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Predator-prey interactions between a recent invader, the Chinese sleeper (*Perccottus glenii*) and the European pond turtle (*Emys orbicularis*): a case study from Lithuania

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Abstract. The European pond turtle, *Emys orbicularis*, is a critically endangered species in most European countries. Habitat degradation and fragmentation are considered the main reasons for the decline of *E. orbicularis*. However, the spread of invasive species may also contribute to the disappearance of *E. orbicularis* populations. We examined the range overlap and predator-prey interactions between the invasive Chinese sleeper, *Perccottus glenii*, and *E. orbicularis* through controlled experiments and in field studies. Field surveys showed that both species occupied similar habitats. Predator-prey experiments suggested that newly hatched turtles are resistant to *P. glenii* predation. Conversely, adults of *E. orbicularis* consumed juvenile *P. glenii* even when other food sources were available. Overall, these findings suggested that *E. orbicularis* is not among the potential prey organisms in the diet of the invasive *P. glenii,* and that this fish does not directly contribute to the decline of *E. orbicularis* in Europe.

Keywords. Turtle, aquatic invasion, endangered species, inland waters, Lithuania.

INTRODUCTION

At present, there is no doubt that one of the main causes of the loss of biodiversity is the spread of introduced, invasive species. These species reduce local biodiversity through both indirect competitive and direct predatory impacts on resident native populations. The spread of invasive species is now considered to be an international problem, and local governments are actively working to reduce their spread and impacts (EU Regulation No 1143/2014). However, aquatic invasive species spread is on-going, and its impacts on local communities cannot be predicted (Sundseth, 2014). Understanding the pattern of invasive species interactions with native species can help us to predict those effects and build better strategies for protection of endangered species. From a biodiversity management point of view, the impact of the invasive versatile predator Chinese sleeper, *Perccottus glenii* (Dybowski, 1877) on populations of the endangered native European pond turtle, *Emys orbicularis* (Linnaeus, 1758) is one such case in point.

Perccottus glenii, a fish native to the Amur River basin, eastern Asia (Mori, 1936; Berg, 1949). This is one of the most widespread alien invasive freshwater fish in Eurasia (Reshetnikov, 2010; Reshetnikov and Ficetola, 2011). It is also a recent invader in the Baltic Sea region (Aleksejevs and Birzaks, 2011; Witkowski and Grabowska, 2012; Reshetnikov and Karyagina, 2015; Pupina et al., 2015; Rakauskas et al., 2016). In Europe *P. glenii* occurs mostly in water bodies that either have weak current or are stagnant, with well developed aquatic vegetation. Such habitats include river flood plains, littoral zones

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of lakes, and swampy water bodies (Reshetnikov, 2010; Reshetnikov and Ficetola, 2011; Pupina et al., 2015).

Shallow, well-vegetated and isolated lakes, ponds, drainage ditches and oxbows are important reserves of biological diversity for many groups of aquatic and semi-aquatic animals, including pond turtles. Colonisation of such water bodies by *P. glenii* leads to a dramatic simplification of ecosystem taxonomic structure. *P. glenii* is a versatile predatory fish and represents a specific threat for macroinvertebrates and small fish and amphibians (Shlyapkin and Tikhonov, 2001; Reshetnikov, 2003; Reshetnikov, 2004; Koščo et al., 2008; Grabowska et al., 2009; Reshetnikov, 2013).

Due to its generalist predatory habit, it has been assumed that *P. glenii* preys upon hatchling *E. orbicularis* turtles (Pupina et al., 2015). Adult turtles can deter predation by their size and bony shell, but hatchlings lack the adult's size and shell strength. Populations of *E. orbicularis* hatchlings were assumed to be under *P. glenii* predation pressure until their first or second years.

This paper addresses the predator-prey interactions between *P. glenii* and locally endangered *E. orbicularis*. Concerns about *P. glenii* are based on observations that this fish (1) inhabits similar habitats as *E. orbicularis* (Mitrus, 2004; Najbar, 2007; Briggs and Reshetylo, 2009; Reshetnikov, 2010; Reshetnikov and Ficetola, 2011); (2) is an opportunistic, competitive predator that rises to the top of the food chain in invaded ecosystems (Reshetnikov 2003; Reshetnikov, 2004; Reshetnikov, 2013); and (3) grows large enough to prey on newly hatched *E. orbicularis*. This scenario, however, has not been well substantiated for interactions in European waters.

