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EPIPHYTIC ORGANISMS (PERIPHYTON) INHABITING READ, *PHRAGMITES AUSTRALIS* AND ARTIFICIAL SUBSTRATES IN LAKE KOPAŃ

Zbigniew Piesik, Krystian Obolewski

Department of Ecology and Protection of the Sea,
Pomeranian Pedagogical University,
Arciszewskiego St. 22 b, 76-200 Słupsk, Poland
e-mail:Piesik@wsp.slupsk.pl

Abstract

Periphytic organisms inhabiting biotic and artificial substrates in Polish lagoons, locally known as „coastal lakes" are little known. In the frames of an interdisciplinary studies on the revitalisation of eutrophicated Lake Kopań, a study on different ecological formations, including the periphyton formations inhabiting *Phragmites australis* (CAV.) TRIN. ex STEUD. and artificial stilon (Polish trade name of a nylon) substrates, was carried out in 1999.

It was demonstrated, that the average concentration of periphytic algae on reed in Lake Kopań amounted to 104 000 cells m^{-2}, periphytic microfauna - 54 874 specimens m^{-2}; and macrofauna - 1 598 specimens m^{-2}. The concentration of periphyton on the studied biotic substrate was considerably lower compared to the organisms growing on the artificial substrate (potato-bag fabric, stilon fabric, foil), which were placed in Lake Kopań. The periphytic formation will play a significant role in the revitalisation project of the lake, by purification and deeutrophication of the waters, and in creating an additional, abundant food base for extensive culture of the rainbow trout.

Key words: periphyton, fouling, revitalisation of coastal lakes, mariculture

INTRODUCTION

Until recently, the majority of studies conducted in the Polish lagoons (often referred to as „coastal lakes") dealt with physical chemistry, plankton and benthos ecology, and ichthyology (Orzechowski 1999, Paturej 2000). The periphyton formation in these lakes has not been very well known. More quantitative and qualitative data have been collected for periphytic organisms from the River Odra estuary and the Puck Bay (Chojnacki 1993; Chojnacki and Ceronik 1997; Piesik 1978, 1992; Szlauer and Szlauer 1998). The hitherto conducted studies have shown, that a particularly intensive qualitative-quantitative development of fouling organisms in the above

mentioned brackish waters, took place on artificial, openwork substrates (potato-bag fabric, stilon netting, artificial concrete reefs). In the proposed conception of revitalisation and development of coastal lakes and their shore zones on the Polish coast (Piesik 1997, 1998) the periphytic formation developing on the installed artificial, openwork substrates will play a significant role in monitoring, water cleaning, as well as creating a supplementary food base for the extensive fish culture (Piesik 1992, 1998). The discussed conception of revitalisation of highly degraded lakes assumes the improvement of water quality for recreational and mariculture purposes. The result of the foreseen controlled manipulation will be a temporary change of the present-day low-salinity environment inhabited mainly by freshwater organisms, to a brackish-water Baltic environment (5-7%). Such change will be achieved with the aid of a pipeline providing Baltic coastal waters to the lake, with the use of wind energy (Piesik 1998). The change of the aquatic environment, the rearrangements of hydrobionts as well as the use of biological methods of purification and deeutrophication of water (active substrate method and ecological biomanipulation method) will contribute to the improvement of environment quality, and promoting biodiversity. It will also enable mariculture operations. It must be emphasized, that the exchange of the lake water to Baltic water, will contribute to the restoration of the original state of this body of water developed 4 thousand years ago.

The aim of the present study was a qualitative-quantitative assessment of the periphytic organisms before the introduction of Baltic waters, which in the second stage will enable to monitor the expected rearrangement of organisms in periphyton, after the change of the aquatic environment to a brackish-water one. The description of the periphyton will aid usefulness assessment of this formation in purification, deutrophication of the waters, and their use for mariculture purposes.

