

Original Research

Research of Different Types of Peatbogs: Relationships of Bioceonosis Structures and Physico-Chemical Parameters

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Abstract

The majority of ecological research on the food web has so far focused more on sea and lake ecosystems than on peatbog habitats. The primary objectives of this paper were to analyze the protozoa, metazoa, and macroinvertebrate assemblages in different types of peatbogs, and to assess the influence of potential predators on protozoa communities. Sampling was done in six peatbogs from May to October 2012 in a transect including lagg and open peatbog. The results of DCA analysis showed that Axis 1 and Axis 2 explained 49.8% of the total variance in composition of studied zoocenosis. The distribution of samples in ordination space led us to conclude that studied habitats are distributed along the falling gradient of water level and rising gradient of total organic carbon and nitrate nitrogen. Nevertheless, the number of significant correlations between the main groups of organisms forming the food web was different among sites, and in highmoore peatbogs the relationships between food web components were the strongest.

Keywords: peatbogs, nutrients, ciliates, metazoan, macroinvertebrates

Introduction

Since 1950 a lot of peatbog areas in Europe have been seriously damaged, destroyed, and eliminated. However, various types of peatbogs can be distinguished, depending on their hydrology, concentrations of nutrients, pH, and

dominant vegetation [1, 2]. We hypothesized that microbial and macrobial communities differed among different types of peatbogs and these differences could be related to moisture conditions and water chemistry. Peatbogs are generally characterized by rich biodiversity and also play key roles in preserving the stability of ecological relationships in particular regions. At the same time, they belong to the fastest disappearing and most endangered ecosystems [3].

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However, ecologists have paid little attention to peatbogs compared to other aquatic ecosystems [4, 5]. In peatbogs, animal communities, especially invertebrates, are sufficiently known [6]. By contrast, little or no attention is given to the abundance and biomass of protozoans and metazoans and their relationships to environmental parameters in these specific ecosystems [7]. Quantifying the diversity and distribution of ciliates, rotifers, crustaceans, and macroinvertebrates in aquatic habitats is important to gain a better understanding of food webs in these systems. These organisms are important consumers of pico- and nano-sized producers, as well as important food sources for higher trophic levels [1, 8, 9]. Even less knowledge exists concerning the regulating mechanisms of ciliates, with respect to species composition and abundance of metazoan and macroinvertebrates. As revealed in the studies performed by Błędzki and Ellison [10], both rotifers and crustaceans may reach a relatively high abundance in peatbog ecosystems. Thus, they seem to play a significant role in controlling the number of protozoa. Both rotifers and copepods may also indirectly affect the occurrence of ciliates through eating up potential food resources for these microorganisms. In fresh water the most widely distributed are dipterans from the family of Chironomidae [11]. Due to their high densities, rapid growth, and high grazing rates, chironomid larvae have a great potential to regulate the abundance of lower trophic levels.

The detail aims of this study were to examine the community structure and distribution of ciliates, rotifers, crustaceans, and macroinvertebrates in three types of peatbogs, as well as to assess the influence of potential food resources (algae, Chl-a) and predators (rotifers, cladocerans, copepods and Chironomids) on protozoa communities.

Methods

Study Area

The study area comprised six peatbogs: highmoor peatbogs – Międzyrzeki and Tory 1 (HP), transitional peatbogs – Kosobody and Tittenbruna (TP), and lowmoor peatbogs – Tory 2 and Tory 3 (LP) located in Roztocze National Park (eastern Poland, 50°37.663'663 N, 23°03.147'E). The peatbogs represent various trophy and vegetation types [12]. In highmoor peatbogs the vegetation were dominated by *Sphagnum angustifolium* (C.C.O. Jensen ex Russow), *Sphagnum cuspidatum* Ehrh. ex Hoffm., *Sphagnum magellanicum* Bird., *Oxyccocus palustris* L., and *Eriophorum vaginatum* (L.). The transitional peatbogs were dominated by *Carex lasiocarpa* Ehrh., *Carex limosa* L., *Scheuchzeria palustris* L., *Calla palustris* L., *Eriophorum vaginatum* (L.), *Carex acutiformis* Ehrhart., *Carex gracilis* Curt., *Sphagnum angustifolium* (C.C.O. Jensen ex Russow), *Sphagnum cuspidatum* Ehrh. ex Hoffm., and *Polytrichum* sp. The lowmoor peatbogs were colonized by *Cladium mariscus* (L.), *Carex buxbaumii* Wahlenb., *Schoenus nigricans* L., *Carex acutiformis* Ehrhart., *Phragmites australis* (Car.), and *Utricularia* sp.

