Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2012, 9, 44–57

LONG TERM CHANGES OF PLANKTONIC ROTIFERS OF TEN LAKES OF DIFFERENT TROPHIC STATUS

Andrzej Demetraki-Paleolog

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

Summary. Studies of planktonic rotifers were conducted in ten lakes situated on the area of Łęczyńsko-Włodawskie Lakeland. The lakes differ in trophic status and represent mesotrophic lakes, big eutrophic lakes, scattered eutrophic lakes, dystrophic lakes and lakes transformed into retention reservoirs. In total, in the studied lakes were noted 90 species of planktonic rotifers, including 13 indicatory species of eutrophic waters and 6 indicatory species of oligotrophic or humic waters. The studies involved species diversity of rotifers, density, domination structure and its sustainability. The group of dominants constituted of common rotifer species: *Keratella cochlearis, Polyarthra vulgaris, Kellicottia longispina, Asplanchna priodonta, Synchaeta pectinata, Keratella quadrata, Keratella cochlearis* f. tecta*, Filinia longiseta, Brachionus angularis* and *Ascomorpha odalis*. Rotifer assemblages showed high faunistic similarity (from 36 to 60%) among the studied lakes. In the paper, were also studied changes of planktonic rotifers structure throughout the last forty years. The results of long-term studies showed that species richness of planktonic rotifers raised and the number of indicatory species of oligotrophic, eutrophic and humic waters visibly increased.

Key words: lakes, planktonic rotifers, Łęczyńsko-Włodawskie Lakeland

INTRODUCTION

Rotifers inhabiting lake ecosystems constitute an important component of small zooplankton. These organisms show a wide food spectrum, including detritivorous, algivorous, omnivorous species as well predators [Gliwicz 1974]. As a consumers of bacteria, algae and protozoa, rotifers may control the abundance of these microorganisms and play a key role in planktonic food web in lakes [Radwan 1973]. Some rotifer species are good indicators of trophic status of water ecosystems [Karabin 1985, Radwan *et al.* 1988, Paleolog *et al.* 1997]. The detailed information about the presence or absence of relict, rare and invasive species in rotifer communities may be successfully used as a tool in evaluation of ecological status and biodiversity of water ecosystems [Radwan *et al.* 2004].

The present studies were performed in ten markedly different lakes of Łęczyńsko-Włodawskie Lakeland, such as mesotrophic lakes, big eutrophic lakes, scattered eutrophic lakes, dystrophic lakes and lakes transformed into retention reservoirs. Studies were undertaken to evaluate the actual structure of rotifer communities in lakes of different trophic status and to describe the changes in rotifer biocenosis which have occurred over the last few decades.

MATERIAL AND METHODS

Samples were collected in spring, summer and autumn of 2007 and 2008 from ten lakes of Łęczyńsko-Włodawskie Lakeland (eastern Poland); mesotrophic lakes (Piseczno, Białe Włodawskie), big eutrophic lakes (Kleszczów, Uściwierz), scattered eutrophic lakes (Płotycze Ursz., Rogóźno Włod.), dystrophic lakes (Brzeziczno, Moszne) and lakes transformed into retention reservoirs (Mytycze, Bikcze). Each time samples of planktonic rotifers were collected from littoral and pelagic zone. One sample consisted of 10 dm^3 of water taken at the depth of 0–1 m. Collected water was sieved through the planktonic sieve no. 25 and condensed to the constant volume of 100 cm^3. Next the samples were fixed with Lugol's iodine and 4% formaldehyde with glycerin. Collected rotifers were counted and identified under inverted microscope. Number of individuals was calculated per 1 dm^3 of water.

Test of Shapiro-Wilk was used to verify the normal distribution of collected data. The differences of rotifer densities between studied lakes were verified by means of non-parametric ANOVA (test of Kruskal-Wallis). Statistical analysis were performed using SAS programme [SAS Institute Inc. 2001]. Similarity of rotifer assemblages between lakes was determined by clustering method and calculation of Sörensen coefficient using Multi Variate Statistical Package – MVSP-3,1. The analysis of similarity was performed using UPGMA method (Unweighted Pair-Group Method Using Arithmetic Averages).

For all identified rotifer species were calculated domination coefficient. As a dominants were classified species which relative abundances were equal or higher than 7%; as subdominants species which relative abundance ranged between 1.1 to 6.9% and as recedents species which relative abundance amounted 1% or less. Sustainability of domination structure of rotifer assemblages was evaluated based on relative abundances of rotifer species [Bielańska-Grajner 2005]. Additionally for all rotifer assemblages were calculated Shannon-Wiener index of species diversity [Shannon and Wiener 1963]. Rare or indicatory rotifer species were identified after Radwan [1973], Karabin [1985] and Eismont-Karabin *et al.* [2004]. Changes in rotifer assemblages which have been occurred over last few decades were evaluated by comparing the data obtained in the years 2007–2008 with results of Radwan from the years 1966 and 1967 [Radwan 1973, 1976].

