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PHYTOPLANKTON COMMUNITY STRUCTURE IN TWO TYPES (FOREST VS. FIELD) OF SMALL WATER BODIES

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ABSTRACT. The catchment area which relates to different land use in the ponds surroundings may be one of the most important factors which influence the functioning of small water bodies. Thus, the fields or forest that surround the ponds may contribute to changes in the physical-chemical parameters of waters and therefore the phytoplankton communities inhabiting those two types of small water bodies may differ. The aim of this study was to examine the structure of the phytoplankton communities of two different types of water bodies – located within a field and forest catchment area – in order to find the specific features of each group of ponds. Six small and shallow water bodies (three mid-forest ponds and three mid-field) of the Wielkopolska Lakeland were investigated during the summer period of 2005. The obtained results demonstrated a great differentiation in the structure of phytoplankton communities between the two types of small water bodies – forest versus field, which was related to considerable variation in the physical and chemical features of the water in these two different kinds of ponds. In the examined ponds a great species richness of phytoplankton was recorded with high participation of chlorophytes and diatoms. The number of phytoplankton taxa was considerably higher in the mid-forest water bodies (72) compared to the mid-field ponds (48), while the mean phytoplankton densities reached a higher level level in the mid-field ponds (54 963 ind.$\cdot$ml^{-1}), than in the mid-forest (1622 ind.$\cdot$ml^{-1}). The common features for both groups of ponds (also stated in literature as common for small water bodies) was dominance of chlorophytes and diatoms in the taxonomical structure of the phytoplankton communities, quantity dominance of euglenoids as well as a high participation of small species of chlorophytes and cryptophytes representing r-strategy.

KEY WORDS: phytoplankton, chlorophytes, mid-forest pond, mid-field pond

INTRODUCTION

Small water bodies may greatly differ according to their origin, the character of their catchment area as well as their size. The quality of surface waters, especially in the case of small water bodies, will mainly depend on the land use in the catchment area. Thus, fields or forest which surround the ponds may contribute to changes in the physical-chemical parameters of their waters and therefore the phytoplankton communities inhabiting those two types of small water bodies may differ. The phytoplankton community in a pond is usually comprised of numerous species that live in a horizontal band or zone near the water surface. Representatives of algae produce most of the oxygen through photosyntheses.

Phytoplankton is critical to a pond's food chain as it provides food for the multiplicity of microscopic animals that in turn are eaten by fish fry or larger invertebrates. Occasionally, planktonic algae can form *a* large floating mass and bloom to significant levels which may necessitate the use of control methods. A high abundance of algae can block sunlight to underwater stands of aquatic vegetation.

Due to limited depth and volume the waters of ponds are characterised by a great variability of environmental conditions. Moreover, biotic and abiotic parameters such as the physical features of an environment e.g. temperature, concentration of nutrients, as well as the density and quality of fish and invertebrate communities may be very unstable here (Joniak et al. 2006, 2007). All these parameters should be taken into consideration when analysing the structure of any phytoplankton community within a small water body.

Owing to their small area and depth ponds are susceptible to degradation and they often undergo changes in their trophic status. Even in the same pond the living conditions of aquatic organisms may be affected by trophy or changes in environmental conditions, including water level fluctuations (Valk and Davis 1976, Kuczyńska-Kippen and Nagengast 2006). Ponds are also known to maintain a high level of biodiversity by creating favourable conditions for its inhabiting organisms (Biodiversity... 1996, Kuczyńska-Kippen et al. 2003).

The object of the study was to examine the structure of the phytoplankton community of two different types of water bodies – located within the field and forest catchment area – in order to find the specific features of each group of ponds. Moreover, the impact of physical-chemical parameters on the algae densities was taken into consideration.

MATERIAL AND METHODS

Six small and shallow water bodies of the Wielkopolska Lakeland (western part of Poland) near the city of Poznań were investigated during the summer period of 2005: three mid-forest ponds (No. 1 – Krucz II, No. 2 – Krucz I, No. 3 – Owcza) and three mid-field (No. 4 – Mankol, No. 5 – Tarnowo Podgórne 21, No. 6 – Tarnowo Podgórne 10). Ponds No. 3 and 4 were situated within the borders of the city of Poznań, while No. 5 and 6 were west of Poznań and No. 1 and 2 north of Poznań (Fig. 1). The analysis included stands located in the open water zone. The depth of all the ponds did not exceed 1.8 m and the surface 1 ha.

