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UNIONID CLAMS AND THE ZEBRA MUSSELS ON THEIR SHELLS (BIVALVIA: UNIONIDAE, DREISSENIDAE) AS HOSTS FOR TREMATODES IN LAKES OF THE POLISH LOWLAND

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Abstract: The aim of this work was to determine the diversity and the prevalence of trematodes from subclasses Digenea and Aspidogastrea in native unionid clams (Unionidae) and in dreissenid mussels (Dreissenidae) residing on the surface of their shells. 914 individuals of unionids and 4,029 individuals of *Dreissena polymorpha* were collected in 2014 from 11 lakes of the Polish Lowland. The total percentage of infected Unionidae and Dreissenidae was 2.5% and 2.6%, respectively. In unionids, we found three species of trematodes: *Rhipidocotyle campanula* (Digenea: Bucephalidae), *Phyllodistomum* sp. (Digenea: Gorgoderidae) and *Aspigdogaster conchicola* (Aspidogastrea: Aspidogastridae). Their proportion in the pool of the infected unionids was 60.9%, 4.4% and 13.0%, respectively. We also found pre-patent invasions (sporocysts and undeveloped cercariae, 13.0%) and echinostome metacercariae (8.7%) (Digenea: Echinostomatidae). The majority of infected *Dreissena polymorpha* was invaded by echinostome metacercariae (98.1%) and only in a few cases we observed pre-patent invasions (bucephalid sporocysts, 1.9%). The results indicate that in most cases unionids played the role of the first intermediate hosts for digenetic trematodes or final hosts for aspidogastrean trematodes, while dreissenids were mainly the second intermediate hosts.

Key words: Unionidae, *Dreissena polymorpha*, Digenea, Aspidogastrea, *Rhipidocotyle*, *Phyllodistomum*, *Aspidogaster*, prevalence, Poland

INTRODUCTION

Unionidae live in flowing and stagnant waters of North America, Eurasia and Africa (Walker et al. 2001). In Poland they are represented by six native (*Unio crassus* Philipsson, 1788, *U. pictorum* (Linnaeus, 1758), *U. tumidus* Philipsson, 1788, *Anodonta anatina* (Linnaeus, 1758), *A. cygnea* (Linnaeus, 1758), *Pseudoanodonta complanata* (Rossmässler, 1835)) and one alien (*Sinanodonta woodiana* (Lea, 1834)) species (Piechocki 2008). The unionids are important players in the functioning of freshwater ecosystems (Dillon 2000, Vaughn & Hakenkamp 2001). They constitute a significant benthos biomass (Ökland 1963, Piechocki 1999) and filter large volumes of water (Lewandowski & Stańczykowska 1975, Strayer et al. 1994), thus contributing to purification of aquatic systems (Pusch et al. 2001). They are a source of food for other organisms (Zahner-Meike & Hanson 2001) and may also provide a habitat for various free-living and parasitic symbionts (Piechocki & Dyduch-Falniowska 1993). Field observations carried out by several authors indicate that the surface of unionid shells is often overgrown by *Dreissena polymorpha* which usually occur at high density and form colonies of tens to hundreds of individuals (Lewandowski 1976, Schloesser et al. 1996, 1998, Burlakova et al. 2000). Such spatial and temporal relationship of bivalves with different life strategies is interesting for parasitologists, as both families are intermediate or definitive hosts for digenetic and aspidogastrean trematodes (Grizzle &

Brunner 2009, Yuryshynets & Krasutska 2009). The number of digenetic trematodes is estimated at 18,000 (Littlewood & Bray 2001) to 25,000 of species (Esch et al. 2002) and most of them use snails as obligatory first intermediate hosts. There are 66 and 9 digenean families encountered within Gastropoda and Bivalvia, respectively (Ponder 1998). Among them, Bucephalidae (e.g., *Bucephalus polymorphus* Baer, 1827, *Rhipidocotyle campanula* (Dujardin, 1845) and *R. fennica* Gibson, Taskinen et Valtonen, 1992) and Gorgoderidae (*Phyllodistomum folium* (Olfers, 1816), *P. elongatum* Nybelin, 1926) are commonly found in freshwater bivalves of Europe (Taskinen et al. 1991, Peribáñez et al. 2006, Yuryshynets & Krasutska 2009, Lajtner 2012, Müller et al. 2015). In turn, Aspidogastrea comprise about 80 species (e.g., *Aspidogaster conchicola* Baer, 1827, *A. limacoides* Diesing, 1835) whose life cycle involves only molluscs (as final hosts) or facultative or obligate vertebrate final hosts such as teleosts and freshwater turtles (Rohde 2001, 2002).

