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Zooplankton community structure within various macrophyte stands of a small water body in relation to seasonal changes in water level

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Abstract

Different morphological features of particular water bodies, physical and chemical factors of their waters and sediments will have an impact on the development of specific aquatic vegetation types, which in turn will affect the creation of specific communities of plankton organisms. Therefore the aim of this study was to analyse the quantity and quality changes of macrophyte structure in relation to the lowering of the water level. Furthermore, the relationship between zooplankton community densities and environmental parameters was studied. Another aspect of

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the study was to investigate the similarity of the zooplankton communities of particular sampling stations in the three examined seasons.

The study was carried out on Dąbrówka water body, a shallow and macrophyte-dominated pond, situated 10 km west of Poznań, Wielkopolska region, western Poland. The examination was conducted in the three seasons: spring, summer and autumn.

The results revealed that during one vegetative period, including three seasons – spring, summer and autumn, three different layouts of aquatic vegetation were obtained, which reflected a significant transformation in the macrophyte cover. Along with the lowering of the water level the structural changes, especially in the case of submerged vegetation were recorded, which in each season was represented by different dominating species.

Only three significant correlations between zooplankton densities and environmental factors observed. Negative relationship concerned total nitrogen and two positive related to biometric parameters of the macrophyte habitat (plant biomass plant stem volume). The plant biomass was a predictor of cladoceran abundance and plant stem volume referred to rotifers, which may reflect the complexity of the aquatic plant habitat, indirectly relating to the effectiveness of the macrophyte stand as anti-predator refuge.

The analysis of the similarity of the zooplankton communities of particular sampling stations in the three examined seasons did not reveal any clear relationship, either in relation to a particular season or a sampling station. The participation of eutrophic species was highest in the spring and lowest during the autumn season. The open water zone possessed the highest participation of these species compared to the macrophyte zones.

INTRODUCTION

The initial aim of the study was to analyze the structure of the zooplankton community in differentiated phytocoenosis of hydromacrophytes with a special focus on the impact of environmental parameters, including a sudden water level decrease between the two seasons of spring and summer (Kuczyńska-Kippen and Nagengast 2006a). As a consequence of the lowering in the water level of the studied pond, some significant changes in the structure of the aquatic vegetation were observed, which, in turn, had an effect on the structuring of the rotifer and crustacean community (Kuczyńska-Kippen and Nagengast 2006a). This led to undertaking a further examination in the fall. The quantity and quality changes of aquatic vegetation were studied and analyzed in relation to the lowering of water level. Furthermore, the distribution of zooplankton species adapted to the littoral zone of water bodies as well as of species associated with eutrophic conditions provided the focus of the research. Another aspect of the study was to investigate the relationship between zooplankton densities and environmental parameters.

The lack of rain and the lowering of the water level within a short period of time leads to the overgrowing of small water bodies, a disappearance of the water basin, and the domination of helophytes in places previously occupied by submerged vegetation. On the other hand, in conditions of very abundant rain fall, the overgrowth process becomes suppressed, and, furthermore, previously existing water bodies reappear and in the short period of one vegetative season

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communities of submerged macrophytes can cover the unvegetated bottom of a pond (Kraska et al. 2002).

Thomaz et al. (2006) stated that the biomass and maximum depth of the colonization of *Egeria najas* and the biomass and frequency of occurrence of a stand of *Eichornia crassipes* and *Salvinia herzogii* were changeable with respect to the drawdown in the water level of the Itaipu Reservoir (Brazil-Paraguay). The authors above gave some possible explanations for the reaction of aquatic plants to the changes in environmental conditions. They predicted that propagules may remain viable in the dried-out sediments, germinating once the water level had recovered. Moreover, propagules moved to deeper sites before the drawdown, which encountered favorable conditions for germination when such sites became shallower and more light reached the sediment.

In small water bodies zones of rush vegetation, submerged macrophytes, plants with floating leaves, or pleustophytes can occur. However, macrophytes usually create a mosaic (Ozimek and Rybak 1994), and life conditions resemble the littoral zone of lakes.