Table 1. Results of physical-chemical features of water in particular ponds

Forest ponds	Mean	Min.	Max	SD
pH	7.43	6.80	8.35	0.71
Temperature (°C)	23.3	18.6	27.2	4.36
Conductivity (μS·cm^{-1})	366.67	150.00	545.00	173.44
Visability (m)	1.20	0.90	1.60	0.31
TP (mg·l^{-1})	0.12	0.07	0.19	0.05
TN (mg·l^{-1})	0.72	0.50	0.89	0.17
Chlorophyll *a* (μg·l^{-1})	95.56	18.02	244.92	112.05
Field ponds	**Mean**	**Min.**	**Max**	**SD**
pH	7.59	6.80	8.41	0.70
Temperature (°C)	20.50	19.40	21.80	1.05
Conductivity (μS·cm^{-1})	1 040.33	214.00	1 589.00	630.76
Visability (m)	0.77	0.40	1.40	0.48
TP (mg·l^{-1})	0.63	0.07	0.93	0.42
TN (mg·l^{-1})	1.59	0.71	2.22	0.68
Chlorophyll *a* (μg·l^{-1})	82.80	5.23	236.08	114.96

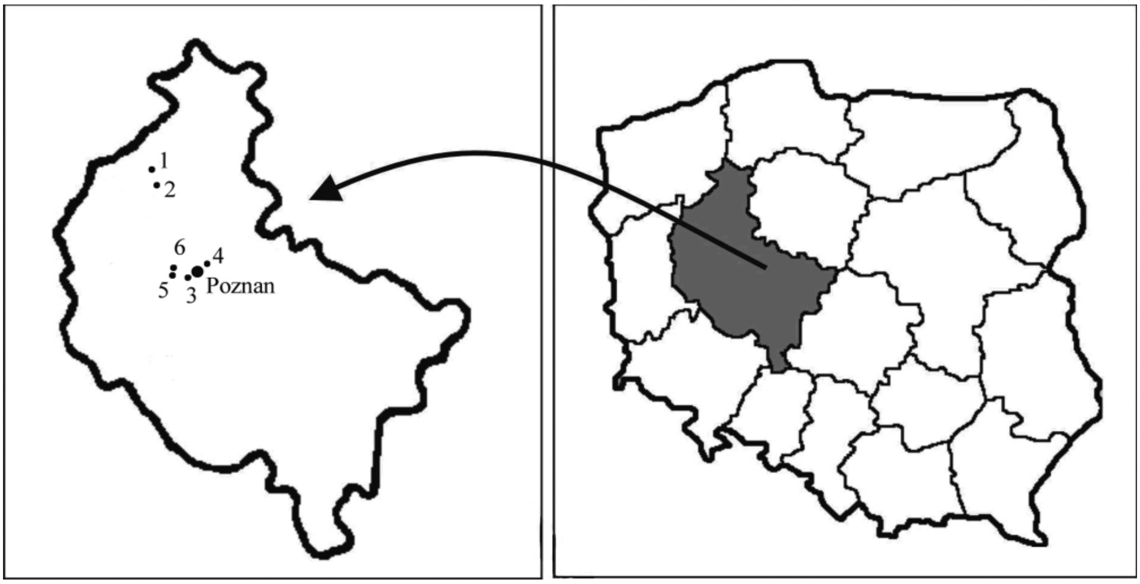

Fig. 1. Location of the studied ponds
Legend: mid-forest ponds (No. 1 – Krucz II, No. 2 – Krucz I, No. 3 – Owcza) and mid-field (No. 4 – Mankol, No. 5 – Tarnowo Podgórne 21, No. 6 – Tarnowo Podgórne 10).

These two types of ponds differed in respect to their aquatic vegetation cover and physical-chemical parameters. Total phosphorus concentration differed greatly between both types of water bodies. The mean and maximum concentrations of this nutrient was five times higher in the mid-field ponds compared to the mid-forest ponds. Also conductivity was almost three times higher and total nitrogen concentration twice as high in the field ponds. Moreover, in this type of pond the mean concentrations of oxygen were lower in comparison to the forest ponds (Table 1).

