

## Short Communication

## Arrival of round goby *Neogobius melanostomus* (Pallas, 1814) and bighead goby *Ponticola kessleri* (Günther, 1861) in the High Rhine (Switzerland)

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### Abstract

A number of Ponto-Caspian gobiid species are currently invading European coasts and freshwaters. They do not only present a nuisance to fishermen, but evidence suggests that they compete with native benthic fishes and may contribute to changes in ecosystem function. This paper reports the presence of round goby *Neogobius melanostomus* individuals and an established population of bighead goby *Ponticola kessleri* in the High Rhine.

**Key words:** gobiidae; non-native; alien; invasion; High Rhine; Switzerland

### Introduction

Several goby species from the Caspian and Black Sea are currently spreading in European rivers. *Ponticola kessleri* (Günther, 1861; Neilson and Stepien 2009), *Neogobius melanostomus* (Pallas, 1814), *Proterorhinus marmoratus* (Pallas, 1814), *Neogobius fluviatilis* (Pallas, 1814), and *Babka gymnotrachelus* (Kessler, 1857) have expanded their territories as far westwards as the Rhine. *Ponticola kessleri* (bighead goby) and *Neogobius melanostomus* (round goby) have now been recorded in the High Rhine at Basel, Switzerland.

The rapid spread of non-native gobies (see Figure 1A for a timeline of round goby spread) can be largely attributed to human operations. A network of navigable passages today penetrates former geographic barriers and connects European freshwaters from Russia to Spain. In particular, the opening of the Rhine-Main-Danube canal in 1992 connected the Northern Sea drainage (including the Rhine) with the Danube. Even prior to its opening, this so-called Southern Invasion corridor (MacIsaac et al.

2001) was predicted to promote westward migration of fish species (Balon et al. 1986), including Ponto-Caspian gobiids (*Proterorhinus marmoratus*). In the meantime, five of six gobiid species predicted to invade the Rhine (Freyhof 2003) have indeed arrived. Their dispersal appears to be facilitated by shipping, as round goby dispersal has followed shipping routes (Brown and Stepien 2009; LaRue et al. 2011), displaying a saltatory dispersal pattern along dams and harbours (Wiesner 2005) and spreading much faster than suggested by naturally observed migration behaviour (Ray and Corkum 2001). Additionally, and possibly most important for successful establishment in the new range, all major European rivers have a history of habitat disturbance. Water temperatures and flow regimes of European waterways have been greatly altered by hydropower dams and power plant outlets to generate a warmed and almost lentic environment, which resembles conditions in the species' native range (Harka 2007).

The arrival of bighead goby in the High Rhine was discovered in winter 2011, when three individuals were identified during 5-year interval

**Table 1.** Round goby specifications.

individual	sex <sup>1</sup>	sex.maturity <sup>2</sup>	TL (cm)	weight (g)
Nm_1	m	yes	10.8	20.90
Nm_2	f	-	9.7	13.83
Nm_3	f	-	9.4	11.14
Nm_4	m	yes	10.8	16.95
Nm_5	n.a	-	9.4	11.80
Nm_6	n.a	-	9.6	11.49
Nm_7	f	stage 3	8.3	8.80
Nm_8	f	stage 3	8.1	7.56
Nm_9	f	stage 2	7.7	5.95
Nm_10	f	stage 2	9.0	10.45
Nm_11	f	-	8.3	8.40

<sup>1</sup> m, male. f, female. n.a, sex could not be determined.

<sup>2</sup> -, not mature. stage 2, immature eggs. stage 3, mature eggs.

governmental electro-samplings on the river banks in Basel. In the following study, we set out to: i) identify the establishment status of bighead goby at Basel and ii) test for the presence of other goby species.

## Methods

Sampling was undertaken in a local harbour (Kleinhüningen), which we suspected to be an invasion hot spot for reasons mentioned above. We used passive sampling to carry out long term monitoring regularly, with low manpower and at low cost. Notably, electro-sampling is rather ineffective at recovering round goby (Johnson et al. 2005), and little suited to sample benthic fish at water depths of 4 metres. We set crayfish traps and/or metal minnow traps baited with four pieces of dry dog food (Frolic®) at 3-4m depth at five sites in Kleinhüningen Harbour (Figure 1B, 47°35' N, 7°35' W), and emptied them every other day.