To fill this knowledge gap, we performed predator-prey experiments between *P. glenii* and two aquatic turtle species. In laboratory experiments we tested the capacity of *P. glenii* to consume newly hatched Chinese pond turtles, *Mauremys reevesii* (Gray, 1831), when it is the only available prey. It was assumed that there would be no differences in *P. glenii* feeding preferences for same-sized *E. orbicularis* and *M. reevesii* juveniles. Additionally, we tested the capacity of the adult *E. orbicularis* to consume 0+ age *P. glenii* when several prey sources were available. As a complement to the laboratory studies, we analyzed the overlap of recent distributions of *P. glenii* and *E. orbicularis* species in natural Lithuanian freshwaters.

MATERIAL AND METHODS

Study area

Natural habitat overlap between *P. glenii* and *E. orbicularis* species was assessed for the inland waters of Lithuania. Lithuania stands within the Baltic Sea drainage basin, along the south-eastern shore of the Baltic Sea. The country has a territory of 64,800 km^2, which is divided by seven main river basins (Kažys, 2013) (Fig. 1A). There are 2,850 lakes that have surface areas larger than 0.005 km^2, and 3,150 smaller lakes, with a combined area of 913.6 km^2. In addition, there are 1,132 reservoirs and more than 3,000 ponds in Lithuania (Kažys, 2013).

Distribution of P. glenii *and* E. orbicularis

The recent distribution of *P. glenii* and *E. orbicularis* in Lithuanian inland waters was calculated from widely published (Rakauskas et al., 2016) and specialty (Bastytė, 2015) publications. Additional data on the presence of *P. glenii* within the local range of *E. orbicularis* was provided by our own (to be published) surveys.

The results of our surveys include data from 32 lentic water bodies, each with a surface area smaller than 0.3 km^2 and each known to have been occupied by *E. orbicularis* (Fig. 1B). *P. glenii* populations were investigated by dip net (25 × 25 cm opening, 1.5 mm mesh size) sampling in water depths of 0.3-1.3 m in areas of the vegetated littoral zone (Pupina et al., 2015). From five to ten study sites were examined on each water body waving with a dip net for ten minutes at each study site. In general, if *P. glenii* was to be found in a body of water, it was caught within the first 5 minutes (Rakauskas pers. obs.).

*Experiment 1 (*P. glenii *vs.* M. reevesii*)*

Predator-prey experiments (*P. glenii* vs. *M. reevesii*) were conducted to determine if the invasive predator *P. glenii* recognize newly hatched aquatic turtles as potential prey, and if they consume them under experimental conditions. *M. reevesii* was chosen as a model for *E. orbicularis* as it is easy available, not protected, and is of similar size and coloration as *E. orbicularis* (Mitrus and Zemanek, 2000; Stephens and Wiens, 2003; Lovich et al., 2011; Lin et al., 2015). Previous studies have shown that *E. orbicularis* juveniles are similar length (approximate 26 mm) (Drobenkov, 2000; Mitrus and Zemanek, 2000; Zinenko, 2004; Najbar and Mitrus, 2013) when they first reach the water, as were the *M. reevesii* juveniles used in these experiments (3.0 ± 0.1 mm). *E. orbicularis* is less available and is protected by European and local laws (Council Directive 92/43/EEC; Rašamavičius, 2007).

Newly hatched (two week old) *M. reevesii* were transported to the laboratory one week before the experiments from the local zoo-shop. The experiment turtles were maintained in twelve 10.6-L aquaria (22.5 cm deep and long × 21 cm wide) filled with tap water forming a closed circulation system with an ammonia filter (38.5 cm deep and wide × 49.0 cm long aquarium filled with expanded clay and JBL filter start (GmbH & Co, Germany)). During this period, daily rations of frozen midge larvae were provided.

