Acta Agrophysica, 2006, 7(2), 415-422

CHANGES IN THE ZOOPLANKTON COMMUNITY STRUCTURE AS A RESULT OF SYNTAXONOMICAL REBUILD OF SUBMERGED VEGETATION OF A MID-FOREST WATER BODY *

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A b s t r a c t. The research was carried out on a shallow, macrophyte-dominated mid-forest water body. The aim of the study was to analyse the impact of various macrophyte habitats, differing in the spatial structure and biomass, representing four ecological groups (helophytes, submerged elodeids, nymphaeids and stonewort meadows) on the zooplankton communities. There were 110 zooplankton species identified, however, the macrophyte stands were characterised by richer taxonomical structure and higher species biodiversity index than the open water zone between particular plant beds, a result of the greater mosaic of the vegetated biocoenoses which create more ecological niches compared to the open water area. The analyses of zooplankton communities in 2002 and 2004 revealed that along with the syntaxonomical rebuild in the submerged vegetation cover the structure of zooplankton communities, including the quality structure, abundance and the dominating species, had also changed. Out of the total of 23 dominating species only 4 dominated in both years.

K e y w o r d s: macrophytes, small water body, zooplankton

INTRODUCTION

A small water body is usually treated as a uniform whole, where the differentiated areas covered by macrophytes are unified into one unvegetated part of the bottom [2]. However, the functioning of small water bodies depends on a combination of various environmental elements which have an impact on the creation of differentiated flora or fauna or specific plankton communities. Zooplankton seeks a refuge against predators, both vertebrate or invertebrate ones, among aquatic

* The paper was presented and published in the frame of activity of the Centre of Excellence AGROPHYSICS – Contract No.: QLAM-2001-00428 sponsored by EU within the 5FP.

plant beds [7,12,18]. When the vertebrate predation is of stronger influence most zooplankton communities gather among vegetated areas during the light hours [15]. Moreover, macrophyte stands may provide zooplankton with a nutritional food base which consists of algae present in the spaces filling the plant stems, accompanied by great amounts of detritus, bacteria or protozoans [11,17].

The communities of freshwater organisms, including small habitats such as ponds, are often single genus, closely related, with habitat and food niche overlapping, so the recognition of the spatial mosaic of various habitats will help to maintain the species diversity of the aquatic biocoenosis at the level enabling its survival [5].

The aim of the study was to compare the structure of zooplankton communities inhabiting various hydromacrophyte associations, differing spatially and morphologically, with emphasis on changes in species composition of the submerged macrophyte cover. Water vegetation of the examined reservoir represented three ecological groups – rush vegetation (*Schoenoplectus lacustris* L. and *Phragmites australis* (Cav.) Trin. ex Steud.), submerged macrophytes (*Potamogeton lucens* L.), and stonewort meadows (*Chara fragilis* Desvaux).

MATERIAL AND METHODS

The research was carried out on a mid-forest retentional reservoir – Gazbruchy Większe, which is situated in the Wilczak waterway, Krucz forestry district, Wielkopolski region. Its catchment area is 100% overgrown by forest; there are also a few traffic routes around this water body. Its area is about 5 ha and mean depth around 0.5 m, however these measurements change with the water level fluctuations.

In 2002, at the Gazbruchy Wielkie water body, communities of water and rush vegetation such as *Phragmitetum communis* (Gams 1927) Schmale 1939, *Sparganietum erecti* Roll 1938, *Scirpetum lacustris* (Allorge 1922) Chouard 1924, *Eleocharidetum palustris* Schennikow 1919, *Polygonetum natantis* Soó 1927, *Potametum pectinati* (Hueck 1931) Carstensen 1955, *P. lucentis* Hueck 1931, *Charetum fragilis* Fijałkowski 1960 and *Nitelletum syncarpae* (Corillion 1957) Dąmbska 1966 were observed, while in 2004 – *S. erecti*, *E. palustris*, *Ph. communis*, *S. lacustris, P. pectinati* and *P. lucentis*.

Zooplankton was collected twice during the day hours in the summer season of 2002 and 2004, from 7 stations in total. Material was sampled in triplicate, in the vertical profile, from the depth of 0-1.5 m, using a plexiglass core sampler (method for sampling in the littoral zone recommended by e.g. Schriver *et al.* [16]). 10-L samples were thickened using a planktonic net (45 μm) and preserved with 4% formaldehyde. Moreover, in 2004 a physical-chemical analysis of water was conducted together with biometric measurements of the plant matter at each investigated station (Tab. 1).

