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DIATOMS OF THE ROSNOWSKIE DUŻE LAKE IN THE WIELKOPOLSKA NATIONAL PARK IN THE YEARS 2002 AND 2003

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ABSTRACT. The presented studies refer to the qualitative and quantitative structure of diatoms against the background of the remaining systematic groups of phytoplankton in four basins of the Rosnowskie Duże Lake. Samples were taken from 18 localities including different types of habitats. Thirty eight diatoms were identified being 27% of the total number of phytoplankton taxa.

Key words: diatoms, eutrophic lake, nymphaeids, elodeids, helophytes, pelagic zone

Introduction

The Rosnowskie Duże Lake is situated in the north-western part of the Wielkopolska National Park in the vicinity of the Poznań-Wrocław highway and Rosnówko village. The lake represents a strongly elongated and narrow reservoir without surface flow, with an inflow from the Chomęcickie Lake overgrown by a compact cover of vegetation. In result of a progressing process of becoming shallower and overgrown by communities of macrophytes, the lake has been naturally divided into four basins differentiated from the morphometric point of view and regarding the species composition of macrophyta. Between the lake basins, there occur narrow passages permitting water flow. In the eutrophic Rosnowskie Duże Lake, there occurs a zonal distribution of water vegetation: emerged plants (helophytes) creating a rush zone, plants with floating leaves (nymphaeids) and submerged plants (elodeids).

In spite of the fact that since 1978, studies on the lake's phytoplankton have been carried out, the knowledge of changes in the communities of plankton algae developed under the influence of different hydromacrophyte communities is rather fragmentary.

The objective of the present studies was the qualitative and quantitative analysis of diatoms in the Rosnowskie Duże Lake against the background of the remaining systematic groups of algae in different communities of hydromacrophytes. An additional pur-

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pose was the ecological characteristics of diatoms basing on the system of **Van Dam** et **al.** (1994) and **Lange-Bertalot** and **Steindorf** (1996).

Methods

Phycological studies were carried out in 2002 and 2003, in the vegetation period of hydromacrophytes (from April till September). Because of the development degree of water vegetation habit, data were divided into year seasons:

– spring – April, May, beginning of June (initial stage of plant development)

– summer – end of June, July, August, beginning of September (plants in their optimum development)

In spring, samples were taken every two weeks, while in summer, it was done once a month.

18 research localities were determined including different habitat types: in the zone of elodeids in basin II (2 localities in patches with *Ceratophyllum demersum* L. s. str.); in nymphaeid zone in basins III and IV (2 localities in patches with *Nymphaea alba* L.); in the pelagic zone of each basin (4 localities); in helophyte zone (in high rushes) of each basin (5 localities) and in the so called "transitory zone" between rushes and pelagic zone in each basin (5 localities). Totally, 253 samples were taken for phycological analyses.

Water samples were taken from the surface level and they were fixed with Lugol's fluid and 4% formalin solution. Afterwards, samples were sedimented to the volume of 10 ml (from 1 litre) and they were subject to qualitative and quantitative analyses. The counting of algae cells was carried out in Fuchs-Rosenthal chamber (chamber parameters: height: 0.2 mm, surface area of 1 field: 0.0625 mm^2); biomass was determined by the method of cell volume (**Kawecka** and **Eloranta** 1994).

Parallel with the plankton samples, in the particular localities, water samples were taken for analysis of chlorophyl-*a* concentration.

In the sampling sites, each time the following measurements were carried out: water surface temperature, pH, concentration of oxygen solved in water, electrolytic conductivity and visibility of Secchi's disk.

The current state of the lake trophy was defined on the basis of the Trophic State Index (TSI) in **Carlson's** (1977) logarithmic transformation calculated for chlorophyl-*a* concentration and Secchi's disk visibility.

Analysis of variance was carried out in order to check the significance level of the spatial differentiation of the number of diatoms in the lake. Only those days of studies were taken into consideration in which samples were taken from all 18 localities (end of spring, summer). The hypothesis about the absence of significant difference was discarded at $p < 0.05$.

