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Charophyte species and communities of different types of water ecosystems of the Ziemia Lubuska region (Western Poland)

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Abstract: The aim of the paper was to present the floristic and phytocoenotic diversity of charophytes (Characeae family) in the aquatic ecosystems of the Ziemia Lubuska region in Poland. Data set was collected during the study of rush and aquatic vegetation carried out between the years 2000 and 2005. From amongst 34 species of the Characeae family expected in Polish waters 21 were found in different aquatic ecosystems of the region of Ziemia Lubuska, representing all 5 genera known from Poland. Considering charophyte vegetation, out of 30 associations 15 were found in the region: 14 in lakes and one in old riverbeds and ponds. Among these associations *Charetum hispidae*, *Charetum intermediae*, *Lychnothamnetum barbati* and *Nitelletum opacae* were observed sporadically. Considering 50 lakes surveyed, phytocoenoses of charophyte associations were found in 25 of them. In further 13 lakes single specimens, clusters or small patches of charophytes occurred. The highest number of species per lake was 7; it was also the highest number of charophyte communities. The analysis of habitat conditions in lakes revealed that such important parameter as phosphorus content was not involved in the habitat differentiation of lakes with the varied development of charophyte vegetation.

Key words: charophytes, Characeae, *Chara*, *Nitella*, *Nitellopsis*, *Lychnothamnus*, *Tolypella*, *Charetea*, Ziemia Lubuska, Western Poland

1. Introduction

Within aquatic vegetation submersed macrophytes are of greatest importance for aquatic ecosystems (Carpenter & Lodge 1986; Søndergaard & Moss 1998). Among them macroscopic chlorophytes called charophytes or stoneworts (Characeae family) are supposed to play an especially important habitat and environment forming role and influence on the water abiotic and biological parameters. The primary effect of charophytes on the water properties results from the mechanism of photosynthesis and the capability to use bicarbonate as an alternative to carbon dioxide (McConnaughey 1997). According to this, charophytes are claimed to prefer environments with elevated pH (van den Berg *et al*. 1998), although they may also grow in waters with low pH level (Vieira & Necchi 2003). Extensive patches of large charophyte species, particularly when they grow over the whole water column at shallow sites, significantly affect the water chemistry. Due to different mechanisms (e.g. stabilizing sediments, intensifying particle sedimentation, phosphorus co-precipitation with calcite and competition for light and nutrients with phytoplankton) charophytes may improve water transparency and create their own light environment, which promotes this group of submersed macrophytes over broad range of trophic conditions (van den Berg *et al*. 1998, 1999; van Donk & van de Bund 2002; Kufel & Kufel 2002). Still, despite their habitat and environment transforming abilities, charophytes are considered sensitive indicators of clear and nutrient-poor waters (Forsberg 1964; Krause 1981, 1997). Along with increasing trophic level, varied charophyte species, particularly large species with shoot diameter >1 mm, are among the first submersed macrophytes to disappear (Ozimek & Kowalczewski 1984; Blindow 1988, 1992a, 1992b). Considering all the above, charophytes, their communities and habitats should be protected, as suggested by

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the EC Habitat Directive. Since 2004 many species of those macroalgae have been added to the list of plant species protected by the Polish law.

Despite its great variety of aquatic ecosystems, the hydrobiological knowledge of the region of Ziemia Lubuska (mid-Western Poland) is quite poor. Since 2000 rush and aquatic vegetation has been studied within the framework of different research projects (Pełechaty *et al*. 2002; Pełechaty & Kałuska 2003; Pełechaty & Pukacz 2004; Pukacz *et al*. 2005). This paper focuses on the flora and vegetation of charophytes of Ziemia Lubuska, which were the subject of only fragmentary studies in the past (Dąmbska 1962, 1964, 1966).

