Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2008, 5, 85–94

THE SPATIAL STRUCTURE OF ZOOPLANKTON COMMUNITIES AND TROPHIC STATE OF MID-CITY STRZESZYŃSKIE LAKE

Natalia Kuczyńska-Kippen, Kasper Świdnicki

Department of Water Protection, Adam Mickiewicz University,
Umultowska str. 89, 61–614 Poznań, kippen@hot.pl

Summary. Studies on Strzeszyńskie Lake were conducted in May and June 2007. The main aim of this study was to compare the composition and dynamics of the zooplankton communities between two different zones: the open water area and the littoral zone (including *Chara tomentosa* and *Typha angustifolia* stands). The stand located within *Chara tomentosa* possessed the highest number of identified species and most abundant zooplankton communities, while the station located within the pelagic zone was characterised by the poorest taxonomic structure and the lowest mean zooplankton densities for both rotifers and crustaceans. Zooplanktonic organisms moved in a horizontal direction in order to avoid predators. In the littoral zone, markedly high densities of pelagic species were also recorded. Furthermore, in the zone of stoneworts six *Chara*-associated species were found. The open water zone of Strzeszyńskie Lake was dominated by limnetic species, while within macrophyte-dominated stands a more diverse dominating structure occurred, representing both limnetic and littoral species. Among dominating species the presence of species indicating low trophic conditions was recorded. The low state of the trophic conditions of the water of Lake Strzeszyńskie was also confirmed by the participation of mesotrophic species in the total zooplankton abundance which reached between 14 and 72%.

Key words: rotifers, crustaceans, habitat selectivity, mid-city lake

INTRODUCTION

The quality of surface waters of lakes is influenced by many environmental parameters, however, the character of the direct catchment area surrounding a lake may often play a decisive role. The number of inflowing nutrients, particularly phosphorus and nitrogen, which can lead to a considerable enrichment of plant and other organic productivity in freshwaters, is often con-

nected with the kind of land use in areas neighbouring a lake [Kuczyńska-Kippen *et al.* 2003]. Not only the direct catchment area, e.g. the degree of agriculture or industry, will influence the degradation of surface waters but also any enrichment from further areas, e.g. acid rains, may contribute to a decrease in the chemical and biological quality of water. Such a eutrophication process may result in accelerated rates of decomposition and in changes in chemical features which to a large extent reduce or even eliminate the available habitat for many species of plants and animals [Wetzel 2001]. This is why controlling local biodiversity is so important.

Zooplankton may be used in monitoring the state of inland waters for many of their characteristics which can make them valuable bioindicating organisms. They are among the most common elements of water ecosystems. They consist of nearly 3.000 species and their geographical distribution is cosmopolitan. Representatives of zooplankton, apart from some forms that are predacious, feed mainly on algae, protozoans, bacteria, organic matter and periphyton [Gons 1979, Jürgens *et al*. 1994, Theil-Nielsen and Søndergaard 1999]. Many of them have already been described as excellent indicators of water quality and water pollution [Mäemets 1983, Sládeček 1983, Saksena 1987].

Habitat structure is one of the fundamental factors determining the distribution of organisms on all spatial scales, and vegetation is of primary importance in shaping the structural environment for invertebrates in many systems [McAbendroth *et al*. 2005], contributing to an increase in the biodiversity level of a particular environment.

To determine the influence of differentiated habitats (two vegetated habitats and the open water zone) on zooplankton abundance and species composition, planktonic components were sampled in Strzeszyńskie Lake, situated within the borders of the city of Poznań. Thus, the aim of this study was to compare the structure of both rotifer and crustacean communities inhabiting various habitats and also to analyse the trophic conditions of the waters based on zooplankton communities.

MATERIALS AND METHODS

Strzeszyńskie Lake, which is of post-glacial origin, is located within the borders of the city of Poznań (52º27.7';16º49.5'). It is a dimictic lake with an area of 34.9 ha, maximum depth of 17.8 m and mean depth of 8.2 m. A belt of rushes with predominant *Typha angustifolia* L. and also *Cladium mariscus* (L.) Pohl. surrounds the lake along the western shore. Among submerged macrophytes *Chara tomentosa* (L.), *Myriophyllum spicatum* (L.) and *Potamogeton lucens* (L.) occur [Szeląg-Wasielewska 2005].

