

## CHANGES OF VEGETATION STRUCTURE IN THE NATURAL MEROMICTIC CZARNE LAKE IN THE DRAWA NATIONAL PARK (NW POLAND)

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**Abstract:** Lake Czarne in the Drawa National Park is meromictic. Because of the lack of its thorough mixing (which results in limited mobilization of the nutrients deposited in bottom sediments and deeper water layers) as well as the low level of human impact, the lake is characterized by a low fertility. The species diversity of aquatic plants, which colonize the steep lake bottom in the littoral zone, is low and the vegetation is dominated mostly by stoneworts (*Charophyta*). However, vegetation structure in the lake has changed markedly in time. This study compares vegetation structure in the lake in the 1980s, 1998, and in 2005. The comparison reveals a great variation in its taxonomic composition. The mechanisms and causes of these changes are discussed in the paper.

**Key words:** meromictic Lake Czarne, vegetation, changes of *Chara* vegetation, Drawa National Park

### INTRODUCTION

Lake Czarne in the Drawa National Park is a meromictic water body. Usually meromixis is a consequence of the influence of chemical factors, e.g. inflow of saline waters into a water body. Meromixis caused by lake and catchment morphology is relatively rare, but it is the case in Lake Czarne (Kraska *et al.* 2001). A characteristic feature of this lake are the steep, wooded slopes of its direct catchment, which in combination with the relatively small size and large depth of the lake, substantially limit the influence of wind and its ability to mix lake waters. The littoral zone of Czarne Lake is characterized by steep slopes of the lake basin, so its biodiversity is low, reflected particularly in the presence of common aquatic plant associations, composed of perennial vascular species. Additionally, the low fertility of the surface layers of water in this lake is accompanied by the mechanism typical of meromictic lakes: sedimentation and permanent deposition of organic matter and mineral suspensions in the monimolimnion and bottom sediments. This mechanism also limits the potential for development of plant communities composed of vascular species.

On the other hand, this results in a high water transparency, which enables the colonization of the slopes of the lake basin by lower plants, mostly stoneworts

(*Charophyta*). It has been shown that charophytes are decomposed less quickly than vascular plants, because of the high calcium content of charophyte cells. Nutrient uptake from sediments (commonly observed in vascular plants) does not play such an important role in charophytes, because they are anchored to the substrate only by means of rhizoids. Charophytes can also indirectly affect nutrient circulation in lakes. The utilization of carbonates as a carbon source during photosynthesis results in calcium precipitation, which facilitates phosphorus immobilization in insoluble calcium compounds or sorption on sedimenting mineral particles. Dense charophyte meadows cause a good oxygenation of the surface layer of bottom sediments, which causes inhibition of nutrient release from bottom sediments, and consequently blocks this important source of nutrients for plankton (L. Kufel, J. Kufel 2002). Thus, these underwater meadows can function as nutrient traps.

In this study, we attempted to assess the range and causes of variation in the structure of littoral vegetation in this lake.

## STUDY LAKE

Lake Czarne, surrounded by forest, is oval in shape, and its long axis is oriented in a roughly north-south direction. It is located in the southern part of the Drawa National Park. Its shoreline is regular, relatively uncomplicated, without any remarkable inlets. Its maximum depth is 29 m (Tab. 1). The lake is located in a local depression, so it is surrounded by rather steep slopes. In the west, the boundary of its catchment undulates across hilltops, and borders on catchments of other lakes in the Drawa NP. The highest hill rises 23.1 m above the lake level. The catchment of Lake Czarne is characterized by a high level of habitat homogeneity. The lake is surrounded mostly by beech-oak forests (*Fago-Quercetum*

Table 1 – Tabela 1  
Morphometric characteristics of Lake Czarne and its catchment  
Dane morfometryczne Jeziora Czarnego i jego zlewni

