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FOULING ORGANISMS (PERIPHYTON) INHABITING COMMON REED *PHRAGMITES AUSTRALIS* IN LAKE JAMNO

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Abstract

Coastal Lake Jamno is located on the Polish middle coast of the Baltic Sea. It has a potential of playing an important role in the tourist development of the region, because of a splendid landscape of its surroundings. Taking into account its very high eutrophication level, it would be necessary to revitalize the lake, using periphyton among other measures. A qualitative-quantitative survey of the epiphytic assemblage was carried out on reed (*Phragmites australis*), the most common biotic substrate of this lake. Dead and live shoots of the reed were inhabited by epiphytic microalgae (Bacillariophyta, Chlorophyta, and Cyanophyta), micro- and macrozoo periphyton (Protozoa, Nematoda, Rotatoria, Oligochaeta, Cladocera, and larvae of Chironomidae). The dead shoots were 1.4-fold more intensively covered by fouling organisms, than the live ones. The epiphytic assemblages of reed contributed to a substantial enhancement of biodiversity in this ecologically compromised body of water.

Key words: Polish coastal zone of Baltic, estuary, *Macoma balthica*, abundance and biomass

INTRODUCTION

Epiphytic organisms (periphyton) inhabiting various substrates submerged in water are poorly known in estuary-type bodies of water, both flowing and stagnant ones. Periphyton studies on various substrates in Polish estuaries have been carried out in the Odra River estuary (Odra River, Świna Strait, Szczecin Lagoon, and Pomeranian Bay), Puck Bay, and in some lagoons (locally known as coastal lakes) (Chojnacki, Ceronik 1997, Piesik 1978, 1983, 1992).

Detailed surveys of epiphytic micro-organisms (algae, fauna) on the biotic substrate provided by common reed, *Phragmites australis* were carried out in lagoons Kopań and Bukowo, locally known as coastal lakes and in the Odra River es-

tuary (Piesik, Obolewski 2000, 2001, Piesik, Wawrzyniak-Wydrowska in press).

An epiphytic assemblage, finding itself a sufficient substrate area in surface waters, may play a significant ecological role also in such a polluted and degraded lake as Lake Jamno. Establishment of an epiphytic assemblage enhances biodiversity, contributes to the processes of self-purification of waters (biofiltration, biosedimentation, bioaccumulation), and it delivers additional biomass to the food web of a given ecosystem (Piesik 1992). Fouling organisms inhabiting artificial substrates (nylon nets) are considered the key feature in the revitalisation plans for Lake Jamno (Piesik 1998).

The aim of this study was a qualitative-quantitative survey of periphyton inhabiting reed, *Phragmites australis* in Lake Jamno and the assessment of its potential for revitalisation of this degraded body of water.

MATERIALS AND METHODS

The periphyton in Lake Jamno was studied in July 1997. The reed with the epiphytic organisms was collected from 4 sampling sites at depths 0.7-1 m (Fig. 1).

Fig. 1. Location of sampling stations in the Jamno Lake

To acquire periphyton samples, three current-year- and three previous-year reeds were collected from each site. From each read three 6–12-cm fragments were taken from lower-, middle-, and upper stretch, respectively. The upper subsample was taken 20 cm below the water surface, because of water lever fluctuations. The periphyton was subsequently brushed off the substrates following fixation in formalin.

The removed material was rinsed on a plankton net (No. 25), transferred to a graduated cylinder, and supplemented with water up to 100 cm^3. Assured that the organisms were equally distributed in the water volume, three 1-ml subsamples were taken from each cylinder and transferred to a plankton counting chamber. The quantities of the algae were determined by counting their numbers in ten view fields (0.07 cm2 each) of a microscope under magnification of 180x (10 x 1.5 x 12). The densities of algae (per 1 m2) of substrate were calculated from average results from ten view fields and three chambers. The actual area of the reed fragments studied ranged from 404 to 528 cm^3. The quantities of fouling macrofauna was determined in a similar way as the quantities of the algae, using plankton counting chamber with linear divisions (5x lens x 1.5 x 12 eyepiece = 90x).