Table 1. Biometric parameters of macrophytes (length of macrophyte stems per water unit – m l^{-1} biomass – biomass of macrophyte stems per water unit – g l^{-1}) and the physical-chemical analysis ($N\text{-}NH_4$ P_{tot} O_2 in mg l^{-1}; conductivity in µs; temperature in °C) in 2004

Parameter	Length	Biomass	$N\text{-}NH_4$	P_{tot}	O_2	Temp	Cond	pH
Phragm	31.9	1.17	1.34	0.06	10.2	20	471	7.88
Plucens	18	0.5	1.61	0.05	13.4	21	401	8.62
Open water	–	–	1.22	0.05	11.8	20	469	8.06

(Phragm – *Phragmites australis*. Plucens – *Potamogeton lucens*)

The Shannon-Weaver biodiversity index [10] was used to define the species diversity of zooplankton inhabiting different types of habitats.

The Mann-Whitney U-test was used in order to determine the effect of site and time on the distribution of rotifer and crustacean communities (N = 21).

RESULTS AND DISCUSSION

The examination of the water and rush vegetation of the Gazbruchy Wielkie water body in 2002 and 2004 revealed the presence of 9 communities. Throughout the whole time the same rush communities occurred (*Scirpetum lacustris*, *Eleocharidetum palustris* and *Phragmitetum*) and two of elodeids (*Potametum pectinati* and *P. lucentis*). In the first year, additionally nymphaeids (*Polygonetum natantis*) and charoids (*Nitelletum syncarpae* and *Charetum fragilis*) appeared. Phytocoenosis of stoneworts created very thick and dense beds, covering one third of the pond bottom. However, in 2004 a community with *Peucedanum palustrae* (L.) Moench was present. The changeability and mosaic character of aquatic communities in ponds is typical of small water bodies [13].

As a result of anlysis of zooplankton community, the presence of a total of 110 species was found (59 Rotifera, 35 Cladocera and 16 Copepoda). The vegetated stands were characterised by richer taxonomical structure compared to the open water zone, where in the following years 27 and 18 zooplankton species only were recorded (Fig. 1). The entanglement of the spatial distribution and the morphology of macrophyte stands is followed by the creation of numerous differentiated ecological niches [4], thus providing more species with favourable living conditions. Taking into consideration all the macrophyte stands it was noticed that *Potamogeton lucens* had the most diverse taxonomical structure (67 species in the first year of examination and 37 in the second). The architecture of a particular macrophyte habitat is often a factor responsible for the distribution of zooplankton communities within the vegetated regions as stated by Cyr and Downing [1] or Paterson [14]. Also on comparing the quality structure of the two years of examination considerable variation was observed. In 2002, when four zones were studied (*Schoenoplectus lacustris, Potamogeton lucens, Chara fragilis* and open water station), the presence of 100 zooplankton species was recorded, while in 2004, when three zones were investigated (*Phragmites australis, P. lucens* and open water), only 55. In the first year of examination rotifers dominated taxonomically (57% of the quality structure), while in the following year crustaceans dominated (58%).

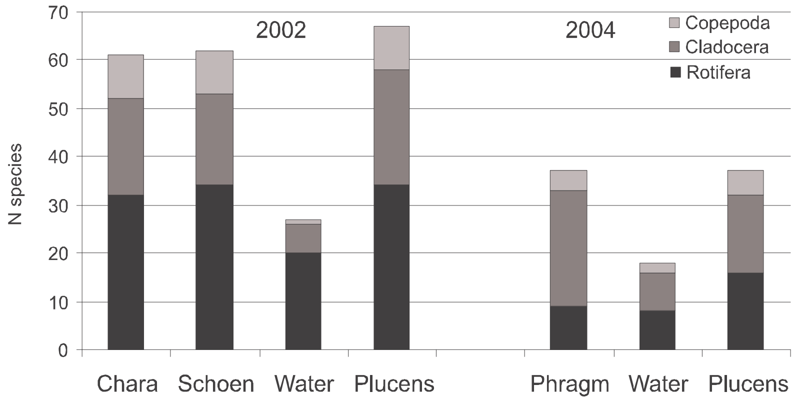

Fig. 1. Number of zooplankton species in the Gazbruchy Większe water body (Chara – *Chara fragilis*; Schoen – *Schoenoplectus lacustris*; Water – open water zone; Plucens – *Potamogeton lucens*; Phragm – *Phragmites australis*)

