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CHARACTERISTICS OF AN EPIPHYTIC ASSEMBLAGE (PERIPHYTON) INHABITING REED, *PHRAGMITES AUSTRALIS* (CAV.) TRIN. ex STEUD. IN BUKOWO LAKE

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Abstract

Bukowo Lagoon (known locally as a lake) is one of 9 coastal lakes (or lagoons) situated on the Polish coast of the Baltic Sea. In the frames of an extensive ecological research project carried out in this body of water, among many different topics, an epiphytic assemblage inhabiting reed, *Phragmites australis* was studied in a three-year period. This plant substrate featured abundantly developing algae, dominated by Bacillariophyta ($\overline{x}$ = 49 395 cells m^{-2}). The density of Chlorophyta was lower and it amounted to 31 082 cells m^{-2}, on average Cyanophyta occurred sporadically, reaching density of 9 682 cells m^{-2}. Epiphytic microfauna was represented on this substrate by Protozoa, Nematoda, Rotatoria, and Oligochaeta. The dominant group were Protozoa. Three taxa were identified in macrofauna and the dominant species was *Cordylophora caspio*. Qualitative-quantitative studies of the periphyton indicate that this formation plays a visible ecological role in Bukowo Lake, contributing to enhancement of biodiversity, purification and de-eutrophication of lacustrine waters, providing a food base for other animals, in this number also economically important fish.

Key words: periphyton, coastal lake, coastland

INTRODUCTION

Epiphytic organisms (periphyton) inhabiting various substrates submerged in the water are poorly known in Polish bodies of water and estuaries. A limited number of scientific works dealing with qualitative-quantitative aspects of this ecological formation in the estuaries of the Odra River and coastal lake Kopań have been hitherto published (Piesik 1992, Piesik and Obolewski 2001). Studies on fouling organisms in Polish estuaries were carried out in the Odra River estuary (Odra River, Świna Strait, Szczecin Lagoon, Pomeranian Bay, and Puck Bay (Chojnacki 1997; Piesik 1978, 1983, 1992). Numerous publications describe periphyton, while quantitative studies are focused mainly on epiphytic macrofauna (Ravano and Relini 1970; Relini et al. 1976).

Detailed studies on fouling microorganisms (algae, fauna) on a biotic substrate provided by reed, *Phragmites australis* were carried out in a coastal lake Kopań and in the Odra River estuary (Piesik and Obolewski 2001; Piesik and Wawrzyniak-Wydrowska - unpublished). A fouling formation with sufficient substrate area in the water can play a significant role, especially in degraded aquatic ecosystems such as polluted and degraded Bukowo Lake.

The aim of this study was a qualitative-quantitative characteristics of periphyton inhabiting *Phragmites* in Bukowo Lake, as well as determination of the food base provided for fishes by the fouling organisms.

MATERIAL AND METHODS

Periphyton in Bukowo Lake was studied in July 2000. The reed inhabited by fouling organisms was collected at 8 sites at the depths of 0.7-1.0 m (Fig. 1).

