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DIEL CHANGES IN THE PLANKTON COMMUNITIES OF THE ECOTONE ZONE OF A PEAT MAT OF THE DYSTROPHIC LAKE „GŁODNE JEZIORKO" (DRAWIEŃSKI NATIONAL PARK)*

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A b s t r a c t. Analysis of net phytoplankton revealed that the taxonomically richest were Chrysophyceae with dominating genus *Dinobryon*, mainly *Dinobryon pediforme,* and Zygnematophyceae, mainly genera *Closterium*, *Micrasterias* and *Staurastrum*. Less often appeared Dinophyceae, Raphidophyceae and Bacillariophyceae. In the open water zone the colonies of *Dinobryon* and one-cell desmides prevailed, while within the peat mat the participation of filamentous green algae increased. As a result of zooplankton examination, the presence of 47 species (33 Rotifera, 10 Cladocera, 4 Copepoda) was recorded. In most cases the quantity dominance of rotifers over crustaceans, irrespective of the station (A and B) or time of day (day or night), was noticed. The zooplankton densities were much higher within the peat mat stations compared to the open water zone during the daylight hours at both stations. However, the analysis of zooplankton distribution during the night hours revealed a shift of the total densities in the direction of the open water. Such a pattern of the diurnal dynamics of zooplankton communities suggests the use of the peat mat as a day-time refuge for zooplankton against the vertebrate predators.

K e y w o r d s: peat mat, zooplankton, phytoplankton, dystrophic lake

INTRODUCTION

The examined water body is one out of five dystrophic reservoirs creating a complex called 'Głodne Jeziorka', situated in the north-western part of the Drawieński National Park. The studied lake is of a small area (0.65 ha), but is relatively deep (max 6.8 m and mean depth >3 m). A specific feature of this reservoir is

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a zone of peat mat with the participation of transition and ombrotrophic peatbogs. The peat mat overlaps the water surface.

The inflow of great amounts of humic compounds from the surrounding peatbogs into the lake influences the physical-chemical parameters of the water. The humic substances are responsible for the brown colour of the water, which restricts solar penetration and causes acidification. Therefore, the production of phytoplankton is very low. The main stream of energy flows through a heterotrophic chain of bacteria and fagotrophic algae and through predatory and detritophagous zooplankton.

METHODS

The research was carried out during the summer stagnation period of 2004. The samples were collected from two stations: A – southern; st B – northern part of the lake.

At each station the material was collected from three places: P – from under the peat mat, S – at the border of the peat mat, and T – from open water area. The distance between particular stations was about 1.5 m. The samples were taken from a depth of about 1 m.

Samples were taken twice in the 24-hour cycle: D – during the day time (about 2 p.m.) and N – at night (about 12:00 a.m.).

Plankton and water for chemical analyses were sampled using a plexiglass core sampler of 1m length (∅ 50 mm). The plankton material of a volume of 5 l was concentrated using a 45-μm plankton net and was fixed immediately with 4% formalin.

During the time of examination the temperature, oxygen concentration, conductivity an pH were measured at each station, and additionally at the central part of the lake, using a YSI 2000 meter. The chemical analyses were conducted according to the Standard Methods for Examination of Waters and Wastewaters [16].

The Mann-Whitney U-test was used in order to determine the statistical differences of zooplankton densities between particular stations ($N=36$).

RESULTS AND DISCUSSION

As a result of the examination, differences in the physical-chemical parameters of water between particular stations were found. The most significant of these (observed at station A and B) were noticed between water from under the peat mat and the remaining places of sample collection (Tab. 1). Peat-mat water was characterized by more acidic reaction, considerably lower oxygen and higher nutrient concentration, especially in the case of ammonium nitrogen and total phosphorus. It also had a more intensive brown colour of water compared with the bordering part of the peat mat and the open water zone. It seems probable that specific features of physical-chemical conditions of water from under the peat mat is connected with the inflow of water from peatbog surrounding the lake. Many authors [2,7-10] have noted that waters flowing into water reservoirs from high and transition peatbogs are characterized by a high concentration of nutrients, acidic reaction, and extremely low oxygen concentrations.

At the same time, temperature from all the sampling places of station A was higher in comparison with station B (Tab. 1), which was probably an effect of the complete overshadowing of station B and the inflow of colder underground waters.

