 (diversity of coastal species).

Coptodon zillii; Lake Köyceğiz, Türkiye; male, ~160 mm SL.

Coptodon zillii; Lake Maryut, Egypt; nuptial male, ~100 mm SL.

Coptodon zillii

Common name. Redbelly tilapia.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● chest red or red and black in adults, red colour restricted to lateral chest in juveniles (rarely absent) / ○ lower jaw not projecting / ○ caudal with tessellate pattern / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 8–11 gill rakers on lower part of first branchial arch / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 400 mm SL, usually about 200 mm SL.

Distribution. In West Asia, native to Jordan drainage and possibly a few adjacent coastal streams. Introduced in Köyceğiz and Burdur basins in Türkiye; Euphrates and Tigris in Syria, Iraq, and Iran; Azraq oasis in Jordan; and Ceyhan and Orontes drainage in Syria and Türkiye. Also native to Nile drainage and Lakes Albert and Turkana. Widespread in West Africa, including Senegal, Gambia, Niger, Chad, and Volta, and many coastal rivers in Ivory Coast and between Volta and Niger. Occurs in Ubangui, Ulele, and Ituri in central Congo basin. Morocco: Lower valley of Oued Dr'aa and Oued Aouedri, a small Saharan valley between Tan Tan and Tarfaya. Algeria: Tolga, Zibans, and Touggourt oases in northern Sahara and on western slopes of Ahaggar, in Tassili n' Ajjer, and Arak, a tributary of Botha, all in southern Algerian Sahara. Tunisia: Kebili oasis and perhaps more widely in eastern and southern Chott el Djerid basin. In Sahara: Tibesti, Ennedi, and Borkou mountains. Introduced almost everywhere in subtropical and tropical areas of Southeast Asia, Australia, India, Madagascar, New Caledonia, Fiji, Guam, Taiwan, China, Philippines, Japan, Antigua, Mexico, and the USA, including Hawaii and elsewhere.

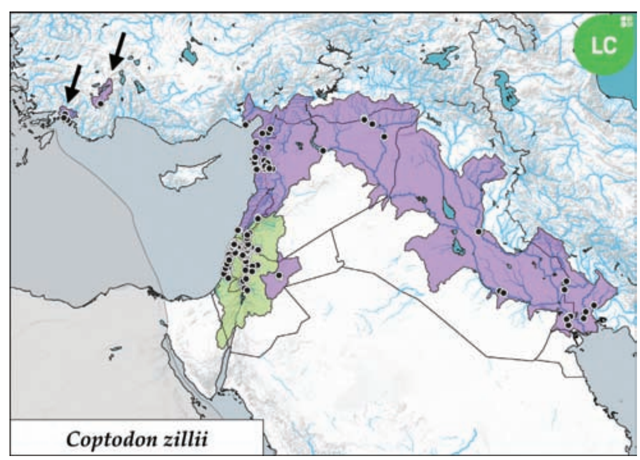
Habitat. Hypersaline desert ponds and wadis to small rainforest streams with soft and acidic water. Often very abundant in standing water, such as lakes, large rivers, or reservoirs with dense riparian vegetation.

Biology. Usually lives 3–5 years. Matures at about 80 mm SL. Growth extremely variable depending on temperature and food availability; may spawn after a year in West Asia but mature within 4 months in tropics. Forms pairs that defend territories against other fish. Usually, females defend a smaller inner territory and males a larger outer territory around spawning site. Females lay sticky eggs on surfaces such as stones or wood, often in shelters or small depressions in substrate dug by both parents. Spawns throughout year in tropical range, late spring to summer in West Asia when water temperatures rise above 20°C. Stops spawning when water temperature rises above 28°C. Both parents fan eggs, picking up debris and dead eggs. Larvae usually hatch 48 hours after spawning (25°C) and are transferred to small burrows in substrate or under wood or stones. Larvae begin to feed about a week after spawning. Both parents guard larvae and juveniles for about 4 weeks. Survives temperatures as low as 6.5 and as high as 42.5°C, but only briefly, unable to survive below 10°C for more than a few hours. Harsh winters cause mortality in northern part of range. Survives in salinities up to 45 ‰ and reproduces in salinities up to 29 ‰. Feeds mainly on aquatic and terrestrial macrophytes but also on invertebrates, algae, detritus, and virtually all organic matter. Of great economic importance in sub-Saharan Africa as a food fish for small-scale fisheries, rarely used in aquaculture. Introduced for aquatic weed and mosquito control, as forage or food fish, and for aquaculture. Several studies show negative impacts on native biodiversity, adverse effects on aquatic plants, and it is a pest in rice plantations.

Conservation status. LC.

Remarks. Populations of *C. zillii* from Morocco, Algeria, West Africa, the Nile, and Jordan are almost identical in their mitochondrial DNA, suggesting a very recent invasion of this species into the Levant and a recent interruption of gene flow between the Niger, Senegal, Nile, and many coastal rivers in West Africa. Locally misidentified as *C. rendalli* in 20th century.

Further reading. Geiger et al. 2014 (molecular diversity); Nico et al. 2016 (distribution, effects of non-native populations).



Haplochromis

Haplochromis and related genera from Africa's Lake Victoria region represent the largest cichlid fish genus and the most species awaiting description. These fishes provide textbook examples of adaptive radiations and the role of hybridisation in speciation and evolution. While being very speciose and morphologically as well as ecologically very diverse in Africa, there is only one species native to Asia, which is distantly related to the "Lake Victoria Region Superflock."

Further reading. Meier et al. 2017 (phylogeny, species diversity, evolution); Moser et al. 2018 (fast speciation).

Haplochromis flaviijosephi; Jordan drainage, Syria; male, neutral mood; ~70 mm SL.

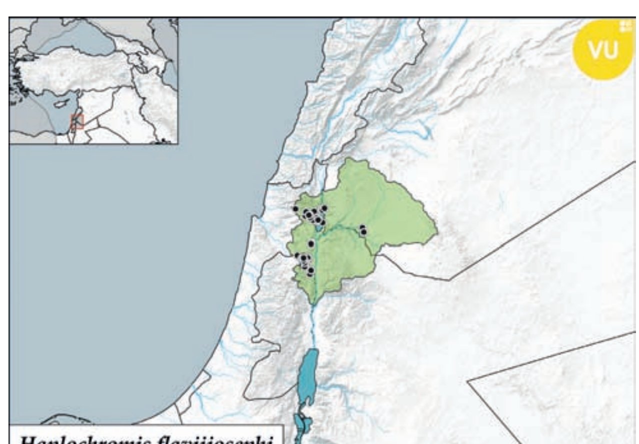
Haplochromis flaviijosephi; Jordan drainage, Israel; male, territorial mood; ~80 mm SL. © E. Schraml.

