

PLANKTONIC ROTIFERS OF THREE EUTROPHIC LAKES OF ŁĘCZYŃSKO-WŁODAWSKIE LAKELAND (EASTERN POLAND)

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Summary. Planktonic rotifer assemblages were studied in three shallow eutrophic lakes of Łęczyńsko-Włodawskie Lakeland (Bikcze, Mytycze and Płotycze). The lakes differ in terms of surface area catchment area and the structure of its land use. Samples were taken in spring, summer and autumn of 2007, 2008 and 2012. In studied lakes were noted 68 species of *Rotifera*. Mean density ranged from 275 ind. · dm⁻³ in lake Mytycze to 3410 ind. · dm⁻³ in lake Bikcze. The rotifer assemblages were dominated by common species: *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *Polyartchra vulgaris*, *Kellicottia longispina*, *Asplanchna priodonta* and *Ascomorpha ovalia*. Domination structure and high species diversity of planktonic rotifers observed in lake Mytycze indicate the highest ecological status of the lake in comparison to the remaining two lakes. Although the rising percentage of *Keratella cochlearis tecta* suggests high trophic status of the lake. The analysis of faunistic similarity of rotifer assemblages and their ecological groups indicate the possibility of mutual relationships between littoral and pelagic rotifers.

Key words: lake Bikcze, lake Mytycze, lake Płotycze, eutrophic 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 important link in 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 Biczce, Mytycze and Płotycze represent the group of shallow, eutrophic lakes, numerous in the region. The zones of emergent and submerged vegetation are well developed; the lakes differ in terms of surface area and structure of land use in catchment area. The studies of planktonic rotifers were undertaken to recognize the species structure and density and to compare the rotifers communities between the littoral and pelagic zone of studied lakes.

STUDY AREA

Lakes Biczce, Mytycze and Płotycze belong to one of the most valuable regions of Poland-Łęczyńsko-Włodawskie Lakeland [Chmielewski (ed.) 2006]. The area is characterized by a high degree of naturalness. On the area is situated Poleski National Park, 3 landscape parks, 7 areas of NATURE 2000 and 12 nature reserves. The whole region has a status of Biosphere Reserve UNESCO. Studied lakes are shallow and eutrophic. The maximum depth ranged from 1.2 m (lake Mytycze) to 3.4 m (lake Płotycze) (Tab. 1). The lakes represent pike-perch

Table 1. Morphometric and hydrological characteristic of three eutrophic lakes of Łęczyńsko-Włodawskie Lakeland [acc. Harasimiuk *et al.* 1998]

| Lake | Surface area, ha | Max. depth., m | Fishery type | Catchment area, ha | Structure of land use |
|----------|------------------|----------------|--------------|--------------------|--|
| Biczce | 74.0 | 3.3 | tench-pike | 183.3 | 40% lake, 47% meadows, 10% arable lands, 3% others |
| Mytycze | 24.2 | 1.2 | tench-pike | 256.2 | – |
| Płotycze | 10.9 | 3.4 | tench-pike | 565.3 | 2% lake, 37% meadows, 26% forests, 33% arable lands, 2% others |

fishery type and are used mainly for fishery purpose [Harasimiuk (ed.) 1998]. The catchment area of the studied lakes ranged from 183.3 ha (lake Biczce) to 565.3 ha (lake Płotycze). In the structure of land use prevailed meadows and pastures, arable lands and forests (Tab. 1).

MATERIAL AND METHODS

Studies were conducted in spring, summer and autumn during the years 2007, 2008 and 2012 in three lakes of Łęczyńsko-Włodawskie Lakeland (Eastern Poland); lakes Bikcze, Mytycze and Płotycze. Each sampling date rotifers were collected in littoral and pelagic zone, in three replicates. Samples were collected by taken 10 cm³ of water using 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 by Lugol’s liquid and after some hours by 4% formaldehyde with glycerine. In preserved samples planktonic rotifers were identified and counted. Number of individuals was calculated per 1 dm³ of water. The normal distribution of the data was checked by Shapiro-Wilk test. The significance of differences of rotifer densities between lakes and zones were verified using non-parametric rang test of Kruskal-Wallis using SAS Programme [SAS Institute Inc. 2001]. The similarity of rotifer communities between zones and lakes were estimated using Sørensen index and cluster analysis performed by MVSP-3.1. The similarity analysis was performed using UPGMA method (Unweighted Pair-Group Method Using Arithmetic Averages). The effect of dominating species on the similarity of rotifer communities was evaluated using PCA analysis (Principal Components Analysis) using MVSP-3.1. The ecological analysis included: index of domination, evaluation of sustainability of domination structure [Bielańska-Grajner 2005], species diversity index of Shannon-Wiener [Shannon and Wiener 1963], classification of rotifer species to ecological groups [Radwan 1973].

