FOLIA MALACOLOGICA
Folia Malacol. 26(3): 167–175
ISSN 1506-7629 (print) • ISSN 2300-7125 (on-line)
The Association of Polish Malacologists
Faculty of Biology, Adam Mickiewicz University
Bogucki Wydawnictwo Naukowe
Poznań, September 2018
https://doi.org/10.12657/folmal.026.016

MOLLUSCS OF EXTREMELY ARTIFICIAL, SMALL TEMPORARY WATER BODIES IN A CITY PARK

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Abstract: The Pole Mokotowskie Park in Warsaw contains small, artificial and temporary water bodies created in the 1970s and supplied with water from waterworks. In them, molluscs constituted the dominant group of macroinvertebrates. They were represented by eight gastropod and one bivalve species. Both Prosobranchia (mainly *Bithynia tentaculata* and *Valvata piscinalis*), and Pulmonata (mainly *Radix balthica*, *Planorbis planorbis* and *Bathyomphalus contortus*) occurred abundantly. The bivalve *Musculium lacustre*, listed in The Red List of Threatened and Endangered Species in Poland, was also numerous. A large spatial diversity of species composition and abundance of molluscs was observed in a small and relatively homogenous area. The role of this type of water bodies in the creation of mollusc habitats as well as the possibility of colonisation of man-made and artificially drained water bodies by these animals are discussed.

Key words: gastropods, bivalves, small drainage ponds, park

INTRODUCTION

Small water bodies are a significant element of landscape diversification and they contribute to the maintenance of biological diversity at a high level (Banaszak 1994, Ożgo 2010, Forman 2014, Spyra 2017). Urban parks often include not only natural aquatic habitats (e.g., ponds and oxbow lakes) or semi-natural ones (e.g., clay pits), but also a new, artificial water bodies, which are created as ornamental features. Such water bodies can be found in cities all over Poland (Spyra 2018). Such ponds differ from natural ones e.g., in bottom type (often concrete bottom), water supply (water from a pipe supply) and drainage (often in the period of the winter season). In city ponds the impact of human management is seen most obviously in their shore zones (Kołodziejczyk 1976). They may contain fragments of bricks, rubble or slag, and be reinforced with fascine. In artificial ponds, the bottom can be concreted and devoid of macrophytes. Hence, the presence of a rich and diverse aquatic fauna is not expected. The most frequent records from such habitats would be the periodic occurrence and colonisation of insect e.g., imago and/or their larvae such as Coleoptera, Hemiptera, Odonata and Diptera, which can get to these habitats by the air way and reproduce in the period of spring and summer (Williams 1987, 2008). For animals that spend their entire life cycle in water, including molluscs, this type of environment would seem to be extremely unfavourable. Although some species of snails are able to survive the lack of water in a state of anabiosis, this is associated with burying in the bottom sediments, which are not present in the habitats of this study. According to Williams (1987) temporary waters can be considered as an "islands" in time and space.

The aim of the research was to investigate the composition of the mollusc fauna occurring in the small, artificial, periodically drained water habitats located in one of the city parks in Warsaw.

Ministry of Science and Higher Education
Republic of Poland

Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland, under agreement no 534/P-DUN/2018 of April 4th, 2018 allocated to the activities for disseminating science:
Task 1: Preparation of English versions of publications (sum funded by DUN 12,000 PLN) and
Task 2: Digitalisation of publications and scientific monographs to enable their open access in the Internet (sum funded by DUN 11,070 PLN).