Haplochromis flaviijosephi

Common name. Jordan mouthbrooder.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● scales ctenoid / ● yellow or orange ocelli on anal in adults / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 3 anal spines / ○ flank with a short stripe between opercle and about middle of spined part of dorsal, continued as 1–2 blotches on lateral midline behind spined part of dorsal / ○ bold bar between eye and corner of mouth / ○ flank with indistinctive dark-grey or brown bars. Size up to 100 mm SL.

Distribution. Jordan drainage, where it occurs in Lake Muzayrib (Syria) and Lake Kinneret (Israel) basins, in Ajami



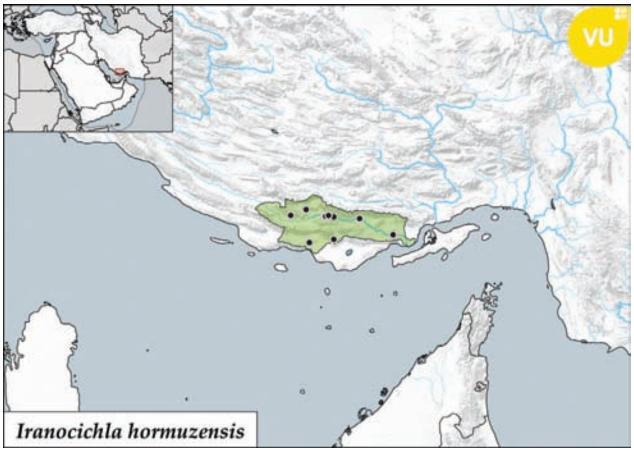
and Al Asha'ari springs (southern Syria), and in vicinity of Lake Kinneret and the Baisan Valley (Israel).
Habitat. Shallow shores of lakes, springs, and streams where it occurs among rocks and vegetation.
Biology. Maternal mouthbrooders without permanent pair-bonding. Spawns several times between April and July. Nuptial males occupy a territory with a shallow nest in center. Female spawn with territorial males. After fertilisation in nest, female takes eggs in mouth. In Lake Kinneret, females feed mainly on chironomid larvae, oligochaetes, and amphipods, while males feed primarily on snails.
Conservation status. VU; appears to be relatively secure in Lake Kinneret but declining in its small range outside the lake.
Remarks. *Haplochromis flaviijosephi* does not appear to be closely related to any African *Haplochromis* species. There must have been a recent biogeographic window that allowed *C. zillii*, *O. aureus*, and *S. galilaeus* to invade the Jordan from the Nile. However, both *H. flaviijosephi* and *Tristramella* must have existed in Levant before the biogeographic connection to the Nile, and a much earlier invasion from the Nile could be proposed. Alternatively, *Tristramella* and *H. flaviijosephi* may be relics of a once widespread range of cichlids on the Arabian Peninsula and may have invaded the Jordan from Saudi Arabia.
Further reading. Goren 1974 (distribution); Werner 1976 (reproduction); Spataru & Gophen 1985a (food).

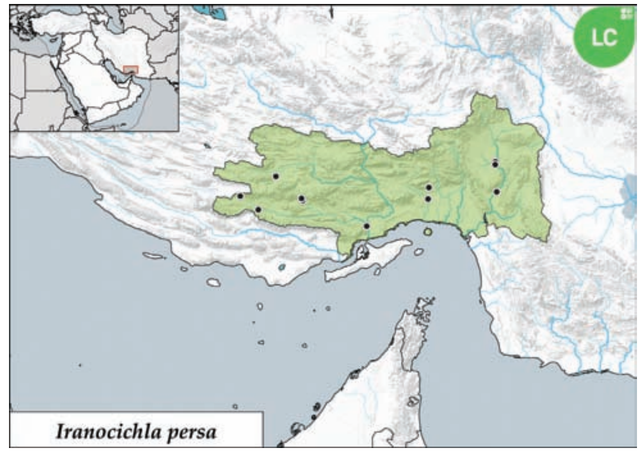
Iranocichla hormuzensis; Mehran drainage, Iran; mouth-brooding female, ~70 mm SL. A. Lamboj.

Iranocichla

Iranocichla is a genus comprising two species, both of which are highly similar. *Iranocichla* is endemic to Iran, and it was previously hypothesised that it is closely related to *Danakilia*, a genus with two species from Ethiopia and Eritrea. However, molecular data does not support this hypothesis; *Iranocichla* is close to *Tristramella*. **Further reading.** Steinitz & Ben-Tuvia 1960 (revision of genus); Dunz & Schliewen 2013 (phylogeny); Esmaeili et al. 2016b (review); Schwarzer et al. 2016 (phylogeny of populations).

Iranocichla hormuzensis; Mehran drainage, Iran; nuptial male, ~80 mm SL. © A. Lamboj.





Iranocichla hormuzensis

Common name. Persian pearl cichlid.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● lower part of head and chest in nuptial male black / ○ black blotch on last spinous part of dorsal distinct / ○ no or very few white spots on caudal / ○ no scales on chest, belly, and isthmus in front of pelvic origin / ○ 3 anal spines / ○ scales cycloid. Size up to 120 mm SL.

Distribution. Iran: Middle and lower Mehran drainage.

Habitat. Freshwater to hypersaline streams, often partially drying up in summer and forming isolated pools. Area around Strait of Hormuz is rich in salt domes and hypersaline streams; up to about 1½ marine salinity, are found. Water temperatures range from 15 to 33°C in winter (November to March) and up to 40°C in summer.

Biology. Maternal mouthbrooders without permanent pair-bonding. Spawns in spring. Nuptial males occupy a territory with a shallow nest in center. Female spawn with territorial males. After fertilisation in nest, female takes eggs in mouth and returns to schools.

Conservation status. VU; appears to be declining within its small range.