MATERIAL AND METHODS

The periphyton studies on the biotic substrate of *Phragmites australis* were conducted in three seasons of the year: spring (March), summer (July), and autumn (October) of 1999. The fouling material from artificial substrate: potato-bag fabric, foil, stilon bag, came from the summer season, and the substrates were placed in a reed strip on the depth up to 70 cm. In the outer reed strip (depth: 0.7-1.0 m) 3 current-year shoots of *Phragmites* were obtained from each sampling site, and from each shoot 3 portions were cut out (a total of 9 sub-samples). A 5-7 cm - long piece was cut out from each *Phragmites* shoot in three places: the upper portion situated 15 cm below the water surface, the middle portion, and the near-bottom one. The collected fragments of the substrate were preserved in 8% formaldehyde solution. In the laboratory the fouling was brushed off from the reed shoot fragments collected from each sampling site. They were subsequently sieved through a No. 25 plankton net, and placed, depending on concentration of material, in a 50-250 ml graduated cylinder. After an even mixing of the material in the cylinder, three 1 ml sub-samples were taken using a graduated pipette. The sub-samples were transferred to a plankton chamber and a quantity analysis was done under a microscope. The number of the algae was determined by recording their number in nine view fields of the microscope (each field = 0.0157 cm^2) under a magnification of 180 times (10 × 1.5 × 12 ×

eyepiece). The averaged results from the nine fields of view of the microscope from three chambers, served as abase for calculating the number of algae on a 1 m^2 surface of the substrate.

The occurrence frequency of the periphytic animals was determined according to the following formula:

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

where: n, number of samples where the given taxon occurred; N, total number of samples collected in the study period.

The readings of the water transparency (Secchi disc), water pH, water salinity, oxygen content, were all carried out at 15 sampling sites (Fig. 1).

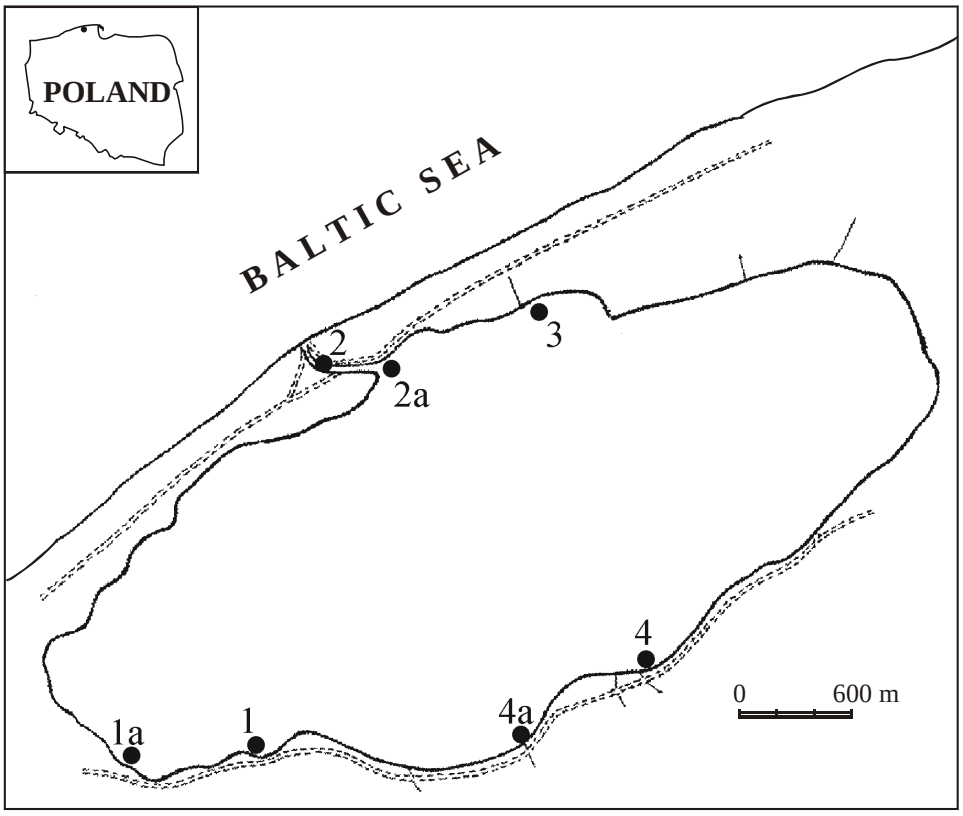

Fig. 1. Location samplings sites in Lake Kopań

RESULTS

Periphytic organisms, represented by bacteria, algae and animals were recorded on the biotic substrates of Lake Kopań.

A mass occurrence of bacteria was observed in the material obtained from the studied substrates, but their qualitative and quantitative aspects were not studied.

The biotic substrate of *Phragmites australis* was settled by periphytic algae, dominated by *Bacillariophyta* diatoms, which constituted 77% of the phytoplankton (Table 1). The concentration of diatoms on the reeds ranged from 12 170 to 190 000 cells m^{-2} ($\overline{x}$ = 77 400 cells m^{-2}). The diatoms occurred in all studied sub-samples collected from the reed (F = 100%). The intensive development of diatoms on this biotic substrate took place in the spring and, which is unusual, in October (Fig. 2).

