Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2008, 5, 58–66

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

Andrzej Demetraki-Paleolog

Department of Hydrobiology, University of Life Sciences in Lublin,
B. Dobrzańskiego str. 37, 20–262 Lublin, daga@pro.onet.pl

Summary. Lakes: Białe Włodawskie, Uściwierz, Piaseczno and Rogóźno are situated in the area of Łęczyńsko-Włodawskie Lakeland, one of the most nature valuable regions of Poland. The lakes are dimictic, and differ in the maximum depth, surface and catchment areas and structure of land use. The species composition and density of planktonic rotifers of the lakes were investigated in spring, summer and autumn of 2007 and 2008. The studies showed the occurrence of 75 *Rotifera* species; the mean density ranged from 191 ind. dm^{-3} in Lake Białe Włodawskie to 1068 ind. dm^{-3} in Lake Rogóźno. The group of dominants included common species: *Polyarthra vulgaris*, *Keratella cochlearis*, S*ynchaeta pectinata*, *Kellicottia longispina*, *Filinia longiseta* and *Brachionus angularis*. The sustainable domination structure and high species diversity in Lake Rogóźno indicate a higher ecological status of the lake in comparison to the other reservoirs, although high densities of rotifers together with high share of *Keratella cochlearis* f. tecta can indicate the rising fertility of the lake. The studies of faunistic similarity between particular zones and lakes showed high similarity between rotifer communities within one lake and differentiation of rotifer communities among dimictic lakes.

Key words: dimictic lakes, planktonic rotifers, lakes: Białe Włodawskie, Uściwierz, Piaseczno, Rogóźno

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: Białe Włodawskie, Uściwierz, Piaseczno and Rogóźno represent the group of dimictic lakes, which are rarely represented in this region of Poland.

The lakes differ in maximum depth and surface area. The studies of planktonic rotifers were undertaken to identify the species structure and abundance and to compare the rotifer communities between different zones of studied lakes.

STUDY AREA

Lakes: Białe Włodawskie, Uściwierz, Piaseczno and Rogóźno are situated in the area of Łęczyńsko-Włodawskie Lakeland, one of the most nature valuable regions of Poland [Chmielewski (ed.) 2006]. The whole region in characterised

Table 1. Selected features of four dimictic 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 catchment area
Białe	106.5	33.6	mesotrophic	bream--whitefish	941.38	46% lake, 15% pastures, 7% arable lands, 32% others
Piaseczno	83.2	38.8	mesotrophic	bream--whitefish	284.88	29% lake, 24% forests, 29% arable lands, 18% others
Rogóźno	52.2	25.4	mesotrophic	bream--whitefish	774.79	6% lake, 37% forests, 38% arable lands, 19% others
Uściwierz	256.3	6.6	eutrophic	bream--zander	532.30	48% lake, 38% pastures, 12% arable lands, 2% others

by high naturalness. On the area is situated Poleski National Park, 3 landscape parks, 7 areas of NATURA 2000 and 12 nature reserves. The region has the status of a UNESCO Biosphere Reserve. Studied dimictic lakes are rarely distributed on this area. Except for Lake Uściwierz the maximum depth exceeded 25 m (Tab. 1). The shallowest (max. depth 6.6 m) Uściwierz is classified as eutrophic, bream-zander fishery type. The remaining lakes are mesotrophic, bream-whitefish fishery type [Harasimiuk *et al.* 1998]. The catchment area of studied lakes ranged from 284.88 ha (Lake Piaseczno) up to 941.38 ha (Lake Białe Włodawskie). The structure of land use is dominated by pastures, arable lands and forests (Tab. 1). Lakes: Białe Włodawskie, Piaseczno and Rogóźno are used for the recreational purpose, Lake Uściwierz is used for fishery [Harasi-

miuk *et al*. 1998].

MATERIAL AND METHODS

Samples were taken in spring, summer and autumn during the years 2007–2008 from four lakes of Łęczyńsko-Włodawskie Lakeland (Eastern Poland): Białe Włodawskie, Uściwierz, Piaseczno and Rogóźno. Each time three zooplankton samples were taken in littoral zone and in the zone of open water. Samples were collected by taking 10 cm^3 of water using the sampler „Toń II" from the depth of 0 to 1 m. The water was sieved through a planktonic net No. 25 and condensed to constant volume of 100 cm^3. Samples were preserved with Lugol 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 dm^3 of water. The normal distribution of the data was checked by Shapiro-Wilk test. The significance of differences in rotifer densities between particular lakes and zones was verified using non-parametric rang test of Kruskal-Wallis using SAS Programme [2001]. The similarity of rotifer communities in particular zones and lakes were estimated using Sörensen index and cluster analysis performed by MVSP-3.1. The analysis of similarities were done using UPGMA method. The effect of dominating species on the similarity of rotifer communities were estimated using PCA analysis using MVSP-3,1 programme. The 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 particular ecological groups [Radwan 1973].