The direct catchment area is covered by forests and meadows; the eastern part of the lake is a popular place for weekend and summer recreation for local

inhabitants [Szeląg-Wasielewska 2005]. It is the cleanest lake within the city of Poznań.

Strzeszyńskie Lake is managed by the Polish Angling Society of Poznań.

Research on the spatial and temporal distribution of zooplankton communities was carried out in May and June 2007.

The zooplankton samples were taken in four repetitions (N = 24) at each site using a plexiglass core sampler (method for sampling in the littoral zone recommended by e.g. Schriver *et al*. [1995]) in the littoral zone and a calibrated vessel of a volume of 5L in the open water area.

To estimate the species diversity of rotifers inhabiting particular zones in the lake the Shannon-Weaver index was applied [Margalef 1957].

Additionally, the Mann-Whitney U-test was applied in order to determine the effect of site on the distribution of zooplankton densities (N = 24).

RESULTS

The presence of 97 zooplankton species in total (65 Rotifera, 23 Cladocera and 9 Copepoda) was found in Strzeszyńskie Lake during the examinations carried out in May and June of 2007.

The station located within the pelagic zone was characterised by the poorest taxonomic structure (34 species) as compared to the vegetated zones. The stand located within *Chara tomentosa* possessed the highest number of identified species (84), followed by the rush zone dominated by *Typha angustifolia* (71).

The mean zooplankton densities differed significantly between the examined stations (Rotifera – $Z = -2.2054$, $p < 0.05$; Crustacea – $Z = -3.3607$, $p < 0.01$). The zone within the stoneworts was characterised by the highest mean abundance of zooplankton communities, both rotifers and crustaceans, with the maximum values obtained for rotifers. The lowest mean zooplankton densities were noted in the open water area, compared to the remaining stations (Fig. 1).

Analysing single zooplankton species a similar spatial distribution pattern was observed. Significant differences between particular stations were recorded for the following species: *Conochilus hippocrepis* (Schrank) ($Z = -3.1506$, $p < 0.01$), *Acroperus harpae* (Baird) ($Z = -2.9931$, $p < 0.01$), *Alonella nana* (Baird) ($Z = -2.7831$, $p < 0.01$), *Simocephalus exspinosus* (Koch) ($Z = -2.5205$, $p < 0.05$), *Acanthocyclops viridis* (Jurine) ($Z = -2.4155$, $p < 0.05$), *Harpacticoidae* ($Z = -25205$, $p < 0.05$) (Fig. 2).

The mean Shannon-Weaver biodiversity index values ranged from 0 to 2.14, with the lowest values within the open water zone and the highest among vegetated beds, especially in the samples collected in June. In most cases crustacean communities were characterised by higher values of the biodiversity index (Fig. 3).