	Unit	Value
Surface	ha	19.6
Maximum depth	m	29.0
Mean depth	m	11.2
Volume	10 <sup>3</sup> m <sup>3</sup>	2 137.75
Direct catchment area	ha	25.8
Catchment area of infiltration hollow	ha	7.8
Total catchment area	ha	33.6

Tx. 55), which are degenerated to a large extent due to human activity. The hydrogenic soils, developed around Lake Czarne, are covered by ash-alder forest (*Fraxino-Alnetum*) and fertile alder forest (*Ribo nigri-Alnetum*); another typical community of this group of soils is the willow thicket *Salicetum pentandro-cinereae* (Borysiak *et al.* 1998). Lake waters are supplied by surface runoff from the catchment and by underground waters. A characteristic feature of Lake Czarne is a small effluent situated at the southern end of the lake, where lake water flows into a small depression. Water from the depression infiltrates into the substrate, to the underground aquifers. The effluent functions only in some periods, when the water level in Lake Czarne is high. In earlier reports the catchment area of the lake was estimated at 33.6 ha, but considering this effluent to the infiltration basin and its catchment (7.8 ha), the true catchment area of Lake Czarne is 25.8 ha (Fig. 1).

The trophic state analysis in Lake Czarne, performed according to the OECD (1982), as well as according to the trophic state index (Carlson 1977), indicate that this water body is oligotrophic or mesotrophic. However, it must be remembered that this applies to the mixolimnion, without consideration of the

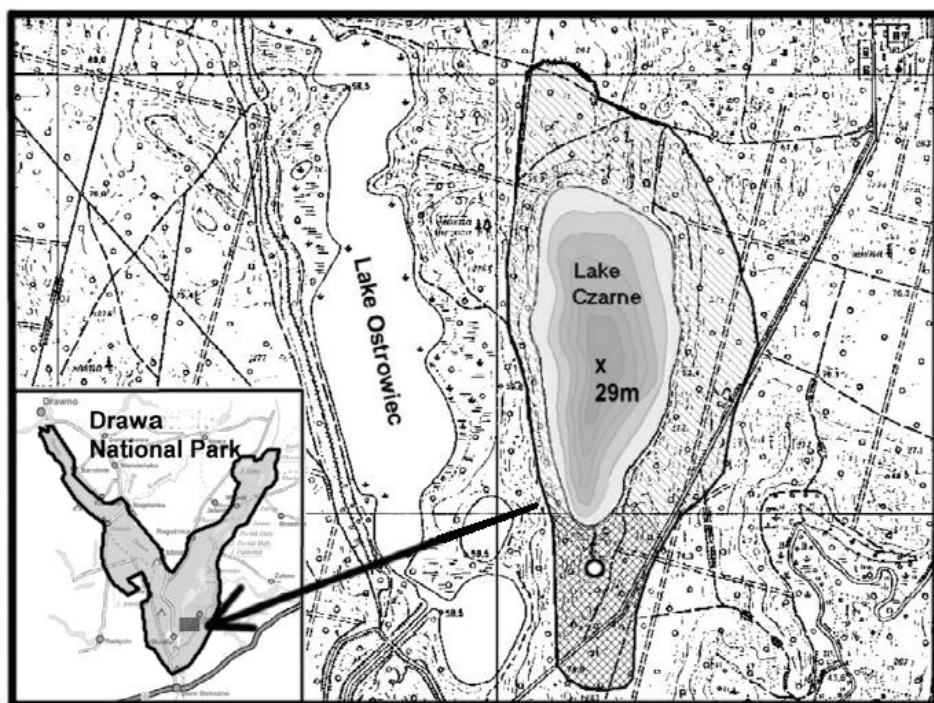


Fig. 1. Location of Czarne Lake and its catchment  
Ryc. 1. Lokalizacja Jeziora Czarnego i jego zlewnia

much more fertile monimolimnion, continuously supplied with the sedimenting suspension from the surface layers (Kraska *et al.* 2006a)