The occurrence frequency of the epiphytic organisms was determined from the following formula

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

where:

n, number of samples where given taxon was present

N, number of all samples collected in this study.

RESULTS

Biotic substrate provided by reed, *Phragmites australis* was inhabited by bacteria, algae, and epiphytic fauna. Because of the assumed methodology, neither bacteria nor fungi were studied for their numbers and specific identity. Only their presence was recorded during microscopic observations.

Primary producers, on the reed substrate, were represented by epiphytic algae (Bacillariophyta, Chlorophyta, and Cyanophyta).

Bacillariophyta dominated among epiphytic algae on both live- (77.1%) and dead (74.8%) substrates. Their densities ranged from 52 000 to 163 000 cells m-2 (x = 124 000 cells m-2) on live substrate and from 53 000 to 210 000 cells m-2 (x = 140 000 cells m-2) on dead substrate. Diatoms were the most abundant on reed from site 4 located at the south-western shore of the lake (Tab. 1).

Chlorophyta constituted some 20% of the epiphytic algae in Lake Jamno. Their density ranged from 20 000 to 42 000 cells m-2 (x = 32 000 cells m-2) on live reed and from 27 000 to 66 000 cellsm-2 (x = 42 000 cells m-2) on dead substrate. The highest density of green algae on dead reed was noted at site 4. Green algae similarly as diatoms inhabited reed at all sampling sites (F = 100%). The density of Chlorophyta was two-fold higher on live and dead reed from the southern shore of the lake, compared to the reed growing on the northern shore and exposed to sea water.

Cyanophyta were not abundant and they constituted as little as about 3% of all epiphytic algae found on live and dead reed. The density of blue-green algae on live reed ranged from 4.3 to 5.8 thousand cells m^{-2} (x + 5.6 thous. cells m^{-2}), whereas on dead reed—from 3.3 to 6.5 thous. cells m^{-2} (x = 4.9 thous. Cells m^{-2}; Tab. 1).

Table 1

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

Taxon	Sampling site								$\bar{x}$		%	
	1		2		3		4					
	Live reed	Dead reed	Live reed	Dead reed	Live reed	Dead reed	Live reed	Dead reed	Live reed	Dead reed	Dead reed	Dead reed
Bacillario phyta	136.6	138.3	51.6	53.2	144.2	157.0	163.3	210.0	123.9	139.6	77.1	74.8
Chloro-phyta	36.7	45.0	20.0	26.8	28.6	31.2	42.5	66.2	31.9	42.3	19.9	22.6
Pedias-trum	3.8	4.4	3.1	3.7	1.5	3.0	4.1	5.3	3.1	4.1	1.9	2.2
Scenedes-mus	27.4	33.5	13.8	18.5	20.4	20.6	31.3	50.8	23.2	30.6	14.5	16.4
other Chloro-phyta	5.5	7.1	3.1	4.6	6.7	7.6	7.1	10.1	5.6	7.4	3.5	4.0
Cyano-phyta	4.3	3.3	4.5	4.6	4.5	5.3	5.8	6.5	4.8	4.9	3.0	2.6
Total	**177.6**	**186.6**	**76.1**	**84.6**	**177.3**	**193.5**	**211.6**	**282.7**	**160.6**	**186.8**	**100**	**100**

The epiphytic fauna of Lake Jamno was represented by 9 microfauna taxa and as few as 2 macrofauna ones (Tab. 2).

