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BIOMETRIC PARAMETERS OF VARIOUS MACROPHYTE SPECIES IN LAKE WIELKOWIEJSKIE: THE IMPACT OF SEASON AND CHEMICAL VARIABLES

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Summary. The research was carried out in the spring and autumn of 2001 on lake Wielkowiejskie in five stands of *Typha angustifolia, Nymphaea alba, Utricularia vulgaris, Chara hispida,* and *C. tomentosa*. The aim of the study was to describe the impact of a particular season and the chemical features of water within the plant habitat on the macrophyte biometric variables (stem length and dry mass in one litre of lake water) of the chosen aquatic vegetation communities. As a result of this investigation it was found that the stems of *Nymphaea alba* and *Typha angustifolia* differed significantly between the two seasons and were much longer per water unit in the spring. There was also a high similarity between the communities of both *Chara* species obtained in relation to the TOC in the water and to the stem length. Moreover, the communities of stoneworts were similar to those of the narrow leaf cattail in relation to dry mass. A positive relationship between the water hardness and the dry mass of stoneworts was found for the spring season. The obtained results indicate that the two seasons – spring and autumn – have a differentiating influence on the aquatic plant communities in relation to chemical variables and biometric parameters of plant habitat.

Key words: macrophytes, stem length, dry mass, impact of season, chemical variables

INTRODUCTION

The functioning of macrophyte-dominated lakes differs in many aspects from that of deep and stratified lakes [Scheffer 2001]. Aquatic vegetation is able to create favourable conditions for many aquatic organisms and the macrophyte spatial build and specific morphology may influence the physical-chemical characteristics within the plant stand. Analysis of the species composition as well as of the condition of particular macrophyte species may provide information relating to water quality changes and to the type of water body or the kind of littoral [Szmeja 2002, Nurminen 2003]. Habitats build by species of hydromacrophytes may differ in stand density (stated as stem length per 1 litre

of water), biomass (dry mass l^{-1}) and volume (infested volume l^{-1}), percentage of macrophyte cover or morphological build of particular plant species. The biomass of certain species of macrophytes relates to their ability to grow to the water column or surface and to the season. The biometric parameters of a plant habitat often relate to a particular ecological group of macrophytes. Aquatic plants are grouped into several growth forms which include, among others, elodeids (submerged plants, poorly rooted), nymphaeids (plants attached to lake bottom with floating leaves) and helophytes (plants which have their perennating organs in soil or mud below water-level).

This paper presents the results obtained as a result of comparison of biometric parameters of aquatic vegetation stands of emerged, submerged and floating leaved plants from investigations undertaken in two seasons in the shallow and macrophyte-dominated lake Wielkowiejskie. The aim of the investigations was to describe the differentiation of the macrophyte biometric variables in relation to a particular season, to quantify the relationship between density as well as dry mass and some chemical features of water within the plant habitat, and to compare the similarities between the biometric parameters of each habitat and chemical variables in different habitats.

MATERIAL AND METHODS

Wielkowiejskie lake, a shallow macrophyte-dominated lake situated in the Wielkopolski National Park, has an area of 13.3 ha, maximum depth of 2.8 m and mean depth of 1.4 m. A belt of rushes, predominately with *Typha angustifolia* L. and *Phragmites australis* (Cav.) Steud, surrounds the lake. Nearly the whole basin is covered by submerged macrophytes (mainly *Chara hispida* L., *C. tomentosa* L., *Myriophyllum verticillatum* L., *Nitellopsis obtusa* (Desvaux) Groves and *Utricularia vulgaris* L.). Stands of *Nymphaea alba* L. cover approximately 20% of the water surface. The macrophyte beds are single-species stands, separated from each other.

The research was carried out twice – in late spring and early autumn of 2001. The plant material was cut from a known area (0.25 × 0.25 m) and depth (the entire water column occupied by macrophytes). The length of particular macrophyte stems and their biomass per 1 litre of lake water were estimated. This is why the length of plant stems should be understood as the plant density. In the case of *Chara* species, stems were understood as the main stem with branchlets, while of *Utricularia* as the main stem with leaves. Branches of the subsequent order were treated as separate stems. The underwater *Typha* stem, together with its adherent leaves, was treated as a single length unit. The length of an underwater *Nymphaea* stem was equal to the length of its petiole. Particular plant matter samples were taken in triplicate from the same places as the chemical samples had been collected earlier.