Field Sampling

Protozoa, Metazoa, and macroinvertebrate communities were examined in a transect including open peatbog and/or lagg. Collected data were presented from May to October 2012. During each sampling occasion three samples were collected from each site. At each of the sites, free water (water between mosses on the surface) was sampled by means of a plexiglass corer (length 1.0 m, Ø50 mm) to a depth of 1 m. The plexiglass corer was closed at each end with a cork and then water samples were collected using a glass pipette. The volume of water extracted from plexiglass corers ranged between 300-500 ml. The abundance of algae, ciliates, rotifers, cladocerans, and copepods and their community composition were determined using the Utermöhl's method. For rotifers and crustaceans 2 l samples were filtered through a plankton net of 10 µm mesh size. Protozoa samples (whole sample = 500 ml) were sedimented for 24h in cylinder, stoppered with parafilm, then the upper was gently removed. In order to determine the density, three samples were preserved with Lugol's solution. Ciliates are highly perishable, and their type of motility is a species-specific feature; for this reason, species determination and measurements were carried out on live material immediately after return to the laboratory and after silver impregnation. Samples of chironomid larvae were taken simultaneously with microbial communities. Larvae were collected using a perspex tube (length 1.0 m, Ø50 mm). The tubes were gently lower inside *Sphagnum* hollow and/or mud bottom hollow and the upper end of the tube were close with the bung. Next the tubes were risen vertically, the down bung were remove, and the water flowed through the sieve (mesh size 100 µm). Midge larvae collected with water remained on the sieve. All collected larvae were put into small plastic bottles and preserved in 4% formaldehyde solution. One sample consisted of three tube subsamples. In the investigated period water samples (volume of 500 ml) for chemical analyses were taken. Temperature, dissolved oxygen (DO), conductivity (EC), and pH were determined *in situ* with a multi-parametric probe (Hanna Instruments). Water samples were analyzed in the laboratory: total organic carbon (TOC), using the spectrophotometer PASTEL UV (Secomam, France), TSS using a gravimetric method after filtration through filters GF/C, total phosphorus (P_{tot}) and orthophosphates using a spectrophotometer UV-1610 Shimadzu (with molybdate method after mineralization with a mixture of HNO₃ and H₂SO₄), nitrate (with sodium salicylate method) [13, 14]. Chlorophyll a was determined spectrophotometrically after extraction with ethanol [15]. Water level (WL) was measured within a centimetre measure. Zero level was marked by the top part of the peat mosses.

Data Processing

The differences of physical and chemical water parameters among peatbogs were analyzed by means of one-way ANOVA. Tukey's multiple range test (at P< 0.05) was used to compare means when significant differences were found. The analysis was performed using PAST software.

Table 1. Physical and chemical characteristics of water in investigated peatbogs.

Parameters		Highmoor peatbogs		Transitional peatbogs		Lowmoor peatbogs	
		Międzyrzeki	Tory 1	Kosobudy	Tittenbruna	Tory 2	Tory 3
Water level	m	0.16	0.10	0.32	0.1	0.8	0.70
Temp.	°C	24.70	19.62	17.56	17.40	14.48	26.30
pH	pH	4.02	3.65	4.69	4.65	7.05	7.41
EC	$\mu\text{S}\cdot\text{cm}^{-1}$	24	35	29	36	203	268
DO	$\text{mgO}_2\cdot\text{dm}^{-3}$	3.73	4.35	3.10	3.67	4.79	8.04
N-NO ₃	$\text{mgN}\cdot\text{dm}^{-3}$	0.833	0.645	0.661	0.639	0.342	0.334
P-PO ₄	$\text{mgPO}_4\cdot\text{dm}^{-3}$	0.064	0.637	0.346	0.393	0.055	0.070
P _{tot}	$\text{mgP}\cdot\text{dm}^{-3}$	0.067	0.441	0.537	0.516	0.180	0.102
Chl- <i>a</i>	$\text{mg}\cdot\text{dm}^{-3}$	28.0	42.4	36.1	12.3	3.3	12.9
TSS	$\text{mg}\cdot\text{dm}^{-3}$	260.0	158.0	163.0	183.0	147.0	119.5
TOC	$\text{mgC}\cdot\text{dm}^{-3}$	36.0	29.8	23.8	27.5	19.8	17.0