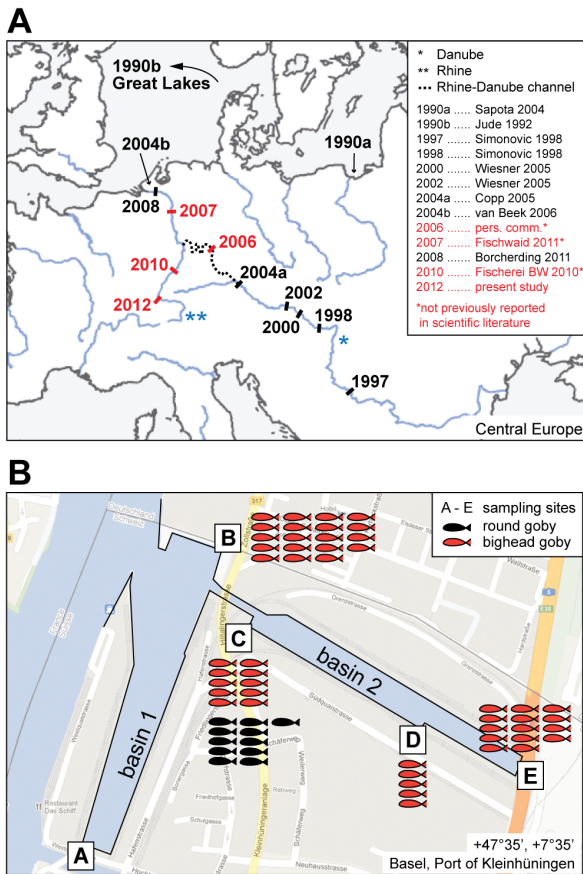
Processing and analysis involved storing the fish individually in plastic bags at -80°C for subsequent laboratory examination. After thawing, fish were photographed, measured for total length and weight, then dissected to determine sex, reproductive stage and parasite load. Ageing was performed by counting the number of winter bands on sagittal otoliths. Reproductive stage was classified following Almqvist (2008).

## Results and discussion

The results confirmed the presence of an established population of bighead goby *Ponticola kessleri*. Additionally, and unexpect-

edly, we detected round goby *Neogobius melanostomus*. In the following, we focused our analysis on round goby. Species identity was confirmed by DNA barcoding (Ward et al. 2005, GenBank accession numbers JX473740-JX473750). All specimens were between 0+ and 1+ years of age (Table 1). Several individuals were sexually mature, and one male displayed dark spawning coloration (Marentette et al. 2009), indicating that round goby are locally reproducing and currently establishing in the High Rhine. Parasite load appeared to be low or absent according to abdominal cavity inspection, arguing for parasite release (Torchin et al. 2003) as a contributing factor for goby invasion success.

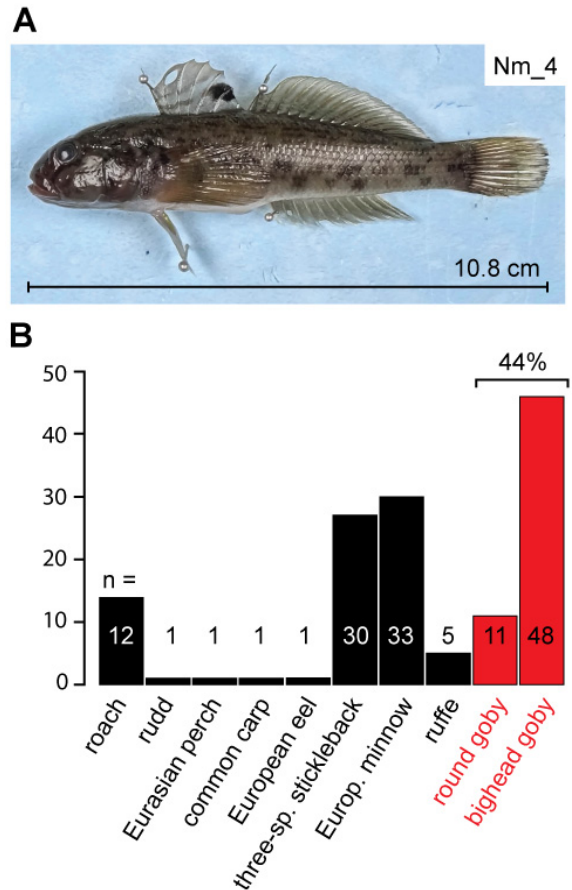
Eleven specimens of round goby (Figures 1B, 2A) were captured along with 48 bighead goby, 33 European minnow *Phoxinus phoxinus* (Linnaeus, 1758), 30 threespine stickleback *Gasterosteus aculeatus* (Linnaeus, 1758), 12 roach *Rutilus rutilus* (Linnaeus, 1758), 5 ruffe *Gymnocephalus cernuus* (Linnaeus, 1758), and single specimens of rudd *Scardinius erythrophthalmus* (Linnaeus, 1758), Eurasian perch *Perca fluviatilis* (Linnaeus, 1758), common carp *Cyprinus carpio* (Linnaeus, 1758), and European eel *Anguilla anguilla* (Linnaeus, 1758) (Figure 2B). In total, non-native goby represented 44% of all caught fish (Figure 2B), and the majority of fish biomass. Bighead goby was more abundant than round goby. In Central Europe, bighead goby invasions have usually preceded round goby invasions, with the latter eventually displacing the former (Kovac et al. 2009). Because bighead goby have been reported up to Birsfelden, 2 km downstream of Basel, whereas round goby have not been reported outside of



