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Parasite fauna of native and non-native populations of *Neogobius melanostomus* (Pallas, 1814) (Gobiidae) in the longitudinal profile of the Danube River

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Summary

Parasite fauna of round goby *Neogobius melanostomus* (Pallas, 1814) in the Danube River was investigated in both its native range (two sites in the Bulgarian stretch of the Danube) and non-native range of distribution (Croatian, Slovak and Austrian stretches) during 2005 and 2006. The aim was to identify possible changes in parasite communities associated with the introduction of a host into the new environment. A total of 29 metazoan parasite species were found to parasitize round goby in the Danube River; twelve of these parasite species were found in both the native and non-native range of distribution. Introduction of a novel parasite species to the non-native range via the round goby was not found. Eight parasite species occurred only in the native range and nine species only in the non-native range of the round goby distribution. Losses of native parasite species in non-native round goby populations and ⁄ or acquiring of novel parasite species in a new environment were not significant. Thirteen parasite taxa were recorded for the first time in round gobies. Three parasite taxa (*Diplostomum* spp., *Pomphorhynchus laevis* and *Raphidascaris acus*) were found in high prevalence and abundance at each sampling site in both the native and non-native range. Parasite species diversity was assessed for each sampling site and season using three diversity indices (the Shannon, Simpson and Equitability indices), with the highest same-season values found in a non-native site in Slovakia (1.38, 0.69 and 0.60, respectively) and the lowest in a native site in Bulgaria (0.28, 0.12 and 0.14, respectively). Species diversity was higher in both non-native round goby populations (Slovak and Austrian) compared to native Bulgarian populations. However, diversity indices values varied among almost all sampling sites.

Introduction

Non-native species often become a matter of concern because, under certain conditions, they may become invasive (Kolar and Lodge, 2001; Sakai et al., 2001), potentially threatening native biodiversity and functioning of the ecosystem (Williamson, 1996). Potentially invasive species usually possess some characteristics (e.g. adaptability to a wide range of ecological conditions) that predispose them to succeed and spread in a new environment (Sakai et al., 2001). There are, however, other factors influencing the success or failure in the process of invasion, one of them being parasites (Prenter et al., 2004; Taraschewski, 2006). Non-native species may lose some of their parasites during translocation out of their native range or during establishment in a new environment, e.g. due to unsuitable abiotic conditions or absence of a required intermediate host (enemy release hypothesis). In other cases, parasites may follow their host into a new territory where transmission of parasites from non-native to native hosts can occur. But the non-native species may be infected with novel parasite species as well (Torchin et al., 2003). Parasite transmission is related to congeniality of host species and parasite specificity and can result in a spread of new diseases in the area of introduction (Bauer, 1991).

The round goby *Neogobius melanostomus* (synonym *Apollonia melanostoma*) (Pallas, 1814) (Gobiidae) is a fish species native to the Ponto-Caspian region and the lower sections of adjacent rivers, including the lower part of the Danube River up to the town of Vidin (Smirnov, 1986). During the late 1980s, this species was introduced into the Great Lakes in North America (Jude et al., 1992). A few years later, the round goby was observed in the Baltic Sea (Skóra and Stolarski, 1993). In 2004, the first individuals were recognized in the North Sea basin (van Beek, 2006). Since 1997, this fish species has spread in upstream sections of the Danube River outside its native range (Simonović et al., 1998; Erös et al., 2005; Jurajda et al., 2005; Wiesner, 2005) and attained high population densities and an even larger mean size in the non-native Danube stretches (Polačik et al., 2008a).

The parasite community of the non-native round goby population in the Danube River was first studied by Ondračková et al. (2005) in the Slovak section of the river (metazoan parasites). Further, protozoan and metazoan parasites of round goby were investigated in Hungarian (Molnár, 2006) and Austrian (Mühlegger et al., 2010) sections of the Danube River. Round gobies were found to be infected with a total of 15 metazoan parasite species at those three sites.

