INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

No IV/2/2017, POLISH ACADEMY OF SCIENCES, Cracow Branch, pp. 1673–1686
Commission of Technical Rural Infrastructure

DOI: http://dx.medra.org/10.14597/infraeco.2017.4.2.126

ZOOPLANKTON STRUCTURE IN MIDFIELD PONDS IN NORTH-WEST PART OF POLAND

Adam Brysiewicz[1], Marek Jankowski[2], Adam Tański[2]
[1]Institute of Technology and Life Sciences, Kuyavian-Pomeranian Research Centre
[2]The West Pomeranian University of Technology in Szczecin

Abstract

Midfield ponds are characterised by a rich biodiversity. A significant role in the function of these specific water ecosystems is played by resident zooplankton, which is a valuable component of numerous trophic networks. The aim of the present work was to study the taxonomic composition, concentration and biomass of zooplankton in two midfield ponds situated in the area of one commune, but geomorphologically different from each other. Experiments were conducted in the summer seasons (June-August) in the years 2011-2013 in two ponds. The presence of 55 zooplankton taxa, commonly present in such water reservoirs in Poland, was observed. Most species were determined. The largest group comprised rotifers (Rotifera) – 35 taxa. The crustacean zooplankton was less diverse: 11 taxa of copepods (Copepoda) and 9 taxa of water fleas (Cladocera) were found. The reservoir in Stare Czarnowo exhibited a greater number of taxa, where as many as 40 taxa were observed. However, 35 taxa belonging to various zooplankton groups were found in the pond in Żelisławiec. The relatively low Jaccard index confirmed small qualitative similarity between the studied ponds. Both reservoirs contained representatives of species defined as characteristic for oligosaprobic and mesosaprobic waters, which may indicate small contamination of the two ponds and the occurrence of a large amount of organic matter undergoing decomposition.

Key words: zooplankton, midfield pond, agricultural areas

INTRODUCTION

Small midfield ponds are the habitat for precious and frequently rare plant and animal species (Raniszewska 2009). These closed shallow reservoirs are characterised by the area of approximately 1 ha and the maximum depth of up to 3 m. They are situated in natural dips supplied by groundwater, rainwater and meltwater. The range of living organisms using these small basins is wide, from invertebrates to mammals (Czerniawski *et al*. 2013, Kraska and Kaniecki 1985). Organisms living in ponds are characterised by rich biodiversity and they determine the biological properties of the area in which they reside.

We tend to forget many useful functions of ponds in creation of the specific microclimate and in water accumulation (small retention) that is so indispensable in view of recent atmospheric droughts (Bernaciak *et al.* 2015, Bieroński 2005). Their unquestionable and invaluable role in the agricultural landscape and their rich biodiversity cause them to be a very good object for studies (Downing 2010). Zooplankton, as a specific bioindicator of the water environment, also constitutes a rich source of information about its condition.

The aim of the present work was to study the taxonomic composition, concentration and biomass of zooplankton in two midfield ponds situated in the area of one commune, but geomorphologically different from each other.

DESCRIPTION OF THE STUDIED AREA, MATERIAL AND METHODS

The studies were conducted in the years 2011 – 2013 in two midfield ponds in the protection zone of the Szczecin Landscape Park, in the area of Stare Czarnowo commune. One of the studied ponds is located in the village of Stare Czarnowo (53°16′4.47″N, 14°46′5.94″E). The reservoir was characterised by an oblong shape with the area of 0.8 ha. It was supplied by groundwater and surface runoff from adjacent agricultural areas. The pond was divided into two parts, which were separated by a belt of bushes and rushes. The western part had a constant low water level (periodic desiccation) and intensive rushes overgrowth. The other part (the eastern side) was more exposed with permanent water. The bottom of the pond was mainly sludgy and the maximum depth in the eastern part of the reservoir on average exceeded 1.5 m.

During the study, the following crops were grown in the agricultural areas adjacent to the pond: winter rape (*Brassica napus L. var. napus*), winter barley (*Hordeum vulgare* L.) and triticale (*xTriticosecale Wittm. ex A. Camus*). The pond in Stare Czarnowo was overgrown with rushes – great manna grass (*Glyceria maxima* (Hartm.) Holmb.) as a simplified community characterised by accumulation of one species. Great manna grass occurred in shallow waters between 20-30 cm. In deeper waters, two simplified rushes communities were present: common reed (*Phragmites australis* (Cav.) Trin. Ex Steud) and common bulrush (*Typha latifolia* L.). Communities of submerged vegetation were located in the pelagic zone and its main representative was the hornwort (*Ceratophyllum demersum* L).

