Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2009, 6, 153–161

ZOOPLANKTON COMMUNITY STRUCTURE OF FIVE NEIGHBOURING SMALL WATER BODIES OF ANTHROPOGENIC ORIGIN

Natalia Kuczyńska-Kippen, Małgorzata Wiśniewska, Tomasz Joniak

Department of Water Protection, Adam Mickiewicz University,
Umultowska str. 89, 60–614 Poznań, kippen@hot.pl

Summary. Spatial patterns in species richness and zooplankton community composition were documented with respect to five different small water bodies of anthropogenic origin, neighbouring each other, and in relation to a particular habitat within one pond. As a result of the present study the presence of a total of 84 zooplankton species was found. The number of zooplankton species differed between the particular water bodies and between the three examined habitats (open water, *Potamogeton natans*, *Ceratophyllum demersum*). Aquatic vegetation stands were characterised by considerably richer communities compared to the open water zone. Rotifers dominated over crustaceans taxonomically and in abundance, which is typical for ponds with fish predation present and also for water bodies of high trophic conditions. The eutrophic conditions in all the examined ponds was confirmed by the dominating species, where *Anuraeopsis fissa* and *Keratella cochlearis* f. *tecta* prevailed. Only in the case of crustacean densities were differences between particular water bodies and between three different habitats significant. Among single species, *Ceriodaphnia quadrangula* revealed significant differences between each of the five ponds and the examined habitats. The higher densities of this cladoceran among *Ceratophyllum demersum* and the lowest in the open water area suggest more advantageous refuge conditions within the dense and most complex vegetation stand in the pond with fish predation.

Key words: rotifers, crustaceans, macrophytes, eutrophic conditions

INTRODUCTION

The functioning of small water bodies differs from that of lakes in many respects, including the spatial and vertical distribution of physicochemical parameters and also their biological features, although, in both types of reservoirs aquatic plants may play an important role in the structuring of freshwater communities [Meerhoff *et al*. 2003, Kuczyńska-Kippen and Nagengast 2006a].

Moreover, the functioning of a number of inland water bodies, and especially of mid-field ponds, will also depend on water level fluctuations, which is a typical feature of small and shallow reservoirs [Kuczyńska-Kippen 2006, Kuczyńska-Kippen and Nagengast 2006b] affecting both their inhabitants and pond functioning. The transformation of life cycles and processes within the smaller ponds is the fastest, as these warm up a lot quicker than larger and much deeper ponds.

Water level changes, especially within short periods of time, may contribute to the variation in the life cycles and processes in shallow ponds and also lead to the impoverishment of aquatic vegetation cover and, in consequence, to the impoverishment of the structure of other organism communities that inhabit the differentiated habitats of a small water body [Kuczyńska-Kippen 2006].

The aquatic vegetation of small water bodies, which creates here a mosaic structure [Ozimek and Rybak 1994], often overgrowing the whole pond bottom, may be an effective refuge for zooplankton organisms against both invertebrate predators and young stages of fish, and may also have an impact on the nutritional conditions for animals [Degans and De Meester 2002], the availability of which differs between the pelagic and littoral zones [Messyasz and Kuczyńska-Kippen 2006, Joniak *et al.* 2007].

Rotifers and larger crustaceans among vegetated sites actively search for concealment against predators [Williamson 1983a, b, Telesh 1993], and the refuge effectiveness may differ depending on the spatial and morphological structure of a plant stand or the structure of young fish which also utilise macrophytes as concealment against predatory fish [Cyr and Downing 1988, Chick and McIvor 1994, Lauridsen and Lodge 1996].

Small water bodies influence the water balance, the speed of outflow, and also a small degree of water retention [Bałazy and Ryszkowski 1992]. The ponds that underwent the present examination were located in the Gniezno Lake District where water deficiency occurs. Therefore, monitoring of such endangered ecosystems is particularly essential. Thus the aim of the present study was to analyse the structure of zooplankton communities in five small water bodies located within the pastoral catchment area. They were situated within small distances between each other (< 0.5 km). Moreover, in the case of one water body, a thorough analysis concerned zooplankton communities inhabiting different habitats, including the open water zone and two different plant stands – nymphaeids and elodeids.