Analysing zooplankton densities, high discrepancies between both years of examination were noticed and they were statistically significant both for rotifers ($Z = 2.7890$; $p=0.0053$) and for crustaceans ($Z=2.5354$; $p=0.0112$). In 2002 higher abundances (nearly 4-times on average) were found (Fig. 2). In the first year the open water zone was characterised by much higher densities in relation to the macrophyte areas (especially due to the mass occurrence of pelagic rotifers – *Keratella cochlearis* and *Polyarthra vulgaris*) – the total densities reached then 3779 ind l^{-1}. This was probably due to the lack of fish, because otherwise pelagic zooplankton seeks a day-time refuge among macrophytes [6,9,16]. The lowest numbers were also observed in the case of the open water zone, but in 2004 (55 ind l^{-1}). Densities within the vegetated stands did not reveal such great differences (at the zone of *Potamogeton lucens* the abundance reached between 1490 and 1075 ind l^{-1} in the following years). In most cases crustaceans dominated over rotifers, with the exception of the open water zone in 2002 (98% of the total zooplankton densities) and the stand of *Potamogeton lucens* in 2004 (75%) where rotifers predominated. The low numbers of rotifers seem to be a result of the exploitative competition for the shared food resources between rotifers and crustaceans, which results in the suppression of the smaller rotifers by the bigger crustaceans [19] which, due to the lack of predation from fish, developed in great quantities (e.g. *Daphnia magna*).

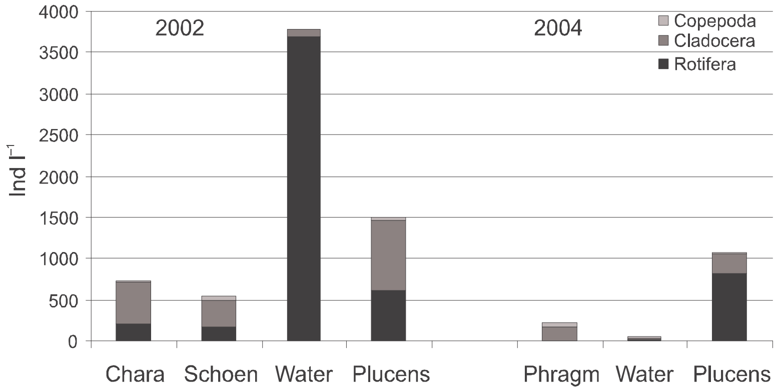

Fig. 2. Densities of zooplankton communities in the Gazbruchy Większe water body (Chara – *Chara fragilis*; Schoen – *Schoenoplectus lacustris*; Water – open water zone; Plucens – *Potamogeton lucens*; Phragm – *Phragmites australis*)

Out of the whole community of dominants, consisting of 23 species (11 Rotifera, 11 Cladocera and 1 Copepoda), only 4 species dominated in both years – *Keratella cochlearis* (Gosse), *Lecane closterocerca* (Schmarda), *Alonella exigua* (Lilljeborg) and *Ceriodaphnia pulchella* Sars (Tab. 2).

Table 2. The dominating species of zooplankton of the Gazbruchy Większe water body

2002	2004
Rotifera	***Rotifera***
Brachionus angularis	*Bdelloidae*
Keratella cochlearis	*Colurella uncinata*
Lecane closterocerca	*Keratella cochlearis*
Mytilina mucronata	*Keratella quadrata* f. *dispersa*
Mytilina ventralis	*Lecane closterocerca*
Polyarthra vulgaris	*Lecane luna*
Testudinella patina	***Crustacea***
Crustacea	*Alonella excisa*
Alonella exigua	*Alonella exigua*
	Ceriodaphnia pulchella
Bosmina coregoni	*Chydorus sphaericus*
Ceriodaphnia pulchella	*Daphnia magna*
Ceriodaphnia quadrangula	*Polyphemus pediculus*
Lathonura rectirostris	*Scapholeberis mucronata*
Pleuroxus laevis	*Eudiaptomus gracilloides*

In the dominant structure the littoral species such as *Colurella uncinata* (O. F. Müller), *Lecane closterocerca*, *L. luna* (O. F. Müller), *Mytilina mucronata* (O. F. Müller), *M. ventralis* (Ehrenberg), *Testudinella patina* (Hermann), *Ceriodaphnia pulchella* or *C. quadrangula* (O. F. Müller) prevailed [3,8]. Moreover, a considerable number of typical 'pond' species, such as *Keratella quadrata* f. *dispersa*

Carlin, *Daphnia magna* Straus, *Lathonura rectirostris* (O. F. Müller) or *Pleuroxus laevis* Sars were present. The open water zone was characterised by the lowest number of dominant species (3 and 4 in the following years), while the macrophyte stands usually possessed 6 such species, irrespective of the year of examination or ecological type of the plant microhabitat.

