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

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Summary. Planktonic rotifer assemblages were studied in three deep mesotrophic lakes of Łęczyńsko-Włodawskie Lakeland (Białe Włodawskie, Piaseczno and Rogoźno). 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 82 species of *Rotifera*. Mean density ranged from 210 ind. dm^{-3} in lake Białe to 1168 ind. dm^{-3} in lake Rogóźno. The rotifer assemblages were dominated by common species: *Polyartchra vulgaris, Keratella cochlearis, Synchaeta pectinata, Kellicottia longispina, Filinia longiseta* and *Brachionus angularis*. Sustainable domination structure and high species diversity of planktonic rotifers observed in lake Rogóźno indicate the highest ecological status of the lake in comparison to the remaining two lakes. Although high abundance of rotifers as well the high percentage of the form *tecta* in *Keratella cochlearis* population suggests high trophic status of the lake. The analysis of faunistic similarity of rotifer assemblages between studied lakes showed high similarity between littoral and pelagic zone within a single lake than between lakes and some variation of rotifer assemblages inhabiting different mesotrophic lakes.

Key words: lake Białe, lake Piaseczno, lake Rogoźno, mesotrophic 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 Białe Włodawskie, Piaseczno and Rogóźno represent the group of mesotrophic lakes, which area rarely represented in this region of Poland. The lakes differed in maximum depth and surface area. The studies of planktonic

rotifers were undertaken to recognize the species structure and abundance and to compare the rotifers communities between different zones of studied lakes.

STUDY AREA

Lakes Białe Włodawskie, Piaseczno and Rogoźno belong to one of the most valuable regions of Poland-Łęczyńsko-Włodawskie Lakeland [Chmielewski 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. The studied lakes are deep (maximum depth exceeds 25 m) and mesotrophic (Tab. 1). The lakes represent bream-whitefish fishery type [Harasimiuk 1998].

Table 1. Morphometric and hydrological characteristic of three mesotrophic 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
Białe	106.5	33.6	bream--whitefish	941.4	46% lake, 15% pastures, 7% arable lands, 32% others
Piaseczno	83.2	38.8	bream--whitefish	284.9	29% lake, 24% forests, 29% arable lands, 18% others
Rogóźno	52.2	25.4	bream--whitefish	774.8	6% lake, 37% forests, 38% arable lands, 19% others

The catchment area of the studied lakes ranged from 284.9 ha (lake Piaseczno) to 941.4 ha (lake Białe). In the structure of land use prevailed meadows and pastures, arable lands and forests (Tab. 1). All the lakes are used mainly for recreational purpose [Harasimiuk 1998].

MATERIAL AND METHODS

Studies were undertaken in spring, summer and autumn during the years 2007, 2008 and 2012 in three lakes of Łęczyńsko-Włodawskie Lakeland (Eastern Poland); lakes Białe Włodawskie, Piaseczno and Rogoźno. Each sampling date rotifers were collected in littoral and pelagic zone, in three replicates. Samples were collected by taken 10 cm^3 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 cm^3. 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 dm^3 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 Sörensen index and cluster analysis performed by MVSP-3.1. The similarity analysis was performed using UPGMA method (*Unweighted Pair-Group Method Using Arithmetic Avarages*). 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

1. Species richness, diversity and ecological structure

In the studied lakes total number of planktonic rotifer species amounted 82. In the littoral number of species varied between 19 (lake Rogóźno) and 32 species (lake Piaseczno). In the pelagic zone number of species was lower and ranged from 19 species (lake Rogóźno) to 32 species (lake Piaseczno) (Tab. 2). The highest species richness of planktonic rotifers was observed in lake Piaseczno and the lowest in mid-forest lake Rogóźno (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 lakes of high total species richness; but littoral and pelagic zone did not differ significantly in the number of euplanktonic species (Tab. 2). In lake Piaseczno the number of benthic-periphytic rotifer species was high and probably affected by well developed littoral zone. Such a relationship point out other studies [Bielańska-Grajner 1987, Radwan *et al.* 1988, Paleolog *et al*. 1997, Demetraki-Paleolog 2007]. In general bentic-periphytic species were observed mostly in littoral zone (Tab. 2). Number of periphytic rotifer species was the highest in lake Białe; epibiontic species were noted in littoral and pelagic zone of lake Białe (Tab. 2).