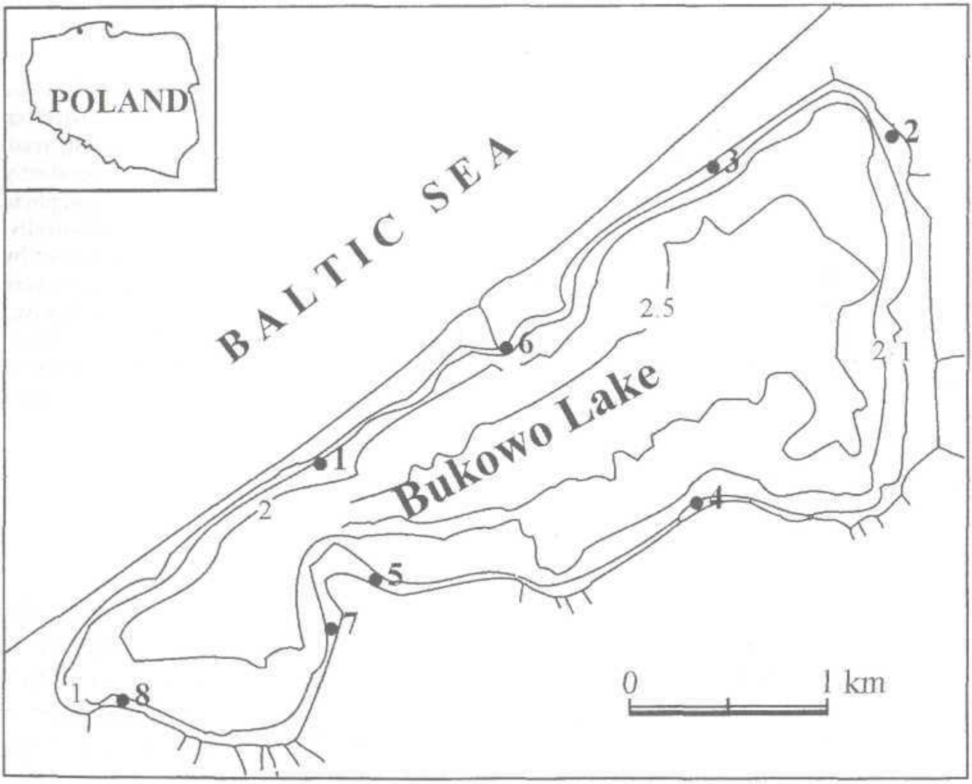

Fig. 1. Localisation of periphyton sampling sites

At each site, 3 shoots of live reed were cut out and dead last-year shoots were left behind. Periphyton was brushed away following its fixation in 10% formalin solution. The brushed-off material was rinsed in a plankton net (No. 25) and transferred to a graduated cylinder. Depending on the density of the fouling organisms, the material in the cylinder was supplemented with water up to the volume of 0.025-0.1 dm^3. Three 1-ml subsamples were taken from each cylinder with the aid of a pipette following a uniform stirring. The subsamples were then placed in a plankton chamber and subjected to a quantitative analysis under a microscope. The quantities of algae were determined by counting their numbers in 9 view fields (0.0157 cm^2 each field) of a microscope under 180 x magnification (10 x 1.5 x 12 x eye piece). Averaged results from 9 view fields of a microscope, determined in 3 chambers were calculated to obtain the density of algae on 1 m^2 of substrate.

The frequency of fouling organisms was determined according to the following formula:

$$F = \frac{n}{N}\ 100\%,$$

where: n, number of samples where a given taxon was present; N, number of all samples collected during this study.

Measurements and readings of: water transparency, water pH, water salinity, oxygen content in the water were carried out at 15 sites with the aid of Secchi disc, CP-101ph-meter, CC-103 salinometer, and CO-315 O_2-meter, respectively.

RESULTS

Biotic substrate provided by *Phragmites australis* was inhabited by bacteria, algae, and epiphytic fauna. Because of the methodology used, no bacteria and fungi were studied qualitatively-quantitatively and only their presence was recorded in the course of microscopic examination.

Primary producers on the reed substrate were represented by fouling algae of *Bacillariophyta*, *Chlorophyta* and *Cyanophyta*.

Bacillariophyta dominated among epiphytic (54.8%) and their density ranged from 24 thousand to 136 thousand cells m^{-2} ($\overline{x}$ = 49 thousand cells m^{-2}). Diatoms inhabited reed at all sites studied (F = 100%). The most abundant on reed were diatoms at site 3 near the north shore of the lake (Table 1). Only at site 2, near the eastern shore of the lake diatoms were less abundant than green algae.

Chlorophyta constituted 34.5 % of fouling algae on the reed in Bukowo Lake. Their density ranged from 10 thousand to 52 thousand cells m^{-2} ($\overline{x}$ = 31 thousand cells m^{-2}). The highest density of green algae was recorded on reed at site 6 near the mouth of a canal connecting the lake with the sea. Green algae, similarly as diatoms inhabited reed at all sites studied (F = 100%). The density of *Chlorophyta* was twice as high on the reed growing near the northern shore of the lake, than it was on the reed occurring on the southern shore of this body of water.