Chemical stratification of waters of Lake Czarne has proved to be significant. The mixolimnion and monimolimnion, as two water layers permanently separated by a chemocline, differ in chemical composition and fertility (Kraska *et al.* 2006a). The mixolimnion is much poorer in minerals than the monimolimnion, which is characteristic of meromictic lakes (Balistrieri *et al.* 1994; Chojński 1995; Galas 2003). This is reflected in electrolytic conductivity, which clearly increases above the chemocline, reaching maximum values near the bottom. Such a stratification is observed also in autumn and spring. The deoxygenated monimolimnion is continuously enriched with the sedimenting organic matter from the overlying layers. In anoxic conditions this water layer is also enriched with nutrients released from bottom sediments. As a result, the monimolimnion is much more fertile than the mixolimnion and chemocline. Phosphorus content is several-fold higher in the monimolimnion.

The vertical distribution of nitrogen in Lake Czarne is similar. Organic nitrogen dominates in the whole water column. Among mineral forms, the highest concentrations in all layers are reached by ammonium nitrogen. In this form of nitrogen, the most conspicuous differences between layers were observed. From the mixo- to monimolimnion,  $\text{NH}_4$  concentration increased nearly four-fold.

Also indices of organic matter content ( $\text{BOD}_5$  or COD) attest to a much higher fertility of the anoxic monimolimnion, as compared to the mixolimnion. However, these differences are not as dramatic as those observed in lakes with the chemical type of meromixis (Dickman 1979; Aeschbach-Hertig *et al.* 2002; Watanabe *et al.* 2003; Galas 2003).

A characteristic feature of Lake Czarne is the high abundance of purple sulphur bacteria of the genus *Chromatium* in the chemocline (Kraska *et al.* 2001). They are photosynthetic, using infrared and red radiation of more than 700 nm (Lampert, Sommer 2001). Maximum values of their abundance in this study (at the depth of 15–20 m) were so high, that lake water was purple. Water blooms caused by sulphur bacteria in the chemocline are frequent in meromictic lakes (Cloern *et al.* 1983; Overman *et al.* 1996; Pimenov *et al.* 2003; Tonolla *et al.* 2004).

## METHODS

Floristic composition of communities patches was conducted in summer time of the 1998 and 2005 years in transects. Each the transect was 10 m wide, however their length depended on the extend of vegetation into the lake. In each year of the study laid out 22 transects. The number of transects was adequate to diversity of vegetation and length of shoreline (1935 m). In each phytocenosis

of the transect cover of species was evaluated in percentage. In this paper we used also results of a previous phytosociological study of the lake, conducted in 1983–1984 (Dąmbaska, Kraska 1986).

The analysis of physico-chemical parameters was conducted seasonally from 1998 to 2005. Water pH, concentration of soluble oxygen, saturation of water with oxygen, water temperature and conductivity were measured in the field using a YSI multiparameter probe 600R. Other physico-chemical (water colour, BOD<sub>5</sub>, COD, concentration of nitrogen, phosphorus, sulfides, chlorides, manganese, potassium, sodium, calcium, iron, magnesium), and biological parameters of the water were investigated in each thermo-oxygen zone. Water samples were collected every 1 metre, and then pooled for each zone. Parameters were analysed according to Standard Methods for Waters and Wastewaters Examination (1992). The trophic state of Lake Czarne was assessed according to OECD guidelines and Carlson's (1977) Trophic State Index.

## RESULTS

Lake Czarne, like the other lakes in the Drawa NP dominated by charophytes, are characterized by a limited distribution of sedge communities and other helophytes (Kraska 1998). The helophyte belt is well developed only at the opposite ends of Lake Czarne, while in other parts of the shoreline it is either absent or forms a very narrow zone dominated by the common reed. These are as a rule floristically very poor patches of the association *Phragmitetum*, sometimes with participation of *Typha angustifolia*. The floristic composition of patches of *Phragmitetum* depends to some extent on the water level in the lake. In wet years, the increasing water level sometimes resulted in enriching their floristic composition with typical aquatic species (hydrophytes), but it also eliminated the species that do not tolerate waterlogged conditions. This caused changes in floristic composition of the helophyte belts between years, as well as changes in the area covered by littoral sedges, in this case *Carex acutiformis*, which is characteristic of the association *Caricetum acutiformis* (Tab. 2).