RESULTS AND DISCUSSION

Species structure

In four lakes during the two-year studies a total of 75 rotifer species were noted. The total number of species in the littoral zone ranged from 18 in Lake Rogóźno to 53 in Lake Uściwierz. In the zone of open water the number of rotifer species was lower and ranged from 17 (Lake Rogóźno) to 43 (Lake Uściwierz). The highest species diversity was observed in Lake Uściwierz, characterised by dense well developed macrophyte stands. In both deep mesotrophic lakes Piaseczno and Białe, intensively used for recreational purposes, species diversity of rotifers was lower. In lake Rogóźno, surrounded by forests, the species diversity reached the lowest values (Tab. 2).

Studied lakes were inhabited by four ecological groups of planktonic rotifers: the most numerous were euplanktonic species, less numerous were benthic-periphytic, periphytic and epibiontic species. The higher number of euplanktonic forms was noted in lakes characterised by higher species diversity; the littoral

and open water zone did not differ much in terms of the occurrence of that eco-

Table 2. Ecological characteristic of planktonic rotifer communities of four dimictic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007–2008

Lakes	Białe		Piaseczno		Rogóźno		Uściwierz	
Features	littoral	pelagic zone	littoral	pelagic zone	littoral	pelagic zone	littoral	pelagic zone
Number of species	31	25	33	30	18	17	53	43
Euplanktonic	17	16	19	19	15	14	23	20
Benthic-periphytic	9	5	13	9	1	1	22	17
Periphytic	4	3	1	2	2	2	6	5
Epibiontic	1	1	0	0	0	0	2	1
Indicator of eutrophic waters	6	6	4	5	7	7	4	4
Indicator of oligotrophic waters	4	4	4	4	3	2	3	3
Indicator of dystrophic waters	1	1	1	1	1	1	1	1
Shannon index	1.827	1.974	1.7044	1.8448	2.3751	2.4166	1.5641	1.7434
Density, ind. dm^{-3}	190.92	655.75	276.75	257.08	963.5	1068	763.95	493.56

logical group. The number of periphytic-benthic species was lower in lakes of high total species diversity. A lower number of this form was observed in lake Piaseczno in comparison to Lake Białe, which can be explained by better development of littoral zone in lake Piaseczno. Such a regularity was observed by other authors [Bielańska-Grajner 1987, Radwan *et al*. 1988, Paleolog *et al.* 1997]. The number of periphytic-benthic species was higher in the littoral zone than in the zone of open water, except for Lake Rogóźno where the number of periphytic-benthic species reached similar numbers in both studied zones (Tab. 2). Periphytic species occurred in the highest numbers in densely vegetated Lake Uściwierz, lower numbers were observed in Lake Białe. The periphytic species in the remaining lakes were poorly represented. The number of periphytic species did not differed visibly between studied zones. Only single epibiontic species were noted in the littoral and open water zone in lakes Uściwierz and Białe (Tab. 2).

In four studied lakes no rare rotifers species of Polish fauna were noted, only indicatory species. Although three of the studied lakes are classified as mesotrophic (Tab. 1), eutrophobiontic species occurred to be the most numerous. In lakes Białe and Rogóźno their number reached 6 and 7, in Lake Piaseczno and in the eutrophic Lake Uściwierz – 4 and 5. The number of indicatory species for eutrophic waters did not differ visibly between the zone of open water and littoral (Tab. 2). In lakes Białe and Piaseczno 4 indicatory species of oligotrophic waters were noted, in the remaining lakes their number ranged from 2 to 3. Number of indicatory species for oligotrophic water similarly to the previous group of species, didn't show visible differences between zone of open

water and littoral (Tab. 2).