Adults of *P. glenii* were collected from small lakes using electric fishing gear (Samus-725mp) in September 2015. For one week before conducting the experiments, all fish were acclimated separately in twelve 92.4-L rectangular tanks (49.0 cm deep and long × 38.5 cm wide) filled with tap water forming a closed circulation system with an ammonia filter. During this period, daily rations of live *Rutilus rutilus* (Linnaeus, 1758) fry were provided at ~4% of the fish's body weight. The fish were starved for 48 h before the predation experiment. In total, 12 *P. glenii* and *M. reevesii* individuals were used in these experiments (Tables 1 and 2).

Predator-prey experiments were performed in the same experimental aquaria where fish were acclimatised. Each experimental aquarium was filled with tap water to 44 cm depth resulting in an actual water volume of 83 L per aquarium, with water flow through each experimental aquarium of 3.0 L min^{-1}. Animals were kept under a 15 hours per day photoperiod and at a temperature of 19 °C throughout these studies. No substrate was added into the experimental aquaria. After acclimation period, a single individual of *M. reevesii* was added to each aquarium. During the experiments, turtles were fed frozen midge larvae every second day. Overall, the fish were allowed to forage for one week, after which turtles were removed back to their acclimation aquaria and the conditions of all turtles in each experimental aquarium were recorded. Assessment of turtle condition was based on appearance and movement. Surviving turtles were crawling and no injuries were seen on their skin or carapace. These turtles were kept for three months after the experiments to confirm that they retained their normal viability and activity levels.

*Experiment 2 (*E. orbicularis *vs.* P. glenii*)*

Predation experiments (*E. orbicularis* vs. *P. glenii*) were conducted to determine if *E. orbicularis* recognize *P. glenii* juveniles as prey and consumed them. Approximately 150 *P. glenii* juveniles were collected from a small lake using a standard dip net (25 × 25 cm) in August 2015. All fish were small enough to be preyed upon by turtles and were selected for size similarity (body length of 3.3 ± 0.2 cm) to avoid cannibalism. For one week before conducting the experiments, all specimens were acclimated in six 92.4-L rectangular tanks (49.0 cm deep and long × 38.5 cm wide) filled with tap water forming a closed circulation system with an ammonia filter. Daily rations of live midge larvae were provided.

Predator-prey experiments (*E. orbicularis* vs. *P. glenii*) were performed in August 2015. Three concrete water reservoirs were used for the experiments. Reservoirs were in cages under the natural outdoor conditions. Cages were made from stainless steel to protect the experiment from wild birds and animals. The first cage contained two identical reservoirs of approximate 5 m^2 area (2.8 m long × 1.8 m wide, with a range of 5–45° slope and 0.1–0.6 m of water depth). The second cage contained one large rectangular reservoir of approximate 10 m^2 area (4.5 m long × 2.3 m wide, with a range of 5-45° slope and 0.1-0.7 m of water depth). All reservoirs were filled with tap water. Woody shelters, stones and muddy gravel substrate were present in all experimental reservoirs. An average noonday temperature of

Table 1. *Percottus glenii* specimens used in predator-prey experiments. Values are means ± standard deviation.

	Experiment I	Experiment II first cage	Experiment II second cage
Number of used specimens	12	27	33
Range of total body length, cm	17.0-24.7	2.9-3.2	3.3-3.7
Average of total body length, cm	20.3 ± 3.0	3.0 ± 0.2	3.5 ± 0.1
Range of total weight, g	90.3-280.0	0.9-1.5	1.1-1.8
Average of total weight, g	150.8 ± 62.1	1.2 ± 0.2	1.4 ± 0.2
Range of *P. glenii* mouth diameter, cm	3.0-4.8	–	–
Average of *P. glenii* mouth diameter, cm	3.7 ± 0.6	–	–

Table 2. *Mauremys reevesii* and *Emys orbicularis* specimens used in predator-prey experiments. Values are means ± standard deviation.