Table 1

The average concentration (cells m^{-2}) and distribution microflora on different substrates in Lake Kopań

Taxon	Stilon fabric		Potato-bag fabric		Foil		Reed	
	$\overline{x}$ density	%	$\overline{x}$ density	%	$\overline{x}$ density	%	$\overline{x}$ density	%
Bacillariophyta	660 000	40.1	1 815 000	81.0	1 421 430	51.3	77 400	77.0
Chlorophyta	860 000	52.3	425 000	19.0	985710	35.6	21 310	21.0
Cyanophyta	125 000	7.6	0	0	364290	13.1	1 740	2.0
Total	**1 645 000**	**100**	**2 240 000**	**100**	**2 771 430**	**100**	**100 450**	**100**

The *Chlorophyta* developing on the reed in Lake Kopań constituted 21% of the periphytic algae. The concentration on *Phragmites* on individual sampling stations varied from 0 to 49 900 cells m^{-2} ($\overline{x}$ = 21 310 cells m^{-2}). Among periphytic green algae, the distinct dominant were representatives of the genus *Scenedesmus* (0-52 500 cells m^{-2}). The abundance of *Chlorophyta* on this plant substrate, was high and amounted to F = 92.3%. The concentration of *Chlorophyta* on the reed in the studied months is shown on Fig. 2.

Cyanophyta were not permanent inhabitants of the reed (F = 25%). The percentage share of cyanophytes among periphytic algae on the reed was low and amounted to merely 2%. The concentration of this periphytic algal taxon ranged from 0 to 9 830 cells m^{-2} ($\overline{x}$ = 1 740 cells m^{-2}). The presence of blue algae on the reed was recorded on sampling sites 2 and 4 (July, October, Fig. 2).

Periphytic algae settled artificial substrate exposed for a period of three months in the area where the canal from the sea enters Lake Kopań (Site 2a). They settled foil substrate (2 771 400 cells m^{-2}) as well as potato-bag fabric (2 240 000 cells m^{-2}) most intensively. A smaller concentration of the algae was stated on stilon fabric (1 645 000 cells m^{-2}).

The most dominant of periphytic algae on the discussed artificial substrates were *Bacillariophyta*, with the exception of stilon fabric, where *Chlorophyta* dominated (52%). *Chlorophyta* were a subdominant on foil (35%) and potato-bag fabric (11%). Fouling *Cyanophyta* (if present) on the discussed artificial substrates, reached the lowest concentration among phytoperiphyton (Table 1).

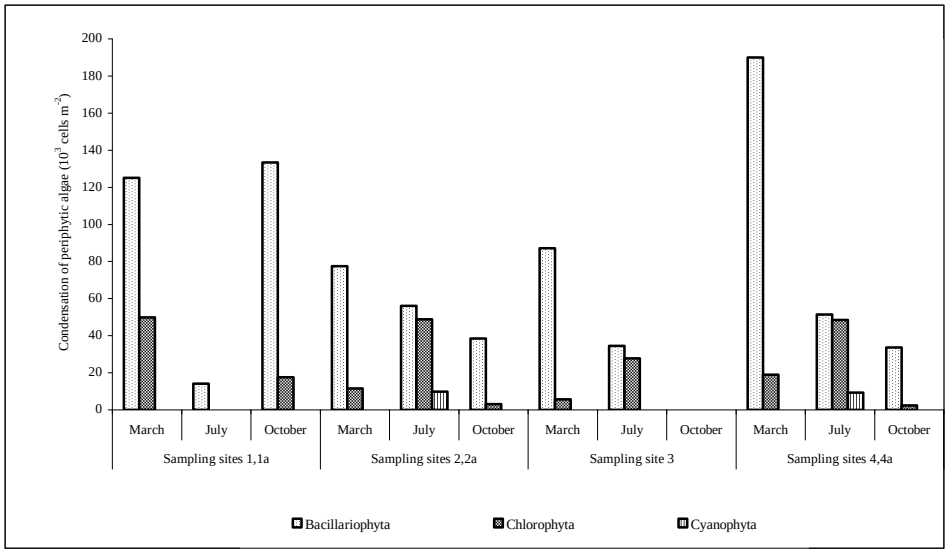

Fig. 2. Condensation of periphytic algae on reed in Lake Kopań in different seasons

Biotic substrates formed by *Phragmites australis* as well as artificial substrates in Lake Kopań were a place of development of fouling animals represented by *Protozoa*, *Rotatoria*, *Nematoda*, *Oligochaeta*, *Crustacea*, *Hydracarina*, *Insecta*, as well as *Bryozoa*.