Table 1. Physical-chemical parameters of water of examined stations (T – open water, S – border zone between the peat mat and open water, P – water under the peat mat)

Parameters		Station A			Deepest point	Station B		
		T	S	P		T	S	P
Temperature	°C	18.6	18.6	16.2	18.5	17.5	17.5	16.1
Water colour	mg Pt l^{-1}	107	111	134	108	109	112	139
pH		5.24	5.1	4.89	5.2	5.2	5.1	4.8
Conductivity	µS cm^{-1}	38	38	32	38	38	38	32
Oxygen	mg O_2 l^{-1}	9.2	9.2	5.3	9.2	9.2	9.2	5.8
Ammonium N	mg N l^{-1}	0.38	0.32	0.96	0.32	0.3	0.29	1.1
Nitrite N	mg N l^{-1}	0.002	n.d.	n.d.	n.d.	n.d.	0.002	n.d.
Nitrate N	mg N l^{-1}	0.12	0.1	0.14	0.1	0.1	0.1	0.1
Organic N	mg N l^{-1}	0.62	0.66	1.02	0.62	0.6	0.6	0.86
Orthophosphate	mg P l^{-1}	n.d.	n.d.	0.045	n.d.	n.d.	n.d.	0.032
Total P	mg P l^{-1}	0.098	0.102	0.45	0.1	0.078	0.104	0.52

n.d. – not detected.

In the net plankton 28 taxa belonging to 5 groups were identified. Most of them constituted taxa of Chlorophyta (16 taxa – 57% participation of the phycoflora), and next Chrysophyta (8-29%). Cyanophyta (2 taxa), Raphidophyta andi Pyrrophyta (1 taxon each) were less numerously represented. The most diverse taxonomically were genera of *Dinobryon* and *Staurodesmus* (Tab. 2). The poor taxonomical structure of the phytoplankton community was due to the fact that dystrophic lakes along with their surrounding peatbogs create an extremely poor living environment for phycoflora, resulting from the brown colour of the water and therefore reduced light penetration, as well as low water reaction. Such factors may restrict the algae flora typical for lakes or rivers and thus the peatbog areas are inhabited mainly by highly specialized acidophilic species.

A negative correlation between the species diversity and pH was often observed [18]. Moreover, Peterson *et al.* [11] explained that together with the decrease of pH the amount of biogene intake decreases and metal toxicity increases.

This was also stated by Hendrey (after [15]), who in acid waters (with pH 4.9) found the occurrence of 27 species.

The total abundance of microplankton varied between 97 (open water during darkness at station B) and 733 cells l^{-1} (open water during the day at station A).

Table 2. The numbers of taxa of phycoflora community of the examined stations (T – open water, S – border zone between the peat mat and open water, P – water under the peat mat)

Taxa	AD			AN			BD			BN		
	T	P	S	T	P	S	T	P	S	T	P	S
CYANOPHYTA												
Cyanophyceae												
Pseudanabaena sp.				242						32	21	
Oscillatoria sp.												
PYRROPHYTA												
Dinophyceae												
Peridinium willei Huitfelt-Kaas	1											
RAPHIDOPHYTA												
Raphidophyceae												
Gonyostomum semen (Eher.) Diesing	11	2		35	74		42		11	26	32	42
CHRYSOPHYTA												
Chrysophyceae												
Dinobryon bavaricum Imhof							42				21	
Dinobryon divergens var. *schauinslandii* (Lemm.) Brunthaler	53	21	2					32	105		25	
Dinobryon pediforme (Lemm.) Steinecke	525	294	105	112	42	105	452	95	126	32	252	284
Rhipidodendron splendidum Stein	2	84	2	5	11		21	24		3		11
Bacillariophyceae												
Eunotia exigua (Bréb.) Rabh.	32			21		11		21				
Navicula sp.	11	11		2								
Synedra sp.											11	11
Tabellaria	21											
CHLOROPHYTA												
Chlorophyceae												
Microspora *sp.*											24	
Oedogonium *sp.*		1					21					
Zygophyceae												
Closterium limneticum *Lemmermann*		1										
Closterium striolatum			1									1
Closterium tumidum Johnson					1							
Micrasterias sol (Ehr.) Kütz.			1									

Most abundant were usually chrysophytes (from 35 to 580 cells l^{-1}), then chlorophytes (from 5 to 212 cells l^{-1}) Among the chrysophytes the most abundant populations were those of *Dinobryon pediforme* (Lemm.) Steinecke. At the same time it was the only species that was present throughout the whole examination period in all habitats. During the daylight hours, at both stations A and B, it was most abundant in the open water zones, whereas during the night sampling at station A its densities were similar in the open water and under the peat mat. However, at station B its numbers were greater under and at the border zone of the peat mat, compared with the open water area. *Gonyostomum semen* (Eher.) Diesing, a reasonably large microplanktonic flagellate, although it occurred at all the habitats of the station A, preferred the open water and the peat mat. Moreover, it was also found under the peat mat of station B. This species, earlier treated as rare, has recently been found more frequently in Poland [3-6,17-20]. *Gonyostomum semen*, as stated by Arvola *et al*. [1], occurs numerously in phytoplankton of small mid-forest lakes with brown colour of water.

Additionally, greater densities of the filamentous green algae from the genus *Mougeotia* were observed during the night samplings at station A. Representatives of this genus usually develop in the near-shore of small water bodies and in the open water zone their occurrence is rather accidental.