RESULTS AND DISCUSSION

In total, in ten lakes, during two year studies were noted 90 species of planktonic rotifers. Number of species ranged from 17 species in scattered eutrophic Lake Płotycze Ursz. to 60 species in big eutrophic Lake Uściwierz (Tab. 1). In other eutrophic lakes number of rotifer species varied from 17 to 19. In retention reservoirs number of species was visibly higher and amounted from 22 to 33; in mesotrophic lakes were observed 33 and 36 rotifer species (Tab. 1).

Species diversity of planktonic rotifers showed the highest values (H` index = 2.4) in dystrophic Lake Brzeziczno, scattered eutrophic Lake Rogóźno Włod. and in retention reservoir Mytycze (H = 2.16) (Tab. 1). In mesotrophic lakes values of Shannon-Wiener index were lower and varied from 1.81 to 1.89. The lowest species diversity of planktonic rotifers was observed in other eutrophic lakes and dystrophic Lake Moszne; H index ranged from 1.39 to 1.75 (Tab. 1).

In studied lakes were noted 4 rare rotifer species; all the species were observed in big eutrophic Lake Uściwierz, 2 of rare species were noted in scattered eutrophic Lake Płotycze Ursz. and 1 rare species was found in mesotrophic Lake Piaseczno (Tab. 1).

In studied ecosystems were also observed indicatory species, mostly indicators of eutrophic waters, which amounted 13 species. The lowest number of indicatory species of eutrophic waters (two species) was observed in dystrophic lakes and in macrophyte dominated eutrophic Lake Kleszczów – three species (Tab. 1). Five indicatory species of eutrophic waters was noted in mesotrophic Lake Piaseczno and eutrophic lakes Płotycze Ursz. and Uściwierz. In other lakes (Białe Włod., Rogóźno Włod., Mytycze and Bikcze), number of indicatory species of eutrophic waters was the highest and ranged from 6 to 7 species. The results suggest the strongest eutrophication of these four lakes. The group of indicatory species of oligotrophic and humic waters was represented by 6 species (Tab. 1). The highest, 5 indicatory species was observed in mesotrophic lakes (Białe Włod., Piaseczno); 4 indicatory species in eutrophic lakes (Kleszczów, Uściwierz), dystrophic lake Moszne and scattered eutrophic Lake Rogóźno Włod. High number of indicatory species of oligotrophic waters and high value of Shannon-Wiener index observed in Lake Rogóźno are not typical for scattered lakes and suggest higher ecological status of the lake. In eutrophic Lake Bikcze and dystrophic Lake Brzeziczno were noted respectively 2 and 3 indicatory species for oligotrophic and humic waters; in scattered eutrophic Lake Płotycze Ursz. and retention reservoir Mytycze was found only 1 indicatory species.

The highest mean density of rotifers, for 1016 ind. dm^{-3} to 1178 ind. dm^{-3} was observed in small, scattered eutrophic lakes Rogóźno Włod. and Płotycze Ursz. (Tab. 1). In big eutrophic lakes and retention reservoirs mean abundances showed much lower values and varied from 312 ind. dm^{-3} to 730 ind. dm^{-3}. The lowest densities of planktonic rotifers were noted in mesotrophic and dystrophic lakes; from 103 ind. dm^{-3} to 267 ind. dm^{-3} (Tab. 1). Mean abundances of rotifers

in scattered eutrophic lakes were significantly higher than in remaining lakes. Differences between mean abundances of rotifers in dystrophic and mesotrophic lakes were not significant. In all the studied lakes, common rotifer species belong to the group of dominants: *Keratella cochlearis, Polyarthra vulgaris, Kellicottia longispina, Asplanchna priodonta, Synchaeta pectinata, Keratella quadrata, Keratella cochlearis* f. tecta*, Filinia longiseta, Brachionus angulari* and *Ascomorpha ovalis* (Fig. 1).