Our study is focused on the comparison of parasite fauna of round goby in both its non-native and native Danubian populations. This approach may provide useful insight into the changes in parasite community structure of the non-native host. The aim of our study was (i) to compare the parasite community composition and species diversity between native and non-native round goby populations and (ii) to identify possible significant parasite loss, parasite introduction or acquiring of novel parasite species in the non-native round goby populations in the upper and middle Danube River.

Material and methods

Round goby population samples were collected from two sites in their native and three sites in their non-native range of the Danube River in spring (April) and autumn (October) 2005 and 2006. The native range was represented by the Bulgarian stretch of the river, with sampling sites (i) near the town of Ruse, 490–498 river km, and (ii) near the town of Vidin, 783–806 river km. The non-native range was represented by the Croatian stretch of the river, (iii) near the town of Osijek, 1327–1423 river km, by the Slovak stretch of the river, (iv) near the town of Gabčíkovo, 1812–1819 river km, and the Austrian stretch of the river, (v) near the town of Orth an der Donau, 1899–1903 river km (Fig. 1). Sampling was made within an ichthyological study; for data on fish abundance see Polačik et al. (2008a). In our study, a total of 393 round goby specimens were used altogether from Bulgarian, Slovak and Austrian stretches. Only three specimens of *N. melanostomus* were caught in the Croatian stretch of the river and are therefore not included in the analyses.

Fish were collected by electrofishing or by a beach seine, depending on the habitat type, and transported live in aerated tanks with riverine water to the field laboratory for immediate dissection. Each specimen was measured (standard length SL) to the nearest millimeter (Table 1). All fish were then examined under binocular microscope for the presence of metazoan parasites using standard protocol (Ergens and Lom, 1970). Collected parasites were preserved in 4% formaldehyde (Acanthocephala, Digenea, Cestoda, Bivalvia, Crustacea), in a mixture of glycerine and ammonium picrate (Monogenea) and in a mixture of glycerine and alcohol (Nematoda). Parasites were identified using a light microscope equipped with phase-contrast, differential interference contrast (DIC) and image analysis (MicroImage 4.0 for Windows).

Parasite infection was characterized according to Bush et al. (1997): prevalence defined as the percentage of fish infected by a given parasite species in a sample; mean abundance defined as the average number of parasites per host (infected and non-infected). According to prevalence, parasite species were characterized as core (dominant) species (prevalence over 50%), intermediate species (10–50%) and satellite species (< 10%) (Esch and Fernández, 1993). Species diversity was characterized by diversity indices according to Stiling (1996): Shannon diversity index, Simpson index (= 1 − dominance) and Equitability index. Data was analyzed using Microsoft Office Excel 2007 for Windows and Statistica 7.0 for Windows. Values of diversity indices were calculated using PAST software (Hammer et al., 2001), which was also used to perform comparisons of values among parasite communities by a permutation test; for the comparison, only fish of comparable standard lengths were used (Table 2).

Results

Overall character of parasite community and local composition

A total of 16 995 metazoan parasites belonging to 29 species and seven taxonomic groups were found in the parasite community of round goby in Bulgarian, Slovak and Austrian stretches of the Danube River (Table 3). Three individual fish were found to be parasite-free. Infected fish were parasitized with a minimum of one (all sites) and a maximum of seven (Slovak site) parasite species, simultaneously. Maximum intensity of infection was 369 (Bulgarian site, Vidin). Trend of higher total parasite abundance was found in the native round goby populations compared to the non-native populations.

