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IMPACT OF A SUDDEN WATER LEVEL DECREASE ON THE BIOCOENOTIC STRUCTURE OF A SMALL PASTORAL WATER BODY

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Summary. A recurrent tendency which often arises while discussing the functioning of ponds is the trend of water level decrease which may lead to the drying up of reservoirs and which causes significant changes in the structure of freshwater organisms. A hydrobiological study was conducted on Dąbrówka water body (western Poland) twice: in the late spring when *Typhetum latifoliae, Phragmitetum communis*, *Potametum pectinati*, *Zannichellietum palustris* and *Potametum lucentis* dominated, as well as in mid-summer when the water level had dropped dramatically at which point the aquatic plant transformation was recorded. At that time the rush vegetation that was present in June was above the water level, however, *Typhetum latifoliae* appeared in the middle of the pond. Out of the previously recorded submerged species, only *Potamogeton pectinatus* remained, but in turn a new bed of *Ceratophylletum demersi* had emerged. The aim of the study was to control the behaviour of zooplankton communities in particular macrophyte phytocoenosis, with emphasis on the impact of environmental parameters, including sudden water decrease and the subsequent macrophyte cover transformation. Out of 60 identified zooplankton species only 26 were common for both seasonal periods. Analysing the distribution of zooplankton it was observed that in the case of rotifers and copepods their densities differed significantly between particular stations. Moreover, there were 21 zooplankton species characterised by differentiated distribution among particular habitats, which was probably due to typical habitat selectivity and seasonality that some genera or species undergo, or to environmental changes.

Key words: water level decrease, macrophytes, rotifers, cladocerans, copepods

INTRODUCTION

The functioning of small water bodies depends on a variety of environmental parameters, e.g. the concentration of biogenic elements – nitrogen and phosphorus, concentration of dissolved minerals, pH or water transparency, which can occur in a wide range, influencing the structure of inhabiting biocoenosis. The shallow depth and therefore small water volume of a pond results in fluctuation of its physical parameters, among which is temperature.

Variation in the morphological features of particular water bodies, the physical and chemical factors of their waters and sediments, will influence the development of specific aquatic vegetation types [Arczyńska-Chudy 1990, Bosiacka and Radziszewicz 2002], which in turn will have an impact on the creation of specific communities of plankton organisms [Chmielewski 1990]. In vegetated stands zooplankton actively searches for concealment against predators, both invertebrate and young stages of fish [Williamson 1983a, b, Telesh 1993]. Furthermore, in the macrophyte bed, apart from phytoplankton which can create a nutritional food source, it can also find great amounts of detritus, protozoans and bacteria [Moore *et al*. 1994, Jürgens *et al*. 1994, Theil-Nielsen and Søndergaard 1999]. In small water bodies the following types of macrophytes can be present – rush vegetation, submerged, floating leaved or pleustophytes. However, macrophytes create here a mosaic structure [Ozimek and Rybak 1994], where the life conditions remain littoral as in lakes.

Frequent tendency which often arises while discussing the functioning of ponds is the trend of the water level decrease which may lead to the drying up of water reservoirs and which causes significant changes in the structure of freshwater organisms. At the same time ponds play an important role in increasing local water retention, which is vital in areas with sparse water reserves [Ludden *et al*. 1983, Hubbard and Linder 1986].

Small water bodies contribute to the maintenance and enrichment of biodiversity, creating optimal living habitats for numerous groups of organisms [Hawksworth 1996]. They are also a link connecting the remaining types of water reservoirs, such as rivers and lakes, enabling the migration of species, both of flora and fauna.

In literature there is a lot of data considering the zooplankton of ponds, however, the results of those analyses treat a water reservoir as a whole, unifying the differentiated areas into one point, which is usually the unvegetated part of the pond bed [Klimowicz 1970, Ejsmont-Karabin and Kuczyńska-Kippen 2001, Kuczyńska-Kippen 2001]. However, the functioning of small water bodies is not so simple and thus requires more attention, to be concentrated on variation in the physical-chemical changeability and development of differentiated types of aquatic vegetation. Hence, the aim of the study was to control the behaviour of zooplankton communities in particular macrophyte phytocoenosis, with emphasis on the impact of environmental parameters connected with sudden water decrease. Additionally, it was planned to describe the habitat preferences of particular species.