Species diversity of planktonic rotifers differed from species richness. Values of Shannon-Wiener index showed the highest values in lake Rogóźno (H = 2.4 in littoral and H = 2.5 in pelagic zone). In two remaining lakes, H index was lower and ranged from 1.8 in littoral of lake Piaseczno to 2.0 in pelagic zone of lake Białe (Tab. 2).

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

Specification	Białe		Piaseczno		Rogóźno	
	littoral	pelagic zone	littoral	pelagic zone	littoral	pelagic zone
Number of species	33	25	35	32	19	19
Euplanktonic	17	16	19	21	15	16
Benthic-periphytic	10	5	14	9	2	1
Periphytic	5	3	2	2	2	2
Epibiontic	1	1	0	0	0	0
Indicators of eutrophic waters	6	7	6	5	7	7
Indicators of oligotrophic waters	5	5	5	5	4	3
Indicators of humic waters	1	1	1	1	1	1
Shannon-Wiener index	1.9	2.0	1.8	1.9	2.4	2.5
Density, ind. dm^{-3}	210	670	270	295	1050	1168

In all of the studied lakes were observed indicatory species. Although the lakes are mesotrophic the most numerously were represented indicators of eutrophic waters; their number ranged from 5 to 7 species (Tab. 2). In littoral and pelagic zones of lakes Piaseczno and Białe) were observed 5 indicators of oligotrophic waters; in lake Rogóźna number of this indicatory species was little lower and amounted 3 (littoral) and 4 species (pelagic zone) (Tab. 2).

2. Density and domination structure

The highest abundance of planktonic rotifers was noted in lake Rogóźno; mean density ranged from 1050 ind. dm^{-3} (littoral) to 1168 ind. dm^{-3} (pelagic zone). In two remaining lakes, Białe and Piaseczno density of planktonic rotifers was 2 or 3-times lower and varied between 210 ind. dm^{-3} and 295 ind. dm^{-3}, only in pelagic zone of lake Białe, rotifers density reached 670 ind. dm^{-3} (Tab. 2). Lakes Rogóżno and Piaseczno as well Rogóźno and Białe differ significantly in total density of planktonic rotifers. Significant differences between littoral and pelagic zone were observed only in lake Białe.

In all the studied lakes dominated common rotifer species, *Polyartchra vulgaris* and *Keratella cochlearis*. In addition to the dominants in lake Rogóźno belonged *Synchaeta pectinata*; in pelagic zone of lake Białe, *Kellicottia longispina* and in lake Rogóźno *Filinia longiseta* and *Brachionus angularis* (Fig. 1).

Rotifer assemblages were classified according Łuczak and Wierzbowska [1981], Müller [1984] and Bielańska-Grajner [2005] as assemblages with sustainable or

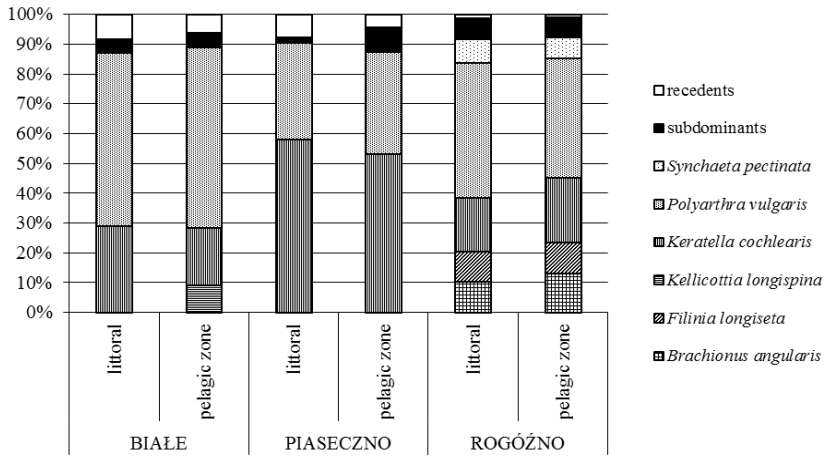

Fig. 1. Domination structure of planktonic rotifers of three mesotrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