Mid-forest water bodies were characterised by higher phytosociological variation. Apart from single specimens of certain aquatic plants there were five well developed communities recorded in this type of ponds, while in the mid-field water bodies there were only two communities found on average (Table 2). 16 phytocoenoses were recorded, while 15 were noted in the mid-forest ponds and only six in the mid-field water bodies.

Samples for phycological investigations were collected from the surface water layer, and fixed with Lugol's solution and preserved with 4% formalin. Afterwards,

TABLE 2. Aquatic plant communities of the examined ponds (forest and field). Numbers represent particular water bodies

Plant communities	Forest			Field		
	1	2	3	4	5	6
Kl. *Lemnetea minoris* (R.Tx. 1955) de Bolos et Masclans 1955						
Lemno-Spirodeletum polyrrhizae W. Koch 1954 ex Th. Muller et Gors 1960	×		×			
Lemnetum minoris Soó 1927		×			×	
Riccietum fluitantis Slavinić 1956		×				
Lemno-Hydrocharitetum morsus ranae (Oberd. 1957) Pass. 1978			×			
Kl. *Charetea fragilis* Fukarek 1961 ex Krausch 1964						
Charetum fragilis Fijałkowski 1960	×					
Kl. *Potametea* R.Tx. et Prsg. 1942 ex Oberd. 1957						
Potametum pectinati (Hueck 1931) Carstensen 1955	×					
Najadetum marinae Fukarek 1961	×					
Ceratophylletum demersi Hild 1956	×		×			
Ceratophylletum submersi Soó 1927						×
Kl. *Phragmitetea australis* (Klika in Klika et Novak 1941) R.Tx. et Preising 1942						
Scirpetum lacustris (Allorge 1922) Chouard 1924	×				×	
Typhetum latifoliae Soó 1927 ex Lang 1973	×				×	
Sparganietum erecti Roll 1938	×					×
Phragmitetum communis (W. Koch 1926) Schmale 1939	×			×		
Glycerietum maximae (Allorge 1922) Hueck 1931	×					
Caricetum acutiformis Eggler 1933			×			
Kl. *Artemisietea vulgaris* Lohmeyer, Preising et R.Tx. 1950						
Eupatorietum canabini R.Tx. 1937	×					
The number of phytocoenoses	11	2	4	1	3	2

Legend as in Figure 1.

they were sedimented to the volume of 5-20 ml (from 1 litre), and next analysed qualitatively and quantitatively. Numbers of cells of cyanoprokaryotes and eukaryotic algae were counted in Fuchs-Rosenthal chambers. Single cells and algae cenobia were regarded as one individual. In the case of trychomes, one segment of 100 µm length was regarded as one individual; in the case of the colony of cyanobacteria (*Merismopedia*, *Microcystis* and *Woronichinia*) a surface of 400 μm^2 was regarded as one individual. A species was regarded as a dominant if its contribution to total phytoplankton abundance exceeded 10% in a sample.

Water temperature, dissolved oxygen, pH, conductivity were measured directly at the sampling sites. Secchi disc transparency was measured with a 30 cm diameter white disc. Water samples were analysed in the laboratory to determine total phosphorus (TP), total reactive phosphorus (TRP), nitrates (NO_3), nitrites (NO_2) and ammonium nitrogen (NH_4) (HERMANOWICZ et AL. 1999). The chlorophyll *a* concentration was determined with a spectrophotometer following extraction in acetone (WETZEL and LIKENS 2000). The trophic conditions were estimated using the trophic state index (TSI) as described by CARLSON (1977), where the total values of total phosphorus concentration (TSI_{TP}), chlorophyll *a* (TSI_{Chl}) and water transparency (TSI_{SD}) were taken into consideration (JONIAK et AL. 2007).

RESULTS AND DISCUSSION

In the examined ponds a great species richness of phytoplankton, which is characteristic of small water bodies (DUELLI and OBRIST 2003, DELLA BELLA et AL. 2008) was recorded. A high participation of chlorophytes and diatoms (mainly periphytic and benthic forms, e.g. genera of *Gomphonema*, *Navicula*, *Nitzschia*, *Fragilaria*, *Cymbella*, *Cymatopleura*, *Pinnularia* and *Eunotia*) was found in the taxonomical structure (Fig. 2). Among green algae, taxa of the order Chlorococcales dominated, however, species belonging to desmids (from genera *Cosmarium* and *Closterium*), which are characteristic of alkaline habitats (KOSTKEVICIENE et AL. 2003) also occurred frequently. Members of the *Cosmarium* and *Closterium* genera are often found to be common in both eutrophic and mesotrophic water bodies (SAHIN 2000). The number of phytoplankton taxa was considerably higher in the mid-forest water bodies compared to the mid-field ponds (Fig. 2, 3). Similar results were obtained in the case of zooplankton, which also build