Additionally, chemical analysis was made in order to evaluate the content

of N, P, C and Ca of the water filling the spaces between the plant stems.

The similarities between the biometric parameters of each habitat and the chemical variables in different habitats were compared using the Ward method and the Euclidean distance measure [Sokal 1961].

The U-Mann test was used for statistical analysis in order to evaluate the seasonal differences in the biometric parameters of particular macrophyte species (N = 6) and the differences of the length and dry mass between particular macrophyte species in a particular season (N = 15).

The relationship between biometric and chemical variables of a particular macrophyte species was checked by the Pearson correlation (N = 30).

RESULTS AND DISCUSSION

Vascular as well as macroalgae aquatic plants create an important component of the biocoenosis of the littoral area of a variety of water bodies, including ponds and lakes. Aquatic vegetation contributes to the creation of specific conditions within the littoral area and therefore it can also influence the physical-chemical features [Raspopov *et al.* 2002] and also life conditions for other organisms inhabiting vegetated zones. Hydromacrophytes, and especially stoneworts, are known to maintain a clear water state in many shallow lakes [Scheffer *et al.* 1993]; they may also contribute to water purification in the primary production process. Furthermore, they serve as a vast substrate for development of epiphytic algae [Gons 1979, Messyasz and Kuczyńska-Kippen 2006] and phytophilous invertebrates [Paterson 1993, Duggan 2001]. The grazing activity of animals associated with macrophytes may cause the removal of periphytic communities from plant surfaces and thus enable better plant growth [Jones *et al.* 2000, James *et al.* 2000]. The influence of expanding macrophyte density, through enlargement of the possible substrata surface, on the increase of the total periphyton biomass is a well known phenomenon [Pieczyńska 1976].

Analysing the relationship between chemical and biometric variables of plants in the spring and autumn seasons a positive correlation was found for the water hardness and the dry mass of stoneworts ($r = 0.8441$; $p < 0.05$). This is consistent with the literature data which emphasise the relationship of the occurrence of species from the genus *Chara* and the water hardness [Dąmbska 1964, Krause 1997]. It should also be mentioned that this positive correlation was only obtained for the spring season. The lack of such relationship in the autumn may be connected with the fact that along with the increase of participation of the stonewort meadows in the lake, the consumption of dicarbonates in the process of photosynthesis and the precipitation of calcium carbonate also increased [McConnaughey 1997]. Similarly, Pełechaty *et al.* [2007], conducting research in the water bodies of the Lubuskie Lakeland, found low concen-

trations of calcium in lakes with the highest participation of stonewort meadows.

The comparison of the biometric features (plant density and dry mass) of particular macrophyte communities between particular seasons of this examination revealed statistically significant differences for *Nymphaea alba* ($Z = 1.9633$; $p < 0.05$) and *Typha angustifolia* ($Z = 1.9639$; $p < 0.05$) for the stem length in one litre of lake water between both seasons (spring and autumn) – Fig. 1. The