The other reservoir was located 10 km to the East in the fields of the village of Żelisławiec (53°26′95.94″N, 14°66′68.37″E). The midfield pond in Żelisławiec also is a closed reservoir, but with a slightly larger area (0.9 ha). It was characterised by an oval shape. There were no trees and bushes around it, which caused stronger mixing of waters. Its shoreline was characterised by the occurrence of two simplified rushes communities with accumulation of one species, those were: common reed and common bulrush. The depth of the Żelisławiec pond during the study ranged from 60 to 180 cm measured from the water surface. The bottom of the pond in the littoral part was hard and in the central part it was covered with a layer of sludge. The pelagic zone featured submerged plant communities of two species: water smartweed (*Persicaria amphibian* (L.) Delarbre) and floating pondweed (*Potamogeton natans* L). During the three-year of the study, the following crops were grown in the agricultural areas adjacent to the pond: winter rape wheat (*Triticum aestivum* L.) and spring combinations (oat (*Avena sativa* L.) and barley.

Four points of zooplankton sample collection were determined in each pond. One of the points, marked P, was located in both cases in the central pelagic part of the reservoirs. The other points L1, L2 and L3 were located in the littoral zones.

Samples of the pelagic zooplankton (P) were collected using a 5 dm^3 Patalas sampler. A cumulative sample was collected from a vertical of water from the surface to the bottom. A sample from three samplers (15 dm^3) was strained through a net with 0.05 mm eyes and placed in a container, once a year in the summer (June). Littoral sample were collected using a 5 dm^3 graded bucket. Sampling five times, the volume of 25 dm^3 of water was collected at each point and strained through a 0.05 mm screen . The collected sample was placed in a container and immediately preserved with a 4% formalin solution.

Next, a quantitative laboratory Institute of Technology and Life Sciences in Szczecin analysis were performed to determine the taxonomic composition (Table 1-2), the concentration of zooplankton (Table 3) and the volume of biomass (Figure 1). The collected sample was placed in a graded cylinder and distilled water was added to obtain the volume of 50 ml. Using a pipette equipped with a ring, the content of the cylinder was mixed, and 1 ml of the material was collected and transferred to a measuring chamber, where it was measured thoroughly. The action was repeated in the case of each sample at least twice, but before the second count the material was condensed. Depending on the density and the degree of sample contamination, it was 25, 20 or 10 ml. The concentration of zooplankton calculated as items$\cdot dm^{-3}$ is presented in Tables 3-4.

For comparison of the qualitative composition of zooplankton, the Jaccard similarity coefficient was used according to the formula:

$$J = c/(a + b - c),$$

where: a – number of taxa in reservoir A,
b – number of taxa in reservoir B,
c – number of taxa common for both lakes (Kawecka and Eloranta 1994).

The coefficient assumes values from 0 to 1, where 0 indicates no common species and 1 indicates identical taxonomic composition of the studied reservoirs.

In order to determine biomass, the mean length of individuals from each zooplankton taxon was measured using a measuring eyepiece. The rotifers biomass was calculated using Ejsmont-Karabin (1998) tables and the crustacean biomass using Starmach (1989) tables. Due to the very small figures relating to biomass of individual zooplankton species (especially rotifers), they are presented collectively for the whole groups.

RESULTS

Three years of studies demonstrated the presence of 55 zooplankton taxa on the whole, commonly present in selected reservoirs in Poland. Most species were determined. The largest group comprised rotifers (Rotifera) – 35 taxa. The crustacean zooplankton was less diverse: 11 taxa of copepods (Copepoda) and 9 taxa of water fleas (Cladocera) were found on the whole. It has to be emphasised that in the community of rotifers, the group of *Bdelloidea* (were not determined in this type of studies) encompassed at least a few species, like the group of Rotifera n.d. (non-determined rotifers). The real species composition of both reservoirs may therefore be slightly richer.

