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RESEARCH PAPER OPEN ACCESS

Can *Potamopyrgus antipodarum* (Gastropoda) affect the prevalence of *Trichobilharzia szidati* in *Lymnaea stagnalis* populations?

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Abstract – Swimmer's itch is an emerging disease caused by bird schistosomes affecting people all over the world. Lymnaeidae – main host snails in Europe – are the source of harmful cercariae of these zoonotic parasites. The aim of this work was to determine whether Polish lakes, inhabited by *Potamopyrgus antipodarum* (Gray, 1843), result in a lower potential risk of swimmer's itch compared to lakes uninhabited by this non-native snail species. As a result of the dilution effect created by increasing the diversity of co-occurring non-host targets for miracidia, the risk of this zoonosis may be reduced. We studied the prevalence of digenean trematodes in *Lymnaea stagnalis* (Linnaeus, 1758) populations from 30 water bodies partly inhabited by *P. antipodarum*. The bird schistosome infection in snail hosts was found in five lakes inhabited and 11 lakes uninhabited by the non-native snails. The prevalence of these parasitesin host snail populations in the lakes uninhabited was significantly higher than in lakes inhabited by *P. antipodarum.* We conclude that *P. antipodarum* seems to be a good potential target for reducing the risk of swimmer's itch via the dilution effect. We expect from our point of view to stimulate a discussion on the use of this species to protect bathing areas against the threat of swimmer's itch.

Keywords: *Lymnaea stagnalis* / bird schistosomes / swimmer's itch / *Trichobilharzia szidati* / *Potamopyrgus antipodarum*

Résumé – *Potamopyrgus antipodarum* (Gastropoda) peut-il affecter la prévalence de *Trichobilharzia szidati* dans les populations de *Lymnaea stagnalis* ? Le prurit du nageur est une maladie émergente causée par les schistosomes des oiseaux et qui touche des personnes dans le monde entier. Les Lymnaeidae – principaux escargots hôtes en Europe – sont la source des cercaires nuisibles de ces parasites zoonotiques. Le but de ce travail était de déterminer si les lacs polonais, habités par *Potamopyrgus antipodarum* (Gray, 1843), entraînent un risque potentiel plus faible de démangeaison du baigneur par rapport aux lacs non habités par cette espèce d'escargot non indigène. Grâce à l'effet de dilution créé par l'augmentation de la diversité des cibles non-hôtes co-occurrentes pour les miracidies, le risque de cette zoonose pourrait être réduit. Nous avons étudié la prévalence des trématodes digéniques dans les populations de *Lymnaea stagnalis* (Linnaeus, 1758) provenant de 30 plans d'eau partiellement habités par *P. antipodarum*. L'infection par le schistosome des oiseaux chez les escargots hôtes a été trouvée dans cinq lacs habités et 11 lacs inhabités par les escargots non indigènes. La prévalence de ces parasites dans les populations d'escargots hôtes dans les lacs inhabités était significativement plus élevée que dans les lacs habités par *P. antipodarum*. Nous concluons que *P. antipodarum* semble être une bonne cible potentielle pour réduire le risque de démangeaison du baigneur via l'effet de dilution. Nous espérons de notre point de vue stimuler une discussion sur l'utilisation de cette espèce pour protéger les zones de baignade contre la menace de démangeaisons des baigneurs.