RESULTS AND DISCUSSION

Species richness, diversity and ecological structure

In total, 68 species of planktonic rotifers were noted in the studied lakes. In the littoral number of species varied between 18 (lake Płotycze) and 33 species (lake Bikcze). In the pelagic zone number of species was lower and ranged from 14 species (lake Płotycze) to 30 species (lake Bikcze) (Tab. 2). The highest species richness of planktonic rotifers was observed lake Bikcze and the lowest in small lake Płotycze (Tab. 2).

The studied lakes inhabited four ecological groups of planktonic rotifers; euplanktonic, benthic-periphytic, periphytic and epibiontic species. The highest number of euplanktonic rotifers was observed in large lakes with well developed pelagic zone (lakes Bikcze and Mytycze), but any significant differences were not observed between littoral and pelagic zone (Tab. 2). Benthic-periphytic and periphytic rotifers preferred lake Bikcze, with well developed zone of submerged macrophytes. Similar relationship was noted in the lakes of studied region in 70’s of XX century [Radwan 1973]. In lakes Mytycze and Płotycze number of benthic-periphytic and periphytic rotifers was much lower. In general

Table 2. Ecological structure of planktonic rotifer assemblages of three eutrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

| Factors of studies | Lake | | | | | |
|------------------------------------|----------|--------------|----------|--------------|----------|--------------|
| | Bikcze | | Mytycze | | Płotycze | |
| | littoral | pelagic zone | littoral | pelagic zone | littoral | pelagic zone |
| Number of species | 33 | 30 | 22 | 18 | 18 | 14 |
| Euplanktonic species | 12 | 15 | 12 | 14 | 12 | 12 |
| Benthic-periphytic species | 12 | 9 | 7 | 3 | 4 | 2 |
| Periphytic species | 8 | 6 | 3 | 1 | 2 | 0 |
| Epibiontic species | 1 | 0 | 0 | 0 | 0 | 0 |
| Indicators of eutrophic waters | 8 | 8 | 6 | 6 | 5 | 5 |
| Indicators of oligotrophic waters | 1 | 2 | 0 | 0 | 0 | 0 |
| Indicators of dystrophic waters | 0 | 1 | 1 | 1 | 1 | 1 |
| Shannon-Wiener index | 1.7 | 1.5 | 2.1 | 1.8 | 0.8 | 1.4 |
| Density (ind. · dm ⁻³) | 580 | 3410 | 275 | 399 | 1460 | 850 |

these ecological groups were observed mostly in littoral zone (Tab. 2). Preference of rotifer species to habits densely overgrown by macrophytes was frequently observed in other lakes [Bielańska-Grajner 1987, Paleolog *et al.* 1997, Radwan *et al.* 1988, Demetraki-Paleolog 2007, 2008, 2009]. Epibiontic rotifers were represented by one species, noted in littoral of lake Bikcze (Tab. 2).

Species diversity of planktonic rotifers differed from species richness. Values of Shannon-Wiener index showed the highest values in lake Mytycze ($H = 2.1$ in littoral and $H = 1.8$ in pelagic zone). In lake Bikcze values of H index amounted 1.7 and 1.5, respectively and in lake Płotycze Shannon-Wiener index reached the lowest values, 0.8 (littoral) and 1.4 (pelagic zone). In general, planktonic rotifers showed higher species diversity in littoral than in pelagic zone (Tab. 2).

In the studied lakes were observed indicator species. The most numerously were represented indicators of eutrophic waters; their number ranged from 5 species in lake Płotycze to 8 species in lake Bikcze. Number of species did not differ between littoral and pelagic zone (Tab. 2). Indicators of oligotrophic waters were noted only in lake Bikcze, 1 (littoral) and 2 species (pelagic zone). In each of the studied lake was observed one indicator species of humic waters (Tab. 2).

Density and domination structure

The highest abundance of planktonic rotifers was noted in lakes Bikcze and Płotycze. In lake Bikcze mean density of rotifers ranged from 580 ind. · dm⁻³ (littoral) to 3410 ind. · dm⁻³ (pelagic zone); in lake Płotycze, number of individuals varied between 850 ind. · dm⁻³ (littoral) and 1460 ind. · dm⁻³ (pelagic zone). In lake Mytycze density of rotifers was lower and amounted from 275 to 399 ind. · dm⁻³ (Tab. 2). In all the studied lakes, planktonic rotifers showed significantly lower densities in littoral than in pelagic zone.