STUDY AREA AND METHODS

The study was carried out in the Pole Mokotowskie Park, which was created in the 1970s in an area that up to the early 19th century was still a homogenous area of arable land. From 1820 it was an area of military exercises; from 1910 to 1939 Mokotowskie Airport occupied part of this area, and in the 1920–1930s there was also a horse racing track (PRZENIOSŁO 2017). The Park, located in the area of the Warsaw

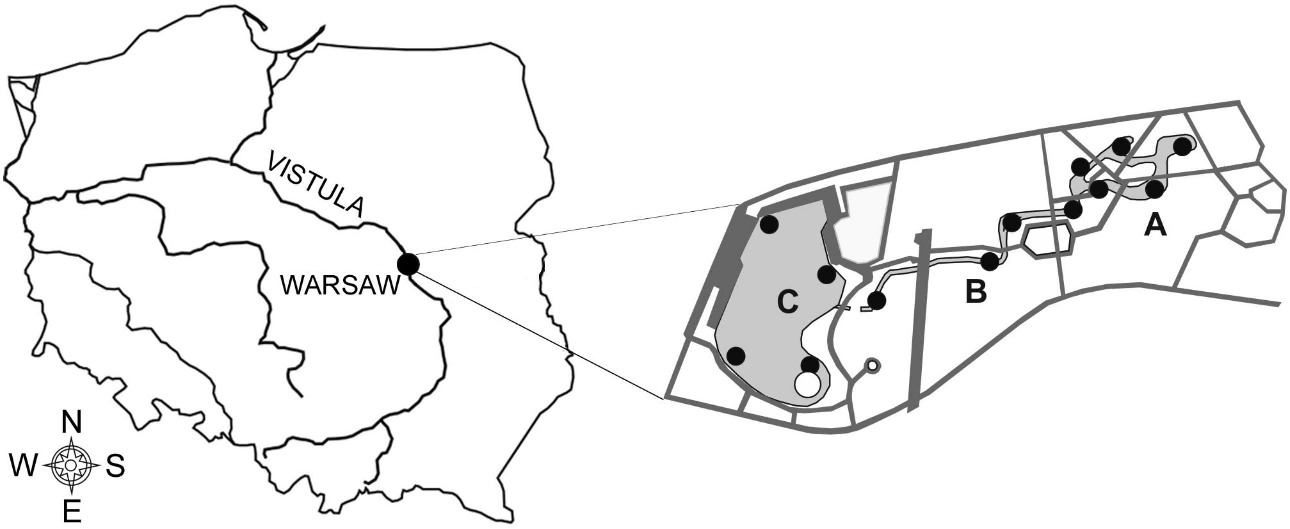

Fig. 1. A part of the Pole Mokotowskie Park in Warsaw (Poland). A – small ponds, B – small canal, C – big pond; black points indicate the sampling sites

Fig. 2. One of small ponds in the Pole Mokotowskie Park; visible concrete elements that separate the ponds. Photo: K. LEWANDOWSKI

Fig. 3. Small canal connecting water bodies in the Pole Mokotowskie Park. Photo: K. LEWANDOWSKI