**Figure 1.** **A** – Records of round goby along the southern invasion corridor. Round goby have rapidly colonized navigable European freshwater systems during the last decade (see details in Appendix 1). **B** – Round and bighead goby records in Kleinhüningen Harbour, Basel, CH, between 22 May and 4 June 2012, 48 bighead goby and 11 round goby were collected.

Kleinhüningen Harbour, the colonization of the High Rhine by Ponto-Caspian gobiids is assumed to be at an early stage, but this requires further study.

Both species are expected to spread more widely in Switzerland. Ecosystem degradation is known to facilitate successful invasions (Moyle 1986; Burkhardt-Holm et al. 2005), and benthic invertebrate communities in both the Rhine and in sub-alpine lakes are already dominated by non-native species (Rey et al. 2004; Mürle et al. 2008). Several of the invaders are of Ponto-Caspian origin (e.g. killer shrimp *Dikergammarus villosus* (Sowinsky, 1894), the mysid shrimp *Limnomysis benedeni* (Czerniavsky, 1882), and the zebra mussel *Dreissena*



**Figure 2.** **A** – Male round goby from Kleinhüningen Harbour. **B** – Round and bighead goby represent 44% of all fish caught by passive sampling methods in the harbour between 22 May and 4 June 2012.

*polymorpha* (Pallas, 1771)). This could facilitate establishment of non-native gobiids by community reconstitution. Species commonly found to associate with a particular species assemblage are more likely to establish in places where that species assemblage is found (Paini et al. 2010). Both bighead and round goby are known to strongly rely on non-native prey items in their invasive range (Brandner et al. 2012).

Non-native gobiids are expected to exert profound changes on Swiss aquatic ecosystems, if only by their sheer numbers – up to 435 individuals have been reported per 100 m in the Danube (Wiesner et al. 2005). They are expected to compete with the native endangered European bullhead *Cottus gobio* (Linnaeus, 1758) (Van

Kessel et al. 2011). Their presence warrants the development of molecular monitoring methods, i.e. so-called environmental DNA techniques (Darling and Mahon 2011; Dejean et al. 2012; Thomsen et al. 2012). These approaches are certainly the future of monitoring, in particular for species eluding conventional methods and monitoring schemes for reasons of habitat preference. At present however, detection rates are organism-dependent and, in lotic and marine environments, lag behind classical counts (e.g. Thomsen et al. 2012). Sampling pseudo-lentic riverine environments (harbours and upstream of weirs) may enhance detection rates – an approach we will assess in the future.

More than 80% of all cargo ships calling at Swiss harbours originate from the Netherlands. Under the assumption that cargo traffic contributes to the spread of Ponto-Caspian gobiids, and considering the timeline of first records (Figure 1, Appendix 1), it remains to be determined whether non-native gobiids have reached Switzerland by the Southern Invasion corridor (MacIsaac et al. 2001) or from the North Sea/Baltic Sea populations.

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#### Appendix 1. First records of round goby in Central Europe and in North American Great Lakes.

Location	Coordinates		Record date	Number of collected fish	Reference
	Latitude	Longitude			
Gulf of Gdansk, Poland	54.60	18.78	June 1990	n.a	Sapota 2004
St. Clair River, USA	42.00	-82.46	Summer 1990	3	Jude et al. 1992
Danube, Yugoslavia	44.30	22.60	September 1997	13	Simonovic et al. 1998
Danube, Austria	48.16	16.51	2000	n.a	Wiesner 2005
Danube, Austria	48.40	15.64	2002	>64	Wiesner 2005
Danube, Germany	48.57	13.43	2004	n.a	Copp et al. 2005
River Leek, Netherlands	51.56	4.51	December 2004	1	Van Beek 2006
Rhine Main Danube canal, Germany	49.89	10.90	2006	n.a	Pers. communication (Fachberatung für Fischerei, Upper Franconia)
Middle Rhine, Germany	n.a	n.a	2007	n.a	Pers. communication (Dr. Stefan Staas, Limnoplant)
Rhine, Germany	51.13	6.85	2008	n.a	Borcherding et al. 2011
Rhine, Germany	49.19	8.27	2010	n.a	Fischerei in Baden-Württemberg 2010
Rhine, Switzerland	47.35	7.35	2012	11	Present study