The group of dominants included common rotifer species, such as: *Keratella cochlearis*, *Polyarthra vulgaris* (lakes Bickcze and Mytycze), *Keratella quadrata* (lake Płotycze), *Keratella cochlearis tecta* (lakes Płotycze, Bickcze and Mytycze) and *Ascomorpha ovalia* (lake Bickcze) (Fig. 1). The classification of domination structure of rotifer assemblages as sustainable or non-sustainable was accepted according Łuczak and Wierzbowska [1981], Müller [1984] and Bielańska-Grajner [2005].

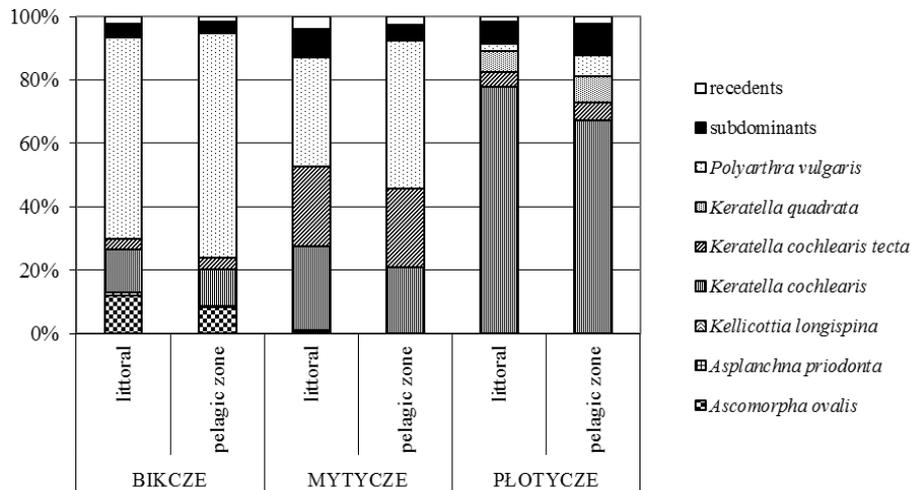


Fig. 1. Domination structure of planktonic rotifers of three eutrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

The assemblage is sustainable if it can be divided into three classes: dominants, subdominants and recedents, at least three species belong to the dominants and none of them does not exceed 45% of the total density. According to these criteria the domination structure of planktonic rotifers was sustainable only in lake Mytycze (Fig. 1). Sustainable domination structure can indicate higher ecological status of the lake and low trophy [Bielańskiej-Grajner 2005]. Although, high percentage of *Keratella cochlearis tecta* in lake Mytycze denies its high ecological status. The presence of this species, mostly its high share in *Keratella cochlearis* population is considered as indicator of eutrophic waters [Radwan *et al.* 2004, Karabin and Ejsmont-Karabin 1996].

Classification of rotifer assemblages

Cluster analysis of rotifer assemblages of lakes and zones led to classify them into two groups (Fig. 2). To the first group belong littoral and pelagic zones of lakes Płotycze and Mytycze. Inside the group, the highest similarity showed rotifer assemblages of littoral and pelagic zone of lake Mytycze (0.81), little lower rotifers of littoral and pelagic zone of lake Płotycze (0.78). Rotifer

assemblages of lakes Mytycze and Płotycze showed visibly lower similarity (0.46). To the second group belong littoral and pelagic zone of lake Bikcze. The similarity of rotifer assemblages between littoral and pelagic zone, expressed as value of Sorensen index, amounted 0.86 (Fig. 2).

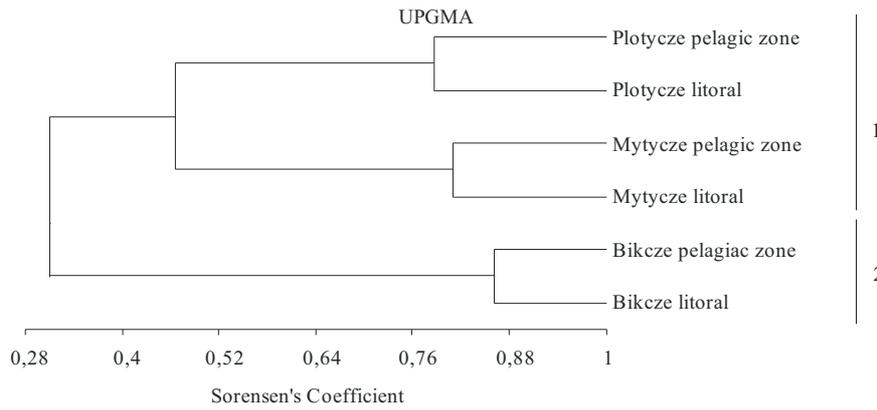


Fig. 2. Diagram of cluster analysis for planktonic rotifer assemblages of three eutrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

