

Bitterling (*Rhodeus sericeus*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, December 2019
Revised, December 2019
Web Version, 3/18/2021

Organism Type: Fish
Overall Risk Assessment Category: Uncertain



Photo: G. Chernilevsky/USGS. Public domain. Available:
<https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=643>. (November 19, 2019).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2019a):

“Asia. Amur basin and Sakhalin Island, Russia.”

“[In China,] Amur basin and Lake Khanka. Distributed in the Heilong River [=Amur River] [Institute of Hydrobiology, Academia Sinica, Shanghai Natural Museum and Ministry of Agriculture of China 1993]. Ranges from Inner Mongolia to to [sic] Heliongjiang [Lin 1998].”

“Occurs in Lake Buir and in Rivers Kherlen, Onon, Khalkh and Orshuun [in Mongolia] [Kottelat 2006].”

“Occurs in the entire Amur basin, the Ussuri River, Lake Khanka, rivers flowing into the Sea of Okhotsk up to the Uda River in the north and Sakhalin (the Tym and Poronai rivers [in Russia] [Reshetnikov et al. 1997]. Reported from River Tym, Dnieper and Lake Khasan [Russia] [Bogutskaya and Komlev 2001].”

Froese and Pauly (2019a) also list *Rhodeus sericeus* as native to South Korea.

Froese and Pauly (2019a) state that records of *R. sericeus* from Belarus, Belgium, Czech Republic, Denmark, France, Germany, Greece, Hungary, Latvia, Lithuania, Moldova, Netherlands, Poland, Romania, Serbia, Slovakia, Switzerland, Ukraine, and Uzbekistan are misidentifications of the congener *R. amarus*. See Remarks, below, for a discussion of the history of taxonomic confusion between the two species.

Froese and Pauly (2019a) state that *R. sericeus* is native to Iran and Kazakhstan but according to Bogutskaya and Komlev (2001) those areas are considered part of the native range for the European bitterling (*R. amarus*).

Status in the United States

According to Nico and Fuller (2019), the introduction to the Sawmill River was recorded as *Rhodeus amarus*. While other authors have used the name *R. sericeus* to refer to the introductions in the Sawmill and Bronx rivers (e.g. Schmidt et al. 1981; Smith and Lake 1990; Schofield et al. 2005 (below)) based on information originally published about those introductions (Dence 1925; Meyers 1925; Greely 1936) and the taxonomic history of *R. amarus* and *R. sericeus* (see Remarks, below for more discussion) this screening treats the introductions in the Sawmill and Bronx rivers in New York as introductions of *R. amarus*. They are mentioned in this ERSS due to the history of taxonomic confusion and for completeness of information but those records will not be used in assessing the history of invasiveness or climate match for *R. sericeus*.

From Schofield et al. (2005):

“The only known introductions of Bitterling [*Rhodeus sericeus* and *R. amarus* treated as same species using *R. sericeus*] into the U.S. were in the state of New York. The species was introduced into the Sawmill and Bronx rivers sometime before 1925 (Dence, 1925; Myers, 1925). No Bitterling have been collected in the Sawmill River since 1951, and that population is assumed to be extirpated (Schmidt and others, 1981). In the early 1980s, the Bronx River population was estimated to number only about 900 individuals and inhabit 1-2 km of the river (Schmidt and McGurk, 1982). Although native mussels (needed for reproduction) still occur in the Bronx River, the population of Bitterling appears to be declining (R. Schmidt, personal commun., 2005; J. Rachlin, personal commun., 2005).”

No records of *Rhodeus sericeus* for sale within the United States were found. However, a listing for a bitterling assortment, described as *Rhodeus* sp., was found for sale (LiveAquaria 2019).

Rhodeus sericeus is on Hawaii's Conditional Animal List (Hawaii Department of Agriculture 2019).

Rhodeus sericeus falls within Group I of New Mexico's Department of Game and Fish Director's Species Importation List (New Mexico Department of Game and Fish 2010). Group I species "are designated semi-domesticated animals and do not require an importation permit." Species within family Cyprinidae have the additional restriction of "Not to be used as bait fish."

Rhodeus sericeus is on Ohio's Injurious Aquatic Invasive Species list (Ohio DNR 2020). "Under Ohio Administrative Code 1501:31-19-01, it shall be unlawful for any person to possess, import or sell live individuals of the species listed below. With the exception of White Perch, the species listed below must be headless, preserved in ethanol or formaldehyde, or eviscerated (internal organs removed)."

Means of Introductions in the United States

No records of *Rhodeus sericeus* introductions in the United States were found. The means of introduction for the introductions of the closely related *R. amarus* in New York was through ornamental trade (Meyers 1925; FAO 2019).

Remarks

This ERSS was previously published in June 2015. Revisions were done to incorporate new information and to bring the document in line with current standards.

There is considerable confusion around the taxonomy of *R. sericeus*. *Rhodeus sericeus* is commonly confused with *Rhodeus amarus* or sometimes considered the same species. However, the current valid taxonomy considers them two separate species, primarily due to a wide geographic gap between European and East Asian ranges of bitterling. This assessment considers *R. sericeus* as having a native range within East Asia, following the most recent accepted taxonomy. However, much of the literature refers to *R. sericeus* as the bitterling whose native range spans throughout parts of Europe or as having a range extending from Europe to East Asia. When a discrepancy like this appears in the literature used for this assessment, an explanation is provided above the corresponding quotation referring the reader to this section for more detail. To the best of the author's ability this assessment only includes information pertaining to *R. sericeus* with a native range in East Asia, conforming to current valid taxonomy. The following quotations within this section will provide more information on the history of the taxonomic naming of bitterlings.