Pearson's correlation coefficients were calculated in order to specify the interactions between components of food web. Detrended correspondence analysis (DCA), was used to measure and illustrate the variability gradients indicated by ciliates, rotifers, cladocerans, copepods, and macroinvertebrates. Because the length of the gradient was >2 standard deviations, CCA (canonical correspondence analysis) was used to explore the relationships between the abundance of taxonomic groups and environmental variables between different peatbog habitats and within different types of peatbogs [16, 17]. The ordination analyses were performed by means of CANOCO 4.5 for Windows.

Results

Abiotic Variables

The samples spanned a depth to water table gradient (measured with a tape gauge, and the zero level was defined as the top of the mosses) from 0.10 to 0.70 m. From all the studied peatbogs, the highest pH values were noted in lowmoor peatbogs (pH=7.05-7.41) and the lowest in highmoor peatbogs (pH=3.65-4.02). The chemical properties of water were significantly different between peatbogs (ANOVA, $F=21.07-30.27$, $P=0.011-0.030$). Conductivity reached the highest values in lowmoor peatbogs, and the remaining factors (TOC, TSS, P_{tot}, P-PO₄, N-NO₃) in highmoor and transitional peatbogs. The chemical characteristics of these peatbogs are summarized in Table 1.

Algae, Ciliates, Metazoa and Macroinvertebrate Communities – General Results

Algal communities were differentiated among studied peatbog habitats. Highmoor peatbogs were dominated by

periphytic and benthic diatoms (*Eunotia* sp.), euglenids (*Trachelomonas* sp., *Lepocinclis* sp., *Phacus* sp., *Euglena* sp.), and filamentous green algae (*Mugeotia* sp.). The highest abundances of nanoflagellates, euglenids (mainly *Euglena* sp.), and green flagellate (*Sphaerellopsis* sp.) were observed at transitional peatbogs. Algal communities in lowmoor peatbogs were represented mainly by filamentous cyanobacteria (*Anabena* sp., *Lyngbya* sp.).

The results of one-way ANOVA showed the significant influence of peatbog type on ciliate abundance ($F = 13.9$; $P < 0.001$). Mean abundance of ciliates varied from 12 cells·ml⁻¹ (HP) to 69 cells·ml⁻¹ (LP). At highmoor peatbogs, three ciliate species, *Paramecium bursaria*, *Cinetochilum margaritaceum*, and *Prorodon* sp. showed the highest abundances. On transitional peatbogs, *Colpidium colpoda*, *Paramecium bursaria*, and *Prorodon* sp. were dominant and on lowmoor peatbogs, the dominant group included *Paramecium bursaria* and *Strombidium viride*.

Rotifer abundances were similar at HP (24-48 ind.·dm⁻³) and TB (25-53 ind.·dm⁻³). Higher, but not significant, densities showed rotifers at lowmoor peatbogs (66-70 ind.·dm⁻³). At highmoor and transitional bogs, Bdelloidea, *Lecane* sp., and *Lepadella* sp. were the most abundant. At lowmoor peatbogs *Elosa* sp., *Lepadella* sp., and *Keratella* sp. dominated. The mean densities of *Cladocerans* were similar for highmoor and transitional peatbogs and varied between 58 and 109 ind.·dm⁻³. At lowmoor peatbogs abundances of cladocerans were lower at 14-36 ind.·dm⁻³. Studied peatbog habitats differ in domination structure of crustaceans; at HP, *Daphnia pulex*, *Chydorus sphaericus*, and *Scapholeberis mucronata* dominated; at TP habitats, *Alonella excisa*, *Chydorus ovalis*, and *Simocephalus vetulus* were the most abundant; at LP, *Daphnia pulex* and *Scapholeberis spinosus* became dominants. The abundances of Copepods ranged from 19 to 68 ind.·dm⁻³ and did not show a clear dependence on peatbog type. Two copepod species,

Table 2. Detrended Correspondence Analysis: inter-set correlations of environment variables with Axis 1 and 2 of DCA for studied peatbog habitats.