The aim of our work was to determine the diversity and the prevalence of trematodes of subclasses Digenea and Aspidogastrea in the native unionid clams and in the zebra mussels residing on the surface of their shells. We also wanted to check if there were any differences in the role of Unionidae and Dreissenidae in the life cycle of trematodes.

MATERIAL AND METHODS

Unionids (*A. anatina*, *U. tumidus*, *U. pictorum*) and *D. polymorpha* overgrowing their shells were collected from April to September 2014 from 11 lakes of the Polish Lowland (Fig. 1): (A) Iławskie Lake District (Szymbarskie – 53°38'39"N, 19°29'6"E), (B) Brodnickie Lake District (Bachotek 53°17'18"N, 19°28'27"E, Dębno 53°23'01"N, 19°24'50"E, Łąkorz 53°25'10"N, 19°20'50"E, Niskie Brodno 53°16'25"N, 19°23'02"E, Sosno 53°20'15"N, 19°20'55"E, Strażym 53°20'28"N, 19°25'30"E, Wądzyńskie 53°18'47"N, 19°15'27"E, Zbiczno 53°20'28"N, 19°24'50"E), (C) Dobrzyńskie Lake District (Włocławek Reservoir 52°37'03"N, 19°19'44"E), (D) Gnieźnieńskie Lake District (Licheńskie 52°19'24"N, 18°20'55"E). The clams were collected by hand from a sandy and silty bottom (depth of ca. 0.5–1.5 m) and transported to the laboratory in containers with a small amount of water, under a wet cloth. Unionidae and

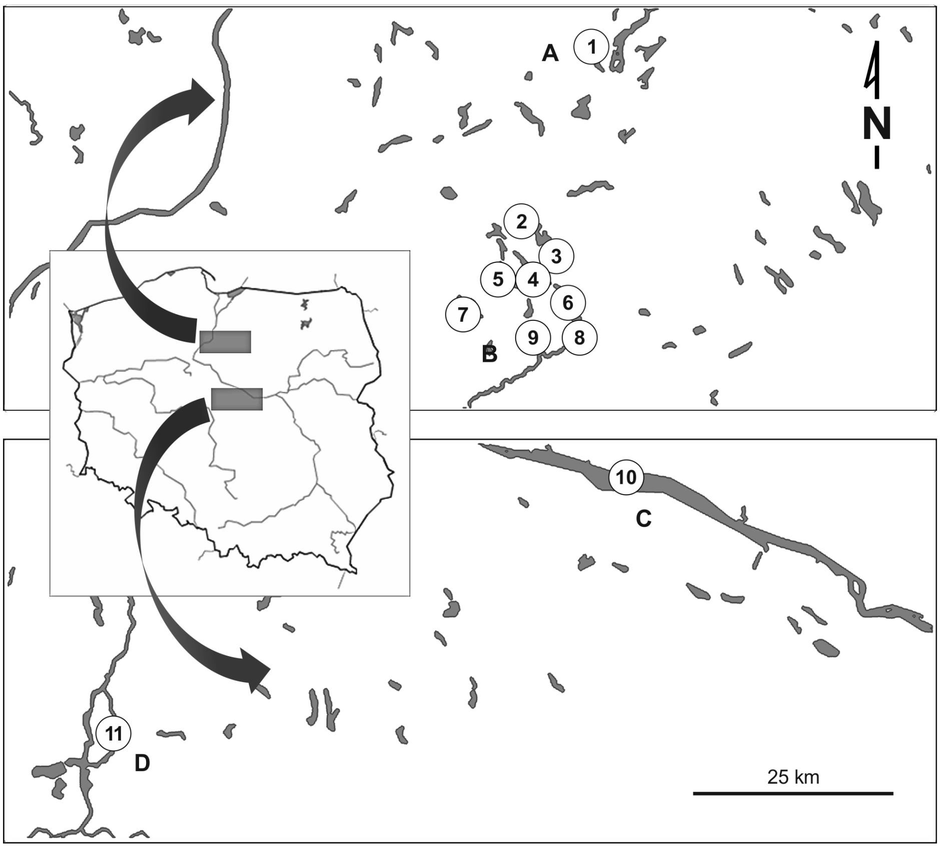

Fig. 1. Study sites: Iławskie Lake District (A): 1 – Szymbarskie; Brodnickie Lake District (B): 2 – Łąkorz, 3 – Dębno, 4 – Zbiczno, 5 – Sosno, 6 – Strażym, 7 – Wądzyńskie, 8 – Bachotek, 9 – Niskie Brodno; Dobrzyńskie Lake District (C): 10 – Włocławek Reservoir; Gnieźnieńskie Lake District (D): 11 – Licheńskie

Dreissenidae were identified on the basis of shell morphology (PIECHOCKI & DYDUCH-FALNIOWSKA 1993). Aspidogastrea and Digenea were searched microscopically in the organs of dissected unionids. Zebra mussels were crushed in Petri dishes and then examined for the presence of trematodes. Tissue sections were examined under Primostar Carl Zeiss microscope. The genus or species of the trematodes were identified based on digenean cercariae (ORECCHIA et al. 1975, BATURO 1977, TASKINEN et al. 1991, KUDLAI & YANOVICH 2013) or aspidogastrean adult (ROHDE 2002, GAO et al. 2003) morphology.

