

COMPOSITION OF SELECTED PHYTO- AND ZOOCENOZIS IN SMALL, ASTATIC WATER BODIES

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Summary. Studies on the quantitative and taxonomic structure of phytoplankton and invertebrate macrofauna were carried out in 2010–2011 in a complex of four small water bodies. Due to the rainfall drainage of forest catchment the water was brown in colour and characterized by low acidity and conductivity. Phytoplankton was represented mainly by representatives of flagellates, and the most common were euglenophytes, chrysophytes and chlorophytes from the genus *Volvocales*. Among them the dominant species were *Trachelomonas volvocinopsis* and *T. oblonga*, *Synura uvella* and *Dinobryon sociale*, *Eudorina elegans* and *Pandorina morum*, respectively. In some cases they achieved the 70–80% dominance of total phytoplankton numbers. Dominant taxa of macrofauna were represented by pioneer organisms belonging to Heteroptera, Culicidae and Anisoptera groups and they were: *Callicorixa praeusta* and *Hesperocorixa sahlbergi*. The density of macrofauna was low and ranged from 10 to 34 ind. · m⁻². Taking into account an invertebrate macrofauna no differentiation in taxonomic and quantitative structure between the water bodies were noted. Nevertheless, the examined water bodies provide an interesting object to analyze natural colonization processes of small water bodies due to their isolation and protection by surrounding forest.

Key words: astatic water bodies, phytoplankton, flagellates, invertebrate macrofauna

INTRODUCTION

Small water bodies can be an excellent site for the development of algal flora that is characterized by its great diversity. In such water bodies phytoplankton may be represented by species from almost all taxonomic groups [Kuczyńska-Kippen 2009]. Mostly, phycoflora of such reservoirs consists mainly eurytopic species which find there appropriate conditions for development [Bucka and Wilk-Woźniak 2002]. Waters brown in colour are mostly settled by representatives of species being adapted to functioning in low light availability conditions. First of all, these are mixotrophic organisms that prefer reservoirs rich in particulate or/and dissolved organic matter [Jones 2000]. At the same time for colonizing the water bodies invertebrate macrofauna is important stage of succession, resulting in development of habitat and trophic. Particularly important aspect is the colonization of the degree of isolation between hydrogenic habitats. Invertebrate macrofauna constitutes the upper floors of the trophic pyramid in emerging reservoirs. Due to large dispersion possibilities macrofauna colonization reservoirs is really fast.

The aim of the study was to determine the taxonomic and quantitative structure of algae as well as an invertebrate macrofauna within four shallow, forest water bodies. We had also aimed to investigate the following stages of natural succession of phyto-and zoocenosis in these water bodies.

STUDY AREA, MATERIAL AND METHODS

The study area encompassed four small (20–30 m²) and shallow (up to 0.7 m) post-excavation reservoirs situated in the river Bystrzyca valley, in Nowiny village near Lublin (N51°8'57", E22°29'15"). The water bodies are isolated from the river Bystrzyca by a dense forest complex and are, therefore, mainly supplied by rainwater. During abundant rainfalls, the water bodies merge into one, but in the summer, when evapotranspiration processes are intensified, the reservoirs are separated from one another forming two large and two small pools. The water in the reservoirs is brown in colour, has an acid reaction and shows low conductivity (Tab. 1) due to a high content of humic substances coming from forest catchment drainage, the surrounding sandy soil and rainfall water. The dystrophic character and low trophic status of the water in the pools, as manifested by the low content of nutrients (Tab. 1), may be one of the causes of the absence of vascular plants in the studied water bodies. The vegetation is only represented by mosses from the genera *Polytrichum* and *Sphagnum*.

The studies on the structure of phytoplankton and invertebrate macrofauna in astatic water bodies were carried out in 2010–2011 (May, July, August and October). In order to determine physical and chemical conditions of habitats where mentioned assemblages occurred, the following measurements were conducted in the field: temperature, electrolytic conductivity, pH and oxygen con-