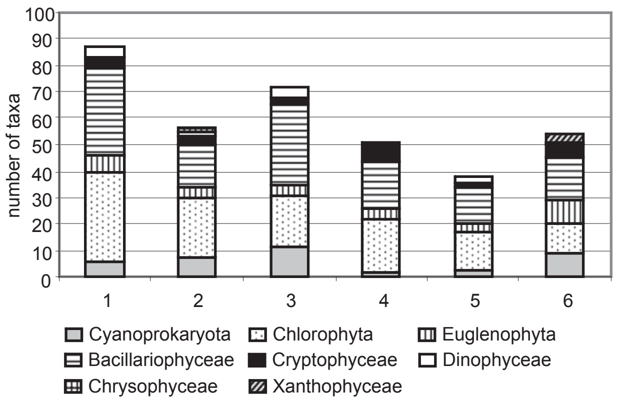

FIG. 2. Number of phytoplankton taxa at particular examined stations (legend as in Table 2)

the richest communities in water bodies located within the forest catchment area. In the mid-forest ponds the mean number of taxa within cyanoprocaryota, chlorophytes and diatoms was also higher compared with the mid-field ponds (Fig. 3). However, in both groups of small water bodies the same systematic groups of algae (chlorophytes and diatoms) dominated.

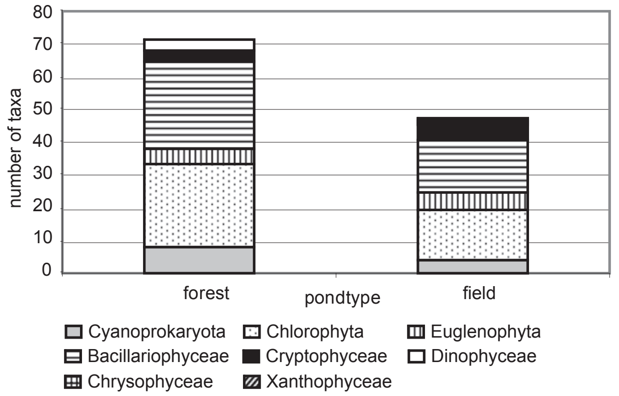

FIG. 3. Mean number of phytoplankton taxa in the mid-forest and mid-field ponds

The analysis of phytoplankton community densities revealed a considerably high differentiation between the studied water bodies (both in respect to the participation of particular systematic groups of algae as well as in the structure of the dominating species; Fig. 4, Table 3). This may have been connected with great differences in the values of physical-chemical variables between particular samples (Table 1). In the mid-forest ponds chlorophytes and dinoflagellates contributed to the highest participation in the total phytoplankton abundance, while in the mid-field pond – chlorophytes and cryptophytes (Fig. 5). The mean phytoplankton densities reached a level of 54 936 ind.·ml^{-1} in the field ponds, while in the forest water bodies only 1622 ind.·ml^{-1}. The considerably low number of phytoplankton specimens in the ponds located within the forest catchment area may be a result of the restricted light conditions in this kind of water body. KOČARKOVA et AL. (2004) stated that overshaded mid-forest ponds are characterised by a low abundance of algae communities.

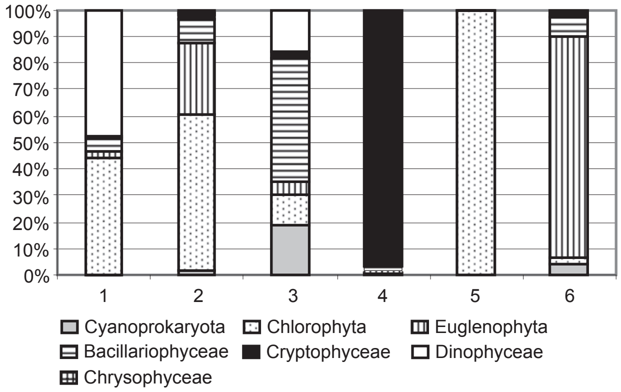

FIG. 4. Percentage participation of particular systematic groups of phytoplankton (quantitative structure) in the examined water bodies (legend as in Table 2)

