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THE PHYTOPLANKTON COMMUNITY IN THE PERMANENT POND OF THE DENDROLOGICAL GARDEN, POZNAŃ UNIVERSITY OF LIFE SCIENCES IN SPRINGTIME 2011

Sofia Celewicz-Gołdyn, Ilona Boryca

S. Celewicz-Gołdyn, I. Boryca, Department of Botany, Poznań University of Life Sciences, Wojska Polskiego 71 C, 60-625 Poznań, Poland, e-mail: celewicz@up.poznan.pl

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ABSTRACT. Phycoflora of the permanent pond located in the Dendrological Garden of the Poznań University of Life Sciences, in springtime 2011 consisted together of 67 taxa. The phytoplankton community was dominated by Bacillariophyceae both qualitatively (30 taxa, mainly indicatory of eutrophic waters), and quantitatively (e.g. *Navicula cuspidata*, *Eunotia bilunaris*) and Euglenophyta. The occurrence of *Trachelomonas volvocinopsis*, with the highest incidence and greatest abundance during the study period, was negatively correlated with water pH. A large share of cosmopolitan and ubiquistic species, as well as many taxa typical of small water bodies were observed in the investigated pond. In comparison to the qualitative analysis the quantitative analysis showed that phytoplankton was characterised by greater fluctuations in time. The aim of this study was to examine the phytoplankton community structure of the investigated pond in spring 2011.

KEY WORDS: phytoplankton, permanent pond, springtime, Dendrological Garden of the Poznań University of Life Sciences

INTRODUCTION

The Dendrological Garden of the Poznań University of Life Sciences was created for research, scientific, teaching and recreational purposes. Almost 200 species of herbaceous plants and about 1000 species, subspecies and varieties of woody plants, including both trees and shrubs found in Poland in their natural environment, as well as numerous species of foreign origin, mostly Asian and North American, currently grow over an area of 4.86 ha of exhibition grounds (Danielewicz and Maliński 2011). In addition to vascular plants also many phytoplankton taxa from various systematic groups may be found in the pond, which can be very useful in practical field classes with students especially in spring and early summer. The investigated pond plays an important role in the Dendrological Garden not only because of the teaching and recreational purposes and its aesthetic value, but also thanks to the conservation of valuable plant specimens (e.g. *Taxodium distichum* (L.) Rich.) associated with this freshwater ecosystem. The planktonic algae of the pond, the primary producers forming the first trophic level in the food chain and being good indicators of environmental features, had never been studied until spring 2011.

Ponds are shallow and continuously mixing reservoirs. Moreover, they are usually of a small size, which is connected with a great variability of environmental conditions and results in the creation of specific communities and great dynamics of phytoplankton abundance. According to Reynolds (1984) and Burchardt et al. (2006), algal communities in small water bodies are usually characterised by high species richness. Also Rajagopal et al. (2010) reported that the diversity of planktonic organisms is high in fertile standing reservoirs. Moreover, plankton diversity responds rapidly to changes in these aquatic environments particularly in relation to nutrients (Chellappa et al. 2008).

The aim of this study was to examine the phycoflora and temporal changes in phytoplankton abundance of the investigated pond in spring 2011, including water temperature and pH. The preliminary phycological research was conducted six years after the bottom deposits had been removed from the pond. After bottom sediment removal no water blooms have been observed in summer. Such bottom treatments probably cause an improvement of water quality conditions in the investigated small water body.