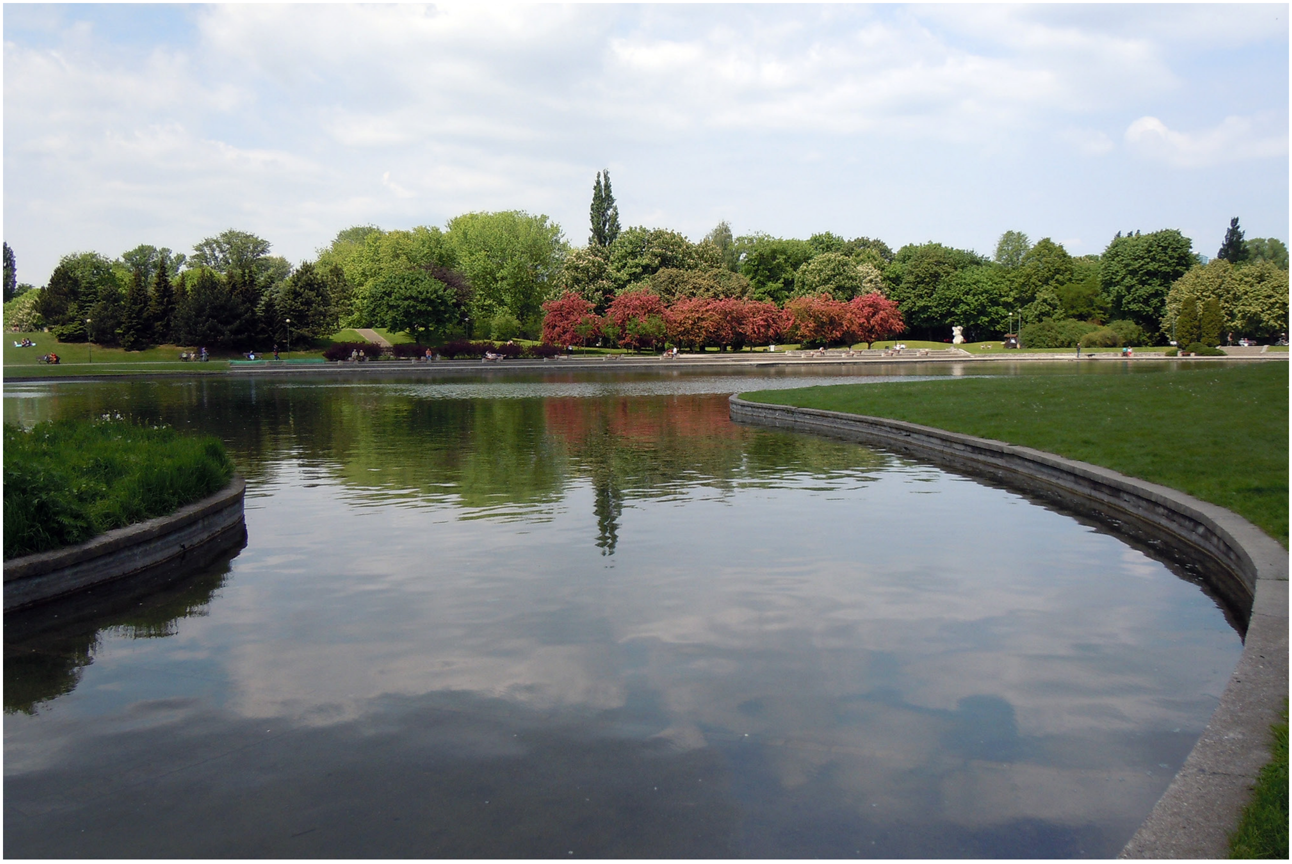

Fig. 4. Big pond in the Pole Mokotowskie Park. Photo: K. LEWANDOWSKI

Fig. 5. Emerging macrophytes in one of small ponds in the Pole Mokotowskie Park. Photo: K. LEWANDOWSKI

Fig. 6. Leaves fallen from the trees on the bottom of one of ponds – February 2018. Photo: A. KOŁODZIEJCZYK

Plateau, lies outside the influence of the waters of the Vistula River, and the series of small water bodies created (Fig. 1) were supplied with water from waterworks and drained out for the winter season.

A number of small and shallow (approx. 0.3 m), inter-connected water bodies (52°12'40"N, 21°00'04"E), may be considered as a single reservoir which is divided with concrete slabs into several smaller ponds (Fig. 2). The water flows through a shallow and only periodically active small canal (Fig. 3), which is about 150 m long and about 1.5 m wide, to a large (Fig. 4), deeper (about 1 m) recreational pond (52°12'38"N, 20°59'47"E).

The water bodies in the Park are filled with tap water for a relatively short period of time; in 2018 for example, this process began only in the first half of May. As a result, these habitats are excluded from routine control studies and inspection. As part of a social research project Konopski & Szumacher (2017) found neutral and alkaline pH of their water (7.2–8.5) and an increased content of nitrates and phosphates.

The bottom and shores of all of the water habitats from this study are made of concrete, but in a few of the smaller ponds they are sporadically overgrown with small aggregations of emergent macrophytes (*Glyceria* sp., *Iris pseudacorus* L. – Fig. 5). The riparian zone of the smaller water bodies and partially also the small canal are overgrown with trees, which are the main source of allochthonous matter (fallen leaves). In the water of small ponds filamentous algae aggregations as well as aggregations of Cladocera and Ostracoda were observed. In the summer amphibians such as *Lissotriton vulgaris* (Linnaeus, 1758), was also observed in the bottom. In the biggest pond frog tadpoles numerously occurred in the spring. After the pond draining out in the winter period, the partially dry leaf deposits remain on the concrete bottom of the small ponds and in the part of the canal (Fig. 6).