Variables	Correlations	
	Axis 1	Axis 2
Temperature	-0.1652	-0.0665
WL	0.0764	-0.3803
pH	0.3728	-0.2383
TSS	0.1599	0.3624
EC	0.4101	-0.2434
DO	0.3582	0.0733
Chl- <i>a</i>	0.0478	0.3379
N-NO ₃	0.1171	0.6071
P _{tot}	0.1627	0.2993
P-PO ₄	0.0019	0.1855
TOC	-0.0244	0.5209

Explanations as on Fig. 2.

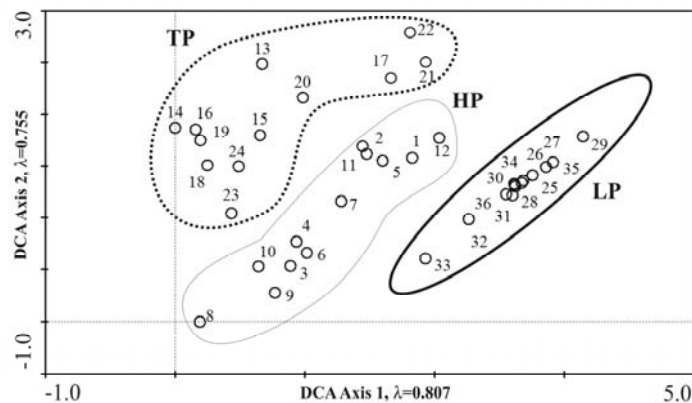
Cyclops strenuus and *Metacyclops planus*, dominated at HP. On TP, *Diacyclops languidus* and *Eucyclops serrulatus* were the most numerous. At LP, *Eucyclops serrulatus* and *Megacyclops viridis* showed the highest abundances.

Mean densities of chironomids were significantly affected by peatbog type (ANOVA, $F = 35.5$; $P = 0.014$) and reached the highest values at LP (mean 246 ind. \cdot m⁻²) and the lowest at HP (mean 57 ind. \cdot m⁻²). The domination structure of chironomid assemblages depended on peatbog habitat. At HP, *Corynoneura lobata*, *Psectrocladius dilatatus*, and *Chironomus* sp. were the most abundant; at TP, two chironomids, *Psectrocladius* sp. (gr. sordidelus) and *Einfeldia* sp., were dominant. At LP, *Phaenopsectra flavipes* and *Ablabesmyia phatta* showed the highest abundances.

Ordination Analysis – Environmental Gradient

The results of detrended canonical analysis showed the distinction of studied zoocenosis between three types of peatbogs. The DCA explained 65.6% of the cumulative variability in the study, the first axis accounted for 43.3%

A) Samples



B) Taxonomic groups

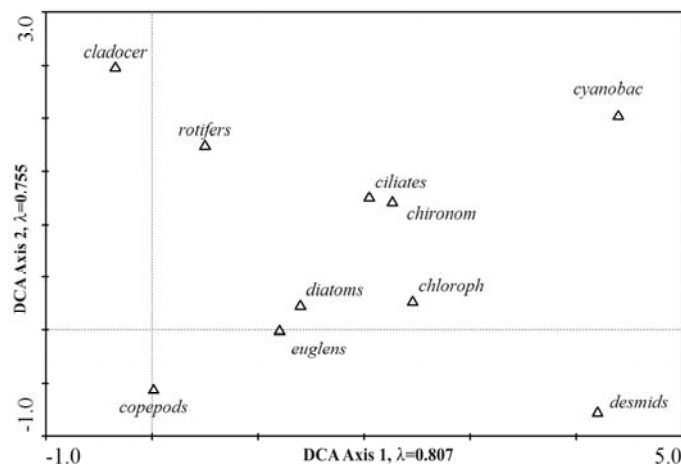


Fig. 1. Detrended correspondence analysis (DCA) plots for A) sampled peatbog habitats and B) studied zoocenosis. Samples collected in different peatbogs are marked with Arabic numerals: 1-12 – highmoor peatbogs (HP), 13-24 – transitional peatbogs (TP), 25-36 – lowmoor peatbogs (LP).