MATERIAL AND METHODS

The investigation was carried out on five small mid-field ponds (Cotoń, Cotoń Dziadkowy, Cotoń Pijawka, Przysieka, Cotoń Oczko) located within the area of the Gniezno Lake District (Żnin District, Kujawsko-Pomorskie voivodeship; 52°40'N, 17°39'E). They were all situated within a short distance (less than

0.5 km) of each other. The area of examination is characterised by very low precipitation, which is responsible for supplying the upland areas with water [Łoś and Zań 2000].

The investigated ponds are all of anthropogenic origin. They originated several dozen years ago during the process of peat excavation. Cotoń Oczko is the youngest water body, having been dug approximately three years prior to the examination.

Zooplankton material was collected in June of 2006. The zooplankton samples were taken in triplicate at each site using a calibrated vessel in the case of the pelagic zone and a plexiglass core sampler (∅ 50 mm), which is the method advised for studies within the littoral zone [Schriver *et al*. 1995], in the case of vegetated habitats (*Potamogeton natans* and *Ceratophyllum demersum*) in pond Cotoń. The 5 L samples were concentrated using a 45-µm plankton net and were fixed immediately with 4% formalin.

The U-Mann test was used for statistical analysis in order to evaluate the differences in the density of zooplankton communities between particular water bodies (N = 21) and between particular habitats in the case of the Cotoń pond (N = 9).

In addition, the dominating species among both rotifers and crustaceans were designated in particular water bodies. The dominating species of the zooplankton community were calculated as those which exceeded 10% of the total zooplankton abundance at each station.

RESULTS AND DISCUSSION

Ponds are specific environments whose characteristics may place them apart from other aquatic ecosystems. They are often highly dynamic systems and therefore they may be characterised by strong spatial and temporal turnover in both the flora and fauna inhabiting them, especially when they are exposed to disturbance effects and periodic drought. Small water bodies often harbour a significant proportion of the total species richness of plants and animals, and the species composition of associated organisms may differ from each other due to those unstable conditions. As a result of an analysis of the zooplankton community present in five small water bodies located near the area of the village Cotoń (Dziadkowy Cotoń, Cotoń Oczko, Cotoń, Cotoń Pijawka i Przysieka Cotoń), the presence of a total of 84 species was found (62 Rotifera, 14 Cladocera and 8 Copepoda). The smallest fraction of the zooplankton community dominated taxonomically, reaching nearly 75% of the species richness at each open water zone. In the case of the *Ceratophyllum* zone in pond Cotoń an almost equal species number of rotifers and crustaceans (17 and 14, respectively) was observed. This was due to the occurrence of typically littoral species of crustaceans, such as e.g. representatives of the genera *Alona*, *Alonella*, *Pleuroxus* or *Simocephalus*, that were associated with this macrophyte bed. The number of zooplankton spe-

cies differed between the particular water bodies, with the higher number in the pond Cotoń (35), Cotoń Pijawka (32 species), followed by Dziadkowy Cotoń (22), Cotoń Oczko (21) and finally Przysieka Cotoń (21). The number of species reflected the size, age and the variation of macrophyte cover in those water bodies. Pond Cotoń, characterised by the richest taxonomic composition, was the largest pond and possessed the most varied macrophyte stands.

The analysis of the density distribution of zooplankton communities in all five ponds also revealed a domination of Rotifera over Crustacea (Fig. 1), which is typical for ponds with fish predation present and also for water bodies of high