Material was collected twice, in May and July in 2016, from 13 sampling sites (five from small ponds, four in the canal and four from the big pond). Semi-quantitative samples (one per site) were collected from a depth of 0.2–0.3 m using bottom scratch sampler (side length 20 cm, D-frame, mesh size of net 0.2 mm; Zhadin 1966), which was dragged along the bottom for a length of 1 m. The material collected was preserved in 4% formalin. In the laboratory samples were washed on a sieve of 1 mm mesh size and segregated. After conservation in 70% alcohol, molluscs were counted and determined. The identification of mollusc species was carried out according to Piechocki & Wawrzyniak-Wydrowska (2016). The relative abundance of mollusc species was assessed (as percentages) and general diversity (Shannon-Wiener index, $H = -\sum p_i \ln p_i$) was also determined.

RESULTS

2,157 live specimens of mollusc were collected from all of the studied habitats (Table 1), which constituted 42.4% of the whole invertebrate fauna by numbers. Among the remaining taxa, reported in Kołodziejczyk & Lewandowski (2017a), the most numerous were Ostracoda, Chironomidae larvae and the corixid *Paracorix concinna* (Fieber, 1848). The richest faunas, clearly dominated by molluscs (74.3%), were found in small ponds. In the small canal, where a total of 2,217 invertebrates were collected, molluscs constituted only 12.9%. The invertebrate fauna of the big pond was very poor: only 336 specimens were retrieved, of which only four were gastropod molluscs, found in the July samples.

Nine species of molluscs were found in the studied environments – eight species of gastropods (three

Table 1. Molluscs of water bodies in Pole Mokotowskie Park (Warsaw, Poland). A – May; B – July

Species	Small ponds		Small canal		Big pond	
	A	B	A	B	A	B
Bithynia tentaculata (Linnaeus, 1758)	+	+	+	+		
Valvata piscinalis (O. F. Müller, 1774)	+	+	+	+		
Valvata cristata O. F. Müller, 1774	+	+				
Radix balthica (Linnaeus, 1758)	+	+	+			+
Galba truncatula (O. F. Müller, 1774)	+[1]					
Planorbis planorbis (Linnaeus, 1758)	+	+	+	+		
Bathyomphalus contortus (Linnaeus, 1758)	+	+	+			
Acroloxus lacustris (Linnaeus, 1758)	+[1]					
Musculium lacustre (O. F. Müller, 1774)	+	+	+	+		
Number of taxa	9	7	6	4	0	1
Number of collected individuals	350	1,516	16	271	0	4

[1]Only one individual collected.