Table 1

Density of epiphytic microalgae (cells m^{-2}) on reed *Phragmites australis* in Bukowo Lake

Taxon	Samplings sites								$\overline{X}$ density	Proportional participation %	F (%)
	1	2	3	4	5	6	7	8			
Bacillariophyta	48 000	27 400	136 000	29 060	24 000	30 000	30 000	70 700	49 395	54.8	100
Chlorophyta	28 200	52 080	62 100	19 070	24 500	10 950	8 800	42 960	31 082	34.5	100
Cyanophyta	1 300	3 700	37 300	29 100	2 600	950	0	2 590	9 682	10.7	80
Total	**77 500**	**83 180**	**235 400**	**77 230**	**51 100**	**41 900**	**38 800**	**116 250**	**90 159**		

Cyanophyta inhabited reed most extensively and they constituted 10.7% of all fouling algae studied. The density of blue algae ranged from 0 to 37 thousand cells m^{-2} ($\overline{x}$ = 9 680 thousand cells m^{-2}). The blue algae the most extensively inhabited reed at sites 2 and 3 (Table 1). Frequency of occurrence of this taxon was high and it amounted to F = 87%. Epiphytic algae were the most abundant on reed at sites 3 and 8 (Table 1).

Epiphytic fauna inhabiting reed in Bukowo Lake was represented by 12 microfauna taxa and only 3 taxa representing macrofauna (Table 2).

Table 2

Mean density, proportional participation and frequency of epiphytic fauna (specimens m^{-2} of substrate) on reed *Phragmites australis* in Bukowo Lake

Taxon	Sampling sites								$\overline{X}$	Proportional participation %	F (%)
	1	2	3	4	5	6	7	8			
microfauna											
Total *Protozoa*	**7 934**	**2 717**	**21 266**	**67 431**	**6 267**	**6 428**	**68 571**	**12 963**	**24 197**	**57.4**	**100**
Testacea	1 767	0	3 733	278	0	0	0	370	768	1.8	50
Ciliata libera	1 000	0	200	278	500	238	238	0	306	0.7	75
*Peritricha**	5 167	2 717	17 333	66 875	5 767	6 190	68 333	12 593	23 122	54.8	100
Rotatoria	**2 000**	**2 783**	**3 767**	**278**	**2 000**	**714**	**1 427**	**2 222**	**1 899**	**4.5**	**100**
Nematoda	**6 000**	**3 733**	**97 333**	**7 708**	**21 333**	**3 095**	**6 190**	**23 704**	**10 187**	**24.1**	**100**
Total *Oligochaeta*	**0**	**0**	**0**	**1 195**	**177**	**238**	**1 904**	**370**	**485**	**1.1**	**62**
Stylaria sp	0	0	0	570	177	238	952	370	288	0.7	62
Chaetogaster sp	0	0	0	625	0	0	952	0	197	0.5	25
Total *Copepoda*	**1 677**	**1 250**	**3 373**	**571**	**373**	**1 428**	**1 190**	**3 333**	**1 649**	**3.9**	**100**
nauplius	177	1 250	373	0	0	476	238	370	360	0.8	75
Harpacticoida	1 500	0	3 000	571	373	952	952	2 963	1 289	3.0	87
Cladocera (*Chydorus* sp.)	**1 767**	**417**	**3 733**	**1 875**	**3 000**	**6 667**	**4 048**	**6 148**	**3 707**	**8.8**	**100**
Hydracarina	0	0	0	0	0	0	476	0	60	0.1	12
Total	**19 378**	**10 900**	**41 872**	**79 058**	**33 150**	**18 570**	**83 806**	**50 740**	**42 184**		
macrofauna											
*Cordylophora caspia**	2 000	417	4 000	417	177	238	7 619	5 556	2 553	59.5	100
Chironomidae larvae	373	2 500	677	174	2 000	0	714	5 925	1 545	36.0	100
Asellus sp	0	0	0	0	0	0	1 190	370	195	4.5	25
Total	**2 373**	**2 917**	**4 677**	**591**	**2 177**	**238**	**9 523**	**11 851**	**4 293**		

* condensation in zooids m^{-2} of reed

In the microfauna assemblage the most dominant were *Protozoa*, which constituted 57% of the microscopic-size animals. The highest density among *Protozoa* was represented by sessile ciliates of the phylum *Peritricha* (up to 68 330 zooids m^{-2}), which dominated among the epiphytic fauna (55%) and occurred at al sampling sites (F = 100%). *Ciliata libera*, freely-moving on the substrate (*Holotricha* and *Hypotricha*) constituted only 0.7% of the epiphytic microfauna on reed (F = 75%) and the share of Testacea in colonisation of the substrate studied was as low as 1.8% with frequency of F = 50%. A subdominant taxon in the microfauna turned out to be *Nematoda* (24%), which inhabited reed at all sites (F = 100%). Percentage shares of the remaining taxa of epiphytic microfauna were low and they did not exceed 5%. *Cladocera* were represented mainly by *Chydorus sphaericus*, constituting some 9% of the microfauna inhabiting reed. The density of individual taxa of epiphytic microfauna on *Phragmites* is shown in Table 2. Density of the microfauna studied was the highest at sites 4 and 7 and it reached 83 800 specimens m^{-2}.