At all sampling sites, most of the parasite species were found in low abundance and prevalence (satellite species). Only three taxa occurred at each sampling site: *Diplostomum* spp. (Digenea), *Pomphorhynchus laevis* (Acanthocephala) and *Raphidascaris acus* (Nematoda); they were also the only ones to always occur as core (dominant) or intermediate parasites, usually in relatively high abundance. High prevalence was also found in glochidia infection: *Anodonta woodiana* in the native

Fig. 1. Map of study area; sampling sites represent native range of round goby – site of Ruse (i) and Vidin (ii) in the Bulgarian stretch of the Danube River, and non-native range – site of Osijek (iii), Gabčíkovo (iv) and Orth an der Donau (v) in the Croatian, Slovak and Austrian stretches of the Danube River, respectively

Table 1
Number of all fish specimens with mean (in mm), standard error (SE) and minimum-maximum of standard length (SL). Values expressed as: number regarding all fish specimens (spring sample / autumn sample)

	Native round goby population		Non-native round goby population	
	Bulgaria-Ruse	Bulgaria-Vidin	Slovakia-Gabčíkovo	Austria-Orth / Donau
Number of fish	38 (0 / 38)	169 (81 / 88)	60 (60 / 0)	126 (31 / 95)
SL	65.8	64.6 (58.9 / 69.6)	64.7	84.0 (83.2 / 84.2)
SE	2.7	1.4 (1.9 / 1.9)	1.9	2.1 (5.2 / 2.2)
Minimum SL	50.6	35.9 (35.9 / 49.9)	46.1	26.3 (26.3 / 52.0)
Maximum SL	110.1	117.0 (113.8 / 117.0)	99.3	120.0 (116.3 / 120.0)

Table 2
Selected fish groups for analyses of diversity indices and between-group comparison: number of fish specimens by season and sampling site (BG, Bulgaria; SK, Slovakia; AT, Austria) with mean (in mm), standard error (SE) and minimum-maximum of standard length (SL)

	Spring sample			Autumn sample		
	BG-Vidin	SK	AT	BG-Ruse	BG-Vidin	AT
Number of fish	20	20	19	21	37	25
SL (SE)	82.3 (3.7)	80.3 (3.3)	89.3 (3.4)	74.3 (4.0)	77.1 (1.9)	75.2 (3.5)
Minimum SL	64.8	64.1	59.1	59.3	60.0	60.0
Maximum SL	113.8	99.3	109.1	110.1	100.0	101.2

Table 3
List of all parasite species found in round goby during the study (n, number of fish examined; P, prevalence; A, mean abundance)

	Native round goby population				Introduced round goby population			
	Bulgaria-Ruse (n = 38)		Bulgaria-Vidin (n = 169)		Slovakia-Gabčíkovo (n = 60)		Austria-Orth/Donau (n = 126)	
Parasite species	P (%)	A	P (%)	A	P (%)	A	P (%)	A
Cestoda								
[a]*Triaenophorus crassus* Forel, 1868 – pl					1.7	0.02		
Digenea								
Apatemon cobitidis proterorhini Vojtek, 1964 – mtc			0.6	0.03	3.3	0.07		
[a]*Apophallus* spp. – mtc	2.6	0.03	1.2	0.01				
Bucephalus polymorphus Baer, 1827 – mtc							8.7	0.46
Diplostomum spp. – mtc	18.4	0.2	17.9	0.24	46.7	4.57	12.7	0.15
[a]*Holostephanus* spp. – mtc			1.8	0.02	1.7	0.02		
Metagonimus yokogawai Katsurada, 1912 – mtc			2.4	0.03				
Nicolla skrjabini (Iwanitzky, 1928)	7.9	0.3	3.6	0.1			2.4	0.06
[a]*Nicolla* sp.	2.6	0.7	1.2	0.02				
Tylodelphys clavata (Nordmann, 1832) – mtc					6.7	0.08		
Digenea sp. 1 – mtc			0.6	0.01				
Digenea sp. 2 – mtc							0.8	0.01
Digenea sp. 3 – mtc					1.7	0.07		
Monogenea								
[a]*Gyrodactylus papernai* Ergens et Bychowsky, 1967			0.6	0.01				
Gyrodactylus proterorhini Ergens, 1967			0.6	0.01				
[a]*Gyrodactylus sedelnikowi* Gvozdev, 1950			0.6	0.01				
[a]*Gyrodactylus* sp.1			0.6	0.01				
Acanthocephala								
Pomphorhynchus laevis (Müller, 1776) – subadult, adult	94.7	22.1	99.4	43.3	43.3	1.65	96	32.05
Nematoda								
Anguillicoloides crassus Kuwahara, Niimi et Itagaki, 1974 – L3			2.4	0.03	10	0.1	6.3	0.09
[a]*Camallanus lacustris* (Zoega, 1776)					3.3	0.05		
Camallanus sp. – L4					1.7	0.02		
Eustrongylides excisus Jägerskiöld, 1909 – L3	5.3	0.1	7.1	0.09			1.6	0.02
[a]*Pseudocapillaria salvelini* (Dujardin, 1843) – L4					1.7	0.02	0.8	0.01
Pseudocapillaria sp. – larva					1.7	0.05		
Raphidascaris acus (Bloch, 1779) – L3	31.6	0.8	11.3	0.2	76.7	4.08	96.8	20.73
Streptocara crassicauda (Creplin, 1829) – L3			0.6	0.01	1.7	0.05	0.8	0.01
Bivalvia								
Anodonta anatina Linnaeus, 1758 – gloch			2.4	0.04	83.3	7.53	24.6	2.77
[a]*Anodonta woodiana* (Lea, 1834) – gloch	65.8	1.7	0.6	0.01			0.8	0.01
[a]*Pseudoanodonta complanata* Rossmässler, 1835 – gloch			12.5	2.15	11.7	0.47		
Crustacea								
[a]*Argulus foliaceus* Linnaeus, 1758					1.7	0.02		
[a]*Caligus* sp. – chalimus					1.7	0.02		