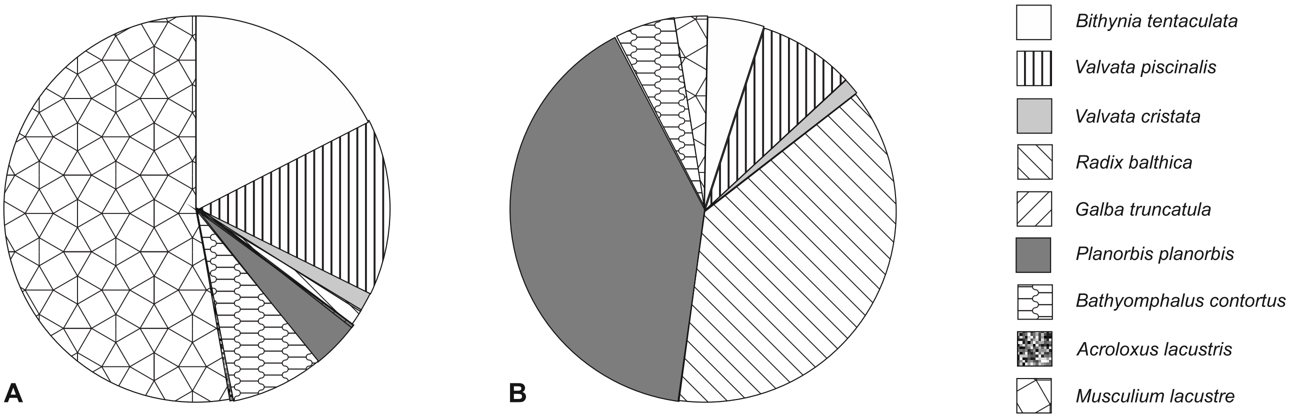

Fig. 7. The relative abundance of freshwater molluscs in small ponds: A – May, B – July

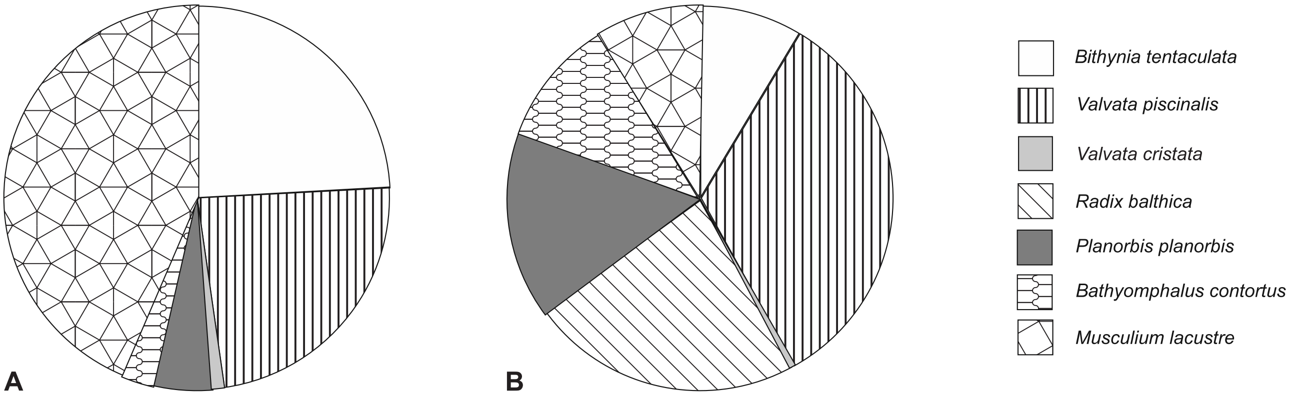

Fig. 8. The relative abundance of freshwater molluscs in a small canal: A – May, B – July

prosobranch and five pulmonate species) and one species of bivalve, *Musculium lacustre* (O. F. Müller, 1774) (Table 1). All species were found in small ponds, but *Galba truncatula* (O. F. Müller, 1774) and *Acroloxus lacustris* (Linnaeus, 1758) were found only in the spring, each represented by a single specimen (Table 1). The values the Shannon-Wiener diversity index, calculated in May and July were similar (1.24 and 1.42, respectively). In the small canal six species were found and the values of the diversity index amounted to 1.32 and 1.68 (May and June, respectively). In the big pond, only one species – *Radix balthica* (Linnaeus, 1758) was found in the summer (Table 1).

The total number of molluscs was greater in summer than in spring. The mean density expressed as number of individuals per 1 m^2 in small ponds was 165 ind./m^2 (from 0 to 555) in spring and 1,340 ind./m^2 (from 385 to 2,310) in summer, whereas in the canal the corresponding figures are 250 ind./m^2 (0–915) and 560 ind./m^2 (20–875). This increase of density was observed in both environments, in eight out of nine sampling sites as a result of the increased abundance of *R. balthica*, *Planorbis planorbis* (Linnaeus, 1758), and *Bathyomphalus contortus* (Linnaeus, 1758). In the summer we found numerous young individuals of *P. planorbis* and *R. balthica*, up to 2 mm in maximum shell size. No live specimens (or empty shells in collected samples) with maximum size for these species were found, in contrast with e.g., *Bithynia tentaculata* (Linnaeus, 1758) or *Valvata piscinalis* (O. F. Müller, 1774).

