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ECOLOGICAL NICHE OF *DREISSENA POLYMORPHA* (PALL.) AGGREGATIONS IN THE HEATED KONIN LAKES SYSTEM

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ABSTRACT. The zebra mussel, *Dreissena polymorpha* (Pall.) inhabits various live and dead substrates of the lotic and lentic zones of the heated Konin lakes. Occurring at depths from 20 cm to 3.5 m, this species showed a preference for Unionidae mussels as a substrate. Aggregations of *D. polymorpha* varied in number from 2 000 to 2 million individuals per m^2, while the biomass reached more than 12 kg m^{-2}. The most numerous were one year old mussels 5 mm in length, which comprised from 60-80% of the population. In the preliminary cooling reservoir, newly settled post-veligers comprised as much as 94% of the total of *D. polymorpha* numbers. The largest mussels did not exceed 35 mm. Aggregations of *D. polymorpha* contained 49 invertebrate taxa, and the most frequently occurring subdominants were from the Corophidae and Gammaridae families. The diel destruction of organic matter in the aggregations varied between 20 and 370 kJ m^{-2}, depending on the number of animals and their biomass. The turnover coefficient (R/B) in the heated zones was 1.5 times higher, on average, than in the non-heated parts of the system.

Key words: *DREISSENA POLYMORPHA* (PALL.), UNIONIDAE, LAKES, CHANNELS, THERMAL POLLUTION, PERIPHYTON, BENTHIC FAUNA

INTRODUCTION

Dreissena polymorpha (Pall.) may occur in aggregations as the dominant species and form a habitat for other organisms (Kharchenko and Protasov 1981). It is an important species in the benthic and periphyton communities of the heated Konin lakes (Stańczykowska 1976, Stańczykowska et al. 1988, Protasov et al. 1993, Zdanowski et al. 1996). This mussel plays a key role in the processes of the biological self-purification of water in lakes and channels (Protasov et al. 1994, 1997). The distribution of aggregations of this species depends on the occurrence of sufficient solid substrates.

The purpose of the present study is to describe the ecological niche of *D. polymorpha* that inhabit the heated Konin lakes system, and also to determine the role of aggregations of this mussel in the formation of habitats for other aquatic invertebrates.

MATERIAL AND METHODS

The aggregations of *D. polymorpha* studied in the Konin lakes in July 1997 occurred in a wide variety of environmental conditions. The zebra mussel inhabited various substrates, both dead and live, which included stones, concrete, sandy bottoms, tree branches, and living organisms, i.e. Unionidae. Detailed studies of the mussels were done at seven sampling sites (Table 1, Fig. 1). Of these, sites 1, 2, and 3 were situated along the short hydraulic duct of the water circulation in the system, while sites 4, 5, and 6 were located along the long duct. Site 7 was outside of the cooling system and was used as a control for comparison.

TABLE 1

Characteristics of *D. polymorpha* sampling sites in the Konin lakes system

Site			Temperature [°C]	Depth [m]	Substrate	Form of settlement on substrate
1	1a	Channel of water intake by the Konin power plant	22	1.0	stone, concrete	aggregations
	1b			3.0	sand	aggregations
2	2a	Preliminary cooling reservoir of discharge water from the Konin power plant: above the overflow partition	28	1.5 - 3.0	stone	shoal
	2b		28	2.5 - 3.5	stone	shoal
	2c	Preliminary cooling reservoir of discharge water from the Konin power plant: 100 m below dam	29	3.0	stone, Unionidae shells	shoal
	2d	Preliminary cooling reservoir of discharge water from the Konin power plant: above sluice gate at Morzysławski Channel	24	0.2	stone	dispersed colonies
3	3	Warta-Gopło Channel (lower site)	25	3.0	Unionidae shells	shoal
4	4	Licheńskie Lake; channel entrance to the lake	32	3.0	Unionidae shells	aggregations
5	5a	Piotrkowicki Channel; above pumping station	28	3.0	sand	aggregations
	5b			2.0 - 3.0	Unionidae shells	aggregations
	5c			0.2	Unionidae shells	shoal
	5d			0.2 - 0.3	Wooden bridge poles	aggregations
6	6	Piotrkowicki Channel; (100 m below pumping station)	27	3.0	stone	shoal
7	7	Warta–Gopło Chanel (upper site)	24	2.0-2.5	stone	shoal

