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Expansion of round gobies in a non-navigable river system

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ABSTRACT

A number of Ponto-Caspian Gobiid species have greatly increased their geographical ranges over recent decades. Most expansion studies to date, however, have focused on navigable waterways. In this study, we present a summary of six-years (2008–2013) monitoring of round goby *Neogobius melanostomus* expansion along two connected non-navigable rivers. Contiguous range expansion was observed in both rivers, with dispersal rate ranging from 1.2 to 3.2 km/year. Gobies at newly invaded sites ranged from 20 to 117 mm, with both juveniles and adult fish observed. Though the data did not allow us to see any consistent pattern in the first years after detection, there was some evidence for a shift to a female-biased, juvenile-dominated population over time. While the abundance of non-native tubenose goby *Proterorhinus semilunaris* appeared to be negatively influenced by round goby establishment, diversity of nearshore native fish showed no evidence of dramatic decline attributable to round goby.

1. Introduction

Several Ponto-Caspian gobiid species have greatly increased their ranges over recent decades (see Roche et al., 2013 for a review). Of these, the most successful has been the round goby *Neogobius melanostomus*, which has now spread throughout several major European river basins, including the Rhine (Borcherding et al., 2011) and Danube (spreading beyond their original range; Jurajda et al., 2005; Wiesner, 2005; Paintner and Seifert, 2006). In addition, round gobies have been introduced into the Laurentian Great Lakes Basin of North America and have gone on to colonise a number of major rivers and streams (Marsden and Jude, 1995).

While this range expansion has been the subject of numerous studies in recent years, most have described expansion along navigable rivers and canals, presumably as transport in and on shipping is considered the main vector for long-range, 'leap-frog' dispersal (e.g. see Ahnelt et al., 1998; Wiesner, 2005; Gutowsky and Fox, 2011; Cammaerts et al., 2012; Roche et al., 2013). To date, relatively little has been written on 'natural' expansion (i.e. continuous range expansion by swimming alone) into and along non-navigable rivers and streams. Furthermore, most existing studies have concentrated on round goby occurrence in tributaries of the Great Lakes (Phillips et al., 2003; Krakowiak and Pennuto, 2008; Bronnenhuber et al., 2011; Brownscombe and Fox, 2012). To the best of our knowledge, just two studies have examined natural dispersal of round goby in non-navigable European tributaries, that of Brandner et al. (2013b), who reported rapid spread of round gobies in an area immediately adjacent to (and partially overlapping with) the navigated section of the upper Danube, and Zarev et al. (2013), who documented round gobies 100 km upstream along non-navigable tributaries of the Danube in the species' native range (Bulgaria), though the authors provided no information on the rate of movement.

Those studies that have examined expansion along non-navigable tributaries (USA or Europe) have noted considerable variation in the results. Speed of expansion, for example, was recorded at 0.5 km per year by Bronnenhuber et al. (2011) but at 17 km per year by Brandner et al. (2013b). There is also disagreement over the character of 'pioneer' fish found at the invasion front, with some studies reporting larger individuals (Gutowsky and Fox, 2011; Brandner et al., 2013b) and others suggesting that the driving force behind the invasion process are smaller (mainly male) fish that are forced into new areas through competition with larger individuals (Ray and Corkum, 2001; Brownscombe and Fox, 2012; Masson et al., 2016).

On top of this, relatively little is known about how non-native gobies affect fish assemblages in rivers, despite this being one of the major concerns of gobiid invasion (Janssen and Jude, 2001; French and Jude, 2001; Balshine et al., 2005). Experimental studies suggest that round goby should have a negative impact on native fish assemblages via competition for shelter and food, spawning interference and predation on eggs and juveniles (e.g. Steinhart et al., 2004; Balshine et al., 2005; Bergstrom and Mensinger, 2009), with benthic species utilising similar niches considered the most vulnerable (Van Kessel et al., 2011). This

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includes not only native cottids (Verreycken, 2015) but also other non-native gobiids. Valová et al. (2015), for example, suggested that tubenose goby *Proterorhinus semilunaris*, another, smaller Ponto-Caspian invader with a similar distribution to round goby, should prove an inferior competitor. Studies that have actually set out to determine impact at the population/assemblage level in the field are even rarer, with only three assessing round goby impact in rivers (Kornis et al., 2013; Janáč et al., 2016; Van Kessel et al., 2016). While studies from the Great Lakes have tended to document immediate and profound impacts on demersal fish communities following introduction of round goby (e.g. Janssen and Jude, 2001; Lauer et al., 2004), such an impact has only been observed in one (Van Kessel et al., 2016) of the three riverine studies thus far undertaken.

Clearly, more studies are needed before population patterns prevalent at the goby invasion front can be generalised and actual impacts on native fish communities identified, both essential for the future management of this invasive species. In this paper, we present long-term data on the expansion of round goby along two connected non-navigable European rivers. In doing so, we a) estimate speed of colonisation, b) describe population structure characteristics (body size, sex-ratio, proportion of juveniles) at first occurrence (along with any changes over the years following first occurrence), and c) assess possible impacts on the assemblage of fish captured in the nearshore rip-rap zone over time.

2. Material and methods

2.1. Study area

This study took place on the Rivers Morava and Dyje in the Czech Republic (Fig. 1). Both the Morava, a main tributary of the Danube, and the Dyje, the Morava's most important tributary, are non-navigable throughout (with the exception of occasional recreational canoes). The study covers a 44 km stretch of the Morava starting from the Czech border (70 km from its confluence with the Danube) and a 42 km stretch of the Dyje, starting from its confluence with the Morava (Fig. 1).