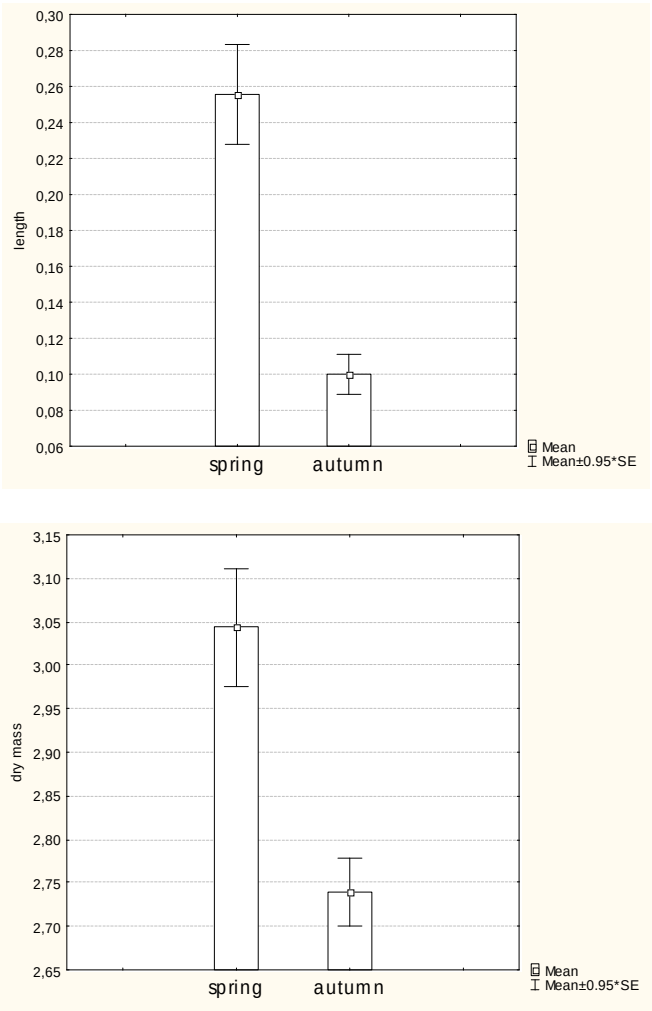

Fig. 1. Mean dry mass (g dm^{-3}) and length (cm dm^{-3}) of *Nymphaea alba* stems in one litre of the lake water in spring and autumn

biomass of aquatic plants typically increases in a sigmoid pattern during the growing season [Wetzel 2001]. In the examined lake some discrepancies from this pattern were noticed, however, the study concerned only two seasons – late

spring and early autumn. Considerably lower values of stem length and also of dry mass ($Z = 1.9640$; $p < 0.05$) during the autumn season for white waterlily is probably connected with the process of the plant dying off during the autumn. Leaves of representatives of nymphaeids, which are usually quite large and broad, resistant to tearing from wave action [Sculthorpe 1967], seem to loose their dry mass in the case of Wielkowiejskie lake towards the end of their development.

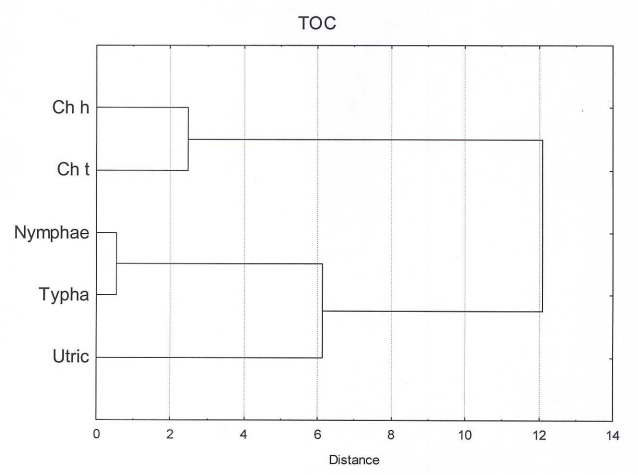

Fig. 2. Mean value of similarity of concentration of TOC (mg dm^{-3}) (the Ward method and Euclidean distance measure) in Wielkowiejskie lake between particular stands of examined macrophytes (Ch h – *Chara hispida*, Ch t – *Chara tomentosa*, Nymphae – *Nymphaea alba*, Typha – *Typha angustifolia*, Utric – *Utricularia vulgaris*)

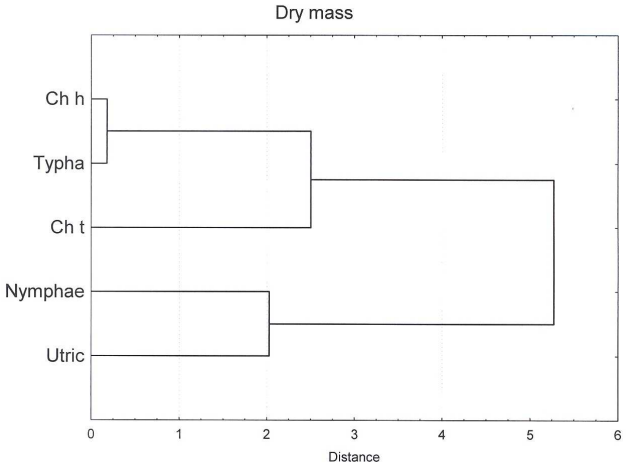

Fig. 3. Mean value of similarity of plant dry mass (g dm^{-3}) (the Ward method and Euclidean distance

measure) in Wielkowiejskie lake between particular stands of examined macrophytes (Ch h – *Chara hispida*, Ch t – *Chara tomentosa*, Nymphae – *Nymphaea alba*, Typha – *Typha angustifolia*, Utric – *Utricularia vulgaris*)