The presence of 12 microfauna taxa was stated on the reed (Table 2), where their average concentration amounted to 54 847 specimens m^{-2}. The highest average quantitative concentration among the fouling microfauna was that of rotifers (41%). Sedentary ciliates of the class *Peritricha* turned out to be the subdominant (30%). A significant concentration on this plant substrate was reached by *Nematoda* (15%). *Testacea*, *Stylaria*, *Harpacticoida* as well as *Cladocera* settled on *Phragmites* in a considerably lower degree. Their share in the fouling microfauna ranged from 1.6 to 4.1%. The remaining taxa did not reach a high concentration and represented 0.02-0.5% of microfauna on the reed substrate (Table 2). The concentration of individual taxa varied in a wide range, and some of the taxa were not stated in any of the sampling sites (*Ciliata libera*, *Nais* sp., *Chaetogaster* sp., *nauplius*, *Harpacticoida*, *Hydracarina*). The concentration of individual microfauna taxa settling *Phragmites* in Lake Kopań is presented in Table 2.

The reed macrofauna was not very abundant qualitatively and was represented by 3 taxa, among which sedentary hydrozoa *Cordylophora caspia* as well as *Chironomidae* larvae reached significant concentrations. Sporadically occurred water hoglice (*Asellus aquaticus* L.), (Table 2).

Table 2

Average concentration (specimens m^{-2} of substrate) of fouling animals on reed in Lake Kopań

Taxon	Sampling site				$\overline{x}$	%
	1	2	3	4		
microfauna						
Total *Protozoa*	**10 335**	**16 927**	**24 772**	**26 223**	**19 564**	
Testacea	2 082	2 172	4 091	652	2 242	4.1
Ciliata - libera	440	0	714	0	288	0.5
*Peritricha**	6 731	14 755	19 967	25 571	16 756	30.5
Rotatoria	**11 143**	**8 409**	**61 266**	**9 778**	**22 649**	**41.3**
Nematoda	**8 750**	**8 016**	**12 954**	**3 952**	**8 418**	**15.3**
Total *Oligochaeta*	**2 374**	**1 314**	**454**	**754**	**1 224**	
Stylaria sp.	1 667	657	454	698	869	1.6
Nais sp.	443	465	0	0	227	0.4
Chaetogaster sp.	264	192	0	56	128	0.2
Total *Copepoda*	**1 082**	**1 386**	**5 518**	**0**	**1 996**	
nauplius	139	64	1 363	0	392	0.7
Harpacticoida	943	1 322	4 155	0	1 605	2.9
Cladocera	**1 639**	**0**	**2 500**	**1 008**	**1 286**	**2.3**
Hydracarina	**0**	**0**	**0**	**57**	**14**	**0.02**

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

Artificial substrates of stilon fabric in Lake Kopań were settled by 9 taxa of microfauna, among which *Nematoda* were dominant, reaching a concentration of over 10^{-6} specimens m^{-2}. A significant concentration on this substrate was reached by *Testacea* (515 000 specimens m^{-2}), *Harpacticoida* (185 000 specimens m^{-2}) as well as *Chaetogaster* sp. (120 000 specimens m^{-2}). The concentrations of the remaining microfauna taxa on stilon fabric were not very high and ranged from 15 to 80 thousand specimens m^{-2} (Table 3).

Table 3

Comparison condensations of algas periphiton (in alga individuals) on basis biotic and artificial in select types of waters

Type of waters	Localisation	Type of substrate	Algae density (10^3 cells m^{-2} of substrate)	Author
Sewage ditch	Kanał Młyński (Okunica)	nets	88 200	Piesik (1992)
Stream	Strumień Leśny (Słupsk)	potato-bag fabric	12 900	Piesik (1997)
River	Rzeka Odra (Jasienica)	trzcina	128 100	Piesik, Wawrzyniak-Wydrowska (unpublished)
River	Rzeka Płonia (Okunica)	potato-bag fabric	45 400	Piesik (1992)
Strait	Nurt Jamnieński (Unieście)	reed	8 020	Piesik, Wiśniewska (unpublished)
Strait	Nurt Kopański (Jez. Kopań)	reed	81	Piesik, Obolewski (author's data)
Lake	Jez. Kopań	reed	104	Piesik, Obolewski (author's data)
Lake	Jez. Jamno	reed	20 480	Piesik, Wiśniewska (unpublished)
Lake	Jez. Kopań	potato-bag fabric	2 240	Piesik, Obolewski (author's data)
Lake	Jez. Kopań	foil	2 771	Piesik, Obolewski (author's data)
Lake	Jez. Kopań	stilon bag	1 645	Piesik, Obolewski (author's data)
Lagoon	Zalew Szczeciński	reed	74 600	Piesik, Wawrzyniak-Wydrowska (unpublished)