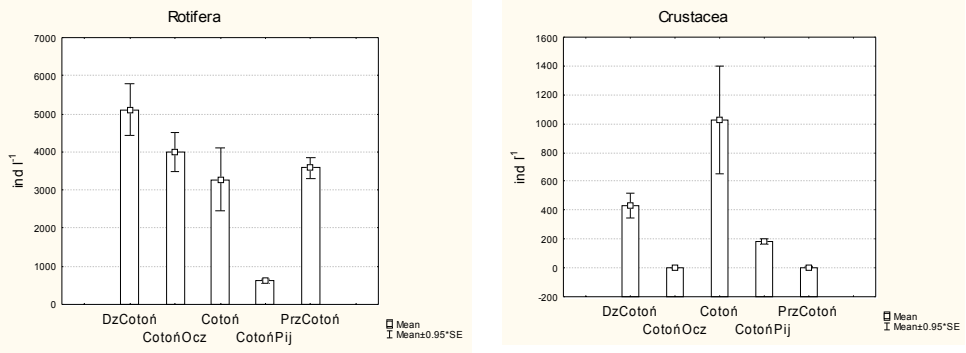

Fig. 1. Mean densities of rotifers and crustaceans in five small water bodies (DzCotoń – Dziadkowy Cotoń, CotońOcz – Cotoń Oczko, CotońPij – Cotoń Pijawka, PrzCotoń – Przysieka Cotoń)

trophic conditions [Mikulski 1974]. The mean rotifer densities did not differ significantly between the examined ponds, irrespective of the station ($p > 0,05$), however, the highest mean abundance was found in the case of the Dziadkowy Cotoń pond and the lowest in Cotoń Pijawka. Significant differences were found between the investigated ponds for crustaceans ($Z = 1.963$, $p = 0.049$), with the highest abundance recorded in the pond Cotoń and the lowest in Cotoń Oczko (Fig. 1). Among single species such differences were found for *Ceriodaphnia quadrangula* (O.F. Müller) ($Z = 2.087$, $p = 0.037$) which prevailed in the Cotoń water body (Fig. 2).

In the largest of the studied ponds (Cotoń) a spatial analysis was made, including the open water zone and two vegetated zones (*Ceratophyllum demersum* and *Potamogeton natans*), and differences in the zooplankton community structure concerned both the species richness and abundance. Aquatic vegetation stands were characterised by considerably richer communities (32 species) compared to open water zone (14). The entanglement of the spatial area and morphology of macrophyte stands is followed by the creation of numerous differentiated ecological niches [Gliwicz and Rybak 1976, Kuczyńska-Kippen and Nagengast 2006a], thus providing more species with favourable living conditions. Moreover, macrophytes constitute a surface for periphyton development,

thereby increasing the available food conditions for inhabiting animals [Gons 1979, Messyasz and Kuczyńska-Kippen 2006].

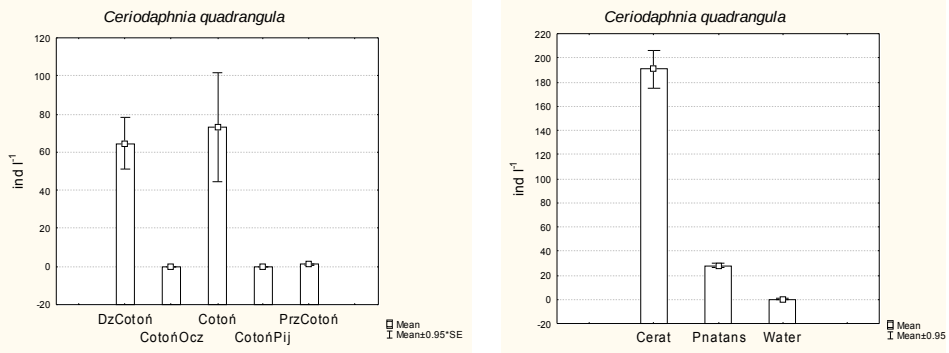

Fig. 2. Mean densities of *Ceriodaphnia quadrangula* in five small water bodies (DzCotoń – Dziadkowy Cotoń, CotońOcz – Cotoń Oczko, CotońPij – Cotoń Pijawka, PrzCotoń – Przysieka Cotoń) and between three habitats in the pond Cotoń (Cerat – *Ceratophyllum demersum*, Pnatans – *Potamogeton natans*)

A spatial differentiation in crustacean abundance was found ($Z = -2.673$, $p = 0.008$), with the highest densities among the hornwort stand, followed by the stand of pondweed which does not build so spatially and morphologically complex stands as *C. demersum*. The opposite pattern of density distribution, however, not significant ($p > 0.05$), was found for rotifers, which was due to a mass occurrence of pelagic species *Keratella cochlearis* f. *tecta* (Lauterborn). The highest densities of this group of animals were recorded in the open water zone, while the lowest among the hornwort stand (Fig. 3). *C. quadrangula* also revealed significant differentiation ($Z = -2.850$, $p = 0.004$) in respect to the studied