Table 1. Basic physicochemical properties of water of studied water bodies

Properties of water (ranges of values)	
Temperature, °C	6.5–18.2
Conductivity, $\mu\text{S} \cdot \text{cm}^{-1}$	41.0–77.0
pH	3.5–6.7
O ₂ , $\text{mg} \cdot \text{dm}^{-3}$	3.1–10.7
TOC, $\text{mg C} \cdot \text{dm}^{-3}$	5.4–15.6
TP, $\text{mg} \cdot \text{dm}^{-3}$	0.027–0.195
P-PO ₄ , $\text{mg} \cdot \text{dm}^{-3}$	0.009–0.022
N-NO ₃ , $\text{mg} \cdot \text{dm}^{-3}$	0.012–0.509
N-NH ₄ , $\text{mg} \cdot \text{dm}^{-3}$	0.521–1.810

centration. These measurements were done by using the multiparametric YSI probe. Analyses of biogenic concentrations were done in the laboratory [Hermanowicz *et al.* 1999]. The determination of total organic carbon (TOC) was measured by spectrophotometer Pastel UV. Samples for quantitative analysis of phytoplankton were taken from the central part of each water body, from the depth of about 0.2 m. Then samples were preserved with Lugol's solution. Phytoplankton was analyzed according to the Utermöhl technique using an inverted microscope [Utermöhl 1958]. Single cells, whole colonies as well as filaments were counted as one algal unit. Samples for qualitative studies were taken by use a planktonic net (mesh size 10 μm) and the analyses were done only on fresh material. Invertebrate macrofauna samples were taken in four iterations from the depth of 0.2 m. The area of sample 0.25 m^2 . The samples were taken using metal frame and hand net. Samples were preserved immediately with alcohol 80%. Morphological identifications of the invertebrates macrofauna were mainly based on works by Macan [1976], Jacewski and Wróblewski [1975], Kołodziejczyk and Koperski [2000].

RESULTS

Phytoplankton assemblage composition

Phytoplankton of studied water bodies was represented by a total of 43 taxa belonging to six algal groups: Cyanoprokaryota, Euglenophyta, Dinophyceae, Chrysophyceae, Bacillariophyceae and Chlorophyta. Taking into consideration the whole period of studies (2010 and 2011) the structure of phytoplankton of each water body, both quantitative and qualitative were similar (Fig. 1). The common feature of phytoplankton assemblage was clear share, or even dominance reaching about 70% of flagellates (e.g. in case of water bodies 1 and 2 in 2010) (Fig. 1). However, taking into account the composition and the abundance of algae in the following months of the research the structure was diversified. In the spring 2010 euglenophytes dominated the phytoplankton structure in water body no. 1. Their most abundant species were representatives of the genus *Trachelomonas* with the greatest percentage of *T. volvocinopsis* Svirenko. This species reached signifi-

cant abundance in the whole period of studies ($1.2\text{--}3.2 \cdot 10^6 \text{ dm}^{-3}$), similarly as *T. oblonga* Lemmermann which was characterized by a slightly lower abundance ($0.6\text{--}1.7 \cdot 10^6 \text{ dm}^{-3}$). In the summer (July and August) a total rebuilding of the phytoplankton structure was observed. Green algae from the order Volvocales: *Eudorina elegans* Ehrenberg and *Pandorina morum* (O.F. Müller) Bory de Saint-Vincent replaced then euglenophytes. During autumn *Dinobryon sociale* (Ehrenberg) Ehrenberg belonging to the class Chrysophyceae occurred in the most abundance in this water body. In 2010 phytoplankton of water body no. 2 was totally dominated by colonial chrysophyte *Synura uvella* Ehrenberg and its abundance expressed by the numbers reached from 2.3 to $3.8 \cdot 10^6 \text{ dm}^{-3}$. The abundance of this flagellate upheld on the high level in all months, while in remaining water bodies rebuilding, even complete of the phytoplankton assemblage structure was observed month after month. In this water body accompanying taxa were small green algae, e.g. *Monoraphidium contortum* (Thuret) Komárková-Legnerová, *Tetraedron minimum* (Brown) Hansgirg and single filaments of cyanophyte *Anabaena* sp. as well as single cells of dinoflagellate *Peridinium voltzii* Lemmermann. In the largest water body no. 3, which had slightly coloured waters (light yellow) phytoplankton was more diverse. Nevertheless, in the following month the dominance of particular taxa was observed. Thus, in the spring phytoplankton was dominated by chrysophyte *Dinobryon sertularia* Ehrenberg ($1.3 \cdot 10^6 \text{ dm}^{-3}$), in the summer (July and August) by green alga *Eudorina elegans* ($2.2 \cdot 10^6 \text{ dm}^{-3}$) and in the autumn (October) the dominance of diatom *Aulacoseira granulata* (Ehrenberg) Simonsen ($1.1 \cdot 10^6 \text{ dm}^{-3}$) was occurred. Water body no. 4 was

