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STRUCTURES OF PROKARYOTIC AND EUKARYOTIC ALGAE FROM DRAINAGE DITCH IN OLIGOTROPHIC PEAT BOG COMPLEX (ROZTOCZE NATIONAL PARK)

Agnieszka Szczurowska

Department of General Ecology, University of Life Sciences in Lublin,
Akademicka str. 15, 20–950 Lublin, agnieszka.szczurowska@up.lublin.pl

Summary. There is a unique natural and landscape complex of oligotrophic peat-bogs in the southern part of Roztocze National Park. A major fragment of the area was degraded as a result of drainage system building in the 60's and 70's of the 20th century. At present, due to re-naturisation works, drainage ditches that cross the peat-bog do not play their melioration role any longer and they have become the habitat for many species. The qualitative and quantitative structure of pro- and eukaryotic algae in an overgrown drainage ditch was analysed on the background of physico-chemical conditions. The dystrophic character of water in the studied ditch affected the characteristic structure of algae communities. In total, 37 algae taxons from 7 taxonomic groups were determined. Chroococcal blue-green algae, flagellate algae with *Euglenophyta*, *Chrysophyceae*, and *Cryptophyta,* two diatom species, and filamentous blue-green alga – *Mougeotia* sp., were characteristic taxons. Biomass oscillated within quite a wide range, from 4.19 to 38.9 mg dm^{-3}. The highest biomass values were recorded in autumn and *Trachelomonas volvocina* dominated in that period.

Key words: algae, drainage ditch, dystrophy, Roztocze

INTRODUCTION

Wide swamp areas with well-formed tall and transitional peat-bogs could be found in southern part of Roztocze National Park during the interwar period. According to the forest statement from 1946 [after Kraczek and Tittenbrun 1995], the swamps occupied 154.25 ha. The melioration operations made in the 70's of the 20th century greatly accelerated the dehydration of peaty areas and their degradation. According to taxation descriptions from 1992 [after Kraczek and Tittenbrun 1995], only 3.21 ha of swamps remained, i.e. 2.1% of the area in 1946, including a major part nowadays protected in the peat-bog reserve

Międzyrzeki. This oligotrophic peat-bog complex is a natural valuable habitat and it plays an important role in shaping the water balance within the area [Bartoszewski and Lorens 1999].

Drainage ditches, after damming, may function as habitats for natural plant communities and contribute to the enhancement of biological diversity of a given area. Dystrophic waters are rare within the Roztocze National Park. The knowledge on the species diversity and rules governing that type of habitats is still insufficient.

The study aimed at learning the qualitative and quantitative structure of pro- and eukaryotic algae in a drainage ditch crossing the oligotrophic peat-bog complex, on the background of habitat conditions.

MATERIAL AND METHODS

An overgrowing drainage ditch of about 80 m width and maximum depth up to 50 cm was selected to the physiological studies. The ditch, with blurred edges of slopes, borders on a transitional peat-bog on one side, and swamp forest *Vaccinio uliginosi-Pinetum* on the other.

The algological works were carried out in 2003 and 2004. Live samples and partially conserved samples were collected from every stand for qualitative analyses. Taxonomic classification was made on the basis of the system set by van den Hoek *et al*. [1995].

Water samples of a specific volume were collected from the bulk of water for quantitative assays of algae. Organisms were counted in sedimentation chambers. Algae biomass was estimated by means of the volumetric method, by comparing the algae shapes to geometric shapes [Utermöhl 1958].

At the same time, general physicochemical analyses of water were performed in the field – temperature, electrolytic conductivity, and water acidity. Water chemical composition was determined once a season.

In order to determine the distribution of taxons and samples along environmental gradients, the direct arrangement method – Canonical Correspondence Analysis – CCA [ter Braak 1995, Lepš and Šmilauer 2003] was applied.

RESULTS

Characterisation of physicochemical parameters of the studied drainage ditch water is presented in Table 1.

Water from the studied habitat was characterised with brown colour, acidic reaction, low electric conductivity, and low nutrients concentrations.