and the second axis 13.1%. The eigenvalue for Axis 1 amounted to 0.257 and for Axis 2 – 0.076. Axis 1 was the most strongly positively correlated with pH and DO; Axis 2 with N-NO₃ and TOC (Table 2). On the DCA plot samples collected on highmoor peatbogs (HP), transitional peatbogs (TP) and lowmoor peatbogs (LP) are visibly separated (Fig. 1A). Two taxonomic groups of algae (euglens and diatoms), as well ciliates and chironomids, appear to show higher abundances on HP; rotifers seem to prefer TP habitats, while the presence of cyanobacteria and chlorophytes are closely related to LP (Fig. 1B). Crustaceans (cladocerans and copepods) do not appear to show habitat preferences.

Canonical correspondence analysis (CCA) performed in order to specify the direct influence of environmental variables specific for a given peatbog habitat on the abundance of the studied taxonomic groups confirmed the distribution of studied zoocenosis between different peatbog habitats obtained in the DCA analysis (Fig. 2A). On the CCA biplot the distribution of chlorophytes, euglens, diatoms, desmids, and chironomids was significantly influ-

enced (results of Monte Carlo permutation test) by N-NO₃ ($\lambda = 0.10$; $F = 3.72$; $P = 0.016$), P_{tot} ($\lambda = 0.06$; $F = 2.52$; $P = 0.040$), and TSS ($\lambda = 0.08$; $F = 3.84$; $P = 0.006$). The presence of ciliates and cyanobacteria was significantly related to temperature ($\lambda = 0.07$; $F = 2.63$; $P = 0.034$), EC ($\lambda = 0.07$; $F = 2.52$; $P = 0.032$) and DO ($\lambda = 0.09$; $F = 2.94$; $P = 0.031$). Rotifers and crustaceans (cladocerans and copepods) did not show any significant relationship with environmental variables (Fig. 2B).

CCA analysis performed in order to recognize environmental parameters affected the abundance of taxonomic groups with regard to peatbog type showed that on HP all variables together explained 52.5% of total variance. However, the results of Monte Carlo permutation test showed the significant influence of three variables: WL ($\lambda = 0.27$; $F = 4.05$; $P = 0.014$), total suspension ($\lambda = 0.12$; $F = 2.05$; $P = 0.040$), and TOC ($\lambda = 0.28$; $F = 3.16$; $P = 0.004$). On the CCA biplot for taxonomic groups crustaceans are separated from algae, ciliates, rotifers, and chironomids (Fig. 3A). It may suggest important trophic relationships between algae and their potential consumers (ciliates,