MATERIALS AND METHODS

The study was carried out on Dąbrówka pond, situated 10 km west of Poznań, Wielkopolska region, western Poland. This is a shallow, macrophyte-dominated pond (length - 85 m, width - 50 m, surface area – ca. 0.5 ha, maximum depth – 1.5 m, depth during the study – 0.7 m). The research was conducted in the spring, summer (Kuczyńska-Kippen and Nagengast 2006a) and fall periods.

In the spring (Fig. 1a) in the examined water body, three rush communities were identified: *Typhetum latifoliae*, *Phragmitetum communis*, and *Caricetum ripariae*. The central part of the pond was mainly dominated by elodeids with *Zannichellia palustris, Potamogeton pectinatus, P. crispus*, and *Chara fragilis*. In the summer (Fig. 1b), after the water level had fallen from 0.7 m to 0.15 m, changes in the structure of elodeids were recorded. The previously identified elodeids were replaced by *Ceratophylletum demersi* with the participation of *Ceratophyllum submersum*. Helophytes appeared partly outside the water and additionally a stand of *Typha latifolia* in the central part of the pond was observed (Kuczyńska-Kippen and Nagengast 2006a)

The floristic and phytosociological examination, chemical analyses, chlorophyll *a* concentration, and zooplankton samplings were performed using methods described in Kuczyńska-Kippen and Nagengast (2006a).

The Pearson correlation was applied to verify the relationship between chemical parameters, biometric macrophyte variables, and the numbers of zooplankton communities.

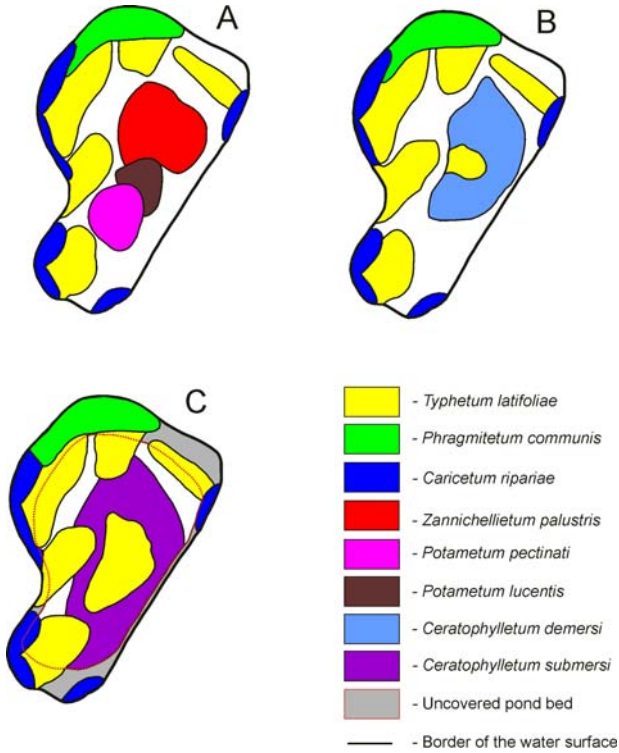


Fig. 1. Distribution of aquatic vegetation in Dąbrówka pond (1a – spring; 1b – summer; 1c – fall).

The distribution of littoral as well as eutrophic forms of zooplankton was also included in the fauna analyses. Additionally, similarities between zooplankton communities in different habitats were compared using the Ward method and the Euclidean distance measure (Sokal 1961), which is presented as a tree-diagram (Krebs 1989).

RESULTS

The results obtained showed that during one vegetative period that included three seasons (spring, summer, and fall), three different layouts of aquatic vegetation were noted.

In fall (Fig. 1c), in relation to the spring and summer (Fig. 1a and b), the water level decreased to 0.1 m (the area of the water surface decreased by 32% from the beginning to the end of the study period). The fall changes in macrophyte cover, similar to the summer season, were only in quality and

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concerned elodeids. In the examined water body a transformation from phytocoenosis of *Ceratophylletum demersi* dominating in the summer into *Ceratophylletum submersi* with a single specimen of common hornwort was observed in the fall. Quantity changes were also recorded. Stands of *Typhetum latifoliae* increased by 9.5% in the summer and 15.7% in the fall compared to the area they occupied during the spring (Table 1).