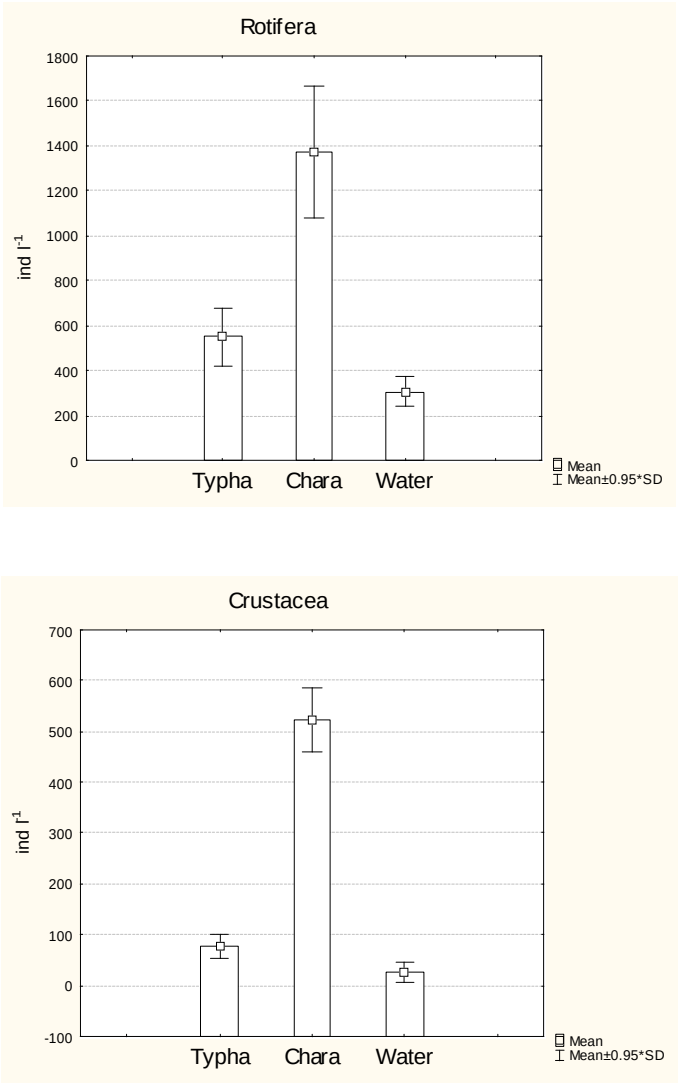
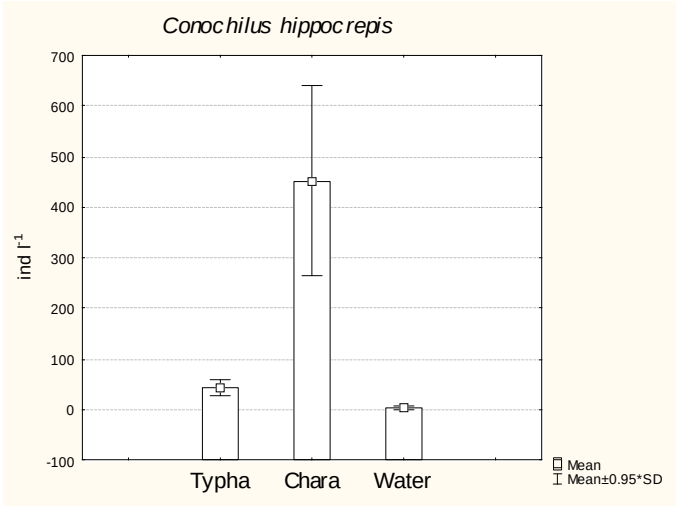


Fig. 1. The mean densities of zooplankton communities (Rotifera and Crustacea) in in the examined lake (Typha – *Typha angustifolia*; Chara – *Chara tomentosa*; Water – open water zone), irrespective of the examination season

The dominance structure comprised a total of 14 zooplankton species, 6 rotifer and 8 crustacean (Tab. 1). In the open water area only 4 dominating species were found – *Gastropus stylifer* Imhof, *Kellicottia longispina* (Kellicott), *Keratella cochlearis* (Gosse) and *Bosmina coregoni* Baird. The vegetated stands were characterised



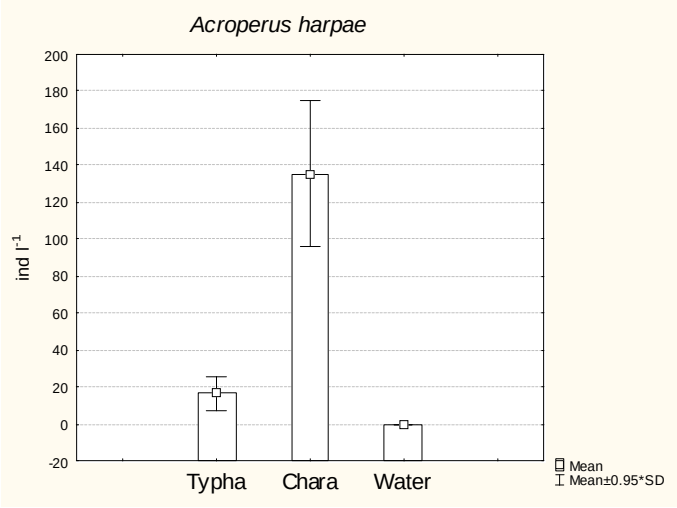


Fig. 2. Habitat preferences of particular zooplankton species in the examined lake (Typha – *Typha angustifolia*; Chara – *Chara tomentosa*; Water – open water zone), irrespective of the examination season