Table 1. List of Rotifera taxa occurring in each point in the midfield ponds in the years 2011 – 2013

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Keratella cochlearis					+	+	+	+
Keratella cochlearis tecta	+			+				
Keratella quadrata	+				+	+	+	+
Brachionus angularis					+	+	+	+
Brachionus quadridentatus						+	+	+
Brachionus rubens					+	+	+	+

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Platyias quadricornis	+	+	+			+		+
Anuraeopsis fissa				+	+	+	+	+
Euchlanis deflexa			+					
Euchlanis dilatata		+	+	+	+			+
Euchlanis incisa							+	
Mytilina mucronata	+	+	+	+				
Mytilina ventralis	+	+	+	+				
Trichotria pocillum	+	+		+				
Lepadella ovalis	+	+	+	+			+	+
Lepadella rhomboides		+				+		
Lecane bulla	+	+	+	+	+	+	+	+
Lecane hamata	+	+	+	+				
Lecane closterocerca		+	+	+	+			
Lecane quadridentata			+					
Lecane sp.		+	+					
Colurella sp.	+	+	+	+				
Trichocerca insignis				+				
Trichocerca rattus		+		+			+	+
Cephalodella sp.	+			+				
Monommata aequalis	+			+				
Scaridium longicaudum	+			+				
Polyarthra dolichoptera	+			+	+	+	+	+
Polyarthra vulgaris					+	+	+	
Synchaeta sp.				+				
Hexarthra sp.					+	+	+	+
Asplanchna sp.	+		+		+	+	+	+
Testudinella patina	+	+	+				+	
Bdelloidea	+	+	+	+				
Rotatoria n.d.	+	+	+	+	+	+	+	+
Total Rotifer taxons	**18**	**16**	**16**	**20**	**13**	**14**	**16**	**15**

+ occurrence

Both studied ponds exhibited great taxonomic diversity of each group. The pond in Stare Czarnowo featured a slightly bigger number of taxa, i.e. 40, including 28 rotifers, 4 water fleas and 8 copepods. In Żelisławiec 35 taxa were observed, including 20 rotifers, 8 water fleas and 7 copepods. The general numbers of taxa in both studied ponds were observed to be similar with differences in species composition in each group (Tables 1 and 2).

Table 2. List of Crustacea taxa occurring in each point in the midfield ponds in the years 2011 – 2013

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Cladocera								
Daphnia hyalina					+	+	+	+
Daphnia longispina						+		
Alona guttata				+				+
Oxyurella tenuicaudis								+
Scapholeberis mucronata						+	+	+
Pheracantha truncata						+	+	+
Simocephalus expinosus		+	+					
Simocephalus vetulus			+	+			+	+
Chydorus sphaerictus		+	+	+	+	+	+	
Total Cladocer taxa	**0**	**2**	**3**	**3**	**2**	**5**	**5**	**6**
Copepoda								
Eucyclops serrulatus		+				+	+	
Eucyclops macruroides					+			
Ectocyclops phaleratus			+					
Cryptocyclops bicolor			+	+				
Diacyclops bicuspidatus			+	+				
Cyclopoida – samce		+						+
kopepodit Cyclopoida	+	+	+	+	+	+	+	+
nauplii Cyclopoida	+	+	+	+	+	+	+	+
Megacyclops viridis		+						
kopepodit Calanoida					+	+	+	+
nauplii Calanoida					+	+	+	+
Total Copepod taxons	**2**	**5**	**5**	**4**	**5**	**5**	**5**	**5**
Total zooplankton taxa	**20**	**23**	**24**	**27**	**20**	**24**	**26**	**26**

* – Cyclopoida males and development stages of copepods are not counted as separate taxa; + occurrence

The tabular presentation also displays significant differences between the studied ponds. Only 20 taxa were common for both ponds. Those were 13 rotifer taxa, 3 water fleas and 4 copepods. Also, the Jaccard similarity coefficient indicates relatively great diversity. It was 0.36 for the studied ponds. It indicates small similarity between the zooplanktons of both ponds. It is also worth noting that as many as 34 taxa were only characteristic of one of the ponds. More of these were observed in the Stare Czarnowo pond – 20, whereas in Żelisławiec there were only 14 such taxa.

The biggest mean concentration of zooplankton was observed in the pelagial zone of the Żelisławiec pond and amounted to 1,683.3 individuals·dm^{-3}. Such high concentration especially occurred in the case of rotifers. The lowest concentration was observed in all the samples in the group of water fleas (Tables 3 and 4).