From Smith et al. (2004):

"The classification of the European bitterling has been problematic, because of its discontinuous distribution across its range. In the west of its distribution, it is found in Europe and Asia Minor. In the east, bitterling are reported from the River Amur system [forming the border of the Russian Far East and China], Sakhalin Island and rivers emptying into Peter the Great Bay and Sea of Japan (Holčík, 1999). Western populations are sometimes considered a separate species, *R. amarus* Bloch, distinct from the eastern *R. sericeus*. The western species was later reduced to a subspecies of the eastern, with the designation *R. sericeus amarus* (Bloch) (Svetovidov &

Eremeev, 1935). However, Holčík & Jedlička (1994) demonstrated that the characters used to separate the eastern and western species/subspecies were size and temperature dependent and could not be reliably used to separate the two, reverting to the designation *R. sericeus* for both the eastern and western populations. In a recent review of the taxonomy of European freshwater fish, Kottelat (1997) re-classified the western bitterling as *R. amarus*, but without clear justification.”

From Bogutskaya and Komlev (2001):

“The Amur common bitterling was described as *Cyprinus sericeus* by Pallas (1776) from River Onon (Upper Amur system) and the European bitterling, *Cyprinus amarus*, some years later by Bloch (1782) from River Elbe. They were considered to be close or conspecific by many authors, for example, Dybowski (1869, 1877) and Warpachowski (1887). The study by Svetovidov and Eremeyev (1935) showed that European and Asian bitterlings are slightly different in some characters and proposed to give them a rank of subspecies of one and the same species. According to their data, *Rhodeus sericeus sericeus* is characterized by *D* III 9, 10 (11); *A* III 8-10; *sq. l.* 36-40; *l. l.* 5-10 (on the average 6.58), while *Rhodeus sericeus amarus* has a lower number of pored scales (*l. l.* 4 to 6, averaging 5.24) as well as a slightly longer and deeper head and a longer caudal peduncle. Besides these, Svetovidov and Eremeyev (1935) considered *Rhodeus sinensis* Günther, 1868 to be a subspecies of *R. sericeus* which is only different in having a wider 3rd infraorbital bone.”

“*Rhodeus sericeus* and *R. amarus* are treated again as distinct species by Kottelat (1997) since the European [*sic*] and East Asian stocks are unarguably distinct lineages separated for an estimated 2 to 4 million years (data from Holčík, Jedlička, 1994) by 4000 km. Having based on data of these authors, Kottelat considered them to be diagnosable by modal values of lateral line pored scales (4-6 in *R. amarus* vs. 6-7 in *R. sericeus*, ranges 0-9 and 4-10 respectively) and gill-rakers (10-12, vs. 12-14; ranges 9-13, vs. 9-16). The author realizes that the differences between the two stocks are slight but, to his opinion, when taken together with the huge geographic distance they give enough reason for considering both stocks as two species under the Phylogenetic Species Concept.”

From Bohlen et al. (2006):

“The reconstruction of the phylogenetic relationships of bitterlings from the EMZS (European-Mediterranean zoogeographic subregion) and the Amur basin revealed that the bitterlings from the Amur form the sister-clade to all bitterlings from the EMZS. This finding contradicts the former hypothesis that based on morphological investigations that the populations in East Asia derived from European populations. Our genetic data show four major lineages within the EMZS, indicating the existence of a higher diversity than previously known. We suggest to use [*sic*] for the East Asian populations the scientific name *Rhodeus sericeus*, for the population in the River Vardar in Greece *R. meridionalis*, for the population from River Notabeni in Georgia *R. colchicus* and for the populations from Central and Eastern Europe *R. amarus*.”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Fricke et al. (2019):

“Current status: Valid as *Rhodeus sericeus* (Pallas 1776)”

From ITIS (2019):

Kingdom Animalia

Subkingdom Bilateria

Infrakingdom Deuterostomia

Phylum Chordata

Subphylum Vertebrata

Infraphylum Gnathostomata

Superclass Actinopterygii

Class Teleostei

Superorder Ostariophysi

Order Cypriniformes

Superfamily Cyprinoidea

Family Cyprinidae

Genus *Rhodeus*

Species *Rhodeus sericeus* (Pallas, 1776)

Size, Weight, and Age Range

From Froese and Pauly (2019a):

“Maturity: L_m ?, range 3 - 4 cm

Max length : 11.0 cm TL male/unsexed; [Page and Burr 1991]; max. reported age: 5 years [Gerstmeier and Romig 1998]”

Environment

From Froese and Pauly (2019a):

“Occurs in ponds, lakes, marshes, muddy and sandy pools and backwaters of rivers [Page and Burr 1991]”

“Freshwater; benthopelagic; pH range: 5.8 - 6.3; dH range: 2 - 3; potamodromous; [...] 18°C - 21°C [assumed to be recommended aquarium temperature; Riehl and Baensch 1991]; [...]”

Climate

From Froese and Pauly (2019a):

“Temperate; [...]; 60°N - 35°N, 5°W - 145°E”

Distribution Outside the United States

Native

From Froese and Pauly (2019a):

“Asia. Amur basin and Sakhalin Island, Russia.”

“[In China,] Amur basin and Lake Khanka. Distributed in the Heilong River [=Amur River] [Institute of Hydrobiology, Academia Sinica, Shanghai Natural Museum and Ministry of Agriculture of China 1993]. Ranges from Inner Mongolia to to [sic] Heliongjiang [Lin 1998].”

“Occurs in Lake Buir and in Rivers Kherlen, Onon, Khalkh and Orshuun [in Mongolia] [Kottelat 2006].”

“Occurs in the entire Amur basin, the Ussuri River, Lake Khanka, rivers flowing into the Sea of Okhotsk up to the Uda River in the north and Sakhalin (the Tym and Poronai rivers [in Russia] [Reshetnikov et al. 1997]. Reported from River Tym, Dnieper and Lake Khasan [Russia] [Bogutskaya and Komlev 2001].”

Froese and Pauly (2019a) also list *Rhodeus sericeus* as native to South Korea.

Froese and Pauly (2019a) state that records of *R. sericeus* from Belarus, Belgium, Czech Republic, Denmark, France, Germany, Greece, Hungary, Latvia, Lithuania, Moldova, Netherlands, Poland, Romania, Serbia, Slovakia, Switzerland, Ukraine, and Uzbekistan are misidentifications of the congener *R. amarus*. See Remarks, above, for a discussion of the history of taxonomic confusion between the two species.

