PLANKTONIC ROTIFERS OF FOUR POLIMICTIC LAKES OF ŁĘCZYŃSKO-WŁODAWSKIE LAKELAND (EASTERN POLAND)

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Summary. Lakes Bikcze, Brzeziczno, Mytycze and Płotycze are situated in the area of the Łęczyńsko-Włodawskie Lakeland. The lakes are polymictic and they differ in the surface and catchment areas and structure of land use. Studies of density and species diversity of planktonic rotifers were conducted in spring, summer and autumn of 2007 and 2008. The results showed the presence of 62 Rotifera species; the mean density ranged from 84 ind. dm⁻³ in Lake Brzeziczno to 3376 ind. dm⁻³ in Lake Bikcze. The group of dominants included common species: *Keratella cochlearis, Keratella cochlearis tecta, Keratella quadrata, Polyartchra vulgaris, Kellicottia longispina, Asplanchna priodonta, Ascomorpha ovalia.* The structure of domination and high species diversity of planktonic rotifers in Lake Mytycze indicated a higher ecological status of the lake in comparison to the other reservoirs. Numerous abundance of *Keratella cochlearis f. tecta* indicates high fertility of lake waters. The studies of faunistic similarity and occurrence of different ecological groups of planktonic rotifers showed the possibility of mixing and mutual influence of littoral and pelagic rotifers in these shallow lakes.

Key words: Lake Bikcze, Lake Brzeziczno, Lake Mytycze, Lake Płotycze, polymictic lakes, shallow lakes, planktonic rotifers

INTRODUCTION

Rotifers inhabiting lake ecosystems constitute the main part of small zooplankton. They are consumers of microorganisms, such as bacteria, algae, protozoans. Some species are detritivorous. So, rotifers are an important link in the trophic structure of water reservoirs [Radwan 1973]. Some species are good indicators of water trophy [Karabin 1985, Radwan *et al.* 1988, Paleolog *et al.* 1997].

Lakes Bikcze, Brzeziczno, Mytycze and Płotycze represent the group of shallow, polymictic lakes, numerously occurring in the region. The zones of emergent and submerged vegetation are well developed; the lakes differ in terms of surface area and main use. The studies of planktonic rotifers were undertaken to recognize the species structure and density and to compare the rotifer communities between the littoral and pelagic zones of studied lakes.

STUDY AREA

Studied shallow lakes Bikcze, Brzeziczno, Mytycze and Płotycze are situated in the area of the Łęczyńsko-Włodawskie Lakeland, a region of high ecological value [Chmielewski (ed.) 2006]. The whole region has the status of a UNESCO Biosphere Reserve – within the area the Poleski National Park, 3 landscape parks, 7 areas of NATURA 2000 and 12 nature reserves are situated. The investigated lakes are polymictic, except for Lake Mytycze (maximum depth of 1.2 m), their maximum depth ranges from 2.5 to 3.4 m (Tab. 1). Lake Brzeziczno is surrounded

 Table 1. Selected features of four polymictic lakes of Łęczyńsko-Włodawskie Lakeland

 [acc. Harasimiuk et al. 1998]

Lake	Surface area, ha	Max. depth., m	Trophy type	Fishery type	Catchment area, ha	Structure of land use
Bikcze	74.0	3.3	eutrophic	tench-pike	183.32	40% lake, 47% mead- ows, 10% arable lands, 3% others
Brzeziczno	8.7	2.54	dystrophic	common carp	666.51	2% lake, 57% forests, 38, arable lands, 3% others
Mytycze	24.2	1.2	eutrophic	tench-pike	256.21	_
Płotycze	10.9	3.4	eutrophic	tench-pike	565.25	2% lake, 37% meadows, 26% forests, 33% arable lands, 2% others

by forest, difficult to explore, and is not used for recreation nor fishery purposes. The lake is dystrophic and represents the common carp type. The remaining lakes are eutrophic, tench-pike type, used mainly for fishery purposes [Hara-simiuk (ed.) 1998]. The catchment areas of the studied lakes range from 183.32 ha (Lake Bikcze) to 666.51 ha (Lake Brzeziczno). The structure of land use is dominated by meadows, pastures, arable lands and forests (Tab. 1).

MATERIAL AND METHODS

Samples were taken in spring, summer and autumn of 2007 and 2008 from four lakes of Łęczyńsko-Włodawskie Lakeland (E Poland): Bikcze, Brzeziczno, Mytycze and Płotycze.