Further reading. Coad 1982b (description); Esmaeili et al. 2016b (review); Schwarzer et al. 2016 (phylogeny).

Iranocichla persa; Shur drainage, Iran; nuptial male, 90 mm SL. © A. Hartl.

Iranocichla persa

Common name. Eastern pearl cichlid.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● lower part of head and chest in nuptial male orange / ○ black blotch on last spinous part of dorsal pale-grey or invisible / ○ white spots forming wavy bars or stripes on caudal / ○ no scales on chest, belly and isthmus in front of pelvic origin / ○ nuptial male dark-grey or black with many white spots or short vermiculation on flank / ○ 3 anal spines / ○ scales cycloid. Size up to 120 mm SL.

Distribution. Iran: Kol, Shur, Hasan Langi, and Minab drainages.

Habitat. Freshwater to hypersaline streams, often forming isolated pools in summer. Water temperatures range from 15 to 33°C in winter (November–March) to 40°C in summer.

Biology. Maternal mouthbrooders without permanent pair-bonding. Spawns in spring. Nuptial males occupy a territory with a nest in center. Nests are shallow pits about one body length in diameter. Females form shoals in deeper water. Nuptial females approach nests to spawn. Female spawn with territorial males, and sneaking appears to be common. After fertilisation in nest, females take eggs in mouths and return to school. Up to 153 offspring recorded in one mouth, ranging in length from 9.6 to 10.9 mm SL (from a female of 117 mm SL). Feeds on diatoms and other algae scraped from rocks and sediments.

Conservation status. LC.

Remarks. Molecular data suggest that all *Iranocichla* populations are closely related. The two *Iranocichla* species form only slightly distinct clades, diagnosable by several fixed mutations in ND2, D-loop, and very small differences in cytochrome oxidase 1 sequences. Fish from the Kol drainage, the largest *Iranocichla* population between the Mehran and Shur drainages, agree with *I. hormuzensis* in their male nuptial colour but cluster with *I. persa* in their mitochondrial sequence characters.

Further reading. Esmaeili et al. 2016b (description); Schwarzer et al. 2016 (phylogeny).

Iranocichla persa waiting for food in an eutrophicated pool in Iran.

Taiwanese red tilapia *O. niloticus* x *O. mossambicus*; Wadi Fania, Oman; male, 145 mm SL.

Oreochromis

Oreochromis comprises approximately 20–40 species, depending on the generic concept. Most *Oreochromis* are found in East Africa, although two are native to West Asia. Some authors have recognised *Alcolapia*, *Neotilapia*, *Nyassalapia*, and *Vallicola* as valid genera. Still, molecular studies have challenged the generic concept of mouth-brooding tilapias, and these may ultimately be reclassified as *Oreochromis*. The phylogeny of *Oreochromis* also shows widespread discordance between nuclear DNA and mitochondrial DNA trees. It seems premature to propose a revision of mouth-brooding tilapias, which are unlikely to form a natural group.

Several *Oreochromis* species are attractive targets for aquaculture, with at least eight species actively farmed globally, many in warm-water farms. *Oreochromis niloticus* and its hybrids are the most widely farmed aquaculture warm-water species globally. Additionally, in certain West Asian regions, an expanding aquaculture industry is cultivating primarily hybrid tilapia (*O. niloticus* x *O. aureus*). Other tilapias, including *Oreochromis niloticus*, *O. aureus*, and *O. mossambicus*, as well as hybrids between *O. mossambicus* and *O. niloticus* (Taiwanese red tilapia), are maintained in experimental farms and are cultivated in limited quantities before being released into natural waters. *Oreochromis spilurus*, a salt-tolerant species, was introduced from Kenya to Saudi Arabia and was reportedly bred and cultured in saline waters of the Red Sea. While it cannot be ruled out that fish have escaped and established themselves in the Red Sea basin, there is no evidence to confirm this. Therefore, *O. spilurus* has been excluded from the list of non-native species in Arabia.

A few *Oreochromis* from Oman have been studied for their mitochondrial molecular characters. The results suggest that either *O. niloticus* has already hybridised with *O. mossambicus* in Oman or that the introduced fish had already been hybridised, and these Omani populations might be feral Taiwanese red tilapia. Phenotypically, these fish are close to *O. niloticus*. Introgressed mitochondrial DNA is a trace of past hybridisation events. The aquaculture industry has a significant environmental impact, as fish inevitably escape and potentially establish local populations. This has occurred locally in West Asia, where *Oreochromis* have become invasive in the Persian Gulf basin and the Levant. Many species of *Oreochromis* have a substantial invasive potential, and four species are currently listed on the Global Invasive Species Index. **Further reading.** Genner et al. 2013 (invasion); Shechonge et al. 2019 (invasion); Ford et al. 2019 (phylogeny); IUCN 2020 (invasive species list).

Oreochromis spilurus; Kenya, male, 150 mm SL.

Tilapia, a global business. Tilapias have been an important component of subsistence fisheries since pre-humans first began to consume fish as food. They have been farmed for over 4000 years in Egypt. The most commonly cultured tilapia species is *Oreochromis niloticus*, followed by *O. aureus*. These two species are responsible for the significant increase in global tilapia aquaculture production. Tilapia has evolved from a relatively obscure fish to one of the world's most productive and internationally traded food fish. Tilapia fillets are commonly available in supermarkets. In 2021, approximately 7.2 million tonnes of tilapia were produced, and China accounted for 1.8 million metric tons. By 2017, the global value of tilapia products, predominantly frozen fillets, exceeded 25 billion euros. Of this total, 12 billion euros was generated in China alone. Tilapia farming encompasses various operations, from rural subsistence farming to large-scale commercial enterprises. In light of the ongoing commercialisation and expansion of the tilapia industry, the commodity has emerged as the second most important farmed fish globally, after carp. It is also regarded as the most significant aquaculture species of the 21st century. Tilapia is cultivated in approximately 150 countries worldwide, with approximately 98 % of the tilapia produced in these countries being grown outside their native range. The major producing countries are China, Egypt, and Indonesia. However, tilapia farming is increasingly conducted in the Caribbean, Latin America, and temperate countries where warm water is artificially created. *Oreochromis niloticus* and *O. aureus* are the most important domesticated animals from Africa. Surprisingly, the production in Africa, except Egypt (Egypt 237,000 tonnes in 2017), remains relatively small. African countries import frozen, whole tilapia from China, which accounts for 98 % of the marketed Tilapia in Africa (outside Egypt). The domestication of tilapia is a relatively rapid process. The introduction of superior strains and the development of Genetically Improved Farmed Tilapia (GIFT) technology, based on traditional selective breeding, are intended to enhance the commercially important traits of tropical farmed fish. Through combined selection technology, GIFT achieved an average genetic gain of 12–17 % per generation over five generations and a cumulative increase in the growth rate of 85 % in *O. niloticus*. It is evident that these tilapias no longer resemble their wild counterparts. Several strains exhibit orange or pink hues, frequently marketed as pink tilapia or red snapper, a marine fish. It is also noteworthy that tilapia often escapes from farms and has become one of the most prevalent non-native fish species globally. **Further reading.** Freyhof et al. 2020.