Table 1. Physicochemical characteristics of drainage ditch water in 2003–2004

pH	average*	4.02
	median	4.04
	stan dev.	0.25
	min/max	3.7/4.63
Conduct, µS cm^{-1}	average	96.34
	median	98.7
	stan dev.	16.77
	min/max	67.8/123.7
Tot-N, mg N dm^{-3}	average	1.61
	median	1.73
	stan dev.	0.59
	min/max	0.86/2.35
$N\text{-}NO_3$, mg N dm^{-3}	average	0.15
	median	0.02
	stan dev.	0.24
	min/max	0.003/0.56
$N\text{-}NO_2$, mg N dm^{-3}	average	0
	median	0
	stan dev.	0
	min/max	0/0.002
$N\text{-}NH_4$, mg N dm^{-3}	average	0.54
	median	0.5
	stan dev.	0.23
	min/max	0.29/0.86
Tot-P, mg P dm^{-3}	average	0.02
	median	0.03
	stan dev.	0.01
	min/max	0.006/0.04
$P\text{-}PO_4$, mg PO_4 dm^{-3}	average	0.01
	median	0.01
	stan dev.	0
	min/max	0.012/0.016

*average value, median, standard deviation, minimum/maximum

Taxonomic structure of algae communities on particular study dates was similar (Fig. 1). In total, 37 prokaryotic and eukaryotic algae taxons from 7 systematic groups were recorded. The most numerous were algae of the groups: *Chlorophyta* – 10 taxons (27% of total taxons number), *Cyanoprokaryota* and *Bacillariophyceae* – 7 taxons each (19%). Among *Chrysophyceae* and *Euglenophyta*, 5 taxons each were present (13%), two taxons from *Xanthophycae*, and a single species from *Cryptophyta*. The taxonomic structure of algae communities on particular study dates was similar – *Chlorophyta* and *Cyanoprokaryota* were the most numerous; only in a spring sample the largest number of *Bacillariophyceae* species were recorded. Among 10 *Chlorophyta* taxons, only 2 desmids species were found: most frequent were *Mougeotia* sp. and *Chlamydomonas acidophila*, as well as *Staurastrum dispar* (Bréb.). Among *Cyanoprokaryota*, *Chroococcus turgidus* and *Pseudanabaena* sp. were most frequent, among *Euglenophyta*

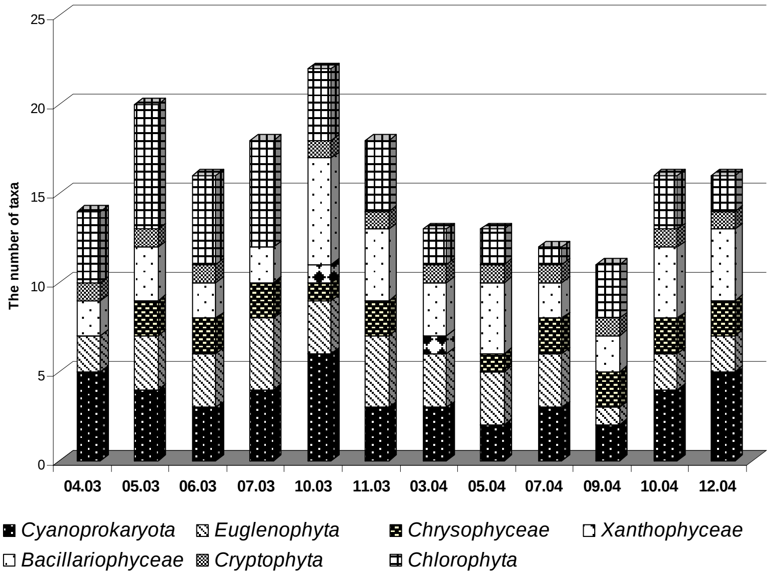

Fig. 1. The share of the specific groups of algae in the studied drainage ditch in 2003–2004

– *Euglena mutabilis* and T*rachelomonas volvocina*, among *Chrysophyceae* – *Mallomonas denticulata*, among diatoms – *Eunotia exigua* and *E. bilunaris* var. *bilunaris*, and among *Cryptophyceae* – *Cryptomonas czosnowskii*.