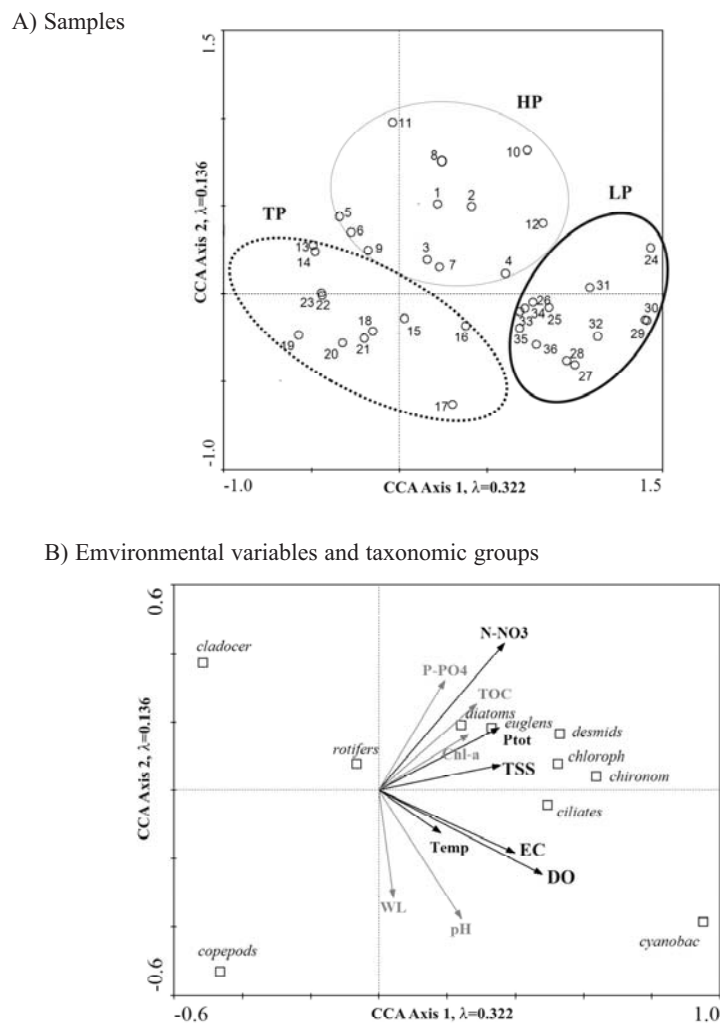


Fig. 2. Canonical correspondence analysis (CCA) biplots for A) sampled peatbog habitats and B) environmental variables and studied zoocenosis.

WL – water level, Temp-water temperature, TSS – total suspended solids, EC – electrical conductivity, DO – dissolved oxygen, Chl-*a* – chlorophyll-*a*, N-NO₃ – nitrate nitrogen, P_{tot} – total phosphorous, P-PO₄ – dissolved orthophosphates, TOC – total organic carbon, 1-12 – highmoor peatbogs (HP), 13-24 – transitional peatbogs (TP); 25-36 – lowmoor peatbogs (LP).

rotifers, and chironomids). The CCA for transitional bogs showed the significant influence of P_{tot} ($\lambda = 0.12$; $F = 2.57$; $P = 0.024$) and $P\text{-}PO_4$ ($\lambda = 0.26$; $F = 4.62$; $P = 0.004$) on the abundance and distribution of studied zoocenosis. Similarly to HP, on the TP diagram crustaceans are separated from ciliates, rotifers, chironomids, and algae (euglens, diatoms,

chlorophytes) (Fig. 3B). On LP, WL ($\lambda = 0.14$; $F = 3.09$; $P = 0.026$), and dissolved oxygen ($\lambda = 0.17$; $F = 3.59$; $P = 0.022$) were the significant variables affecting abundances of studied zoocenosis. On the CCA biplot ciliates, rotifers and chironomids are situated together with chlorophytes and cyanobacteria (Fig. 3C). Probably on LP these two groups of algae constitute the main food source for both micro and macroinvertebrates.

Relationships Among Food Web Components

Generally the biomass of algae was negatively correlated with the abundance of ciliates, rotifers, and chironomids ($r = -0.61$ to $r = -0.51$, $P \leq 0.01$). Additionally, the abundance of ciliates was negatively correlated with the abundance of macroinvertebrates and metazoans. However, the number of significant correlations between the main group of organisms forming the peatbog food webs differed between sites. In HP, abundance of ciliates correlated with the density of cladocerans and copepods (from $r = 0.66$ to $r = -0.71$, $P \leq 0.01$), and/or macroinvertebrates ($r = -0.46$, $P \leq 0.05$). The abundance of small metazoa correlated with the density of macroinvertebrates ($r = 0.48$, $P \leq 0.05$). In the TP and LP there was a significant and positive correlation between Metazoa density and ciliates ($r = 0.61$, $P \leq 0.01$). Macroinvertebrate density correlated positively with the abundance of copepods ($r = 0.63$, $P \leq 0.01$).

Discussion

Algae, Ciliates, Metazoa, and Macroinvertebrate Communities

So far, comparative data concerning distribution of algae, protozoa, small metazoan, and macroinvertebrates in the different type of peatbogs are very scarce. This study suggests significant relationships between the abundance and the type of habitat. In the HP, a significantly higher abundance of micro- and macroorganisms were recorded in comparison to the TP and LP. Analysis of investigated groups of organism data and environmental variables in all of the studied habitats revealed seasonal changes in species composition and environmental conditions. Microalgae represented a significant proportion of the total microbial biomass. The algae was dominated by Desmidiaceae, Euglenophyceae, and Bacillariophyceae. The higher biomass of cyanobacteria in fens with the lower N concentrations is in agreement with the competitiveness of these microorganisms for N under low N conditions [18]. The number of ciliates is comparable with other studies [19]. The differentiation between different types of peatbogs probably resulted from fertility of the habitat (contents of nutrients). Their concentrations indirectly are an occurrence of protozoa by affecting abundance of bacteria [19]. The highest contribution among ciliates was reached by species belonging to Colpodea, occurring in the highest numbers. The species was observed both in mosses in *Sphagnum* peatlands and in surface layers of soils [20]. The abundance of small