Density and relative abundances

The highest densities of planktonic rotifers were noted in mesotrophic Lake Rogóźno; values ranged from 963 ind. dm^{-3} in the littoral to 1068 ind. dm^{-3} in the zone of open water. Much lower densities were observed in eutrophic Lake Uściwierz. In lakes Białe and Piaseczno the densities amounted to nearly 200 ind. dm^{-3}, only in the pelagic zone of Lake Białe rotifers density reached 655 ind. dm^{-3} (Tab. 2). Observed differences between lakes were significant, with the exception of lakes Białe and Piaseczno. The densities of planktonic rotifers in the zone of open water and littoral depended on the lake. In lakes Piaseczno and Rogóźno densities of rotifers did not differ significantly between studied zones. In Lake Białe rotifers densities in the pelagic zone were significantly higher than in the littoral. In Lake Uściwierz the density reached significantly lower values in the open water zone.

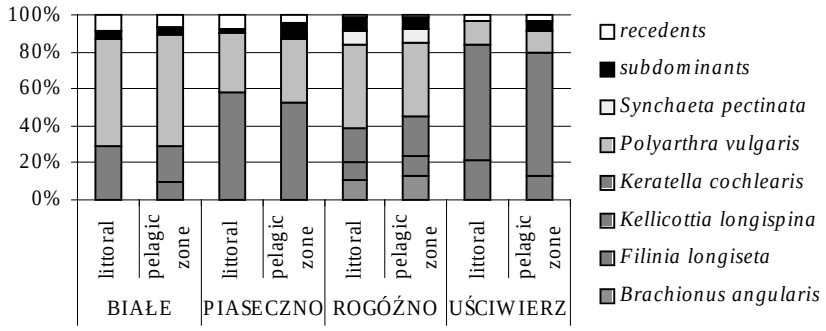

Fig. 1. Relative abundances of particular rotifers species of four dimictic lakes of Łęczyńsko--Włodawskie Lakeland during the years 2007–2008

In all studied lakes and zones common rotifers species dominated: *Polyarthra vulgaris* and *Keratella cochlearis*. Additionally, in Lake Rogóźno the group of dominants included *Synchaeta pectinata*, in lakes Uściwierz and Białe – *Kellicotia longispina,* and in Lake Rogóźno – *Filinia longiseta* and *Brachionus angularis* (Fig. 1). Rotifer communities were classified according to Łuczak and Wierzbowska [1981], Müller [1984] and Bielańska-Grajner [2005], in the sustainable and non-sustainable domination structures. The Authors classified the community as sustainable when three domination classes {dominants, subdominants and recedents) could be distinguished, at least three species belonged to the dominants, and none of them exceeded 45% in the total density. Classification under such criteria showed sustainable domination structure of planktonic rotifers only in the littoral and open water zone of Lake Rogóźno. In the remaining lakes, which are classified as mesotrophic [Radwan 1973, Harasimiuk *et al*.

1998], rotifer communities were non-sustainable (Fig. 1). The low fertility of studied lakes is confirmed by low densities or lack of usually dominating population of *Keratella cochlearis* f. tecta. Radwan *et al*. [2004] stressed high importance of that index in different water types.

Classification of rotifer communities

Cluster analysis of planktonic rotifer communities in the four lakes, based on species structure of these organisms, led to a division of the studied lakes into two groups (Fig. 2). The first group included lakes Uściwierz and Piaseczno.

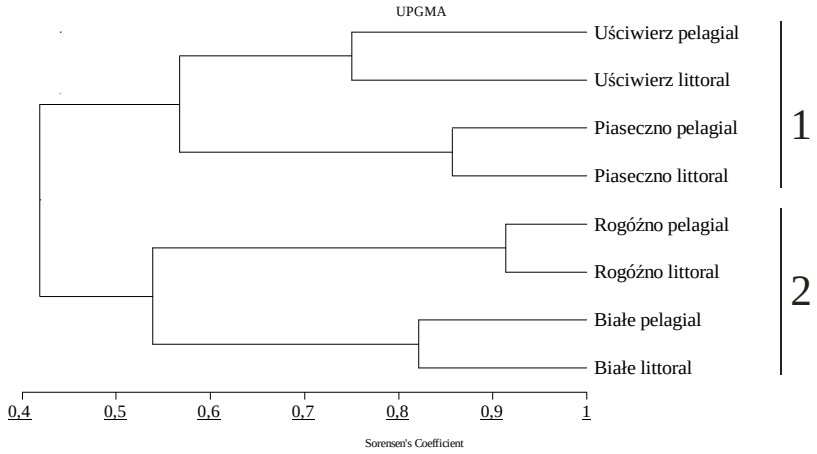

Fig. 2. Structure of similarity of rotifer communities based on species structure of rotifers of four dimictic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007–2008