STUDY AREA

The investigated pond is located in the central part of the Dendrological Garden, in the north-western part of Poznań (Figs 1, 2). The Garden (with geographical location: latitude 52°25'37" north, longitude 16°53'48" west) is situated on the slightly inclining south-facing

Fig. 1. Location of the studied pond in the Dendrological Garden of the Poznań University of Life Sciences

slopes of the Bogdanka stream valley (Danielewicz and Maliński 2011). The flow pond is eutrophic, with a surface of approx. 300 m^2, maximum depth of 2 m and waters rich in iron (unpublished data). It is a permanent reservoir, containing water throughout the year. In the summer of 2006 a layer of approx. 1 m of bottom deposits were removed. At that time a great abundance of filamentous green algae was observed in the surface water layer. In the past, there used to be a lot of fish in the pond, but later they were removed. The shore zone of the reservoir is dominated mainly by *Iris pseudoacorus* L. and *Typha latifolia* L. Two interesting species of trees from the family Taxodiaceae: *Taxodium distichum* (L.) Rich. and *Metasequoia glyptostroboides* Hu & W.C. Cheng grow in the vicinity of the pond. A collection of species from the genus *Viburnum* was created around the pond.

The pond dates back to the times before World War I. The initiative for the creation of the Dendrological Garden was put forward in 1920. The main type of natural vegetation that had existed in the area of the present Dendrological Garden was oak-hornbeam forest. Nowadays many old trees are preserved, e.g. *Tilia cordata* Mill., *Quercus robur* L., *Carpinus betulus* L., *Acer campestre* L., *Acer pseudoplatanus* L. and *Acer platanoides* L., along with riparian vegetation.

Fig. 2. View of the investigated pond in 2011

MATERIAL AND METHODS

Water samples for phycological and physico-chemical analyses were collected every week in spring 2011 (from March to June), from the surface layer of the western part of the pond, after the ice cover had melted.

Samples for qualitative phytoplankton analyses were poured through a 10 µm mesh plankton net and then examined in vivo using a BIOLAR light microscope. Taxonomic keys employed in the identification included: Hindák (1984, 1988 a, b), Komárek and Anagnastidis (2005), Krammer and Lange-Bertalot (1986, 1988, 1991 a, b), Popovský and Pfiester (1990), Starmach (1966, 1968, 1972, 1974, 1983, 1989), Wołowski (1998) and Wołowski and Hindak (2005). Photographic documentation of the most commonly appearing algae was prepared under a microscope equipped with a MOTIC digital camera, which directly transmits images to the computer monitor.

Phytoplankton samples for quantitative analyses with a volume of 1 l were immediately conserved on site with Lugol liquid (J in KJ). The material was then sedimented and condensed to 5 ml. In the course of sampling basic physico-chemical measurements (water temperature and pH) were also taken.

Phytoplankton was counted in a Fuchs-Rosenthal chamber using a light microscope. Single cells and algal cenobia were regarded as one individual. In case of trychomes, one segment of 100 µm in lenght was regarded as one individual, and in case of a colony (*Synura uvella*) the area of 400 µm^2 was accepted as one individual. The phytoplankton taxa which made up at least 10% of the total abundance in a given sample were regarded as dominants.

The van Dam evaluation scale (van Dam et al. 1994) was used for ecological characteristics of diatoms.

To analyse the relationship between phytoplankton abundance and physico-chemical water properties (temperature and pH), the Spearman correlation coefficients were calculated (significance at $p < 0.05$). The data were processed with STATISTICA 6.0 PL 2002 software (Statistica for Windows... 2002).

RESULTS AND DISCUSSION

Temporal changes in the physico-chemical properties of water in the investigated pond are presented the Figure 3. Water pH fluctuated between 6.35 and 7.86. Water temperature remained at a relatively low level (mean value of approx. 11°C) most of the time and then increased (from 24 May).

In the investigated pond in spring 2011, 67 algae taxa were identified, among which there are representatives of systematic groups (Cyanoprokaryota – 4 taxa, Chlorophyta – 17 taxa, Euglenophyta – 9 taxa, Bacillariophyceae – 30 taxa, Chrysophyceae – 4 taxa, Cryptophyceae – 2 taxa, Dinophyceae – 1 taxon; Table 1).