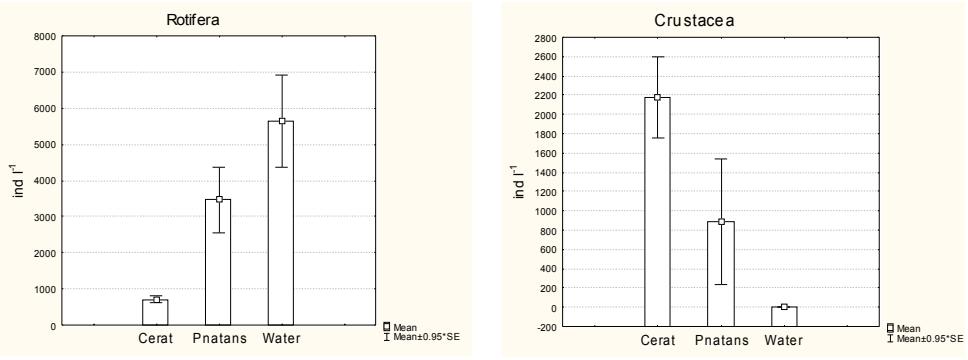

Fig. 3. Mean densities of rotifers and crustaceans between three habitats (Cerat – *Ceratophyllum demersum*, Pnatans – *Potamogeton natans*) in the pond Cotoń

stations. This cladoceran prevailed among *C. demersum*, while the lowest densities were found in the open water area (Fig. 2). The differentiation of the *C. quadrangula* numbers between the examined zones may have been the result of predation present in these habitats. The higher abundance of this cladoceran within the most complex habitat may suggest more advantageous refuge conditions within the dense vegetation stand in the pond with fish predation. Basu *et al*. [2000] described a positive relationship between morphological structure and zooplankton abundance.

The community of dominants was created by 8 rotifer species and 6 crustacean species (Tab. 1). There were few widespread dominating species and more narrowly distributed species. Only *Anureopsis fissa* (Gosse) dominated in four ponds,

Tabela 1. Dominating species of zooplankton in particular stations of the five examined water bodies

Species	Dziadkowy Cotoń	Cotoń oczko	Cotoń			Cotoń Pijawka	Przysieka Cotoń
	Water	Water	Water	Cerat	Pnatans	Water	Water
Rotifera							
Anuraeopsis fissa	x	x				x	x
Keratella cochlearis f. *tecta*			x	x	x		
Lecane closterocerca						x	
Lepadella ovalis				x		x	
Lepadella patella						x	
Mytylina mucronata				x			
Polyarthra remata			x				
Trichocerca rattus				x			
Cladocera							
Alonella excisa						x	
Bosmina longirostris		x					
Ceriodaphnia quadrangula	x					x	x
Chydorus sphaericus			x	x	x		x
Daphnia pulex	x						
Simocephallus exspinosus				x			

Cerat – *Ceratophyllum demersum*
Pnatans – *Potomogeton natans*

and in three of them it reached over 90% of the rotifer densities. The occurrence of this species in such high densities may suggest a high trophy in the four ponds. In the fifth pond (Cotoń), *K. cochlearis* f. *tecta*, which is also an indicator of high trophy, dominated at all the stations [Karabin 1985, Radwan *et al*. 2004]. Among the group of crustaceans *C. quadrangula* dominated in three water bodies, while *Chydorus sphaericus* (O.F. Müller) in two. The latter species obtained 94% of the total crustacean densities in the pond Cotoń (at the stand of *P. natans*), which

also confirms the eutrophic character of this water body. Both cladoceran species are characterised by a wide range of their distribution and these small-bodied species, which can inhabit open water areas and also macrophyte-dominated zones of various types of water bodies, may feed well on detrital particles [Vijverberg and Boersma 1997, Jurasz 2005]. These cladoceran species often occur as very frequent element of crustacean community [Flössner 1972] and may often create a nutritional ford source for almost all species of fish fry [Amoros 1984, Jurasz 2008].