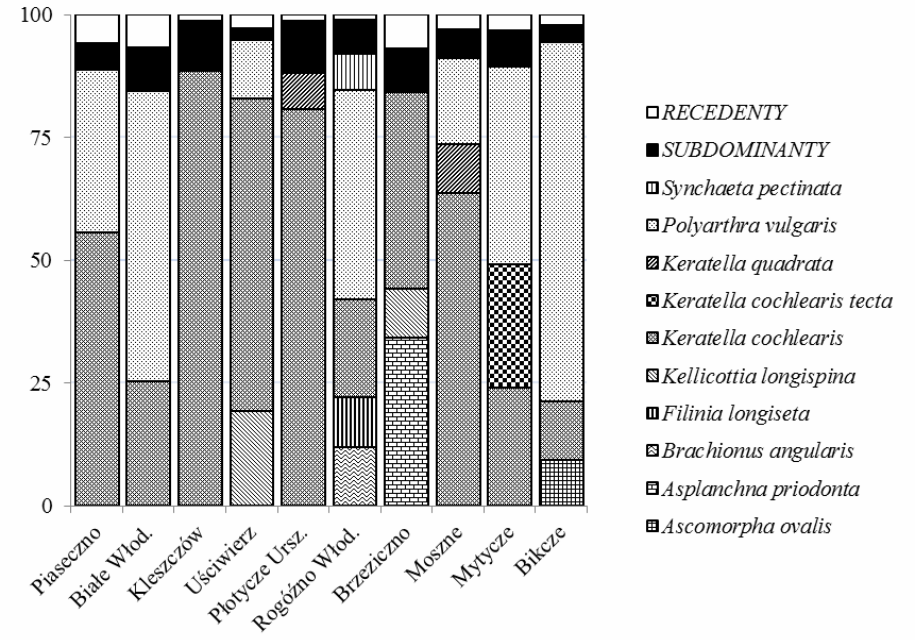

Fig. 1. Domination structure of rotifers of ten lakes of Łęczyńsko-Włodawskie Lakeland in 2007–2008

Rotifer assemblages were classified according Łuczak and Wierzbowska [1981], Müller [1984] and Bielańska-Grajner [2005] for two groups: assemblages with sustainable and non-sustainable domination structure. The authors assumed that sustainable domination structure is typical for communities with three classes of domination, with at least three dominant species and when any of dominant species doesn`t show higher relative abundance than 45%. According to these criteria domination structure was sustainable only in three of studied lakes: scattered eutrophic Lake Rogóźno Włod., dystrophic Lake Brzeziczno and retention reservoir Mytycze. Rotifer assemblage in Lake Rogóźno has four dominant species *Polyarthra vulgaris*, *Keratella cochlearis*, *Brachionus angularis* and *Filinia longiseta*. In Lake Brzeziczno group of dominants included three rotifer species, *Keratella cochlearis*, *Kellicottia longispina* (indicator of oligotrophic lakes) and *Asplanchna priodonta* (predatory species). In Lake Mytycze dominated indicators of eutrophic waters: *Polyartchra vulgaris*, *Keratella coch-*

Table 1. Mean densities of rotifers of ten lakes of Łęczyńsko-Włodawskie Lakeland in 2007-2008 (e – indicators of eutrophic waters; o – indicators of oligotrophic and humic waters, r – rare species for Polish fauna)

Taxon \ Lake	Piaseczno	Białe Włod.	Kleszczów	Uściwierz	Płotycze Ursz.	Rogóźno Włod.	Brzeziczno	Moszne	Mytycze	Bikcze
Lake type	mesotrophic		big eutrophic		scattered eutrophic		dystrophic		retention reservoirs	
Anuraeopsis fissa Gosse (e)		0.29							12.11	
*Ascomorpha ovalis (*Berg.)										67.33
Ascomorpha saltans Bartsch (r)				0.72	20.06					
Asplanchna priodonta Gosse	3.67	2.29		0.82	3.39	2.33	35.47		2.17	
Asplanchna sieboldi (Leydig)			4.67	0.43						
Brachionus angularis Gosse (e)		1.54			5.67	120.50			7.22	
Brachionus calyciflorus Pall. (e)		0.17				39.25		0.33	1.39	0.88
Brachionus diversicornis (Daday) (e)								0.56	3.33	1.92
Brachionus falcatus Zach.	0.21		0.22	0.12			0.33			
Brachionus forficula Wierz.				0.32						
Brachionus leydigii Cohn	0.75			0.67				0.11		
Brachionus quadridentatus Herm. (e)	0.29			0.15						
Brachionus rubens Ehrb.		0.58		0.13						0.04
Cephalodella forficula (Ehrb.)										0.13
Cephalodella gibba (Ehrb.)	0.50	0.17	0.11	1.13				0.33		
Colurella adriatica Ehrb.		0.08		0.32	0.06	0.17	0.42			0.50
Colurella colurus (Ehrb.)		1.00			0.06	0.58	0.81	2.67		
Chromogaster ovalis (Berg.) (o)	1.00	1.04		0.18		0.42		0.44		0.08
Chromogaster testudo (Laut.) (o)	0.46		0.11			0.08				
Elosa spinifera Wiszn.	1.83		0.22							0.04
Euchlanis deflexa Gosse				0.12			0.25		1.00	
Euchlanis dilatata Ehrb.								0.44		0.58
Euchlanis parva Rouss.				0.09			0.39			0.42
Filinia longiseta (Ehrb.) (e)	0.96	1.54		2.40	2.83	103.67			0.72	
Filinia maior Cold.		0.33					0.25		0.06	