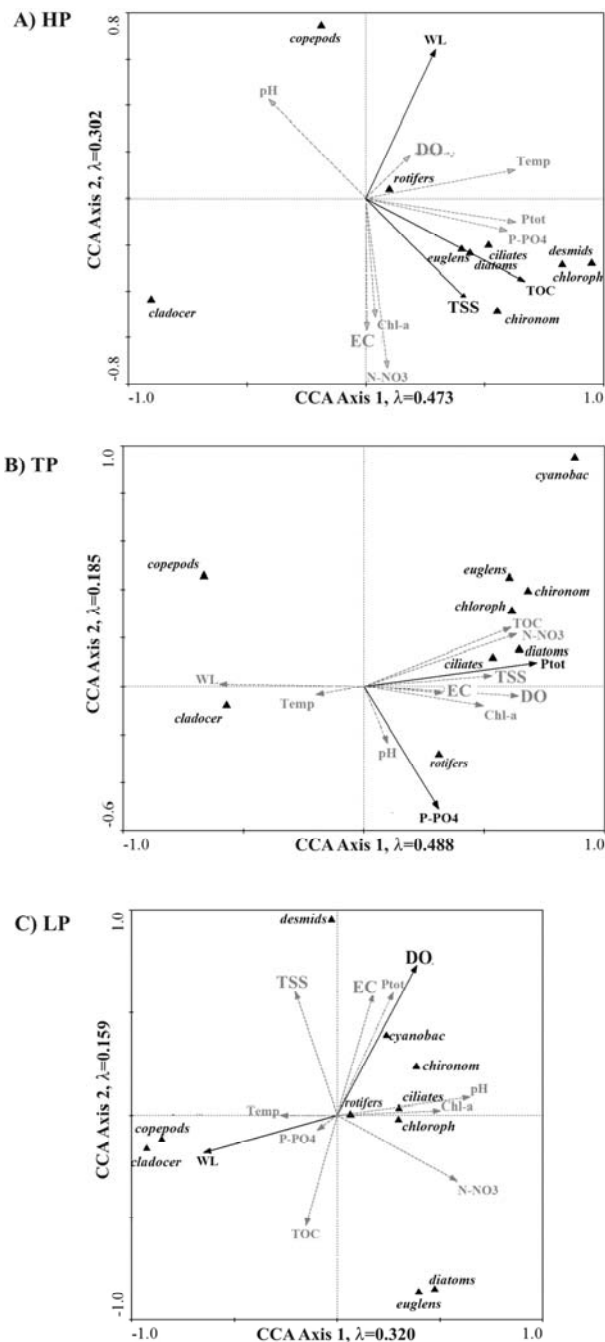


Fig. 3. Canonical correspondence analysis (CCA) biplots for environmental variables and studied zoocenosis in different peatbog habitats: A) highmoor peatbogs (HP), B) transitional peatbogs (TP), C) lowmoor peatbogs (LP).

WL – water level, Temp – water temperature, TSS – total suspended solids, EC – electric conductivity, DO – dissolved oxygen, Chl-a – chlorophyll-a, N-NO₃ – nitrate nitrogen, P_{tot} – total phosphorous, P-PO₄ dissolved orthophosphates, TOC – total organic carbon.