The study sites of zebra mussel aggregations were chosen when the contribution of the mussel in either the total biomass or the numbers of the periphyton or benthos exceeded 50% (Protasov et al. 1994). Aggregations of *D. polymorpha* were studied

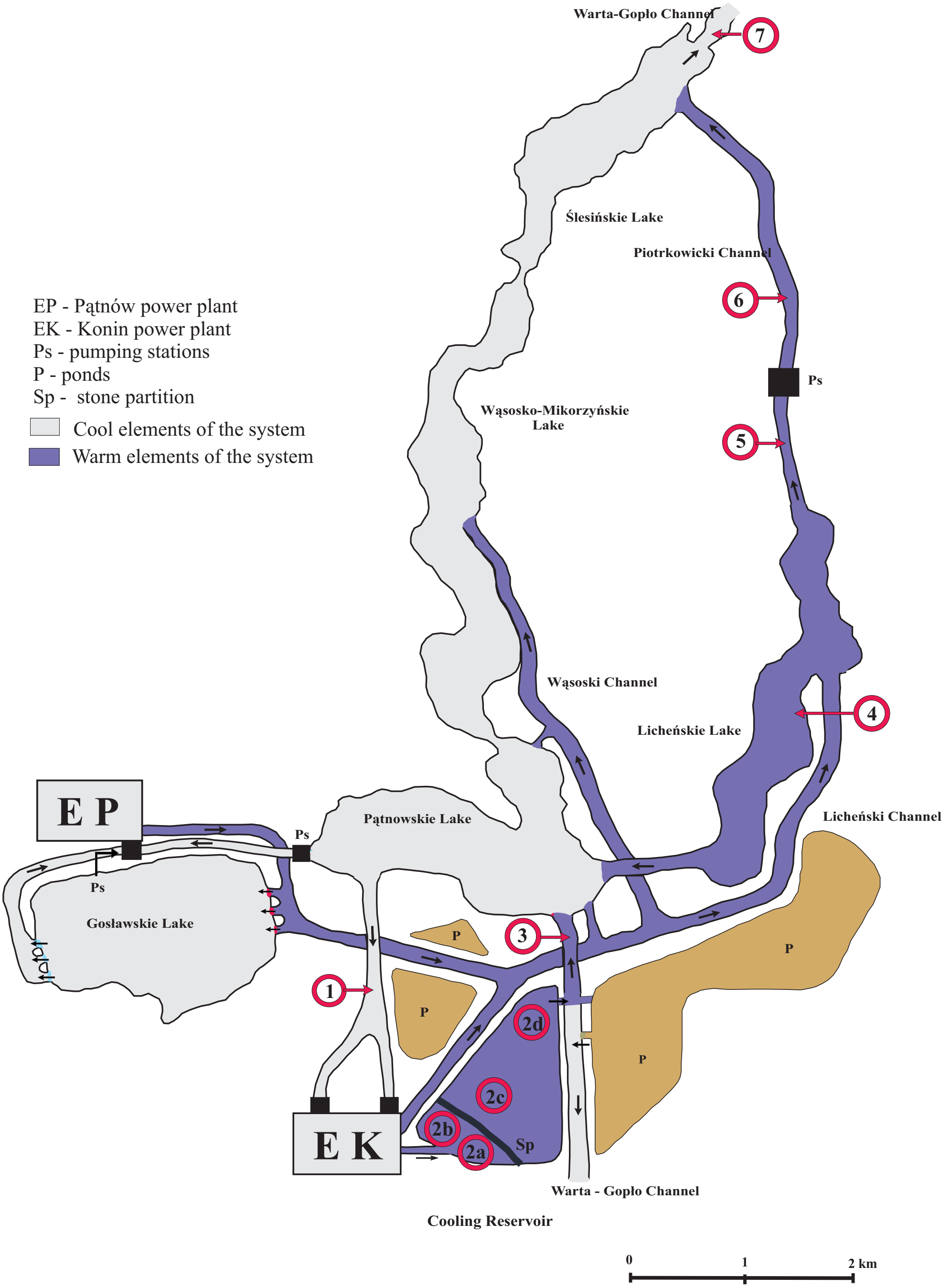

Fig. 1. Map of the Konin lakes system and location of the sampling sites.

