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ORIGINAL PAPER

Gyrodactylus proterorhini Ergens, 1967 (Monogenoidea, Gyrodactylidae) in gobiids from the Vistula River—the first record of the parasite in Poland

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Abstract During a parasitological survey of two non-native fish species—racer goby *Neogobius gymnotrachelus* and monkey goby *Neogobius fluviatilis*—in the Włocławek Reservoir on the lower Vistula River, the monogenean *Gyrodactylus proterorhini* was recorded for the first time in Poland, and for the first time, the racer goby was listed as the parasite host. Specimens of *G. proterorhini* were detected on body surface, fins, and gills of the fish studied. In 2006, the monkey goby was infected with the prevalence 41%, racer goby with the prevalence of 47%, at maximal intensity of 6 and 9 parasites per fish, (respectively). The infection level in relation to the fish size and sampling season was also discussed. The presented study supports the hypothesis of progressive introduction of the parasite with gobiids to the colonized areas.

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Introduction

The Włocławek Reservoir on the lower course of the Vistula River (Fig. 1) was recently colonized by three species of Ponto–Caspian goby fish. Racer goby *Neogobius gymnotrachelus* (Kessler, 1857) has been noted there since 2000 (Kostrzewa and Grabowski 2001) and Monkey goby *Neogobius fluviatilis* (Pallas, 1814) since 2002 (Kostrzewa and Grabowski 2002). Quite recently in 2008, tubenose goby *Proterorhinus marmoratus* (Pallas, 1814) has appeared in the lower Vistula River course near Plock (Grabowska et al. 2008). Subsequently, it has been found in fish catches in the central part of the Włocławek Reservoir, but described as *P. semilunaris* (Heckel, 1837) (Piotr Hliwa unpublished). The natural range of the above-mentioned gobiids is Eurasia; rivers and estuaries of Black, Azov, and Caspian Seas. *Proterorhinus* spp. also occur in the Mediterranean area—in the Evros and Strymon systems, which empty in the northern Aegean Sea (Kvach and Oğuz 2009). Those three fish species reached the Vistula basin and Poland probably through the Pripyat-Bug canal commonly crossed by Ponto–Caspian organisms on their way to Europe (Bij de Vaate et al. 2002; Grabowska et al. 2008). Goby fish have become a numerous species in the near-shore fish communities in the lower Vistula and stimulated considerable changes in the local food webs (Kakareko et al. 2003; 2005; 2009; Grabowska and Grabowski 2005; Grabowska et al. 2009).

Non-native species could introduce exotic parasites to the colonized areas. Monitoring of this “secondary”

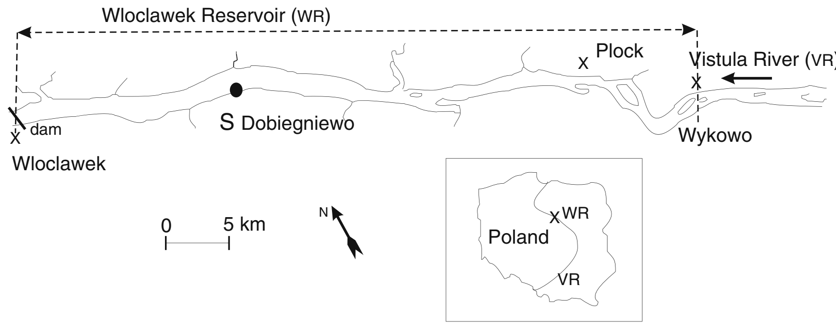

Fig. 1 Sampling site (*S*) of gobiids in the Włocławek Reservoir (*WR*) and a map of Poland, with the Vistula River (*VR*) position shown

introduction (in the meaning of symbiotic species introduction with their introduced host) is essential in predicting the effects of biological invasions, due to the potential susceptibility of native fish species for infection with an alien parasites, or indirectly, due to changes in the communities structure of native parasites (Torchin et al. 2003; Torchin and Mitchell 2004).