Subject to calculation was also the correlation according to Pearson (significance at $p < 0.05$) between the number of taxa, the number and biomass of diatoms, on the one hand and the electrolytic conductivity, oxygen and water temperature in the particular lake zones, on the other hand. In the calculation of correlation, pH was not taken into account, because the reaction values principally did not change during the total study period and they were similar in all localities (ranging between 7.6 and 8.3).

Results

In the eutrophic Rosnowskie Duże Lake, 38 taxa of diatoms (Bacillariophyceae) were found to occur and they made 27% of the total number of procaryotic and eucaryotic algae (142 taxa). As far as the number of taxa is concerned, among diatoms there dominated the Pennales order (35 taxa), while within the Centrales order, only three species were identified:

Order: Centrales
- *Cyclotella distinguenda* Hustedt
- *Cyclotella radiosa* (Grun.) Lemm.
- *Stephanodiscus parvus* Stoermer et Hakansson

Order: Pennales
- *Achnanthes flexella* (Kütz.) Grun.
- *Asterionella formosa* Hassal
- *Cocconeis placentula* Ehr.
- *Cymbella helvetica* Kütz.
- *Cymbella lanceolata* (Ehr.) Kirchner
- *Cymbella ventricosa* Kütz.
- *Diatoma elongatum* (Lyngb.) Ag.
- *Epithemia sorex* Kütz.
- *Epithemia turgida* (Ehr.) Kütz.
- *Epithemia turgida* var. *granulata* (Ehr.) Grun.
- *Epithemia zebra* (Ehr.) Kütz.
- *Fragilaria capucina* Desm.
- *Fragilaria capucina* var. *capucina* Desm.
- *Fragilaria construens* (Ehr.) Grun.
- *Fragilaria dilatata* (Bréb.) Lange-Bertalot
- *Fragilaria fasiculata* (Ag.) Lange-Bertalot sensu lato
- *Fragilaria ulna* (Nitzsch) Lange-Bertalot
- *Fragilaria ulna* var. *acus* (Kütz.) Lange-Bertalot
- *Gomphonema acuminatum* Ehr.
- *Gomphonema augur* Ehr.
- *Gomphonema constrictum* Ehr.
- *Gomphonema lateripunctatum* Reich. & Lange-Bertalot
- *Gomphonema parvulum* (Kütz.) Grun.
- *Gyrosigma attenuatum* (Kütz.) Rabenhorst
- *Navicula cryptocephala* Kütz.
- *Navicula cuspidata* Kütz.
- *Navicula radiosa* Kütz.
- *Nitzschia sigma* (Kütz.) W. Smith
- *Nitzschia sigmoidea* (Ehr.) W. Smith
- *Pinnularia maior* (Kütz.) Rabenhorst
- *Rhopalodia gibba* (Ehr.) O. Müll
- *Rhopalodia gibba* var. *ventricosa* (Ehr.) Grun.
- *Surirella linearis* var. *constricta* W. Smith
- *Tabellaria fenestrata* (Lyngb.) Kützing
- *Tabellaria flocullosa* (Roth) Kützing

Phytoplankton of the lake was dominated by representatives of Chlorophyta, Bacillariophyceae and Cyanoprokaryota (Fig. 1). The remaining algae groups: Euglenophyta, Cryptophyceae, Dinophyceae and Chrysophyceae were represented by a small number of specimens and their participation amounted only to several percent.