STUDY AREA, MATERIALS AND METHODS

The Dąbrówka water body, situated in central part of the Wielkopolska region, western Poland, about 10 km west from the border of the city of Poznań, is a shallow, macrophyte-dominated pond (surface area – 0.5 ha, maximum depth – 1.5 m). It is located at the edge of the village of Dąbrówka, partly surrounded by fields. It has a tree-lined circumference with dominating *Alnus glutinosa* (L.) Gaertn.

The research was carried out twice: in late spring time (22nd June) and in the middle stage of the summer period (25th August).

Zooplankton material was taken in triplicate at each site using a plexiglass core sampler (∅ 50 mm), which is the method advised for studies within the littoral zone [Schriver *et al*. 1995]. The 10 l samples were concentrated using a 45-µm plankton net and were fixed immediately with 4% formalin.

Additionally, water samples were collected in order to analyse the chemical content, in order to evaluate the concentration of N and P in a particular habitat.

Chlorophyll *a* was determined fluorometrically and corrected for degradation products according to Lorenzen [1966]. The concentrations of chlorophyll *a* are given as active photosynthetic pigments.

In order to define the species diversity of zooplankton inhabiting different types of water vegetation the Shannon-Weaver index was calculated [Margalef 1957].

In both months the floristic and phytosociological examination was performed, using the Braun-Blanquet method [Fukarek 1967], together with the collection of plant material for the analyses of density and biomass in particular macrophyte stands. The plant material was cut from a known area and depth. The length of particular macrophyte stems and their biomass adequate to 1 litre of water were estimated. Particular plant matter was taken in triplicate.

The ANOVA test with the *posteriori* Tukey Test [Sokal and Rohlf 1995] was used in order to evaluate differences in zooplankton densities between particular stations (N = 18).

RESULTS

Water vegetation

In the spring season a belt of rush vegetation, of an approximate width of 1-3 m (with the exception of the western part where it reached 6-10 m), surrounded the pond basin. In a few places the rushes had been trampled by fishermen. This created a mosaic of three communities: *Typhetum latifoliae* Soó 1927 ex Lang 1973, *Phragmitetum communis* (W. Koch 1926) Schmale 1939, and *Caricetum riparie* Soó 1928. Besides the dominating species the presence of *Alisma plantago – aquatica* L.*, Berula erecta* (Huds.) Coville*, Scutelaria galericulata* L. and *Epilobium hirsutum* L. was also recorded. In the middle part (from the south) of the water body a stand of *Typhetum latifoliae* appeared (in June there was just a single specimen of a height of a few cm). The bottom of the pond was overgrown up to 70% by patches of: *Potametum pectinati* (Hueck 1931) Carstensen 1955, *Zannichellietum palustris* (W. Koch 1926) Lang 1967, and *Potametum lucentis* Hueck 1931. The first two communities were created at a depth of 0.4-0.6 m, consisting of very thick and compact beds. *Zannichellietum palustris* had the greatest participation among elodeids and was found in three variants: monospecies stands with *Zannichellia palustris* L., stands with the participation of *Potamogeton pectinatus* L. and of *Chara fragilis* Desvaux. Phytocoenosis of *Potametum pectinati* occurred as single species beds together with the participation of *Chara fragilis* and *Potamogeton crispus* L. Stands of *Potametum lucentis* were built by one characteristic species *Potamogeton crispus*. Small patches of *Lemnetum minoris* Soó 1927 were recorded between the rushes and the pond bank.

During the summer period, within two months the water level dramatically decreased from 0.7 to 0.15 m, which led to a total rebuilding of the syntaxonomical structure of the submerged vegetation. Moreover, rush vegetation was out of the water (although its structure had not changed). An exception was a stand of *Typhetum latifoliae* (in June hardly developed), which covered the middle part of the pond. In the 15-cm layer of water, apart from a single specimen of *Potamogeton pectinatus*, there was a lack of the phytocoenosis recorded in spring. However, a large and compact bed of *Ceratophylletum demersi* Hild 1956 appeared.

Analysis of the plant density and biomass revealed that in the spring season a stand with *Phragmites australis* was of the lowest density (stated as the total length of plant stems in one litre of pond water) but the highest biomass, while *Zannichellia palustris*, due to its characteristic fragile build, was of the greatest density but the lowest biomass (Tab. 1).