Bacillariophyceae constituted the most dominant group in the qualitative structure of phytoplankton and their participation in the total phytoplankton taxa was 45% (Fig. 4). This group also predominated in particular samples collected throughout the entire study

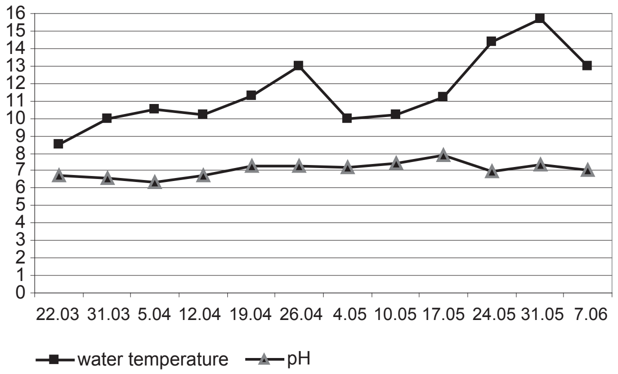


Fig. 3. Temporal changes in water temperature and pH in the pond

Table 1. List of algae taxa reported in spring 2011

Taxa
1
Cyanoprokaryota
Jaaginema pseudogeminatum (Schmid) Anagn. et Kom.
Oscillatoria granulata Gardner
Oscillatoria limosa Agardh ex Gomond
Pseudanabaena limnetica Lemm. Kom.
Chlorophyta
Chlorella radiosa J.B. Petersen
Chloromonas sp.
Cladophora sp.
Closterium ehrenbergii Menegh. ex Ralfs
Closterium moniliferum Bory
Coelastrum microporum Näg.
Mougeotia sp.
Oocystis sp.
Pediastrum boryanum (Turpin) Menegh. var. *boryanum*
Planktonema lauterbornii Schmidle
Sphaerocystis planctonica (Korsch.) Bourrelly
Spirogyra sp.
Ulothrix implexa Kützing
Ulothrix sp.
Uronema confervicolum Lagerh.
Zygnema sp.
Euglenophyta
Euglena proxima Dangeard
Euglena sp. 1
Euglena sp. 2
Lepocinclis ovum Ehrenberg
Lepocinclis texta (Dujardin) Lemmermann
Phacus acuminatus Stokes
Trachelomonas hispida (Perty) Stein

Table 1 – cont.

1
Trachelomonas oblonga Lemmermann
Trachelomonas volvocinopsis Swirenko
Bacillariophyceae
Achnanthes sp.
Caloneis silicula Ehrenberg
Cocconeis placentula Ehrenberg
Cyclotella radiosa (Grun.) Lemmermann
Epithemia turgida (Ehr.) Kützing
Eunotia bilunaris Ehrenberg
Eunotia pectinalis (Dillwyn) Rabenhors
Fragilaria construens Ehrenberg
Fragilaria crotonensis Kitton
Fragilaria dilatata (Brébisson) Lange-Bertalot
Fragilaria intermedia Grunow
Fragilaria ulna (Nitzsch) Lange-Bertalot
Fragilaria ulna var. *acus* Kützing
Gomphonema acuminatum Ehrenberg
Gomphonema capitatum Ehrenberg
Gomphonema olivaceum Krammer & Lange-Bertalot
Gomphonema olivaceum var. *calcareum* Cleve
Melosira varians Agardh
Navicula cryptocephala Kützing
Navicula cuspidata Kützing
Navicula minima Grunow
Navicula radiosa Kützing
Navicula sp. 1
Navicula sp. 2
Nitzschia acilularis Kützing
Nitzschia linearis Grunow
Nitzschia palea Kützing
Pinnularia borealis Ehrenberg
Pinnularia sp.
Stauroneis anceps Ehrenberg
Chrysophyceae
Mallomonas acaroides Perty
Mallomonas denticulata Matvienko
Mallomonas sp.
Synura uvella Ehrenberg
Cryptophyceae
Cryptomonas rostrata Troitzskaja emend I. Kiselev
Cryptomonas sp.
Dinophyceae
Woloszynskia pascheri (Schuchland) von Stosch

