

Family Acheilognathidae

Bitterlings

A family that includes about 75 species placed in seven genera distributed mostly in East Asia. Bitterlings are deep-bodied, compressed, and small-sized fishes. Males have plates bearing tubercles on the snout. All species have a complex reproduction cycle involving mussels. The female has a long, flexible ovipositor, which she inserts into the mussel's exhalant siphon to deposit a few eggs. The diversity of *Rhodeus* in West Asia and Europe is likely overestimated. All populations are very closely related, and external characters distinguish only *R. colchicus*. The most comprehensive phylogenetic analyses identified six different molecular groups of populations. These include *R. colchicus* (eastern Black Sea basin), *R. caspius* (southern Caspian basin), *R. meridionalis* (Vardar & Pinios in Greece

and North Macedonia), *R. amarus* (Europe from east to Elbe drainage, Black Sea basin). Two additional lineages occur, one in the Danube, the Ionian Sea basin, and Central Europe west of the Elbe drainage, and a last one in the Strymon and a few adjacent rivers in the northern Aegean basin. The phylogenetic structure of these six clades is poorly supported. Therefore, *R. colchicus* might be the sister group of all other western Palearctic bitterlings. This would mean that all these populations can be identified as *R. amarus*, as they are closely related and not distinguished by morphological characters. However, a consensus on the species status of *R. colchicus* has not yet been reached. Thus, we retain *R. amarus*, *R. caspius*, and *R. colchicus* as separate species in West Asia. **Further reading.** Arai & Akai 1988 (systematics); Okazaki et al. 2001 (genetics); Liu et al. 2006 (host specificity); Bartáková et al. 2019 (phylogeny).



Rhodeus amarus; oviposition; Danube drainage, Germany; male (left) and female (right, with ovipositor), ~50 mm SL. © A. Hartl.



Rhodeus amarus; Odra drainage, Germany; female, ~45 mm SL.



Rhodeus amarus; Sakarya, Türkiye; male, ~60 mm SL.

Rhodeus amarus

Common name. Bitterling.

Diagnosis. Distinguished from *R. colchicus* by: ● second infraorbital bone narrow ● 35–38, usually 36–37, total vertebrae / ● 34–41, usually 36–40, scales in lateral series. No morphological character known to distinguish from *R. caspius*. Size up to 95 mm SL.

Distribution. Marmara and Black Sea basins (except easternmost) and all rivers draining into Aegean south to Büyük Menderes. Very widespread and invasive in Europe, where it is native in northern Aegean basin west of Nestos. Widespread from France to Volga, in southern Russia in Don and Kuban drainages, Crimea, Great Britain, north of Italy, and possibly elsewhere. Suspected to be native only to middle and lower reaches of Black Sea tributaries and Aegean basin.

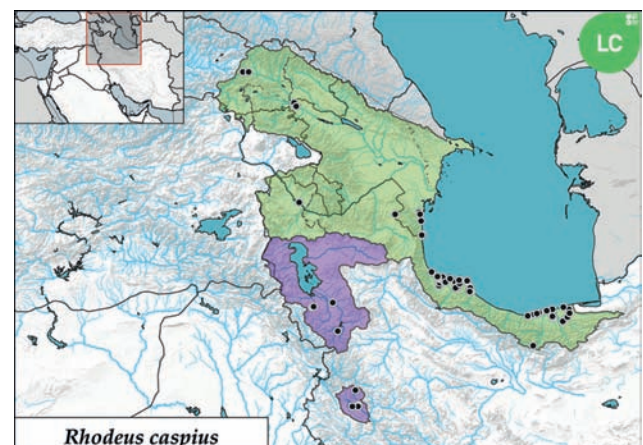
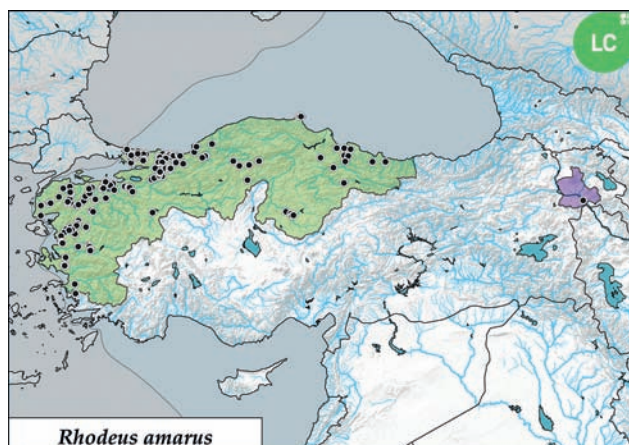
Habitat. Still or slow-flowing waters with dense aquatic vegetation and sandy-silt bottoms, such as lowland ponds, canals, streams, rivers, backwaters, and oxbows where mussels are present. Often in artificial waterbodies, rare in fast-flowing habitats.