non-sustainable domination structure. 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 Rogóźno; in two remaining lakes [Radwan 1973, Harasimiuk 1998] although their mesotrophic status, domination structure of rotifer assemblages was non-sustainable (Fig. 1). The mesotrophic status of the studied lakes confirm the low percentage of the form *tecta* in *Keratella cochlearis* population. The high relevance of this indicator in different lake types pointed Radwan *et al.* [2004].

3. Classification of rotifer assemblages

Cluster analysis of rotifer assemblages separated studied lakes into two groups. The first group included rotifer assemblages of littoral and pelagic zones of lakes Białe and Rogóźno (Fig. 2). Within this group, the highest similarity showed rotifer assemblages of littoral and pelagic zone of lake Rogóźno (0.92), little lower rotifers of littoral and pelagic zone of lake Białe (0.82). Rotifer assemblages of lakes Rogóźno and Białe showed lower similarity (0.54) than rotifers inhabiting different zones within the lakes. To the second group belong rotifer assemblages of littoral and pelagic zone of lake Piaseczno. Similarity of rotifer assemblages between littoral and pelagic zone, express as value of Sorensen index amounted 0.88. The faunistic similarity of rotifer assemblages between studied lakes was lower than between zones within the lakes (Fig 2). The high faunistic similarity between littoral and pelagic zone was positively related to the lower surface area of lake.

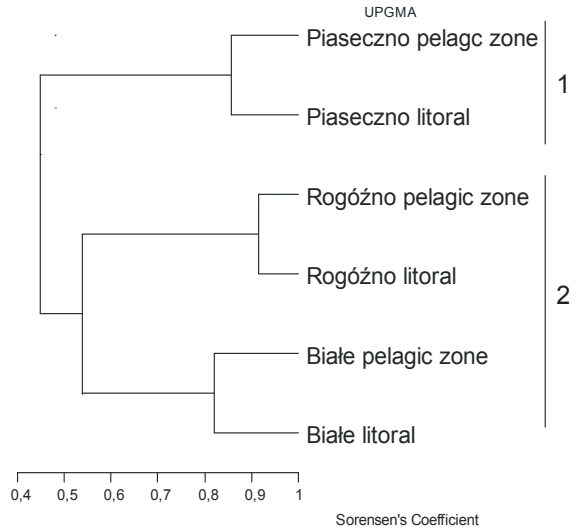

Fig. 2. Diagram of cluster analysis for planktonic rotifer assemblages of three mesotrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