Froese and Pauly (2019a) state that *R. sericeus* is native to Iran and Kazakhstan but according to Bogutskaya and Komlev (2001) those areas are considered part of the native range for the European bitterling (*R. amarus*).

Introduced

According to Pagad et al. (2018), *R. sericeus* is reported as introduced to the Russian Federation. No further information was available.

Froese and Pauly (2019a) list an introduction of *R. sericeus* to Ontario, Canada which did not result in an established population.

From Carosi et al. (2017):

“Imported from eastern Asia to Europe in the 1960s, *Rhodeus sericeus* is a small cyprinid species that requires the presence of mussels in which to incubate the eggs to complete its life cycle; this species has rapidly expanded its range of distribution in the Tiber River basin [Italy].”

“*Rhodeus sericeus* and *Rutilus rutilus* established rapidly in the Tiber River basin since their introduction in 2003 and 2004, respectively, although their distribution is currently more

fragmented than is the gudgeon. [...] *Rhodeus sericeus* was present intermittently along the main river channel and in three of its main tributaries: the Chiascio, Nestore and Paglia rivers.”

The FAO (2019) quotations below state that *R. sericeus* was introduced from Europe or “unknown”. These introductions may refer to *R. amarus*, a closely related *Rhodeus* species with a native range throughout Europe, due to confusion around the taxonomy of these two species. See “Remarks” for more information.

From FAO (2019):

“*Rhodeus sericeus* introduced to Italy from Eastern Europe
Date of introduction: 1980s [...]
Status of the introduced species in the wild: Established [...]
The introduced species is established through: Natural reproduction”

“*Rhodeus sericeus* introduced to Croatia from unknown
Date of introduction: Unknown [...]
Status of the introduced species in the world: Probably established [...]
The introduced species is established through: No data”

“*Rhodeus sericeus* introduced to United Kingdom from Europe
Date of introduction: 1920s [...]
Status of the introduced species in the wild: Established [...] The introduced species is established through: Natural reproduction”

Means of Introduction Outside the United States

The FAO (2019) quotations below state that *R. sericeus* was introduced from Europe or “unknown”. These introductions may refer to *R. amarus*, a closely related *Rhodeus* species with a native range throughout Europe, due to confusion around the taxonomy of these two species. See “Remarks” for more information.

From FAO (2019):

“*Rhodeus sericeus* introduced to Italy from Eastern Europe
[...]Reasons of Introduction: 1) unknown [...]”

“*Rhodeus sericeus* introduced to Croatia from unknown
[...] Reasons of Introduction: 1) unknown”

“*Rhodeus sericeus* introduced to United Kingdom from Europe
[...] Reasons of Introduction: 1) unknown”

Short Description

From Froese and Pauly (2019a):

“Dorsal spines (total): 3; Dorsal soft rays (total): 8-10; Anal spines: 3; Anal soft rays: 8 - 10; Vertebrae: 34 – 38”

From Bogutskaya and Komlev (2001):

“The present study confirms the data of some earlier publications on external morphological characters in *R. sericeus sericeus* and *R. sericeus amarus*. Both European and Asian bitterlings have a small subterminal mouth with a horseshoe-like mouth cleft. The lower lip is well developed but not thick, interrupted in the middle. The barbels are absent in all specimens examined.”

“**The lateral line** (*l. l.*) is incomplete. The number of pored scales does not exceed 10 varying [...] from 3 to 9, commonly 5 or 6, in the Asian one.”

“No marked variation was found also in the number of transversal rows of scales: in both forms it ranges between 34 and 41 with modal values from 36 to 40.”

Biology

From Froese and Pauly (2019a):

“Feeds mainly on plant material but also on small larvae of insects. Its occurrence is related to those of the bivalve *Anodonta cygnea* and other freshwater mussels [Billard 1997]. Known for its habit of laying its eggs in the mantle cavity of freshwater mussels [Welcomme 1988]. Reproduction takes place from April to June [Billard 1997].”

“Hides eggs in live invertebrates such as mussels, crabs or ascidians. The female develops a conduit ovipositor by which it deposits its ovules between the gills of the bivalve. The male then comes to deposit its seed close to the respiratory opening of the bivalve; at the interior of which fertilization takes place. The male keeps the eggs and alevins until they leave the refuge. In exchange, the fish rids the bivalve of its parasites [Billard 1997]. The young leave the mussel about 28 days after hatching, having reached a length of about 10 mm [Pinder 2001].”

From Reichard et al. (2006; concerning populations in central Europe):

“The relationship between *R. sericeus* [possibly referring to *R. amarus*] and mussels has popularly been considered mutualistic on the premise that bitterling use mussels as spawning sites, while the mussel benefits by using bitterling as hosts for their glochidia (e.g. Wheeler, 1978). However, recent studies have shown the evidence for a mutualistic relationship to be weak.”

“In the present study, we found experimental evidence for a direct cost to mussels associated with hosting *R. sericeus* [possibly referring to *R. amarus*] embryos. Mussels that hosted *R. sericeus* embryos suffered significantly reduced growth over the entire growing season [...].

Because there is strong evidence across several unionid mussel species (including our study species) that mussel size is positively correlated with fecundity (Bauer, 1994), any reduction in mussel growth will directly translate into a fitness cost. This result demonstrates that *R. sericeus* are parasites of their mussel hosts, at least in Europe.”

Human Uses

From Froese and Pauly (2019a):

“Fisheries: of no interest; aquarium: public aquariums”

A listing for a bitterling assortment, described as *Rhodeus* sp., was found for sale (LiveAquaria 2019).

Diseases

There are no OIE-reported diseases (OIE 2019) recorded for *Rhodeus sericeus*.

Ondračková et al. (2002) list *Rhodeus sericeus* as a host for *Posthodiplostomum cuticola*, which is a causative agent for black spot disease.