Filinia terminalis (Plate)	0.08			0.11						
Gastropus stylifer Imh. (o)	1.17	0.25		1.72				0.56		
Kellicottia longispina (Kell.) (o)	3.50	11.96	15.67	123.28			10.33			4.00
Keratella cochlearis f. *cochlearis* (Gosse)	148.67	46.79	605.22	406.66	950.83	202.42	41.61	147.56	74.67	87.46
Keratella cochlearis f. *tecta* (Gosse) (e)	0.25	2.00			62.67	30.50	0.17		78.50	25.17
Keratella hiemalis Carl. (o)		0.88	0.11			1.00		0.11		
Keratella quadrata (Müll.) (e)	2.29	0.46	13.00	6.85	87.89	0.83		23.22		0.50
Lecane bulla (Gosse)			0.67							0.21
Lecane closterocerca (Schm.)	0.58	0.04	0.22	0.31			1.00		0.33	0.33
Lecane crenata Harr.	0.13	0.04	0.44	0.12			1.44			0.71
Lecane furcata (Murray)		0.04		0.08				0.22	0.06	
Lecane hamata (Stokes)	0.08	0.42		0.05			0.17	0.44	0.06	
Lecane luna (Müll.)	0.33	0.04		0.42			0.11			0.54
Lecane lunaris (Ehrb.)	0.13		0.22	0.23			0.06	1.00		
Lecane quadridentata (Ehrb.)	0.42			0.06			0.08	0.11		
Lecane rhenana Hauer			0.11	0.25						
Lecane signifera (Jennings) (r)				0.11	0.06					
Lecane stenroosi (Meissn.)					0.06		0.06			
Lecane stichaea (Harr.)				0.06			0.17	0.11		
Lecane stokesi (Pell.)				0.06						
Lepadella acuminata (Ehrb.)				0.68		1.17				0.04
Lepadella cristata (Rouss.)				0.12						
Lepadella ovalis (Müll.)	0.33		1.00	0.09	0.06				1.83	0.38
Lepadella patella (Müll.)	0.88			0.06			1.47		0.11	
Lepadella rhomboides (Gosse)	0.17	0.17		0.17			0.81	0.22		
Mytilina mucronata (Müll.)	0.08			1.05				0.22		
Mytilina ventralis (Ehrb.)							0.11	0.56		0.25
Notholca acuminata (Ehrb.)		0.13		0.21					0.06	

Notholca labis Gosse	0.13	0.17		0.05			0.28			
Notholca squamula (Müll.)	0.08			0.08			0.56		0.11	
Plationus patulus (Müll.)				0.12					0.06	
Platyias polyacanthus (Ehrb.)	0.08			0.14						
Platyias quadricornis (Ehrb.)				0.14						
Pleurotrocha petromyzon Ehrb.									0.33	
Pleurotrocha robusta (Glass.)		0.04		0.06	0.06					
Polyarthra dolichoptera Idels		0.46	0.11							
Polyarthra euryptera Wierz. (e)	0.38					2.33				
Polyarthra vulgaris Carl.	88.67	109.75	40.56	76.99	41.44	432.75	5.17	40.67	126.06	533.83
Pompholyx sulcata Huds. (e)				0.05	1.67	1.00				1.21
Scaridium longicaudium (Müll.)										0.25
Synchaeta pectinata Ehrb.	7.38			7.84		76.00				
Testudinella parva (Teren.)				0.03			0.08	0.44		0.08
Testudinella truncata (Gosse)				0.14				0.22		
Trichocerca bicrystata (Gosse)				0.06				0.11	0.28	
Trichocerca capucina (Wierz. et Zach.) (e)			0.44							0.75
Trichocerca cylindrica (Imh.) (e)		1.71		0.47			0.11			
Trichocerca elongata (Gosse)							0.33			
Trichocerca pusilla (Laut.) (e)										0.75
Trichocerca rattus (Müll.)		0.50				0.08				0.04
Trichocerca similis (Wierz.) (o)	0.63	0.29	0.89	1.02	0.94	0.67	1.25	10.44	1.56	0.21
Trichocerca tigris (Müll.)		0.04								0.21
Trichotria pocillum (Müll.)				0.11			0.08			0.08
Trichotria sp.				0.06	0.17					
Trichotria tetractis (Lucks.)		0.04		0.12						
Trichotria truncata (Whitel.)				0.06						
Bdelloidea non. det.								0.33		0.25
Collotheca mutabilis (Huds.)	0.58									