However, the greatest changes were observed in submerged vegetation. In 1984 and 1998 in Lake Czarne, relatively large areas of the shallower parts of the littoral zone were covered by phytocoenoses of *Charetum asperae*, whereas slightly deeper down, patches of *Charetum tomentosae* were found (Dąmbaska, Kraska 1986). Characteristic species of those two plant associations colonized the littoral zone to the depth of 3–4 m. Their patches formed a mosaic with *Najadetum marinae*. It seemed that these were permanent elements of this lake ecosystem. However, changes in proportions between the various plant communities, as well as disappearance of some of them, prove to be unavoidable in the dynamic stages of plant succession in lakes.

Table 2 – Tabela 2

Plant communities of the phytosociological classes *Charetea*, *Potametea* and *Phragmitetea* found in the littoral of Lake Czarne in 1998 and 2005  
Zbiorowiska roślinne z klas *Charetea*, *Potametea* i *Phragmitetea* występujące w Jeziorze Czarnym w latach 1998 i 2005

Association	1998					2005					
	Charetum fragilis	Charetum tomentosae	Nitelletum flexilis	Nitelletum opaceae	Najadetum marinae	Phragmi tetum	Nitelletum flexilis	Nitelletum opaceae	Najadetum marinae	Phragmi tetum	Caricetum acutiformis
Year											
Species characteristic for associations from classes: Charetea, Potametea and Phragmitetea											
Chara fragilis	V <sup>3-4</sup> 5000	I <sup>1</sup> 62	I <sup>1</sup> 83	I <sup>1-3</sup> 327	II <sup>2</sup> 438	.	I <sup>1</sup> 1	.	I <sup>1</sup> 12	.	.
Chara tomentosa	.	V <sup>3-5</sup> 4375	I <sup>1</sup> 83	I <sup>3</sup> 292	V <sup>1-2</sup> 1125	.	V <sup>1-5</sup> 7916	I <sup>2</sup> 210	I <sup>1-1</sup> 12	.	.
Nitella flexilis	.	.	V <sup>3-4</sup> 5000	IV <sup>1-3</sup> 885	.	.	I <sup>1-1</sup> 12	V <sup>1-5</sup> 6971	.	.	.
Nitella opaca	.	.	V <sup>2-3</sup> 2458	V <sup>2-5</sup> 5712	.	.	I <sup>1</sup> 1	III <sup>1-3</sup> 788	V <sup>3-4</sup> 4821	IV <sup>1-2</sup> 266	.
Najas marina	V <sup>1-3</sup> 1900	V <sup>1-2</sup> 1844	.	I <sup>1-3</sup> 327	V <sup>1-3</sup> 2438	.	.	.	I <sup>1-2</sup> 142	V <sup>3-5</sup> 6250	V <sup>1-2</sup> 1312
Phragmites australis	.	.	.	.	III <sup>1-2</sup> 450	V <sup>1-5</sup> 3292	.	.	.	II <sup>1-2</sup> 99	V <sup>3-5</sup> 4950
Carex acutiformis	.	.	.	.	.	.	.	.	.	.	.
Another species from classes Charetea, Potametea and Phragmitetea											
Nitellopsis obtusa	.	I <sup>1</sup> 62	.	I <sup>2</sup> 135	.	.	I <sup>1-2</sup> 140	.	.	.	.
Myriophyllum spicatum	.	II <sup>2</sup> 219	.	.	.	.	I <sup>1</sup> 1	.	IV <sup>1-2</sup> 409	II <sup>1</sup> 6	.
Potamogeton pectinatus	.	.	.	.	III <sup>1-3</sup> 1062	.	.	.	II <sup>1-2</sup> 166	I <sup>1</sup> 1	.
Typha angustifolia	.	.	.	.	II <sup>1</sup> 125	I <sup>1-1</sup> 56	.	.	.	III <sup>1-2</sup> 202	.
Scirpus lacustris	.	.	.	.	.	I <sup>1</sup> 42	.	.	.	.	.
Utricularia vulgaris	.	.	.	.	.	.	.	.	II <sup>1</sup> 3	IV <sup>1-</sup> 172	.
Carex elata	.	.	.	.	.	.	.	.	.	I <sup>1</sup> 1	I <sup>1</sup> 31
Dryopteris thelypteris	.	.	.	.	.	.	.	.	.	I <sup>1</sup> 28	I <sup>2</sup> 188
Solanum dulcamara	.	.	.	.	.	.	.	.	.	I <sup>1</sup> 14	II <sup>1</sup> 62
Alnus glutinosa	.	.	.	.	.	.	.	.	.	I <sup>1</sup> 1	III <sup>1</sup> 4
Mentha aquatica	.	.	.	.	.	.	.	.	.	II <sup>1</sup> 6	III <sup>1-1</sup> 60