TABLE 3. Structure of phytoplankton dominants in particular ponds

Pond, Total abundance	Dominating groups of algae	Dominating species
Krucz II 3600 ind.·ml^{-1}	Dinophyceae, Chlorophyta	*Peridinium* sp., *Hyaloraphidium contortum* Pasch & Korš.
Krucz I 796 ind.·ml^{-1}	Chlorophyta, Euglenophyta	*Cosmarium laeve* Rabenhorst, *Trachelomonas* sp.
Owcza 469 ind.·ml^{-1}	Bacillariophyceae	–
Mankol 7360 ind.·ml^{-1}	Cryptophyceae	*Chroomonas acuta* Utermöhl, *Cryptomonas erosa* Ehr.
Tarnowo 21 157 178 ind.·ml^{-1}	Chlorophyta	*Chlamydomonas reinhardtii* Dang.
Tarnowo 10 352 ind.·ml^{-1}	Euglenophyta	*Trachelomonas volvocina* Ehr.

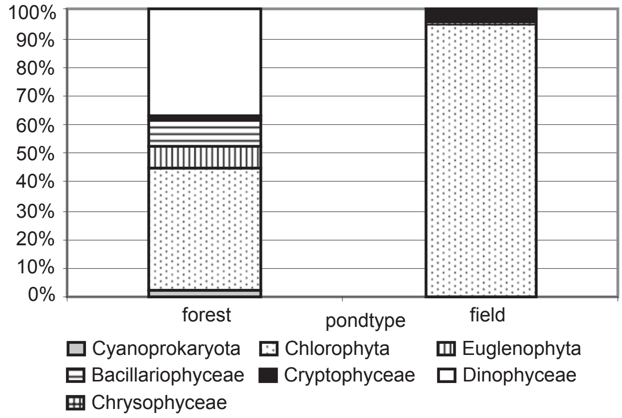

FIG. 5. Percentage participation of particular systematic groups of phytoplankton (quantitative structure) in the mid-forest and mid-field ponds

The much higher densities of phytoplankton within the mid-field water bodies were due to higher values of conductivity and particularly to higher concentrations of nitrogen and phosphorus compounds (Table 1). Mid-field ponds are often enriched in nutrients from the surrounding fertilized fields. Statistical analysis confirmed a positive relationship between the total phytoplankton abundance and electrical conductivity ($r = 0.72$, $p < 0.05$) as well as between total phytoplankton abundance and total phosphorus concentration ($r = 0.57$, $p < 0.05$). Leibold (1999), who examined 31 fishless ponds in southern Michigan has also found that the density of phytoplankton was positively correlated with nutrient levels. In the mid-field water bodies there were also higher densities of chlorophytes (52 177 ind.·ml^{-1}), euglenophytes (256 ind.·ml^{-1}) and cryptophytes (2410 ind.·ml^{-1}), which prefer nutrient-rich waters (John et al. 2002, Celekli et al. 2007). Green algae of the order Chlorococcales dominate in shallow and eutrophic water bodies (Reynolds 1984), which was confirmed in the case of our studies. In pond No. 5 a bloom of *Chlamydomonas reinhardtii* of the order Volvocales was also recorded, which led to low water transparency (0.4 m) and high concentrations of chlorophyll a (236.08 µg·l^{-1}) in the water. It was also found that an abundance of chlorophytes and euglenophytes was positively correlated with total phosphorus concentration ($r = 0.58$, $p < 0.05$ and $r = 0.52$, $p < 0.05$ respectively), while an abundance of chlorophytes and cryptophytes with electrical conductivity ($r = 0.70$, $p < 0.05$ and $r = 0.50$, $p < 0.05$ respectively). A positive relationship between the densities of cryptophytes and electrical conductivity was also confirmed by Pinilla (2006). A high participation of small forms of chlorophytes and cryptophytes (of r-strategy) in the structure of dominating species of the phytoplankton community (Table 3), indicates unstable conditions for the inhabiting organisms (Burchardt and Messyasz 2004), which are often attributed to the small water bodies. The dominance of euglenoid *Trachelomonas volvocina* in pond No. 6, was attributed to the high concentration of ammonium (1.92 mg·l^{-1} NH_4 – the highest values out of all the ponds). Also according to Pinilla (2006) the numbers of this species are positively correlated with the concentration of ammonium. Moreover, Prasad et al. (2000) and Sen and Sonmez (2006) state that euglenophytes prefer high concentrations of ammonia and organic matter.