Oreochromis aureus; Ceyhan drainage, Türkiye; ~200 mm SL.

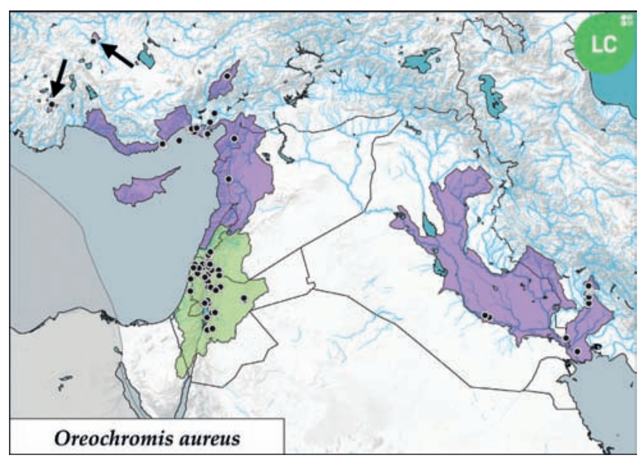
Oreochromis aureus

Common name. Blue tilapia.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ○ caudal usually tessellate, marbled, or with blotches not forming regularly shaped and set bars or, if bars present, then short, not reaching from upper to lower caudal rays / ○ flank scales with scales pockets darker than scale margins / ○ tip of membrane between dorsal spines orange or red / ● nuptial male bright blueish or grey with whitish lower part of head and orange dorsal and caudal margins / ○ snout not duck-bill-like, elongated in male larger than 200 mm SL / ○ anterior processes of lower pharyngeal bone clearly projecting beyond anterior margin of toothed pads / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ chest never red / ○ 18–26 gill rakers on lower part of first branchial arch / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 380 mm SL.

Distribution. Native to Jordan drainage and lower Nile downriver of Cairo. Also native to Oued Draa drainage in southern Morocco, Senegal, central Niger and Benue, and Lake Chad basin, including lower Shari and Logone. Widely introduced in Israel, Azraq oasis in Jordan and Orontes in Syria and Türkiye, Ceyhan, Seyhan and Sakarya in Türkiye, lower Euphrates and Tigris in Iraq and Iran, Wadi Haneefah in Riyadh, Al-Kharj and Layla Aflaj south of Riyadh, and Al-Ahsa oasis in Saudi Arabia. Probably more widespread. Also established in Cyprus, Florida, South Africa, Central America, Southeast and East Asia, Hawaii, Madagascar, and elsewhere.

Habitat. Slow-flowing rivers, backwaters, lakes, and coastal lagoons.



Biology. Lives up to 5 years. Spawns in second year, usually with 160–180 mm SL. Males larger than females, and branched dorsal and anal rays longer in males. Posterior margin of dorsal membrane thickened in nuptial male. Spawning begins in late March–early April in Lake Kinneret at water temperatures above 20–22°C and lasts until late May in Kinneret or until November in Nile Delta. Males establish territories near shores in shallow water. Territory radius (0.7–3.0 m) depends on strength of male. Territories are often concentrated in leks that form breeding colonies. Within a territory, males dig a shallow nest in substrate and attempt to attract females. Eggs are laid in batches, immediately fertilised by male and taken into mouth by female. No permanent pair bond. Females may spawn with several males in a breeding colony. Females spawn several times during summer. Larvae hatch after 3 days, and females swallow eggshells. Female keeps eggs and larvae for about 13–14 days and guards free-swimming juveniles for a few more days, returning them to mouth at night. Can live in brackish water up to at least 10 ‰. Juveniles usually cannot survive temperatures below 9°C. Adults can survive night temperatures as low as 5°C for a few days if daytime temperatures are higher. Juveniles inhabit shallow habitats. Opportunistic feeders, usually phytoplankton but also zooplankton, epiphytic algae, and detritus.

Conservation status. LC.

Remarks. Very important species for aquaculture, produced in large quantities in tropical and subtropical countries and warm-water facilities in Europe. This species is often misidentified as *O. niloticus* or *Sarotherodon galilaeus*, and hybrids between these three species have been recorded in the wild. Hybrids between *O. aureus* and *O. niloticus* are produced for aquaculture.

Further reading. Trewavas 1983 (description, biology); Freyhof et al. 2020 (distribution in Saudi Arabia).

How to eliminate females in tilapias? In *Oreochromis*, males exhibit faster growth and greater uniformity in size than females. Consequently, the farming of monosex fish, which is achieved through manual sexing, direct hormonal sex reversal, hybridisation, or genetic manipulation, has been proposed as a solution to the problem of early sexual maturation and unwanted reproduction. Hybridisation between various species of *Oreochromis* typically results in fertile all-male hybrids. Despite these developments, hybridisation did not effectively solve the problem of unwanted reproduction. This is mainly due to the difficulty of sustaining all-male hybrids' production. This is most likely caused by insufficient care in keeping the broodstock segregated by sex and species and preventing the introduction of hybrids into the broodstock ponds. The masculinisation of the entire tilapia population through hormonal sex reversal by the addition of steroids to the food for a short period during the fry stage has been demonstrated to be an easily applied and relatively consistent technique for producing nearly all-male populations. However, this technique has yet to be fully accepted in some countries due to environmental and social constraints. For example, the effects of the degradation products of synthetic androgen on the environment still need to be fully understood in fish. A recently developed technique for obtaining monosex populations is the production of "supermales" through genetic manipulation. In a breeding program in *O. niloticus*, a technology was developed that produces genetically male tilapia with an average sex ratio of >95 % male and a 40 % increase in yield (GMT®). This combines hormonal feminization of male fry, which are then crossed to normal (XY) males, producing ¼ XX, ½ XY, and ¼ YY. Males with the YY genotype only produce male (XY) offspring in crosses with normal females (XX). **Further reading.** Mair et al. 1997 (sex ratio); Eknath & Acosta 1998 (genetic methods); Guerrero & Guerrero-del Castillo 2002 (Tilapia farming).