Between 1968 and 1982, both rivers were channelised and their riverbanks stabilised with rip-rap, that on the Morava generally larger (30–80 cm max. diameter) than on the Dyje (15–25 cm; though stones of 40–60 cm are found at some locations). Channel width on the Morava varies between 40 and 60 m and depth ranges between 0.8 and 1.0 m. The Dyje is slightly narrower at 30–50 m, with depth similar at between 0.5 and 1.0 m. Annual mean discharge near the confluence is 61.1 $m^3 s^{-1}$ for the Morava and 41.7 $m^3 s^{-1}$ for the Dyje (Czech Hydrometeorological institute; http://portal.chmi.cz). Current speed along the banks rarely reaches 0.2 m s^{-1} on the Morava and 0.4 m s^{-1} on the Dyje. The bottom substrate of both rivers comprises sand, gravel and pebbles with patches of silt. Aquatic vegetation, woody debris, pools and riffles occur rarely.

Prior to round goby invasion, both rivers supported a relatively diverse fish assemblage (Valová et al., 2006) dominated by native cyprinid species (e.g. roach *Rutilus rutilus*; chub *Leuciscus cephalus*; common bream *Abramis brama*; barbel *Barbus barbus*; bleak *Alburnus alburnus*; European bitterling *Rhodeus amarus* and white-finned gudgeon *Romanogobio albipinatus* (Jurajda and Peňáz, 1994), along with a stable population of non-native tubenose goby *Proterorhinus semilunaris*, which quickly became established after its introduction in the 1990s (Janáč et al., 2012).

Round goby have been recorded in the middle Danube since 2000

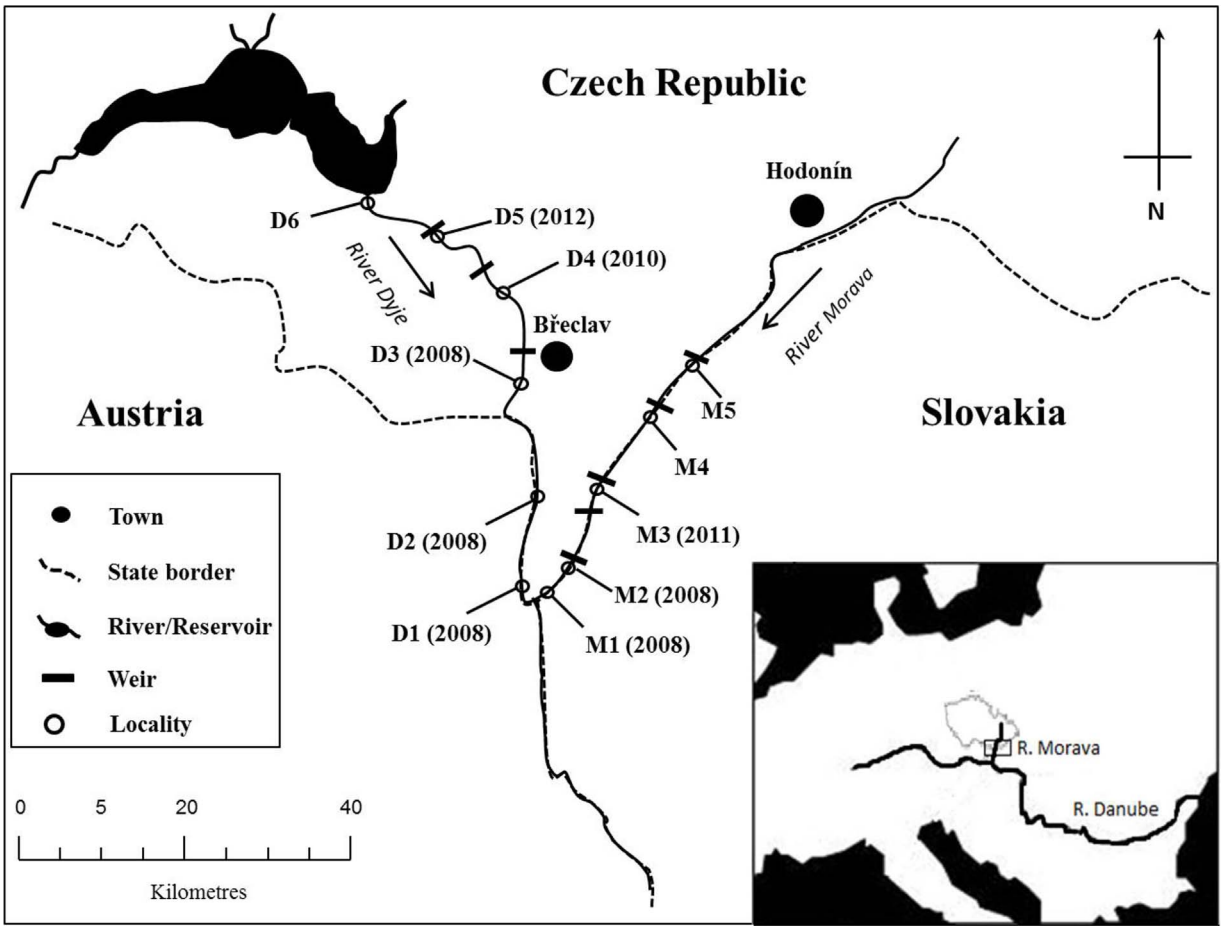

Fig. 1. The Rivers Morava and Dyje, with the study sites indicated. In the brackets are listed first records of the round goby. Please check Table 1 for precise location of the sites.