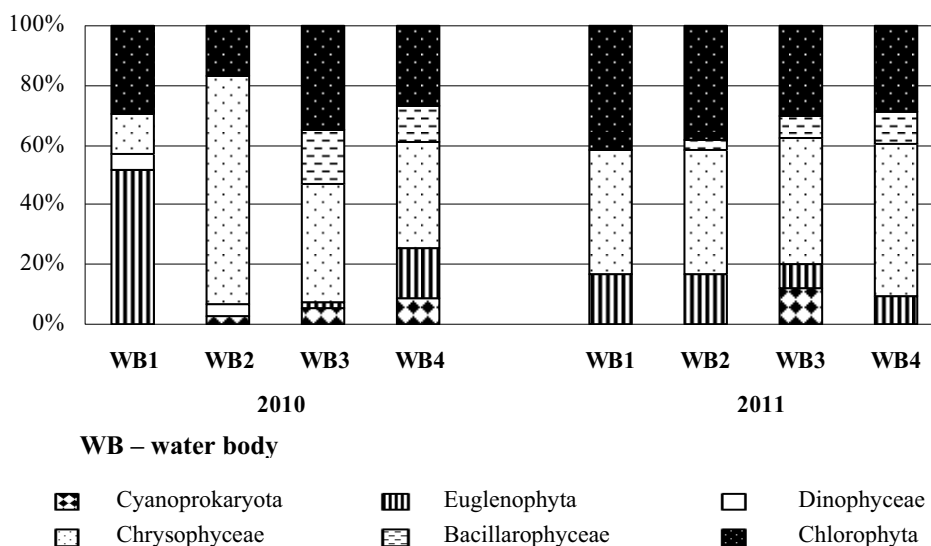


Fig. 1. Percentage in density of phytoplankton groups of water bodies examined (seasonal average of values in 2010 and 2011)

Table 2. Species with the greatest percentage share in phytoplankton in studied water bodies (WB)

Year	WB 1	WB 2	WB 3	WB 4
2010	<i>Trachelomonas volvocinopsis</i> , <i>T. oblonga</i> <i>Dinobryon sociale</i> <i>Eudorina elegans</i> , <i>Pandorina morum</i>	<i>Synura uvella</i>	<i>Dinobryon sertularia</i> , <i>Aulacoseira granulata</i> , <i>Eudorina elegans</i>	<i>Dinobryon sertularia</i> , <i>Eudorina elegans</i> , <i>Pandorina morum</i>
2011	<i>Synura uvella</i> , <i>Dinobryon sertularia</i>			
	<i>Lepocinclis tripteris</i> , <i>Phacus longicauda</i> <i>Pediastrum tetras</i>	<i>Euglena hemichromata</i> , <i>Lepocinclis tripteris</i>	<i>Coelastrum reticulatum</i> , <i>Closterium monilatum</i> , <i>Cl. pronum</i> , <i>Cl. limneticum</i>	<i>Euglena hemichromata</i> , <i>Coelastrum reticulatum</i> , <i>Tetrastrum triangulare</i>

characterized by very similar density of phytoplankton, to that in water body no. 3. In this water body the most numerous were chrysophytes and greens (Fig. 1, Tab. 2).

In 2011, due to abundance of spring rainfalls, water bodies were periodically connected together. This phenomenon was reflected in the phytoplankton structure, which was more unified and predominated by two taxa of chrysophytes – *Synura uvella* and *Dinobryon sertularia* (Tab. 2). They usually constituted over 40% in the total numbers of phytoplankton (Fig. 1). During summer months their dominance was weakened by green algae reaching even 30–40% (Fig. 1). Greens were represented by species of the order Chlorococcales: *Coelastrum reticulatum* Dangeard, *Pediastrum tetras* Ehrenberg, *Tetrastrum triangulare* Chodat and additionally of the order Desmidiaceae: *Closterium moniliferum* Ehrenberg ex Ralfs, *Cl. pronum* Brebisson, *Cl. limneticum* Lemmermann. In 2011 significant share (10–18%) was achieved by euglenoids, but they were represented mainly by *Lepocinclis tripteris* (Dujardin) Marin&Melkonian, *Phacus longicauda* (Ehrenberg) Dujardin and *Euglena hemichromata* Skuja (Tab. 2), not by the genus *Trachelomonas*, as it was observed a year before.