Mots clés : *Lymnaea stagnalis* / schistosomes des oiseaux / prurit du nageur / *Trichobilharzia szidati* / *Potamopyrgus antipodarum*

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1 Introduction

Our research has focused on how the presence of a non-host snail species in the environment disturbs the transmission of bird schistosomes (Schistosomatidae, Digenea), zoonotic parasites whose larvae can penetrate the human skin. In the literature, there are numerous reports on the occurrence of a persistently itchy rash known as swimmer's itch (cercarial dermatitis) that appear after penetration of cercariae of parasite species belonging to the genera *Trichobilharzia*, *Bilharziella*, *Allobilharzia* into the skin of people wading in water reservoirs (Żbikowska *et al.*, 2001; Żbikowska, 2004; Jouet *et al.*, 2008; Lawton *et al.*, 2014; Horák *et al.*, 2015; Marszewska *et al.*, 2016; Selbach *et al.*, 2016; Caron *et al.*, 2017; Marszewska *et al.*, 2018; Liberato *et al.*, 2019; Tracz *et al.*, 2019). The attempts to control swimmer's itch on the etiology of bird schistosomes, in particular in Europe and America, are mainly undertaken in bathing areas where omissions regarding biological health hazards may result in economic losses to owners and managers of recreation alplaces (Soldánová *et al.*, 2013). Snails are the target group of organisms against which efforts are directed to reducethe risk of infection (King and Bertsch, 2015). In the life cycle of all schistosomes, including those that infect birds, snails play the role of intermediate hosts and are crucial for the transmission of the parasites (Huot *et al.*, 2020). Host snails are actively infected by ciliated miracidia hatching from the eggs, which find the host by chemoreception. The invasive larva penetrates the snail tegument and transforms inside the host into a mother sporocyst (Allan *et al.*, 2009). In mother sporocysts, daughter sporocysts are formed, and inside them – cercariae invasive for final or accidental hosts develop. The total number of cercariae released from the snail during months of infection reaches values from several to several hundred thousands (Thieltges *et al.*, 2008; Braun *et al.*, 2018). The risk of swimmer's itch depends on the presence of snails infected with bird schistosome larvae in an environment. Even low prevalence (less than 10%) in snail populations is sufficient for the high risk of cercarial dermatitis (Soldánová *et al.*, 2013). The control of human schistosomiasis is sometimes achieved by exterminating the host snails in the environment (Nelwan, 2019). Apart from the use of molluscicides, the methods of biological control of parasitic infections, such as dilution effect, deserve special attention (Johnson and Thieltges, 2010). Dilution effect means the decrease of infection levels in host population by competitors that reduce the host density. However, opponents of this method emphasize the lack of its universality (Civitello *et al.*, 2015), but followers of introducing non-host species of snails into ecosystems to reduce parasite transmission underline that wherever it brings the expected positive effects – it should be used (Johnson *et al.*, 2009).

1.1 Community diversity can mediate infection levels and disease

The choice of the species expected to produce a dilution effect and to decrease the transmission of parasites is crucial. Introduced snails should act as "dead-end" hosts or to be effective competitors for the natural hosts. The choice of some alien species in the controlled areas is one of the proposed ideas (Pointier and Jourdane, 2000).

The issue of the alien species has been one of the most common research trends in the recent literature (Da Silva *et al.*, 2019; Rachalewski, 2019; Arumugam *et al.*, 2020; Jermacz *et al.*, 2020; Kondakov *et al.*, 2020; Larson *et al.*, 2020). The scientific focus on the research concerning the threat to native communities from alien fauna often results in overlooking their potential positive impacts (Goodenough, 2010). An example of an alien species considered to have a negative effect on native communities is the New Zealand mud snail (NZMS) – *Potamopyrgus antipodarum* (Gray, 1843) (Caenogastropoda, Hydrobioidea, Tateidae) (Brown *et al.*, 2008). However, *P. antipodarum* exhibits parthenogenetic reproduction, resulting in extremely high population density, reaching many thousands of individuals per square meter, and it seems to be a better "dead-end" host for bird schistosomes than native non-host snail species (Brown *et al.*, 1988; Hall *et al.*, 2003; Levri *et al.*, 2007; Davidson *et al.*, 2008). According to these researchers, the species affects the consumption of a large part of primary production in ecosystems. The high effectiveness of *P. antipodarum* in the new areas is due to their high dietary and other phenotypic plasticity, including a generalist diet that comprises periphyton, diatoms, as well as plant and animal detritus. This feature makes this species a very effective competitor of other benthic invertebrates (Levri *et al.*, 2007; Alonso and Castro-Díez, 2008; Brown *et al.*, 2008).