Oreochromis mossambicus; aquarium stock, Germany; mouth-brooding female, ~150 mm SL. © A. Spreinat.

Oreochromis mossambicus; aquarium stock, Germany; nuptial male, ~200 mm SL. © A. Spreinat.

Oreochromis mossambicus

Common name. Mozambique tilapia.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● nuptial male black or dark-grey with whitish lower part of head / ● snout duck-bill-like elongated in male larger than 200 mm SL / ○ orange or red dorsal- and caudal margins in nuptial male / ○ tip of membrane between dorsal spines orange or red / ○ caudal with small spots or blotches not forming regularly shaped and set bars / ○ all flank scales with dark-grey scale pockets in preserved individuals, dark-grey scales pockets never organised in fields / ○ center of flank scales above lateral midline, sometimes also below, darker than scale pockets / ○ anterior processes of lower pharyngeal bone clearly projecting beyond anterior margin of toothed pads / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 350 mm SL.

Distribution. Introduced in Saudi Arabia (details unknown) and in Yemen, locally introduced in UAE but not recorded from Oman. A non-native population in Algeria. Native to lower Zambezi, lower Shire, and coastal plains from Zambezi Delta to Algoa Bay. Occurs south to rivers in Eastern Cape and Transvaal to Limpopo. Widely introduced beyond this range into inland areas and south-western and western coastal rivers, including lower Orange River and rivers of Namibia. Introduced for aquaculture, escaped and established in tropical countries worldwide.

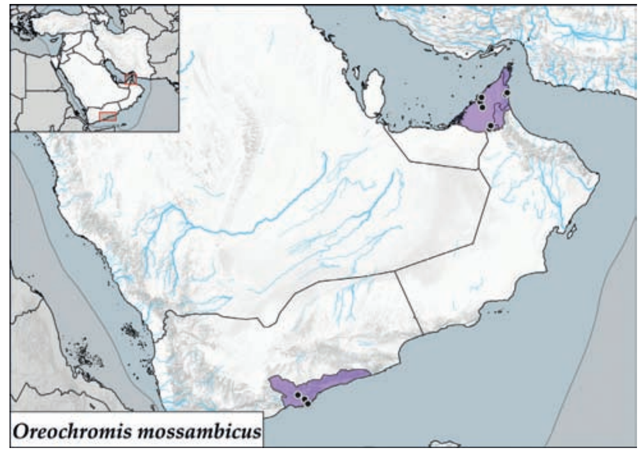
Habitat. Various standing and slow-flowing waters include coastal lakes, lowland rivers, streams, drains, reservoirs, and marshes, usually over muddy bottoms, often in well-vegetated areas. Fresh to marine waters, can survive in hypersaline waters. Spawns only in fresh and brackish waters of low salinity, along shorelines in stagnant or slow-flowing waters, and on sandy or muddy bottoms.

Biology. Lives up to 11 years. Females usually begin spawning at about 120 mm SL, but in dense populations, at 60–70 mm SL and about 2 months. Territorial males excavate and defend a basin-shaped burrow in center of their territory, where they spawn with females. Often forms leks in dense colonies. Females only visit pits to spawn. Male actively courting female to nest in pit. Territorial males produce sounds during all stages of courtship, but especially during late stages, including spawning. Subordinate males without territory may adopt pseudo-female behaviour and sneak into nests during spawning. Female lays 100–1700 eggs in multiple portions. Female take eggs in their mouths as they are laid, before, during, or after fertilisation. No permanent pair bond formed; females incubate eggs alone while males court other females. Females may spawn a full clutch with one male or several males in a series so that siblings have different fathers. Females do not feed during brood care or take small food items, some of which are eaten in mouth by juveniles. Water is circulated over eggs by chewing movements of female's jaws. Fry hatch in female's mouth after 3–5 days, depending on temperature. Juveniles are released 10–14 days after spawning. Female guards fry, encouraging them to enter her mouth if threatened, for about 3 weeks. Juveniles swarm in shallow water and feed during day, retreating to deeper water at night. Females produce several broods in a season. Non-spawning individuals, as well as mouth-brooding females, gregarious along shores. Can tolerate temperatures ranging from 8 to 42°C; natural temperature range is 17–35°C. Tolerates low dissolved oxygen levels and utilises atmospheric oxygen when aquatic oxygen levels drop. Omnivorous, feeds mainly on algae and phytoplankton.

Conservation status. Non-native; released for mosquito control. NT in its native range, threatened by hybridisation with non-native *Oreochromis niloticus*.

Remarks. While this species was of great importance in aquaculture and is one of the best-studied freshwater fishes in the world, it is now largely replaced by *O. niloticus* and *O. aureus*.

Further reading. Crass 1964 (biology); Pienaar 1978 (biology); De Silva & Chandrasoma 1980 (reproduction); Pullin & Lowe-McConnell 1982 (biology, reproduction); Gregg et al. 1998 (hybridisation); Fuselier 2001 (ecological impact of invasion); Skelton 2001 (native distribution, biology); Allen et al. 2002 (habitat choice in Australia); Amorim et al. 2003 (sound production).



Wadi Bani Khalid in Oman is full of non-native Taiwanese red tilapia.

Oreochromis niloticus; Fossa Calda, Italy; ~200 mm SL.