[a]Taxa recorded in round goby for the first time. pl, plerocercoid; mtc, metacercaria; gloch, glochidia.

range in a Bulgarian site, Ruse, and *Anodonta anatina* in the non-native range in Slovak and Austrian sites (Table 3).

In the native range (both Bulgarian sites), the parasite community was represented predominantly by one species (*Pomphorhynchus laevis*). In the non-native range, the parasite community in the Slovak site was composed mainly of *Anodonta anatina* and *Diplostomum* spp. as well as by *Pomphorhynchus laevis* and *Raphidascaris acus*. In the Austrian site, the parasite community was composed mainly of three species in spring (*P. laevis*, *R. acus* and *A. anatina*) and two species in autumn (*P. laevis* and *R. acus*) (Fig. 2a,b).

Most of the parasites were found in larval stages, using the round goby as an intermediate or paratenic host (see Table 3). *Nicolla skrjabini* (Digenea), *Gyrodactylus* spp. (Monogenea),

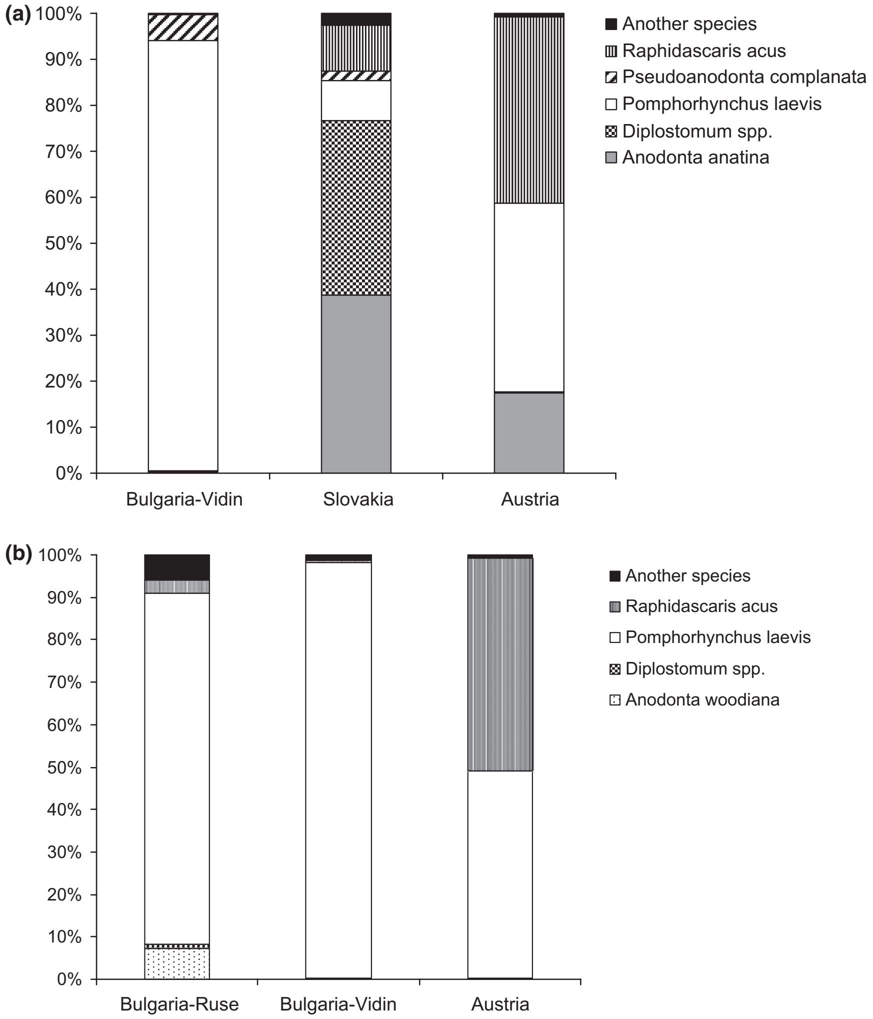

Fig. 2. (a): Proportion of parasite species in total parasite abundance – data from spring sample (see Table 4). (b) Proportion of parasite species in total parasite abundance – data from autumn sample (see Table 5)

Argulus foliaceus (Crustacea) and *Pomphorhynchus laevis* (Acanthocephala) were the only species parasitizing round goby in the adult stage. The parasite fauna of the round goby was composed predominantly of endoparasitic species.

Three specimens of *N. melanostomus* collected in the Croatian stretch of the Danube River were infected with a total of five parasite taxa (*Diplostomum* spp., *Pomphorhynchus laevis*, *Pseudocapillaria* sp., *Raphidascaris acus* and *Anodonta woodiana*). Acanthocephalans *P. laevis* and larval nematodes *R. acus* were found in all three fish specimens and in relatively high abundance.

Occurrence of parasite species in native and non-native round goby populations