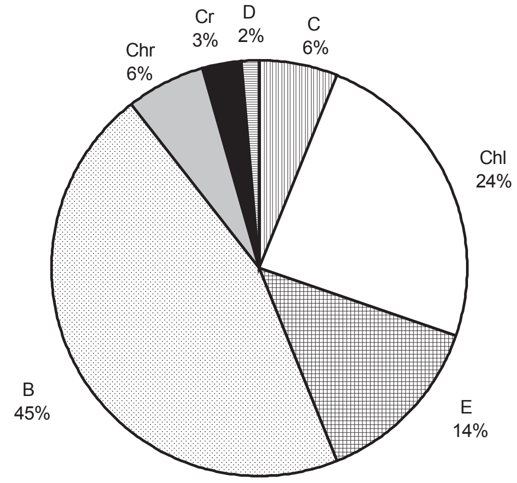


Fig. 4. Percentage contributions of particular systematic groups to the total number of phytoplankton taxa in spring 2011 (C – Cyanoprokaryota, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Chr – Chrysophyceae, Cr – Cryptophyceae, D – Dinophyceae)

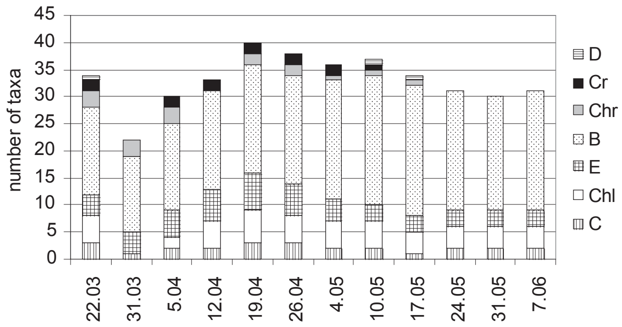
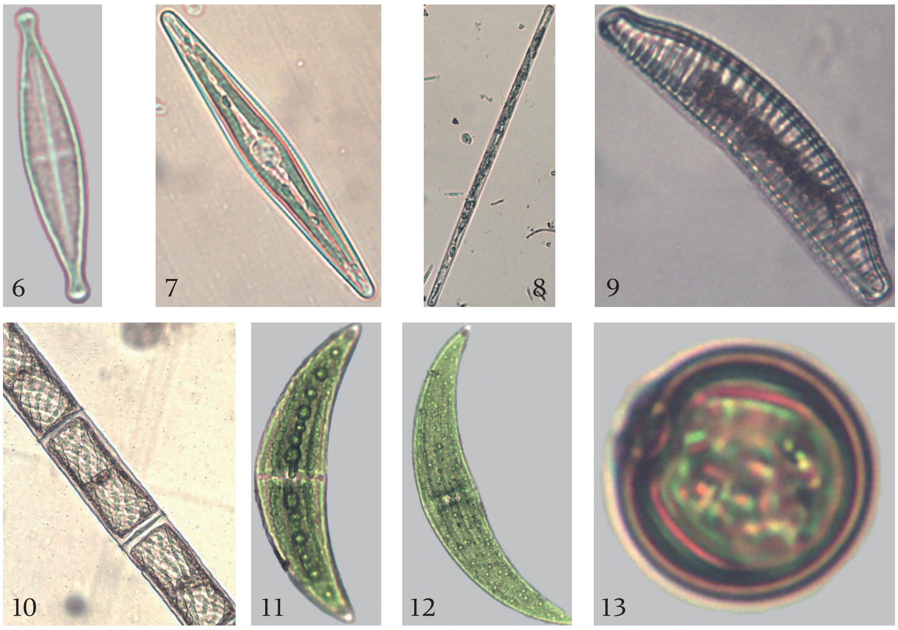


Fig. 5. Temporal changes in the number of phytoplankton taxa in spring 2011 (C – Cyanoprokaryota, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Chr – Chrysophyceae, Cr – Cryptophyceae, D – Dinophyceae)

period (Fig. 5). Chlorophyta and Euglenophyta were the co-dominating groups, accounting for 24% and 14% respectively.