2. Material and methods

Material for the present paper was collected during the field investigations which followed the various study projects and themes. Therefore, different types of aquatic environments, such as old river-beds, fishponds and ditches regulating water level in the latter ones, particularly in SW part of the region, near Tuplice village were surveyed (Pukacz & Pełechaty 2004). Most studies, however, concentrated on the lakes in the area of Lubuskie Lakeland, centrally located and covering most of the Ziemia Lubuska region. The lakes represent different trophic, morphometric and overturn regime, including rarely observed meromictic type, e.g. Lake Lubińskie (Pełechaty *et al*. 2004a; Pukacz *et al*. 2005). 50 lakes were studied between summer 2000 and the end of June 2005. Detailed data set, concerning not only macrophyte vegetation but also physicochemical properties of the lakes' water, was gathered in 30 lakes (Pukacz *et al*. 2005). A common mid-European phytosociological method was applied in the vegetation analyses. Macrophytes were searched from the boat using a small anchor with a calibrated rope. Charophyte specimens were identified according to Dąmbska (1964) and Krause (1997) and with the use of Stereo microscope Olympus SZX 9. Species names follow Dąmbska (1964). Principal components analysis (PCA) was undertaken to characterize the habitat conditions in lakes with different number of charophyte associations.

3. Results and discussion

3.1. Species diversity

Out of 34 species of the Characeae family expected in Polish waters 21 were found in different aquatic ecosystems of Ziemia Lubuska, representing all 5 genera known from Poland (Dąmbska 1964). All the species found are listed below with the types of ecosystems in which they occurred.

Charoideae. *Chara aspera* (Deth.) Willd. – lakes; *C. coronata* Ziz. (frequently used name: *C. braunii* Gmel.) – ponds, ditches; *C. contraria* Kütz. – lakes, ponds, old river-beds; *C. delicatula* Ag. – lakes, ditch, river; *C. fragilis* Desvaux – lakes, ditches, old river-bed; *C. hispida* L. – lakes; *C. aculeolata* Kütz. (frequently used name: *C. intermedia* A. Br.) – lake; *C. polyacantha* A. Br. – lakes; *C. rudis* A. Braun – lakes; *C. tomentosa* L. – lakes; *C. vulgaris* L. – ponds, old river-beds; *Nitellopsis obtusa* (Desvaux) J. Groves – lakes; *Lychnothamnus barbatus* (Meyen) v. Leonhardi – lake.

Nitelloideae. *Nitella batrachosperma* (Reichenbach) A. Br. – ditch; *N. capillaris* Gr. et Bull. Webst. – ditch; *N. flexilis* (L.) Agardh – lakes, ditch; *N. gracilis* (Smith) Agardh – lakes, ditch; *N. mucronata* A. Br. – lakes; *N. opaca* Agardh – lakes; *N. syncarpa* (Thuillier) Kützing – ditch; *Tolypella glomerata* (Desvaux) v. Leonhardi – lake.

Amongst interesting and rare *Chara* species *Chara braunii* represents the group of uncorticated species (the only representative of this group in Poland). It is mostly southern species with occurrence limited to fishponds (Dąmbska 1964). This species was found not only in a fishpond (near the above-mentioned Tuplice village), but also in a ditch regulating water level in fishponds. The detailed information on this locality was given by Pukacz & Pełechaty (2004). Among other *Chara* species *Chara delicatula* is worth to be mentioned as its localities were found for the first time in this region in the year 2001, although the distribution of this species – in the light of Polish and international literature – was linked with clear water oligo- and mesotrophic lakes with so called lobelian vegetation (Dąmbska 1964, 1966; Krause 1997; Pełechaty *et al*. 2004b). *Chara delicatula* is a common species in the region, occurring in a wide range of abiotic conditions and not only in lakes. The fact that Dąmbska did not found this species might have possibly resulted from a small number of ecosystems surveyed. To the group of species rarely noted in Poland belongs *Chara polyacantha*, which forms their own community very rarely observed and restricted to mesotrophic waters (Gąbka & Pełechaty 2003). This species was found in three lakes, and its community – in two of them. Interestingly, first locality where the species occurred and where it has been extensively growing was a shallow lake with tendencies to higher trophic regime (Pełechaty *et al*. 2003; Pełechaty & Pukacz 2004). In accordance with the theory of alternative stable states in shallow lakes (Scheffer *et al*. 1993; Jeppesen 1998) the abundant submersed vegetation, and particularly charophytes, may maintain clear water conditions, although nutrient level is rather high. In such conditions diverse and even rare and sensitive macrophyte species, including charophytes, may grow.