Biology. Spawns first time at 1 year and about 30–35 mm SL. Exceptionally lives up to 5 years, but most individuals do not survive year of first reproduction, and population sizes might fluctuate greatly over years. Spawns April–August at water temperatures above 15°C. Males defend small territories around one or a few bivalves (mostly *Unio* spp.), moving with bivalves. Females select bivalves with high oxygen concentrations in exhalation siphon. Avoid bivalves that already contain high numbers of *R. amarus* larvae or are gravid with glochidia (bivalves' own larvae). Also, avoid *Anodonta cygnea*, which can expel most eggs and larvae and usually has low oxygen concentrations in its exhalation siphon. Males display pre-oviposition ejaculation when females inspect or approach mussel. When a female is ready to spawn, she extends ovipositor and muscular conical structure at its base. A batch of eggs is positioned at basal opening

of ovipositor, behind which urine collects. She then pushes cone into mussel's siphon. The cone contracts, and urine, under pressure, forces eggs through ovipositor. Oviposition is a rapid process. At same time, male releases sperm into inhalant siphon. After spawning, sneaking males attempt to fertilise eggs. Females typically lay 80–250 eggs yearly, spawning up to five times per season. Eggs are oval, about 2.5–3.0 mm long, and are incubated within gill chamber of mussel. Yolk sac has lateral outgrowths, which allow larvae to attach to mussel's gills. After 20–30 days, feeding larvae leave mussel. Larvae show adaptations to very low oxygen concentrations in mussels, such as very rapid hatching (36 h) and enlarged skin respiratory system. Wing-like yolk projections hold larvae in mussel's gills. Bitterlings and mussels have a parasitic relationship. Mussels suffer a reduction in fitness when carrying *R. amarus* larvae. Larvae and mussels compete for oxygen, and larvae appear to inhibit free water circulation through mussel gills, which may damage them. Bitterlings are rarely infested by glochidia (ectoparasitic mussel larvae). Feeds mainly on algae, diatoms, and other plant material. Frequently translocated, bred, and used for human pregnancy testing before development of modern techniques, resulting in numerous introductions. Females injected with a pregnant woman's urine protrude their ovipositor. Has spread since Middle Ages and is widely introduced with carp stocked from fish farms inhabited by bitterlings. Warm-water species expanding its range due to climate change.

Conservation status. LC; abundant and expanding throughout most of its range. A major invasive species in Europe.

Further reading. Abdurakhmanov 1962 (morphology, biology); Holčík & Jedlička 1994 (morphology); Kottelat 1997 (systematics); Holčík 1999 (biology); Bogutskaya & Komlev 2001 (morphology); Smith et al. 2004 (reproduction); Bohlen et al. 2006 (genetics); Van Damme et al. 2007 (invasion); Bartáková et al. 2019 (phylogeny).





Rhodeus caspius; Lenkoran, Azerbaijan; male, ~45 mm SL.

Rhodeus caspius

Common name. Caspian bitterling.

Diagnosis. Distinguished from *R. colchicus* by: ● second infraorbital bone narrow / ○ 35–36 total vertebrae / ● 34–37 scales in lateral series. No morphological character known to distinguish from *R. amarus*. Size up to 60 mm SL, likely to grow larger.

Distribution. Caspian basin from Kura east to Gorgan (Iran). Introduced to Lake Urmia basin, upper Karkheh in Iran, and possibly elsewhere. Distribution in northern Caspian unknown.

Habitat. Slow-flowing streams and small rivers, backwaters, ponds, and lakes, usually with dense underwater vegetation and sand-silt substrate.

Biology. Spawns April–September. Mating and spawning Behaviour similar to *R. amarus*. Larvae incubated by *Unio* bivalves. Feeds on algae, benthic insect larvae, and planktonic crustaceans.

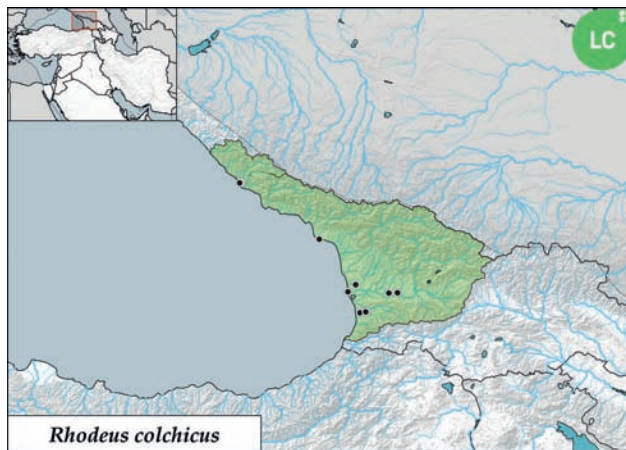
Conservation status. LC.

Remarks. Diagnostic character proposed to distinguish this species from *R. amarus* could not be confirmed.

Further reading. Bartáková et al. 2019 (phylogeny); Esmaeili et al. 2020a (description).



Eggs of *Rhodeus* in the gills of a *Unio* mussel. © M. Reichard.





Rhodeus colchicus; Sochi, Russia; ~65 mm SL.

Rhodeus colchicus

Common name. Georgian bitterling.

Diagnosis. Distinguished from other species of *Rhodeus* in West Asia by: ● second infraorbital bone wide / ● 33–36, usually 34–35, total vertebrae / ● 30–38, usually 33–35, scales in lateral series. Size up to 81 mm SL.

Distribution. Caucasian Black Sea basin of Russia from Kherota south to Natanebi in Georgia.

Habitat. Slow-flowing streams and small rivers, backwaters, ponds, and lakes, usually with dense underwater vegetation and sand-silt substrate.

Biology. Spawns April–September. Mating and spawning behaviour similar to *R. amarus*. Larvae incubated by *Unio* bivalves. Feeds on algae, benthic insect larvae, and planktonic crustaceans.

Conservation status. LC; frequent and widespread within its small range.

Further reading. Elanidze 1983 (morphology, biology); Bogutskaya & Komlev 2001 (description); Bohlen et al. 2006 (phylogeography); Bartáková et al. 2019 (phylogeny).



Stream in Lake Sapanca basin, Türkiye. A typical habitat of *Rhodeus amarus*.