Bacillariophyceae were represented mainly by taxa from the genus *Fragilaria* and *Navicula*, with a wide ecological scale and mostly cosmopolitan. Based on the ecological scale of van Dam et al. (1994) a significant prevalence was observed in case of alkaliphilic diatoms (e.g. *Cyclotella radiosa*, *Fragillaria crotonensis*, *Fragilaria ulna* var. *acus*), diatoms preferring high oxygen concentrations in water (e.g. *Stauroneis anceps*, *Fragillaria crotonensis*), tolerating greater concentration of organic nitrogen (e.g. *Eunotia bilunaris*, *Gomphonema olivaceum*, *Navicula radiosa*) and diatoms indicatory of eutrophic waters (e.g. *Cyclotella radiosa*, *Gomphonema olivaceum*, *Fragilaria dilatata*) were stated.

Among Dinophyceae, there was only one taxon identified, i.e. *Woloszynskia pascheri*, which is typical of cold and small water bodies (Starmach 1974, Popovskỳ and Pfiester 1990).



Figs 6-13. 6 – *Stauroneis anceps*, 7 – *Navicula radiosa*, 8 – *Fragilaria ulna*, 9 – *Epithemia turgida*, 10 – *Spirogyra* sp., 11 – *Closterium moniliferum*, 12 – *Closterium ehrenbergii*, 13 – *Trachelomonas volvocinopsis*

Some of the frequent algal species in the investigated pond are present in Figures 6-13.

Temporal changes in the total number of phytoplankton taxa were not marked (Fig. 5). Similarly, the qualitative participation of the particular systematic algae groups in the study period did not change significantly (Fig. 14).

The most frequent taxa in the study period belong to Euglenophyta (*Trachelomonas volvocinopsis*), and Bacillariophyceae (*Epithemia turgida*, *Eunotia bilunaris*, *Fragilaria crotonensis*, *Fragilaria dilatata*, *Gomphonema acuminatum* var. *coronatum*, *Navicula cuspidata* and *Navicula radiosa*).

The quantitative analysis of phytoplankton showed greater fluctuations with time in relation to the qualitative analysis (Fig. 15). These changes were connected with abundance fluctuations in Bacillariophyceae and Euglenophyta, i.e. the groups with the greatest share in the total algal abundance in the investigated pond. Euglenophyta are typical of small and shallow water bodies with high values of organic matter content (Wetzel 1983, Kawecka and Eloranta 1994, Noga 2006, Wołowski and Kowalska 2009), as well as high concentrations of ammonia (Sen and Sonmez 2006). Intense mixing of water in the pond leads to an increased organic matter release from the sediments to the water column (Kawecka and Eloranta 1994). Total phytoplankton abundance in the first half of the study period was relatively high reaching up to 570 ind.·ml^{-1} (on 31 March; Fig. 15). Temporal changes of the total algal abundance rapidly fluctuated from 22 March to 26 April, and then the number of individuals strongly decreased (from 4 May to 31 May) to about 100 ind.·ml^{-1}, and peaked again on 7 June (Fig. 15).

The most common dominant group of algae were Bacillariophyceae, whose participation evidently changed with time (Fig. 16).

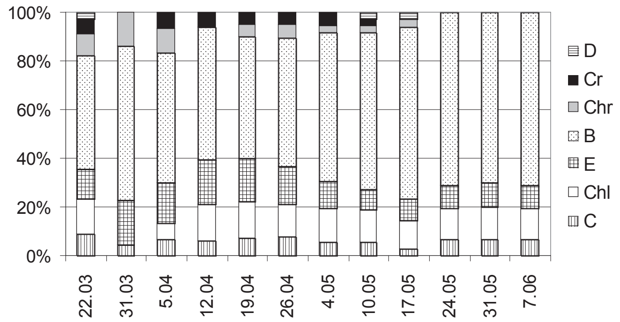


Fig. 14. Percentage contributions of particular systematic groups to the total number of phytoplankton taxa in the studied pond (C – Cyanoprokaryota, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Chr – Chrysophyceae, Cr – Cryptophyceae, D – Dinophyceae)