There were only three significant correlations between zooplankton densities and environmental factors observed in total. Only one negative relationship concerning a chemical variable was obtained (total nitrogen $r = -0.7137$; $p<0.05$) and two relating to biometric parameters of the macrophyte habitat. It was found that cladoceran densities positively correlated with the plant biomass ($r = 0.5477$; $p<0.05$), while rotifers correlated with the plant stem volume ($r = 0.5315$; $p<0.05$).

The analysis of the similarity of the zooplankton communities of particular sampling stations in the three examined seasons did not reveal any clear relationship, either in relation to a particular season or sampling station (Fig. 2). The participation of species indicating eutrophic conditions within the total zooplankton abundance reached values between 1 and nearly 58%. The mean participation of such species was 25% in the spring, 9% in the summer and only 3% during the fall seasons. The open water zone possessed the highest participation of these species (58% and 5%, respectively), compared to the macrophyte zones, while in the summer the proportions between sampling sites were equal (Fig. 3). Furthermore, on analyzing the participation of littoral species it was observed that the highest values were recorded in the fall (Fig. 3).

Table 1

Participation (in %) of particular aquatic plant communities in the total area of the examined water body.

Plant communities	spring	summer	fall
Phragmitetum communis	7.8	7.8	7.9
Typhetum latifoliae	26.3	35.8	42.0
Caricetum ripariae	8.1	8.1	8.2
Zannichellietum palustris	13.6	-	-
Potametum pectinati	6.6	-	-
Potametum lucentis	3.9	-	-
Ceratophylletum demersi	-	19.9	-
Ceratophylletum submersi	-	-	24.5
Total	66.3	71.6	82.6

- not present

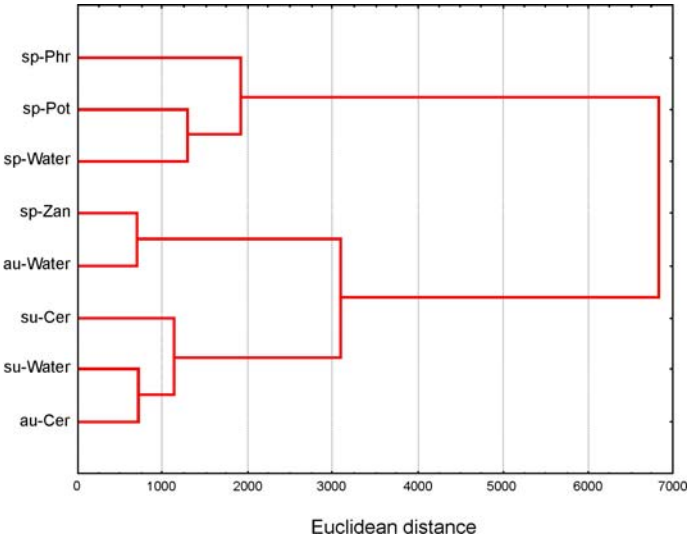


Fig. 2. Mean similarity coefficient of zooplankton communities in particular zones in spring, summer, and fall (Euclidean distance measure; Ward method).

DISCUSSION

Fluctuations in the water level are one of the most important features of shallow water bodies. The distribution of aquatic vegetation, depending on the lowering or increasing of the water level, has already been described by some authors, e.g., van der Valk and Davis (1976). They found that during the summer draft the area of elodeids become partly uncovered; however, different plant species react in different ways. A trend in the vegetation cover transformation in the direction of draftness has been observed. Moreover, a tendency towards seed sprouting of emerged species, which have moved in between the stands of elodeids, is observed. Thereby they contribute to the increase of species diversity and the biomass of aquatic vegetation. This reflects individual mechanisms of particular species or types of macrophytes that are undergoing changes in the water level in small water bodies to yield from a pond or to change their typical distribution pattern connected with vegetation zonation. Peltier and Welch (1970), Jackson and Starret (1959), Hestand et al. (1973), as well as Nichols (1975) also suggested that aquatic vegetation, and particularly submerged species, are characterized by differentiated growth and development depending on the fluctuations of water level in shallow water