Colurella uncinata (Müller)				0.75						
Euchlanis lucksiana Hauer	0.33									
Lecane flexilis (Gosse)				0.38						
Lecane levistylla (Olof.)	0.17						0.17	0.33		0.50
Lecane ludwigii (Eckst.)				0.13						
Platyias p-stulus (Müll.) (r)				0.38						
Trichocerca cavia (Gosse) (r)	0.58			0.44						
Trichocerca porcellus (Gosse)							0.33			
Density	267.75	185.25	684.00	639.91	1177.89	1015.75	103.86	231.78	312.00	729.67
Number of species	36.00	33.00	19.00	60.00	17.00	19.00	31.00	26.00	22.00	33.00
Shannon-Wiener index	1.81	1.89	0.76	1.68	1.13	2.40	2.40	1.75	2.16	1.39
Number of indicators of eutrophic waters	5.00	7.00	2.00	5.00	5.00	7.00	2.00	3.00	6.00	7.00
Number of indicators of oligotrophic and humic waters	5.00	5.00	4.00	4.00	1.00	4.00	2.00	4.00	1.00	3.00
Number of rare species	1.00	0.00	0.00	4.00	2.00	0.00	0.00	0.00	0.00	0.00

learis f. tecta and *Keratella cochlearis*. Despite sustainable domination structure in Lake Mytycze was noted very high, almost 50%, relative abundance of *Keratella cochlearis* f. tecta. Such a result, according to many researchers [Radwan *et al.* 2004, Karabin and Ejsmont-Karabin 1996] indicates the eutrophication process of lake ecosystem. In mesotrophic lakes domination structure of planktonic rotifers was non-sustainable, in the lakes were noted two dominants: *Polyarthra* vulgaris and *Keratella cochlearis* (Fig. 1). In big eutrophic Lake Kleszczów, dominated *Keratella cochlearis*, the species reached 88% of total rotifers density. In the second eutrophic lake, Uściwierz dominated *Kellicottia longispina* and *Polyarthra vulgaris* (Fig. 1). In eutrophic, scattered Lake Płotycze Ursz., visibly dominated *Keratella cochlearis* (mean 81%) and *Keratella quadrata*. In dystrophic Lake Moszne dominated *Keratella cochlearis, Keratella quadrata*, *Polyartchra vulgaris*. In retention reservoir Bikcze, dominated *Polyarthra vulgaris*, indicatory species of eutrophic waters, its relative abundance amounted 73%. Such a high percentage of one species is typical for non-sustainable domination structure of planktonic rotifers, even if there are noted two others dominants – *Keratella cochlearis* and *Ascomorpha odalis* (Fig. 1).

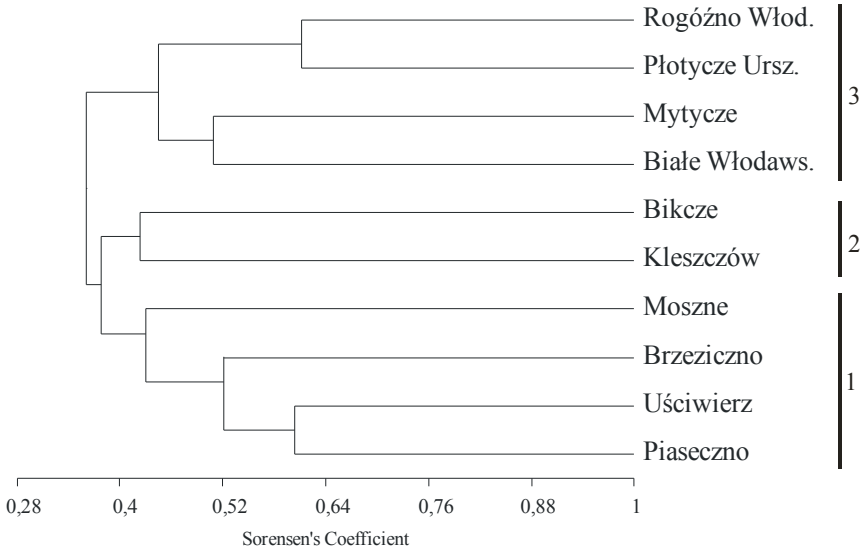

Fig. 2. Structure of similarity of rotifer assemblages performed on rotifers density of ten lakes of Łęczyńsko-Włodawskie Lakeland in 2007–2008