The fouling macrofauna on the above-mentioned substrate was represented by merely two taxa, among which *Chironomidae* larvae reached a concentration of 485 000 specimens m^{-2}, and the concentration of *Asellus aquaticus* amounted to a mere 5000 specimens m^{-2}.

Stilon in Lake Kopań was settled similarly to potato-bag fabric by 9 microfauna taxa. The dominant taxon also turned out to be *Nematoda* (285 000 specimens m^{-2}). A higher concentration characterised: *Peritricha* (90 000 specimens m^{-2}), *Stylaria* sp. (70 000 specimens m^{-2}), as well as *Rotatoria* (60 000 specimens m^{-2}). The concentrations of the remaining taxa did not exceed 45 000 specimens m^{-2} (Table 3).

The macrofauna on potato-bag fabric in the lake studied was represented only by *Chironomidae* larvae, which reached a concentration of 365 000 specimens m^{-2}.

Among the studied artificial substrates, significantly lower concentrations of microfauna characterised the foil substrate, where 7 taxa were stated (Table 3). *Rotatoria* were a dominant among the microfauna on this substrate (185 000 specimens m^{-2}), and sedentary ciliates of the *Peritricha* group turned out to be the subdominant (107 000 specimens m^{-2}). A significant concentration characterised *Nematoda* (71 000 specimens $m^{-2)}$ as well as *Cyclopoida* (64 000 specimens m^{-2}). The concentration of the remaining taxa did not exceed 28 000 specimens m^{-2}.

On foil, similarly to the potato-bag fabric, only the occurrence of *Chironomidae* larvae was stated (50 000 specimens $^{-2}$).

The visibility of the Secchi disc in Lake Kopań varied in different seasons from 0.25 to 0.9 m ($\overline{x}$ = 0.5m).

DISCUSSION

Lake Kopań is a shallow reservoir ($\overline{x}$ depth = 1.9 m) of an area of 790 hectares. Direct inflows of brackish waters from the Baltic via the Kopański Canal (length ≈ 500 m) are seasonal (up to 2 weeks a year). A very important feature of this body of water, constituting a cryptodepression, seems to be the infiltration of Baltic waters through a sandy bar which separates the lake from the sea. The small influx of fresh water from drainage ditches is an essential feature in maintaining the brackish environment (β-oligohaline). The average salinity within the study period amounted to 97.9 mg Cl^{-} dm^{-3} (1.9 PSU), (Trojanowski unpubl.). Waters of the lake are highly eutrophicated (polytrophy) and the average content of nitrogen was: 0.048 mg $N\text{-}NH_3$ dm^{-3} and 0.88 mg $N\text{-}NO_3$ dm^{-3} while the average content of phosphates: 0.058 mg $P\text{-}PO_4$ dm^{-3} (Trojanowski unpubl.).

On the south coast of the lake (in the village of Palczewice, Fig. 1) in the period preceding the study a large-scale pig fattening farm was operating. Its activity undoubtedly had an influence on the contamination and eutrophication of Kopań Lake. Before the farm opened in the 60s, the total phosphorus content amounted to 0.19 mg on an average TP dm^{-3}, and after its liquidation - 0.21 mg TP dm^{-3} (Trojanowski *et al*. unpubl.). In the period when the farm operated the water pH in the lake was dangerously high and it was between 9.4 and 9.6 (Trojanowski *et al.* 1990), which threatened the development of many aquatic animal species („alcalosis"; Liebmann 1960). After the farm closed down in the study period the water pH varied

from 7.1 to 9.1 pH ($\overline{x}$ = 7.7). Favourable oxygen conditions prevail in Lake Kopań in the vegetative season: 9.0-13.8 mg O_2 dm^{-3} (Trojanowski unpubl.). Despite the polymictic character of the lake, a decrease of the oxygen content above the muddy bottom was observed. Presumably, the muddy bottom and the periodically unfavourable oxygen conditions in the benthic layer of the water were among the reasons of the poor quality of benthos invertebrates in the central part of the lake. Macrobenthos of this area was represented mostly by *Chironomidae* larvae and *Oligochaeta*, with a total absence of *Mollusca* (Dobrowolski unpubl.). Saltwater species represented by *Rotatoria*, *Copepoda*, and *Cladocera* were dominant in the plankton (Paturej 2000). In the catches, the dominant fish species were the zander and the silver bream. The average fisheries productivity of Lake Kopań is estimated for some 10 kg ha^{-1} and is the lowest among Polish coastal lakes (Orzechowski 1997 and Orzechowski unpubl.).