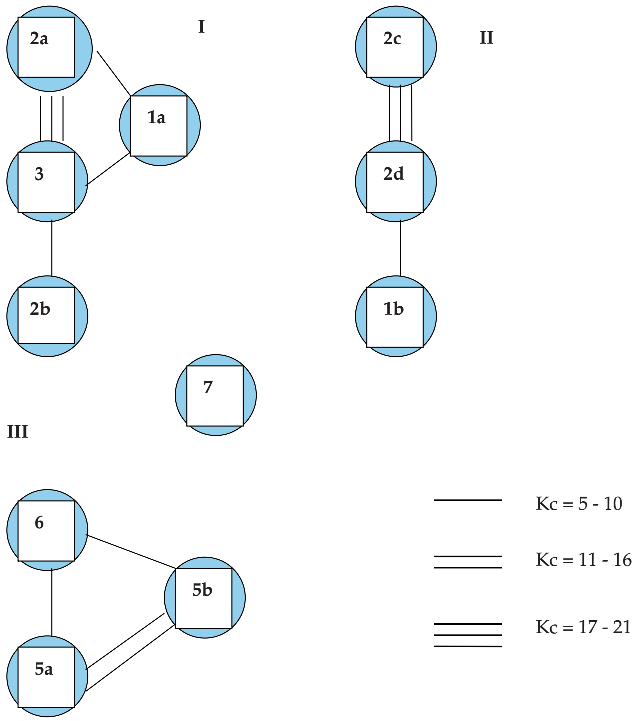

Fig.2. Similarity schemes of *D. polymorpha* aggregations in the Konin lakes system (according to the Smirnov's coefficient) (see Table 1).

using underwater methods which allowed reliable samples to be collected and the substrate distribution to be mapped. Samples of *D. polymorpha* from the bottom sediments were obtained with a box-shaped scoop with a 100 cm^2 surface area. The samples were scraped off of the large, solid substrates or washed off of the smaller ones. Overgrowths of mussels on the bottom or over large Unionidae were counted under water in a surface area of 0.25 m^2. Similarities between aggregations were estimated using the Smirnov's coefficient (Pesenko 1982) (Fig. 2).

RESULTS AND DISCUSSION

Zebra mussels at sites 1, 2, 3, and 4 were represented by one year old individuals of up to 5 mm (60-80%) or 10 mm in length (40-50%). Mussels of 16-20 mm which had settled in the previous year were also frequently found attached to the shells of Unionidae at sites 2 and 5. Mainly young mussels of up to 10 mm long occurred in the section of the Piotrkowicki Channel beyond the pump installation which does not contain water in the periods of autumn and spring, but is included in the cooling system during each vegetative season. At sites located farther from the water discharge, which mainly contained mussels 16-20 mm long (site 5 – this section of the Piotrkowicki Channel is filled with water throughout the year), or mussels 16-30 mm long (site 7 - Warta-Gopło Channel), young representatives of *D. polymorpha* did not exceed 50% of the total numbers.

The numbers of zebra mussel in aggregations varied from 2 000 to more than 2 million individuals m^{-2}. When all the sampling sites are compared, from the water intake by the power plant (site 1) towards the water outlet into the Warta-Gopło Channel (site 3), the most mussels were found in the zone of the direct discharge of used water into the preliminary cooling reservoir (sites 2a and 2b). The numbers were much lower beyond this reservoir's bulkhead and in the vicinity of the sluice gate (sites 2c and 2d), and still fewer were in the Warta-Gopło Channel (site 3). The highest numbers of post-veligers were recorded at stations 2a and 2b in the zone where the discharge water current is slower. Their numbers in this area were 2 000 individuals m^{-2}. The quantities of freshly settled zebra mussel in the cold intake channel (stations 1a and 1b) did not exceed 270 000 individuals m^{-2}.