Out of 20 parasite species found in the native range and 21 species from the non-native range, 12 species occurred in both areas. All species parasitizing *N. melanostomus* either only in the native (eight species) or only in the non-native range (nine species) occurred sporadically in low abundances and belonged to satellite species.

No parasite species known to use round goby as a specific host was found in the native or in the non-native range of distribution; 13 parasite taxa were recorded for the first time in round gobies (five taxa were found only in the native range, five taxa only in the non-native range, three taxa in both the native and the non-native ranges) (see Table 3).

Parasite species diversity in native and non-native round goby populations

In native (Bulgarian) round goby populations, the highest parasite species richness (20 spp.) and the lowest parasite species richness (eight spp.) was found in the Vidin site and the Ruse site, respectively. The mean infracommunity richness, however, was higher in the Ruse site (2.3) than in the Vidin site (1.7). Regarding non-native populations, 16 parasite species were found in fish from the Slovak site and 12 species from the Austrian site. Mean infracommunity richness reached a value of 3.1 in the Slovak site (the highest value) and 2.5 in the Austrian site.

Higher values of all diversity indices (calculated for all data) were found in parasite communities from fish collected in both non-native sites compared to both native sites. Data of comparable fish lengths (for both spring and autumn seasons) provided the same results. In spring samples, all diversity indices were lowest in the Vidin site (native range), but significant differences were revealed in all cases with the exception of Equitability index values between the parasite community from the Slovak and Austrian sites (both in the non-native range) (Table 4). In autumn samples, all diversity indices were similarly lowest in the Vidin site (native range), but significant differences were again revealed in all cases with the exception of the Shannon diversity index between the parasite community from the Bulgarian site of Ruse (native range), and the Austrian site (non-native range) (Table 5).