The periphyton formation will play a significant role in the processes of the biodiversity enhancement, purification, and deutrophication of waters as well as formation of a food base primarily for the extensive culture of the rainbow trout using the active substrate method, developed by Szlauer (1974, 1980) and Piesik (1978, 1992). The presently conducted studies of the periphyton on different substrates in Lake Kopań will allow, in the near future, to determine the directions of qualitative and quantitative changes of this formation after the introduction of Baltic waters to this body of water.

The periphyton studies conducted by the authors in the years 1999-2000 demonstrated, that phytoperiphyton in Lake Kopań developed best on polyethylene foil substrate (2 771 000 cells m^{-2}) as well as on potato-bag fabric (2 240 000 cells m^{-2}). The concentration of periphytic algae was lower on the thick stilon fabric (1 645 000 cells m^{-2}), where surprisingly, *Chlorophyta* were the most abundant. It is an unusual phenomenon for periphyton studied in different environments, where on each substrate the dominants used to be *Bacillariophyta* (Piesik 1992). In Lake Kopań the phytoperiphyton exhibited the poorest development on the biotic substrate of *Phragmites australis* (Table 1). It is evident from a comparison of the concentration of periphytic taxa on different substrates in Polish water courses and other water bodies, that the phytoperiphyton concentrations in Lake Kopań are the lowest, which means that the environmental conditions there are not favourable for the mass development of algae growing on substrates (Table 3).

Periphytic microfauna reached its highest quantitative development on the thick stilon fabric (2 100 000 specimens m^{-2}). Openwork potato-bag fabric substrate was settled less extensively (705 000 specimens m^{-2}) similarly as polyethylene foil (606 000 specimens m^{-2}). Similarly as phytoperiphyton, the microfauna was least abundant on the reed (54 000 specimens m^{-2}). The number of microfauna taxa on the studied substrates of Lake Kopań varied from 8 to 12 and did not differ much from the number of taxa stated on the substrates in different aquatic environments (Table 4). It is evident from the data shown in Table 4, that among the periphytic microfauna, the best development on substrates, also in Lake Kopań, was achieved by *Peritricha*, *Nematoda* and *Rotatoria*.

Table 4

Comparison of mean density (specimens m^2 of substrate) of microperiphyton and macrozooperiphyton growing on biotic and on artificial substrate in selected watercourses, rivers, lake and the Puck Bay

Taxon	On *Phragmites australis*			On potato-bag fabric substrate				Stilon bag	Utility foil
	River Odra (Piesik, Wawrzyniak-Wydrowska, unpubl.)	Lake Jamno (Piesik, Wiśniewska, unpubl.)	Lake Kopań (author's data)	Młyński Canal (sewage ditch Okunica) (Piesik 1992)	River Płonia (Okunica) (Piesik 1992)	Net Pucka Bay (Piesik 1992)	Lake Kopań (author's data)	Lake Kopań (author's data)	Lake Kopań (author's data)
microfauna									
Total *Protozoa*	**607 300**	**1 381 030**	**19 286**	**39 211 200**	**11 616 970**	**3 292 950**	**140 000**	**595 000**	**10 7143**
Testacea	0	5 810	2 242	2 700	29 010	0	35 000	515 000	0
Ciliata – libera	0	0	288	4 553 000	370 940	0	15 000	0	0
*Peritricha**	275 590	72 100	16 756	34 620 00	11 213 000	457 560	90 000	80 000	107 143
Suctoria	331 710	32 400	0	35 500	4 020	2 835 390	0	0	0
Rotatoria	**46 570**	**69 633**	**22 649**	**136 320**	**921 360**	**12 010**	**60 000**	**70 000**	**185 714**
Nematoda	**50 570**	**40 000**	**8 418**	**58 800**	**584 320**	**120 150**	**285 000**	**1 020 000**	**71 428**
Total *Oligochaeta*	**1 866**	**39 533**	**1 224**	**3 260**	**610 570**	**3 900**	**0**	**0**	**0**
Stylaria sp.	+	+	869	0	+	0	70 000	60 000	14 286
Nais sp.	+	+	227	0	+	0	0	0	0
Cheatogaster sp.	+	+	128	0	+	0	45 000	120 000	14 286
Tubificidae	0	0	0	3 260	0	0	0	0	0
Total *Copepoda*	**0**	**0**	**1 996**	**158**	**15 580**	**0**	**40 000**	**0**	**92 857**
nauplius	0	0	392	158	740	44 020	10 000	0	28 571
Cyclopoidae	3 500	0	0	0	14 580	480	0	15 000	64 286
Harpacticoida	1 920	0	1 605	0	0	10 740	30 000	185 000	0
***Cladocera (Chydorus* sp.)**	**0**	**14 733**	**1 286**	**0**	**0**	**0**	**25 000**	**35 000**	**27 851**
Hydracarina	**0**	**0**	**14**	**0**	**0**	**0**	**0**	**0**	**0**
Bivalvia (Dreissena* sp.– *postveliger)	**711 706**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Explanations:
*concentration in zooids m^{-2} of reed
+ occurrence single individuals