Analysis of species biodiversity revealed that the values among macrophyte stations were mostly quite high, reaching in the case of rotifers 2.81 in the *Chara* stand and 2.77 in the *Schoenoplectus* bed in 2002. However, the highest value of this index for crustaceans was 2.57 in the *Phragmites australis* stand (2004) and 2.41 in the *Schoenoplectus* bed (2002). It was noticed that in the first year of examination biodiversity values were higher for rotifer communities, while in the second year among macrophytes these values were higher for crustacean communities. For both years the lowest values were obtained for the open water zone, both for rotifers and crustaceans (Fig. 3).

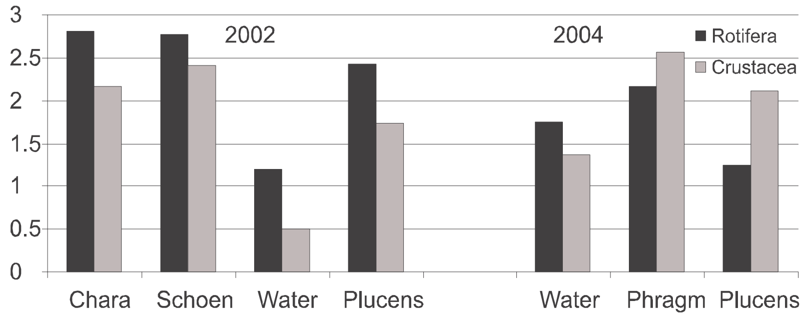

Fig. 3. Biodiversity index of zooplankton communities in the Gazbruchy Większe water body (Chara – *Chara fragilis*; Schoen – *Schoenoplectus lacustris*; Water – open water zone; Plucens – *Potamogeton lucens*; Phragm – *Phragmites australis*)

It was found that along with the syntaxonomical change of the submerged vegetation cover at the Gazbruchy Większe water body the structure of zooplankton communities had also been transformed. The changes involved the taxonomical structure, densities, as well as the dominating species. It was also proved that competition between rotifers and crustaceans played an important role in modelling the distribution of zooplankton communities in the examined water body.

CONCLUSION

The study indicated that along with the syntaxonomical change of the aquatic vegetation the structure of zooplankton communities had also undergone transformation. However, despite the seasonal changes, the highest zooplankton diversity always characterised the plant habitats and the lowest the open water zone.