The high population density of *P. antipodarum*as a non-native species has led some authors to the conclusion that this species contributes to a dangerous change in the community structure of water ecosystems (Gérard *et al.*, 2003; Kerans *et al.*, 2005; Brown *et al.*, 2008; Lysne and Koetsier, 2008). However, it should be noted that the European populations of this species are characterised by large density fluctuations, which significantly reduce their impact on native community. High density followed by local extinction(Moffitt and James, 2012) results from the low genetic diversity of *P. antipodarum* individuals (Dorgelo *et al.*, 2014). The low diversity of *P. antipodarum* haplotypes as a non-native species has also implications for a parasitic invasion (Lively, 1987). Some authors highlighted the probable negative impact of *P. antipodarum* as the host of parasites in new-inhabited ecosystems (Morley, 2008). However, *P. antipodarum* in its native area is the first intermediate host for at least 20 species of highly host-specific trematode parasitic castrators (Hechinger, 2012), with the prevalence of trematodes varying among the snail populations from 9% to 80% (Winterbourn, 1973, 1974; Lively, 1987; King *et al.*, 2011). In the areas outside New Zealand only few cases of the infection with cercariae or metacercariae in the snails have been reported (Larson and Krist, 2020).

Long-term monitoring of the parasitic infection of snails in the lakes of the Polish Lowlands and intensive annual surveys of the *P. antipodarum* populations in the post-mining tanks in Silesia, resulted in finding one individual infected with lophocercariae (Żbikowski and Żbikowska, 2009), five individuals infected with pre-adult forms of *Aspidogasterconchicola* and 39 snails infected with echinostome metacercariae (Cichy *et al.*, 2017). Additionally, the experimental infection of this snail with the miracidia of *Trichobilharzia* spp. conducted in our laboratory was unsuccessful (Marszewska *et al.*, 2018, 2020). These data have indicated that the threat concerning the host role of *P. antipodarum* in European waters

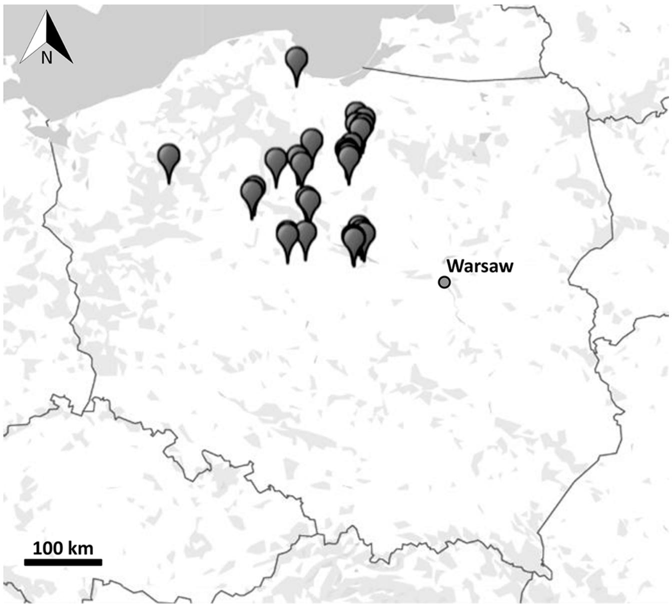

Fig. 1. Map of study lakes in the Polish Lowlands.

(Morley, 2008) is highly exaggerated. The alien species can both negatively and positively affect the native species by influencing parasite-host dynamics and disease occurrence (Kopp and Jokela, 2007; Marszewska *et al.*, 2018; Goedknegt *et al.*, 2019). Moreover, these authors have highlighted that there is surprisingly little research on the impact of the alien species on the parasite infection patterns in the native host communities (Goedknegt *et al.*, 2019). They have also emphasised that the large-scale field studies are favourable for the detailed assessment of the aforementioned mechanism.