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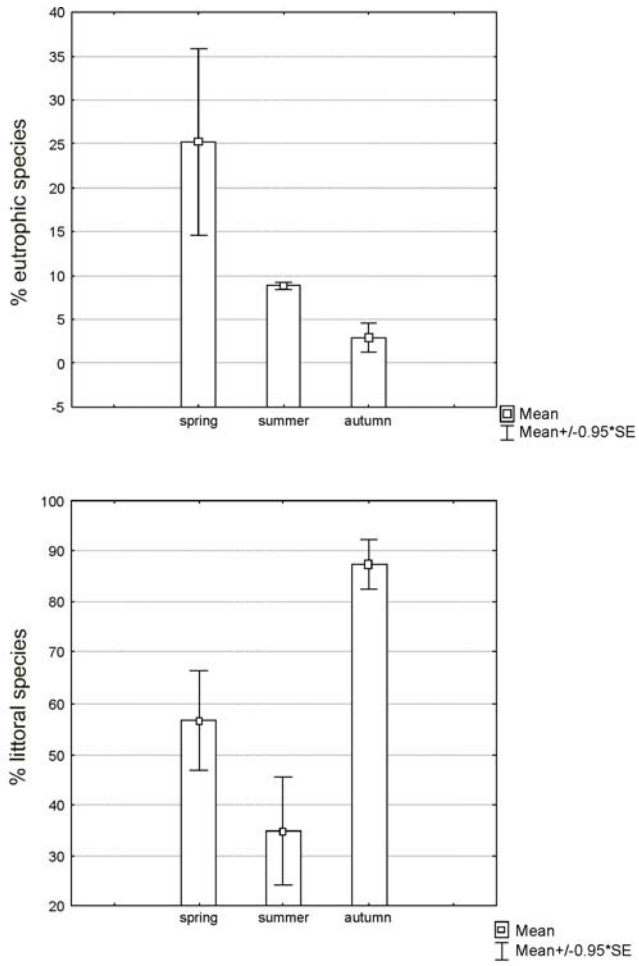


Fig. 3. Participation of eutrophic and littoral species in the total densities of zooplankton communities of Dąbrówka pond.

bodies. Similar results were also obtained in the case of the studied Dąbrówka pond, where, within one vegetative period (spring, summer, and fall) a significant transformation in macrophyte cover was observed. Along with the lowering of water level, structural changes, especially in the case of submerged vegetation, were recorded, which, in each season, was represented by different dominating species. Kraska et al. (2002), analyzing the macrophyte vegetation of small water bodies near Turew (western Poland) found that as a result of a

sudden drought in one year of long-term studies *Typha latifolia* increased their area by 72%. While the spatial expansion of helophytes may have been explained by the water level decrease, the transformation within one macrophyte genus (also described by different authors, e.g., Kraska et al. 1994, Gołdyn 2000) from *Ceratophylletum demersi* to *C. submersi* was probably due to climatic conditions that influenced water temperature. *Ceratophyllum submersum* is of a higher temperature requirement compared with *C. demersum* (Casper and Krausch 1981).

In the present study aquatic vegetation increased its range, thereby causing a drastic decrease in the unvegetated open water area. This process contributed to the increase in the mean participation of the littoral species of zooplankton communities at the end of the study season and might have also been a result of the much reduced participation of eutrophic species in the investigated water body since species indicative of eutrophic conditions belong to typical representatives of the pelagic zone.

On analyzing the relationships between zooplankton densities and environmental variables, only three significant correlations were found. The plant biomass was a predictor of cladoceran abundance, which may reflect the complexity of the aquatic plant habitat, indirectly relating to the effectiveness of the macrophyte stand as anti-predator refuge (Schriver et al. 1995, Kairesalo et al. 1998). A positive relationship between rotifer densities and plant stem volume was also observed in many cases in research carried out on the shallow and macrophyte-dominated Lake Wielkowiejskie (Kuczyńska-Kippen and Nagengast 2006b).

Very few significant relationships between zooplankton numbers and environmental parameters as well as the lack of similarity between zooplankton densities and season or particular habitat were probably due to the rapidity of the changes in the examined water body. The lowering of the water level, the exchange of the elodeid communities, the increase in the area covered by helophytes, and changes in the physicochemical features of the water of Dąbrówka pond (Kuczyńska-Kippen and Nagengast 2006a) took place within a very short time period from June to October, which contributed to the unstable character of the relationships between animal plankton communities and environmental variables.

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