Oreochromis niloticus

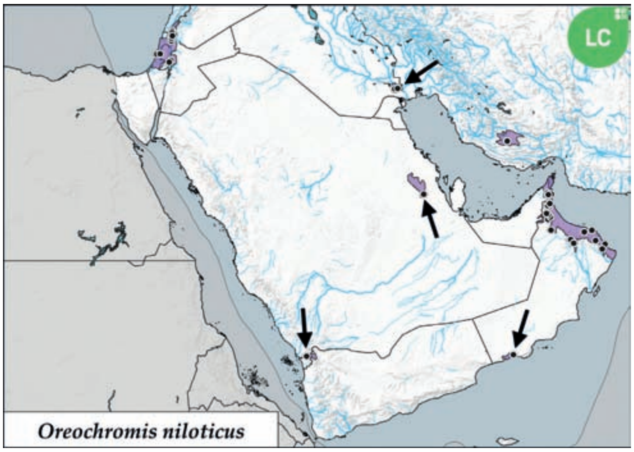
Common name. Nile tilapia.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● 3–40 dark-grey to black, regularly shaped and set vertical bars on caudal (number increasing with size) / ○ usually all flank scales with dark-grey scale pockets in preserved individuals, dark-grey scales pockets never organised in fields / ○ tip of membrane between dorsal spines black or grey / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ● nuptial male whitish with pink anterior body and caudal / ○ snout not duck-bill-like elongated in male larger than 150 mm SL / ○ anterior processes of lower pharyngeal bone clearly projecting beyond anterior margin of toothed pads / ○ chest never red / ○ 19–25 gill rakers on lower part of first branchial arch / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 395 mm SL.

Distribution. Widely introduced in Oman, UAE, Saudi Arabia, and Yemen, but many might be Taiwanese red tilapia. Also introduced in North Africa, Jordan, Orontes, Iran, and Iraq. Native to Nile drainage (including Lakes Albert, Edward, and Tana), Jebel Marra, Lakes Kivu, Tanganyika, Awash, and Omo, various Ethiopian lakes, Lake Turkana, Suguta, and Lake Baringon. Also native to West Africa in Senegal, Gambia, Volta, Niger, Benue, and Chad drainages. Widespread introduction for aquaculture in other parts of Africa, Europe, and tropical countries worldwide.

Habitat. Lakes, backwaters, and slow-flowing rivers. Very common in reservoirs, canals, and other artificial water bodies. Spawns along banks in stagnant or slow-flowing water. A freshwater species that does not inhabit brackish water.

Biology. Lives up to 5 years. Matures at 3–6 months or much younger, depending on temperature and food availability. Sexually monomorphic, male larger. Spawns when temperatures exceed 20°C between April and August in North Africa. Begins spawning in February in Lake Nasser (Egypt). Non-spawning individuals are gregarious along banks. Males form territories and dig shallow depressions in sandy or muddy shores to attract females. Nest is a circular depression up to 100 cm in diameter and 50 cm deep, usually twice length of breeding male. Males often builds their nests close together, forming leks. Females only visit nest to spawn. Courtship lasts several hours. Up to 200 eggs are laid in about 20 portions over 45–120 minutes. Eggs are picked up and placed in mouth by female as they are laid, before, during, or after fertilisation. No permanent pair bond; females incubate eggs alone while males court other females. Females may lay a full clutch with one male or several males in a series so that siblings have different fathers. Females do not feed during brood care or take small items of food, some of which are eaten in mouth by young. Water is circulated over eggs by chewing movements of female's jaws. Females spawn several times during summer, often once a month. Females hold eggs and larvae in their



mouths for about 20 days and guard-feeding juveniles for up to 2 weeks. Expanded temperature range: 8–42°C; natural temperature range: 13–33°C. Juveniles are omnivorous; juveniles and adults feed mainly on planktonic and epilithic blue-green algae, diatoms, and macrophytes.
Conservation status. Non-native; LC in its native range; released or escaped from fish farms. It significantly impacts native fish due to its dense population and competition for habitat and food; its nesting activity and territorial behaviour disturb habitat and spawning grounds. International and national agencies that promote its stocking largely ignore these negative impacts. Globally, *O. niloticus* is the most important tilapia species in aquaculture and also supports major capture fisheries where it is established. It is highly invasive and is known to hybridise with many other *Oreochromis* species. For this reason, further stocking has been banned in several countries, including South Africa, Malawi, and Zambia.

Remarks. This species is important for aquaculture worldwide and is cultivated in many countries, and escapes are expected elsewhere. Several records of *O. niloticus* from Türkiye are unconfirmed and all these records have been identified as *O. aureus*.
Further reading. Pullin & Lowe-McConnell 1982 (biology); Trewavas 1983 (description, biology). Siddiqui & Al-Harbi 1995 (hybrid tilapias in Saudi Arabia).

Sarotherodon

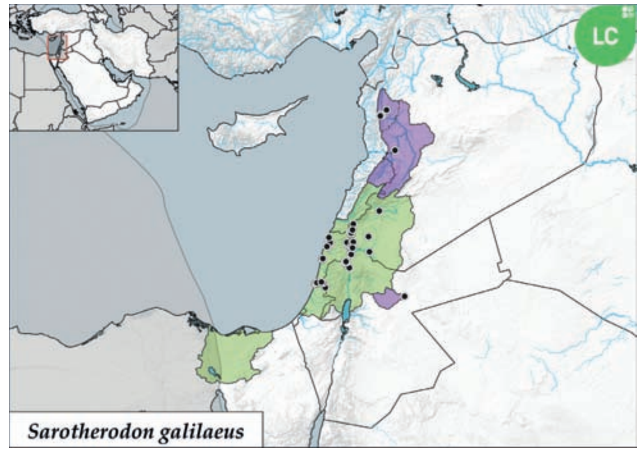
Sarotherodon comprises approximately 25 species of mouth-brooding tilapias, all but one of which are endemic to West and Central Africa. Of particular interest is the adaptive radiation of 11 closely related species in Barombi Mbo, a crater lake in Cameroon. This represents one of the most spectacular examples of sympatric speciation. It appears that *Sarotherodon* is paraphyletic, with several new generic names expected to be described. It is unlikely that *S. galilaeus* will remain in that genus. Alternatively, several other genera of mouth-brooding tilapias, including *Iranocichla*, *Oreochromis*, and *Tristramella*, might become synonyms of *Sarotherodon*. However, no conclusive phylogenetic concept has been proposed until now. Furthermore, *S. galilaeus* appears to have been largely introgressed by *Oreochromis aureus*, indicating that both species have undergone extensive hybridisation in the past. Additionally, there is a high genetic diversity within *S. galilaeus*, particularly in West and Central Africa. Consequently, a critical taxonomic revision of this species is required. **Further reading.** Trewavas et al. 1972; Schliewen et al. 1994 (Barombi Mbo); Dunz & Schliewen 2013 (phylogeny).