As a result ofthedilution effect created by increasing the diversity of co-occurring potential targets, the risk of various parasitic diseases may be reduced (Keesing *et al.*, 2006; Kopp and Jokela, 2007; Cichy *et al.*, 2017). Non-native species (*i.e.*, *P. antipodarum*) seem to be good potential targets for creating a dilution effect because they lack natural enemies in the habitats.

The aim of this study was to check if there is arelationship between the presence of *P. antipodarum* and the infection of bird schistosomes in *Lymnaea stagnalis* (Linnaeus, 1758) populations in lakes of Polish Lowland. On the basis of long-term field study, we tested the hypothesis that an alien to Europe, such as *P. antipodarum*, has the potential for abiological control of swimmer's itch in recreational bathing areas.

2 Material and methods

2.1 Snail sampling and laboratory study

The material used for the parasitological studies were *L. stagnalis* specimens from 30 lakes in the Polish Lowlands inhabited and uninhabited by *P. antipodarum* (Fig. 1, SM 1). No empty shells of *P. antipodarum* in lakes uninhabited by this snail indicates that the lack of its individuals was not the result of local extinction (SM 1). *Lymnaea stagnalis* or *P. antipodarum* were dominant in the malacofauna of the studied sites. Snails, for parasitological diagnostic were collected manually only five times in each lake –from May to September between 2002 and 2019. Along with the acquisition of the malacological material for the parasitological studies, the presence of the invasion of the alien *P. antipodarum* in all sampling locations was verified. For this purpose, a semi-quantitative method was used, which was carried out with a 25 cm dredge. The samples from the area of 0.25 m × 0.25 m were taken three times in each lake during each sampling period.

During the snail sampling in most water bodies, the measurements of basic environmental parameters were made applying the MultiLine P4 (WTW) Universal Pocket Sized Meter. The pH, conductivity, water temperature and the oxygen content were measured. The characteristics of the lakes have been presented in Table 1 and SM 1.

A single malacological sample for parasitological diagnostics comprised at least 25 individuals of *L. stagnalis*. All of them were tested by standard procedures according to Blankespoor and Reimink (1991). The species of the recorded cercariae were determined on the basis of the morphological and anatomical characteristics (Cichy and Żbikowska, 2016).

2.2 Statistical analysis

The Shannon-Wiener Index (H') was applied to calculate the species diversity of digeneantrematodes in *L. stagnalis* individuals from the lakes inhabited and uninhabited by *P. antipodarum*.

Due to strong deviations of our data from the assumption of normality and homoscedascity (high variation at zero density of NZM and lower at its higher densities) non-parametric Spearman correlation coefficient was used to check the relationship between NZMS density and the prevalence of digenean trematodes as well as between NZMS density and the prevalence of bird schistosomes.

The χ^2 test of the contingency table was applied to compare the number of the lakes inhabited and uninhabited by *P. antipodarum* in terms of lymnaeid snails infected and non-infected by bird schistosomes. All the analyses were performed with PAST Statistical Software Package version 3.0 (Hammer *et al.*, 2001). Statistical significance was assumed for $p < 0.05$.

The term "total infection" was used as a percentage of all *L. stagnalis* individuals infected with the digenean species in relation to all the individuals collected, whereas the term "prevalence" was used as a percentage of lymnaeid individuals infected with one digenean trematode species collected from one lake.

3 Results

In the study, 17 lakes without *P. antipodarum* and 13 lakes with *P. antipodarum* were investigated. A total of 4994 individuals of *L. stagnalis* were collected from all the studied lakes, 2231 and 2763 of which came from the lakes inhabited and uninhabited by *P. antipodarum*, respectively.