Water flow through the lakes caused the active transfer of *D. polymorpha* larvae from the littoral to the open water of the lake; this reaction was previously reported by Stańczykowska (1976). It has been also documented by studies on the heated dam reservoirs of Ukraine (Protasov and Afanasjev 1986, 1990, Protasov et al. 1991). The same phenomenon can be observed by the analysis of zebra mussel density variations at sites located at the long cooling system of discharge waters, which, in summer, also includes Ślesinskie Lake. The highest rate of mussel settlement did not occur in the zone of the slower warm water current flow directed to Licheńskie Lake due to the lack of substrates and the low numbers of larvae flowing in through the channel. It did occur, however, on both sides of the pumping system in the Piotrkowicki Channel which provides an outflow route from this lake to Ślesińskie Lake. The numbers of zebra mussels in this area reached as much as $1\ 112 \times 10^3$ individuals m^{-2}.

For this reason, the biomass of the settled zebra mussels in different environments of the Konin lakes varied substantially from 99 g to 12 kg m^{-2} (Table 2). Generally, it was almost two-fold lower in the heated areas than in the Warta-Gopło Channel, i.e. at site 7 outside of the system. The mussels of the heated Konin lakes were smaller and had lower body weights compared with the animals from Mazurian lakes (Stańczykowska 1976). The mean individual body weight of zebra mussels found in the heated water was one order of magnitude lower in comparison with mussels from non-heated sites. Within the hydraulic system (sites 1 to 3), it increased from 0.09 to 0.30 g, and even more up to 0.58 and 0.69 g at sites 4 and 5.

TABLE 2

Ecological characteristics of *D. polymorpha* aggregations in the Konin lakes system

	Site	Numbers [in thousands individuals m^{-2}]	Biomass [g m^{-2}]	Energetic value of biomass [kJ m^{-2}]	Destruction of organic matter [kJ m^{-2} h^{-1}]
1	Channel of water intake by Konin power plant	66 – 275	3966 – 9472	916 – 2225	2.2 - 5.4
2	Preliminary cooling reservoir of discharge water from Konin power plant	12 – 2057	99 – 5988	23 – 1391	0.2 - 6.2
3	Warta-Gopło Channel (lower site)	2	358	67	0.3
4	Licheńskie Lake	11	1009	244	1.7
5	Piotrkowicki Channel (above pumping station)	4 – 1112	372 – 12123	99 – 3143	0.4 – 14
6	Piotrkowicki Channel (100 m below pumping station)	136	3139	1284	5.5
7	Channel Warta-Gopło (upper site)	23	7518	1128	3.6

The mollusks Unionidae were an important substrate for aggregations of zebra mussels. Their numbers were much higher on live Unionidae than on other substrates such as rocks or shells. Translocations of Unionidae for the purpose of finding optimal environmental conditions, an observation reported earlier by Lewandowski (1976), provided better conditions for the development of *D. polymorpha*. Its aggregations inhabited Unionidae at water temperatures of 25 to 32°C. The highest biomass of zebra mussel (1.51 g) in relation to 1 g of Unionidae biomass was noted in Licheńskie Lake, while the lowest weight (0.05 g) was in the Warta-Gopło Channel at site 7 (Table 3). The contribution of *D. polymorpha* and Unionidae to the destruction of organic matter in the first lake was 9 and 91%, respectively; the respective values in the channel were 74 and 26%.