by a more diverse dominating structure, with up to 9 species among the cattail stand. *K. longispina* dominated in five out of six analysed sampling stations while *C. hippocrepis*, *A. harpae* and *A. nana* in three. The open water zones were dominated mainly by limnetic species, while within vegetated stands both limnetic and littoral species occurred.

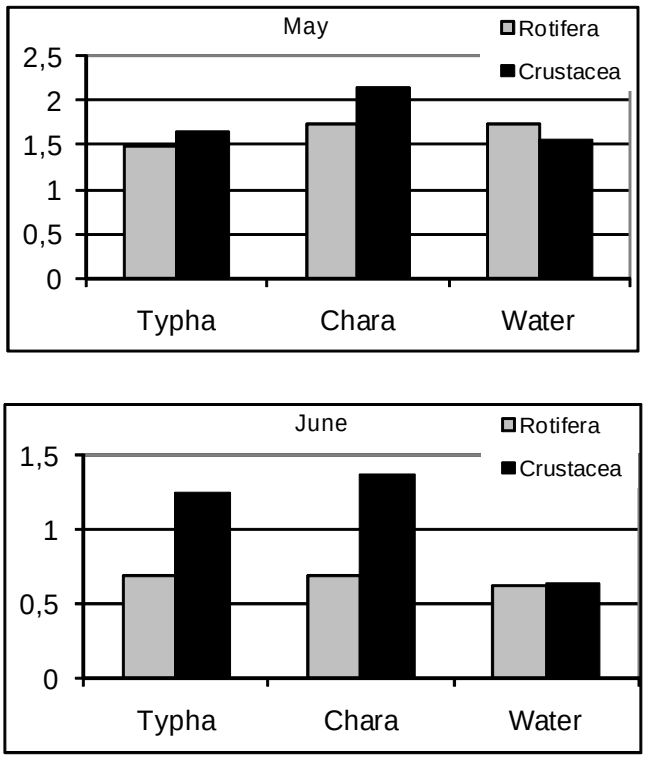


Fig. 3. The biodiversity index of zooplankton communities in the examined lake (Typha – *Typha angustifolia*; Chara – *Chara tomentosa*; Water – open water zone) in two seasons

Table 1. Dominating species in particular stations in Strzeszyńskie Lake in 2007

Station	Typha	Chara	Water	Typha	Chara	Water
Season	May			June		
Ascomorpha saltans				x		
Conochilus hippocrepis		x		x	x	
Gastropus stylifer						x
Kellicottia longispina	x	x	x		x	x
Keratella cochlearis	x	x	x			
Synchaeta pectinata	x					
Acroperus harpae		x		x	x	
Alonella nana		x		x	x	
Eubosmina coregoni	x					x
Ceriodaphnia pulchella					x	
Ceriodaphnia quadrangula					x	
Pleuroxus truncatus				x		
Simocephallus exspinosus	x					
Harpacticoidae	x					

Analysis of the trophic conditions of the examined water body revealed that species characteristic for eutrophic conditions contributed between 1 and 12% of the total zooplankton densities, while species indicating mesotrophic conditions between 14 and 72%, depending on the examined station.

DISCUSSION

The distribution of aquatic organisms in a lake is often related to predation pressure, to optimal nutrition opportunities as well as to adaptations of particular species to pelagic or littoral habitat conditions.

Most rotifers and crustaceans are not planktonic forms but are associated with macrophyte habitats. Many authors have already confirmed the fact that the littoral area harbours much richer zooplankton communities, especially macrophytes with finely divided stems or leaves which represent submerged vegetation [Radwan *et al*. 1998, Kuczyńska-Kippen and Nagengast 2006, Kuczyńska-Kippen 2006, 2007].