Among epiphytic macrofauna on the reed in Bukowo Lake intensive development of *Cordylophora* (2 553 zooids m^{-2}) and *Chironomidae* larvae (1 545 larvae m^{-2}) were observed. The taxa discussed showed a very high frequency and they commonly occurred on the reed. Distinctly less abundant on this substrate was water hoglice, *Asellus aquaticus* L. ($\overline{x}$ = 195 specimens m^{-2}) with small frequency (F), which was as low as 25% (Table 2).

In July, the water transparency in the lake studied, measured with Secchi disc was low and it ranged from 0.4 to 0.55 m ($\overline{x}$ = 0.46 m). Water reaction (pH) in the lake ranged from 8.1 to 8.89 ($\overline{x}$ = 8.5). Oxygen content in the lacustrine water ranged from 4.3 to 6.7 mg O_2 dm^{-3} ($\overline{x}$ =5.9 mg O_2 dm^{-3}), which was possibly caused by the phenomenon of re-suspension, associated with increasing wind force. Similar fluctuations were observed in the oxygen content in the water (52-80%). Chloride content ranged from 0.99 to 1.44 g Cl^- dm^{-3}. The highest concentration of chlorides was recorded at site 8, while the lowest—at site 1 ($\overline{x}$ =1.23 g Cl^-dm^{-3}).

DISCUSSION

Bukowo Lake is an estuary-type body of water, linked with the Baltic Sea through the Szczuczy Canal. The lake is separated from the sea by an elevated sandy reef covered with trees and as recently as 4 thousand years ago it constituted an open bay. The surface area of Bukowo Lake is 1747 ha, water volume - 32 071 thousand m^{-3}. The lake is 8 800 m long and 3 360 m wide, with the average depth of 1.8 m (maximal depth: 2.8 m). The coastal zone of the lake is occupied by a dense macrophyte belt, consisting chiefly of reed, *Phragmites australis*. Similarly as in other water courses and water bodies the reed is inhabited here by epiphytic organisms representing all trophic levels (producers, consumers, reducers).

Among epiphytic algae on different substrates usually dominate *Bacillariophyta*, followed by *Chlorophyta*, while the lowest development is demonstrated by *Cyanophyta* (cf. Piesik 1992). This regularity is also true for biotic substrates provided by *Phragmites*. The density of epiphytic algae is largely dependant on light availability, nutrient contents, and the kind of substrate. It is evident from the data shown in Table 3 that the density of algae in the lake studied is low and similar to their densities previously recorded in Kopań Lake. Comparing the development of epiphytic algae inhabiting reed in the Odra River it is evident that the density of epiphytic algae in Bukowo Lake is over thousand times lower than in the river and over 2 hundred times lower than in Jamno Lake. It is possible that in Bukowo Lake there are no favourable conditions for development of algae inhabiting *Phragmites*.

Table 3

Comparison density of epiphytic algas perifiton (in alga individuals) in bodies of water studied

Type of waters	Localisation	Algae density (10^3 cells m^{-2} of substrate)	Author
River	Rzeka Odra (Jasienica)	128 100	Piesik, Wawrzyniak-Wydrowska (unpublished)
Lake	Jez. Jamno	20 480	Piesik, Wiśniewska (unpublished)
Lake	Jez. Kopań	104	Piesik, Obolewski (2001)
Lake	Jez. Bukowo	90	Piesik, Obolewski (author's data)
Strait	Nurt Jamnieński (Unieście)	8 020	Piesik, Wiśniewska (unpublished)

Similarly as epiphytic algae, also epiphytic microfauna inhabiting reed exhibited weaker development compared to water courses and water bodies in the Odra River Estuary (Table 4).

