Rhinogobius brunneus
Amur Goby
Yoshinobori

Order: Perciformes
Family: Gobiidae
Genus: Rhinogobius
Species: brunneus

NAS Species Fact Sheet
http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=2612

Identification Key

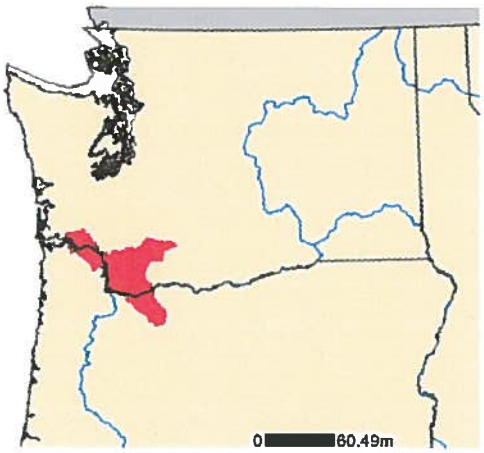
Members of the *R. brunneus* species complex have 6 dorsal spines and 9-10 dorsal rays, with extended second and third dorsal spines (Berg 1965). The males have longer, more elaborate dorsal fins than the females of this species (Suk and Choe 2002a). They also have 8-9 anal rays. The eyes are set prominently on top of the head with a narrow interorbital space. The maxillary extends nearly to the anterior part of the eye. The upper jaw projects slightly beyond the lower jaw and its mouth is lined with small uniform teeth. The caudal and pectoral fins are rounded. The presence of fused pelvic fins are characteristic of gobies, modified into a small scoop-like shape, they do not reach the anal vent in this species (Berg 1965; Günther 1861). This fish can reach sizes between 70 and 100 mm TL (Masuda 1984). There are slight variations in color pattern between the different types, but in general they all have a dark line running from the anterior part of the eye to the end of the snout and breeding males are slightly blue or red in color with iridescent dorsal fins (2).

Species Overview

The following cited papers all reference different types of species within *Rhinogobius* brunneus, including Kohda and Takahashi (2004), Keith (2003), Katoh (1996), Masuda (1984), and Chen and Huang (2007). Sawara (1978) actually describes the differences between the suspected various forms of this species. There is an amphidromous form, meaning that as embryos these fish are born in freshwater and drift out to sea, returning to the streams as juveniles (Iguchi and Mizuno 1990). There is a land-locked river form that has been determined to be a separate species, *Rhinogobius flumineus*, which migrates out to lakes. It is still recognized by some authors of the aforementioned papers as a different type of *R. brunneus*. Within the amphidromous forms, Iguchi and Mizuno (1991) distinguish between four different types based on color

patterns, life history strategies, and egg size. These include the "cross-band", "dark", "large-dark", and "cobalt" types. Masuda (1984) also recognizes the "medium egg", "orange", and "mosaic" types. There are up to 10 different types within the complex and it is clear the taxonomy of this group of fish remains complicated and uncertain (2), therefore the information presented in this profile refers to the *Rhinogobius brunneus* species complex in general and does not refer to specific types.

Origin and Distribution



Extent of the non-native range for the Amur goby in Washington and Oregon http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=2612

The *R. brunneus* species complex has a widespread native range throughout the rivers of East Asia, in Korea, Japan, Taiwan (Suk and Choe 2002a) Hainan and the Phillipines, China, Vietnam, Laos, Cambodia, Thailand (Chen et al. 1999), and Russia (Berg 1965). The extensive range of this species probably assisted its introduction into other areas, including the Kara Kum Canal in Turkmenistan and the Arabian Gulf (2). In 2004, specimens were discovered on the east fork of the Lewis River in Washington and it is suspected that they have already established and are reproducing. Other specimens have been collected from the Columbia River and the Ramsey Wetland in Portland, Oregon, as recently as April 2007 (1)(2).

Life-history and Ecology

Reproductive strategies

R. brunneus species complex has an annual breeding period that lasts from April to July (Sawara 1978; Keith 2003) during which the males build nests under rocks and use elaborate courtship displays to attract females (Suk and Choe 2002a). The first dorsal fin on the male is usually longer and more extravagant in color and shape compared to the females. The males flash their iridescent dorsal fins to intimidate and provoke rivals, as well as to attract females (Suk and Choe 2002b). Females also exhibit a more subtle color display to attract males from a distance (Kohda and Takahashi 2004). A study by Suk and Choe (2002a) revealed that females prefer males with longer dorsal fins and a larger body size. These findings contradict alternative studies which concluded that the

ability of a male to court in faster currents was more likely than body size and dorsal fin length to direct female choice. The theory behind this determination was that stronger males, capable of performing in faster currents, would ensure the survival of more offspring (Kohda and Takahashi 2004; Keith 2003). Females lay 600-1,700 eggs in a single layer on the ceiling of a nest and then abandon the males to care for the clutch, fanning the eggs and defending them from predators. The eggs are elliptical in shape and about 1.48 mm long (Keith 2003). Males do not eat during this time and often resort to consuming their own offspring (Kohda and Takahashi 2004).