Snails infected with digenean trematodes were found in all the lakes, with the total infection of 34.2%. The infection of digenean trematodes in *L. stagnalis* from the lakes inhabited and uninhabited by *P. antipodarum* ranged from 16.4% to

Table 1. GPS of the sampling area, year of research and physicochemical characteristics of investigated water reservoirs.

No.	Lake	GPS	Study year	Temperature [°C] ± SD	pH ± SD	Oxygen [mg/l] ± SD	Conductivity [µS/cm] ± SD
1	Bielkowskie	54°16′16″N 18°28′39″E	2002	20 ± 3.7	8.4 ± 0.1	1.9 ± 0.9	525.2 ± 10.8
2	Czartek	53°19′22″N 19°21′43″E	2008	–*	–*	–*	–*
3	Czerwica	53°43′40″N 19°31′08″E	2002	22.8 ± 1.9	8.7 ± 0.2	–*	740.2 ± 10.8
4	Bielczyńskie Głuchowskie	53°12′32″N 18°34′03″E	2003	20.8 ± 1.8	8.5 ± 0.2	–*	528.6 ± 5.7
5	Jelenieckie	53°16′46″N 18°31′04″E	2004	21.6 ± 2.7	8.2 ± 0.2	–*	637.2 ± 10.3
6	Ostrowąskie	52°49′46″N 18°42′03″E	2008	–*	–*	–*	–*
7	Wielkie Partęczyny	53°24′48″N 19°23′16″E	2004	22.2 ± 2.2	8.28 ± 0.1	2.0 ± 1.0	323.2 ± 6.7
8	Pod Zamkiem	52°25′36″N 19°27′22″E	2002	23 ± 2.3	8.2 ± 0.1	2.0 ± 1.0	536.6 ± 15.3
9	Popek	53°19′22″N 19°21′17″E	2008	–*	–*	–*	–*
10	Rudnickie Wielkie	53°26′04″N 18°45′07″E	2009	20.2 ± 2.2	8.1 ± 0.1	–	544.0 ± 15.2
11	Skulsk	52°28′00″N 18°19′18″E	2018	–*	–*	–*	–*
12	Skulska Wies	52°28′58″N 18°19′34″E	2018	–*	–*	–*	–*
13	Służewskie	52°51′14″N 18°38′38″E	2018	–*	–*	–*	–*
14	Szymbarskie	53°36′52″N 19°30′39″E	2018	–*	–*	–*	–*
15	Tynwałdzkie	53°39′45″N 19°38′05″E	2005	20.4 ± 3.0	8.2 ± 0.2	–*	524.6 ± 9.4
16	Wysokie Brodno	53°18′08″N 19°21′59″E	2008	–*	–*	–*	–*
17	Zielone	53°33′41″N 19°36′37″E	2002	20.4 ± 1.7	8.0 ± 0.0	–*	408.6 ± 11.6
18	Głuszyńskie	52°29′08″N 18°38′13″E	2018	–*	–*	–*	–*
19	Zalew Piechota	52°25′46″N 19°27′20″E	2002	21.8 ± 2.8	8.4 ± 0.1	1.9 ± 0.9	361.8 ± 12.6
20	Borówno	53°14′18″N 18°07′35″E	2004	21.2 ± 1.5	8.2 ± 0.1	1.94 ± 1	599 ± 13.7
21	Sobiejuskie	52°54′52″N 17°42′52″E	2004	22.4 ± 1.5	8.6 ± 0.1	2.2 ± 0.9	354.8 ± 12.8
22	Czarne	52°26′38″N 19°26′31″E	2007	21.6 ± 2.3	8.7 ± 0.1	1.6 ± 0.6	646.6 ± 67.9
23	Niskie Brodno	53°16′26″N 19°23′01″E	2008	–*	–*	–*	–*
24	Bytyń Wielki	53°16′56″N 16°16′54″E	2004	19.2 ± 4.3	8.2 ± 0.1	–*	639.4 ± 11.7
25	Iławskie	53°35′41″N 19°37′05″E	2019	–*	–*	–*	–*
26	Sendeńskie	52°30′17″N 19°35′29″E	2003	21.8 ± 2.3	8.66 ± 0	2.1 ± 0.9	653.2 ± 21.7
27	Górskie	52°28′36″N 19°39′34″E	2003	22 ± 2	8.2 ± 0.1	2.3 ± 0.8	565.6 ± 20.5
28	Wąsoskie	52°56′46″N 17°44′55″E	2004	21.8 ± 1.8	8.72 ± 0.1	2.1 ± 0.9	1,328.8 ± 23.2
29	Sosno	53°20′14″N 19°20′56″E	2008	–*	–*	–*	–*
30	Soczewka	52°32′26″N 19°33′44″E	2003	21.2 ± 2	8.4 ± 0.1	2.2 ± 0.9	444.4 ± 8.8