In the case of the examined lake there were no species that exclusively prevailed in the open water area or among cattails, while six species selected stoneworts (*C. hippocrepis*, *A. harpae*, *A. nana*, *S. exspinosus*, *A. viridis*, *Harpacticoidae*). The harpacticoid copepods are littoral-associated forms, inhabiting a wide range of vegetated habitats as well as littoral sediments. Their mouth parts are adapted for seizing and scraping particles from the substratum. Moreover, two representatives of the family chydoridae (*A. harpae* and *A. nana*) are well adapted to living in macrophytes as they are also able to scrape up pieces of detrital material [Węgleńska and Rybak 1998, Wetzel 2001], one of the most important food sources in the vegetated area. The littoral zone provides zooplankton with phytoplankton present in the interstem spaces, but also periphyton enriched with great amounts of detritus accompanied by bacteria and protozoans [Gons 1979]. The specific morphology and complexity of an aquatic plant may also affect the type of periphyton available, which may provide the best nutritional conditions in the densest and most complicated habitat [Messyasz and Kuczyńska-Kippen 2006]. Such a bed of stoneworts occurred in Strzeszyńskie Lake and thus this macrophyte stand was preferred by a majority of zooplankters. Also the specificity of a macrophyte area influenced species richness and the mean Shannon-Weaver biodiversity index values which reached the highest values in the zone of *Chara tomentosa*, while the lowest values were characteristic in most cases for the most homogenous zone – the open water.

The structural complexity of aquatic vegetation is likely to provide a wide variety of potential refuges for both rotifers and crustaceans from predators and this is why a greater abundance of this group of animals as well as six *Chara*-associated species were found in more heterogeneous habitats. Walsh [1995] no-

ticed that increasing complexity of plant architecture supports organisms by offering better protection from predators. Densities of planktonic communities are usually less abundant [Wetzel 2001]. This was found in the case of Strzeszyńskie Lake. The great diversity and higher densities of littoral communities are a result of a more variable structure of sessile forms of zooplankton. However, planktonic organisms utilise vegetated zones as a day-time refuge against predators [Węgleńska and Rybak 1998]. Moreover, fish may also have a direct impact on zooplankton densities as well as habitat selectivity since they also select certain macrophyte species for shelter sites [Petr 2000]. In Strzeszyńskie Lake the presence of numerous fish species was recorded, including the vendace (*Coregonus albula*), European carp (*Cyprinus carpio*), common eel (*Anguilla anguilla*), common bream (*Abramis brama*), tench (*Tinca tinca*), northern pike (*Esox lucius***)**, white bream (*Blicca bjoerkna*), bleak (*Alburnus alburnus***)**, roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), crucian carp (*Carassius carassius*) and gudgeon (*Gobio gobio*).

In addition, comparing the zooplankton communities from Strzeszyńskie Lake from 2004 [Kuczyńska-Kippen *et al*. 2004, Nowosad *et al*. 2007] with the present study a quantity dominance of rotifers over crustaceans was found, which reflects an exploitative competition between both groups of animals. This is also connected with the presence of 'small' and 'large' forms of algae which constitute a food base for zooplankton [Lampert and Sommer 1996].

The open water zone of Strzeszyńskie Lake was dominated by limnetic species (*G. stylifer, K. longispina*, *K. cochlearis* and *B. coregoni*), while within macrophyte-dominated stands a more diverse dominating structure occurred, representing both limnetic and littoral species. The relatively high participation of species of limnetic origin (e.g. *K. longispina*, *K. cochlearis* and *Synchaeta pectinata* Ehrb.) within stands of aquatic vegetation is a result of their seeking refuge among architecturally complex habitats as well as of interactions between macrophyte-associated zooplankton and organisms which remain temporarily or permanently in the water within the plant stand [Jeppesen *et al*. 1998]. Moreover, in the structure of dominating species a presence of three species (*C. hippocrepis*, *G. stylifer*, *K. longispina*) indicating low trophic conditions [Karabin 1985, Radwan *et al*. 2004] were recorded. The participation of the mesotrophic species in the total zooplankton abundance, reaching 14–72%, confirmed the quite low state of trophic conditions of water of Strzeszyńskie Lake.