The examination of the zooplankton community revealed the presence of 47 species (33 Rotifera, 10 Cladocera, 4 Copepoda), with 34 at station A and 38 at station B. The taxonomical structure of the stations located within the peat mat was richer compared to the open water zone, irrespective of the time of day (Fig. 1).

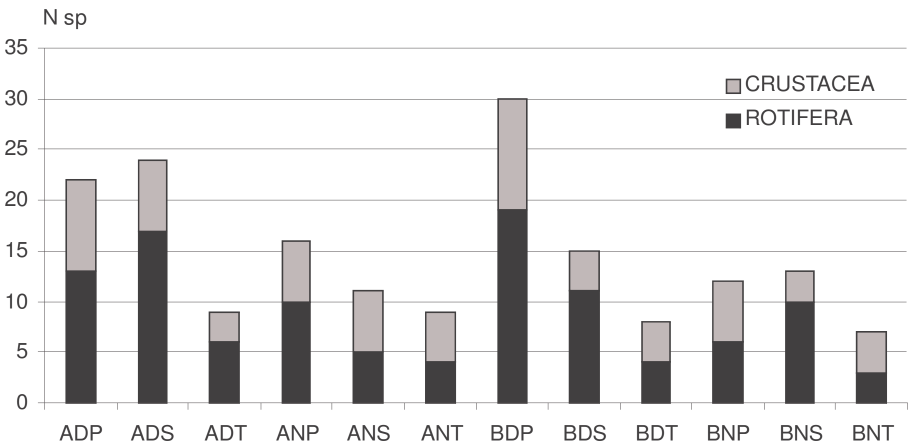

Fig. 1. Number of zooplankton species within the examined stations and times of day (T – open water, S – border zone between the peat mat and open water, P – water under the peat mat, N – at night, A and B – stations, D – day time)

In most cases, a quantity dominance of rotifers over crustaceans was noticed, irrespective of the station or time. Analysing zooplankton abundance it was recorded that higher values, although not statically significant ($p > 0.05$), were characteristic for the zones located within the peat mat (both under the peat mat and in the border zone between the mat and water) (Fig. 2).

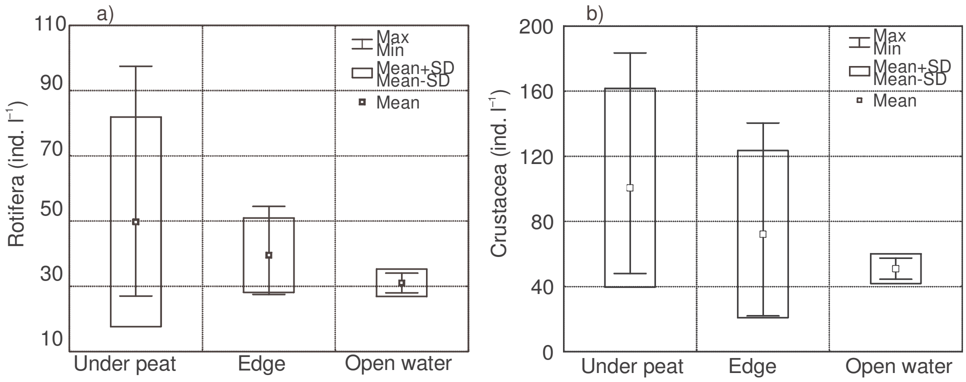

Fig. 2. Differentiation of densities of a) rotifer and b) crustacean communities between particular stations of the examined water body

Moreover, taking into consideration particular sampling times it was found that at both stations (A and B) the zooplankton densities during the daylight hours were considerably higher among the peat mat, especially due to mass occurrence of *Ceriodaphnia quadrangula* (O.F. Müller) at station A and *Alonella excisa* (Fischer) at station B, compared to the open water area (Fig. 3).

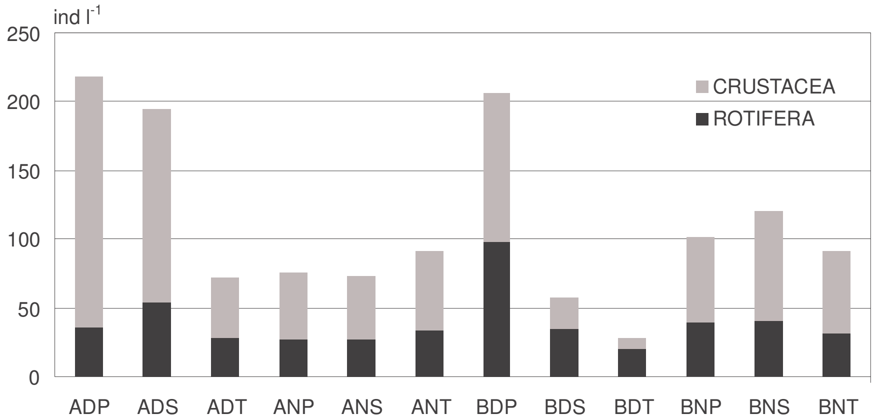

Fig. 3. Densities of zooplankton community within the examined stations and times of day (For explanation see Fig. 1)