Sarotherodon galilaeus; Orontes drainage, Syria; ~150 mm SL.

Sarotherodon galilaeus

Common name. Mango tilapia.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● anterior processes of lower pharyngeal bone not or very slightly projecting beyond anterior margin of toothed pads / ○ flank scales without dark-grey scale pockets in preserved individuals, isolated black scales pockets, or fields of black scale pockets in some individuals / ○ nuptial male pale-grey or pinkish white without white spots or vermiculation on flank / ○ no red or orange colour in life / ○ often with black bars on flank / ○ caudal almost without pattern / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 20–27 gill rakers on lower part of first branchial arch / ○ chest never red / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 320 mm SL.



Distribution. Native to Jordan drainage and coastal rivers Yarkon, Kishon, and Na'aman in Israel. Introduced in Orontes and Syrian part of Euphrates. Native to Congo, Nile drainage including Lakes Albert and Turkana. Also in Lake Chad basin, Borkou in Chad, Ubangui and Ulele, Adar in Mauritania, and West African rivers from Senegal to Guinea, Volta, Niger, and rivers between them and Sanaga in Cameroon.

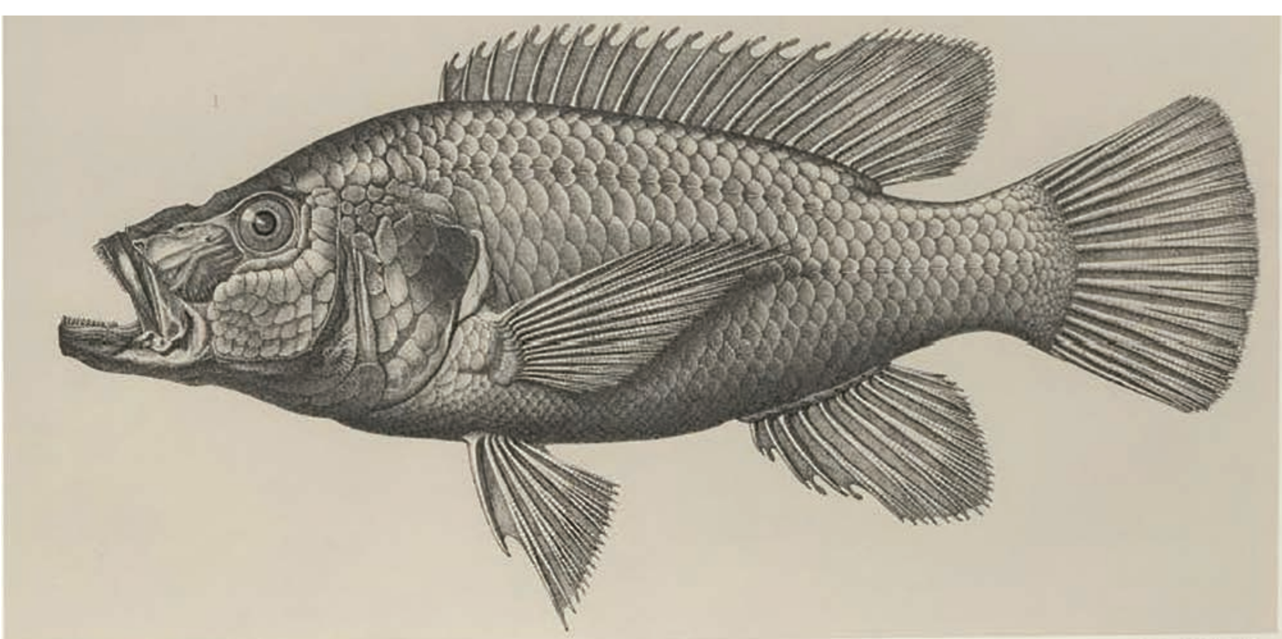
Habitat. Slow-flowing rivers, backwaters, lakes, and coastal lagoons. Often pelagic and very common in reservoirs. Can live in brackish water to at least 20 ‰. Cannot survive if water temperature falls below 10°C for over a few days.

Biology. Live up to 7 years. Usually matures after second winter at about 130–220 mm SL. Sexually monomorphic male over 2 years with slightly larger and longer unbranched dorsal and anal rays. Pairs for a few days to 2 weeks before spawning. Spawns in Lake Kinneret late March–August, each female usually produces two or more clutches. Pair digs a shallow nest. Eggs are laid in batches of 20–40, each batch fertilised by male as it is laid. Eggs remain in nest in clutches. In undisturbed conditions, all eggs laid in nest are taken into mouth by male, female, or both parents after hatching. If predators are present, each batch is taken immediately after fertilisation. Pair bond is broken after spawning. Commitment to brood care by males depends on availability of mature females. Parents release fry after about 14 days and usually do not care for them. Feeds mainly on phytoplankton, including cyanobacteria, epiphytic algae, and detritus.

Conservation status. LC; massively stocked in Lake Kinneret for commercial fisheries.

Remarks. Reports from the Oued Draa drainage in southern Morocco are based on misidentified *O. aureus*.

Further reading. Trewavas 1983 (description, biology); Goren & Ortal 1999 (distribution).



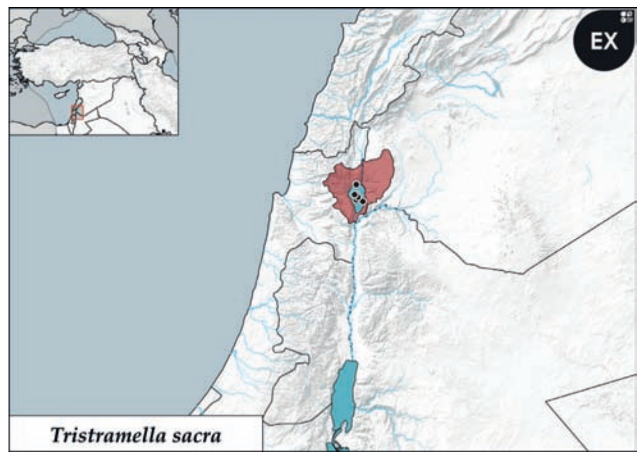
Tristramella sacra; Lake Kinneret, Israel; modified from Lortet 1876.