Table 4
Parasite species diversity counted from selected data in spring sample and results of diversity comparison (BG, Bulgaria; SK, Slovakia; AT, Austria; n, number of fishes). Data from Bulgaria-Ruse not available

	Spring sample					
	BG-Vidin (n = 20)	SK (n = 20)	AT (n = 19)	BG-Vidin × SK (P value)	BG-Vidin × AT (P value)	SK × AT (P value)
Parasite species richness	7	10	7			
Total parasite abundance	1891	481	1380			
Diversity index						
Shannon	0.28	1.38	1.09	< 0.001	< 0.001	< 0.001
Simpson	0.12	0.69	0.64	< 0.001	< 0.001	< 0.001
Equitability	0.14	0.60	0.56	< 0.001	< 0.001	0.83

Table 5
Parasite species diversity counted from selected data of autumn sample and results of diversity comparison (BG, Bulgaria; AT, Austria; n, number of fishes). Data from Slovakia not available

	Autumn sample					
	BG-Ruse (n = 21)	BG-Vidin (n = 37)	AT (n = 25)	BG-Ruse × Vidin (P value)	BG-Ruse × AT (P value)	BG-Vidin × AT (P value)
Parasite species richness	8	10	5			
Total parasite abundance	689	2365	970			
Diversity index						
Shannon	0.72	0.15	0.76	< 0.001	0.44	< 0.001
Simpson	0.31	0.05	0.51	< 0.001	< 0.001	< 0.001
Equitability	0.35	0.07	0.47	< 0.001	< 0.001	< 0.001

Discussion

Occurrence of parasite species in native and non-native round goby populations

In this study, a total of 29 metazoan parasite species were found in round goby in the Danube River. Of these parasite species, only 13 were previously known to parasitize round goby (Gayevskaya et al., 1975; Muzzal et al., 1995; Pronin et al., 1997; Camp et al., 1999; Kvach, 2001, 2002a,b,c, 2004, 2005; Rokicki and Rolbiecki, 2002; Miller, 2003; Ondračková et al., 2005; Molnár, 2006; Rolbiecki, 2006; Kvach and Skóra, 2007; Özer, 2007; Kvach and Stepien, 2008; Mühlegger et al., 2010), and 13 parasite species were recorded to parasitize the round goby for the first time (including parasites found in the native range in Bulgaria) (Table 3). Furthermore, of all parasite species found in our study, some were found only in the native area of round goby distribution, some only in the non-native area, and some in both native and non-native areas of distribution. Our data do not allow us to confirm or refute the introduction of certain parasite species together with round goby into the new areas in the upper and middle Danube River. However, there was no parasite species found to be evidently novel in the upper and middle Danube River that could have been introduced with the round goby. Almost all observed parasite species were native to the Danube River basin (Moravec, 2001), except *Anguillicoloides crassus* and *Anodonta woodiana*, whose introduction cannot be connected with round goby as these species were introduced from east Asia into the middle Danube in the 1980s (Hubenov, 2006; Paunović et al., 2006; Taraschewski, 2006).

Considering round goby from the Bulgarian stretch of the Danube River as a source of non-native populations, there appears to be no potential for introduction of novel parasite species because *N. melanostomus* in the Bulgarian stretch was not infected by specific goby parasites or by parasites distributed only in the lower section of the Danube River. Nevertheless, a suggestion is that the novel parasite species in Austria, *Bucephalus polymorphus,* could have been introduced by the gobies (see Mühlegger et al., 2009). However, this parasite is common in various fish species in the Danube River basin in the Czech and Slovak republics (Moravec, 2001). In our study, instead of being a source of parasite introduction, non-native round gobies were parasitized with nine parasite species that had not been recorded in its native range, although most of these species are also present in the lower Danube River. Parasite species found in only one of the ranges (non-native or native) were of low prevalence and abundance. Infestations with novel parasite species as well as parasite loss were therefore not evident.