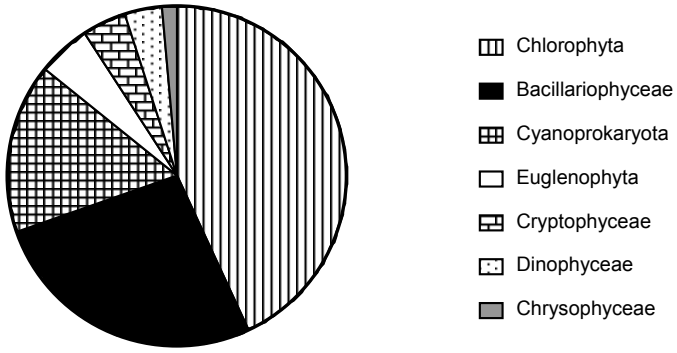

Fig. 1. Percentage participation of diatoms in the total number of phytoplankton taxa
Ryc. 1. Udział procentowy okrzemek w ogólnej liczbie taksonów fitoplanktonu

In the period of spring and summer in both years of studies, the greatest number of diatom taxa occurred in the "transitory zone" and in the zone of helophytes, where also the greatest total number of phytoplankton taxa was found (Fig. 2). In spring, the least number of diatom taxa and the least total number of phytoplankton taxa was found in the zone of nymphaeids and elodeids, while in summer, in the zone of elodeids and

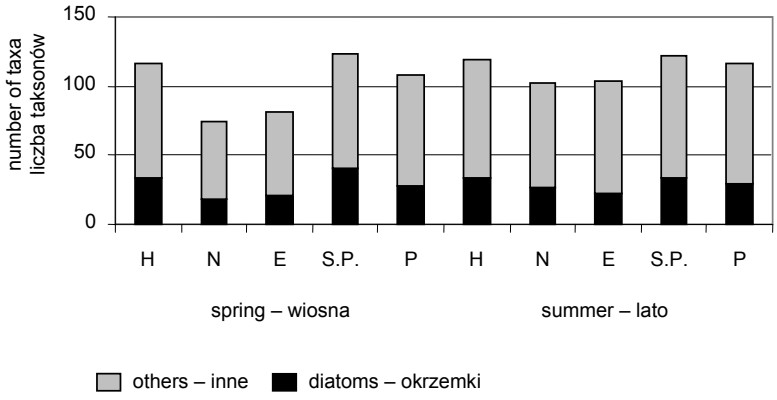

Fig. 2. Number of diatom taxa and the remaining systematic groups of phytoplankton in the Rosnowskie Duże Lake in the particular localities in spring and summer seasons
Ryc. 2. Liczba taksonów okrzemek i pozostałych grup systematycznych fitoplanktonu w Jeziorze Rosnowskim Dużym na poszczególnych stanowiskach w okresie wiosny i lata

nymphaeids. Qualitative analysis showed that the participation of diatoms in the spatial aspect ranged in a similar way as the share of the remaining systematic groups of phytoplankton. On the other hand, in summer, the number of diatom taxa in the zone of elodeids was significantly smaller than in the zone of nymphaeids, and in case of the remaining phytoplankton groups the picture was inverse (the least number of taxa was found in the nymphaeid zone).

Quantitative analysis of phytoplankton indicated that in spring, in both years of studies, the greatest number of diatoms occurred in the zone of helophytes, while the greatest number of the remaining phytoplankton groups was found in the pelagic zone (Fig. 3). The least number both of diatoms and of the remaining phytoplankton groups was found in the zone of elodeids. The highest concentration values of biomass in case of diatoms and the remaining phytoplankton groups were recorded in the zone of helophytes and in the transitory zone, while the lowest values were found in the zone of nymphaeids.