CONCLUSIONS

1. The analysis of rotifer and crustacean plankton community structure of Lake Strzeszyńskie revealed a horizontal differentiation in the case of species diversity.

2. The littoral zone was characterised by higher species richness and higher abundance of both groups of zooplankton. At the same time rotifers dominated over crustaceans.
3. The indicator species of zooplankton confirmed the mesotrophic character of the waters of the examined lake.

REFERENCES

Bielańska-Grajner I., Radwan S., 1997. *Arthropoda* – Stawonogi [in:] Razowski J. (ed.), A list of animals of Poland (in Polish). Wydawnictwa Instytutu Systematyki i Ewolucji Zwierząt PAN, Kraków, vol. IV, part I–XXXI.

Gons H.J., 1979. Periphyton in Lake Vechten, with emphasis on biomass and production of epiphytic algae. Hydrobiol. Bull. 13, 116.

Jeppesen E., Lauridsen T.L., Kairesalo T., Perrow M.R., 1998. Impact of submerged macrophytes on fish-zooplankton interactions in lakes [in:] E. Jeppesen, Ma. Søndergaard, Mo. Søndergaard and K. Christoffersen (eds), The structuring role of submerged macrophytes in lakes. Ecological Studies, Series 131, 91–114, Springer, New York.

Jürgens K., Arndt H., Rothhaupt K.O., 1994. Zooplankton-mediated changes of bacterial community structure. Microbiol. Ecol. 27, 27–42.

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

Kuczyńska-Kippen N., Messyasz B., Nagengast B., 2003. The influence of increasing uncontrolled recreation on the structure of plankton and macrophyte communities in the tunnel-valley lakes located in agricultural catchment area. Rocz. AR w Poznaniu, CCCLIV, Bot. 6, 107–119.

Kuczyńska-Kippen N., Nowosad P., Grzegorz G. 2004. Stan hydrobiologiczny jezior Wielkopolskiego Narodowego i zbiorników rekreacyjnych miasta Poznania. Rocz. AR w Poznaniu CCCLXIII, 193–200.

Kuczyńska-Kippen N., 2006. Zooplankton structure in architecturally differentiated macrophyte habitats of shallow lakes in the Wielkopolska region, Poland. Oceanol. Hydrobiol. Stud. XXXV/2, 179–191.

Kuczyńska-Kippen N., 2007. Habitat choice in Rotifera communities of three shallow lakes: impact of macrophyte substratum and season. Hydrobiologia 593, 27–37.

Kuczyńska-Kippen N., Nagengast B., 2006. The influence of the spatial structure of hydromacrophytes and differentiating habitat on the structure of the rotifer and cladoceran communities. Hydrobiologia 559, 203–212.

Lampert W., Sommer U., 1996. Ekologia wód śródlądowych. PWN, Warszawa, 415 pp.

Mäemets A., 1983. Rotifers as indicators of lake types in Estonia. Hydrobiologia 104, 357–361.

Margalef R., 1957. Information theory in ecology. Gen. Syst. 3, 36–71.

McAbendroth L., ORamsay P.M., Foggo A., Rundle S.D., Bilton D.T., 2005. Does macrophyte fractal complexity drive invertebrate diversity, biomass and body size distribution? Oikos 111/2, 279–290.

Messyasz B., Kuczyńska-Kippen N., 2006. Habitat selectivity of epiphytic algae communities: a comparison of the rushes and stoneworts zones in three shallow lakes (Wielkopolska, Poland). Polish J. Ecol. 54/1, 15–27.

Nowosad P., Kuczyńska-Kippen N., Słodkowicz-Kowalska A., Majewska A.C., Graczyk T.K.,

2007. The use of rotifers in detecting protozoan parasite infections in recreational lakes. Aquatic Ecology 41, 47–54.

Petr T., 2000. Interactions between fish and aquatic macrophytes in inland waters. A review. FAO Fisheries Technical Papers, 185 pp.