RESULTS

We collected 914 individuals of unionids and 4,029 individuals of the zebra mussel from their shells. Zebra mussel was found on 72.4% of the collected unionids. The biggest colony of *D. polymorpha* on the unionid shells was composed of 86 individuals. The collected bivalves were infected with digenetic trematodes of three families – Bucephalidae, Gorgoderidae, Echinostomatidae, as well as by aspidogastreans. The total percentage of infected bivalves was 2.5% and 2.6% in Unionidae and *Dreissena*, respectively. The most infected species of unionid was *A. anatina*, a smaller percentage of invasions was recorded for *U. tumidus*, while *U. pictorum* carried no trematodes (Table 1). The infected unionids were hosts of *Rhipidocotyle campanula* (60.9%) and *Phyllodistomum* sp. (4.4%) cercariae, *Aspigdogaster conchicola* adults (13.0%), sporocysts and undeveloped cercariae (13.0%) and echinostome metacercariae (8.7%) (Fig. 2). *D. polymorpha* found on the unionid shells were mainly infected with echinostome metacercariae (98.1% of the infected dreissenid mussels) and some bucephalid sporocysts (1.9%). In most cases the unionids played the role of the first intermediate hosts for digenetic trematodes, while the zebra mussels were mainly the second intermediate hosts (Fig. 2).

Table 1. Prevalence (%) of digenetic and aspidogastrean trematodes in unionids and zebra mussels

Bivalve species	No. of collected mussels	% of infected mussels	Rc*	Ph*	Ac*	EM*	PI*
Anodonta anatina	459	3.7	2.6	0.2	0.0	0.2	0.7
Unio tumidus	432	1.4	0.5	0.0	0.7	0.0	0.2
Unio pictorum	23	0.0	0.0	0.0	0.0	0.0	0.0
Dreissena polymorpha	4,029	2.5	0.0	0.0	0.0	2.5	< 0.1
Total	4,943	2.5	0.3	< 0.1	< 0.1	2.1	0.1

*Rc – *Rhipidocotyle campanula*, Ph – *Phyllodistomum* sp., Ac – *Aspidogaster conchicola*, EM – echinostome metacercariae, PI – pre-patent invasions