In 2003, algae biomass ranged from 9.07 in April to 30.69 mg dm^{-3} in November (Fig. 2). *Chlorophyta* made up to 52% in April, which was a significant percentage in spring. The taxon that dominated in that group of biomass was

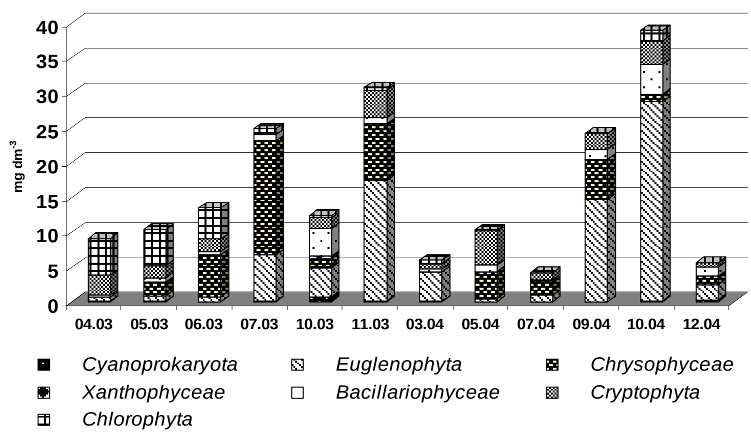

Fig. 2. Changes of algal biomass in the studied drainage ditch in 2003–2004

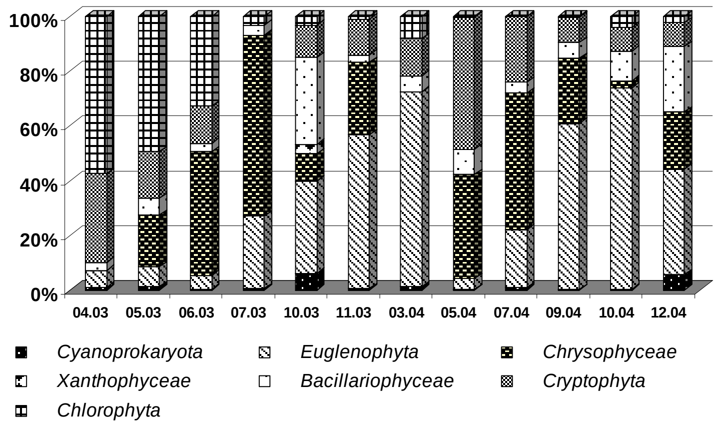

Fig. 3. The percentage participation of the specific groups of algae in the total biomass in the studied drainage ditch in 2003–2004

Mougeotia sp. Among other taxonomic groups, a considerable quantitative percentage was recorded for *Chrysophyceae* (mainly *Synura uvella*), namely in June and July, when they made up 45 and 66% of total biomass, respectively. In autumn, *Euglenophyta* dominated, making up 34% of biomass in October and 56% in November. The species of that group that occurred massively, namely in November, was *Trachelomonas volvocina.* In October, diatoms, with no domination of any species, made up quite a large percentage (Fig. 3).

In 2004, the lowest biomass weight was recorded in July (4.19 mg dm^{-3}) and, as in the previous year, the highest biomass weight (38.9 mg dm^{-3}) was observed in autumn – in October (Fig. 2). The second dominating group in that period was also *Euglenophyta*, when its percentage in September and October amounted to 61 and 73%, respectively. Such a large share in the biomass contribution resulted from massive appearance of *Trachelomonas volvocina.* Only in May, an apparent change of algae composing the biomass occurred (Fig. 3). The co-dominating groups were *Cryptophyta* (49%) and *Chrysophyceae* (38%). Such a high biomass was associated with numerous occurrence of *Cryptomonas czosnowskii* and *Mallomonas denticulata*.

The taxonomic diversity determines the contents of some biogens to some extent. N-NO_3, N-NO_2, and P-PO_4 were highly positively correlated with the second CCA axis, while N-NH_4 and Tot-N – negatively. Analysis of sample and taxon distribution revealed samples No. 3 and 6 (Fig. 4), which were the autumn ones, when the highest concentration of ammonia was recorded in water. Taxons arranged around these samples reached the highest biomass in that period, and the water acidity had relatively high values. Up the diagram, there is a sample from the spring of 2003, when the highest nitrogen concentrations (N-NO_3 and N-NO_2) were observed.