Gyrodactylus proterorhini Ergens 1967 [syns *G. gussevi* Najdenova, 1966; *G. najdenovae* Malmberg 1970, and *G. arcuatus* Bykhovskii sensu Ergens] is a common parasite of gobiids inhabiting a littoral zone of the Black and Azov Seas and their estuaries (Ergens 1972). The species was initially described by Ergens (1967) from the tubenose goby *Proterorhinus marmoratus* in its natural range in the Danube River (in southern Slovakia). Formerly, *G. proterorhini* was incorrectly recognized as *G. arcuatus* from the same fish host in the Czechoslovakian part of the Danube, i.e., outside the natural range of the species (Ergens 1962). Afterwards, four more species of Gobiidae in their natural range were mentioned as the *G. proterorhini* hosts: grass goby *Zosterisessor ophiocephalus* (formerly *Gobius ophiocephalus*), giant goby *Gobius cobitis*, black goby *G. niger*, and round goby *Neogobius melanostomus* (Najdenova 1974; Ergens 1985; Dmitrieva and Dimitrov 2002; Longshaw et al. 2003; Harris et al. 2004; Őzer 2007). Miroshnichenko (2008) adds three further species: monkey goby *N. fluviatilis*, flatsnout goby *N. platyrostris*, and knout goby *Mesogobius batrachocephalus* to this pool. Study of the introduction of *G. proterorhini* broadens the list of the parasite hosts to one more (the eighth)—bighead goby *Neogobius kessleri*, infected with the parasite in the New Danube channel (at the Slovak stretch of Danube) and in the Horn River. The infection of bighead goby was probably related to co-occurrence with tubenose goby at these particular study sites (Ondračková et al. 2005; 2009).

Francová (2007) has confirmed the *G. proterorhini* introduction with round goby in the stretch of the Danube in Slovakia and Austria. However, the round goby in Polish coastal waters of the Baltic Sea (the area invaded in recent decades) is not infected with Monogenea at all (Rolbiecki 2006). Accordingly, the present paper reports for the first time the occurrence of *G. proterorhini* in Poland, as well as for the first time in racer goby *N. gymnotrachelus*. It is worth noting that this species of monogeneans is common for both: the freshwater and the marine tubenose goby (Kvach and Oğuz 2009). The freshwater *Proterorhinus semilunaris*, liberated from the species of *P. marmoratus* on the basis of genetic investigations (see Stepien and Tumeo 2006), is expanding its range widely at present (Manné and Poulet 2008), also in the Vistula River and the Włocławek Reservoir, but till now, there has been no information on *G. proterorhini* introduction to the areas colonized with this fish host (Kvach and Stepien 2008). The population dynamics of the parasite during the widening the list of its hosts and the constant increase of their numbers in the Włocławek Reservoir are interesting and are ongoing.

Material and methods

Specimens of racer goby and monkey goby were collected in the Włocławek Reservoir (central Poland) by electrofishing (battery-powered unit IUP-12, RADET Ltd., Poznań, 225/300 V, 6A, 50–90 Hz) close to Dobiegniewo locality (52° 37–38′ N; 19° 19–20′ E) (Fig. 1) in the shallow (up to 1 m deep) near shore zone of the flooded area of the reservoir. Fish samples were collected three times in 2006: in spring (29th of May), in summer (7th of August), and in autumn (2nd of October). The number of racer goby caught 10, 9, and 10, (respectively in seasons) was larger than number of monkey goby in related samples: 4, 4, and 9. All individuals were measured, weighed, and analyzed for the presence of monogeneans on their gills, fins, and body surface. Monogeneans were removed and fixed with a mixture of glycerine ammonium picrate (GAP) (Malmberg 1970). Smears of scrapings stained with Giemsa dye were also analyzed. Specimen identification was based on morphological analysis and measurements of the haptor's hard elements according to Gusev (1985) under a compound light microscope (Nikon ECLIPSE E600W).

Table 1 Infection of two gobiids species with *Gyrodactylus proterorhini* in the Włocławek Reservoir (Vistula River, Poland)

Sampling data (number of fish)	*G. proterorhini*			
	P (%)	I (mean)	I (range)	A
Racer goby				
05/29/2006 (10)	80.0	2.5	1–6	2.0
08/07/2006 (9)	44.4	1.3	1–2	0.6
10/02/2006 (10)	0.0	–	–	0.0
Totally (29)	41.4	2.1	1–6	0.9
Monkey goby				
05/29/2006 (4)	75.0	2.0	1–3	1.5
08/07/2006 (4)	25.0	9.0	9	2.3
10/02/2006 (9)	44.4	1.0	1–1	0.4
Totally (17)	47.1	2.4	1–9	1.1

P prevalence, *I* intensity of infection, *A* abundance

Prevalence (percentage of the fish infected), intensity of infection (mean value and range of the parasite number per the infected fish), and abundance (mean number of the parasite per fish studied) were estimated to characterize the infection level. The differences in the fish size, as well as the differences in the infection level in samples, were compared by the Mann–Whitney's *U* Test. Spearmann's correlation coefficient was applied to find the relations between the fish size (standard length (SL), total length (TL), and weight) and the infection level (number of *G. proterorhini* per fish studied, both infected and non-infected individuals were included).