REFERENCES

1. **Cyr H., Downing J.A.:** The abundance of phytophilous invertebrates on different species of submerged macrophytes. Freshwat. Biol., 20, 365-37, 1988.
2. **Ejsmont-Karabin J., Kuczyńska-Kippen N.:** Urban rotifers – structure and densities of rotifer communities in water bodies of the Poznań agglomeration (Western Poland). Hydrobiologia, 446/447, 165-171, 2001.
3. **Flössner D.:** Kiemen- und Blattfusser, Branchiopoda, Fischlause, Branchiura. VEB Gustav Fisher Verlag, Jena, 1972.
4. **Gliwicz Z.M., Rybak J.I.:** Zooplankton. [In:] Pieczyńska E. (ed.): Selected problems of lake littoral ecology. Wyd. Uniwersytetu Warszawskiego, Warszawa, 69-96, 1976.
5. **Hillbricht-Ilkowska A.:** Strategy of protection of biological diversity (in Polish).[In:] Ryszkowski L., Bałazy S. (eds): Uwarunkowania ochrony różnorodności biologicznej i krajobrazowej. Materiały Konferencji Naukowej, Poznań, 37-58, 1999.
6. **Kairesalo T., Tátrai I., Luokkanen E.:** Impacts of waterweed (*Elodea canadensis* Michx) on fish-plankton interactions in the lake littoral. Verh. Internat. Verein. Limnol. 26, 1846-1851, 1998.
7. **Kajak Z.:** Ecosystem of Freshwaters (in Polish). PWN, Warszawa, 1998.
8. **Koste W.:** Rotatoria. Die Rädertiere Mitteleuropas. Gebrüder Borntraeger, Berlin, 1978.
9. **Lauridsen T.L., Pedersen L.J., Jeppesen E., Sondergaard M.:** The importance of macrophyte bed size for cladoceran composition and horizontal migration in a shallow lake. J. Plankton Res., 18, 2283-2294, 1996.
10. **Margalef R.:** Information theory in ecology. Gen Syst., 3, 36-71, 1957.
11. **Moore B.C., Funk W.H., Anderson E.:** Water quality, fishery and biologic characteristic in a shallow, eutrophic lake with dense macrophyte populations. Lake Reservoir Managem., 8(2), 175-188, 1994.
12. **Moss B., Beklioglu M., Kornijów R.:** Differential effectiveness of nymphaeids and submerged macrophytes as refuges against fish predation for herbivorous *Cladocera*. Verh. Internat. Verein. Limnol., 26 1863, 1998.
13. **Ozimek T., Rybak J.I.:** Floristic typology of small outflow water bodies of the Suwalski Landscape Park. Lakes of the Suwalski National Park (in Polish). Zeszyty Naukowe Komitetu „Człowiek i Środowisko”, 7, 151-162, 1994.
14. **Paterson M.:** The distribution of microcrustacea in the littoral zone of a freshwater lake. Hydrobiologia, 263, 173-183, 1993.
15. **Rybak J.I., Węgleńska T.:** Temporal and spatial changes in the horizontal distribution of planktonic Crustacea between vegetated littoral zone and the zone of open water. Pol. J. Ecol., 51, 205-218, 2003.
16. **Schriver P.J., Bøgestrand E., Jeppesen E., Søndergaard M.:** Impact of submerged macrophytes on fish-zooplankton-phytoplankton interactions: large scale enclosure experiments in a shallow eutrophic lake. Freshwat. Biol., 33, 255-270, 1995.
17. **Theil-Nielsen J., Søndergaard M.:** Production of epiphytic bacteria and bacterioplankton in three shallow lakes. Oikos, 86, 283-292, 1999.
18. **Timms R.M., Moss B.:** Prevention of growth of potentially dense phytoplankton populations by zooplankton grazing, in the presence of zooplanktivorous fish, in a shallow wetland ecosystem. Limnol. Oceanogr., 29(3), 472-486, 1984.
19. **Wickham S.A., Gilbert J.J.:** Relative vulnerability of natural rotifer and ciliate communities to cladocerans: laboratory and field experiments. Freshwat. Biol., 26, 77-86, 1990.

KSZTAŁTOWANIE SIĘ STRUKTURY UGRUPOWAŃ ZOOPLANKTONU POD WPŁYWEM ZMIAN SYNTAKSONOMICZNYCH ROŚLINNOŚCI ZANURZONEJ W ŚRÓDLEŚNYM ZBIORNIKU WODNYM

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Streszczenie. Badania prowadzono na płytkim, zdominowanym przez makrofity, zbiorniku śródleśnym (Nadleśnictwo Krucz, woj. Wielkopolskie). Celem badań było uchwycenie zależności między zespołami zooplanktonowymi a poszczególnymi zbiorowiskami hydromakrofitów, różniącymi się strukturą przestrzenną, architekturą i biomasą. Ogółem oznaczono 110 gatunków zoopalnktonu (59 Rotifera, 35 Cladocera and 16 Copepoda). Największym bogactwem gatunkowym charakteryzowały się strefy roślinne, najmniejszym natomiast toń wodna rozdzielająca poszczególne płaty makrofitów. Związane to było zapewne z dużo większą mozaikowatością biocenoz roślinnych, które są w stanie 'wykreować' większą liczbę nisz ekologicznych w porównaniu z tonią wodną. Analiza zbiorowisk zooplanktonu w latach 2002 i 2004 wykazała, że wraz z przebudową syntaksonomiczną roślinności zanurzonej zmieniła się również struktura ugrupowań zooplanktonu, zarówno jego struktura taksonomiczna, dynamika liczebności jak i struktura gatunków dominujących.

Słowa kluczowe: makrofity, drobny zbiornik wodny, zooplankton