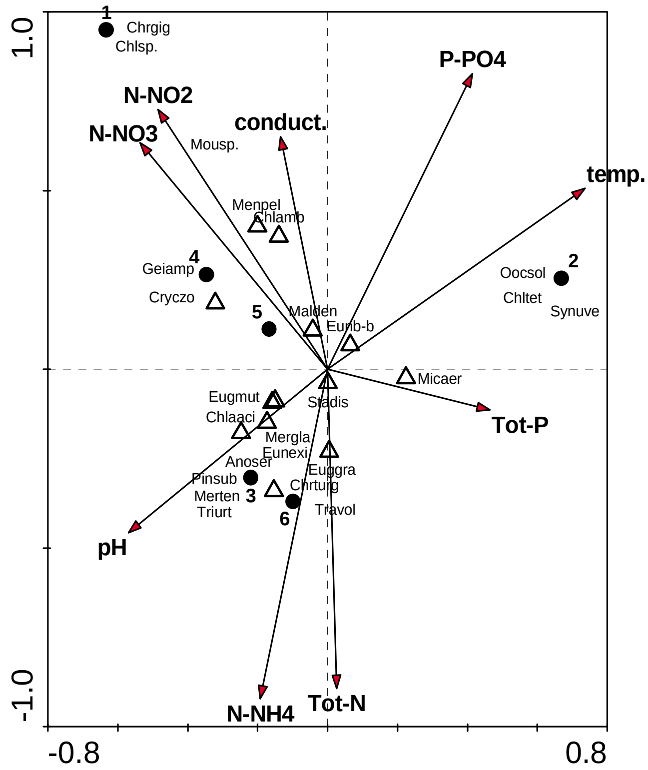

Fig. 4. Distribution of taxons and samples on a base of biomass along environmental gradients on the two first CCA axes: 1 – spring 2003, 2 – summer 2003, 3 – autumn 2003, 4 – spring 2004, 5 – summer 2004, 6 – autumn 2004, Anoser – *Anomeoneis serians*, Chlaci – *Chlamydomonas acidophila*, Chlamb – *Chlamydomonas ambigua*, Chlasp – *Chlamydomonas* sp, Chltet – *Chloropteridella tetragona*, Chrgig – *Chroococcus giganteus*, Chrtur – *Chroococcus turgidus*, Cryczo – *Cryptomonas czosnowskii*, Euggra – *Euglena gracilis*, Eugmut – *Euglena mutabilis*, Eunb-b – *Eunotia bilunaris* var. *bilunaris*, Eunexi – *Eunotia exigua*, Geiamp – *Geitlerinema amphibium*, Malden – *Mallomonas denticulata*, Merten – *Merismopedia tenuissima*, Mergla – *Merismopedia glauca*, Micaer – *Microcystis aeruginosa*, Mousp. – *Mougeotia* sp., Oocsol – *Oocystis solitaria*, Pinsub – *Pinnularia subcapitata*, Pseusp – *Pseudanabaena* sp., Stadis – *Staurastrum dispar*, Triurt – *Tribonema urticulosum*, Travol – *Trachelomonas volvocina*, Synuve – *Synura uvella*

DISCUSSION

The present functioning of the peat-bog complex located in the southern part of the Roztocze National Park results from different changes and transformations due to man. Re-naturisation operations consisting in damming of drainage ditches was the condition of proper functioning the other peat-bog fragments. Today the remains of the drainage system may be a habitat for new species entering the site by means of succession. They are – as in natural water reservoirs (small surface water spots, small ponds) located within oligotrophic peat-bogs – habitats with specific and extreme environmental conditions. Their dystrophic character is associated with acidic water reaction, low concentrations of biogenic substances, reduced light access, having an influence on the qualitative and quantitative structure of algae [Górniak 1996, Hillbricht-Ilkowska 1998, Hutorowicz 2001]. It is difficult to univocally state which of these habitat factors determines the algae flora and quantitative pattern within these communities, as the reaction of algae may be a resultant of many environmental features [Matuła 1995]. Nitrogen and phosphorus are factors that limit algae biomass [Reynolds 1984], however, determining their role in algae structure shaping is complex in the case of habitats with dystrophic character [Arvola *et al*. 1999]. The organic carbon compounds may affect the biogens availability in dystrophic waters [Górniak 1996]. Formed mineral-humus complexes reduce mainly the availability of phosphorus and iron. Such a situation can be met namely in stagnating water within tall and transitional peat-bogs, from which active humic acids binding the minerals penetrate to those reservoirs [Wojciechowski 2003].