Life cycle

The male guards the nest for 3-5 days until the eggs hatch (Suk and Choe 2002b). Newly hatched larvae are about 3.1-3.3 mm TL and are nourished by their yolk sacks for 3-7 days at which time they begin seeking their own food (Keith 2003). The larvae passively drift down their natal rivers to saltwater or freshwater lakes depending on the species type. The planktonic stage is spent feeding and growing, reaching lengths of 17 mm TL (Keith 2003; Iguchi and Mizuno 1999). The returning juveniles migrate upstream from July to September and undergo morphological changes in their transition from saltwater to freshwater. The light colored translucent body of the fish develops pigments and the formerly forked caudal fin becomes larger and truncate. The pectoral fins also enlarge and the structure of the jaw and digestive system are altered so the fish can begin feeding on algae attached to the substrate. These fish return to the rivers to continue growth and reproduce. Studies have been able to determine individual ages of this species by counting the annulus of the scales, information on the lifetime of *Rhinogobius brunneus* is unavailable (Sawara 1978).

Feeding habits

During the larvae migration down the rivers they start to feed on rotifers as their yolk reserves are consumed a few days after hatching (Keith 2003). As adults Amur gobies are omnivores, feeding on benthic organisms and algae covering the substrate. Gut content analysis reveals that they eat an array of diatoms, green algae, midge larvae, mayfly larvae, caddis fly larvae, and cranefly larvae, as well as gammarid amphipods and both adult and larval beetles. The wide range of prey species allows the Amur goby to adjust its feeding behaviors if the conditions and densities of certain prey species are low or if there's competition for a prey item within the habitat (Sawara 1978). The feeding

habits of *R. brunneus* influence the distribution of fishes within their native streams. Fish densities are often highest in areas with little plant cover since sunnier areas encourage primary production of the algae, providing a greater abundance of a major food source for this species. Ample sunlight in these areas also contributes to the intensity of the male courtship displays during the breeding season (Keith 2003).

Environmental optima and tolerances

The ideal habitat for an adult Amur goby is a freshwater stream with shallow, circulating pools and large rocks or pebbles that provide an area for the male goby to dig out a nest (Keith 2003). Areas with faster currents would be ideal for the courtship rituals of this species, as females prefer strong males that can perform and would be physically capable of protecting the offspring without cannibalizing them (Kohda and Takahashi 2004). The ideal temperatures for developing goby embryos are between 9° C and 21° C, from late April to July (Suk and Choe 2002a). Studies have suggested that newly hatched larvae are physiologically better adapted to living in a saltwater environment, since prolonged exposure to freshwater can lead to higher mortality rates and stunted development (Keith 2003). Nesting males that successfully attract females close freshwater sources would ensure a better chance for survival for their offspring. Habitat that provides the goby with ample areas of sunlight to encourage algal production, a primary food source, in addition to healthy populations of various fly speices, amphipods, and beetles would be ideal for *Rhinogobius brunneus*.

Biotic associations

Little is known about the symbiotic relationships that exist between the Amur goby and other organisms, aside from predator and prey relationships. Fukuhara et al. (1986) documented the parasitic relationship between glochidia, a larval form of the mussel, *Anodonta woodiana* and the Amur goby. At a small pond in Osaka, Japan glochidia were found attached to the gill lamellae and pectoral fins of the host gobies year round. There was a peak in the average number of glochidia attached to each fish in April of 1985 at 52 larval mussels.

Invasion Process

Pathways, Vectors, and routes of introduction

The most likely vector for the introduction of this species into the Arabian Gulf was ballast water from ships. The goby was also introduced into Turkmenistan from

China in 1963 from an unknown vector. It is unclear how the goby was introduced into the states of Oregon and Washington; however, it is possible that the aquarium trade was a potential vector (2).

Factors influencing establishment and spread

The Amur goby has a high tolerance for a wide range of salinity levels, from marine to brackish and freshwater environments. While larval Amur gobies can only withstand freshwater for the time it takes for them to passively migrate to the sea after hatching, as adults they become fully acclimated to freshwater environments (Keith 2003). Based on the ideal conditions for this species, it is feasible that planktonic larva could be picked up via ballast water exchange and transported to an estuarine location close to the mouth of a river. There they could migrate upstream, transition into the benthic feeding adult form and establish (Keith 2003). This goby is also a generalist species, it can thrive in slow or swift current rivers (Kohda and Takahashi 2004) and it feeds on a variety of algae, insects, and amphipods (Sawara 1978).

Potential ecological and economic impacts

Little is known about how the Amur goby is currently impacting the environments in Washington and Oregon. A general concern is that they will compete with juvenile salmon for food, as they feed on the same prey sources. It is possible that the introduction of the goby could have devastating impacts on the already depleted salmon populations of the Pacific Northwest.

Management Strategies and Control Methods

There is currently no management plan in effect to determine the extent of this species distribution in Oregon and Washington (Pam Fuller and Paul Heimowitz, per. comm.).

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Expert Contacts

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