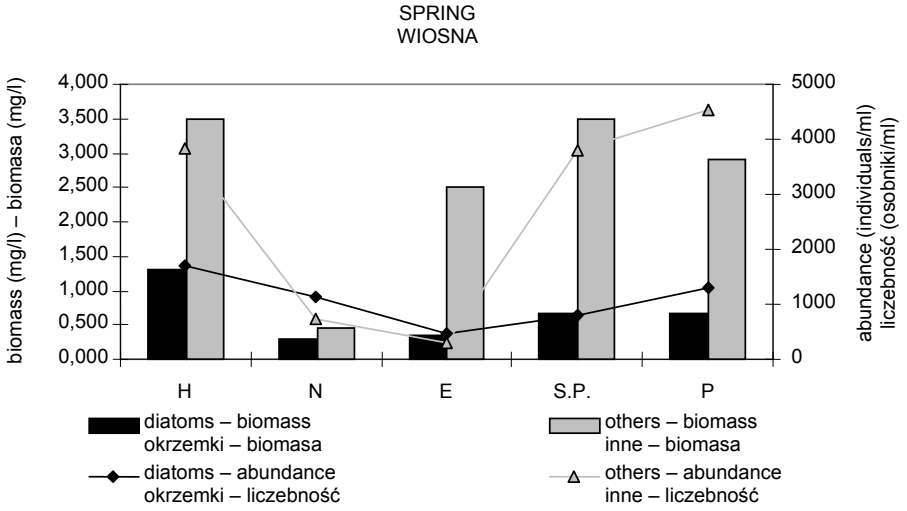

Fig. 3. Number and biomass of diatoms and the remaining groups of phytoplankton in the Rosnowskie Duże Lake in the particular localities in spring season
Ryc. 3. Liczebność i biomasa okrzemek i pozostałych grup fitoplanktonu w Jeziorze Rosnowskim Dużym na poszczególnych stanowiskach w okresie wiosny

In summer the greatest number of individuals and biomass of diatoms were observed in the zone of nymphaeids and in case of the other groups – in the zone of elodeids (Fig. 4). The least number of individuals and biomass of diatoms were found in the zone of elodeids and in case of the other groups – in the zone of nymphaeids.

Statistically significant differences were found in the abundance of diatoms between the following zones: between elodeids and nymphaeids; between elodeids and pelagic zone and between nymphaeids and the transitory zone. In diatom biomass, significant differences occurred between the zone of helophytes and the transitory zone.

In the studied lake, differentiated habitat preferences of the particular phytoplankton species were observed, particularly in spring. Some taxa dominated exclusively in a definite zone of the lake (Table 1).

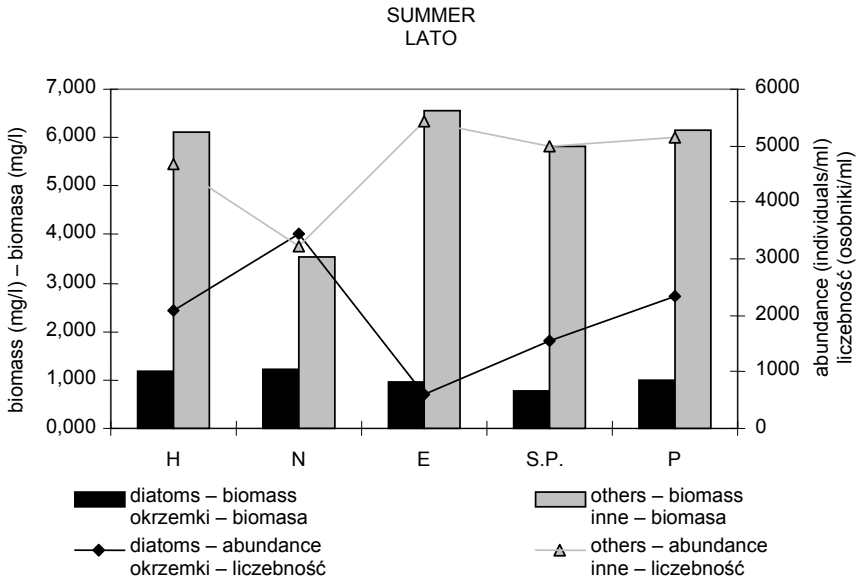

Fig. 4. Number and biomass of diatoms and the remaining phytoplankton groups in the Rosnowskie Duże Lake on the particular localities in summer season
Ryc. 4. Liczebność i biomasa okrzemek i pozostałych grup fitoplanktonu w Jeziorze Rosnowskim Dużym na poszczególnych stanowiskach w okresie lata