Cluster analysis for rotifer assemblages in ten lakes, performed on rotifers density led to divide studied lakes into three groups (Fig. 2). To the first group belong mesotrophic Lake Piaseczno, dystrophic lakes Brzeziczno and Moszne and eutrophic Lake Uściwierz. Within the group, the highest value of similarity

index (0.60) showed rotifer assemblages of lakes Piaseczno and Uściwierz and Lake Brzeziczno (0.52). The highest separateness from the other lakes showed Lake Moszne (0.42). Second group included two lakes Kleszczów and Bikcze, value of Sörensen coefficient for rotifer assemblages of the lakes amounted 0.43. The third group of lakes comprises mesotrophic Lake Białe Włod., retention reservoir Mytycze and two scattered eutrophic lakes Płotycze Ursz. and Rogóźno Włod. The highest faunistic similarity within this group showed rotifer assemblages of lakes Płotycze Ursz. and Rogóźno Włod. (0.61) and Białe Włod. and Mytycze (0.51) (Fig. 2). In spite of existence of three distinct group of lakes, values of Sörensen similarity index within each of the group were very differentiated (range 0.36–0.62). It indicates that rotifer assemblages inhabiting studied lakes were similar in 36% up to 62%. In addition to the high total number of rotifer species (90), studied lakes show high ecological value.

COMPARISON TO THE 60s

Structure of rotifer assemblages obtained during the years 2007–2008 was compared to the results of studies conducted in the years 1966–1967 [Radwan 1973, 1976]. Due to the specificity of previous studies, the comparison will be not sufficient. Material collected almost 40 years ago was very large but comprised only species structure of planktonic rotifers without quantity analysis. However, the only attempt to assess qualitative changes in the composition of the planktonic rotifers of ten lakes of Łęczyńsko-Włodawskie Lakeland after forty years of succession is an interesting challenge. Comparative results are presented graphically (Fig. 3 A, B, C).

In most of studied lakes species richness of planktonic rotifers observed in 2007 and 2008 was greater than that observed in 1966–1967. Only in scattered eutrophic lakes Płotycze Ursz. and Rogóźno Włod. number of rotifer species declined or remained on similar level. Observed differences were probably a result of advanced succession of scattered lake ecosystems. In mesotrophic and dystrophic lakes, as well in retention reservoirs the increase in the number of species ranged from 5 to 17 in compare to 1966–1967 (Fig. 3 A). In big eutrophic lakes increase of species number varied between 2 species (Lake Kleszczów) and 46 species (Lake Uściwierz). The increase of species richness of planktonic rotifers in studied lakes is a positive phenomenon, caused by many complex factors, such as restoration activity and abandonment of drainage and intensive agriculture [Chmielewski 2006].

In majority of lakes was noted the increase of indicatory species for eutrophic waters (Fig. 3 B), in particular in big mesotrophic lakes Białe Włod. and Piaseczno. In the years 1966-1967 indicatory species were not observed in these lakes and now indicatory species appeared in the number from 5 to 7 (Fig. 3 B). Similar pattern was observed in macrophyte dominated Lake Kleszczów. At present, in the lake are noted 2 indicatory species for eutrophic waters and no in-