Table 1. Physical-chemical variables in particular habitats in Dąbrówka water body in the spring and summer periods
Tabela 1. Parametry fizyczno-chemiczne w poszczególnych siedliskach w okresie wiosny i lata w stawie Dąbrówka

Station Stanowisko	Season Pora roku	Density Zagęszczenie cml^{-1}	Biomass Biomasa gl^{-1}	TP	NH_4	NO_3	Chlorophyll *a* Chlorofil *a* μg^{-1}	pH	Conductivity Przewod-nictwo $\mu S\ cm^{-1}$	O_2 mg^{-1}
				mg^{-1}						
Water – Woda		–	–	0.139	0.183	0.118	4.06	7.7	788	3.85
Phr	Spring	27.1	1.93	0.169	0.117	0.126	3.42	7.7	785	2.53
Zann	Wiosna	233.0	0.38	0.134	0.145	0.092	1.92	7.9	784	4.84
Ppect		84.0	0.7	0.154	0.145	0.109	3.85	8.4	769	9.46
Water – Woda	Summer	–	–	0.35	0.404	0.1	12.4	7.0	657	10.01
Cerat	Lato	159.0	0.16	0.68	1.325	0.07	71.85	6.8	650	10.76

Chemical analysis and chlorophyll *a*

Chemical analyses revealed that within the two months between the particular sampling seasons an increase in the trophic conditions of waters of the studied pond appeared. The concentrations of total phosphorus as well as of ammonium nitrogen increased. The highest increase between the spring and summer seasons was found in the mean chlorophyll *a* content (nearly 13-fold) and in oxygen concentration (Tab. 1). During the summer great concentrations of chlorophyll *a* were caused by massive occurrence of phytoplankton, which in turn contributed to high oxygen concentrations.

Zooplankton

As a result of the examination 37 species of Rotifera, 15 of Cladocera and 8 of Copepoda were identified. Comparing zooplankton communities between both seasonal periods an equal number of species was found, however, 43% were common for both seasons and only 6 species (*Keratella quadrata* (O.F. Müller), *Lepadella patella* (O.F. Müller), *Polyarthra vulgaris* Carlin, *Synchaeta* sp., *Ceriodaphnia quadrangula* (O.F. Müller), *Mesocyclops oithonoides* Sars) occurred with 100% frequency at each station. The highest number of zooplankton species was found in the zone of *Ceratophyllum demersum* (38 species) that appeared in the summer season in the pond. The lowest number of species was noticed in the zone of open water (22 species).

The total numbers of rotifer and crustacean communities differed significantly between seasons and stations, reaching values from about 1000 ind l^{-1} (*Zannichellia*) up to 5000 ind l^{-1} (*Phragmites*). Even though the mean zooplankton abundance was similar in both examined periods, cladocerans dominated in the spring (especially in the zones of *Phragmites* and *Potamogeton*), and after the lowering of the water level a shift towards rotifer and copepod dominance was recorded (Fig. 1). Analysing the distribution of zooplankton it was observed that in the case of rotifers and copepods their densities differed significantly between particular stations of the examined pond (Fig. 2). The abundance of the first group in the summer period in the zone of *Ceratophyllum demersum* and open water differed from the stand of *Zannichellia* and of *Potamogeton*, both macrophytes present in the pond in the spring season. However, the numbers of copepods were much higher in the *Ceratophyllum* bed compared with all remaining stations (Fig. 2).

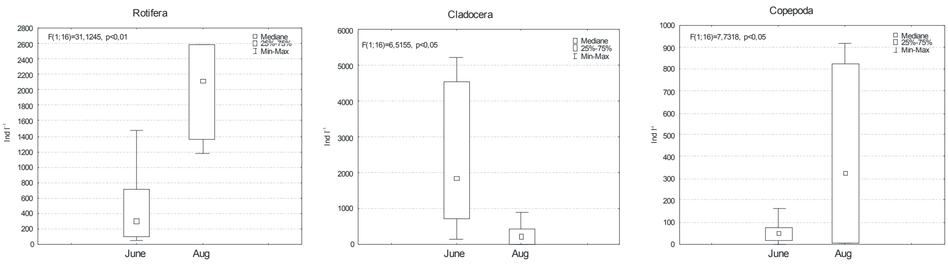

Fig. 1. Total zooplankton community densities in particular seasons of the Dąbrówka water body
Rys. 1. Liczebność ogólna ugrupowań zooplanktonu w poszczególnych sezonach w zbiorniku Dąbrówka