Table 3. Mean concentration of Rotifera taxa [individual·dm^{-3}] in each point in the midfield ponds in the years 2011 – 2013

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Keratella cochlearis					530.0	98.0	10.8	92.0
Keratella cochlearis tecta	6.7			1.6				
Keratella quadrata	3.3				600.0	278.0	54.8	98.0
Brachionus angularis					163.0	54.8	17.6	74.0
Brachionus quadridentatus						0.4	0.8	2.4
Brachionus rubens					3.7	5.6	3.4	10.4
Platyias quadricornis	6.7	2.0	4.0			1.0		0.4
Anuraeopsis fissa				4.8				
Euchlanis deflexa			4.0					
Euchlanis dilatata		12.0	4.0	22.4				
Euchlanis incisa							2.0	
Mytilina mucronata		4.0	12.0	3.2				
Mytilina ventralis	10.0	8.0	16.0	1.6				
Trichotria pocillum	3.3	2.0						
Lepadella ovalis			8.0					
Lepadella rhomboides						0.4		
Euchlanis sp.								
Lecane bulla	3.3	6.0	70.0	3.2				
Lecane hamata	3.3	4.0	8.0	3.2				
Trichotria tetractis								
Lecane closterocerca		8.0	38.0	1.6	1.7			

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Lecane quadridentata			18.0					
Lecane sp.			20.0					
Colurella sp.	3.3	8.0	14.0	4.8				
Trichocerca insignis				1.6				
Trichocerca rattus				1.6				
Cephalodella sp.				1.6				
Monommata aequalis	3.3			0.0				
Scaridium longicaudum				6.4				
Polyarthra dolichoptera	3.3			1.6				
Polyarthra vulgaris					2.3	3.6	1.4	
Synchaeta sp.				16.0				
Hexarthra sp.					9.7	4.0	2.4	2.6
Asplanchna sp.					8.3	2.0	1.0	1.0
Testudinella patina	3.3	2.0	4.0				0.4	
Bdelloidea	400.0	34.0	4.0	75.2				
Rotatoria n.d.					6.7	0.8	1.0	1.0
Total Rotifera	**450.0**	**90.0**	**224.0**	**150.4**	**1325.3**	**448.6**	**95.6**	**281.8**

Table 4. Mean concentration of Crustacea taxa [individual·dm^{-3}] in each point in the midfield ponds in the years 2011 – 2013

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Cladocera								
Daphnia hyalina					0.7	1.2		1.8
Daphnia hyalina juv.					27.0	3.8	1.0	7.4
Daphnia longispina						1.2		
Daphnia longispina juv.						0.4		
Alona guttata				1.6				
Oxyurella tenuicaudis								2.2
Oxyurella tenuicaudis juv.								0.4
Scapholeberis mucronata						4.0	1.8	0.4
Scapholeberis mucronata juv.						2.2	1.2	
Simocephalus expinosus		2.0						

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Simocephalus expinosus juv.		6.0	10.0					
Total Cladocera	**0.0**	**8.0**	**10.0**	**1.6**	**27.7**	**12.8**	**4.0**	**12.2**
Copepoda								
Eucyclops serrulatus		2.0				0.4		
Eucyclops macruroides					10.3			
Ectocyclops phaleratus			2.0					
Cryptocyclops bicolor			4.0	1.6				
Diacyclops bicuspidatus			4.0	1.6				
Cyclopoida – samce		2.0						0.4
kopepodit Cyclopoida	3.3	16.0	60.0	4.8	50.3	17.2	25.4	21.6
nauplii Cyclopoida	3.3	40.0	154.0	20.8	207.0	132.2	125.2	102.0
Megacyclops viridis		2.0						
kopepodit Calanoida					12.7	6.4	5.4	7.6
nauplii Calanoida					50.0	12.0	15.4	52.0
Total Copepoda	**6.7**	**62.0**	**224.0**	**28.8**	**330.3**	**168.2**	**171.4**	**183.6**
Total zooplankton	**456.7**	**160.0**	**458.0**	**180.8**	**1683.3**	**629.6**	**271.0**	**477.6**

While studying the biomass of zooplankton collected from the ponds in question, a significant advantage of the volume of biomass in Żelisławiec was observed. Despite the small number, the largest biomass comprised water fleas (88.96 mg·dm^{-3}). Another group consisted of copepods and the smallest biomass was observed in the case of rotifers (Figure 1).