To the group of species considered rare and threatened on an international scale belong *Lychnothamnus barbatus*,

Tolypella glomerata and *Nitella batrachosperma* (Dąmbska 1964; Balevičius 2001 and personal communication; Hutorowicz and Sinkeviciène personal communications). Only one locality of each of these species was found in the area of Ziemia Lubuska: *Lychnothamnus barbatus* and *Tolypella glomerata* were found in lakes (Pełechaty & Pukacz 2005; Matuszak 2003) whereas *Nitella batrachosperma* – in a ditch regulating water level in fishponds near Tuplice (in June 2004 and confirmed in June 2005). *Lychnothamnus barbatus*, the only representative of the genus, was previously found in the region (Lake Wilkowskie) by Dąmbska (1962) but this locality was not found during field investigations in the summer 2004, when a new locality of this species was found by the authors in Lake Łagowskie. So far, *Tolypella glomerata* has been known in Poland from one locality in Lake Lednica (Dąmbska 1971). In the material collected by Matuszak (2003) in Lake Linie (near Rzepin town) the authors identified *Tolypella glomerata* (identification was confirmed by K. Karczmarz). Unfortunately, the locality was not found in June 2005. In the case of *Nitella batrachosperma* (identification was confirmed by A. Hutorowicz) the locality of interest here seems to be the only contemporary site of this species in Poland (Hutorowicz, personal communication), although a few localities were known in the past (Karpiński 1938; Dąmbska 1964). It is worth to emphasize that apart from *Nitella batrachosperma* three other species representing the *Nitella* genus and three *Chara* species were found in the small area of the abovementioned fishpond and ditch.

3.2. Charophyte vegetation

As far as charophyte vegetation is concerned, 15 associations (out of 30 known from Poland) were found: 14 in lakes and one (*Charetum vulgaris*) in old river-beds and ponds. The list of associations is given below:

Cl. *Charetea* (Fukarek 1961 n. n.) Krausch 1964, **O**. *Nitelletalia flexilis* Krause 1969, **All.** *Nitellion flexillis* (Corill. 1957) Dąmbska 1966, **Ass**. *Nitelletum flexilis* Corillion 1957, *Nitelletum opacae* Corillion 1957, *Nitello-Vaucherietum dichotomae* Krausch 1964; **O**. *Charetalia hispidae* Sauer 1937 ex Krausch 1964, **All.** *Charion fragilis* (Sauer 1937) Krausch 1964 em. Krause 1969, **Ass.** *Charetum fragilis* Fijałkowski 1960, *Charetum hispidae* Corillion 1957, *Charetum polyacanthae* Dąmbska 1966 ex Gąbka et Pełechaty 2003, *Charetum asperae* Corillion 1957, *Charetum intermediae* (Corillion 1957) Fijałkowski 1960, *Charetum contrariae* Corillion 1957, *Charetum rudis* Dąmbska 1966, *Charetum tomentosae* Corillion 1957, *Charetum delicatulae* Doll 1989, *Nitellopsidetum obtusae* (Sauer 1937) Dąmbska 1961, *Lychnothamnetum barbati* (Gołdyn 1984) Brzeg et Wojterska 2001, **All.** *Charion vulgaris* Dąmbska 1966 ex Krause 1981, **Ass.** *Charetum vulgaris* Corillion 1957.