Each time three zooplankton samples were taken in the littoral zone and in the zone of open water. Samples were collected by taking 10 cm³ of water using the sampler Toń II, from the depth of 0 to 1 m. The water was sieved through the planktonic net No. 25 and condensed to the constant volume of 100 cm³. Samples were preserved with Lugol's liquid and, after some hours, with 4% formaldehyde with glycerine. In preserved samples planktonic rotifers were identified and counted. Numbers of individuals were counted per 1 dm³ of water. The normal distribution of the data was checked by the Shapiro-Wilk test. The significance of differences in rotifer densities between particular lakes and zones was verified using the non-parametric rang test of Kruskal-Wallis using SAS Programme [2001]. The similarity of rotifers communities in particular zones and lakes were estimated using Sörensen index and cluster analysis performed by MVSP-3.1. The analysis of similarities was done using UPGMA method. The effect of dominating species on the similarity of rotifer communities was estimated using PCA analysis using MVSP-3,1 programme. The analysis included the index of domination, evaluation of sustainability of domination structure [Bielańska-Grajner 2005], species diversity index of Shannon-Wiener [1963], classification of rotifer species to particular ecological groups [Radwan 1973].

RESULTS AND DISCUSSION

Species structure and diversity

62 planktonic rotifer species were present in the four studied lakes during the two-year studies. The number of species in the littoral zone ranged from 16 in Lake Płotycze to 30 in Lake Bikcze. In the zone of open water the number of taxa showed lower values and varied from 12 (Lake Płotycze) to 28 (Lake Bikcze) (Tab. 2). The highest species diversity was observed in Lake Bikcze. In both small lakes – the dystrophic Lake Brzeziczno and the eutrophic Lake Mytycze, the number of species was lower; in the small eutrophic Lake Płotycze, situated near Urszulin, the number of rotifer species showed the lowest values (Tab. 2). The studied lakes were inhabited by four ecological groups of planktonic rotifers; the most abundant euplanktonic species and less numerous groups of benthic-periphytic, periphytic and epibiontic species. The highest number of euplanktonic species was noted in lakes of large surface area, with a big pelagic zone (lakes Bikcze and Mytycze). Lower numbers of euplanktonic species were observed in the smaller lakes – Brzeziczno and Płotycze. The zone of littoral and

	Bikcze		Brzeziczno		Mytycze		Płotycze	
Lake	littoral	pelagic zone	littoral	pelagic zone	littoral	pelagic zone	littoral	pelagic zone
Number of species	30	28	29	16	20	17	16	12
Euplanktonic species Benthic-periphytic	11	13	10	5	12	13	11	10
species	11	9	14	8	6	3	3	2
Periphytic species	7	6	5	3	2	1	2	0
Epibiontic species	1	0	0	0	0	0	0	0
Indicators of eutrophic waters Indicators	7	7	2	0	6	6	5	5
of oligotrophic waters Indicators	1	2	1	1	0	0	0	0
of dystrophic waters	0	1	1	1	1	1	1	1
Shannon index H	1.641056	1.343352	2.588731	1.75815	2.295199	1.969124	0.982344	1.555297
Density (ind. dm ⁻³)	473.8333	3376	83.625	143.5833	252.25	431.5	1363.917	805.8333

Table 2. Ecological characteristic of planktonic rotifers of four polymictic lakes of Łęczyńsko-Włodawskie Lakeland, during the years 2007–2008

open water did not differ significantly in terms of the presence of euplanktonic rotifer species (Tab. 2). The highest numbers of benthic-periphytic and periphytic species were noted in lakes with highest percentage of the bottom overgrown by vegetation (Bikcze and Brzeziczno). A similar relationship in lakes of that region was observed in the 70's [Radwan 1973]. In lakes Mytycze and Płotycze the benthic-periphytic and periphytic taxa occurred in lower numbers. The littoral zones of the studied lakes were richer in benthic-periphytic and periphytic taxa than the open water zones (Tab. 2). The preferences of these ecological groups to macrophyte dominated habitats were observed in other shallow lakes [Bielańska-Grajner 1987, Radwan *et al.* 1988, Paleolog *et al.* 1997, Demetraki-Paleolog 2007]. Epibiontic rotifers were represented only by one taxon, in the littoral zone of Lake Bikcze (Tab. 2).

The species diversity of planktonic rotifers showed the opposite pattern to species richness. The highest values of Shannon-Wiener index were noted in Lake Brzeziczno (H = 2.59 in the littoral, H = 1.76 in open water zone), while the lowest in Lake Płotycze (H = 0.98 in the littoral and H = 1.55 in the pelagic zone). In the two remaining lakes the values of H index oscillated between 1.64

and 2.29. The littoral zone, except for Lake Płotycze, showed higher species diversity than the zone of open water (Tab. 2).