	Experiment I *M. reevesii*	Experiment II (1) *E. orbicularis*	Experiment II (2) *E. orbicularis*
Number of specimens	12	10	8
Range of carapace length, cm	2.9-3.1	9.5-12	15.2-18.1
Average of carapace length, cm	3.0 ± 0.1	10.8 ± 0.8	16.9 ± 1.1
Range of carapace width, cm	2.3-2.0	7.6-10.1	13.6-16.0
Average of carapace width, cm	2.2 ± 0.1	8.7 ± 0.7	14.8 ± 0.9
Range of plastron length, cm	2.7-2.9	7.8-11.5	12.0-18.5
Average of plastron length, cm	2.8 ± 0.1	9.8 ± 1.6	15.5 ± 2.5
Range of total weight, g	6.8-7.2	10.6-37.1	39.0-167.0
Average of total weight, g	7.0 ± 0.1	22.2 ± 9.8	89.5 ± 42.6

Table 3. Daily turtle diet rations of various food types per specimens during the experiments.

Food type	quantity
Flesh fish	10 (g)
Flesh meat	10 (g)
Dried crustacean	5 (ind.)
Beetle larvae (live)	5 (ind.)
insects (cricket, cockroach) (live)	3 – 4 (ind.)
Earthworm (live)	5 – 10 (ind.)
Snail (live)	3 – 4 (ind.)
Midge larvae (live)	10 (ind.)
Cabbage	1 (g)

20.6 ± 3.2 °C was observed. 18 *E. orbicularis* adults big enough to prey on these juveniles were divided, with ten smaller individuals closed in the first experimental cage and eight larger ones in the second (Table 2).

After an acclimation period, 27 and 33 fish were transferred into the experimental reservoirs of the first and second cages respectively. In the first cage released individuals were equally divided (14 + 13) per each reservoir. Fish in the second cage were slightly bigger compare to the fish in the first one (Table 1). 60 fish were left as a control group in six acclimation tanks (ten individuals per tank) for the whole experiment period. Overall, *E. orbicularis* were kept with *P. glenii* juveniles for two weeks. The turtles and the fish were fed once a day with dried or live insects, earth worms, snails, and small pieces of meat during the experiments. Daily turtle food ratios are presented in Table 3. Moreover, there was lots of naturally breeding *Culex pipiens* (Linnaeus, 1758) larvae inside the reservoirs which were an alternative food source for the fish. The reservoirs were surveyed for dead fish every day during the experiments. After the experiment termination, reservoirs were pumped out, all remained fish were removed back to their acclimation aquaria and the condition of all fish in each reservoir was recorded. Assessment of fish condition was based on appearance and movement. Surviving fish were swimming and no external injuries were seen.

RESULTS

Distribution of P. glenii *and* E. orbicularis

In Lithuania less than 400 *E. orbicularis* survive, mostly in waters of southern part of the country (Bastytė, 2015). Meanwhile *P. glenii* has been recorded in all of the country's river basins (Rakauskas et al., 2016). Analysis of the recent distribution range of *P. glenii* and *E. orbicularis* in the inland waters showed these species overlapping on a regional scale. Both species were recently reported from the Nemunas River basin in southern Lithuania (Fig. 1A). Additionally, our surveys of *P. glenii* presence in well known *E. orbicularis* habitats revealed the small-scale overlap of these two species. Both were found inhabiting one shallow water body (Fig. 1B). Four *P. glenii* individuals of body lengths ranging from 43 to 61 mm were captured in a water body inhabited by *E. orbicularis*. Seven water bodies with well-known *E. orbicularis* populations were occupied by *Carassius carassius* (Linnaeus, 1758).

*Experiment 1 (*P. glenii *vs.* M. reevesii*)*

Experiments showed that none of the tested *P. glenii* adults were capable of ingesting or even injuring newly hatched *M. reevesii* turtles, though tested fish appeared big enough to do so. The mouth diameter of tested fish was significantly larger than the carapace lengths of the turtles (Mann-Whitney U test: $Z = 3.2$, $P < 0.002$; Tables 1 and 2). However, only a few predation signs were observed during the first ten minutes after newly hatched turtles were offered for *P. glenii* predation. The largest tested fish specimens (TL > 22.0 cm and mouth diameter > 4.0 cm) repeatedly attacked turtles for the first few minutes. In these cases the prey was completely sucked in the fish mouth cavity and jaws were fully closed. However, after a few seconds the prey was expelled undamaged. Overall, none of the tested turtles were injured; all were alive and healthy three months after the experiments.