Periphytic macrofauna on the substrates of Lake Kopań was qualitatively poorer (1-4 taxa) in comparison to the number of taxa settling substrates in environments subjected to influx of brackish Baltic waters (estuary parts of the River Odra and the Świna Strait) or those with the salinity below 4 PSU (*e.g.* Puck Bay; 8-9 macrofauna taxa). It is evident from the data in Table 5, that different species of *Hydrozoa* and *Chironomidae* larvae represent the periphytic macrofauna studied in the estuary, while in the Puck Bay different species of *Amphipoda* and *Isopoda* find good conditions for development.

Table 5

Periphytic macrofauna on different substrates in Polish coastal bodies of water

Taxon	Stilon nets		*Phragmites australis*			Stilon bag	Utility foil	On potato-bag fabric substrate
	Stara Świna strait (Piesik 1992)	Puck Bay (Piesik 1992)	Lake Jamno (Piesik, Wiśniewska, unpubl.)	River Odra (Piesik, Wawrzyniak-Wydrowska, unpubl.)	Lake Kopań (author's data)	Lake Kopań (author's data)	Lake Kopań (author's data)	Lake Kopań (author's data)
macrofauna								
Hydra sp.	2 120	0	0	10 400	942	0	0	0
*Cordylophora caspia**	23 020	54 300	0	3 013	0	0	0	0
*Laomedea loveni**	0	0	0	0	0	0	0	0
Turbellaria	100	0	0	0	0	0	0	0
Polychaeta	0	540	0	0	0	0	0	0
Hirudinea	0	0	0	30	0	0	0	0
Gammarus sp.	0	1 780	0	80	0	0	0	0
Corophium sp.	113	0	0	40	0	0	0	0
Idotea sp.	0	1 140	0	0	0	0	0	0
Sphaerom sp	0	140	0	0	0	0	0	0
Balamus sp.	28	450	0	0	0	0	0	0
Asellus sp.	0	0	0	115	16	5 000	0	0
Chironomidae larvae	5 940	250	205	4 030	640	485 000	50 000	365 000
Gastropoda	1	0	194	40	+	0	0	0
Dreissena polymorpha	+	0	0	0	0	0	0	0
Mytilus edulis	+	910	0	0	0	0	0	0
Bryozoa *	0	7 090	0	2 690	0	0	0	0
Total macrofauna	**31 322**	**66 600**	**399**	**20 438**	**1 598**	**490 000**	**50 000**	**365 000**
Number of taxa	8	9	2	9	4	2	1	1

Explanations:
*concentration in zooids m^{-2} of reed
+ occurrence of single individuals

A comparison of the periphytic fauna from substrates in Lake Kopań with the fauna from stilon nets in the Puck Bay (Tables 4 and 5) indicates that after the exchange of fresh water to Baltic water in the lake, the organisms, which eliminate seston through filtration (*Peritricha*, *Balanus improvisus*, *Mytilus edulis*, *Bryozoa*) will develop extensively. Intensively reproducing sedentary predators (*Suctoria*, *Hydrozoa*) will also eliminate plankton from the water, contributing, along with filtrators to its elimination through biosedimentation to the bottom sediments. The development of *Hydrozoa* is one of the reasons for *Gammaroidea*, feeding on them, to settle the substrate in a significant number (Piesik 1992). The mass development of periphytic algae, *Hydrozoa* colonies, and other organisms, which affect the development of periphytic herbivores (*Polychaeta*, *Idotea*, *Sphaeroma*) and the omnivore *Gammaroidea*, contribute to the formation of a rich food base for the rainbow trout culture in the lake.