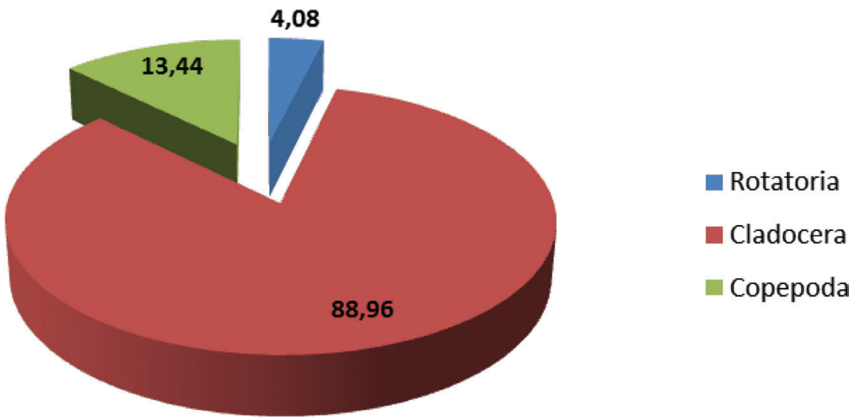

Figure 1. Total biomass (mg·dm^{-3}) of each zooplankton group in both studied ponds in the years 2011 – 2013

Overall, higher concentration of total biomass was observed in points L1, L2 and L3 in Żelisławiec than in the corresponding points in the pond in Stare Czarnowo (Table 5). The biggest biomass in the Żelisławiec pond was observed in the case of Cladocera and amounted to 4.549 mg·dm^{-3} which constituted 67% of the biomass of zooplankton in the littoral of this pond. For comparison, Cladocera also constituted the biggest biomass of zooplankton in the Stare Czarnowo pond, but it only amounted to 46%. The overall biomass of zooplankton in the littoral of the Żelisławiec pond was 67% and 33% in Stare Czarnowo.

Table 5. Mean biomass of zooplankton [mg·dm^{-3}] in each point in the midfield ponds in the years 2011 – 2013

Taxon	Stare Czarnowo				Żelisławiec			
	P	L1	L2	L3	P	L1	L2	L3
Rotifera	0.843	0.112	0.129	0.225	0.841	0.341	0.097	0.193
Cladocera	0.000	1.180	0.200	0.160	0.781	2.508	0.934	1.107
Copepoda	0.018	0.580	0.659	0.134	3.645	0.474	0.467	0.675
Total zooplankton	**0.862**	**1.872**	**0.988**	**0.518**	**5.267**	**3.323**	**1.498**	**1.974**

The annual increase in the number of zooplankton taxa was observed within the three-year period of studies. The smallest number of taxa in the Stare Czarnowo pond was observed in 2012 when water fleas were not detected and the number of rotifers and copepods was also smaller than in the Żelisławiec pond (Figure 2).

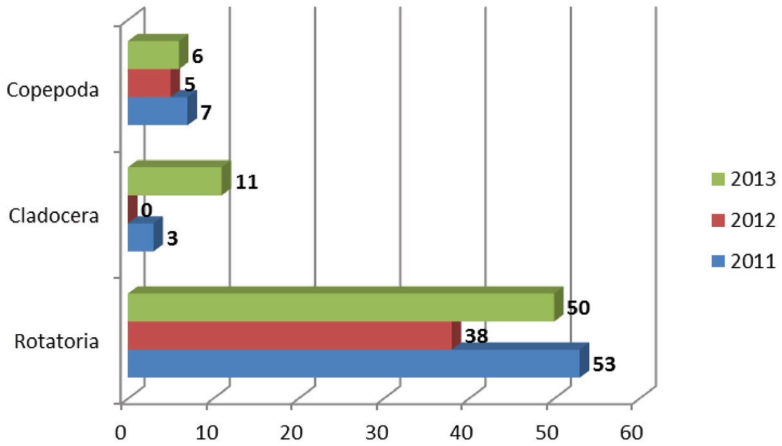

Figure 2. Number of taxa of each zooplankton group of the Stare Czarnowo pond in the three years of studies (2011-2013)

The Żelisławiec pond was characterised by a smaller number of taxa from groups of copepods, which was smaller than in the other pond in each year (Figure 3).