The occurrence of 49 taxa of invertebrates was recorded in the aggregations of *D. polymorpha*. The greatest variety was noted among Oligochaeta, Cladocera, Chironomidae, Gastropoda, and Bivalvia. The richest fauna, 21-23 taxa, was noted in *D. polymorpha* colonies at sites 1a and 7, and the least number of taxa, 11-14, at sites 2b, 2d, and 5a. Analysis of the similarity of fauna compositions led to the distinction of three different groups of *D. polymorpha* aggregations. The first group included sites

TABLE 3

Biomass of *D. polymorpha* (a) and Unionidae (b) and the mussels' participation in the destruction of organic matter in the Konin lakes system

Site	Biomass (g m^{-2})		Destruction (kJ m^{-2})		Contribution (%) to destruction	
	a	b	a	b	a	b
Preliminary cooling reservoir of discharge water from the Konin power plant	99	916	23	1264	18	82
Warta-Gopło Channel	357	7468	67	10311	9	91
Licheńskie Lake	1067	704	255	971	74	26
Piotrkowicki Channel	372	821	99	1134	48	52

1a, 2a, 2c, and 3; the second sites 1b, 2b, and 2d; and the third sites 5a, 5b, and 6. The aggregation located outside the heated water system at site 7 showed the highest variety of taxa and a distinct difference compared to the other sites. It did not contain Corophidae and Gammaridae, which commonly occurred elsewhere, although *Asellus aquaticus* L. and *Theodoxus fluviatilis* L. were present only at this site.

The strong similarity (50%) of the taxonomic compositions of *D. polymorpha* aggregations at group 1 sites 2a and 3 was determined by the extreme thermal conditions in the preliminary cooling reservoir and in the Warta-Gopło Channel (site 3). Water flow in the former limited the amount of loam settling on the substrates, which, in turn, prevented the occurrence of typical benthic forms, such as the large Tubificidae. Rocks that were lightly covered with loam made substrates for periphyton colonies of the Bryozoa, *Plumatella emarginosa* Allm and the sponges, *Cordilophora caspia* Pall and *Spongilla lacustris* L. Although the zebra mussel assemblages at sites 2a and 2c were located close together, their species composition differed. The bottom of both of these sites is divided by a rocky barrier, a former road, which causes different hydrological and thermal conditions in this part of the reservoir. On the other hand, sites 5 and 6 had 60% of the species in common, including the snails, *Acroluxus lacustris* L., and other taxa such as Hydracarina, Chironomidae and Heleidae, none of which were found at the other sites.

The highest numbers and biomass of all aquatic organisms, up to 2 316 × 10^3 individuals per m^2 and 12 300 g m^{-2}, which formed one assemblage with *D. polymorpha*, were recorded in the most intensely heated areas (sites 2, 3, and 5a), while the lowest respective values (up to 5 000 individuals m^{-2} and 4 000 g m^{-2}) were observed in the coldest parts (sites 1, 5b, and 7). Aggregations of zebra mussels inhabiting the rocky barrier in the preliminary cooling reservoir contained the highest numbers of other

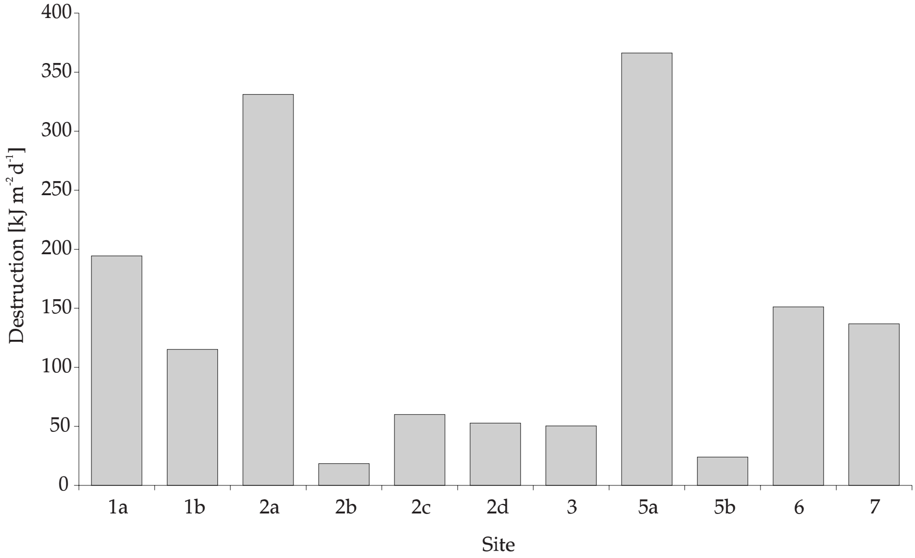

Fig. 3. Destruction of organic matter within aggregations of *D. polymorpha* at the sampling sites in the heated Konin lakes system.

organisms at 43 individuals per g of mussel mass. The numbers of these organisms in other places did not exceed 20 individuals, while only several of them per gram of *D. polymorpha* mass were observed in the Piotrkowicki Channel (site 5) or in the Warta-Gopło Channel (site 7).