Metazoa (rotifers, cladocerans, and copepods) varied greatly from highmoor peatbogs to lowmoor peatbogs. The density of rotifers was higher in LP than in HP and TP. This is in agreement with a previous study and probably related to the differences in moisture content and pH between HP, TP, and LP [1, 2]. Among rotifers, in all the studied habitats, bdelloids were the most abundant. Most of the dominant species of rotifers were characterized by a broad range of pH tolerance. *Sphagnum* acidifies its habitat, so rotifer diversity is limited to the species that tolerate a low pH. Similar relationships were observed in different types of peatbogs in eastern Poland [1, 2, 21]. Such a high tolerance may be associated with their mode of reproduction, i.e. obligatory parthenogenesis, and – consequently – with its colonization strategy [22]. The species distribution of crustacean patterns also showed a higher variation in wet habitats, with Cladocera to Copepod assemblages from drier microhabitats. In addition, *Sphagnum* mosses, when they are sufficiently humid, can harbour copepods and, in the wettest parts of peatlands, Cladocera [23]. In this study, we detected a significant positive correlation between metazoa abundance and the concentration of phosphates and nitrates. A similar pattern also was observed in lakes [24], it seems that nutrients have an indirect influence on the abundance of protozoans and small metazoa, through the control of food abundance (mainly bacteria, fungi, or other protists). As it was reported by researchers, food availability has the primary influence on the grazer community [25]. The species diversity of macroinvertebrates was similar to that recorded in other regions of Europe [26]. Such a similarity is not surprising in view of the largely cosmopolitan character. Species diversity, however, showed clear differentiation between peatlands. Particularly low species diversity in rich fen probably results from low humidity of the microhabitat.

Relationships between Food Web Components

The analysis of trophic relationships in the system ciliates-rotifers-crustaceans-macroinvertebrates reveals a clear differentiation and strength of mutual relations between the peatbogs analyzed. The highest number of significant correlations were determined in the highmoor peatbogs, and the lowest number in the lowmoor peatbogs. The present study has revealed a remarkable relationship between the abundance of ciliates and rotifers. The decrease in the abundance of ciliates in spring coincided with the peak of rotifer abundance. Similar results were observed in peatbogs located in Poleski National Park [2]. In the present study, significant correlations were also determined between chlorophyll-*a* concentrations and ciliates. This suggests that organic substances excreted by algae constitute one of the main sources of carbon for bacteria (potential food for ciliates). Similar patterns were also observed in the lakes [27]. Irrespective of the type of peatbogs, ciliates correlated with cladocerans and copepods. This suggests that the microorganisms could constitute potential sources of food for a number of groups within the peatbog food web. According to a study conducted by

Wickham [28], ciliates are frequently consumed by crustaceans from the genus *Cyclops*, e.g. small *Scuticociliatida* or *Halteria* to the amount of 20-30 ciliates copepod⁻¹h⁻¹. Strong predation pressure of crustaceans on ciliates was particularly confirmed by observations in the summer season, when the numbers of protozoa clearly decreased along with an increase in the numbers of cladocerans and copepods. Crustaceans probably selectively consumed protozoan communities, which was also reflected in the predominance of small taxa of ciliates, particularly in the summer season. The present study suggests a strong impact of the crustacean copepods on the abundance and structure of the ciliates assemblage. The shift in metazoa composition between the seasons, from dominance of rotifers in spring to dominance of copepods in summer, was probably the decisive factor for the reduction in protozoa numbers. The present study confirms the general observations that protozoa and rotifers often co-occur in higher numbers in freshwater ecosystems. The fact that rotifers can serve as alternative food sources for copepods is another indirect positive effect on protozoa [29]. As has been reported by many researchers, food availability is a primary influence on the grazer community. The larvae of chironomids have been described as being able to grow on diverse food sources, including algae, ciliates, or metazoan [30]. In the present study the abundance of chironomids was negatively correlated with the biomass of algae and concentrations of chlorophyll-*a*. According to Danger et al. [31], macroinvertebrates are known to prey intensively on algae and can easily affect their biomass. In investigated peatbogs, the highest densities of chironomids were observed in summer when the biomass of algae was low. This observation may suggest high grazing pressure of midges on algae. The highest abundances of ciliate and metazoa were noted in autumn, when predation pressure was low, whereas their population was strongly reduced in summer at high abundance of epiphytic chironomids. A strong decline of ciliate populations in early summer was reported as a result of predation by chironomid larvae of the *Cricotopus sylvestris* group [25].

Conclusions

1. The distribution of protozoa, metazoa, and macroinvertebrate samples in ordination space led us to conclude that studied habitats are distributed along the falling gradient of water level and rising gradient of total organic carbon and nitrate nitrogen.
2. The composition and dynamics of the components of the peatbog food web were regulated both by bottom-up and top-down mechanisms.
3. Comparison of bog along trophic gradient revealed that grazing seems to be of major importance for the determination of abundance and biomass of protozoa populations. However, an decreasing decoupling between protozoa and metazoa was observed across the trophic gradient.

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