In the four shallow lakes no rare species were noted, only indicatory species. The most numerous group was that of eutrophobionts. In lakes Bikcze, Płotycze and Mytycze the numbers of those species ranged from 5 to 7. In the dystrophic Lake Brzeziczno the number of species indicatory for eutrophic waters amounted to 2, those taxa being noted in the littoral zone. The total number of indicatory species did not differ significantly between the littoral and open water zones (Tab. 2). Indicatory species for oligotrophic waters were observed only in lakes Bikcze and Brzeziczno, where their number ranged from 1 to 2 (Tab. 2). In each of studied lake one species typical for dystrophic waters was noted.

Density and relative abundances

The highest density of planktonic rotifers was observed in the largest eutrophic Lake Bikcze (474 ind. dm⁻³ in littoral; 3376 ind. dm⁻³ in open water) and in the eutrophic Lake Mytycze (806 ind. dm⁻³ in littoral and 1364 ind. dm⁻³ in pelagic zone). In the remaining lakes rotifer densities ranged from 84 ind. dm⁻³ to 431 ind. dm⁻³ and reached the lowest values in the distrophic Lake Brzeziczno (Tab. 2). The observed differences between the lakes were significant. In all the lakes, except for the small Lake Płotycze, densities of planktonic rotifers were significantly higher in the zone of open water than in the littoral.



Fig. 1. Relative abundances of particular rotifers species in four polymictic lakes of Łęczyńsko--Włodawskie Lakeland during the years 2007–2008

The group of dominants included common rotifer species. Irrespective of the lake, rotifer community was dominated by *Keratella cochlearis*. Additionally, *Polyartchra vulgaris* dominated in lakes Bikcze and Mytycze; *Keratella quadrata* in Lake Płotycze; *Keratella cochlearis tecta* in lakes Płotycze, Bikcze and Mytycze; *Kellicottia longispina* and *Asplanchna priodonta* in Lake Brzeziczno and *Ascomorpha ovalia* in Lake Bikcze (Fig. 1).

Rotifer communities were classified according to Łuczak and Wierzbowska [1981], Müller [1984] and Bielańska-Grainer [2005] as sustainable and nonsustainable domination structure. Those authors classified a community as sustainable when three domination classes could be distinguished (dominants, subdominants and recedents), at least three species belonged to dominants and none of them exceeded 45% in the total density. Based on those criteria, only in the littoral zone of Lake Mytycze the domination structure of planktonic rotifers was sustainable. In other lakes and zones none of the dominants exceeded 45% of total rotifer density. Only in the pelagic zone of Lake Mytycze one of the dominant species accounted for nearly 40% of total density. The presence of sustainable domination structure confirms high ecological status of the lake and low fertility of its waters [Bielańska-Grajner 2005]. On the other hand, high percentage of Keratella cochlearis f. tecta is an evidence of higher trophy of that lake. That rotifer species was noted as a dominant in lakes Bikcze and Płotycze. Keratella cochlearis f. tecta, and especially its share in the total density of Keratella cochlearis population, is used as an indicator of lake fertility [Karabin and Ejsmont-Karabin 1996, Radwan et al. 2004].

Classification of rotifers communities

Cluster analysis for planktonic rotifer communities in the four lakes, performed on the basis of species diversity, divided the studied lakes into two groups (Fig. 2). The first group included the littoral and open water zones of lakes



Fig. 2. Structure of similarity of rotifers communities based on species diversity of four polymictic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007–2008

Płotycze and Mytycze. The highest similarity within the group was displayed by rotifer communities in the open water and littoral zones of Lake Mytycze (0.81), a little lower by rotifers in the littoral and pelagic zones of Lake Płotycze (0.79). Rotifer communities inhabiting lakes Mytycze and Płotycze were less similar (0.46) than rotifer communities living in different zones within each lake. The second group included the littoral and pelagic zones of lakes Brzeziczno and Bikcze. The highest similarity was noted for rotifer communities inhabiting the littoral and pelagic zones of Lake Bikcze (0.86), and lower for rotifers in the littoral and pelagic zones of Lake Brzeziczno (0.62). Rotifer communities inhabiting lakes Bikcze and Brzeziczno showed lower similarity (0.35) than communities living within particular lakes. The rotifer communities living in two remaining two lakes (0.31) (Fig. 2).