Tristramella

Tristramella, which is endemic to the Levant, comprises only two species. Phylogenetic analysis suggests that *Tristramella* is related to *Iranocichla*. Some authors have proposed that *T. magdalenae* from the Damascus basin and *T. intermedia* from Lake Hula basin should be considered distinct species. However, we could not identify distinguishing characteristics that would allow us to differentiate these from *T. simonis*. Consequently, we have treated them as conspecific. Both populations and *T. sacra* are extinct. Both species are mouthbrooders, but the details of their breeding behaviour have not been described. There is some doubt whether *T. sacra* should be recognised as a species distinct from *T. simonis*, given that large nuptial male *T. simonis* also have a strongly projecting lower jaw. It would be beneficial to re-examine the original materials of both species to test whether *T. sacra* represents a valid species. **Further reading.** Steinitz & Ben-Tuvia 1960 (revision of genus); Dunz & Schliewen 2013 (phylogeny).

Tristramella sacra

Common name. Long jaw Tristramella.
Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● lower jaw strongly projecting / ● all teeth conical / ○ nuptial male pale-grey or pinkish white without white spots or vermiculation on flank / ○ chest never red / ○ 13 gill rakers on lower part of first branchial arch / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 320 mm SL.
Distribution. Israel: Lake Kinneret.
Habitat. Lacustrine.
Biology. Spawns in April–July. Paternal mouthbrooders. Feeds on zooplankton and small fish.
Conservation status. Extinct; last seen in 1990, despite research both in lake and local markets. Destruction of breeding habitat (marshes in northern part of lake) may be reason for its extinction.
Further reading. Krupp & Schneider 1989 (identification, distribution).



Tristramella simonis; Jordan drainage, Syria; ~90 mm SL.

Tristramella simonis; Lake Kinneret, Israel; ~200 mm SL. © Y. Oksman.

Tristramella simonis

Common name. Short jaw Tristramella.

Diagnosis. Distinguished from other species of Cichlidae in West Asia by: ● lower jaw slightly projecting / ○ outer teeth bicuspid, inner teeth tricuspid / ○ chest never red / ○ nuptial male pale-grey or pinkish white without white spots or vermiculation on flank / ○ 10–12 gill rakers on lower part of first branchial arch / ○ chest, belly, and isthmus in front of pelvic covered by small scales / ○ 3 anal spines / ○ scales cycloid / ○ no ocelli on anal. Size up to 250 mm SL.

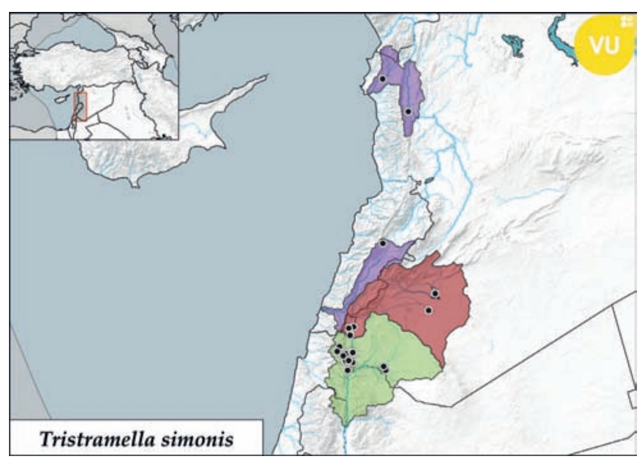
Distribution. Jordan drainage: Lakes Muzayrib (Syria), Hula and Kinneret (Tiberias) (both in Israel), Dara'a reservoir and a canal at Al Asha'ari (Syria), Damascus basin, and Lake Hula. Non-native in Orontes and Nahr al Kabir (Syria).

Habitat. Lakes, reservoirs, springs, and spring-fed streams and canals.

Biology. Spawns March–August. Maternal mouthbrooder or both partners participate in brooding. Feeds on phytoplankton and invertebrates.

Conservation status. VU; extirpated from Hula due to drainage of this wetland and extirpated from Damascus basin due to drying up of lakes it inhabited. Apparently stable in Kinneret. Probably declining outside Lake Kinneret, but inhabiting reservoirs and invasive in Syria.

Further reading. Goren 1974 (distribution); Borkenhagen & Freyhof 2009 (distribution).



Brackish rivers in southern Iran are the habitat of *Iranocichla* species.

The promise and paradox of using artificial intelligence in ichthyology. In a time when artificial intelligence (AI) is reshaping almost every field, ichthyology cannot remain untouched. As in all other disciplines, it presents a double-edged sword, offering powerful new tools while raising complex challenges. AI's capabilities in pattern recognition and data analysis can totally change how we identify species, automate literature reviews, improve ecological modelling, and even help us discover hidden biodiversity by detecting patterns in genes and morphology. Deep learning models can process thousands of specimens with remarkable speed, spot tiny morphological differences invisible to the human eye, and predict species distributions under climate change scenarios. AI can also speed up phylogenetic reconstructions and help to reveal hidden biodiversity in large, under-explored datasets. But, as with anything new, there are risks. Over-reliance on AI-generated identifications without expert validation may introduce and propagate systematic errors. Many algorithms operate as opaque “black boxes,” which makes it hard to understand and doesn't meet the standards of scientific rigour. AI models trained on biased or incomplete datasets can end up making existing taxonomic gaps worse, and this can have a bigger effect on rare or understudied species. Importantly, blind trust in AI threatens to deskill young taxonomists and diminish the value of foundational expertise in morphology, ecology, and evolution—a paradox where technological advancement could weaken the scientific foundation it aims to strengthen. So, recognising this risk calls for a balanced perspective. Further points for consideration could include the following: the potential for the development of standards with which to evaluate and verify AI-driven decisions in the context of taxonomy and conservation. The question of responsibility in the curation of training data and the crediting of AI-assisted contributions is a critical issue. Of equal concern is the potential for AI to produce entire research publications, which could overwhelm scientific literature with unverified content and erode the standards of peer review. The future of ichthyology will not be defined by algorithms alone, but by the wisdom with which we choose to use them.