The majority of the dominating taxa according to the scale of **Van Dam** et **al.** (1994) included alkaliphilous taxa occurring mainly at pH > 7 (*Achnanthes flexella*, *Cyclotella distinguenda*, *C. radiosa*, *Fragilaria ulna* var. *acus*, *Cocconeis placentula*) and taxa indicating the eutrophic character of the lake (*Cyclotella radiosa*, *Fragilaria ulna* var. *acus*, *Cocconeis placentula*, *Stephanodiscus parvus*).

A significant abundance and biomass among diatoms consisted of taxa counted acc. to **Lange-Bertalot** and **Steindorf** (1996) to eutrophic group: *Cyclotella radiosa*, *Rhopalodia gibba*, *Stephanodiscus parvus* and *Fragilaria ulna.*

Abundance of diatoms correlated in a statistically significant way with all three physical and chemical parameters (Table 2). A positive statistically significant dependence was found between the abundance of diatoms and electyrolytic conductivity. Negative relations occurred between diatom abundance vs. water temperature and oxygen. Statistically significant positive correlation was observed also between diatom biomass and electrolytic conductivity, while a negative correlation was shown between diatom biomass and water temperature.

Table 1

Diatoms dominating in the Rosnowskie Duże Lake in the years 2002 and 2003
Okrzemki dominujące w Jeziorze Rosnowskim Dużym w latach 2002 i 2003

Lake zone Strefa jeziora	Spring 2002 Wiosna 2002	Summer 2002 Lato 2002	Spring 2003 Wiosna 2003	Summer 2003 Lato 2003
Pelagial Pelagial	*Fragilaria capucina*	*Cyclotella distinguenda*	*Fragilaria ulna* var. *acus* *Cyclotella distinguenda*	*Cyclotella distinguenda* *Fragilaria ulna* var. *acus*
Helophytes Helofity	*Achnanthes flexella* *Cyclotella radiosa* *C. distinguenda* *Fragilaria capucina* *Fragilaria ulna* var. *acus* *Navicula radiosa* *Cocconeis placentula* *Stephanodiscus parvus*	*Cyclotella distinguenda*	*Fragilaria ulna* var. *acus* *Cyclotella distinguenda* *Fragilaria capucina* var. *capucina* *Cocconeis placentula*	*Cyclotella distinguenda* *Fragilaria ulna* var. *acus*
Transitory zone Strefa przejściowa	*Cyclotella radiosa* *C. distinguenda* *Fragilaria capucina*	*Cyclotella distinguenda*	*Fragilaria ulna* var. *acus* *Cyclotella distinguenda*	*Cyclotella distinguenda*
Elodeids Elodeidy	*Cocconeis placentula*	*Cyclotella distinguenda*	*Fragilaria ulna* var. *acus* *Cyclotella distinguenda* *Fragilaria capucina* var. *capucina*	*Cyclotella distinguenda*
Nymphaeids Nymfeidy	–	*Cyclotella distinguenda*	*Fragilaria ulna* var. *acus* *Cyclotella distinguenda*	*Cyclotella distinguenda*

Table 2

Dependences between the number and biomass of diatoms and the physical and chemical parameters of water
Zależności pomiędzy liczebnością i biomasą okrzemek a parametrami fizyczno-chemicznymi wody

Diatoms Okrzemki	Oxygen Tlen	Electrolytic conductivity Przewodnictwo elektrolityczne	Water temperature Temperatura wody
Abundance Liczebność	–0.21	0.13	–0.13
Biomass Biomasa	0.05	0.12	–0.12

Discussion

In result of phycological analyses, it was shown that the particular communities of hydromacrophytes (emerged, submerged and with floating leaves) affect in a specific and significant way the differentiation of qualitative and quantitative structure of plankton algae communities in the Rosnowskie Duże Lake. A small number of phytoplankton taxa (including also diatoms) is connected with the progressing eutrophication process of the studied reservoir which was also confirmed by physical and chemical analyses of water (**Celewicz-Gołdyn** 2005).