Invertebrates macrofauna composition

In the two years of the study a total of 12 taxa of invertebrate macrofauna were collected in the investigated area. The largest number of taxa (9) were found in July 2011 and July 2010 (8). Slightly fewer species occurred in May 2010 and 2011 (7). The fewest taxa were observed in August and October 2010 (4) (Tab. 3). The highest densities of invertebrate macrofauna of 34 ind. · m⁻² and 30 ind. · m⁻² were recorded in July 2010 and in 2011, respectively. The most numerous taxonomic group were water bugs, and their average density was 23 ind. · m⁻² in 2010 (Tab. 3). In both years of the study, there was a very clear

seasonal increase in the number of taxa beginning in the spring and early summer. Then followed breakdown the numbers and at the same time decrease the number of taxa.

The structure of dominance relationships throughout the study period was constant with a clear predominance of Culicidae. At the same time, in spring and summer months, Heteroptera, particularly *Callicorixa praeusta* and *Hesperocorixa sahlbergi*, and also periodically *Notonecta glauca* and two taxa of Gerridae had a considerable share in the structure of the species. In the spring months of 2010,

Table 3. Density of zoopluston (ind. · m⁻²) in investigated water bodies (mean values for studied period n = 32)

Taxa	2010				2011			
	V	VII	VIII	X	V	VII	VIII	X
<i>Notonecta glauca</i> L.	4	2			3	5		
<i>Hesperocorixa sahlbergi</i> (Fieb.)		8		1	1	2		5
<i>Callicorixa praeusta</i> (Fieb.)		8		3		4	14	
<i>Gerris lacustris</i> (L.)		3	4		2		2	
<i>Gerris argentatus</i> Schumm.		2	2		1	2		
Chironomidae indet.	2		4		1	2	1	
Anisoptera indet.		1				5	4	5
Zygoptera indet.	6	3				1		
Coleoptera dytiscidae indet.	2			1			2	4
Coleoptera hydrophilidae indet.	2					1		1
Tabanidae indet.	2				1			
Culicidae indet.	3	7	3	5	15	8	5	4
Total density	21	34	13	10	24	30	28	19
Total number of taxa	7	8	4	4	7	9	6	5

a clearly marked dominance of Anisoptera larvae was observed. Other taxa were not an important part of the structure of the invertebrate macrofauna of the studied water bodies (Tab. 3).

DISCUSSION

Phytoplankton development is dependent on many environmental factors. A phenomenon of a great diversity of algae in the environment is under the influence of many limiting factors and it has been expressed as Hutchinson's paradox [1961]. According to Connell's theory [1978] disturbances with intermediate frequency and intensity in the environment affect on functioning of phytoplankton assemblage in its equilibrium stage. Disturbances with high/low intensity or frequency lead to lowering of organisms' diversity being a result of decrease a number of niches. These factors that cause disturbances in the environment may be both physicochemical (availability of nutrients, organic matter or water colour) and biological (zooplankton grazing) ones. Waters of studied water bodies were characterized by low amount of easily digestible orthophos-

phates, not exceeding $0.022 \text{ mg} \cdot \text{dm}^{-3}$ and availability of organic matter expressed as total organic carbon (up to $15.6 \text{ mg C} \cdot \text{dm}^{-3}$). In such conditions algae community was dominated by mixotrophic flagellates belonging to Chrysophyceae and Euglenophyta groups. They are often noted in ecosystems with low pH values [Krasznai *et al.* 2010], and such situation was observed in water bodies during studies. Representatives of these groups use osmotrophy or phagotrophy as an additional opportunity to acquire carbon – in the form of DOC (dissolved organic carbon) or POC (particulate organic carbon), that is an alternative to photosynthesis [Jones 2000]. This ability allows them on effective competition with other species of planktonic algae. Rich development of the species of these groups was observed in other forest water bodies in Poland [Kuczyńska-Kippen 2009, Wojciechowska and Solis 2009] and Europe [Trigal *et al.* 2011] and in the oxbow lakes that were characterized by similar habitat conditions, as well [Paształeniec and Poniewozik 2013]. The amount of ammonia nitrogen was on a high level, that promoted the development of euglenoids and other flagellates [Kõiv and Kangro 2005]. On the other hand, species such as *Eudorina elegans* and *Pandorina morum* are known as characteristic for eutrophy [Reynolds 2006], but in the studies performed they occurred in conditions, that seems to deny their habitat preferences. It may indicate either a very wide plasticity of these species with respect to habitat conditions or periodic supply of nutrients and mineral compounds and their rapid utilization by these organisms. In the analyzed community no cryptophytes were present within two years of research. It is interesting phenomenon, because representatives of this group very often initiate start of the freshwaters succession at the beginning of the growing season, tend to be numerous in the end of vegetation period and can maintain throughout the whole season in brown-coloured waters accompanying representatives of other planktonic species [Findlay *et al.* 2005].