In the pond Dziadkowy Cotoń there was a considerable participation (72% of the total crustacean densities) of a large cladoceran species *Daphnia pulex* (De Geer). This cladoceran belongs to the most common species among the genus *Daphnia*. It can inhabit a broad range of habitats. It is commonly found in ephemeral pools, but it also occurs in lakes ranging from ultra oligotrophic to eutrophic [Flössner 1972]. Large densities of representatives of the genus *Daphnia* may also be an indicator of the strength of fish predation in a particular water body. Daphnids will occur abundantly in water bodies with or without strong fish predation present [Steiner 2004].

The analysis of the distribution of zooplankton communities between the five neighbouring water bodies of the same origin revealed differences in respect of species richness and zooplankton community abundance. Moreover, the presence or absence of fish in those ponds appears to play an important role in the distribution pattern of the dominating species. Differentiation was also recorded with respect to the particular habitat within a certain pond. A heterogeneous structure of the aquatic vegetation caused greater species variation and higher densities of crustaceans in the macrophyte beds.

REFERENCES

Amoros C., 1984. Crustacés Cladocères, Introduction à la Systématique des Organismes des Eaux Continentales Françaises vol. 5. Bulletin de la Societe Linneenne de Lyon 53/4, pp. 63.

Bałazy S., Ryszkowski L., 1992. Strukturalne i funkcjonalne charakterystyki krajobrazu rolniczego. Materiały konferencyjne. Poznań, 105–119.

Basu B.K., Kalff J., Pinel-Alloul B., 2000. The influence of macrophyte beds on plankton communities and their export from fluvial lakes in the St Lawrence River. Freshwat. Biol. 45, 373–382.

Chick J.H., McIvor C.C., 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes: viewing a littoral zone as a landscape. Can. J. Fish. Aquat. Sci. 51, 2873–2882.

Cyr H., Downing J.A., 1988. The abundance of phytophilous invertebrates on different species of submerged macrophytes. Freshwat. Biol. 20, 365–37.

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

Degans H., De Meester L., 2002. Top-down control of natural phyto- and bacterioplankton prey communities by *Daphnia magna* and by the natural zooplankton community of the hypertrophic Lake Blankaart. Hydrobiologia 479, 39–49.

Flössner, D., 1972. Krebstiere, Crustacea. Kiemen-und Blattfüßer, Branchiopoda Fischläuse, Branchiura. pp. 478.

Gliwicz Z.M., Rybak J.I., 1976. Zooplankton [in:] E. Pieczyńska (ed.), Selected problems of lake littoral ecology. Wyd. Uniwersytetu Warszawskiego, Warszawa, 69–96.

Joniak T., Kuczyńska-Kippen N., Nagengast B., 2007. The differentiation of physical-chemical features of water and macrophyte habitats of small water bodies. Hydrobiologia 584, 101–109.

Jurasz W., 2005. Wioślarki (*Cladocera*) zbiorników śródpolnych i jezior południowych Kujaw. Studium faunistyczno-ekologiczne. Wydawnictwo Uniwersytetu Łódzkiego, Łódź.

Jurasz W., 2008. Fauna Polski. Wioślarki Cladocera [w:] Charakterystyka i wykaz gatunków W. Bogdanowicz, E. Chudzicka, I. Pilipiuk, E. Skibińska (red.). Tom III. Muzeum i Instytut Zoologii PAN, 262–268.

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

Kuczyńska-Kippen N., 2006. Changes in the zooplankton community as a result of macrophyte cover transformation in the pastoral water body. Teka Kom. Ochr. Kszt. Środ. Przyr. III, 87–95.

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

Kuczyńska-Kippen N., Nagengast B., 2006b. The impact of a sudden water level decrease on the biocoenotic structure of a small pastoral water body. Teka Kom. Ochr. Kszt. Środ. Przyr. III, 104–114.

Lauridsen T.L., Lodge J., 1996. Avoidance of Daphnia magna of fish and macrophytes: Chemical cues and predator-mediated use of macrophyte habitat. Limnol. Oceanogr. 41(4), 794–798.