In the mid-forest water bodies higher mean densities of cyanoprokaryota (41 ind.·ml^{-1}), dinoflagellates (597 ind.·ml^{-1}) and diatoms (151 ind.·ml^{-1}) were found, compared to the mid-field ponds. Statistically significant differences in the phytoplankton densities between the two types of water bodies (mid-forest vs. mid-field) were only found for cyanoprokaryota and dinoflagellates (Fig. 6). Cyanoprokaryotes prefer moderately high concentrations of phosphorus and high temperatures of water (Moss et al. 2003, Svrcek and Smith 2004, Zebek 2005). In the mid-forest ponds the concentrations of phosphorus were lower compared to the mid-field ponds, however, the mean temperatures were higher here (Table 1). There was also a positive correlation between the cyanoprokaryota densities and the water temperature ($r = 0.81$, $p < 0.05$) obtained. Another reason for the presence of higher numbers of this group of algae in the ponds located within the forest catchment area was a lack of water movement related to the water surface being surrounded by a band of trees. A higher abundance of dinoflagellates in the forest type of ponds may have been connected with lower concentrations of phosphorus in these ponds, particularly since Pinilla (2006) states that dinoflagellates develop better in an environment with a lower content of phosphorus.

In the water bodies which were characterised by a slightly acidic pH (No. 2 and No. 6), a dominance of *Eunotia bilunaris* (Ehr.) representing diatoms was recorded. This is in accordance with the findings of Passy (2006), who found that this species prefers acidic environments.

The obtained results demonstrated a great differentiation in the structure of phytoplankton communities between the two types of small water bodies – forest versus field, which was related to considerable variation in the physical and chemical features of the water in the surrounding of the two different kinds of ponds. In the mid-forest ponds a richer mean number of algae taxa and more diverse taxonomical structure within cyanoprokaryota, chlorophytes and diatoms was recorded compared to the mid-field water bodies. In the mid-field ponds higher densities of phytoplankton, as well as of chlorophytes and cryptophytes were found. In the mid-forest water bodies chlorophytes and dinoflagellates occurred in higher densities. The common features for both groups of ponds (also stated in literature as common for small water bodies) was dominance of

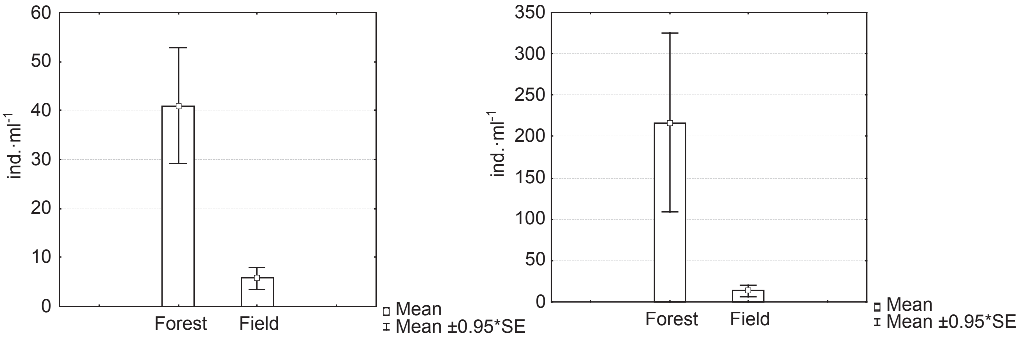

Fig. 6. Mean densities of cyanoprokaryota (A) and dinoflagellates (B) in the mid-forest and mid-field ponds

chlorophytes and diatoms in the taxonomical structure of phytoplankton communities, quantity dominance of euglenoids as well as a high participation of small species of chlorophytes and cryptophytes representing r-strategy.

Small water bodies (both mid-forest and mid-field) remain an interesting object for hydrobiological examination, therefore, there is a need to continue and investigate further in order to obtain detailed data on phytoplankton and also on the relationship between algae and specific environmental conditions, both abiotic and biotic.

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