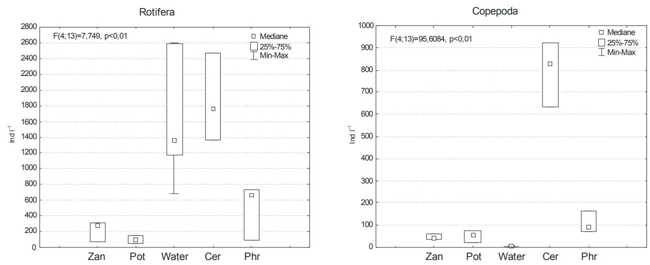

Fig. 2. Total zooplankton community densities in particular sampling stations of the Dąbrówka water body
Rys. 2. Liczebność ogólna ugrupowań zooplanktonu w poszczególnych stanowiskach badawczych w zbiorniku Dąbrówka

Altogether 12 species of dominating status were identified, among which were 3 rotifers, 8 cladocerans and 1 copepod. Among vegetated stands mostly littoral cladocerans, e.g. *Ceriodaphnia pulchella* Sars, *Eurycercus lammelatus* (O.F. Müller), *Scapholeberis mucronata* (O.F. Müller) or *Simocephalus exspinosus* (Koch), dominated. In the spring the dominating structure was more varied (9 species) than in the summer (6). Only three species dominated in both seasons (Tab. 2).

Moreover, there were 21 zooplankton species characterised by differentiated distribution among particular habitats. The densities of taxa such as *Bdelloidae* ($F = 5.691$, $p = 0.007$), *Brachionus quadridentatus* (Hermann) ($F = 14.320$, $p < 0.01$), *Cephalodella catellina* (O.F. Müller) ($F = 22.774$, $p < 0.01$), *C. ventripes* Dixon-Nuttall ($F = 19.757$, $p < 0.01$), *Euchlanis dilatata* Ehrenberg ($F = 5.702$, $p < 0.01$), *Lecane closterocerca* Schmarda ($F = 28.425$, $p < 0.01$), *Lepadella patella* ($F = 7.217$, $p < 0.01$), *Testudinella patina* (Hermann) ($F = 7.210$, $p < 0.01$), *Acanthocyclops* sp. ($F = 5.417$, $p < 0.01$), *Mesocyclops leuckarti* (Claus) ($F = 30.735$, $p < 0.01$) and *M. oithonoides* ($F = 118.288$, $p < 0.01$) appeared in significantly higher numbers in the summer period in the *Ceratophyllum* stand, while of cladocerans – *Chydorus sphaericus* (O.F. Müller) ($F = 7.016$, $p < 0.01$), *Simocephalus exspinosus* ($F = 16.612$, $p < 0.01$) and *S. vetulus* (O.F. Müller) ($F = 6.811$, $p < 0.01$) in *Potamogeton* stand. Furthermore, *Ceriodaphnia pulchella* ($F = 13.711$, $p < 0.01$), *C. reticulata* (Jurine) ($F = 10.824$, $p < 0.01$) and *Scapholeberis mucronata* ($F = 20.190$, $p < 0.01$) seemed to prefer the *Phragmites* zone, while *Polyarthra vulgaris* ($F = 5.877$, $p < 0.01$) only open water area. The abundance of *Eurycercus lammelatus* ($F = 29.351$, $p = 0.000$) was greater among *Zannichellia* and *Potamoge-*

ton sites, while that of *Ceriodaphnia quadrangula* ($F = 8.592$, $p < 0.01$) among *Ceratophyllum* and *Phragmites*.

Table 2. Dominating species of zooplankton community in particular habitats in Dąbrówka water body in the spring and summer periods
Tabela 2. Gatunki dominujące ugrupowania zooplanktonu w poszczególnych siedliskach w okresie wiosny i lata w stawie Dąbrówka

Season – Pora roku	Spring – Wiosna				Summer – Lato	
Station – Stanowisko	Phr	Zann	Ppect	Water – Woda	Cerat	Water –Woda
Rotifera						
Cephalodella catellina					x	
Keratella quadrata	x	x	x	x	x	
Polyarthra vulgaris	x	x	x	x	x	x
Crustacea						
Bosmina coregoni				x		
Bosmina longirostris	x			x		
Ceriodaphnia pulchella	x				x	
Ceriodaphnia quadrangula					x	x
Eurycercus lammelatus		x				
Scapholeberis mucronata	x					
Simocephallus exspinosus		x	x			
Simocephallus vetulus		x	x			
Mesocyclops oithonoides					x	x

The Shannon-Weaver biodiversity index varied between 1.13 (open water area) and 2.65 (*Ceratophyllum* zone) for the whole zooplankton community. However, in the case of rotifers its value ranged from 0.8 in the *Phragmites* stand up to 2.2 in the *Ceratophyllum* bed, and in the case of crustaceans from 0.7 in the open water zone up to 1.8 in the *Phragmites* station. Comparing the values of this index between both sampling periods it was noticed that when the water level dropped they were higher than in the spring. It was also found that in June a higher diversity index was recorded for crustaceans in the stands of *Phragmites australis* and *Zannichellia palustris*.