*Experiment 2 (*E. orbicularis *vs.* P. glenii*)*

Adult *E. orbicularis* were found to consume *P. glenii* juveniles in caged experiments. 15 individual *P. glenii* (55.6% of the cohort) were missing after 14 days in the first cage where smaller turtles were foraging. Similarly, 13 *P. glenii* (39.4%) were missing in a cage with larger turtles. No dead or injured fishes were found during or after the experiment. Predatory behaviour was frequently observed. Turtles stalked and struck at *P. glenii* juveniles. Cannibalism was not observed among the fish, including in control tanks, where all 60 specimens left in tanks survived the experimental period.

DISCUSSION

The European pond turtle, *E. orbicularis* is the most widely distributed freshwater turtle species in Europe (Fritz, 2001, 2003). The geographic range of *E. orbicularis* extends from North Africa over most of Europe to Latvia and to Lake Aral in the Middle East (Fritz, 1998; Fritz, 2001, 2003). However, the turtle is critically endangered in Lithuanian, and all other European waters (Council Directive 92/43/EEC; Fritz, 2001, 2003; Rašamavičius,

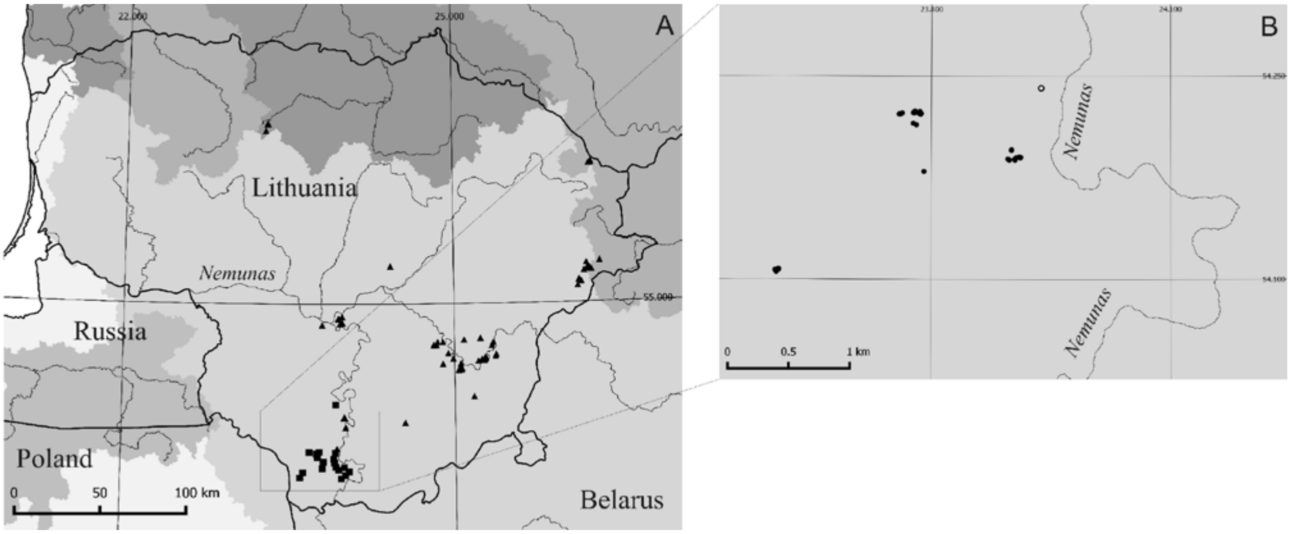

Fig. 1. (A) Distribution of the European pond turtle, *Emys orbicularis* (squares) and the Chinese sleeper, *Perccottus glenii* (triangles) in the inland waters of Lithuania (followed by Bastytė, 2015; Rakauskas et al., 2016). Different river basins are marked by different shading. (B) *P. glenii* presence in water bodies inhabited by *E. orbicularis*: presence (opened circles), absence (closed circles).

2007). In Lithuania reproductive *E. orbicularis* populations number less than 400 turtles and are found mostly in waters of the southern part of a country (Fritz and Günther, 1996; Meeske, 2008; Bastytė, 2015).