From Yamano et al. (2011):

“*Ichthyoxenus amurensis* (Crustacea: Isopoda: Cymothoidae) was found in the body cavity of the Amur bitterling, *Rhodeus sericeus* (Cypriniformes: Cyprinidae), from Primorsky, Russia, in August 2003.”

According to Poelen et al. (2014), *Rhodeus sericeus* can be a host to the following parasites: *Gyrodactylus rhodei* and *Ligula intestinalis*.

Froese and Pauly (2019b) list *R. sericeus* as a host for *Ergasilus briani*, *E. tumidus*, *Glugea rodei*, *Phyllodistomum markevitschi*, *Plagioporus glomeratus*, and *Tracheliastes polycolpus*.

Threat to Humans

From Froese and Pauly (2019a):

“Harmless”

3 Impacts of Introductions

The following quotations in this section come from sources that use the name *Rhodeus amarus*, a closely related *Rhodeus* species with a history of confusion with *R. sericeus*, rather than *R. sericeus*. To clarify, Schmidt and McGurk (1982) and Reichard et al. (2006) both use the species name *R. sericeus*, but also refer to the species as the “European bitterling”. The European bitterling is now considered to be *R. amarus* (see “Remarks” for more information). Further, Breder (1933) uses the species name *R. amarus* to discuss the introduction of bitterling to the United States. However, due to the close relation between these species and the shared method of

reproduction, the authors consider this information important to understanding the potential impacts of *R. sericeus*. Potential impacts are not considered in classifying the history of introduction for this species.

From Schmidt and McGurk (1982; concerning the population in the Bronx River, New York which is considered *R. amarus*):

“Bitterlings feed primarily on diatoms and the digestive system is typical of a surface scraping herbivore. Impact of this exotic species on the ecosystem appears minimal. It is unlikely that the species would cause appreciable negative impact on any habitat in the northeastern United States.”

“The bitterling's small size and herbivorous diet preclude the species from being a serious predator on other fishes. It is unlikely that it would compete with native species for food since only the golden shiner may possibly utilize the same food source (Scott & Crossman, 1979). Its small population size would indicate that the bitterling could not possibly reduce the standing crop of diatoms in the river.”

From Reichard et al. (2006; concerning populations in central Europe):

“The relationship between *R. sericeus* [possibly referring to *R. amarus*] and mussels has popularly been considered mutualistic on the premise that bitterling use mussels as spawning sites, while the mussel benefits by using bitterling as hosts for their glochidia (e.g. Wheeler, 1978). However, recent studies have shown the evidence for a mutualistic relationship to be weak.”

“In the present study, we found experimental evidence for a direct cost to mussels associated with hosting *R. sericeus* [possibly referring to *R. amarus*] embryos. Mussels that hosted *R. sericeus* embryos suffered significantly reduced growth over the entire growing season [...]. Because there is strong evidence across several unionid mussel species (including our study species) that mussel size is positively correlated with fecundity (Bauer, 1994), any reduction in mussel growth will directly translate into a fitness cost. This result demonstrates that *R. sericeus* are parasites of their mussel hosts, at least in Europe.”

“*Rhodeus sericeus* [possibly referring to *R. amarus*], as a recent invader of Central and West Europe, may represent a parasite exploiting host populations that did not have sufficient time to evolve counter adaptations.”

From Breder (1933):

“Since *Rhodeus* in Europe [possibly referring to *R. amarus*] is definitely known to regularly use both *Unio pictorum* (Linnaeus) and *Anodonta cygnea* (Linnaeus) at least, it would seem that a large variety of mussels can serve satisfactorily for the reproductive needs. Wording it another way, it seems unlikely that the particular distribution of any of the numerous species of larger fresh-water bivalves restricts the distribution of this cyprinid.”

“In the due course of time post larval bitterling appeared [in the observation aquarium], presumably incubated within the shells of either *Unio complanatus* (Dillwyn) or *Anodonta cataracta* Say [both species of mussel native to the United States], or both. These, the offspring of not more than five females, numbered about one hundred.”

Rhodeus sericeus is regulated in Hawaii, New Mexico, and Ohio.

4 History of Invasiveness

A species of *Rhodeus* was introduced to the United States in the early 1920's. This introduction occurred in the Sawmill and Bronx rivers in New York State where the species became established. Currently, with zero individuals having been caught since 1951, the Sawmill River population is thought to be extirpated. These populations were originally recorded as *R. amarus* and based on the body of literature and current accepted taxonomy and source of these introductions are correctly attributed to *R. amarus* and not *R. sericeus*. Both species rely on parasitism of mussels for reproduction and *R. amarus* has been shown in a laboratory setting to parasitize mussel species native to the United States. *R. sericeus* was introduced to the Tiber River in Italy from eastern Asia and established a population. No information regarding impacts of *R. sericeus* in the Tiber River were found. *R. sericeus* is regulated in Hawaii, New Mexico, and Ohio. *R. sericeus* may be in trade but species specific information was not available. The history of invasiveness category for *Rhodeus sericeus* is Data Deficient due to the lack of documented impacts for the introduction in the Tiber River that is known to be *R. sericeus* and not *R. amarus*.