DISCUSSION

As a result of the changes in the water level the rush vegetation in the summer, even though its composition and structure remained the same, appeared to be out of water. However, elodeids had been totally rebuilt. Communities with *Zannichellia palustris, Potamogeton crispus* and *P. pectinatus* had vanished. Those plants, that were present in the Dąbrówka water body in the first stage of the investigation, were much taller than the water level in the summer (only 15 cm) and therefore they probably dried out and lost out in competition with hornwort which, despite being sensitive to drying up, is also an expansive macrophyte species [Podbielkowski and Tomaszewicz 1996] and the optimum of its communities is found in shallow reservoirs with organic sediments. Phytocoenoses of *Ceratophylletum demersi* supplant the communities of submerged pondweeds or other elodeids [Tomaszewicz 1979].

These observations, even though they concern only a one-year study, have been confirmed by the results of other authors [e.g. Kraska *et al.* 2002] who stated that changes in the water level are an important natural factor affecting changes of macrophyte cover in small water bodies, which can in turn have an impact on the biological structure of organisms, including zooplankton.

Out of 60 identified zooplankton species nearly half of the taxonomical structure was common for both seasons, however, only 6 species, all belonging to cosmopolitan and common forms [Radwan *et al*. 2004], occurred with 100% frequency. The stand of *Ceratophyllum demersum,* which was characterised by high stem length and the highest concentrations of chlorophyll *a*, possessed the highest number of species that appeared in the summer season in the pond. The lowest number of species was found in the most homogeneous area of the water body – in the zone of open water. Moreover, 21 species revealed habitat selectivity and most of them (11) preferred the zone of *Ceratophyllum*. These were mainly littoral-associated forms. Finding so many zooplankton species of habitat-related spatial distribution is due to a variety of factors. Firstly, some species reveal typical habitat selectivity, so their occurrence is restricted to a particular substratum. It has already been recorded by several authors that representatives of water fauna, like rotifers [Pejler 1995], crustaceans [Dvorak and Best 1982, Cyr and Downing 1988a, b], and other groups of freshwater organisms [Pip and Stewart 1976, Lodge 1985, Sheldon 1987], are characterised by their preference towards specific macrophyte types. Particular habitat preferences are determined by a number of factors. Gliwicz and Rybak [1976] suggested that particular kinds of macrophytes may have an impact and they hypothesised that the denser the plant stand is, the more isolated the water within it and the more distinct the zooplankton communities. Cyr and Downing [1988b] found that particular water organisms may choose their habitat selectively, so bigger plants with wider leaves are more often inhabited by heavier crawling invertebrates, while denser plants with finer leaves by smaller organisms like copepods, cladocerans and also rotifers. The specific architectonical type of a particular habitat may also affect the periphyton community structure which may then be preferred by different aquatic organisms. Moreover, the suitability of organisms for living in typically littoral or pelagic environmental conditions seem to have an important impact on the specific habitat-related preferences of particular species [Preissler 1977, Jose-de-Paggi 1993]. This definitely applies to the preference of *Polyarthra vulgaris* for the open water zone, as this species is described by many authors as a limnetic form [Koste 1978]. Furthermore, most species that were found to follow habitat segregation towards a particular macrophyte zone belong to littoral species that have numerous morphological adaptations to living in a thick conglomeration of aquatic plants [Flössner 1972, Hillbricht-Ilkowska 1972, Preissler 1983, Lampert and Sommer 2001], as for example flat loricas enabling some rotifers to migrate between macrophyte stems (*Cephalodella* species or *Testudinella patina*), retractable fingers (*Euchlanis dilatata* or *Lecane closterocerca*) or hooks to help them attach to the vegetative substratum (*Scapholeberis mucronata*). Another reason for recording over 20 species of habitat distinctiveness is the typical seasonality that some genera or species undergo. There are cold- and warm stenotermic forms which, depending on the season, may be replaced by other species within the same genus [Herzig 1987]. Even though the examined water body was of a small size, the division of its area into various macrophyte habitats caused spatial segregation of zooplankton communities, which substantiates the necessity of the examination of microhabitats in the small spatial scale.