The relative abundance of mollusc species changed over time (Figs 7–8). In May, *M. lacustre* was a dominant species, both in small ponds (64.1% of molluscs) and in the canal (43.7%), while *B. tentaculata* (24.1%) and *V. piscinalis* (23.6%) belonged also to the group of dominant species. In the small ponds, *P. planorbis* (Linnaeus, 1758) (40.3%) and *R. balthica* (35.7%) were dominant in July, having occurred only sporadically in May. In the canal, *V. piscinalis* and *R. balthica* were abundant in a relatively high values, 33.2% and 23.1%, respectively, with a considerable share of other species (*P. planorbis* 15.7%, *B. contortus* 10.5%, *M. lacustre* 8.4% and *B. tentaculata* 8.2%).

Huge differences in abundance and the number of mollusc species were observed in small ponds among sampling sites. The number of species found at particular sites ranged from 0 to 7 in May and from 3 to 7 in July, whereas the number of collected individuals ranged from 0 to 111 in May and from 77 to 462 in July. In the canal, the number of species and usually also the number of collected individuals decreased with the direction of the water flow, from small ponds to big park pond.

DISCUSSION

Considering the completely artificial origin of the aquatic environments of this study, their small habitat diversity and the short time of their existence, the mollusc fauna in small ponds and in the canal was rich and diverse, and occurred more numerously compared to organisms which spend only the part of their life cycle in the water. The number of mollusc species found does not differ from that recorded in small, natural, astatic water bodies (Oertli et al. 2002), as well as in the man-made ponds located in forest complexes (Spyra & Strzelec 2014, Spyra 2018). Kołodziejczyk (1994) found the presence of only 10 mollusc taxa, in 21 small water bodies in the Suwałki Landscape Park, with from 0 to 8 in each of them. Koperski et al. (2014) found a total of 14 mollusc species in 22 small, astatic water bodies near the Łuknajno Lake (Masurian Lakeland), from 0 to 9 in each. Both in the aquatic habitats of Pole Mokotowskie and in these natural water bodies, bivalves are represented only by Sphaeriidae. Similarly, the relationship in the number of mollusc species between lakes and small, astatic water bodies in Warsaw is similar, as well as in the area of Suwałki Landscape Park (Kołodziejczyk 1989, 1994, Kołodziejczyk & Dołęga 2004, Kołodziejczyk & Lewandowski 2017b). The shallow zone of small water bodies is usually spatially heterogeneous and offers a mosaic structure that is mainly determined by plants, leaves and fragments serve as microhabitats for the gastropod fauna (e.g., as a substrate, shelter and attachment sites for invertebrates and microorganisms) (Williams 2005, Inkley et al. 2008). In the case of water habitats of this study the artificial concrete bottom creates difficult living conditions for freshwater gastropods.

In the summer, the numerous individuals of *R. balthica* and *P. planorbis* were mainly young animals, hatched in the year of collection. Given the extremely low number of these species (or even lack at sampling sites) in spring and the lack of large shells in the bottom sediments, this may indicate an extremely short lifespan of both species in these environments. This is most likely associated to their high mortality during the winter drainage of ponds along with the absence of bottom sediments (Fig. 6), and can be particularly severe for larger individuals. This is possible due to the fact that pulmonates, which use atmospheric oxygen in their breathing, constitute a good food source for aquatic birds together with the small depth of ponds and the lack of shelters (macrophytes and bottom sediments). Their availability as a food is larger in contrast to gastropods which breath using dissolved oxygen and are related more often with the bottom such as *B. tentaculata* and *V. piscinalis*.