**Sporadic species:** (*Phragmitetum*): *Potamogeton lucens* I<sup>1-1</sup> 12 (1998), *Potamogeton crispus* I<sup>1</sup> 12, I<sup>1</sup> 14, *Hydrocotyle vulgaris* I<sup>1</sup> 2 (1998), (*Caricetum acutiformis*): *Lycopus europaeus* II<sup>1-1</sup> 37, *Carex rostrata* I<sup>2</sup> 187, *Equisetum fluviatile* I<sup>1</sup> 1, *Lysimachia thyrsiflora* I<sup>1</sup> 1, *Carex pseudocyperus* I<sup>1</sup> 1, *Eleocharis palustris* I<sup>1</sup> 1, *Eupatorium cannabinum* II<sup>1</sup> 2, *Salix cinerea* I<sup>1</sup> 1, *Veronica anagallis* I<sup>1</sup> 1

The observations made in 2005 revealed that the patches with *Chara aspera* and *Ch. tomentosa* completely disappeared. The sites previously colonized by those two taxa are now dominated by *Najas marina*. In the current floristic composition of patches of *Najadetum marinae*, many charophyte species are recorded, but they are rare and the above-mentioned two species are lacking. A much higher abundance and percent cover is recorded for *Myriophyllum spicatum* and *Potamogeton pectinatus* (Tab. 2).

The plant communities formed mostly by macroalgae of the genus *Nitella* are a peculiar feature of the vegetation of Lake Czarne. This applies mostly to the patches including *N. flexilis* and *N. opaca*. They are the major components of vegetation in this lake, and colonized the littoral at the depth of 4–7 m, and in some places down to 9 m. The general range of distribution of vegetation in the lake did not change between 1998 and 2005 (Fig. 2). However, the proportion of phytolittoral covered by patches of *Nitelletum opacae* was markedly reduced,