Radwan S., Bielańska-Grajner I., Ejsmont-Karabin J., 2004. Rotifers *Rotifera*. Freshwater fauna of Poland (in Polish). Oficyna Wydawnicza Tercja, 447 pp.

Radwan S., Bielańska-Grajner I., Popiołek B., 1998. Rotifers community in different littoral biotopes and in the pelagic zone of Polesie lakes (in Polish). Ekotony słodkowodne. Struktura – Rodzaje – Funkcjonowanie. UMCS, 284 pp.

Saksena D.N., 1987. Rotifers as indicators of water quality. Acta Hydrochim. Hydrobiol. 15, 481–485.

Schriver P.J., Bøgestrand E., Jeppesen E., Søndergaard M., 1995. Impact of submerged macrophytes on fish-zooplankton-phytoplankton interactions: large scale enclosure experiments in a shallow eutrophic lake. Freshwat. Biol. 33, 255–270.

Sládeček V., 1983. Rotifers as indicators of water quality. Hydrobiologia 100, 169–201.

Szeląg-Wasielewska E., 2005. Cyanobacteria in a slightly eutrophic lake: seasonal fluctuations and contribution to total phytoplankton. Oceanol. Hydrobiol. Stud. XXXIV/3, 115–124.

Theil-Nielsen J., Søndergaard M., 1999. Production of epiphytic bacteria and bacterioplankton in three shallow lakes. Oikos 86, 283–292.

Walsh E.J., 1995. Habitat-specific predation susceptibilities of a littoral rotifer to two invertebrate predators. Hydrobiologia 313–314, 205–211.

Wetzel R.G., 2001. Limnology: Lake and River Ecosystems. Third Edition. Academic Press, 1006 pp.

Węgleńska T., Rybak J.I., 1998. Diurnal horizontal migration of planktonic crustaceans between aggregations of littoral plants and open water (in Polish). Ekotony slodkowodne. Struktura – Rodzaje – Funkcjonowanie. UMCS, 284 pp.

STRUKTURA PRZESTRZENNA UGRUPOWAŃ ZOOPLANKTONU I WARUNKI TROFICZNE ŚRÓDMIEJSKIEGO JEZIORA STRZESZYŃSKIEGO

Streszczenie. Badania prowadzono na Jeziorze Strzeszyńskim w maju i czerwcu 2007 r. Głównym celem tych badań było porównanie kompozycji gatunkowej i dynamiki ugrupowań zooplanktonu pomiędzy dwoma zróżnicowanymi strefami zbiornika: otwartą tonią wodną i strefą litoralu, w skład której wchodziły stanowiska zlokalizowane w obrębie ramienic (*Chara tomentosa*) i strefy szuwarowej (*Typha angustifolia*). Stanowisko w obrębie płatu ramienicy miało najbogatszą strukturę taksonomiczną oraz najliczniejsze ugrupowania zooplanktonu, podczas gdy stanowisko zlokalizowane w obrębie otwartej toni wodnej charakteryzowało się najuboższą kompozycją gatunkową oraz najniższymi liczebnościami zarówno zbiorowisk wrotków, jak i skorupiaków. Organizmy zooplanktonowe wykazały typ poziomego zróżnicowania, który jest charakterystyczny dla jezior z silną presją drapieżniczą ryb planktonożernych. W strefie litoralu, poza organizmami typowo przystosowanymi do życia w obrębie roślinności wodnej, odnotowano także liczny udział organizmów typowo pelagicznych. Strefa toni wodnej zdominowana była przez gatunki limnetyczne, podczas gdy w obrębie siedlisk roślinnych odnotowano bardziej różnorodną strukturę dominacji, obejmującą zarówno gatunki pelagiczne, jak i litoralowe. Również w obrębie gatunków dominujących wykazano obecność organizmów wskaźnikowych dla wód o niskiej trofii, co również znalazło potwierdzenie w udziale gatunków mezotroficznych, stanowiących od 14 do 72% całkowitej liczebności ugrupowań zooplanktonu tego śródmiejskiego jeziora.

Słowa kluczowe: wrotki, skorupiaki, wybiórczość siedliskowa, jezioro śródmiejskie