*no data.

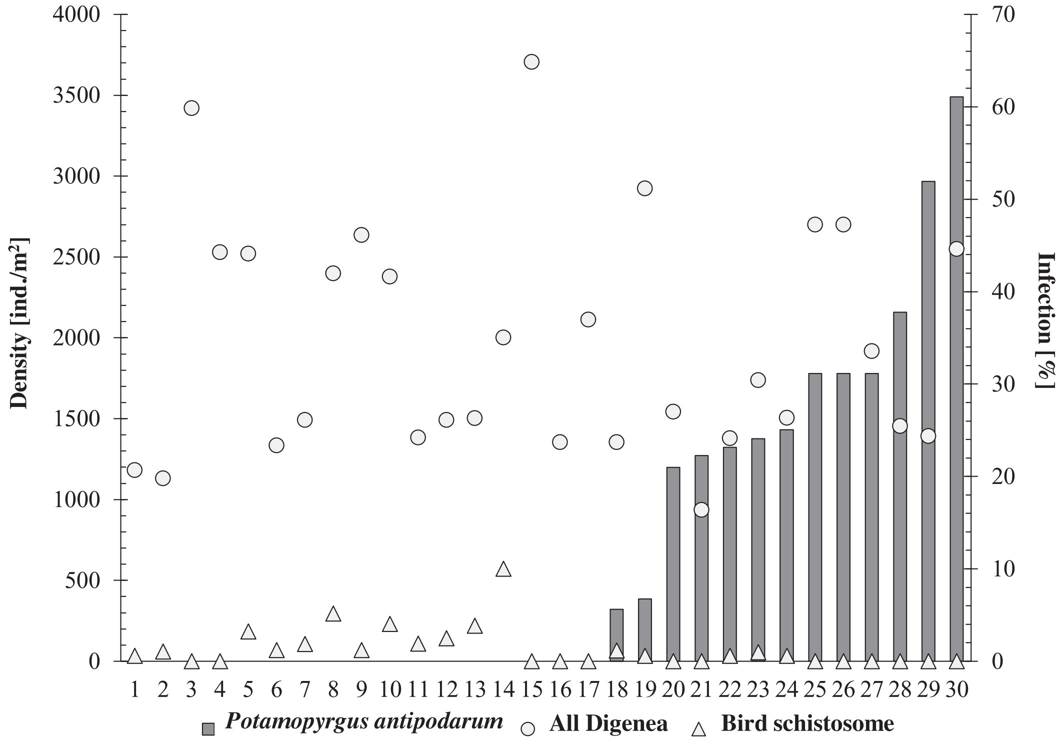

Fig. 2. *Potamopyrgus antipodarum* population density, total infection and bird schistosome prevalence in *Lymnaea stagnalis* populations at sampling sites in lakes: 1–Bielkowskie, 2–Czartek, 3–Czerwica, 4–BielczyńskieGłuchowskie, 5–Jelenieckie, 6–Ostrowąskie, 7–WielkiePartęczyny, 8–Pod Zamkiem, 9–Popek, 10–RudnickieWielkie, 11–Skulsk, 12–SkulskaWies, 13–Służewskie, 14–Szymbarskie, 15–Tynwałdzkie, 16–WysokieBrodno, 17–Zielone, 18–Głuszyńskie, 19–ZalewPiechota, 20–Borówno, 21–Sobiejuskie, 22–Czarne, 23–NiskieBrodno, 24–BytyńWielki, 25–Iławskie, 26–Sendeńskie, 27–Górskie, 28–Wąsoskie, 29–Sosno, 30–Soczewka.

51.2% (with the total infection of 32.4%) and from 19.8% to 64.8% (with the total infection of 35.7%) per lake, respectively (Fig. 2). There was no correlation in the infection of all the digenean species between the lakes inhabited and uninhabited by *P. antipodarum* ($p=-0.21$, $t_{28}=1.13$, $p=0.270$).

Seventeen species of digenean trematodes were found. The Shannon index showed no difference between the studied groups of water reservoirs in terms of the parasite species diversity (Tab. 2).

A significant difference in the number of reservoirs inhabited by snails infected with bird schistosomes was determined in the studied groups of water bodies (Fig. 2; $\chi^2=5.43$; df=1; $p=0.02$). The bird schistosome infection was found in five lakes inhabited and 11 lakes uninhabited by *P. antipodarum*. The total infection of bird schistosomes was 1.4% in *L. stagnalis* from all the investigated water bodies, 0.3% from the lakes inhabited and 2.2% from the lakes uninhabited by *P. antipodarum*. Their prevalence ranged from 0 up to 1.2% and from 0 upto 10% in the lakes inhabited and uninhabited by *P. antipodarum*, respectively (Fig. 2), and was negatively correlated with NZMS density ($p=-0.47$, $t_{28}=2.83$, $P=0.009$) (Fig. 2).

4 Discussion