5 Global Distribution

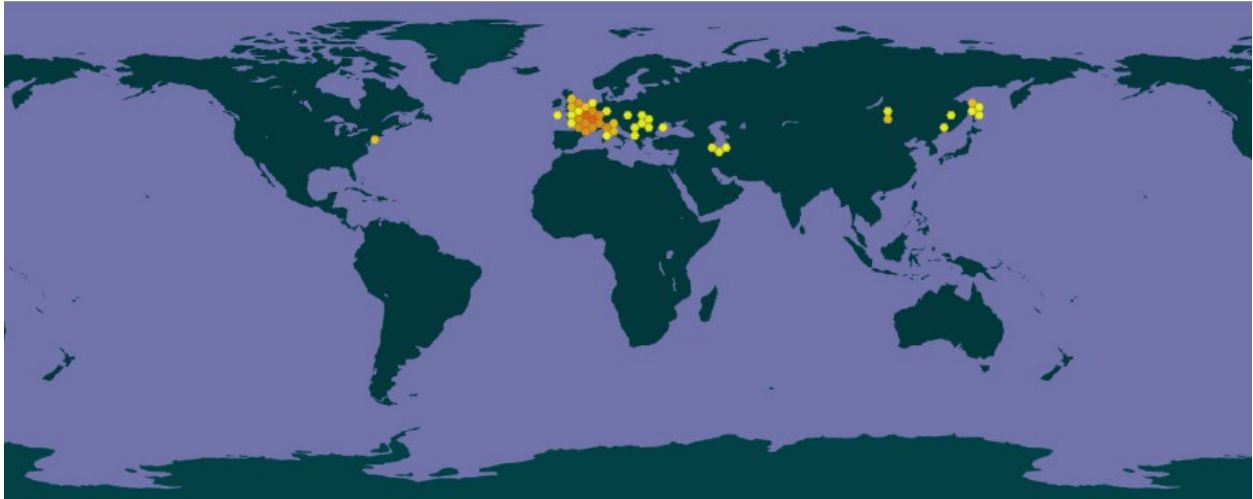


Figure 1. Known global distribution of *Rhodeus sericeus*. Observations are reported from Europe, West and East Asia, and eastern United States. Map from GBIF Secretariat (2019). *Rhodeus sericeus* is considered established in the Amur River basin in Northern China, Mongolia, and Russia. The distribution shown across Europe, western Asia, and the eastern United States are mislabeled observations of *R. amarus*, according to the most recent accepted taxonomy (Bogutskaya and Komlev 2001; Fricke et al. 2019; Froese and Pauly 2019; see Section 1). The locations that represent the distribution of *R. amarus* were not used to select source points for the climate match.



Figure 2. Additional known global distribution of *Rhodeus sericeus*. Observations are in China and Russia. Map from Froese and Pauly (2019a).

Additional georeferenced observations from Mongolia, China, and Russia were given in VertNet (2019) and for the introduced population of *Rhodeus sericeus* in the Tiber River in Italy in Carosi et al. (2017).

6 Distribution Within the United States



Figure 3. Observations reported as *Rhodeus sericeus* in the United States. Map from GBIF Secretariat (2019). *Rhodeus amarus*, a closely related species, was introduced to the United States in the 1920s but due to the complicated taxonomic history of the *Rhodeus* genus specimens of *R. amarus* collected in the Bronx and Sawmill rivers in New York were at times labeled as *R. sericeus*. See Section 1 for a discussion of the taxonomic and introduction history. These observations were not used to select source points for the climate match as this screening treats these introductions as *R. amarus* to comply with currently accepted taxonomy.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Rhodeus sericeus* was high in the upper Midwest and Northern Great Plains. The climate match was low in the southern Atlantic and Gulf regions, much of the central south and most of the West. Patches of medium match were scattered around the west and Rocky Mountain areas. Everywhere else has medium matches. The overall Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.156, high (scores of 0.103 and greater are classified as high). Iowa, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, and Wisconsin had high individual climate 6 scores. Colorado, Idaho, New Mexico, New York, Pennsylvania, Virginia, West Virginia, and Wyoming had medium individual scores. All other States had low scores.