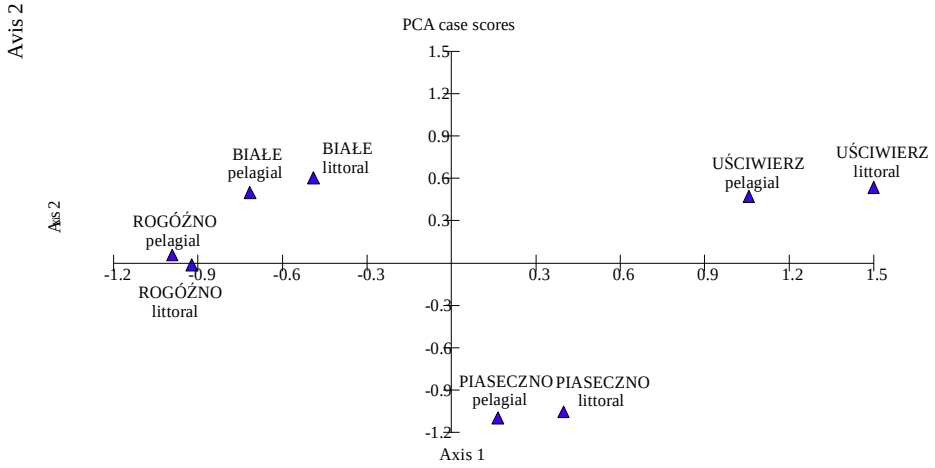

Fig. 3. PCA analysis of planktonic rotifer communities based on species structure of rotifers

of four dimictic lakes of Łęczyńsko-Włodawskie Lakeland during the years 2007–2008

The highest similarity (0.86) of rotifer communities was found between the littoral and pelagic zone of Lake Piaseczno, the similarity index for the littoral and open water zone in lake Uściwierz amounted to 0.75. Rotifer communities inhabiting lakes Uściwierz and Piaseczno showed lower similarity (0.58) than communities living within particular lakes. The second group included lakes Rogóźno and Białe. The highest similarity (0.92) was showed by rotifer communities inhabiting the littoral and pelagic zone of Lake Rogóźno; in Lake Białe the similarity index reached the value of 0.82. The rotifer communities in Lakes Rogóźno and Białe showed lower similarity index (0.54) than communities inhabiting different zones within these lakes. The rotifer communities inhabiting lakes Uściwierz and Piaseczno differed visibly from the communities living in two remaining lakes (0.42) – Fig. 2.

The PCA analysis of rotifer communities in the four dimictic lakes confirmed the results obtained in cluster method and showed higher similarity of rotifer communities inhabiting different zones within one lake than between lakes (Fig. 3). The rotifer communities in lakes Białe and Rogóźno showed higher similarity than in two remaining lakes. Axis I explained 40.76% of rotifers variability, Axis 2–22.84%. The results indicate high mutual influence of planktonic rotifers of littoral and open water zones within one lake.

CONCLUSIONS

1. In four lakes were noted 75 species of planktonic rotifers. 10 species were classified as indicators of eutrophic waters, 4 typical for oligotrophic lakes and 1 indicatory species of dystrophic waters.
2. In all studied lakes euplanktonic species dominated, the other ecological groups – benthic-periphytic, periphytic and epibiontic species – were less abundant. The results indicate strong influence of the zone of open water on the species structure of rotifers in all lake zones.
3. Species richness of planktonic rotifers was higher in the littoral than in open water, species diversity showed higher values in pelagic zone, mean densities of planktonic rotifers ranged from 191 ind. dm^{-3} up to 1068 ind. dm^{-3} dependently on the zone and lake.
4. The group of dominants included common rotifers species: *Polyarthra vulgaris*, *Keratella cochlearis*, *Synchaeta pectinata*, *Kellicottia longispina*, *Filinia longiseta* and *Brachionus angularis*. The domination structure in Lake Rogóźno differed from the other lakes, indicating higher ecological status of the lake.
5. Rotifer communities inhabiting the littoral and open water zone within particular lakes showed higher similarity than communities between

studied lakes. It can indicate high mutual influence of rotifer communities in the zone of littoral and open water within one lake.