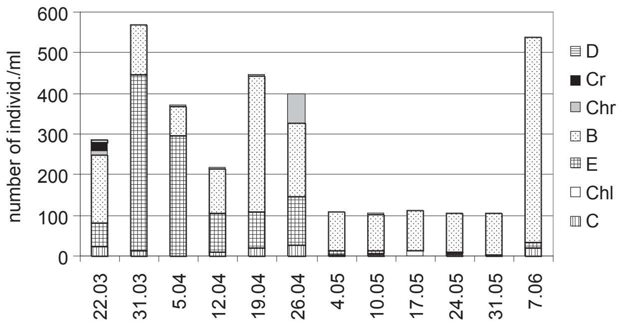


Fig. 15. Temporal changes of phytoplankton abundance in spring 2011 (C – Cyanoprokaryota, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Chr – Chrysophyceae, Cr – Cryptophyceae, D – Dinophyceae)

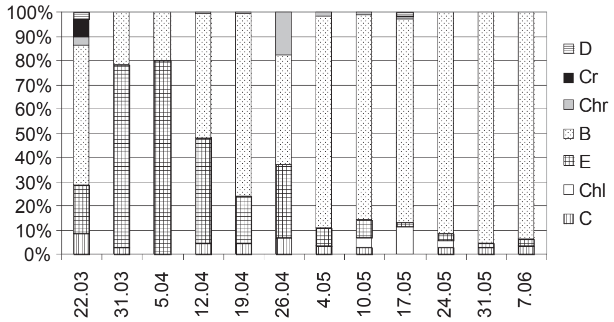


Fig. 16. Percentage contributions of particular systematic groups to the total number of phytoplankton individuals in the studied pond (C – Cyanoprokaryota, Chl – Chlorophyta, E – Euglenophyta, B – Bacillariophyceae, Chr – Chrysophyceae, Cr – Cryptophyceae, D – Dinophyceae)

According to van den Hoek et al. 1995, in temperate climates diatoms are most prevalent during spring, when nutrient levels in waters are high. On 31 March and 5 April Euglenophyta displaced Bacillaroriophyceae as dominants. In the first half of the study period the quantitative participation of Euglenophyta was relatively high, and then at the beginning of May it declined, with a great increase in the share of Bacillariophyceae. The greatest number of individuals among Cryptophyceae was observed only on 22 March, when a significant participation of *Cryptomonas rostrata* (22 ind.·ml^{-1}) was recorded. On 26 April the highest count of Chrysophyceae was found (71 ind.·ml^{-1}), connected with the great number of co-dominant *Synura uvella* individuals. A similar situation was observed by Munawar et al. (1991) in spring in a mesotrophic lake: the domination of diatoms first, followed by that of golden-green algae. Christie et al. (1988) and Kim and Kim (2011) indicated that chrysophytes can thrive not only in oligotrophic, but also in more eutrophic waters and often predominate among spring assemblages of the freshwater phytoplankton, similarly to diatoms (Edson and Jones 1988). According to Boo et al. (2010), Synurophyceae are common freshwater flagellates, which occur principally in diluted and circumneutral to acidic lakes and ponds. Moreover, *Synura uvella* occurs in ponds rich in organic matter (Bucka and Wilk-Woźniak 2007). Spodniewska (1988) and Kajak (1998) reported that in ponds during spring high counts of Bacillariophyceae, Chrysophyceae and Cryptophyceae are usually observed. Chrysophyceae prefer cool and well- oxygenated waters (Noga 2006), and that was probably the reason why they have a great share in the spring phytoplankton community in the investigated pond. The relatively limited Cyanoprokaryota abundance (Fig. 15), created only by species from the order Oscillatoriales, as well as low values of total algal abundance during the study period, confirm the relatively low trophic status of the investigated pond. Zębek (2009) reported that the abundance of blue-green algae often increases in spring in eutrophic, shallow waters and the phytoplankton community could be quantitatively shaped by this algae group. Small abundance of blue-greens in the investigated pond may also be connected with the relatively low values of pH. Shapiro (1990) reported that algae of this group prefer higher pH values. The greatest number of individuals among blue-greens was recorded for *Pseudanabaena limnetica*, *Oscillatoria limosa* and *Jaaginema pseudogeminatum*. A limited share in the total abundance of phytoplankton was also found for Chlorophyta, represented mainly by filamentous taxa (*Mougeotia* sp., *Spirogyra* sp. and *Planktonema lauterbornii*) in quantitative analyses and Dinophyceae (Fig. 15).