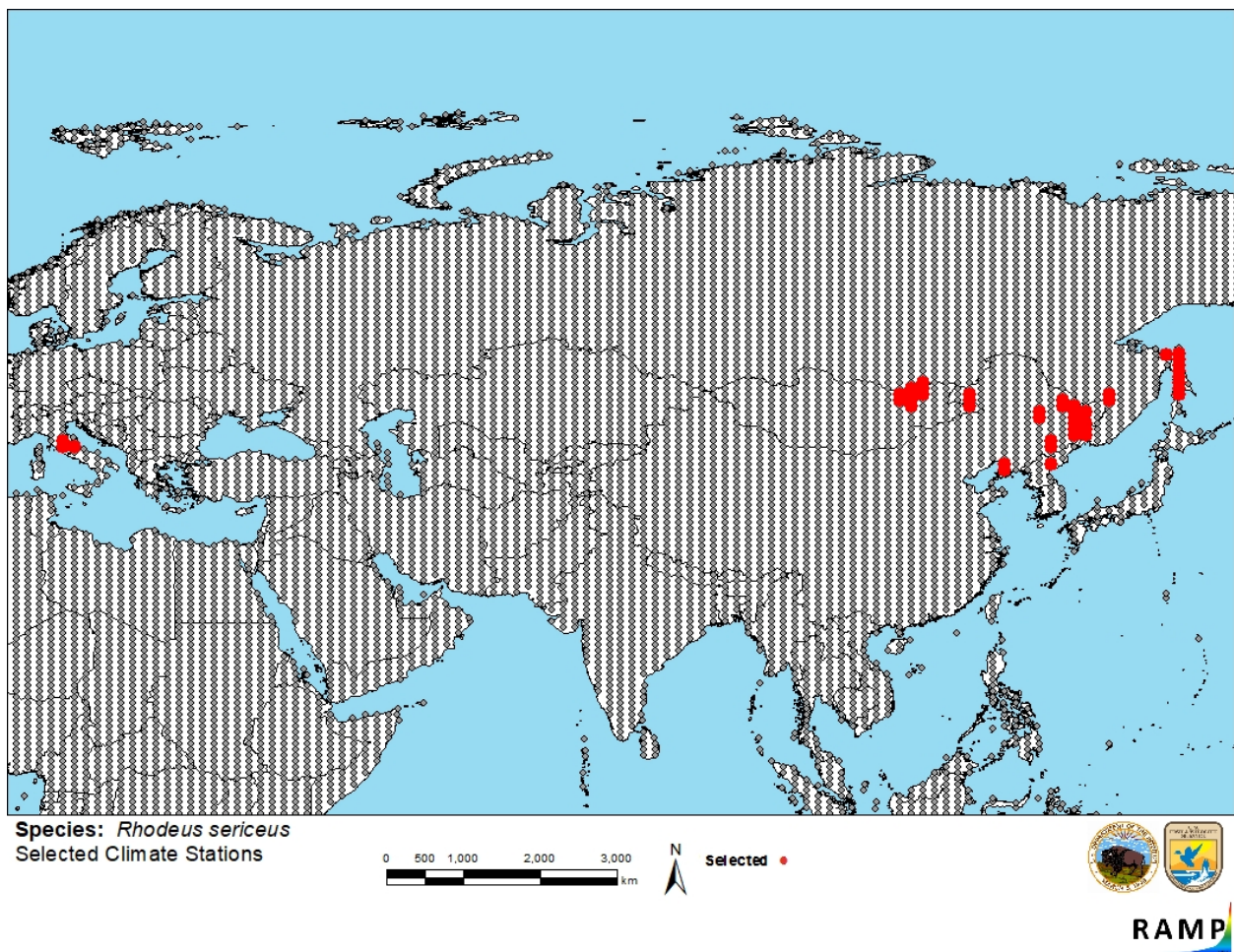


Figure 4. RAMP (Sanders et al. 2018) source map showing weather stations in Europe and Asia selected as source locations (red; Italy, North Korea, Mongolia, China, Russia) and non-source locations (gray) for *Rhodeus sericeus* climate matching. Source locations from Carosi et al. (2017), Froese and Pauly (2019), GBIF Secretariat (2019), and VertNet (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

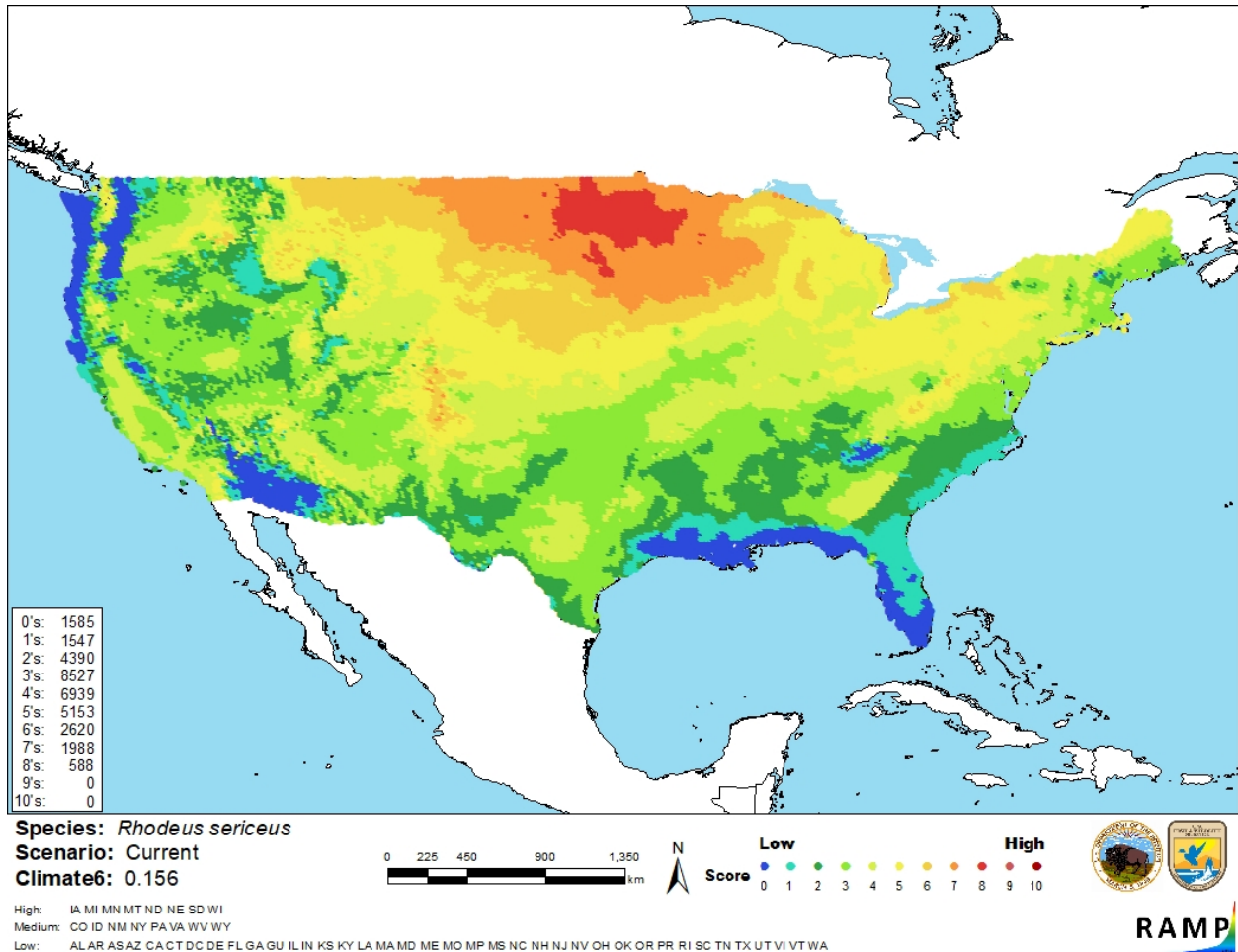


Figure 5. Map of RAMP (Sanders et al. 2018) climate matches for *Rhodeus sericeus* in the contiguous United States based on source locations reported by Carosi et al. (2017), Froese and Pauly (2019), GBIF Secretariat (2019), and VertNet (2019). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
$0.000 \leq X \leq 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