Novel parasite introduction with round gobies has not been recorded in the Great Lakes (Muzzal et al., 1995; Pronin et al., 1997; Camp et al., 1999; Kvach and Stepien, 2008) nor has it been recorded in the Baltic Sea (Kvach, 2002a; Rokicki and Rolbiecki, 2002; Rolbiecki, 2006; Kvach and Skóra, 2007). However, with *N. melanostomus* introductions into distant areas, parasite loss was more likely to occur when compared to introductions within the same river system, e.g. the Danube River. Acquisition of novel parasite species in round goby is also more evident in the distant areas.

Overall character of parasite community

If an introduced species is parasitized in a new environment, in most cases it is infected with generalist parasite species adapted to infect a wide range of host species (Kennedy and Bush, 1994). This hypothesis was confirmed in our study: almost all parasite species found in *N. melanostomus* in the Danube River (in both native and non-native areas of distribution) were generalists. The monogenean species *Gyrodactylus proterorhini* was the only specialist (specializing on the Gobiidae family) found in round goby. This parasite species has been noted as specific for *Proterorhinus marmoratus* (Gobiidae) (Ergens, 1967), but has been also recorded in other gobiid fish (Naydenova, 1974; Dmitrieva and Gerasev, 1997; Ondračková et al., 2005). Sporadic occurrence of *G. proterorhini* was confirmed only in the native range (see Table 3) suggesting a low susceptibility of the round goby to this parasite. Therefore, the absence of *G. proterorhini* in the non-native range is related to the generally low infection rate rather than to parasite loss during fish transportation.

The parasite fauna of round goby was composed of three taxa (*Diplostomum* spp., *Pomphorhynchus laevis*, and *Raphidascaris acus*), which were found to be dominant or intermediate parasites and relatively abundant in all round goby populations, whereas other parasites occurred in low prevalence, low abundance or even accidentally. This was the case of the *Gyrodactylus* species from the Bulgarian stretch of the Danube River. The morphology and morphometry of opisthaptor hard parts corresponded to descriptions of *G. papernai* according to Gusev (1985) and Přikrylová (2008), and *G. sedelnikowi* according to Gusev (1985). *Gyrodactylus* sp. 1 was found to be closest to the description of *Gyrodactylus leucisci* according to Gusev (1985) and Ergens (1991). Transmission of these parasite species to *N. melanostomus* remains a question, especially transmission of *G. papernai* and *G. sedelnikowi* as these species are known to be specific to *Barbatula barbatula* (Gusev, 1985), family Balitoridae, a fish species not confirmed in the main channel of the Danube River in Bulgaria (Vassilev and Pehlivanov, 2005; Polačik et al., 2008b).

The high number of endoparasitic species in the round goby was most likely due to its carnivorous diet composed of bottom dwelling organisms, mainly amphipods (in the native and non-native range) and bivalves (native range) (Simonović et al., 2001; Copp et al., 2008; Borza et al., 2009). Foraging strategy of host species was recognized to be an important factor in its parasite community structure. The carnivorous diet represents a wide range of potential intermediate hosts of endoparasitic species and may lead to an accumulation of endoparasites (Šimková et al., 2001). Four taxonomic groups of endoparasites were recorded in the round goby: Cestoda, Digenea, Acanthocephala and Nematoda – each using a certain group of invertebrates as first intermediate hosts. Amphipods, an important part of the round goby diet (e.g. Copp et al., 2008), serve as first intermediate hosts for acanthocephalan *P. laevis* (McCahon et al., 1991); this diet preference can be an explanation of the high dominance of this parasite in round goby populations. Copepod crustaceans or oligochaetes are denoted as intermediate hosts of the cestode species and most of the nematode species found in the round goby (Bauer, 1987; Moravec, 1994). These invertebrates were found to be supplementary in the diet (planktonic copepods were almost absent) (Polačik et al., 2009), which may correspond to the lower infection rate of cestodes and nematodes in the round goby compared to acanthocephalan infection (with the exception of the nematode *R. acus*). Infection with larval digeneans is caused by contact with cercariae that are released by molluscs (mainly gastropods) and penetrate the fish skin (Thieltges et al., 2008).