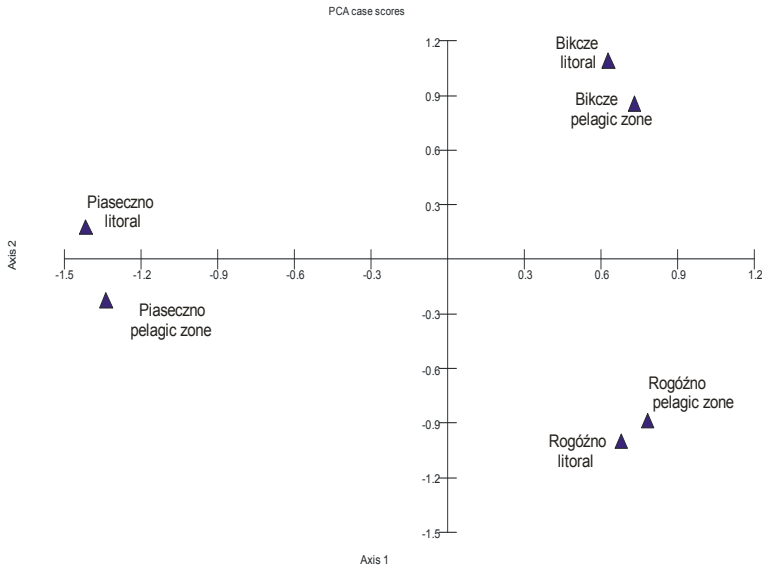

Fig. 3. PCA ordination plot for planktonic rotifer assemblages of three mesotrophic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007, 2008 and 2012

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 within the lake than between lakes (Fig. 3).

The PCA analysis also implies that rotifer assemblages of lakes Białe and Rogóźno showed the highest similarity. On the ordination plot, Axis 1 explained 50% of total variance of rotifer density, Axis 2 – 31%. This configuration of similarities confirms the possibility of strong interaction of rotifer assemblages between littoral and pelagic zone within the lake.

CONCLUSIONS

1. In the studied lakes were noted 82 species of planktonic rotifers; 10 indicators of eutrophic waters, 6 indicators of oligotrophic waters and 1 indicator of humic waters.

2. Advantage of euplanktonic rotifer species on benthic-periphytic, periphytic and epibiontic species can indicate the influence of open water zone on the species structure of littoral rotifers

3. Species richness of planktonic rotifers was usually higher in littoral, while higher species diversity showed visibly higher values in pelagic zone.

4. The group of dominants included common rotifer species: *Polyarthra vulgaris*, *Keratella cochlearis*, *Synchaeta pectinata*, *Kellicottia longispina*, *Filinia longiseta* and *Brachionus angularis*. The domination structure in lake Rogóźno differed from other two lakes indicates higher ecological status of this lake.

5. There was observed the strong resemblance between rotifer assemblages inhabiting different Jones within the lake. The similarity has grown with decreasing surface of the lake. Higher dissimilarities were noted between the lakes. This may indicate the interactions between littoral and pelagic rotifer assemblages.

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

Streszczenie. Jeziora: Białe Włodawskie, Piaseczno i Rogóźno należą do jednego z najcenniejszych przyrodniczo regionów Polski – Pojezierza Łęczyńsko-Włodawskiego. Są one zbiornikami mezotroficznymi o różnej powierzchni lustra wody, różnej powierzchni zlewni, różnej głębokości i różnym użytkowaniu zlewni. Wiosną, latem i jesienią 2007, 2008 i 2012 r. przeprowadzono w nich badania nad składem jakościowym i zagęszczeniem wrotków planktonowych. Badania te pozwoliły na stwierdzenie 82 gatunków *Rotifera* w średnim zagęszczeniu wahającym się od 210 ind. dm^{-3} w Jeziorze Białym do 1168 ind. dm^{-3} w jeziorze Rogóźno. Wśród dominantów znalazły się pospolite gatunki: *Polyarthra vulgaris*, *Keratella cochlearis*, *Synchaeta pectinata*, *Kellicottia longispina*, *Filinia longiseta* i *Brachionus angularis*. Zrównoważona struktura dominacji oraz wysoka różnorodność gatunkowa w jeziorze Rogóźno wskazują na wyższy status ekologiczny tego zbiornika w porównaniu z pozostałymi jeziorami. Jednak duże zagęszczenia wrotków i zwiększony udział formy *tecta* w populacji *Keratelli cochlearis* mogą wskazywać na wzrastającą żyzność jego wód. Badania podobieństw faunistycznych poszczególnych stref i jezior wskazują na duże podobieństwa pomiędzy zgrupowaniami wrotków zasiedlających różne strefy jednego jeziora i na pewne zróżnicowanie zgrupowań wrotków zasiedlających różne jeziora mezotroficzne.

Słowa kluczowe: Jezioro Białe, jezioro Piaseczno, jezioro Rogóźno, jeziora mezotroficzne, wrotki planktonowe