Results

In the Włocławek Reservoir, 41% of racer goby and 47% of monkey goby analyzed in 2006 were infected with *Gyrodactylus proterorhini*. Specimens of the parasite were detected predominantly on fins and body surface of racer goby (18 out of the 25 specimens) and almost exclusively on gills of monkey goby (22 out of the 23 specimens). The prevalence in particular seasons ranged from 0% to 80% and from 25% to 75% in racer goby and monkey goby, respectively (Table 1). According to the *U* test, the infection of racer goby was significantly higher in spring (U=10, z= −3.02, p=0.002) and in summer (U=25, z= −2.30, p=0.022) than in autumn (Table 1). The same test, however, did not confirm the significance (p>0.05) of seasonal differences in the infection level of monkey goby (Table 1). A non-parametric Spearman's test revealed a weak positive correlation between the infection level and the body length of racer goby (sl/number of *G. proterorhini* R=0.22, p<0.05), but did not confirm such a dependence for monkey goby at all (p>0.05). Individuals of racer goby studied in autumn were significantly smaller than those analyzed in the spring (U=15, z=2.65, p=0.008). The sizes of monkey goby in seasonal samples were comparable (U test at p>0.05) (Fig. 2).

Specimen description

Monogeneans detected in round goby and monkey goby were similar. The measurements of haptoral hard parts (Fig. 3) (48 specimens included): anchors with additional processes (Fig. 3a)—the total length of anchor 40–44 µm, the length of shaft 30–35 µm, the length of the root 9–14 µm, and of the point 20–22 µm. Ventral bar with small anterolateral processes (Fig. 3a)—the length of ventral bar 5 µm, the width 18 µm, the length of membrane 12 µm. Dorsal bar (Fig. 3a)—the length 2 µm, the width 19 µm.

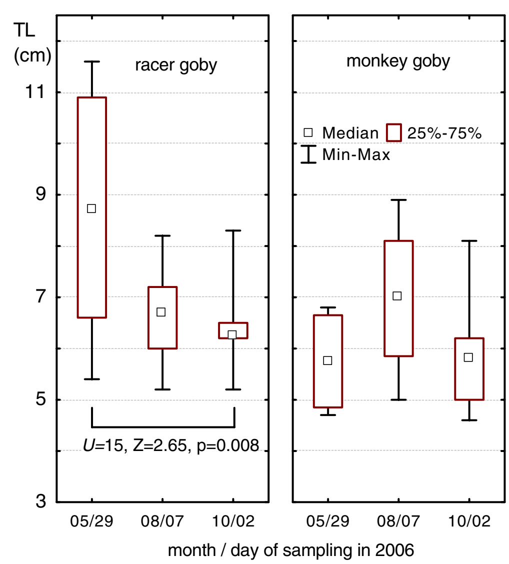

Fig. 2 Comparison of the fish total length (*TL*) in samples by Mann–Whitney *U* test. The fish sampling carried out three times (seasonally): in 2006 (29th of May, 7th of August, and 2nd of October). Individuals of racer goby (*N. gymnotrachelus*) in sample of autumn significantly smaller than those in sample of spring (p<0.05)