Table 2

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

Taxon	Sampling sites								$\bar{x}$		%	
	1		2		3		4					
	Reed											
	lively	dead	lively	dead	lively	dead	lively	dead	lively	dead	lively	dead
Microfauna												
Protozoa	47944	60409	19935	24896	31732	38870	38386	77983	34499	50538	49.3	52.8
1. Testacea	17756	21296	4991	4992	9952	14671	17182	24623	12470	16395	17.8	17.1
2. *Acineta* sp.	7108	16002	7472	9952	7320	7320	5717	13158	6904	11608	9.8	12.1
3. Peritricha*	21326	23111	7472	9952	16879	16879	13763	36088	14860	21507	21.2	22.5
4. Plecostyla	1754	0	0	0	0	0	1724	4115	870	1028	1.2	1.1
Rotatoria	16002	17756	7472	7472	8258	9891	26922	47553	14663	20668	20.9	23.7
Nematoda	10648	14217	0	0	7320	9529	15458	15458	8356	9801	11.9	10.2
Oligochaeta	8832	15973	2480	7471	4900	8228	22717	11102	9732	10693	13.9	11.2
Stylaria sp. *Nalis* sp.	1754	12433	2480	4991	4900	5748	18906	7078	7010	7562	10.0	7.9
2. *Chaetogaster* sp.	7078	3540	0	2480	0	2480	3811	4023	2722	3130	3.8	3.2
Cladocera *Chydorus* sp.	5324	3539	0	0	0	2480	5718	9740	2760	3940	3.9	4.1
Total	**88750**	**111894**	**29887**	**39839**	**83942**	**68998**	**109200**	**161836**	**70010**	**95640**		
Macrofauna												
Chironomidae larvae	117	176	0	0	282	162	246	242	161	145	61.2	34.6
Gastropoda	135	294	0	165	82	315	189	322	102	274	38.8	65.4
Total	**252**	**470**	**0**	**165**	**364**	**477**	**435**	**564**	**263**	**419**		

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

The dominant microfauna group on live- and dead reed were Protozoa, which constituted 49 and 52% of entire micro-zooperiphyton, respectively. The highest density among Protozoa showed sessile ciliates of the phylum Peritricha (from 21.3 thous. zooids m^{-2} on live reed to 36 thous. zooids m^{-2} on dead reed). Peritricha were subdominants among microzooperiphyton constituting almost 21% of epiphytic microfauna on live substrate and 22% on dead one. The percentage share of Testacea in settling the live substrate was 17% and it frequency (F) reached 100%. A substantial share of micro-zooperiphyton took Suctoria of the genus *Acineta*. On live reed substrate they constituted 9% of micro-zooperiphyton, while on dead substrate - over 12%. Rotatoria jointly with Peritricha dominated among epiphytic microfauna, both on dead and on live reed (21-24%) and they occurred at all sampling sites (F = 100). The most favourable conditions for development of Rotatoria were found at site 4, on dead reed. Phytophagous nematodes had good conditions for development in Lake Jamno and they constituted 12% of epiphytic microfauna on live reed and 10% on dead substrate. A similar settling level showed predacious Oligochaetes *Chaetogaster* sp. (12% on live reed). The percentage share of other taxa of epiphytic microfauna was small, not exceeding 10%. Cladocera, represented mainly by *Chydorus sphaericus* constituted about 4% of microfauna on live and dead reed. The densities of individual taxa of the epiphytic microfauna on *Phragmites australis* are shown in Table 2. The microfauna densities on live reed were the highest at sampling site 1 (111.8 thous. specimens m^{-2} of reed surface) and on dead reed - at site 4 (161.8 thous. m^{-2}) where there were convenient conditions for fouling organisms.

The main item of epiphytic macrofauna, developing on reed in Lake Jamno, were Chironomidae larvae. On live reed shoots their mean density was 161 spec. m^{-2}, while on dead shoots - the average of 145 spec m^{-2}. The above - mentioned taxon showed high frequency and they commonly occurred on reed (Table 2). The substrate (*Phragmites*) featured also gastropods, which were dominant element of epiphytic macrofauna on dead reed shoots. The best conditions for development of macrofauna were found at site 4, which was also favoured by microfauna.

DISCUSSION

Lake Jamno (Lagoon) is an estuarine body of water. It is connected with the Baltic Sea through the Jamno Canal. This lagoon is separated from the sea by a san bar. The bar is 350-700 m wide and it features sand dunes elevated 5.3 to 18 m above the sea level and also three villages (tourist resorts): Mielno, Unieście, and Łazy. The surface area of Lake Jamno is 2239.6 ha and the water volume of 31.5 thous. thous. m^3. The shoreline is 28.8 km and the maximum depth reaches 3.9 m (1.4 m in average). The water surface is elevated only 0.1 m above the sea level and its bottom lies below average sea level. The coastal zone of the lake is covered by a dense belt of macrophytes consisting mainly of reed, *Phragmites australis*. Similarly as in other bodies of water the reed is inhabited by epiphytic organisms representing all trophic levels (producers, consumers, decomposers).