In contrast to previously investigated water bodies in Skaryszewski Park (Kołodziejczyk & Lewandowski 2017b) – Kamionkowskie Lake (natural oxbow lake) and park ponds (artificial water bodies, but created in the flood plain area), water habitats in Pole Mokotowskie Park were created in the area located outside the influence of the Vistula River waters. Relatively fast colonisation of these environments (within 30–40 years) by molluscs was probably by air, transported by birds as a vector due to the fact that in the city parks waterfowl are numerous, as shown by many authors (e.g., Roscoe 1955, Boag 1986, Kappes & Haase 2012, Van Leeuwen & Van Der Velde 2012, Van Leeuwen et al. 2013). At a distance of 2.5–3 km, molluscs can be moved from the several large, old water bodies in the three parks. This is reflected by the numerous occurrences of *Anas platyrhynchos* L. 1758 in Warsaw's parks.

Although these cited publications indicate dispersal of pulmonate gastropods by birds, it is possible that at such a small distance prosobranch gastropods, especially small ones, can also be carried attached to bird feathers (Ribi 1986). However, it seems more likely that these gastropods have been introduced as a result of management and maintenance activities which are carried out in the area of city parks, by appropriate services (e.g., on their equipment or protective clothing). *M. lacustre* can spread with large aquatic flying insects. This phenomenon was observed for various species of Sphaeriidae, which were transported by Coleoptera and Heteroptera (Fernando 1954, Lansbury 1955, Fryer 1974). Transport by amphibians has been observed by some authors (Davis & Gilhen 1982, Kwet 1995, Gutleb et al. 2000), but although frogs and newts are present in the park, these water bodies are far from any others, and dispersal by this means seems unlikely.

Similarity in species richness in the faunas the water bodies in Pole Mokotowskie Park and Skaryszewski Park are not matched by the details of species composition and relative abundance (Kołodziejczyk & Lewandowski 2017b), reflecting the different age of these ponds and the type of area on which they were formed. More generally, some molluscs are able to survive the winter season despite the lack of water, but they require the presence of sediments at the bottom, for example in the form of leaf deposits. Such situations apply in forest ponds, located deeply in the forest interior where leaf deposits constitute an important substrate for the occurrence of benthic fauna including gastropods (Spyra 2010, 2011, Piechocki & Wawrzyniak-Wydrowska 2016). The formation of leaf deposits is a typical feature that distinguishes forest ponds from other aquatic environments (Oertli 1993, Dangles et al. 2004). While the ponds in this study do receive fallen leaves, the trees are relatively far from the shorelines and the deposits are thin. Pond freezing in the winter period is also not without significance (Oertli 1995, Spyra & Strzelec 2014), because the deposits of organic matter that cover the bottom of aquatic environments become the habitat for gastropods to survive in.

It appears from our study that some molluscs can survive over winter in these ponds, despite the fragmentary covering surviving routine cleaning, which caused high mortality of *R. balthica* and *P. planorbis,* while *B. tentaculata* reached its natural size because of the presence of an operculum. In the big pond and in the last section of the canal, the extremely low abundance of malacofauna may be caused by the lack of organic debris, the low number of trees in the shore zone of ponds and the easiness of cleaning the bottom after draining out in autumn.

The presence of these small and extremely artificial aquatic reservoirs in the city parks may contribute to the increase of the biodiversity in the area where they were formed. Rare, protected or endangered species may appear, as shown by the presence in large numbers of *M. lacustre,* a species listed in the Red List of Endangered and Threatened Animals in Poland as a vulnerable species (VU) (Dyduch-Falniowska & Zając 2002). A less intensive annual cleaning might further enhance molluscan diversity by allowing the formation of a stable layer of bottom sediments and the development of macrophytes which form a natural, favourable substrate for gastropods and bivalves.

ACKNOWLEDGEMENTS

We would like to express our thanks to M.Sc. Paweł Pstrokoński who encouraged us to undertake the studies in Pole Mokotowskie Park. We are very grateful to Prof. Andrzej Piechocki for the identification of atypical *Planorbis planorbis*. We are also indebted to Dr Ewa Rygielska-Szymańska for drawing the figures. We are very grateful to the anonymous reviewers for their valuable comments which help us to improve manuscript.

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Received: June 31st, 2018
Revised: July 31st, 2018
Accepted: September 19th, 2018
Published on-line: September 29th, 2018