Table 4

Comparison mean density of epiphytic macrofauna on *Phragmites australis* in estuarine waters

Taxon	Roztoka Odrzańska Jasienica Piesik, Wawrzyniak-Wydrowska (unpubl.)	Zalew Właściwy Trzebież Piesik (unpubl.)	Lake Jamno Piesik, Wiśniewska (unpubl.)	Lake Kopań Piesik, Obolewski (2001)	Lake Bukowo Piesik, Obolewski (autor's data)
*Cordylophora caspia**	310	0	0	942	2 553
Hirudinea	70	0	0	0	0
Corophium sp.	105	0	0	0	0
Gammarus sp.	115	0	0	0	0
Chironomidae larv.	3 370	5 500	205	640	1 545
Gastropoda	50	0	194	0	0
*Bryozoa**	60	0	0	0	0
Asellus sp.	0	0	0	16	195
Total	**4 080**	**5 500**	**399**	**1 598**	**4 293**
Number of taxa	7	1	2	3	3

* concentration in zooids m^{-2} of reed

Mean density of microfauna on reed was the lowest (42 thousand specimens m^{-2}) compared to other estuary waters, e.g. the Szczecin Lagoon (Roztoka Odrzańska) where the density of epiphytic macrofauna on this substrate amounted to 791 thousand specimens m^{-2} and it was over 20 times higher in relation to the lake studied. The most extensive growth among epiphytic microfauna growing on reed in Bukowo Lake was demonstrated by sessile ciliates of *Peritricha* and the subdominant turned out to be *Nematoda*. *Peritricha*, *Rotatoria*, and *Nematoda* are the animals of epiphytic microfauna developing best on natural and artificial substrates (Piesik 1992). The remaining taxa, representing predators, phytophages, bacteriophages and omnivorous animals represented low densities (Table 4).

It is evident from the above-mentioned data that epiphytic microfauna inhabiting reed in Bukowo Lake plays substantially smaller ecological role in this ecosystem compared to the microfauna in the Odra River estuary. Comparing densities of epiphytic microfauna on *Phragmites* in the straits connecting coastal lakes (lagoons) with the Baltic Sea it is evident that influenced more frequently by brackish waters the microfauna demonstrates weaker qualitative-quantitative development in relation to epiphytes in the directly connected water bodies (Table 4). Action of brackish Baltic waters has an inhibiting effect on development of essentially freshwater microfauna taxa also in the Szczucki Canal, connecting the lake with the sea.

Epiphytic macrofauna on *Phragmites australis* in Bukowo Lake was poor and it was represented by 3 taxa, similarly as in other coastal lakes (lagoons) where the presence of 2-3 taxa was stated. Data presented in Table 4 show that the most extensive development of epiphytic macrofauna occurred in sheltered parts of the Szczecin Lagoon - the Roztoka Odrzańska, where 7 taxa of macrofauna were stated. In this body of water, in the "corner area", because of intensive wave activity, the reed was inhabited only by larvae of *Chironomidae*. Mean density of coelenterates *Cordylophora caspia* and larvae of *Chironomidae* in Bukowo Lake can be considered high among hitherto studies estuary waters (Table 5). Of particular importance are larvae of *Chironomidae*, which constitute a convenient food base for fishes, in this number also species of commercial importance.

CONCLUSIONS

1. Biotic substrate provided by *Phragmites australis* in Bukowo Lake was a development site of epiphytic assemblage (periphyton) resembling qualitatively the fouling formations from other coastal lakes (Kopań Lake, Jamno Lake).
2. Primary producers on the reed were represented mainly by *Bacillariophyta*, which attained mean density of 49 thousand cells m^{-2} (54.8%). Substantial densities were also reached by epiphytic *Chlorophyta* (31 thousand cells m^{-2}, 34.5%). The lowest density among organisms growing on the reed represented *Cyanophyta* (9.6 thousand cells m^{-2}, 10.7%). The density of epiphytic algae on *Phragmites* in Bukowo Lake should be considered low compared to their densities in other estuary waters.
3. Qualitatively, the epiphytic microfauna was represented by a relatively abundant assemblage with 8 taxa. Quantitatively, the density of the epiphytic microfauna

on reed in Bukowo Lake was the lowest (38 thousand specimens m^{-2}) among hitherto studies estuary waters.

4. Epiphytic macrofauna on *Phragmites australis* in the lake studied was poor and it was represented by as few as 3 taxa (*Cordylophora*, larvae of *Chironomidae*, and *Asellus*). Quantitatively, the density of macrofauna was distinct and the highest compared to other coastal lakes (Kopań Lake, Bukowo Lake).
5. Presently collected quantitative data on epiphytic organisms from Bukowo Lake indicate that in this body of water the epiphytic formation poorly develops and plays decisively the weakest ecological role compared to epiphytic formations in other estuarine waters.

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