Fig. 3. The diagram of PCA analysis of rotifers communities based on species diversity of four polymictic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007–2008

The PCA analysis based on species diversity of planktonic rotifers confirmed the results of the cluster analysis, showed higher similarity of rotifer communities inhabiting different zones within a lake than between the lakes, although rotifer communities inhabiting lakes Mytycze and Płotycze showed very high similarity indexes both within and between the lakes (Fig. 3). PCA analysis showed high dissimilarity of rotifer communities present in lakes Bikcze and Brzeziczno. In Lake Bikcze, probably due to the large area of open water, the differences of rotifer communities in the littoral and pelagic zones were the highest among all of the studied lakes. Axis 1 explains rotifer variability in 37.68%, Axis 2 in 25.40%.

CONCLUSIONS

1. In the four shallow lakes 62 planktonic rotifer species were identified, among which 11 were indicatory species of eutrophic waters, 2 indicatory species of oligotrophic waters and 1 indicator of dystrophic waters.

2. The highest numbers were attained by euplanktonic species, while benthic-periphytic, periphytic and epibiontic species were present in lower numbers. Such a structure indicates the influence of the open water zone on the species composition of rotifers in other lake zones.

3. Species richness and diversity usually showed higher values in the littoral zone, while mean densities (ranged from 84 do 3376 ind. dm⁻³) were higher in the zone of open water.

4. The group of dominants included common rotifers species: *Keratella cochlearis, Keratella cochlearis tecta, Keratella quadrata, Polyartchra vulgaris, Kellicottia longispina, Asplanchna priodonta, Ascomorpha ovalia.* A sustainable domination structure was observed only in the littoral zone of Lake Mytycze, although in that lake a high amount of *Keratella cochlearis* f. *tecta* was noted in the population of *Keratella cochlearis*, which indicates an increase of the trophic status of the lake.

5. The cluster and PCA analyses showed high faunistic similarity of rotifer communities between lakes Płotycze and Mytycze. High similarity of rotifer communities in different zones within one lake can indicate mutual influence of the pelagic and littoral zones which create a kind of ecotonal zone for planktonic rotifers (littoral/open water).

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Acknowledgment. Paper prepared within the framework of research projekt N305 087 31/3325 Transformations of ecological structure and currant conditions of functioning of hydrogenic landscapes of the "West Polesie" Biospere Reserve and prospects of conservation of their nature values, financed by the Ministry of Science and Higher Education.

WROTKI PLANKTONOWE CZTERECH POLIMIKTYCZNYCH JEZIOR POJEZIERZA ŁĘCZYŃSKO-WŁODAWSKIEGO (WSCHODNIA POLSKA)

Streszczenie. Jeziora Bikcze, Brzeziczno, Mytycze i Płotycze należą do jednego z najcenniejszych przyrodniczo regionów Polski – Pojezierza Łęczyńsko-Włodawskiego. Są one płytkimi zbiornikami polimiktycznymi o różnej powierzchni lustra wody, różnej powierzchni zlewni i różnej strukturze użytkowania zlewni. Wiosenną, latem i jesienią 2007 i 2008 roku przeprowadzono w nich badania nad składem jakościowym i zagęszczeniem wrotków planktonowych. Badania te pozwoliły na stwierdzenie 62 gatunków Rotifera w średnim zagęszczeniu, wahającym się w szerokim zakresie od 84 ind. dm⁻³ w j. Brzeziczno do 3376 ind. dm⁻³ w j. Bikcze. Wśród dominantów znalazły się pospolite gatunki: *Keratella cochlearis, Keratella cochlearis tecta, Keratella quadra-ta, Polyartchra vulgaris, Kellicottia longispina, Asplanchna priodonta, Ascomorpha ovalia*. Struktura dominacji oraz wysoka różnorodność gatunkowa w jeziorze Mytycze wskazują na wyższy status ekologiczny tego zbiornika w porównaniu z pozostałymi jeziorami. Podwyższony udział formy *tecta* w populacji *Keratelli cochlearis* świadczy jednak o znacznej żyzność jego wód. Badania podobieństw faunistycznych i udziału różnych zespołów ekologicznych wrotków wskazują na możliwość mieszania się i wzajemnego oddziaływania w tych płytkich zbiornikach zgrupowań wrotków pelagicznych i litoralowych.

Słowa kluczowe: jezioro Bikcze, jezioro Brzeziczno, jezioro Mytycze, jezioro Płotycze, jeziora polimiktyczne, jeziora płytkie, wrotki planktonowe