Localities lying in the high rush zone (helophyte zone and transitory zone) were characterized by the greatest number of phytoplankton taxa, being connected with the participation of diatoms in the qualitative structure of algae. In spring, the greatest abundance and biomass of diatoms was observed. It resulted most probably from the presence of a great number of tychoplankton taxa (pseudoplankton taxa) from periphyton communities which had been detached from hydromacrophytes (*Phragmites australis* (Cav.) Trin. ex Steud. and *Typha angustifolia* L.) in result of water waving (**Kawecka** and **Eloranta** 1994). They consisted of periphyton diatoms from the genera: *Cocconeis*, *Gomphonema*, *Cymbella* and *Fragilaria*. Furthermore, hydromacrophytes present in the rush zone partially retain biogenes flowing off from the catchment area (**Bucka** 1989). A high concentration of nutrients had also an effect on the increase of the total abundance and biomass of phytoplankton in the zone of helophytes in both years of studies. The great number of phytoplankton individuals (except for diatoms) in the pelagic zone in spring period can be explained by the occurrence of significantly smaller number of factors limiting the development of plankton algae in that zone (absence of vegetation and small number of zooplankton).

The least number of taxa, abundance and biomass of diatoms and the remaining systematic groups of phytoplankton frequently occurred in the zones of elodeids and nymphaeids. Numerous studies (**van Donk** and **Gulati** 1995, **Mjelde** and **Faafeng** 1997, **Gross** et **al.** 2003) showed that *Ceratophyllum demersum* secretes allelopatic substances which inhibit the development of phytoplankton. During an analysis of the quantitative structure of diatoms against the background of the remaining phytoplankton groups, it was found that the abundance of this group in the elodeid zone was significantly smaller than that of the remaining groups. Therefore, one can assume that among all systematic groups of phytoplankton which occurred in Rosnowskie Duże Lake, diatoms were the most sensitive ones to the inhibiting effect of *Ceratophyllum demersum*. Furthermore, submerged hydromacrophytes constitute a perfect refuge for zooplankton hiding from predators (**Jeppesen** et **al.** 1997). Low values of diatom abundance in patches of hornwort can be also explained by the pressure of being eaten up by zooplankton.

Small number of taxa, as well as low values of the number of individuals and biomass of phytoplankton in the zone of nymphaeids is caused mainly by the limited access of light to the large leaves of *Nymphaea alba.* Another reason of the low biomass of phytoplankton in epilimnion can be also the significant use of biogenes (mainly nitrogen and phosphorus compounds) by the leaves of hydromacrophytes. White lilies as rooted plants, are able to uptake nutritive substances from bottom sediments and therefore, they gain a domination over phytoplankton, which can use only the nutrients solved in water. This fact has been confirmed by many researchers (**Best** et **al.** 1996, **Królikowska** 1997, **Crossley** et **al.** 2002, **Marion** and **Paillisson** 2003).

In summer, in the studied lake, interesting differences were observed in the quantitative structure between diatoms and the remaining phytoplankton groups. The greatest number and biomass of diatoms in the zone of nymphaeids (in relation to the remaining lake zones) can be explained by the presence of a great number of tychoplankton taxa, which were detaching from macrophyte leaves. The least number of individuals and biomass of diatoms in the zone of elodeids resulted probably from the inhibiting action of the allelopatic substance of hornwort, which was in that period fully developed as well as from the pressure of being eaten up by zooplankton. The highest values of the abundance and biomass of the remaining phytoplankton groups in the elodeid zone in the same period testfty that they are less sensitive to the substances secreted by submerged macrophytes and that they are resistant to eating up by zooplankton (particularly Cyanoprokaryota).