Parasite diversity in native and non-native round goby populations

Diversity indices revealed higher species diversity in parasite communities of fish from non-native compared to native round goby populations. This can also be confirmed by higher infracommunity species richness found in fish from non-native populations. In the native goby population from the Bulgarian site, Vidin, the highest number of parasite species but the lowest diversity was found due to high dominance (in terms of parasite abundance) of one species: the acanthocephalan *P. laevis*. This high dominance of one species also resulted in a relatively low parasite diversity in the Bulgarian goby population from the Ruse site, which also had the lowest species richness. Higher parasite species diversity in non-native round goby populations from the Slovak and Austrian sites (with highest values in the Slovak site) indicated that species abundance was relatively uniform in these communities compared to parasite communities from the native area. Occurrence of the same or even higher species diversity in the parasite community of introduced fish species, compared to the fish species in its native area of distribution, was also reported by Poulin and Mouillot (2003).

Similar equitability of parasite communities was found between the Slovak and Austrian round goby populations, whereas there was significantly lower equitability of parasite communities in the Bulgarian populations (with a significant difference between the Vidin and Ruse sites). The difference between native and non-native communities may be partly associated with different diet patterns of round goby in the native and non-native areas of distribution. Aside from amphipods (the frequent prey item in both native and non-native populations), Polačik et al. (2009) identified molluscs (mainly bivalves) as the frequent prey item of round goby in Bulgaria, and several taxa of non-mollusc invertebrates (trichopters, oligochaetes, chironomids, isopods) as the relatively frequent prey item in Austria. A relatively wide range of non-mollusc invertebrates was also found in the diet of round goby in Hungary (middle Danube) (Borza et al., 2009). The diet in the upper and middle Danube thus comprised a relatively more diverse group of potential intermediate hosts, which might have resulted in more equitable parasite communities of non-native round goby populations. Regarding parasites transmitted via the oral route, *P. laevis* was the only dominant parasitic species in native round goby populations, whereas parasite communities of non-native populations were composed of *P. laevis* and *R. acus*, both with similar infection rates. *R. acus* could have been transmitted by various taxa of non-mollusc invertebrates found in the round goby diet (Moravec, 1994). Similar equitability between parasite communities of Slovak and Austrian round goby populations was, however, a result of similar proportion of all parasite species in the communities, including glochidia of *A. anatina* and digenean *Diplostomum* spp.

Comparison with co-occurring gobiid species

Simultaneously with round goby, the congeneric species bighead goby *Neogobius kessleri* (Günther, 1861) was introduced in the middle and upper Danube River, sharing similar habitat (Polačik et al., 2008a) and diet (Polačik et al., 2009). Parasite fauna of bighead goby was studied extensively in both its native and non-native range in the Danube River (see Ondračková et al., 2005, 2006, 2009, 2010; Molnár, 2006; Mühlegger et al., 2010). The overall structure of the parasite community in *N. kessleri* was found to be similar to that in

N. melanostomus. Likewise, the trend of higher parasite infracommunity richness in a non-native fish population compared to a native population was revealed in both *Neogobius* species. No introduction of novel parasite species, acquisition of novel species, or parasite species loss was proven in bighead goby.

In conclusion, we found that diversity of parasite fauna of *N. melanostomus* differed among particular sampling sites in the longitudinal profile of the Danube River. Nevertheless, the diversity of parasite communities in non-native round goby populations was in general higher than the diversity in native populations. According to our study, the difference in the structure of parasite communities in round goby most probably reflected the ecological conditions of particular sites.

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