Habitat degradation and fragmentation have been identified as the main reasons for the decline of *E. orbicularis* populations (Kovacs et al., 2004; Fritz and Chiari, 2013; Bastytė, 2015). However, the recent spread of invasive aquatic species may also negatively affect *E. orbicularis* populations. The introduction of exotic *Trachemys scripta* (Schoepff, 1792) has been reported to have indirect effects on *E. orbicularis* populations. Introduced *T. scripta* competes against *E. orbicularis* for habitat resources, and reduces the survival of the turtle (Cadi and Joly, 2004; Lacomba and Sancho, 2004). The invasive predatory fish *Micropterus salmoides* (Lacépède, 1802), is assumed to prey on *E. orbicularis* hatchlings and juveniles (Lacomba and Sancho, 2004; Ayres and Cordero, 2007). Correspondingly, direct and/ or indirect interactions between invasive predatory fish *P. glenii* and *E. orbicularis* could be expected. Both species prefer similar habitats and diets. However, the impact of *P. glenii* on the natural populations of *E. orbicularis* in inland European waters remains largely undocumented.

Habitat overlap

Our review of the literature on *P. glenii* and *E. orbicularis* habitat preferences indicated that both species are commonly found in shallow waters with weak or with no current, and with well-developed aquatic vegetation (Mitrus, 2004; Meeske et al. 2006; Najbar, 2007; Briggs and Reshetylo, 2009; Reshetnikov, 2010; Reshetnikov and Ficetola, 2011; Pupina et al., 2015). Both species usually forage in littoral zones of small shallow lakes or swampy water bodies. Both species are particularly abundant in small water bodies unsuitable for most ichthyophagous fishes. In these situations, they are the top predators (Meeske et al., 2006; Briggs and Reshetylo, 2009; Bastytė, 2015; Reshetnikov, 2003; Grabowska et al., 2009). Therefore these two species could be expected to compete against, and even attack each other in these environments.

Our field surveys confirmed that *P. glenii* and *E. orbicularis* may settle in the same water bodies, although both species are relatively rare in the inland waters of Lithuania. The presence of both species in the same water body was also reported from Latvian inland waters (Pupina et al., 2015). However, we found *P. glenii* only in one (3.1%) from all investigated water bodies settled by *E. orbicularis*.

An increase in conflicts between these two species is expected in a future where both species expand their ranges within the inland waters of Lithuania. The rapid natural spread of *P. glenii* is ongoing not only in Lithuanian (Rakauskas et al. 2016) but also in other European waters (Alexandrov et al., 2007; Grabowska et al., 2010; Mastitsky et al., 2010; Wolter and Röhr, 2010; Reshetnikov and Ficetola, 2011; Semenchenko et al., 2011; Movchan 2015). The fish pursues a profligate reproductive strategy, and exhibits resistance to adverse conditions

(Reshetnikov, 2004). On the other hand, an intensive reestablishment program of *E. orbicularis* populations is ongoing in Lithuanian waters. Up to 100 individuals are released annually to areas they formerly occupied (Pikūnienė unpub. data). Therefore, there is little doubt that direct and indirect interactions between these two species will increase.

Predator-prey interactions

In small lakes unsuitable for most ichthyophagous fish, *P. glenii* can grow up to 25 cm in body length (Reshetnikov, 2003; Pupina et al., 2015) and become a top predator (Reshetnikov, 2003; Koščo et al., 2008; Grabowska et al., 2009). In such waters almost all links of the trophic network converge to *P. glenii*. Although adult *P. glenii* feed primarily on fish and large insects, they occasionally prey on newts, frogs or other larger animals (Shlyapkin and Tikhonov, 2001; Reshetnikov, 2003; Reshetnikov, 2004; Koščo et al., 2008; Grabowska et al., 2009; Reshetnikov, 2013). Due to this dietary breadth, it has been assumed that large *P. glenii* individuals are capable of ingesting and eating *E. orbicularis* hatchlings (Pupina et al., 2015). Newly hatched pond turtles are less than 3 cm in length (Najbar and Mitrus, 2013) and could be attacked by *P. glenii,* which has a wide gape (up to 5 cm) and forages in shallow waters.