Łoś M., Zań T., 2000. Melioracje wodne na terenach o dużych walorach przyrodniczych. Problemy ochrony i użytkowania obszarów wiejskich o dużych walorach przyrodniczych. Lublin, 101–106.

Meerhoff M., Mazzeo N., Moss B., Rodriguez-Gallego L., 2003. The structuring role of free-floating versus submerged plants in subtropical shallow lake. Aquatic Ecol. 37, 377–391.

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). Pol. J. Ecol. 54/1, 15–27.

Mikulski S., 1974. Biologia wód śródlądowych. PWN, Warszawa, pp. 433.

Ozimek T., Rybak J.I., 1994. Typologia florystyczna drobnych bezodpływowych zbiorników Suwalskiego Parku Krajobrazowego. Jeziora Suwalskiego Parku Narodowego. Zesz. Nauk. Kom. „Człowiek i Środowisko" 7, 151–162

Radwan S., Bielańska-Grajner I., Ejsmont-Karabin J., 2004. Wrotki *Rotifera*. Fauna słodkowodna Polski. Tercja, Łódź, pp. 447.

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.

Steiner C., 2004. Daphnia dominance and zooplankton community structure in fishless ponds. J. Plankton Res. 26, 799–810.

Telesh I.V., 1993. The effect of fish on planktonic rotifers. Hydrobiologia 255/256, 289–296.

Vijverberg J, Boersma B, 1997. Long-term dynamics of small-bodied and large-bodied cladocerans during eutrophication of a shallow reservoir, with special attention for *Chydorus sphaericus*. Hydrobiologia 360, 233–242.

Williamson C.E., 1983a. Behavioural interactions between a cyclopoid copepod predator and its prey. J. Plankton Res. 5, 701–711.

Williamson C. E., 1983b. Invertebrate predation on planktonic rotifers. Hydrobiologia 104, 385–396.

Acknowledgements. This study was supported by KBN project No. 2 PO6S 008 29

STRUKTURA UGRUPOWAŃ ZOOPLANKTONU PIĘCIU SĄSIADUJĄCYCH DROBNYCH ZBIORNIKÓW WODNYCH POCHODZENIA ANTROPOGENICZNEGO

Streszczenie. Badano przestrzenne zróżnicowanie bogactwa gatunkowego oraz struktury ugrupowań zooplanktonu w pięciu różnych drobnych zbiornikach wodnych pochodzenia antropogenicznego sąsiadujących ze sobą oraz w poszczególnych typach siedliska w jednym z analizowanych stawów. Ogółem wykazano obecność 84 gatunków zooplanktonu. Struktura taksonomiczna zooplanktonu różniła się w poszczególnych stawach i trzech stanowiskach badawczych (otwarta toń wodna, *Potamogeton natans*, *Ceratophyllum demersum*). Wykazano, że stanowiska zlokalizowane w obrębie roślinności wodnej charakteryzowały się bogatszą strukturą taksonomiczną i większymi liczebnościami zbiorowisk zooplanktonowych niż strefa otwartej toni wodnej. Wrotki dominowały nad skorupiakami zarówno jakościowo, jak i ilościowo, co jest zjawiskiem typowym dla stawów z rybami oraz zbiorników wodnych o wysokiej trofii wód. Warunki eutroficzne we wszystkich analizowanych stawach zostały potwierdzone przez duży udział gatunków eutroficznych zooplanktonu, wśród których przeważały *Anuraeopsis fissa* i *Keratella cochlearis* f. *tecta*. Jedynie w przypadku skorupiaków wykazano istotne różnice w liczebności w poszczególnych stawach i trzech stanowiskach badawczych. W obrębie pojedynczych gatunków *Ceriodaphnia quadrangula* wykazała istotne różnice w zagęszczeniu w pięciu stawach oraz trzech siedliskach. Największą liczebność tej wioślarki stwierdzono w płacie *Ceratophyllum demersum*, a najmniejszą w toni wodnej, co sugeruje korzystne warunki kryjówki antydrapieżniczej w obrębie heterogenicznego i skomplikowanego przestrzennie siedliska roślinnego w zbiornikach z rybami.

Słowa kluczowe: wrotki, skorupiaki, makrofity, warunki eutroficzne