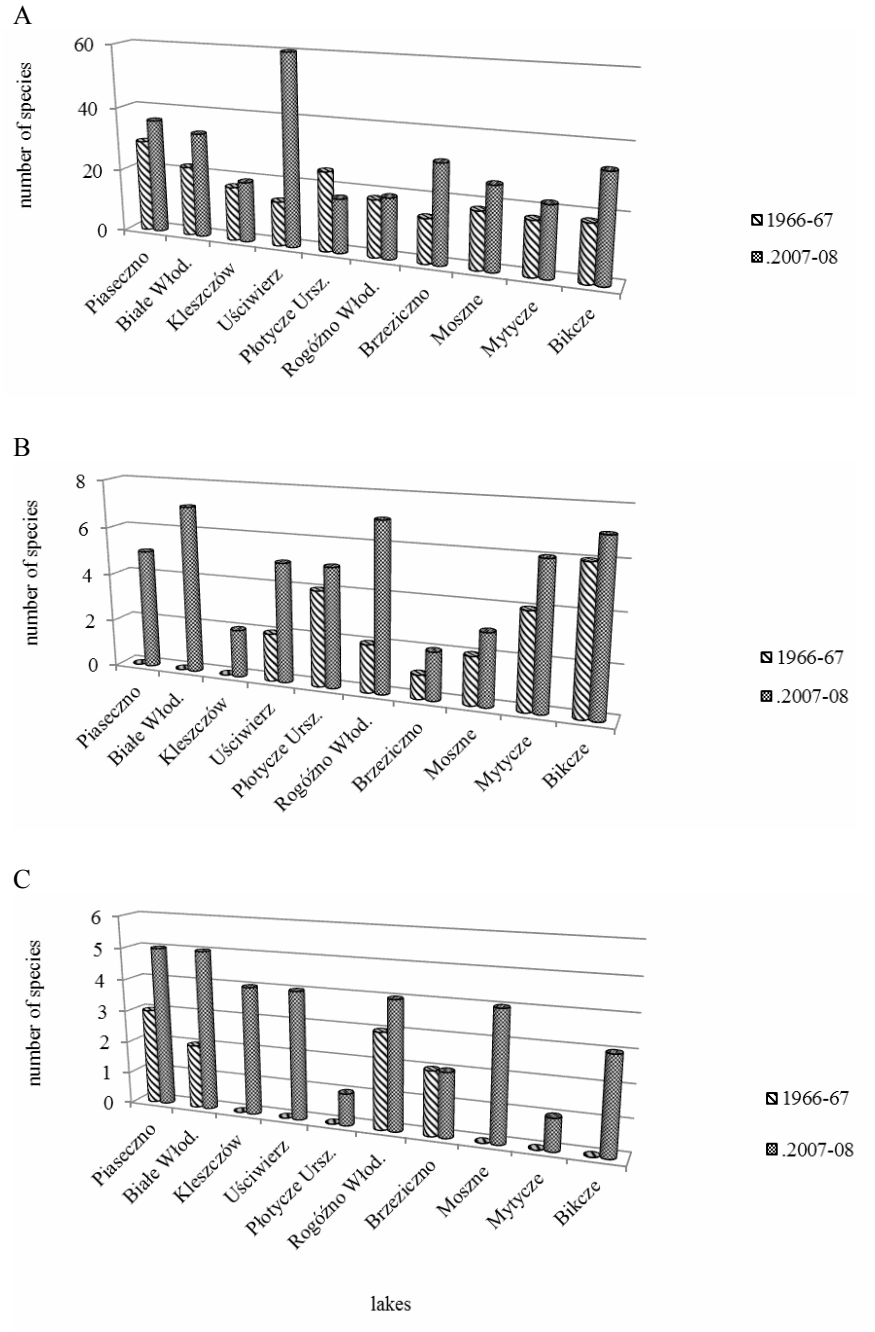

Fig. 3. Number of rotifer species of ten lakes of Łęczyńsko-Włodawskie Lakeland – comparison of the data from the years 1966–1967 [Radwan 1973, 1976] with the data obtained in 2007–2008, A – number of rotifer species, B – number of indicators of eutrophic waters, C – number of indicators of oligotrophic and humic waters

dicatory species was found during the years 1966–1967. Only in scattered eutrophic Lake Rogóźno Włod. number of indicatory species for eutrophic water has risen by five species. In other lakes the increase of indicatory species of eutrophic waters was small (ranging from 1 to 2 species) and may be associated with eutrophication process or with the general increase in the number of rotifer species. In majority of lakes, have been observed the increase of indicatory species for oligotrophic and humic waters, during the last forty years (Fig. 3 C). The changes in the number of bioindicators may indicate a change in the trophic status of lakes. For example, in Lake Uściwierz where there has been observed an exceptionally high increase of species richness of rotifers; increase in the number of indicatory species was not at record high.

It is worth pointed that during the last forty years the number of indicatory species for oligotrophic and humic waters have been visibly increased in majority of lakes. The highest increase in the number of indicatory species (ranging from 3 to 4 species) was noted in eutrophic lakes (Kleszczów, Uściwierz and Bikcze), dystrophic Lake Moszne and mesotrophic Lake Białe Włod. In other lakes the increase was lower (from 1 to 2 species) or remained on the same level (dystrophic Lake Brzeziczno) (Fig. 3 C).

CONCLUSIONS

1. In total 90 rotifer species were noted in ten studied lakes. The results indicate high species diversity of planktonic rotifers in comparison to the 60s.

2. In studied lakes have occurred 13 indicatory species of eutrophic waters and 6 indicatory species of oligotrophic and humic waters. It can stress the eutrophication process of studied lake ecosystems, although the presence of 4 rare rotifer species rises the ecological values of the lakes.

3. In most of lakes, with exception of Lake Kleszczów, besides non-sustainable domination structure, species diversity of rotifers was high. Such a situation was caused by high percentage of recedents and subrecedents and low abundance of visibly dominant species. In the lakes domianted common rotifer species: *Keratella cochlearis, Polyarthra vulgaris, Kellicottia longispina, Asplanchna priodonta, Synchaeta pectinata, Keratella quadrata, Keratella cochlearis* f. tecta*, Filinia longiseta, Brachionus angularis* and *Ascomorpha odalis*.

4. Mean density of planktonic rotifers ranged from 104 ind. dm^{-3} to 730 ind. dm^{-3}. Only in scattered eutrophic lakes, density exceeded 1000 ind. dm^{-3} and was typical for waters of high trophic status.