However, our experiments did not support the hypothesis that *P. glenii* may directly, through the predator-prey interaction, threaten *E. orbicularis* populations. None of the tested specimens of *P. glenii* consumed or injured newly hatched turtles, even though they were big enough to prey on them and even though no other food was available to them. Thus it was concluded that the presence of *P. glenii* would not directly threaten wild *E. orbicularis* populations.

We used a different pond turtle species *M. reevesii* instead of *E. orbicularis* during the experiments. The applicability of our conclusions to *E. orbicularis* is supported by the similarity of the behaviour of the two turtle species in the water and the similarities in their sizes and their camouflage (Mitrus and Zemanek, 2000; Stephens and Wiens, 2003; Lovich et al., 2011; Lin et al., 2015).

Our results showed that only the largest *P. glenii* specimens showed interest in preying on turtle juveniles. *P. glenii* specimens shorter than 22 cm length did not even approach newly hatched turtles. We used *P. glenii* specimens in a range of sizes, up to the largest found in European waters, 24.7 cm of a total body length (the biggest recorded specimens have been 25 cm in total body length; Reshetnikov, 2003; Pupina et al., 2015). Specimens over 20 cm were found only in 11 (14.6%) of a total 75 lentic waters bodies inhabited by *P. glenii* in Lithuania (Rakauskas unpub. data). Similar results were obtained from other countries where *P. glenii* was usually reported to live for about 5-7 years and reach up to 15 cm length (Grabowska et al., 2011; Nowak et al., 2008; Grabowska et al., 2009; Terlecki and Palka, 2012; Kutsokon et al., 2014).

Our findings suggest that *E. orbicularis* consumption by predatory *P. glenii* in natural environments where many of other food sources are available is not likely. Similar results were obtained with other pond turtle and predatory fish species. Britson and Gutzke (1993) revealed that although turtle hatchlings of *T. scripta* and *Chrysemys picta* (Schneider, 1783) were attacked by predatory fish *M. salmoides* they were subsequently rejected unharmed. It was concluded that hatchling behaviour such as clawing or biting may be harmful to the gill apparatus or digestive tract of fish and thus provides defence against predation (Britson and Gutzke, 1993).

Our experiments revealed that adults of *E. orbicularis* preyed on *P. glenii* juveniles even when other food sources were available. Fish fry consumption by *E. orbicularis* has been shown in other studies (Kotenko, 2000; Briggs and Reshetylo, 2009). No cannibalism cases were observed within a control fish group during our experiments, suggesting that the fish were consumed by the turtles. Our findings suggest that not only will *P. glenii* not directly endanger European pond turtle populations, but that *E. orbicularis* may even control *P. glenii* populations where their ranges overlap.

Concluding remarks

The decline in European pond turtle populations likely results from a complex set of factors, linked to the modern decline in biodiversity worldwide. However, this study demonstrates that one factor is probably not the threat posed to these turtles by the invasive predatory fish *P. glenii*. Conversely, we found that mature adults of *E. orbicularis* can prey on *P. glenii* juveniles. The turtle could possible come to control the invasive fish with the increase of the habitat overlap between the two species.

P. glenii may impact local *E. orbicularis* populations indirectly, through depletion of available macroinvertebrate food sources in invaded water bodies (Reshetnikov, 2001; Reshetnikov, 2003). Benthic invertebrates usually dominate in both species diet (Lebboroni and Chelazzi, 1991; Kotenko, 2000; Ottonello et al., 2005; Ficetola and De Bernardi, 2006; Koščo et al., 2008; Grabowska et al., 2009). *P. glenii* may also serve as a vector for *E. orbicularis* parasite transfer (Pupina et al., 2015). The fish is a host for the *E. orbicularis* parasitic nematode *Spiroxys* *contortus* (Rudolphi), whose paratenic hosts also include small fish, insect larvae, tadpoles and adult Anura (Hedrick, 1935, Moravec, 1994). Further investigation of the growth and physiology conditions of *E. orbicularis* during the pre- and post-invasion periods of *P. glenii* in various water bodies will be needed to sort out these multiple effects.

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