The presence of *P. antipodarum* in the lakes did not significantly affect the total digenean trematodes infection of the *L. stagnalis* populations; only in five out of 13 lakes the infection prevalence exceeded 30%, while in the lakes not inhabited by the alien snail species more than 30% infection was recorded in nine out of 17 subjects (Fig. 2). Given that themiracidia of flukes use chemoreception to find the snail host (Haas *et al.*, 1995), it should be assumed that the chemoreception efficiency of most of the detected parasite species was high, regardless of the presence of *P. antipodarum* in the environment.

The Shannon diversity index of trematode parasiteswas similar in both types of lakes, and the only bird schistosome species found was *Trichobilharzi aszidati* (Neuhaus, 1952). However, it is noteworthy that *T. szidati*-infected snails were mainly present in the lakes uninhabited by *P. antipodarum* (Fig. 2). The similar physicochemical and biocenotic conditions in both groups of lakes (SM 1) suggest that the presence of *P. antipodarum* may be an important factor differentiating the occurrence of *T. szidati* larvae in *L. stagnalis* populations. The prevalence of the parasite in the host snailswith one exception did not exceed 5.5%. A small number of snails infected with bird schistosome in the studied lakes was in line with several earlier studies (Loy and Haas, 2001; Żbikowska, 2004; Jouet *et al.*, 2008; Horák *et al.*, 2015). It cannot be ruled out that the presence of non-host snail species in the environment generally disturbs the transmission of bird schistosome affecting a very low prevalence of the parasite. However, a high density of *P. antipodarum* populations could significantly disturb thistransmission. The fact that snails infected with *T. szidati* originated mainly from the lakes uninhabited by *P. antipodarum* may be due to the disturbance in the chemokinetic reaction of its miracidia by substances from the alien occurring at high population densities. The

Table 2. Species diversity of Digenea in the studied populations of *Lymnaea stagnalis*.