However, analysis of zooplankton distribution between particular sampling stations during the night hours showed a shift of zooplankton densities towards the open water zone. Such a pattern of diurnal dynamics of zooplankton community suggests the utilisation of the peat mat as a day-time refuge against vertebrate predators which were present in the examined lake in great amounts. It is a well known phenomenon that a thick conglomeration of aquatic plants creates favourable conditions for concealment, constituting a refuge [12,14], which has also been confirmed in the case of this specific habitat – peatmoss vegetation. Similar results were obtained by Rybak and Węgleńska [13], who suggested that the strong impact of vertebrate predation results in zooplankton gathering among vegetated areas during the light hours.

The dominant community of the examined water body was created by 7 zooplankton species (5 of Rotifera and only 2 of Crustacea): *Bdelloidae*, *Keratella cochlearis* Gosse*, Polyarthra vulgaris* (Carlin), *Synchaeta pectinata* Ehrenberg and *Trichocerca insignis* Carlin from among rotifers, as well as *Alonella excisa* and *Ceriodaphnia quadrangula* among crustaceans. It was found that only *T. insignis* and *C. quadrangula* dominated irrespective of time or station. Moreover, the dominance of *Bdelloidae* and *K. cochlearis* was restricted to the peat-bog areas.

CONCLUSIONS

Differences in the physical and chemical parameters of water between particular stations were found. The most significant of these were noticed between water from under the peat mat and the remaining places of sample collection. Under peat-mat water was characterized by more acidic reaction, considerably lower oxygen and higher nutrient concentration. Simultaneously differences in plankton structure between stations were observed. In the open water zone the colonies of *Dinobryon* and one-cell desmides prevailed, while within the peat mat the participation of filamentous green algae increased. The zooplankton densities were much higher within the peat mat stations compared to the open water zone during the daylight hours at both stations. However, the analysis of zooplankton distribution during the night hours revealed a shift of the total densities in the direction of the open water. Such a pattern of the diurnal dynamics of zooplankton communities suggests the use of the peat mat as a day-time refuge for zooplankton against the vertebrate predators.

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DOBOWE ZMIANY W OBRĘBIE UGRUPOWAŃ FITO- I ZOOPLANKTONU STREFY PRZEJŚCIOWEJ PŁA TORFOWCOWEGO JEZIORA DYSTROFICZNEGO „GŁODNE JEZIORKO” (DRAWIEŃSKI PARK NARODOWY)

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S t r e s z c z e n i e. Próby planktonowe i chemiczne pobierano z dwóch stanowisk: A – zlokalizowanego w południowej, nasłonecznionej, B – w północnej, zacienionej części badanego zbiornika. Na każdym ze stanowisk pobierano materiał z trzech miejsc: spod pła torfowcowego, ze strefy granicznej między płem a tonią wodną oraz bezpośrednio z toni wodnej.

Zaobserwowano nieznaczne różnice właściwości fizyczno-chemiczne wód w punktach poboru prób. Na obydwu stanowiskach (A i B) woda spod pła torfowcowego charakteryzowała się nieco kwaśniejszym odczynem, niższą koncentracją tlenu, ale wyższymi stężeniami pierwiastków biogennych zwłaszcza amonowej formy azotu i fosforu ogólnego, w porównaniu do części skrajnej pła i otwartej toni wodnej.

Analiza fitoplanktonu wskazała, że najliczniejszymi grupami glonów były złotowiciowce (Chrysophyceae) z dominującym rodzajem *Dinobryon*, głównie *Dinobryon pediforme* i sprzężnice (Zygnematophyceae), głównie rodzaje *Closterium*, *Micrasterias* i *Staurastrum*. W toni wodnej przeważały kolonie *Dinobryon* i jednokomórkowe desmidie natomiast w obrębie pła torfowcowego wzrastał udział sprzężnic nitkowatych.

Badania ugrupowań zooplanktonowych wykazały, obecność łącznie 47 gatunków zooplanktonu. W większości przypadków stwierdzono dominację ilościową wrotków nad skorupiakami, niezależnie od stanowiska czy pory dnia. Wykazano, że na obu badanych stanowiskach (A i B) dobowy rozkład liczebności zespołów zooplanktonowych sugeruje wykorzystywanie torfowców jako kryjówki dziennej dla zooplanktonu przed drapieżnikami kręgowymi.

S ł o w a k l u c z o w e: pło torfowcowe, zooplaknkton, fitoplankton, jezioro dystroficzne