REFERENCES

Bielańska-Grajner I., 1987. Comparison of rotifer communities in different types of reservoirs of Upper Silesia (in Polish). Przeg. Zool., 31, 37–47.

Bielańska-Grajner I., 2005. Psammon rotifers (Rotifera) of selected reservoirs of Poland (in Polish). Wyd. Uniw. Śląski, 1–114.

Chmielewski T. (ed.), 2006. Improvement of ecological status and optimisation of recreational use of catchment of lakes Miejskie – Kleszczów as a pilot study for implementation on the post-lakes areas of Euroregion Bug. Programme of ecological cooperation PHARE – Fund of Small Projects (in Polish). Wyd. Gmina Ostrów – Tow. Ziemi Ostrowa Lub., Akapit S.C., 16–17.

Demetraki-Paleolog A., 2007. Planktonic rotifers (*Rotifera*) of the rivers of west Lubelszczyzna (in Polish). WAR Lublin, Rozprawy Naukowe, 317, 1–224.

Harasimiuk M., Michalczyk Z., Turczyński M., 1998. Lakes of Łęczna-Włodawa District – ecological monograph (in Polish). Wyd. UMCS, 1–176.

Karabin A., 1985. Pelagic zooplankton (Rotatoria + Crustacea) variation in the process of lake eutrophication. I. Structural and quantitative features. Ekol. Pol. 33, 567–616.

Łuczak J., Wierzbowska T., 1981. Methods of zoocoenological analysis (in Polish) [in:] M. Górny, L. Grüm (eds). Methods in soil zoology. PWN, Warsaw, 417–436.

Müller H.J., 1984. Ökologie. Gustav Fischer Verlag. Jena, 1–195.

Paleolog A., Radwan S., Kowalik W., Kowalczyk C., Stryjecki R., Zwolski W., 1997. Water invertebrates of „Lasy Janowskie" Landscape Park (in Polish) [in:] Natural environment of „Lasy Janowskie" Landscape Park. Wyd. UMCS, Lublin, 83–227, 1064–X, 117–133.

Radwan S., 1973. Pelagic rotifers of lakes of Łęczyńsko-Włodawskie Lakeland. Faunistic and ecological study (in Polish). Skrót rozprawy habilitacyjnej. AR, Ser. Rozpr. Hab., 8, 1–57.

Radwan S., Jarzynowa B., Zwolski W., Girsztowtt K., Kowalczyk C., Kowalik W., Paleolog A., 1988: Ecological characteristic of upper and middle courses of Bystrzyca Lubelska River, its tributaries and Zemborzycki Reservoir (in Polish). Roczn. Nauk. PZW, t. 1, Warszawa, 123–156.

Radwan S., Bielańska-Grajner I., Ejsmont-Karabin J., 2004. Rotifers (Rotifera). Fauna of freshwaters in Poland (in Polish). 32. Polish Hydrobiological Society, University of Łódź. Oficyna Wydawnicza Tercja, Łódź, 1–146.

Shannon C.E., Wiener W., 1963. The mathematical theory of communication. University of Illinois Press Urban, 1–117.

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

Streszczenie. Jeziora: Białe Włodawskie, Uściwierz, Piaseczno i Rogóźno należą do jednego z najcenniejszych przyrodniczo regionów Polski – Pojezierza Łęczyńsko-Włodawskiego. Są one zbiornikami dimiktycznymi o różnej powierzchni lustra wody, różnej powierzchni zlewni, różnej głębokości i różnym użytkowaniu. Wiosenną, latem i jesienią 2007 i 2008 roku przeprowadzono w nich badania nad składem jakościowym i zagęszczeniem wrotków planktonowych. Badania te po-

zwoliły na stwierdzenie 75 gatunków *Rotifera* w średnim zagęszczeniu wahającym się od 191 ind. dm^{-3} w jez. Białym do 1068 ind. dm^{-3} w jez. 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 jez. Rogóźno wskazują na wyższy status ekologiczny tego zbiornika w porównaniu z pozostałymi jeziorami. Duże jednak zagęszczenia wrotków i podwyższony 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 dimiktyczne.

Słowa kluczowe: jeziora dimiktyczne, wrotki planktonowe, jeziora: Białe Włodawskie, Uściwierz, Piaseczno, Rogóźno