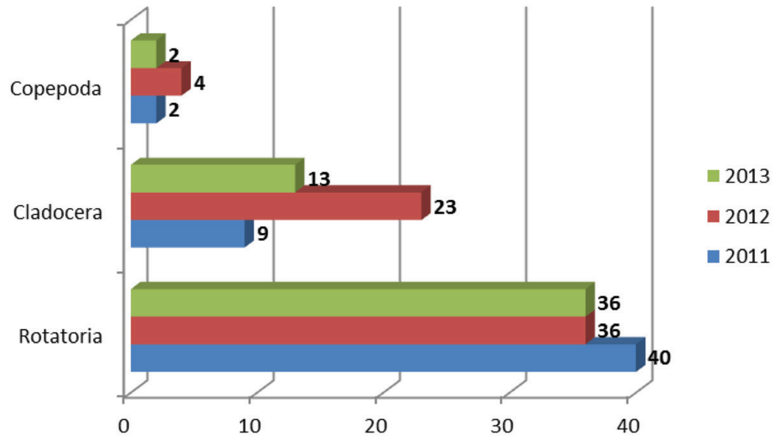

Figure 3. Number of taxa of each zooplankton group of the Żelisławiec pond in the three years of studies (2011-2013)

DISCUSSION

The quantitative, qualitative and size composition of plankters and products of their metabolism affect the quality of water and its usability in recreation and human activity (Grabowska 2008). The species composition of zooplankton characteristic of similar reservoirs was observed in two studied ponds Stare Czarnowo and Żelisławiec (Segers 2008). Clear domination of rotifers over crustaceans been previously demonstrated in regards to the number of taxa and their number (Karabin 1985, Kuczyńska-Kippen 2009).

Certain regularities can be observed in the qualitative distribution in each point although the points located in the pelagial zone were the poorest taxonomically in the case of both ponds. Mainly, this is a phenomenon typical for large reservoirs, where the littoral is normally richer in species than the open-water zone due to the presence of many hideaways. In relatively shallow ponds, which are similar to ponds, the possibility of migration between the littoral and the pelagial zone is more common and therefore qualitative differences between the two zones are not encountered.

It is worth noting the absence of water fleas in the pelagial zone in Stare Czarnowo and the occurrence of only two representative of this group in Żelisławiec – *Daphnia hyaline* and *Chydorus sphaerictus*. The small number of these taxa may be associated with high predatoriness of plankton feeders. The predators, as opposed to water fleas, have significantly better motor abilities, which substantially facilitate feeding. Copepods handle it better because they can avoid their predators more effectively (Pont and Amrani, 1990). The small number of rotifers and water fleas in Stare Czarnowo in the summer could have been caused by progressing recession of the pond. For comparison, in Żelisławiec in the summer crustacean plankton was relatively abundant especially in typically littoral species such as *Scapholeberis mucronata*.

The domination of rotifers is typical of such small and misfiled water ecosystems (Kuczyńska-Kippen 2009). A great value of zooplankton biomass in both ponds is normally dominated by water fleas due to their large size, predominantly when there is no factor that restricts them (Carpenter 1985). The bigger contribution of biomass in the Żelisławiec pond was affected by reduction of rotifers by the filtration mechanisms of large water fleas (Dieguez and Gilbert 2011).

Differences in zooplankton biomass between the two ponds resulted from bigger concentration of the largest water flea species – *Daphnia hyaline* and *Daphnia longispina* in the Żelisławiec pond. This total disappearance in the pelagic zone phenomenon was not observed in Stare Czarnowo, where the main component of zooplankton were large copepods that, however, do not reach such individual mass as water fleas. The cause of such significant concentration of large plankters could have been small pressure from fish, which only began to feed on bigger plankton. This explanation is substantiated by a rapid decrease in the number of water fleas and copepods during the studies, especially their nearly total disappearance in the pelagic zone.

In addition, it has to be noted that the quality of water cannot be determined unambiguously on the basis of the qualitative composition of both ponds because the species occurring in them are characteristic of both the low and high trophies species referred to as characteristic of oligosaprobic and mesosaprobic waters were found in both ponds. For example, in Stare Czarnowo it was a copepod – *Megacyclops viridis* (absent in the other pond). In Żelisławiec it was also a copepod – *Euczclops macruroides.* This species was not detected in the Stare Czarnowo pond. The presence of the aforementioned copepods may indicate small contamination of both ponds with decomposing organic matter.

CONCLUSIONS

1. Rotifers were the dominant group of zooplankton in the studied ponds.
2. The species that were found and determined during the studies belonged to common species observed in such water reservoirs in Poland.