Among epiphytic algae growing on various substrates the dominant items are Bacillariophyta, followed by Chlorophyta. The lowest densities show Cyanophyta

(Piesik 1992). This regularity is true also for biotic substrates provided by *Phragmites australis* (cf. Piesik, Obolewski 2000, 2001). It is possible that among the major factors influencing development of epiphytic algae are the trophic level of water, intensity of PAR radiation reaching reed concentrations, and constant provision of nutrients. The density of epiphytic algae on *Phragmites australis* in highly eutrophied waters of the Odra River estuary was substantially higher (700-fold) compared to their density in Lake Jamno. Substantially lower densities of epiphytic microalgae growing on reed were stated in other Polish lagoons (coastal lakes) of lower trophic status (Piesik, Obolewski 2000, 2001).

The quantities and the specific diversity of the epiphytic microfauna of Lake Jamno are similar to the microfauna of other Polish lagoons (coastal lakes) (Tab. 3), but it is substantially poorer in relation to the microfauna of reed in eutrophied Odra River estuary.

Table 3

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

	Odra River		Kopań Lake Piesik, Obolewski (2000)	Bukowo Lake Piesik, Obolewski (2001)	Lake Jamno Piesik, Obolewski (unpublished data)
	Wąski Nurt Piesik, Wawrzyniak-Wydrowska (2003)	Szeroki Nurt Piesik, Wawrzyniak-Wydrowska (2003)			
Total Protozoa	494380	1354140	19290	24176	33954
1. Testacea	0	0	2240	770	12470
2.Ciliata-libera	0	0	290	306	0
3. Suctoria	64120	1009290	0	0	6904
4. Peritricha*	430260	344850	16760	23100	13703
5. Plecostyla	0	0	0	0	877
Porifera	+	+	+	+	+
Rotatoria	45980	48620	22650	1900	14671
Gastrotricha	0	20	0	0	0
Nematoda	26750	108320	8420	10190	8356
Oligochaeta	2030	1260	1230	490	9732
1. *Stylaria* sp.	2000	600	870	290	7010
2.*Chaetogaster* sp.	30	660	230	200	2722
3.Tubificidae	0	0	130	0	0
Total Copepoda	10410	8180	1990	1650	0
a)nauplius	5050	1160	390	360	0
b)Cyclopoidae	1530	3060	0	0	0
c)Harpacticoidae	3830	3960	1600	1290	0
Cladocera *Chydorus* sp.	5030	8010	1290	3710	2769
Hydracarina	0	190	14	60	0
Bryozoa	2946	1469	0	2555	0
Dreissena – postweliger	170	77	0	0	0
Total	587696	1530286	54884	44731	69482
Number of taxa	13	15	13	13	10

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

The main density of epiphytic microfauna on live reed in Lake Jamno was 70010 spec m^{-2}, while in Odra estuary (Wąski Nurt) it was more then 8-fold higher (588 thous. spec. m^{-2}). The mean densities epiphytic macrofauna of *Phragmites* at Kopań and Bukowo lakes (other coastal lakes) were 1.2- and 1.5-fold lower, respectively. The development of epiphytic macrofauna on reed was substantially lower than that on artificial substrates (fouling). The density of microfauna growing on reed at Lake Jamno was as much as 180 times lower than that growing on nylon nets at lower stretch of the Odra River (Piesik 1978). The highest specific diversity of epiphytic macrofauna growing on reed was noted in the Odra River estuary (15 taxa), slightly lower at lakes Kopań and Bukowo (13 taxa), and the lowest in degraded Lake Jamno (10 taxa). The most intensive growth among the epiphytic microfauna of reeds was recorded for microsedimentators represented by sessile ciliates (Peritricha) and rotifers (Rotatoria) and accounting for 41% of all microfauna. It can be confirmed by the species richness of bioseston (bacteria and algae) in the waters of this eutrophied and polluted body of water. Proper filtrators (Cladocera) did not attain high density (4% of microfauna), which is probably associated with strong pressure of fish fry and other predators. Despite of the availability of a rich food base, provided mostly by epiphytic diatoms, the phytophages (oligochaetes of the genera *Stylaria* and *Nais*) constituted as little as 10% of the epiphytic microfauna. The epiphytic algae were also utilised by representatives of macrofauna (Chironomidae larvae, Gastropoda). Micropredators (*Acineta* sp. Chaetogaster sp.) accounted for 15% of microfauna on the reed. The above-mentioned data confirm the fact that because of the species richness of micro-bioseston, the most favourable conditions for development have microsedimentators, which is significant for using periphyton for the final step of water purification. It must be emphasised that epiphytic macrofauna on *Phragmites* in this degraded lake was very poor qualitatively and quantitatively (Tab. 4).