The macrofauna found in the investigated water bodies was characteristic of periodic and ephemeral water bodies. Taxa occurring in these habitats either have a high dispersion and migration ability or a short life cycle. Examples of such species are water bugs, which were one of the dominant taxa in the study area. They can effectively move between habitats [Tolonen *et al.* 2001, Tolonen *et al.* 2003, Płaska 2007, 2012].

The periodic merging of the studied water bodies as well as their close proximity and very similar habitat conditions led to a lack of taxonomic diversity of invertebrate macrofauna in the whole complex. The species composition, consisting mainly of pioneer species, was probably a consequence of the separation by the forest from potential sources of dispersion found in the valley of the river Bystrzyca 1.5 km away from the investigated complex of water bodies.

The very low numbers and poor composition of invertebrate macrofauna species could also be due to the low trophy of water bodies. Another factor reducing the attractiveness of the habitat was poor aquatic vegetation and lack of rushes, which are an important part of the spatial structure of habitats in small bodies of water [Biesiadka and Moroz 1996, Kurzątkowska 1999, Płaska 2012].

The lack of vegetation and submerged vegetation shows that the water bodies are in early stages of succession and have a low trophy. The water bodies are

an example of the limiting effect of a low trophic and the scarcity of rushes on the colonization of a habitat by invertebrate macrofauna. The early stage of succession is also confirmed by the structure of domination. In particular, the dominance of Culicidae proves the important role of pioneer species and short-life-cycle species. The high percentage of Culicidae points to the lack of larger predators, which prefer a more stable habitat [Płaska 2010].

CONCLUSIONS

1. The phytoplankton assemblage was diversified between water bodies in 2010 and rather unified in the following year because of occurring a connection between them (as a result of rainfalls).

2. Flagellates dominated the structure of phytoplankton; their abundance was high during the whole period of the research.

3. Chrysophyte *Synura uvella* and euglenophyte *Trachelomonas volvocinopsis* reached the highest abundances.

4. The investigated water bodies were characterized by qualitative and quantitative poorness of invertebrate macrofauna caused by the low trophic and poorly developed spatial structure of the habitat.

5. In the structure of dominance, a clear dominance of pioneering taxa such as Culicidae and Heteroptera was observed during the study period.

6. In both years of the study, there was a very clear seasonal increase in the number of taxa starting from spring and early summer. This was probably associated with the development cycle of the dominant taxa of invertebrate macrofauna.

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STRUKTURA WYBRANYCH FITO- I ZOOCENOZ DROBNYCH, ASTATYCZNYCH ZBIORNIKÓW WODNYCH

Streszczenie. Badania nad strukturą ilościową i jakościową fitoplanktonu oraz makrofauny bezkręgowej przeprowadzono w latach 2010–2011 w niewielkim kompleksie czterech drobnych zbiorników wodnych. Z uwagi na leśną zlewnię i zasilanie opadami woda zbiorników miała brunatne zabarwienie, kwaśny odczyn i niskie przewodnictwo elektrolityczne. Fitoplankton reprezentowany był głównie przez przedstawicieli glonów wiciowcowych, a najczęściej występowały eugleniny, złotowiciowce i zielenice z rzędu Volvocales. Wśród nich gatunkami dominującymi były odpowiednio *Trachelomonas volvocinopsis* i *T. oblonga*, *Synura uvella* i *Dinobryon sociale*

oraz *Eudorina elegans* i *Pandorina morum*. Osiągały one niekiedy dominację na poziomie 70–80% w całkowitej liczebności fitoplanktonu. W obrębie makrofauny dominującą grupę stanowiły taksony pionierskie i drobnozbiornikowe: Heteroptera, Culicidae i Anizoptera. Gatunkami dominującymi były *Callicorixa praeusta* i *Hesperocorixa sahlbergi*. Zagęszczenie makrofauny było małe i wynosiło 10–34 os. · m². W przypadku makrofauny bezkręgowej oraz właściwości fizycznych i chemicznych wody brak było zróżnicowania pomiędzy zbiornikami. Badane zbiorniki wodne ze względu na charakter zlewni i odizolowanie od otaczających terenów kompleksem leśnym stanowią interesujący obiekt analizy kolonizacji drobnych zbiorników wodnych.

Słowa kluczowe: astatyczne zbiorniki wodne, fitoplankton, wiciowce, makrofauna bezkręgowca