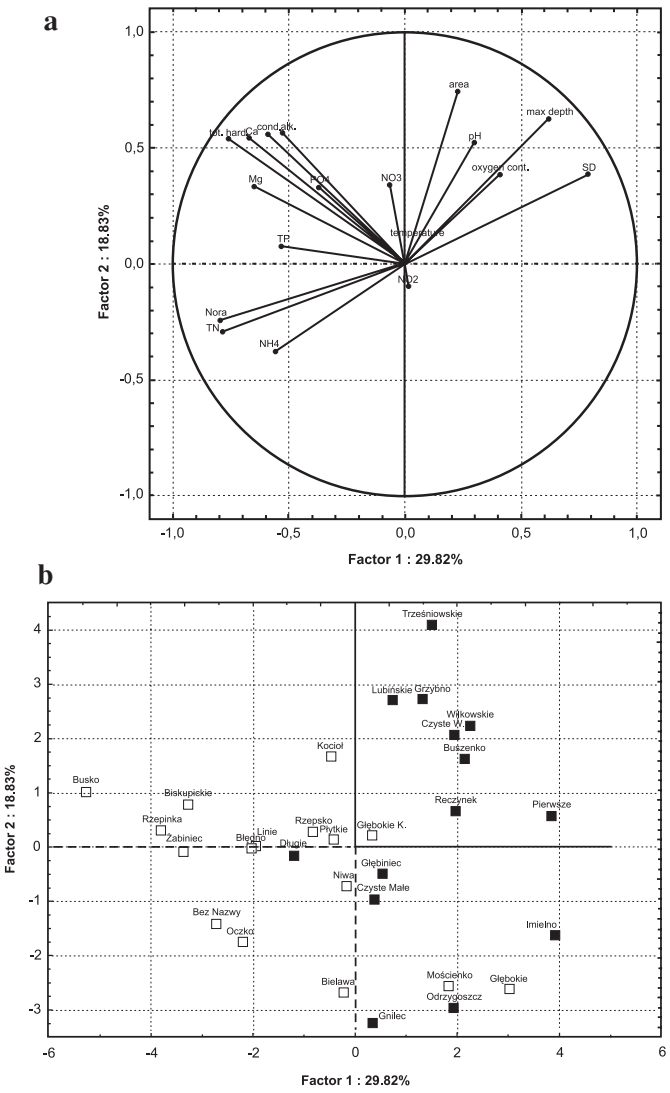

Fig. 1. Results of PCA analysis: a) the contribution of physicochemical properties of lakes' waters in the explanation of the habitat differences in the group of lakes under study; b) habitat differences among three groups of lakes: lakes with 3 and more charophyte associations (black squares), lakes with 1-2 associations (grey squares) and lakes without charophyte vegetation (white squares)

Among these associations *Charetum hispidae*, *Charetum intermediae*, *Lychnothamnetum barbati* and *Nitelletum opacae* were observed sporadically (only one locality in each case). Further three associations (*Charetum polyacanthae*, *Charetum asperae* and *Charetum rudis*) were rare.

Considering all the 50 lakes surveyed, in 25 of them phytocoenoses of charophyte associations were found. In further 13 lakes only single specimens, clusters or small patches of charophytes occurred. The highest number of species per lake was 7, it was also the highest number of charophyte communities. Based on the group of 30 lakes, for which complete data on the vegetation composition and habitat conditions were collected, the principal components analysis (PCA) was carried out

in order to find out which habitat factors play a key role in differentiation of a group of lakes with different number of charophyte communities. It has been stated that morphometric features, water clarity (Secchi disc visibility, SD), hardness, conductivity and nitrogen content are the most differentiating factors (Fig. 1a). By contrast to some literature data (e.g. Forsberg 1964) phosphorus was not responsible for the variation observed. Diverse charophyte vegetation (3 and more charophyte associations) was observed in deep, clear water lakes with lower trophic status (Fig. 1b). By contrast, charophyte communities were not found in shallow, turbid and rich in nutrients lakes. One or two charophyte associations were found in transitional ecosystems. However, to the group of lakes with the highest number of charophyte associations belonged a small and shallow ecosystem – Lake Czyste Małe. Although its abiotic conditions are different from those in deep, clear water lakes, the lake is overgrown by diverse and abundant submersed vegetation, which thanks to the various mechanisms listed in the introductory chapter may affect light conditions and promote occurrence of charophytes, including species considered sensitive indicators of high purity of waters such as *Chara polyacantha* (Pełechaty *et al*. 2003).

4. Conclusions

Although charophytes, and charophyte meadows in particular, are generally claimed to be rare and many of them endangered, the state of their preservation in waters of Ziemia Lubuska may be considered good. The occurrence of sporadic and rare species not only in Poland but also on an international scale, stresses the necessity of further research into charophyte flora and vegetation, and their habitat requirements, particularly under the human impact.

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