8 Certainty of Assessment

The biology and ecology of *Rhodeus sericeus* are well-known, but little information about impacts of the species has been published. Due to taxonomic confusion, *R. sericeus* is commonly confused with *Rhodeus amarus*. This causes some discrepancies with information found in the literature. Certainty of assessment for *Rhodeus sericeus* is Low.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Rhodeus sericeus (bitterling) is a small fish in the carp family, Cyprinidae. Its native range falls within the Amur River basin in western Asia (China, Mongolia, and Russia). *Rhodeus* species, possibly including *R. sericeus*, are in ornamental trade. A significant amount of taxonomic confusion has existed between *R. sericeus* and its close relative *R. amarus*. At present, these fish are considered two separate valid species, but have previously been considered subspecies of *R. sericeus*. The long history of modifications to their taxonomy results in confusion in the literature as to what information pertains to which species. This has complicated determining the identity of the *Rhodeus* species introduced in two rivers in New York. Based on current taxonomy and the current and historical treatment of the introductions in the literature this screening considers the New York introductions to be of *R. amarus*. *Rhodeus sericeus* is regulated in Hawaii, New Mexico, and Ohio. *R. sericeus* has been introduced to and established a population in the Tiber River in Italy. No information was found regarding impacts of this population. Regardless of taxonomic misunderstandings, both *Rhodeus* species parasitize mussels for reproduction, which creates a potential for negative impacts on mussel species outside of the bitterlings' native range. However, no such impacts have been documented in Italy. History of invasiveness is therefore classified as Data Deficient. The climate match with the contiguous United States is high. Most of the contiguous United States had a high or medium climate match except the Atlantic, Gulf, and western areas. Some patches of medium match were found scattered in the Rocky Mountain areas. Certainty of assessment is low due to the history of taxonomic confusion and to lack of data for the history of invasiveness. The overall risk assessment category for *Rhodeus sericeus* is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks/Important additional information:** Often confused with *Rhodeus amarus*.
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 11.

Bogutskaya NG, Komlev AM. 2001. Some new data to morphology of *Rhodeus sericeus* (Cyprinidae: Acheilognathinae) and a description of a new species *Rhodeus colchicus*, from west Transcaucasia. *New Contributions to Freshwater Fish Research* 287:81–97.

- Bohlen J, Šlechtová V, Bogutskaya N, Freyhof J. 2006. Across Siberia and over Europe: Phylogenetic relationships of the freshwater fish genus *Rhodeus* in Europe and the phylogenetic position of *R. sericeus* from the River Amur. *Molecular Phylogenetics and Evolution* 40:856–865.
- Breder CM Jr. 1933. *Rhodeus sericeus* spawning in American mussels. *American Society of Ichthyologists and Herpetologists* 3:147–148.
- Carosi A, Ghetti L, Cauzillo C, Pompei L, Lorenzoni M. 2017. Occurrence and distribution of exotic fishes in the Tiber River basin (Umbria, central Italy). *Journal of Applied Ichthyology* 33(2):274–283.
- Dence WA. 1925. Bitter carp (*Rhodeus amarus*) from New York State waters. *Copeia* 142:3
- [FAO] Fisheries and Agriculture Organization of the United Nations. 2019. Database on introductions of aquatic species. Rome: FAO. Available: <http://www.fao.org/fishery/introsp/search/en> (December 2019).
- Fricke R, Eschmeyer WN, van der Laan R, editors. 2019. Eschmeyer’s catalog of fishes: genera, species, references. California Academy of Science. Available: <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (December 2019).
- Froese R, Pauly D, editors. 2019a. *Rhodeus sericeus* (Pallas, 1776). FishBase. Available: <https://www.fishbase.se/summary/2948>. (December 2019).
- Froese R, Pauly D, editors. 2019b. *Rhodeus sericeus*. World Register of Marine Species. Available: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=154613> (December 2019).
- GBIF Secretariat. 2019. GBIF backbone taxonomy: *Rhodeus sericeus* (Pallas, 1776). Copenhagen: Global Biodiversity Information Facility. Available: <https://www.gbif.org/species/2360803> (December 2019).
- Hawaii Department of Agriculture. 2019. Amendment and compilation of chapter 4-71, Hawaii Administrative Rules. Honolulu: Hawaii Department of Agriculture, Plant Industry Division. Available: <http://hdoa.hawaii.gov/pi/pq/import-program/pq-non-domestic-animal-and-microorganism-lists/> (February 2021).
- [ITIS] Integrated Taxonomic Information System. 2019. *Rhodeus sericeus* (Pallas, 1776). Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=163607#null (December 2019).
- LiveAquaria. 2019. Bitterling – assorted. Rhinelander, Wisconsin: Petco Wellness. Available: <https://www.liveaquaria.com/product/1602/?pcatid=1602> (December 2019).

- Myers GS. 1925. Introduction of the European bitterling (*Rhodeus*) in New York and of the rudd (*Scardinius*) in New Jersey. *Copeia* 140:20–21.
- New Mexico Department of Game and Fish. 2010. Director’s species importation list. Santa Fe, New Mexico Department of Game and Fish. Available: http://www.wildlife.state.nm.us/download/enforcement/importation/information/Directors-Species-Importation-List-08_03_2010.pdf (November 2020).
- Nico L, Fuller P. 2019. *Rhodeus sericeus* (Pallas, 1776). Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: <https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=643> (December 2019).
- Ohio [DNR] Department of Natural Resources. 2020. Ohio’s injurious aquatic invasive species. Publication 5490 R0120.
- [OIE] World Organisation for Animal Health. 2019. OIE-listed diseases, infections and infestations in force in 2019. Available: <http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/> (December 2019).
- Ondračková M, Jurajda P, Gelnar M. 2002. The distribution of *Posthodiplostomum cuticola metacercariae* in young-of-the-year cyprinid fishes. *Journal of Fish Biology* 60:1355–1357.
- Pagad S, Genovesi P, Carnevali L, Schigel D, McGeoch MA. 2018. Introducing the Global Register of Introduced and Invasive Species. *Scientific Data* 5:170202. DOI: <https://doi.org/10.1038/sdata.2017.202>.
- Poelen JH, Simons JD, Mungall CJ. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.
- Reichard M, Ondračková M, Przybylski M, Liu H, Smith C. 2006. The costs and benefits in an unusual symbiosis: experimental evidence that bitterling fish (*Rhodeus sericeus*) are parasites of unionid mussels in Europe. *Journal of Evolutionary Biology* 19:788–796.
- Sanders S, Castiglione C, Hoff M. 2018. Risk Assessment Mapping Program: RAMP. Version 3.1. U.S. Fish and Wildlife Service.
- Schmidt RE, McGurk J. 1982. Biology of the European bitterling *Rhodeus sericeus* (Pisces: Cyprinidae) in the Bronx River, New York, USA: an apparently benign exotic species. *Biological Conservation* 24:157–162.
- Schofield PJ, Williams JD, Nico LG, Fuller P, Thomas MR. 2005. Foreign nonindigenous carps and minnows (Cyprinidae) in the United States - a guide to their identification, distribution, and biology. U.S. Geological Survey. Scientific Investigations Report 2005–5041.