Table 4

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

	Roztoka Odrzańska Jasienica Piesik, Wawrzyniak-Wydrowska (in press)	Szczecin Lagoon Trzebież Piesik (unpubl.)	Kopań Lake Piesik, Obolewski (2000)	Bukowo Lake Piesik, Obolewski (2001)	Jamno Lake Piesik, Obolewski (author's data)
*Cordylophora caspio**	310	0	942	2 553	0
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	640	1 545	205
Gastropoda	50	0	0	0	194
Bryozoa*	60	0	0	0	0
Asellus	0	0	16	195	0

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

In the ecosystem of Lake Jamno, because of poor benthos, the epiphytes growing on reeds - very abundant in this lake - utilises and transforms into biomass nutrients and bioseston. The latter has been poorly utilised by inhabitants of the pelagic zone (zooplankton), where after dying out, it triggers a number of processes negative for the environment. Introduction of bioseston to food web by epiphytic sedimentators, filtrators, and sessile predators, regenerates the food base, accessible for representatives of other ecological formations, including fish. Another chain leads to a periodic reversed eutrophication, through introduction of epiphytic producers (mainly diatoms), nutrient salts from the pelagic zone and re-building of the food base for phytophages, which in turn enhances development of predators (e.g. diatoms – *Nais* – *Chaetogaster* - fish fry - *Perca fluviatilis*).

Comparing the density of epiphytic microfauna on *Phragmites* in the canals connecting lagoons (coastal lakes) with the Baltic, it can be concluded that frequent action of salty waters inhibits their quantities and species diversity. No typically Baltic taxa were recorded on reed, which constitutes an evidence on limited effect of Baltic Sea waters on epiphytic fauna in those canals.

The results of the present study indicate that the epiphytic algae and animals in Lake Jamno grow more extensively on dead reed shoots compared to the live ones. The density of epiphytic microfauna was always higher on dead reed shoots (on average 1.4-fold higher in relation to microfauna on live shoots). Live plants defend themselves against settling by the fast growth of their surface, higher elasticity of the substrate, or excretion of toxic substances (alleopatria). Piesik (1992) and Piesik, Obolewski 2000 demonstrated that on artificial substrates (nylon nets, open-work potato bag fabric) the epiphytic organisms find far more convenient conditions for their development, which is evidenced by their high density compared to those on biotic substrates (e.g. *Phragmites*).

The present study proved a potential of epiphytic formations and their suitability for revitalisation of Lake Jamno using the "active substrate method" as suggested by Piesik (1998). Suitability of the epiphytic assemblage in the Jamno estuary for the process of revitalisation was confirmed by its biological diversity (producers, consumers, decomposers). This assemblage will develop in high numbers on artificial substrates provided in sufficient amounts. Mass development of micro- and macrofauna (sedimentators, filtrators, bacteria feeders, algae feeders, predators and omnivores), will enhance the effects of epiphytic organisms on degraded environment of Lake Jamno. It will contribute to its periodic eutrophication reversal and purification using the active substrate method (Piesik 1978, 1983, 1992, Szlauer 1974, 1979, 1980, Szlauer et al. 2001). Employment of artificial substrates in Lake Jamno will create artificial spawning grounds for phytophilous fish (Piesik 1978, 1989, Wawrzyniak 1987) and will create additional, rich food base for extensive mariculture of amphipods and fishes (Piesik 1992, 1998). The usage of epiphytic organisms on artificial and natural substrates will contribute to enhancement of biodiversity in distinctly degraded bodies of water (Piesik 1992).