3. Higher taxonomic diversity was observed in Stare Czarnowo, where 40 taxa were observed which was by 12.5% higher than Żelisławiec (35 taxa).
4. The Jaccard similarity coefficient calculated for the studied ponds was 0.36, which confirms small qualitative similarity between the ponds.
5. Both reservoirs contained representatives of species defined as characteristic for oligosaprobic and mesosaprobic waters, which may indicate small contamination of the two ponds with decomposing organic matter.

REFERENCES

Bernaciak A., Spychała M., Korytowski M., Powolna P. (2015). *Mała retencja wodna w programach ochrony środowiska gmin Nadwarciańskich*. Inżynieria Ekologiczna, Vol. 44, 121-130.

Bieroński J. (2005). *Zbiorniki małej retencji – problemy funkcjonowania*. Struktura przestrzenno-funkcjonalna krajobrazu, Vol. 17, Uniwersytet Wrocławski, Wrocław, 101-110.

Czerniawski R., Popko R., Krepski T., Domagała J. (2013). *Invertebrates of three small ponds located in stream-pond system*. Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 10, 14-22.

Diéguez, M.C., Gilbert, J.J. (2011). *Daphnia–rotifer interactions in Patagonian communities*. Hydrobiologia, 662 (1), 189-195.

Downing J.A. (2010). *Emerging global role of small lakes and ponds: Little things mean a lot.* Limnetica. Vol. 29. No. 1 s. 9-24.Ejsmont-Karabin J. (1998). *Empirical equations for biomass calculation of planktonic rotifers*. Pol. Arch. Hydrobiol., 45, 4, 513-522.

Grabowska M. (2008). *Charakterystyka fitoplankotnu*. W: Różnorodność badań botanicznych, 50 lat Białostockiego Oddziału Polskiego Towarzystwa Botanicznego 1958-2008. Wydawnictwo Ekonomia i Środowisko, Białystok, 13-24.

Karabin A. (1985). *Pelagic zooplankton (Rotatoria + Crustacea) variation in the process of lake eutrophication*. 1. Structural and quantitative features. Pol. J. Ecol. 33, 567-616.
Kawecka B., Eloranta P.V. (1994). *Zarys ekologii glonów wód słodkich i środowisk lądowych*. Wydawnictwo Naukowe PWN, Warszawa, ISBN: 83-01-11320-0.

Kraska M., Kaniecki A. (1995). *Mała retencja wodna w Wielkopolsce i jej uwarunkowania przyrodnicze*. W: Ekologiczne aspekty melioracji wodnych. Pr. zbior. Red. L. Tomiałojć. Kraków: IOPPAN, 123-139.

Kuczyńska-Kippen N. (2009). *The spatial segregation of zooplankton communities with reference to land use and macrophytes in shallow Lake Wielkowiejskie (Poland).* Int. Rev. Hydrobiol. 94, 267-281.

Pont D., Amrani J. (1990). *The effects of selective fish predation on the horizontal distribution of pelagic Cladocera in a southern French reservoir*. Hydrobiologia, Vol. 207, Iss. 1, 259-267.

Raniszewska M., (2009). *Zmiany we florze śródleśnych oczek wodnych Puszczy Goleniowskiej zachodzące wskutek różnorodnego ich użytkowania.* W: II Ogólnopolska Konferencja Naukowa w Augustowie, Mokradła i ekosystemy słodkowodne – funkcjonowanie, zagrożenia i ochrona, 18– 20.06.2009, 134-135.

Segers H. (2008). *Global diversity of rotifers (Rotifera) in freshwater*. Hydrobiologia 595, 49-59.

Corresponding author: Eng. Adam Brysiewicz, PhD
Institute of Technology and Life Sciences
Kuyavian-Pomeranian Research Centre
Czesława 9,
71-504 Szczecin, Poland
Tel./fax 91 423 1908
e-mail: a.brysiewicz@itp.edu.pl

Eng. Marek Jankowski, MSc
Eng. Adam Tański, PhD, DSc
The West Pomeranian University of Technology in Szczecin,
Department of Hydrobiology, Ichthyology and Biotechnology of Reproduction
Kazimierza Królewicza 4,
71-550 Szczecin, Poland
e-mail: adam.tanski@zut.edu.pl

Received: 10.09.2017
Accepted: 29.11.2017