Smith C, Reichard M, Jurajda P, Przybylski M. 2004. The reproductive ecology of the European bitterling (*Rhodeus sericeus*). *Journal of Zoology* (London) 262:107–124.

VertNet. 2019. VertNet. Available: <http://www.vertnet.org/index.html> (December 2019).

Yamano H, Yamauchi T, Hosoya K. 2011. A new host record of *Ichthyoxenus amurensis* (Crustacea: Isopoda: Cymothoidae) from the Amur bitterling *Rhodeus sericeus* (Cypriniformes: Cyprinidae). *Limnology* 12:103–106.

11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Bauer G. 1994. The adaptive value of offspring size among freshwater mussels (Bivalvia; Unioidea). *Journal of Animal Ecology* 63:933–944.

Billard R. 1997. Les poissons d'eau douce des rivières de France: Identification, inventaire et répartition des 83 espèces. Lausanne, Switzerland: Delachaux et Niestlé. (In French.)

Bloch ME. 1782. *Naturgeschichte der ausländischen Fische*. Volume 7. Berlin: Auf Kosten des Verfassers und in Commission bei dem Buchhändler Hr. Hesse.

Dybowski BN. 1869. Vorläufige Mittheilungen über die Fischfauna des Ononflusses und des Ingoda in Transbaikalien. *Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft* 19:945–958. (In Russian.)

Dybowski BN. 1877. [Fishes of the Amur water system]. Volume 7. *Izvestiya Sibirskogo Otdeleniya Russkogo Geograficheskogo Obshchestva*. (In Russian.)

Gerstmeier R, Romig T. 1998. *Die Süßwasserfische Europas: für Naturfreunde und Angler*. Stuttgart, Germany: Franckh-Kosmos Verlag. (In German.)

Günther A. 1868. *Catalogue of the fishes in the British Museum: Catalogue of the Physostomi, containing the families Heteropygii, Cyprinidae, Gonorhynchidae, Hyodontidae, Osteoglossidae, Clupeidae, ... [thru] ... Halosauridae, in the collection of the British Museum*. Volume 7. London: British Museum (Natural History), Department of Zoology.

Holčík J. 1999. *Rhodeus sericeus*. Pages 1–32 in Bănărescu PM, editor. *The freshwater fishes of Europe 5 I. Cyprinidae*. Wiebelsheim, Germany: AULA-Verlag.

Holčík J, Jedlicka L. 1994. Geographical variation of some taxonomically important characters in fishes: the case of the bitterling *Rhodeus sericeus*. *Environmental Biology of Fishes* 41:147–170.

- Institute of Hydrobiology, Academia Sinica, Shanghai Natural Museum and Ministry of Agriculture of China. 1993. The freshwater fishes of China in coloured illustrations. Volume 3. Institute of Hydrobiology, Academia Sinica and Shanghai Natural Museum and Ministry of Agriculture of China.
- Kottelat M. 1997. European freshwater fishes. *Biologia (Bratisl.)* 52(5):1–271.
- Kottelat M. 2006. Fishes of Mongolia. A check-list of the fishes known to occur in Mongolia with comments on systematics and nomenclature. Washington, DC: The World Bank.
- Lin R. 1998. Acheilognathinae. Pages 413–454 in Chen Y-Y, et al. [source material did not provide full list], editors. *Fauna Sinica. Osteichthyes. Cypriniformes II*. Beijing: Science Press.
- Page LM, Burr BM. 1991. A field guide to freshwater fishes of North America north of Mexico. Boston: Houghton Mifflin Company.
- Pallas PS. 1776. Riese durch verschiedene Provinzen des Russischen Reichs. St. Petersburg, Russia: Kaiserlichen academie der Wissenschaften. (In German.)
- Pinder AC. 2001. Keys to larval and juvenile stages of coarse fishes from fresh waters in the British Isles. Ambleside, United Kingdom: Freshwater Biological Association.
- Reshetnikov YS, Bogutskaya NG, Vasil'eva ED, Dorofeeva EA, Naseka AM, Popova OA, Savvaitova KA, Sideleva VG, Sokolov LI. 1997. An annotated check-list of the freshwater fishes of Russia. *Journal of Ichthyology* 37(9):687–736.
- Riehl R, Baensch HA. 1991. Aquarium atlas. Volume 1. Melle, Germany: Mergus Verlag für Natur-und Heimtierkunde.
- Schmidt RE, Samaritan JM, Pappantoniou A. 1981. Status of the bitterling, *Rhodeus sericeus*, in southeastern New York. *Copeia* 1981:481–482.
- Scott WB, Crossman EJ. 1979. Freshwater fishes of Canada. 2nd edition. *Bulletin of the Fisheries Research Board of Canada* 184:1–966.
- Svetovidov AN, Eremeev GK. 1935. [On the European and Amur bitterling (*Rhodeus sericeus*)]. *Doklady Akademii Nauk SSSR* 1:582–587.
- Warpachowski NA. 1887. Über die Gattung *Hemiculter* Bleek. und über eine neue Gattung *Hemiculterella*. Pages 13–24 in *Bulletin of the Imperial Academy of Sciences of St. Petersburg*. Volume 32. Saint Petersburg, Russia: Akademiia Nauk SSSR. (In French.)
- Welcomme RL. 1988. International introductions of inland aquatic species. *FAO Fisheries Technical Paper* 294:318.

Wheeler AC. 1978. Key to the fishes of Northern Europe: A guide to the identification of more than 350 species. London: Frederick Warne Publishers.