However, in the case of *Typha angustifolia* the co-occurrence of both young leaves and also dry leaves from the previous year seem to affect its obtaining much higher values of plant density in the spring season compared to the results from the autumn.

To estimate the similarity between the examined plant species stands in relation to biometric and chemical variables, a cluster analysis was applied. Based on the chemical parameters two groups of macrophyte species were distinguished. Both communities of stoneworts were similar to each other based on the concentration of the total organic carbon (TOC) in water between the plant stems and also based on the plant length (Fig. 2). Another group consisting of *Chara hispida, C. tomentosa* and *Typha angustifolia* was also distinguished, where a similarity was found in relation to their dry mass (Fig. 3). The similar values of dry mass of these different species is a result of the very high density of both species of charophytes, which also affected the high biomass of these plants in one litre of the lake water. Stoneworts are often the most abundant species in many lakes [Schierup *et al*. 2002, Kuczyńska-Kippen and Nagengast 2006]. In the case of the cattail, naturally high dry mass is a characteristic feature of this plant species [Kuczyńska-Kippen and Nagengast 2003, Kuczyńska--Kippen and Nagengast 2006] due to the specific morphometry of its underwater leaves. Moreover, Wetzel [2001], comparing the annual maximum biomass of various macrophyte species from many lakes all over the world, noticed that *Typha angustifolia* was among those plants which (both as a species or as a representative of emerged plants) have the highest dry mass per square metre.

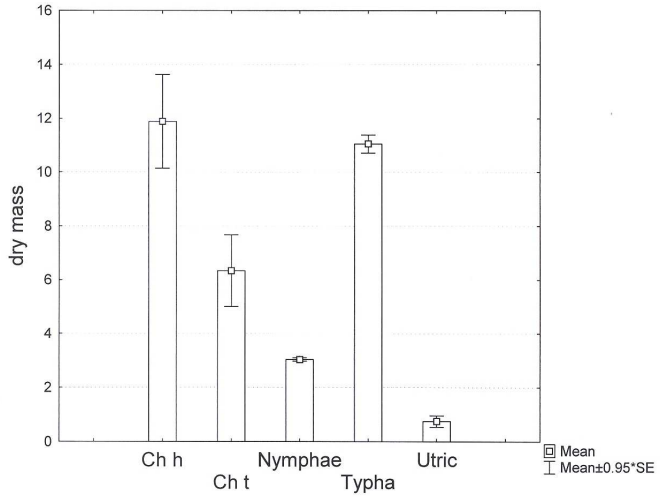

Fig. 4. Mean dry mass (g dm^{-3}) in particular macrophyte stands (Ch h – *Chara hispida*, Ch t – *Chara tomentosa*, Nymphae – *Nymphaea alba*, Typha – *Typha angustifolia*, Utric – *Utricularia vulgaris*)

Biometric parameters and chemical features were also analysed in respect to particular season. In the spring statistically significant differences between particular macrophyte species were obtained for dry mass (Fig. 4; $Z = 1.9630$; $p < 0.05$). The highest values of dry mass were recorded for *Chara hispida*, *Typha angustifolia* and *C. tomentosa*. The stonewort species *C. hispida* was a dominating species in the investigated lake. Moreover, both species of stoneworts were overwintering the examined lake, so their stands were in good condition in the spring season. In the earliest season of the study – spring – stoneworts did not need to compete for light with filamentous algae which occurred in great amounts during the summer season [Messyasz and Kuczyńska-Kippen 2006]. However, *T. angustifolia*, whose density per lake volume is much lower compared to stoneworts, is a plant of very high biomass [Hogg and Wein 1987].