Zooplankton densities differed in regard to season and stations. The rotifers and copepods of the *Ceratophyllum* bed differed from most of the macrophyte stations present in the examined pond in the spring season. Moreover, a shift from the dominance of cladocerans towards rotifers was recorded between both seasons, which was probably caused by the lowering of the water level and the consequent macrophyte cover transformation. Dominance of cladocerans at the end of June might have been connected with a clear water phase which appears in water bodies around that time and was described as a PEG-model of seasonal succession of planktonic events in freshwaters [Lampert and Sommer 2001]. In the spring the structure of dominating species was more varied than that of the summer, which may have been caused by the much more differentiated macrophyte cover in the spring, offering a wider range of differentiated habitats and thus supporting more dominants.

Comparing values of the Shannon-Weaver biodiversity index between both seasons it was found that rotifers reached their maximum values in the *Ceratophyllum* zone and crustaceans in the *Phragmites australis* and *Zannichellia palustris* zones. Such a variation in the index value was due to the density distribution of particular zooplankton groups, where rotifers dominated in the summer, when only the *Ceratophyllum* bed was present within the vegetation cover and cladocerans dominated in the spring season.

CONCLUSION

It may be presumed that the great diversification of the zooplankton community structure found in the *Ceratophyllum demersum* stand was due to the fact that after the lowering of the water level in the Dąbrówka water body that took place between June and August this was the only phytocoenosis within the open area that could support zooplankters with advantageous concealment conditions (hornwort was characterised by spatially and morphologically complicated architecture) and provide them with a nutritional food source (this plant species possessed the highest concentrations of chlorophyll a compared to all the other stations in both study periods). Moreover, the summer season, when *Ceratophyllum* bed appeared, is the optimum period for zooplankton development.

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WPŁYW NAGŁEGO OBNIŻENIA POZIOMU LUSTRA WODY NA STRUKTURĘ BIOCENOTYCZNĄ DROBNEGO ZBIORNIKA WODNEGO

Streszczenie. Podczas dyskusji nad funkcjonowaniem drobnych zbiorników wodnych często pojawia się problem związany z tendencją obniżania się poziomu wody oraz z wysychaniem stawów, co istotnie wpływa na strukturę ugrupowań organizmów słodkowodnych. W okresie wiosennym i letnim prowadzono badania na płytkim małym stawie położonym w zlewni rolniczej przy wsi Dąbrówka (5 km na zachód od Poznania). W okresie wiosennym w zbiorniku odnotowano 6 zbiorowisk w randze zespołu. Szuwar w wielu miejscach poprzecinany dojściami do wody budowały wąskie płaty *Typhetum latifoliae*, *Caricetum riparie* i *Phragmitetum communis*. W wodzie stwierdzono płaty *Potametum pectinati* z udziałem *Chara fragilis*, *Zannichellietum palustris* i *Potametum lucentis*. W okresie letnim w ciągu dwóch miesięcy poziom wody radykalnie się obniżył i nastąpiła przebudowa składu syntaksonomicznego roślinności. Roślinność szuwarowa znalazła się poza zasięgiem wody, a z roślinności zanurzonej pozostały pojedyncze kępy *Potamogeton pectinatus* i nowo powstały duży płat *Ceratophylletum demersi*. Celem prowadzonych badań była analiza struktury ugrupowań zooplanktonu w poszczególnych fitocenozach makrofitów, ze szczególnym uwzględnieniem wpływu czynników środowiskowych, w tym nagłego obniżenia poziomu lustra wody. Spośród 60 oznaczonych gatunków zooplanktonu zaledwie 26 stanowiło element wspólny dla obu sezonów badawczych. Analizując rozmieszczenie zooplanktonu wykazano, że liczebność wszystkich grup różniła się istotnie między obu sezonami, natomiast w przypadku wrotków i widłonogów – liczebności ich różniły się istotnie między poszczególnymi stanowiskami badawczymi. Ponadto 21 gatunków charakteryzowało się zróżnicowanym rozmieszczeniem między poszczególnymi siedliskami, co spowodowane było zapewne typową wybiórczością siedliskową tych organizmów, zmiennością sezonową czy też zmianami parametrów środowiskowych w obrębie badanego stawu.

Słowa kluczowe: obniżenie poziomu lustra wody, makrofity, wrotki, wioslarki, widłonogi