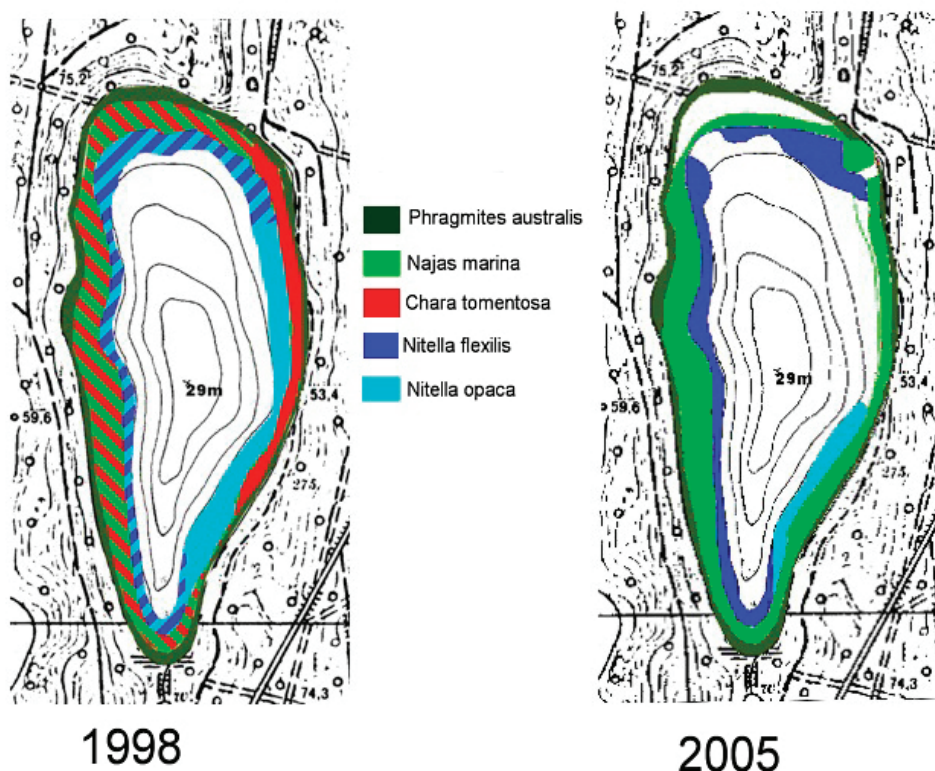


Fig. 2. Comparison of distribution of dominant plant species in Czarne Lake in 1998 and 2005

Ryc. 2. Porównanie rozmieszczenia dominujących gatunków roślin w jeziorze Czarnym w latach 1998 i 2005

while the proportion of *Nitelletum flexilis* increased. Changes were also observed in species composition of patches of *Nitelletum flexilis*, as *Nitella opaca* was absent there in 2005.

Table 3 – Tabela 3

Contributions of various plant communities [in %] to the total area of phytolittoral in 1998 and 2005. (0.1% means sporadic occurrence)

Udział poszczególnych zbiorowisk roślinnych [%] w całkowitej powierzchni fitolitoralu w latach 1998 i 2005 (0,1% oznacza występowanie sporadyczne)

Year	1998	2005
Area of phytolittoral (ha)	9.63	8.3
<b>Patches from All. Magnocaricion</b>	0.2	0.2
<i>Caricetum acutiformis</i> Sauer 1937	0.1	0.1
<i>Caricetum rostratae</i> Rübel 1912	0.1	0.1
<b>Patches from All. Phragmition</b>	17.9	20.5
<i>Phragmitetum</i> (Gams 1927) Schmale 1939	16.7	19.1
<i>Typhetum angustifoliae</i> (Allorge 1922) Soó 1927	1.2	1.4
<b>Patches from All. Potamion</b>	25.3	48.1
<i>Myriophylletum spicati</i> Soó 1927	0.1	0.1
<i>Najadetum marinae</i> (Koch 1926) Phil. 1969	25.2	48.0
<b>Patches from Cl. Charetea</b>	56.6	31.2
<i>Charetum tomentosae</i> (Sauer 1937) Corillion 1957	12.7	0.1
<i>Charetum fragilis</i> Fijałk. 1960	0.1	-
<i>Nitelletum flexilis</i> Corillion 1957	30.5	24.2
<i>Nitelletum opacae</i> Corillion 1957	13.3	7.0

## DISCUSSION

There are no dispersed and point sources of pollution in the lake catchment. The supply of nutrients (N and P) derives mainly from diffuse pollution and precipitation. Results of an assessment of nutrient transport in the lake catchment enable classification of the catchment of Lake Czarne as moderately prone to mobilization of areal nutrient loads. The low ratio of catchment area to lake area, lack of affluents, and wooded catchment, all limit the supply of nutrients to the lake. A less favourable feature, which increases the potential for matter flow into the lake, is the high mean value of slope angle within the catchment, and the permeable substrate (Szyper, Kraska 1999). Also the evaluation of susceptibility of Lake Czarne to degradation indicates that the lake is moderately resistant to external pressure.