The dominant species throughout the entire investigated period belong only to Bacillariophyceae and Euglenophyta (Table 2). The most common dominants in phytoplankton abundance included *Trachelomonas volvocinopsis*, *Eunotia bilunaris* and *Navicula cuspidata*. Another dominant – *Melosira varians*, similarly as other taxa from the genus *Aulacoseira*, favours eutrophic and turbulent conditions (Owen and Crossley 1992, van Dam et al. 1994). *Navicula cuspidata* also prefers eutrophic waters (van Dam et al. 1994, Garg and Garg 2002). *Eunotia bilunaris* and *Navicula cuspidata* tolerate elevated concentrations of organically bound nitrogen (van Dam et al. 1994). The phytoplankton dominant structure was changing with time, but always among the Bacillariophyceae and Euglenophyta groups.

Statistical analysis did not detect any significant correlation between the total algal abundance and water pH or temperature. A significant negative correlation ($r = -0.643$) was found only between the abundance of Euglenophyta and water pH. In the studied pond a significant negative correlation ($r = -0.751$) between the dominant *Trachelomonas volvocinopsis* and water pH was also recorded. The greatest value of abundance for this taxon (from 240 to 363 ind.·ml^{-1}) was observed at the lowest values of pH (Fig. 3). Bucka and Wilk-Woźniak (2007) and Wołowski (1998) confirmed that it

Table 2. Structure of phytoplankton dominants in the pond in spring 2011

Species	22.03	31.03	5.04	12.04	19.04	26.04	4.05	10.05	17.05	24.05	31.05	7.06
Navicula cuspidata	+				+			+				
Trachelomonas volvocinopsis		+	+	+								
Euglena sp.						+						
Melosira varians									+			
Eunotia bilunaris										+	+	+

may occur in acidic waters with pH 5.1-6.6. According to Wołowski (1998), *Trachelomonas volvocinopsis* is a cosmopolitan and common taxon, also in ponds with partly rotted leaves during spring. In the investigated pond there are numerous leaves on the water surface, coming from the trees growing around the reservoir. The rotting leaves probably caused acidification of the pond waters.

CONCLUSIONS

In the investigated pond a large share of cosmopolitan and ubiquistic species was recorded along with many taxa typical of small water bodies (such as e.g. euglenoids and *Woloszynskia pascheri*). A high share of Bacillariophyceae and Chrysophyceae in the quantitative structure of the phytoplankton community was characteristic of springtime. High counts of Euglenophyta and the abundance of *Synura uvella* suggest elevated amounts of organic matter in water. In terms of the qualitative structure, the pond phytoplankton community in spring 2011 was relatively stable with dominant by Bacillariophyceae species, indicatory of eutrophic waters, Chlorophyta and Euglenophyta. On the other hand, a limited share of blue-greens and low values of algal total abundance during the study period showed that the trophic level was not excessively high. In the case of quantitative analyses, they showed great fluctuations in the algae community occuring with time, both in the total abundance and in the proportions of algae systematic groups.

This paper comprises only preliminary studies of the phytoplankton community. Further monitoring of water quality conditions (including phycological and physicochemical analyses) and routine sediment removal in the pond (depending on monitoring results) are recommended. Removal of bottom deposits is important to minimize the accumulation of organic matter in ponds (Yuvanatemiya et al. 2011) and may prevent massive development of phytoplankton.

Acknowledgments

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