The number of taxons (37) determined in the studied ditch is relatively low and comparable to that for dystrophic-character waters [Fiszer and Burhardt 1993, Luścińska and Soska 1998]. Probably selecting the habitat with stagnating water contributed to determining such low number of taxons. According to Luścińska and Soska [1998], peat-bog floating plants are characterised by relatively higher abundance of algae communities than habitats within peat-bogs with stagnating water. The reason can be the mosaic structure of the peat-bog floating plants layer. It was confirmed by algae qualitative survey results achieved from Międzyrzeki in 2002–2004, that took into account the micro-habitats of peat-bog floating plants layers [Szczurowska 2003, 2006].

Desmids are often reported as a dominating component of algae flora in dystrophic waters, which was not observed in the studied habitat. Green algae were the dominating group in the qualitative structure; a comparable number of taxons was determined for *Cyanoprokaryota* and *Bacillariophyceae*. Typical representatives, often recorded in samples, were blue-green algae – *Merismopedia glaca* and *Chrococcus turgidu,* diatoms – *Eunotia exigua* and *Eunotia bilunaris* var. *bilunaris,* as well as flagellates – *Trachelomonas volvocina, Mallomonas denticulata, Cryptomonas czosnowskii.* These taxons have great adaptation abilities: ability to mixotrophy makes it possible for them to use various energy sources, e.g. from organic matter [Reynolds 1980]. *Chlamidomonas acidophil* and *Mogeotia* sp. were characteristic representatives of green algae.

The studied ditch should be counted among astatic habitats dependent on weather conditions and exposed to periodical droughts. Changing environmental conditions force quick changes within algae communities. Short-term increase of algae populations occurred, which is characteristic for temporal reservoirs [Kawecka and Eloranta 1994]. Also the uniqueness of total biomass or within particular systematic groups in particular study seasons may prove the great dynamics of the habitat in question. The highest total biomass weight was recorded in July 2003, with dominating species *Synura uvella*, as well as in autumn 2003 and 2004, when high biomass was produced by *Trachelomonas volvocina,* and when the highest ammonia concentration was recorded in the water.

CONCLUSIONS

1. Number of recorded taxons (37) in studied drainage ditch is comparable to that reported for waters with dystrophic character, but lower than taxons number earlier recorded in peat-bog floating plants layer.
2. Transformed drainage ditches, when they do not play their dehydration roles any longer, may be the habitats for entering species due to succession.
3. Considerable differences in algae quantitative changes with no apparent pattern indicate these habitats instability.
4. The species that reached the highest biomass was *Trachelomonas volvocina* (*Euglenophyta*), that dominated in autumn samples, when the highest concentration of ammonium nitrogen in water was recorded as well.

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STRUKTURA ZBIOROWISK GLONÓW PRO- I EUKARIOTYCZNYCH ROWU MELIORACYJNEGO W KOMPLEKSIE TORFOWISK OLIGOTROFICZNYCH (ROZTOCZAŃSKI PARK NARODOWY)

Streszczenie. W południowej części Roztoczańskiego Parku Narodowego znajduje się unikatowy pod względem przyrodniczym i krajobrazowym kompleks torfowisk oligotroficznych. Znaczna część tego obszaru uległa degradacji w wyniku przeprowadzonych w latach sześćdziesiątych i siedemdziesiątych melioracji odwadniających. Obecnie w wyniku prac renaturalizacyjnych rowy melioracyjne przecinające torfowisko nie pełnią już właściwych funkcji odwadniających i stały się siedliskiem dla wielu gatunków. Analizowano strukturę jakościową i ilościową glonów pro- i eukariotycznych, zarastającego rowu melioracyjnego na tle warunków fizyczno-chemicznych. Dystroficzny charakter wody badanego rowu miał wpływ na wykształcenie charakterystycznej struktury zbiorowisk glonów. Oznaczono łącznie 37 taksonów glonów, z 7 grup taksonomicznych. Taksonami charakterystycznymi były chrookokalne sinice, wiciowce z *Euglenophyta*, *Chrysophyceae* i *Cryptophyta,* dwa gatunki okrzemek oraz nitkowata zielenica *Mougeotia* sp. Biomasa wahała się w dość szerokim zakresie od 4,19 do 38,9 mg $\cdot$ dm^{-3}. Najwyższe wartości biomasy notowano jesienią, a gatunkiem dominującym w tych okresach był *Trachelomonas volvocina.*

Słowa kluczowe: glony, rów melioracyjny, dystrofia, Roztocze