Because of meromixis, there is no possibility (except for some disasters) of matter returning from monimolimnion to the mixolimnion. In other words, it is impossible to replenish the phosphorus and nitrogen content of the surface layer of water.

The presence of charophytes depends on many physical and chemical factors, such as: depth, bottom type, light penetration, concentrations of nutrients, pollution, etc. Most of charophytes do not tolerate phosphate concentrations exceeding 0.02 mg/l (Forsberg 1965). For this reason, charophytes are regarded as good indicators of water quality, and the presence of plant communities of the class *Charetea* is treated as a phytosociological indicator of natural habitats protected within the network of Natura 2000. However, the bioindicative properties of various species of *Charophyta* in Poland are not uniform, e.g. many *Chara* spp. require waters with a high mineral content, rich in calcium and more or less alkaline (pH 7.0–9.0). By contrast, in clear water bodies with a medium calcium content and nearly neutral waters (pH 6.0–8.0), plant communities are poor in species and dominated by *Nitella* spp. As a result, within the environmental type, hardwater oligo- and mesotrophic water bodies with submerged charophyte meadows, two subtypes can be distinguished, of which subtype 2, i.e. charophyte communities of the alliance *Nitellion flexilis* in poorly mineralised oligo- and mesotrophic waters, is relatively uncommon and poorly studied in Poland. It can be expected that this environmental subtype is preserved in an undisturbed state in only a small number of lakes (Piotrowicz 2004). The numerous patches composed of *Nitella* spp., extending to the depth of 9 m, attest to this environmental subtype in the study lake. In this context, the changes observed in taxonomic composition and distribution of patches of these uncommon plant communities within the lake basin, are interesting in themselves, but they do not always attest to unfavourable changes in lake ecosystems.

The major reason for the changes in distribution of charophytes is probably the deterioration of light conditions, caused mostly by an increase in water fertility. Two types of reactions of these macroalgae can be observed. The first and most often reported reaction type is a decline of charophytes (Ozimek, Kowalczewski 1984; Pieczyńska 1988; Mendez, Sanchez 1998). Another strategy is the ‘migration’ of the vegetation to shallower sites (Kraska 1997, 2009) which also applies to the charophytes, mainly to the smaller ones, whose stem diameter does not exceed 1 mm (Pełechaty, Guździół 2002).

This reaction type was recorded in *Chara aspera* and *Ch. jubata* in lakes in the Lubuskie Lakeland (W Poland), which grew at the depth of 0.5 to 1 m. The same species in clearer waters extended to the depth of 3 m. A similar ‘migration’ to shallower waters was noted also in the group of Sławskie Lakes (SW Poland). In some of the lakes, at the depth of 1.0–1.5 m, *Ch. fragilis* and *Ch. contraria* were found, whereas in less fertile water bodies in this region those species were present at the depth of 2.0–3.0 m (Kraska 2009).

The light factor, playing a decisive role in the distribution of not only individual taxa, but also of plant communities composed of macroalgae of the genera *Chara*, *Nitellopsis*, and *Nitella*, is additionally correlated with their requirements concerning light intensity and wavelength, which change with water