In the studied lake, the participation of a great abundance of algae was recorded which represent the r type life strategy (small ones with a quick growth rate). connected with unstable living conditions. They included among others diatoms of *Cyclotella* and *Stephanodiscus* genus. According to the assumptions of seasonal succession model PEG for eutrophic lakes (**Temponeras** et **al.** 2000, **Lampert** and **Sommer** 2001), the domination of small diatoms of *Centrales* order is a phenomenon characteristic of spring season. Furthermore, a great participation of diatoms in spring is connected with mixing in the water column (**Lung'ayia** et **al.** 2000, **Hubble** and **Harper** 2002). Diatoms belonging to *Centrales* order (among others *Cyclotella* and *Stephanodiscus*) have a greater requirement for phosphorus than diatoms from *Pennales* order (**Bucka** et **al.** 1993). Great concentration of soluble orthophosphates in the Rosnowskie Duże Lake (**Celewicz-Gołdyn** 2005) favoured the development of *Cyclotella distinguenda* (in all studied lake zones), *Cyclotella radiosa* and *Stephanodiscus parvus*. The statistical analyses carried out indicate that the development of diatoms in the Rosnowskie Duże Lake is also under the beneficial influence of a great content of mineral compounds solved in water.

Conclusions

Phycoflora of Rosnowskie Duże Lake in the years 2002 and 2003 was comparatively poor (only 142 phytoplankton taxa were found, including 38 taxa of diatoms), which was connected with the increase of the eutrophication process. Quantitatively, there dominated diatoms from *Centrales* order, which develop well in waters rich in orthophosphates. A significant abundance and biomass among the diatoms was created by taxa counted acc, to the scale of Van Dam and Lange-Bertalot to the eutrophic group. The greatest number of taxa and the greatest number of individuals and biomass of diatoms was found in the zone of helophytes, where pseudoplankton taxa abided. Furthermore, it was found that diatoms (in comparison with the remaining systematic groups of phytoplankton) were the most sensitive ones to the inhibiting effect of *Ceratophyllum demersum*. The qualitative and quantitative structure both of diatoms and the remaining systematic groups of phytoplankton were characterized by a high differentiation in the aspect of time and space.

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OKRZEMKI JEZIORA ROSNOWSKIEGO DUŻEGO W WIELKOPOLSKIM PARKU NARODOWYM W LATACH 2002 I 2003

S t r e s z c z e n i e

Celem niniejszej pracy była analiza jakościowa i ilościowa okrzemek eutroficznego Jeziora Rosnowskiego Dużego na tle pozostałych grup systematycznych glonów w różnych zbiorowiskach hydromakrofitów. Próby do badań fykologicznych i fizyczno-chemicznych pobierano w sezonie wegetacyjnym, w latach 2002 i 2003, ze strefy szuwaru wysokiego (strefa helofitów), strefy przejściowej (pomiędzy szuwarem a pelagialem), strefy elodeidów (płaty z *Ceratophyllum demersum*), nymfeidów (płaty z *Nymphaea alba*) i pelagialu.

Struktura jakościowa i ilościowa fitoplanktonu Jeziora Rosnowskiego Dużego odznaczała się dużym zróżnicowaniem czasowym i przestrzennym. W badanym jeziorze stwierdzono jedynie 142 taksony fitoplanktonu, w tym 38 taksonów okrzemek (głównie z rzędu *Pennales*). Ilościowo dominowały okrzemki z rzędu *Centrales*, które dobrze rozwijają się w wodach bogatych w ortofosforany. Znaczną liczebnością i biomasą odznaczały się taksony okrzemek zaliczane według skali Van Dama i Lange-Bertalota do grupy eutroficznych. Największą liczbę taksonów, liczebność i biomasę okrzemek stwierdzono w strefie helofitów. Okrzemki (w porównaniu z pozostałymi grupami systematycznymi fitoplanktonu) były najbardziej podatne na inhibitujący wpływ *Ceratophyllum demersum*.

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