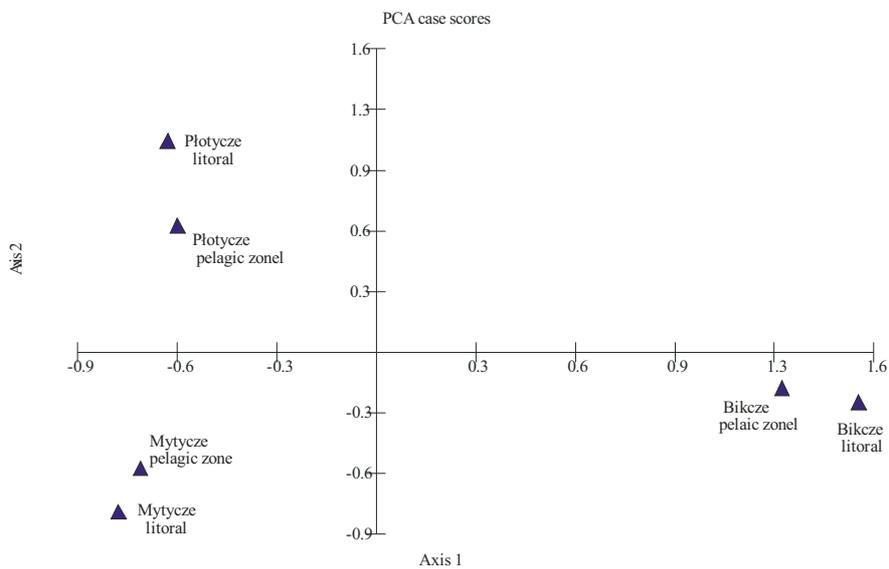


Fig. 3. PCA ordination plot for planktonic rotifer assemblages of three eutrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

The results of PCA analysis of rotifer assemblages confirms the results of cluster analysis and indicate higher similarity between rotifer assemblages inhabited littoral and pelagic zone of single lake than between lakes (Fig. 3). The PCA analysis also implies that rotifer assemblages of lake Bikcze show very low similarity to rotifer assemblages of two remaining eutrophic lakes. On the PCA diagram, Axis 1 explains 56.8% of total variance of rotifer density, Axis 2–25.8%.

CONCLUSIONS

1. In the studied lakes were noted 68 species of planktonic rotifers; 12 indicators of eutrophic waters, 2 indicators of oligotrophic waters and 1 indicator of humic waters.

2. In all the lakes and zones the most numerously were presented euplanktonic rotifers, lower abundances showed benthic-periphytic, periphytic and epibiontic species, that can indicate the influence of open water zone on species structure of rotifers in littoral.

3. Species richness and diversity were higher in littoral zone; while mean density of planktonic rotifers showed relatively higher values in pelagic zone.

4. The group of dominants included common rotifer species: *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *Polyartchra vulgaris*, *Kellicottia longispina*, *Asplanchna priodonta* and *Ascomorpha ovalia*. Only, in lake Mytycze the domination structure of rotifers was sustainable; the high percentage of the form *tecta* in *Keratella cochlearis* population indicate high trophy of the lake.

5. The highest faunistic similarity, based on planktonic rotifers, showed lakes Płotycze and Mytycze. High similarity of rotifer assemblages between littoral and pelagic zone indicate the possibility of mutual relationships between these zones and may create the extensive ecotone (littoral/pelagic zone) for zooplankton.

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WROTKI PLANKTONOWE TRZECH EUTROFICZNYCH JEZIOR POJEZIERZA ŁĘCZYŃSKO-WŁODAWSKIEGO (WSCHODNIA POLSKA)

Streszczenie. Bikcze, Mytycze i Płotycze należą do bardzo cennego przyrodniczo regionu Polski – Pojezierza Łęczyńsko-Włodawskiego. Są one płytkimi zbiornikami eutroficznymi o różnej powierzchni lustra wody, różnej powierzchni zlewni i różnej strukturze użytkowania zlewni. Wiosną, latem i jesienią 2007, 2008 i 2012 roku przeprowadzono w nich badania nad składem jakościowym i zagęszczeniem wrotków planktonowych. Badania te pozwoliły na stwierdzenie 68 gatunków *Rotifera* o średnim zagęszczeniu wahającym się w szerokim zakresie od 275 ind. · dm⁻³ w jeziorze Mytycze do 3410 ind. · dm⁻³ w jeziorze Bikcze. Wśród dominantów znalazły się pospolite gatunki: *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *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 *Keratella cochlearis* świadczy jednak o znacznej żyzności 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 Mytycze, jezioro Płotycze, jeziora eutroficzne, jeziora płytkie, wrotki planktonowe