CONCLUSIONS

1. Biotic substrate provided by *Phragmites australis* in Lake Jamno was inhabited by an epiphytic assemblage (periphyton) similar in respect of its specific composition to periphyton from other Polish coastal lakes (Kopań and Bukowo).
2. Primary producers on reed in the lake studied were represented mainly by Bacillariophyta. Main density of diatoms on live reed were 123 thous. cells m^{-2} (77.1%) and 139.6 thous. cells m^{-2} (74.8%) on dead reed. Substantial densities were also reached by epiphytic Chlorophyta -31.9 thous. cells m^{-2};19.9% on live reed and 42.3 thous. cells m^{-2} (22.6%) on live *Phragmites* shoots. The least represented were Cyanophyta (4.8 thous. cells m^{-2} on either live or dead reed; 3%). The densities of epiphytic algae on *Phragmites* in Lake Jamno should be considered relatively high, compared to their densities in other estuary waters.
3. Epiphytic microfauna on *Phragmites* in Lake Jamno was represented by 9 taxa. Their quantities were low (6.4 thous. spec. m^{-2}) in relation to other already surveyed estuary waters. The dominants among the microfauna were Rotatoria (21%) and Peritricha (19.7%)
4. A comparative study of periphyton revealed that dead reed shoots were 1.2-fold more intensively inhabited by epiphytic algae, 2-fold with microfauna, and 1.6-fold with macrofauna in relation to live shoots (of the current year).
5. Epiphytic macrofauna on *Phragmites australis* in the lake studied was poor and it was represented by only 2 taxa (Chironomidae larvae and Gastropoda), which confirms a bad environmental condition of Lake Jamno. The density of macrofauna in Lake Jamno was lower than in other coastal lakes (Kopań and Bukowo).
6. The quantitative data collected on the epiphytic organisms of Jamno Lake indicate that the epiphytic assemblage on reed in this area develops less extensively and plays distinctly lower ecological role compared to epiphytic assemblages in other estuary waters.
7. The analysis of the biodiversity of epiphytic organisms of reed in Lake Jamno suggests that the majority of taxa recorded there will develop on mass scale after introduction of artificial substrates and it will directly contribute to improvement of the environment quality and will enable mariculture development in the Jamno estuary.

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ORGANIZMY POROŚLOWE (PERIFITON) ZASIEDLAJĄCE TRZCINĘ (*PHRAGMITES AUSTRALIS)* W JEZIORZE JAMNO

Streszczenie

Przymorskie jezioro Jamno położone jest na polskim, środkowym wybrzeżu Bałtyku. Ze względu na korzystne naturalne walory krajobrazowe może odgrywać ważną rolę w rozwoju turystyki.

Ze względu na bardzo silny stopień eutrofizacji i zanieczyszczenia istnieje potrzeba wykonania rewitalizacji jeziora między innymi z wykorzystaniem perifitonu. W celu jakościowo-ilościowej charakterystyki formacji poroślowej zbadano perifiton na naturalnym, najczęściej spotykanym podłożu biotycznym w jeziorze (Phragmites australis). Na martwych i żywych pędach trzciny stwierdzono występowanie mikroglonów poroślowych (Bacillariophyta, Chlorophyta i Cyanophyta) mikro i makrozooperifitonu (Protozoa, Nematoda, Rotatoria, Oligochaeta, Cladocera, larw Chironomidae). Stwierdzono 1,4 -krotnie intensywiejsze zasiedlanie mikrofauną pędów martwej Phragmites w stosunku do pędów żywych. Formacja poroślowa na trzcinie przyczyniała się do znacznego zwiększenia różnorodności gatunkowej w tym zagrożonym ekologicznie estuariowym akwenie.