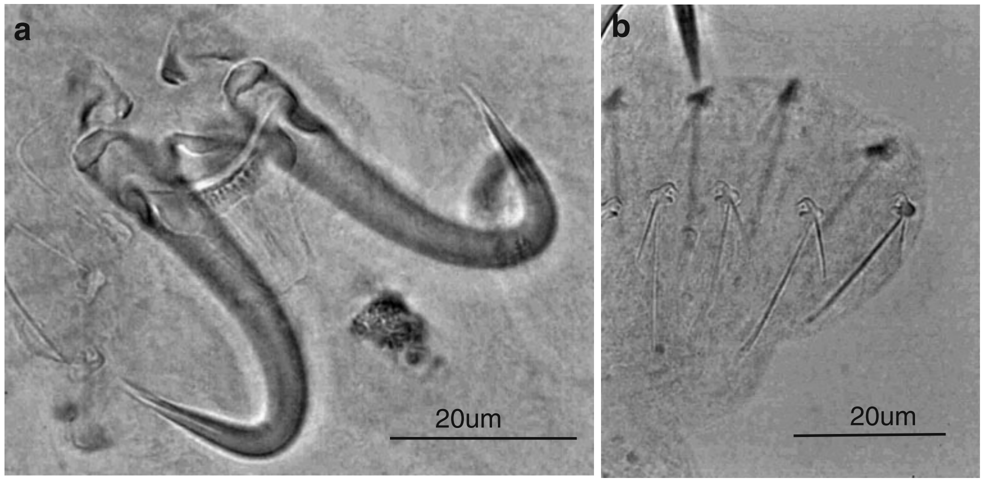

Fig. 3 Haptoral hard parts of *Gyrodactylus proterorhini*. Specimen detected in racer goby from the Włocławek Reservoir (Vistula River, Poland) fixed in GAP. *a* anchors linked with ventral and dorsal bars, *b* marginal hooks

Marginal hooks (Fig. 3b)—total length 22–24 μm, the length of sickle 4 μm. The measurements of monogenean body (15 best-preserved specimens included): total length 330–370 μm and the width 70–90 μm

Discussion

Significant seasonal differences in the occurrence of *G. proterorhini* were not observed in monkey goby but were observed in racer goby (Table 1). This last difference could be related to the significant difference observed in racer goby size collected in different seasons (Fig. 2). The relationship between levels of infection and host size is, however, not completely conclusive in the present work as the Spearman's test indicate no correlation in monkey goby ($p>0.05$) but correlation on racer goby ($R=0.22$, $p<0.05$). All these results should be confirmed in a near future with the observation of a much bigger number of fish host in all seasons.

At natural range, depending on the area of study and the fish species, the infection of Gobiidae with *G. proterorhini* varies substantially. In the Black Sea near Sevastopol, the extremely high intensity of infection up to 500, 320, and 98 parasites per fish was observed (Najdenova 1974) in *Gobius cobitis*, *G. niger* and *G. opiocephalus* (respectively). In the Azov Sea, maximal intensity in *Neogobius fluviatilis* reached 165. However, the marine *Proterorhinus marmoratus*, as well as the freshwater tubenose goby *P. semilunaris*, were infected with relatively low abundance in summer in the Sukhyi Estuary, Gulf of Odessa, and Dniester River did not exceed 0.3 (Kvach and Oğuz 2009).

In the colonized area (the Slovak section of the Danube River), the abundance of *G. proterorhini* in bighead goby *Neogobius kessleri* varied between 0.03 in autumn and 13.25 in spring, at a prevalence of 17% and 90%, respectively (in seasons) (Ondračková et al. 2005; 2009).

In general, the infection of gobiids with *G. proterorhini* in the Włocławek Reservoir was relatively low. The prevalence, as predicted (Chubb 1977), picked in spring, achieving 80% and 75%, but the abundance did not exceed 2.3 parasites per fish, even in warmer months (Table 1). However, the population growth of the parasite during the progressive expansion of its hosts is highly probable and expected. The specific behavior of gobiids during the spawning season: the accumulation of fish in coastal zones, the high concentration of larvae in the spawning grounds, and the quick transmission of monogeneans from males guarding the nest directly to eggs and to offspring, all support the infection process. As the laboratory study proved, the incubated eggs are infected with monogeneans a week after laying, and the larvae are then invaded by the parasite just after hatching (Najdenova 1974). The infection with monogeneans is also reinforced by an increase in temperature during the spawning season and by the reduced immunity of fish after overwintering (Chubb 1977; Appleby 1996).

The occurrence of *G. proterorhini* in the lower course of the Vistula River supports the hypothesis of the progressive introduction of the parasite with gobiids to the colonized areas. This species of monogenea is currently becoming a permanent element of parasite communities in Central and Western Europe (Ondračková et al. 2005; 2009; Francová 2007; Kvach and Oğuz 2009), and its hosts are becoming a permanent component of the ichthyofauna in these areas.

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