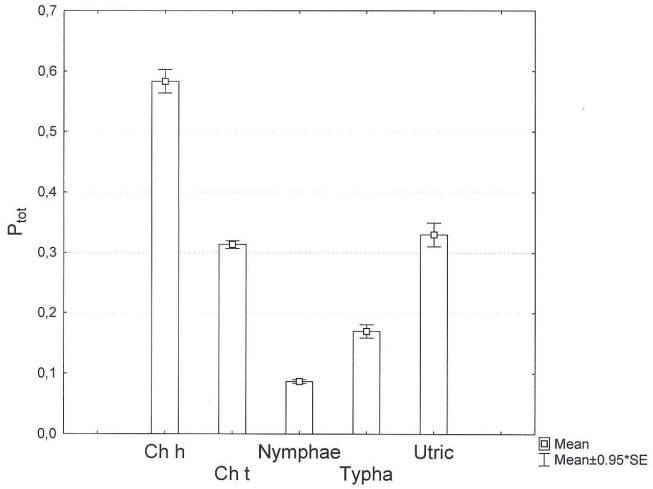

Fig. 5. Mean concentration of total P (mg dm^{-3}) in water of particular macrophyte stands (Ch h – *Chara hispida*, Ch t – *Chara tomentosa*, Nymphae – *Nymphaea alba*, Typha – *Typha angustifolia*, Utric – *Utricularia vulgaris*) in autumn

The concentration of P_{tot} in the water was very low in the spring season, while in the autumn significant differences were found in respect to particular macrophyte species ($Z = 1.9640$; $p < 0.05$). Water among the three species of submerged macrophytes (*C. hispida*, *U. vulgaris*, *C. tomentosa*) was characterised by the highest values of total phosphorus content (Fig. 5). In Lake Wielkowiejskie the highest densities of zooplankton communities were found in the densest and most complex habitats – submerged macrophyte species [Kuczyńska-Kippen and Nagengast 2006, Kuczyńska-Kippen 2007] and zooplankton are known for taking part in the regeneration of phosphorus [Ejsmont-Karabin 1984, Gliwicz 2004], thus the highest concentrations of phosphorus were recorded in those three habitats.

CONCLUSIONS

1. The obtained results indicated a differentiation between the two examined seasons – spring and autumn – in relation to chemical variables of water within a plant habitat and to the biometric parameters of the aquatic plant community. It was found that the stems of *Nymphaea alba* and *Typha angustifolia* differed significantly between the two seasons, with higher values obtained in the spring.

2. A positive relationship between the water hardness and the dry mass of stoneworts was also found for the spring. Moreover, a high similarity between both *Chara* species was obtained in relation to the TOC in water and to their stem length, as well as between stoneworts and narrow leaf cattail in relation to the dry mass.

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PARAMETRY BIOMETRYCZNE RÓŻNYCH GATUNKÓW HYDROMAKROFITÓW W JEZIORZE WIELKOWIEJSKIM: WPŁYW SEZONU I PARAMETRÓW CHEMICZNYCH

Streszczenie. Prace prowadzono wiosną i jesienią 2001 r. na jeziorze Wielkowiejskim w pięciu płatach z *Typha angustifolia, Nymphaea alba, Utricularia vulgaris, Chara hispida* i *C. tomentosa*. Badano wpływ sezonu i parametrów chemicznych na parametry biometryczne (długość roślin i suchą masę na litr wody) wybranych zbiorowisk roślinnych. Celem badań było wykazanie wpływu pory roku i parametrów chemicznych na parametry biometryczne roślin wodnych. Badania wykazały różnice pomiędzy wiosną i jesienią, stwierdzono między innymi, że pędy *Nymphaea alba* i *Typha angustifolia* były istotnie dłuższe w przeliczeniu na litr wody wiosną. Stwierdzono także podobieństwo pomiędzy zbiorowiskami *Chara* pod względem zawartości TOC w wodzie i długości roślin oraz zbiorowiskami ramienic i pałki wąskolistnej pod względem suchej masy. Wiosną wykazano także dodatnią korelację pomiędzy twardością wody a suchą masę ramienic. Wyniki wskazują, iż wiosna i jesień różnicuje zbiorowiska roślinne pod względem parametrów chemicznych i biometrycznych.

Słowa kluczowe: hydromakrofity, długość, sucha masa, zmiany sezonowe, parametry chemiczne