Parasite	Number of lakes with infected *L. stagnalis*	
	Uninhabited by *P. antipodarum**	Inhabited by *P. antipodarum***
Diplostomum pseudospathaceum	17	13
Echinoparyphium aconiatum	17	13
Plagiorchis elegans	16	12
Opisthioglyphe ranae	16	12
Echinostoma revolutum	13	6
Plagiorchis maculosus	9	5
Sanguinicola inermis	6	9
Notocotylus attenuatus	7	9
Hypoderaeum conoideum	8	11
Tylodelphys clavata	4	7
Australpatemon burti	5	5
Paryphostomum sp.	3	5
Trichobilharzia szidati	5	11
Neoglyphe sobolevi	3	5
Asymphylodora tincae	2	0
Echinoparyphium recurvatum	1	1
Xiphidiocercaria C	1	1

[*]Shannon-Wiener Index H'=4.02.
[**]Shannon-Wiener Index H'=3.92

complicated behaviour of schistosome miracidia was studied in the 1960s by MacInnis (1965) and Wright and Ross (1966). The further research on testing of signal compounds has revealed that attractants for parasite larvae include both host-derived and non-host molecules (Allan *et al.*, 2009). Marszewska *et al.* (2020) found that excretory-secretory products derived from *P. antipodarum* effectively disrupt the chemokinetic reaction of *T. szidati* miracidia. Given that miracidia have only one attempt in adhesion to the signal source (Haas *et al.*, 1995), the contact of larvae with the wrong target (*i.e.*, *P. antipodarum*) irreversibly ends the transmission of the parasite. Miracidia within an incompatible snail are eliminated by its hemocytes and/or plasma factors (Bayne *et al.*, 2001). In addition, it has been experimentally confirmed that the effect of *P. antipodarum* on the reduction of bird schistosomes prevalence increases as *P. antipodarum* density also increases (Marszewska *et al.*, 2018). They examined the effectiveness of *T. regenti* invasion into *Radix balthica* (Linnaeus, 1758) (Gastropoda, Basommatophora, Lymnaeidae) co-occurring with the growing density of *P. antipodarum* populations.

On the other hand, Loy and Haas (2001), Żbikowska (2004), Jouet *et al.* (2008), and Horák *et al.* (2015)have agreed that even the low prevalence of the patent invasion of bird schistosomes in the host snail populations is a real threat of swimmer's itch for humans. This opinion has been based on the high productivity of cercariae inside an infected individual of snail (Horák *et al.*, 2015), as well as on the observation that most infections are recorded during the summer, when recreational water use is highest (Żbikowska, 2004).

Previous laboratory tests showed that the average number of cercariae released from one snail per (one) day exceeded even 1800 larvae (Żbikowska and Marszewska, 2018). The effectiveness of attacks of bird schistosomecercariae on humans was also high. Żbikowska *et al.* (2001) presented in detail the changes on the researcher's skin resulting from the penetration of a single or several cercariae during the collection of the field samples.

In light of the results obtained, suggestions for the use of the non-host species of snails for the biological control of parasites seems to be well justified. Of course, introducing non-native species even only on bathing waters requires a detailed analysis of the potential consequences. In the case of *Schistosoma mansoni*, which is responsible for severe human schistosomiasis, this control model exhibited the expected effects (Pointier *et al.*, 2011). In the case of threat of swimmer's itch, the decrease in the prevalence of parasites due to the intentional introduction of non-host *P. antipodarum* into the bathing areas seems to be the form of protection that is worth considering. However, the ecological safety of such activities must be carefully examined and is the subject of ongoing research.

Conflict of interest

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper

Supplementary Material

SM 1 Table. Bottom type and biocenotic characteristics of sampling sites.
SM 2 Figure. Microscopical picture of the *Trichobilharzia szidati cercaria*.

The Supplementary Material is available at https://www.kmae-journal.org/10.1051/kmae/2021014/olm.

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