A supplementary artificial substrate provided in Lake Kopań at the proper time, will also be used as a spawning ground for some fish species (Piesik 1978, 1992; Wawrzyniak 1987). The hatched fry will find shelter and a rich supply of food on openwork substrate. The algae growing on the substrate, mostly diatoms, contribute to competition for nutrients from the plankton, and with a mass development, will not contribute to change of water colour, which would be unfavourable for recreational purposes.

In can be expected, that the introduction of Baltic waters into the excessively eutrophicated Lake Kopań, will be favourable to the growth of benthos, plankton, nekton, as well as periphyton formations. Open-work substrates, can be used for water cleaning (biofiltration, bioaccumulation), as well as for shellfish mariculture (*Amphipoda*, *Isopoda*, *Mytilus*), which can be used as a supplementary source of animal protein for feeds, or as an live feed for trout fry, and other fish try as well.

CONCLUSIONS

1. A growth of organisms, representing all trophic levels (producers, reducers, consumers), was stated on substrates (*Phragmites australis*, stilon fabric, potato-bag fabric, foil) available in Lake Kopań.
2. On the studied substrates, producers were represented mainly by *Bacillariophyta*, with the exception of stilon fabric, where *Chlorophyta* were the dominant. The concentration of periphytic microalgae (algae units) on the studied substrates was not high (1 645-2 771 thousand cells m^{-2}) in comparison to other, earlier-mentioned substrates in various aquatic environments. In Lake Kopań, biotic substrate of *Phragmites australis* was settled the least extensively.
3. Periphytic microfauna on substrates of Lake Kopań was represented by 8-12 taxa, reaching the highest diversity of species on *Phragmites australis*. The periphytic microfauna concentration on individual substrates amounted to 54-2 100 thousand specimens m^{-2} on an average. *Peritricha*, *Nematoda*, and *Rotatoria* had the highest concentrations on Lake Kopań substrates.
4. Periphytic macrofauna on artificial substrates in Lake Kopań was qualitatively poor (1-2 taxa). A somewhat better diversity of macrofauna was observed on biotic substrate (*Phragmites*), where 4 taxa of macrofauna were recorded. Among

the identified taxa, the most dominant were *Chironomidae* larvae, and sporadically the presence of *Asellus aquaticus* was observed.

5. It is evident from the available data sources that Lake Kopań shows much lower extent of development of periphytic complexes compared to those of the Baltic Sea (Puck Bay). Therefore it is possible that the planned exchange of fresh water to Baltic waters will contribute to the promotion biodiversity enhancement in periphyton formations. The latter can be utilised through installation of open-work artificial substrates for water purification, deutrophication, and to mariculture purposes.

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ORGANIZMY POROŚLOWE (PERIFITON) ZASIEDLAJĄCE TRZCINĘ *PHRAGMITES AUSTRALIS* I SZTUCZNE PODŁOŻE W PRZYMORSKIM JEZIORZE KOPAŃ

Streszczenie

Organizmy poroślowe zasiedlające biotyczne i sztuczne podłoża w polskich jeziorach przymorskich są słabo poznane. W ramach interdyscyplinarnych badań nad rewitalizacją zeutrofizowanego jeziora Kopań przeprowadzono w 1999 roku badania różnych formacji ekologicznych w tym formacji perifitonu zasiedlającego *Phragmites australis* oraz sztuczne stylonowe podłoża.

Wykazano, że średnie zagęszczenie glonów poroślowych na trzcinie w jeziorze Kopań wynosiło: 104 000. komórek m^{-2}, mikrofauny poroślowej 54 874 osobn. m^{-2} oraz makrofauny 1 598 osobn. m^{-2}. Zagęszczenie perifitonu na badanym podłożu biotycznym było znacząco niższe w porównaniu do porośli na sztucznym podłożu (roszla, tkanina stylonowa, folia) umieszczonych w jeziorze Kopań. W projekcie rewitalizacji jeziora formacja poroślowa będzie spełniać istotną rolę w doczyszczaniu, deeutrofizacji wód oraz tworzeniu dodatkowej obfitej bazy pokarmowej dla ekstensywnej hodowli pstrąga tęczowego.