5. Significant (60%) faunistic similarity was only found between rotifer assemblages of mesotrophic Lake Piaseczno and dystrophic Lake Uściwierz and between two scattered eutrophic lakes (Rogóźno Włod. and Płotycze Ursz.). The advantage of low faunistic similarity among most of studied rotifer assemblages evidences the high biodiversity of studied lake ecosystems and indicate high ecological value of the lakes.

6. Over the past forty years has increased species richness of rotifers and the number of indicatory species of eutrophic, oligotrophic and humic waters. From the one hand it confirms the previous conclusion about high ecological value of studied lakes; from the other indicates the problem of eutrophication of lake ecosystems.

REFERENCES

Bielańska-Grajner I., 2005. Psammon rotifers of water reservoirs of some areas of Poland. University of Silesia Publishing (in Polish), 114 pp.

Chmielewski T. (ed.), 2006. Improvement of the ecological status and optimizing the recreational use of catchment area of lakes Miejskie-Kleszczów, as a pilot implementation to introduce on the post lakes areas of Euroregion Bug (in Polish). Publisher Ostrów Municipality – Earth Society of Ostrów Lubelski, Paragraph S.C., 40 pp.

Ejsmont-Karabin J., Radwan S., Bielańska-Grajner I., 2004. *Monogononta* – atlas of species. 32 B (in Polish), in: S. Radwan (ed). Rotifers. Freshwater fauna of Poland. Polish Hydrobiological Society, University of Lodz. Tercja Publishing House, Łódź, 147–448.

Gliwicz M., 1974. Trophic status of species of freshwater zooplankton (in Polish). Wiad. Ekol., 20, 3. 197–203.

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

Karabin A., Ejsmont-Karabin J., 1996. Structure, abundance and diversity of zooplankton of Krutynia River (Masurian Lakeland) (in Polish). Scientific Papers of Committee „Man and Environment", 13, 155–171.

Łuczak J., Wierzbowska T., 1981. Methods of analysis of zoocenosis, in: M. Górny, L. Grüm (eds). Methods used in soil zoology. PWN, Warszawa, 417–436.

Müller H.J., 1984. Ökologie (in Polish). Gustav Fischer Verlag. Jena, 195 pp.

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

Radwan S., 1973. Pelagic rotifers of Łęczyńsko-Wodawskie Lakeland. Faunistic and ecological study (in Polish). Shortcut of habilitation dissertation. AR. Ser. Rozpr. Hab., 8, 57 pp.

Radwan S., 1976. Planktonic rotifers as indicators of lake trophy. Ann. Univ. Marie Curie Skłodowska, sec. C, 31, 227–235.

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

Radwan S., Bielańska-Grajner I., Ejsmont-Karabin J., 2004. Main part. Monogononta – Systematic part. 32 A (in Polish), in: S. Radwan (ed.). Rotifers. Freshwater fauna of Poland. Polish Hydrobiological Society, University of Lodz. Oficyna Wydawnicza Tercja, Łódź, 146 pp.

SAS Institute Inc. 2001. SAS User's Guide. Version 8.2 Edition, SAS Institute Inc., Cary.

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

WROTKI PLANKTONOWE DZIESIĘCIU ZRÓŻNICOWANYCH TROFICZNIE JEZIOR – ZMIANY W CZASIE

Streszczenie. Eksploracje wrotków planktonowych prowadzono w dziesięciu zróżnicowanych jeziorach Pojezierza Łęczyńsko-Włodawskiego. Należały do nich: zbiorniki mezotroficzne, duże jeziora eutroficzne, zanikające jeziora eutroficzne, jeziora dystroficzne oraz jeziora przekształcone w zbiorniki retencyjne. Łącznie stwierdzono 90 gatunków wrotków, w tym 13 gatunków wskaźnikowych eutrofii oraz 6 gatunków wskaźnikowych oligotrofii lub wód humusowych. Badano i porównywano różnorodność gatunkową, zagęszczenie, strukturę dominacji i jej zrównoważenie. Do dominujących gatunków należały pospolite wrotki: *Keratella cochlearis, Polyarthra vulgaris, Kellicottia longispina, Asplanchna priodonta, Synchaeta pectinata, Keratella quadrata, Keratella cochlearis f. tecta, Filinia longiseta, Brachionus angularis, Ascomorpha odalis*. Pomiędzy zgrupowaniami wrotków różnych jezior stwierdzono zróżnicowany stopień podobieństwa faunistycznego od 36 do 60%. W pracy dokonano również analizy zmian w strukturze jakościowej wrotków w ostatnim czterdziestoleciu. W tym czasie bogactwo gatunkowe wrotków wzrosło, wzrosła również liczba gatunków wskaźnikowych oligotrofii i wód humusowych oraz liczba gatunków wskaźnikowych eutrofii.

Słowa kluczowe: jeziora, wrotki planktonowe, Pojezierze Łęczyńsko-Włodawskie