The values of the diel destruction of organic matter within *D. polymorpha* aggregations were proportionate to mussel numbers and biomass, and varied from 19 to 366 kJ m^{-2} d^{-1} (Fig. 3). The contribution of subdominants to the general destruction of organic matter could be significant, e.g. *Spongilla lacustris* L. up to 16%; Gammaridae up to 35%; Corophidae up to 48%; large Unionidae up to 73%. The highest turnover time (R/B) in the zebra mussel aggregations was noted at sites where the water temperature did not exceed 28°C, and subdominant groups of Gammaridae and Corophidae were present.

On the basis of numbers, biomass and the contribution of particular trophic groups to the destruction of organic matter, and using the Shannon coefficient H_R values of taxonomic variation, the following four groups of aquatic invertebrates were distinguished in the Konin lakes system:

1. Dominant: *D. polymorpha* (53%). Subdominants: Corophidae (15%); Gammaridae (22%); sponge, *Spongilla lacustris* (6%). Shannon coefficient H_R - 2.07.

2. Dominant: *D. polymorpha* (58 %). Subdominants: Corophidae (24 %); Gammaridae (17 %). H_R - 1.5.
3. *D. polymorpha* settled over the shells of Unionidae, which play the major role in the destruction of organic matter (81 %). H_R - 1.19.
4. Mono-dominant *D. polymorpha* (88%). H_R - 0.71.

CONCLUSION

The zebra mussel is an important element of both the periphyton and benthic communities of the Konin lakes. It is often dominant in aggregations with other species, or it creates conditions for the development of other aquatic invertebrates. It prefers the cool and moderately heated sites of the lakes. The mussels of the family Unionidae are an important substrate for the zebra mussel; they probably provide better conditions for the development of the most numerous zebra mussel populations.

The size structure of *D. polymorpha* in the heated Konin lakes differs markedly from that observed in other lakes, e.g. the Mazurian lakes. Life processes of zebra mussel in the former lakes are more intense and they grow faster, but reach a smaller size of 25-30 mm. The numbers of the aquatic invertebrates associated with the zebra mussel are the highest in the most heated zones of the lakes.

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STRESZCZENIE

NISZA EKOLOGICZNA SKUPISK *DREISSENA POLYMORPHA* (PALL.) W SYSTEMIE PODGRZANYCH JEZIOR KONIŃSKICH

Dreissena polymorpha występowała w systemie jezior konińskich w szerokim spektrum warunków środowiskowych zarówno termicznych, jak i siedliskowych (tab. 1, rys. 1). Występując na głębokościach od 20 cm do 3,5 m zasiedlała rozmaite substraty (kamienie, drewno, beton) i żywe małże (Unionidae). Liczebność *D. polymorpha* w skupiskach wahała się 2 tysięcy do ponad 2 milionów osob. m^{-2}, a biomasa od 99 g m^{-2} do ponad 12 kg m^{-2} (tab. 2). Struktura wymiarowa wykazała, że najliczniejsze (60-80% populacji) były tegoroczne małże do 5 mm długości. Osobniki o wymiarach powyżej 25 mm spotykano sporadycznie. Odnotowano 49 taksonów bezkręgowców zasiedlających muszle *D. polymorpha*, z których najczęstszymi subdominantami były Corophidae i Gammaridae. Poziom destrukcji w skupiskach *D. polymorpha* zmieniał się od 18,5 do 366 kJ m^{-2} d^{-1} (rys. 3). Współczynnik (R/B) na podgrzanych stanowiskach systemu jezior konińskich był średnio 1,5 raza wyższy w porównaniu ze stanowiskiem nie podgrzewanym.

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