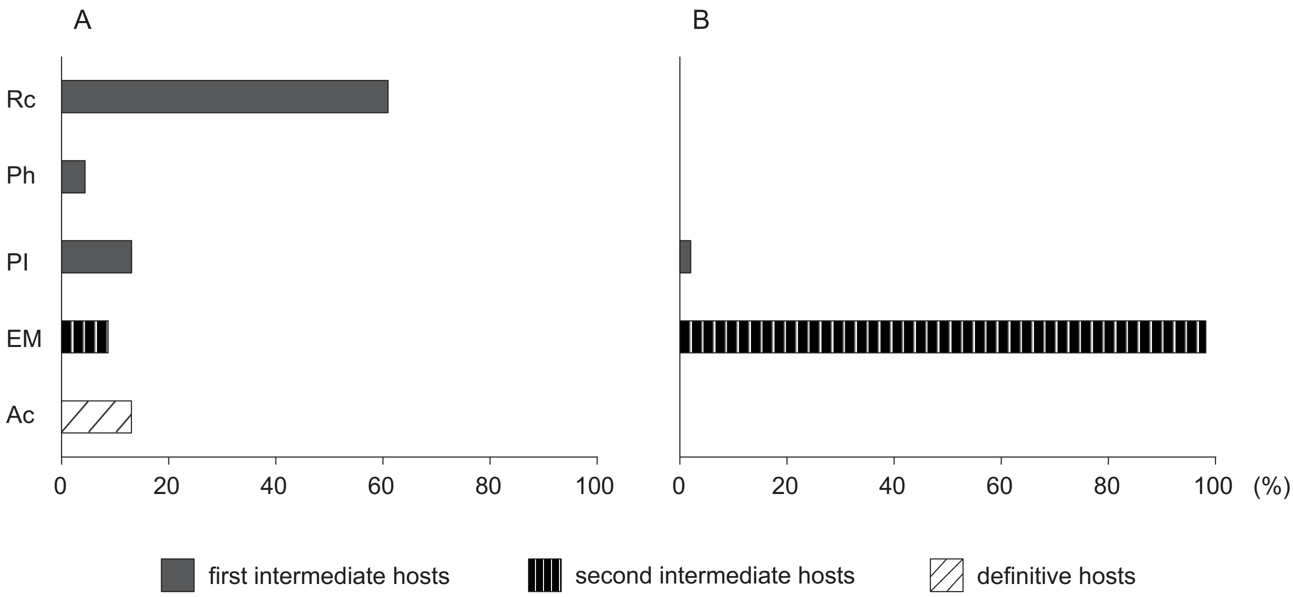

Fig. 2. Proportion (%) of trematodes in the pool of infected Unionidae (A) and Dreissenidae (B): Rc – *Rhipidocotyle campanula*, Ph – *Phyllodistomum* sp., Ac – *Aspidogaster conchicola*, EM – echinostome metcercariae, PI – pre-patent invasions

DISCUSSION

In our material, cercariae of *R. campanula* occurred in *A. anatina* and *U. tumidus*, while *Phyllodistomum* sp. were found only in *A. anatina*. The relatively small diversity of digenetic trematodes in the collected unionids is comparable with the results of Baturo (1977) and Müller et al. (2015). The presence of digenean trematodes in *U. pictorum* was not confirmed in our study due to the small number of collected specimens. The morphological characteristics of *Phyllodistomum* sp. corresponds to the descriptions presented by Orecchia et al. (1975), Kudlai & Yanovich (2013) and Müller et al. (2015) and the trematode probably represents *P. elongatum*. However, a detailed molecular diagnosis is required for the difficult taxonomic verification of species identity within Gorgoderidae (Petkevičiūtė et al. 2003, Grizzle & Brunner 2009).

Fully developed adult forms of *A. conchicola* were found only in three specimens of *U. tumidus,* with a small prevalence of 0.7%. This is probably the first record of this aspidogastrean trematode in *U. tumidus* from Poland. Till now, *A. conchicola* has been recorded in the Polish malacofauna only in *A. anatina*, *A. cygnea* (syn. *A. cellensis*) (Adamczyk 1972) and *S. woodiana* (Yuryshynets & Krasutska 2009). This indicates a need for further research on the diversity of trematodes in the Unionidae from Poland.

D. polymorpha were infected with some bucephalid sporocysts whose morphological characteristics matched the description presented by Baturo (1977) for *Bucephalus polymorphus*. Baturo (1977), Laruelle et al. (2002) and Grizzle & Brunner (2009) suggested that *B. polymorphus* was a specific to Dreissenidae, not Unionidae, and the earlier data on its presence in unionids (e.g. Stadnychenko 1974, Yanovich & Stadnychenko 1997, Piechocki 1999, Chernomaz 2001) should be verified due to the high degree of similarity between the larval stages of *B. polymorphus* and *R. campanula* (Karatayev et al. 2000).

Our study shows that Unionidae and Dreissenidae play a different role in the life cycle of trematodes. The role of unionids as the first intermediate hosts is mainly indicated by the presence of cercariae of *R. campanula*, while the role of the second intermediate hosts of the zebra mussels was defined by the occurrence of echinostome metacercariae. Such separation of the role of unionids and dreissenids may therefore result from the different specificity of miracidia of *R. campanula* which penetrate unionid clams (Baturo 1977) and less specific echinostome cercariae (Żbikowski & Żbikowska 2009) penetrating dreissenid mussels (Molloy et al. 1997). The spectrum of the second intermediate hosts for the echinostome cercariae is relatively large and includes both invertebrates and vertebrates (Kanev 1994). Another reason for the high infestation of *D. polymorpha* by echinostome metacercariae is the higher probability of contact between the parasite and the zebra mussel colonies, than in the case of a single unionid overgrown by *D. polymorpha*. Large colonies of zebra mussels on unionid individuals can prevent valve opening (Burlakova et al. 2000, Grizzle & Brunner 2009) which may additionally reduce the chance of transmission of echinostome cercariae to Unionidae.

There is little information on the diversity and prevalence of digenean and aspidogastrean trematodes in unionids and dreissenids from Poland. Therefore, further studies should focus on the search for new trematode species, using: (i) a large number of study sites, (ii) many native and alien bivalve species and (iii) different research methods, including morphological and molecular diagnosis of trematode species. The research should also contribute to answering the question of the environmental determinants of differences between the infection of Unionidae and Dreissenidae residing on their shells.

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