colour and depth. Literature on this subject includes many examples of positive correlation between water transparency (measured as Secchi depth) and growth of various species of *Charophyta* at various depths (Dąbska 1964; Ozimek, Kowalczewski 1984; van den Berg 1998; Kłosowski *et al.* 2006; Pelechaty *et al.* 2005, Pelechaty, Pukacz 2006). Such uneven sensitivity to light in *Chara*, *Nitellopsis*, and *Nitella*, causes in stratified lakes a specific sequence (zonation) and structure of patches of plant communities at various depths. As a rule, the shallow littoral is covered by patches composed of *Chara* and *Nitellopsis* spp. Deeper parts of the littoral zone are colonized by plant communities dominated by *Nitella* spp. Such a zonation, recorded in Lake Czarne in 1998, was described many times in lakes including relatively numerous patches of plant communities composed of *Chara*, *Nitella* or *Nitellopsis* spp. (John *et al.* 1982; Dąbska, Kraska 1986; Kraska 1998; Kraska *et al.* 2001; Pelechaty *et al.* 2007). Such a zonation is not always confirmed at other latitudes or regions of the world (Schwarz *et al.* 1999).

Charophytes, in spite of their greater sensitivity to changing abiotic conditions and a tendency to fluctuate in abundance (Pelechaty 2005; Kraska *et al.* 2006) or complete disappearance from some lakes, are very often pioneer species. They are the first species to be found in flooded lime quarries, water bodies surrounded by fields, etc. (Dąbska 1964; Kraska *et al.* 2001; Pelechaty, Gąbka 2004; Piotrowicz 2004; Gąbka 2006; Pelechaty, Pukacz 2006), or in a part of a lake disturbed by human activity (Pelechaty 2005), which basically confirms the pioneer character of charophytes. In habitats that are rich in calcium carbonate, also the charophyte species with a long growing period quickly colonize the substrate, which leads to formation of persisting communities composed of a small number of species.

It must be emphasized that the above-mentioned changes in the structure of charophyte vegetation are spontaneous, resulting from natural processes of transformation of the abiotic environment of the lake, as well as the associated biotic changes. Analyses of physicochemical properties of lake waters, conducted since 1997, have not revealed any significant changes (Kraska *et al.* 2001, 2006a). Probably only monitoring of the whole ecosystem, in a long-term perspective, should enable an assessment of the real dynamics and scope of changes, and evaluation of the effectiveness of protective measures (if they are undertaken). Such data would enable answering the following questions. Is this variation a temporary and natural disturbance? Or is it correlated with natural climatic or meteorological fluctuations? Or else, is it due to anthropogenic factors: water pollution, greenhouse effect, and the resultant changes in the functioning of aquatic ecosystems?

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## ZMIANY STRUKTURY ROŚLINNOŚCI NATURALNEGO MEROMIKTYCZNEGO JEZIORA CZARNEGO W DRAWIEŃSKIM PARKU NARODOWYM

### STRESZCZENIE

Jezioro Czarne w Drawieńskim Parku Narodowym należy do grupy zbiorników meromiktycznych. Brak pełnej miksji skutkuje ograniczeniem zasilania powierzchniowej warstwy wód jeziora w substancje biogenne zdeponowane w głębszych warstwach wody i w osadach dennych. Specyfika funkcjonowania tego zbiornika, jego morfometria oraz mała antropopresja powodują, że jezioro to charakteryzuje się niską trofią. Bioróżnorodność hydromakrofitów porastających stromo opadające dno w strefie litoralu jest niewielka i dominują głównie ramienice (*Charophyta*). Jednak struktura tej roślinności wykazuje dużą zmienność czasową.

W pracy przedstawiono wyniki badań roślinności tego jeziora przeprowadzone z różną intensywnością od lat 80. XX w. Potwierdziły one dużą zmienność w składzie roślinności tego zbiornika. Podjęto dyskusję nad mechanizmami i przyczynami tych zmian, wskazując na ich spontaniczność łączącą się z naturalnymi procesami transformacji środowiska abiotycznego jeziora i wynikającymi z tego zmianami biotycznymi. Analizy właściwości fizykochemicznych wód jeziora, prowadzone przez wiele lat, nie wykazały istotnych zmian. Wydaje się, że tylko długoterminowy monitoring całego ekosystemu umożliwi realną ocenę dynamiki i zakresu zmienności jego szaty roślinnej oraz ocenę skuteczności działań ochronnych.