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Factors Differentiating the Habitats Occupied by Phytocoenoses of *Phragmitetum communis* (Gams 1927) Schmale 1939 in Lakes of Wielkopolska Region

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Abstract

In the summers of 1996-1998 habitat studies of 60 phytocoenoses of *Phragmitetum communis* in 30 lakes of Wielkopolska region were carried out. The aim of the study was a comparison of two groups of phytocoenoses exposed to different effects of wind (and waves) and two other groups subjected to a different degree of anthropopressure in respect to 28 properties of water and 23 properties of substrate. Results were expected to answer the question whether the phytocoenoses of this community reveal an internal ecological variability (habitat and floristic) in the local scale as well as to determine which of the two factors has a more important differentiating effect on the phytocoenoses and their habitats.

Keywords: phytocoenoses of *Phragmitetum communis,* effect of wind and waves action, anthropopressue of different intensity, water and substrate properties, internal ecological variability in the local scale.

Introduction

The factors influencing the properties of habitats occupied by water and rush communities, apart from morphometric features of the water ecosystem, include wind-producing waves [1-4], and anthropopressure of different intensity [4-12]. These factors are interrelated, influenced by the morphometry of the water reservoir and exert a combined synergistic effect on the littoral habitats and relevant phytocoenoses. Correct interpretation of results of habitat studies in the phytolittoral zone requires taking these factors into account besides morphometry and physical and chemical characteristics.

In the summer seasons of the years 1996-1998 habitat studies of 60 phytocoenoses of *Phragmitetum communis* of different exposition to wind (waves) and anthropopressure in 30 lakes of Wielkopolska region were performed. Apart from a detailed habitat characteristic of the most common rush community, the aim of the study was a comparison of two groups of phytocoenoses exposed to different effect of wind (and waves) and two other groups subjected to a different degree of anthropopressure due to 28 properties of water and 23 properties of substrate. Moreover, we wished to assess the significance of possible habitat differences and find out whether they are accompanied by floristic differentiation. Results were expected to answer the question whether the phytocoenoses of this community reveal internal ecological variability in the local aspect [13] as well as to determine which of the two factors has a more important differentiating effect on the phytocoenoses and their habitats.

The Study Area

The investigations were carried out in 30 natural lakes from the western Poland region of Wielkopolska, in the Poznan Lake District characterized by a large area, location in the centre of Wielkopolska Lake District, a great number of lakes and geomorphological diversity [14]. The lakes studied included those from the Wielkopolski National Park and its protection zone.

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Material and Methods

The subjects of the studies were phytocoenoses of rush community and their habitats and not the lakes in which investigation were carried out. Releves (phytosociological records) of the phytocoenoses of *Phragmitetum communis* were taken according to the Braun-Blanquet method, samples of water were collected from the central part of the patch and at an intermediate depth, samples of substrate were collected from the root-rhizome zone and the depth of the patch was measured. Physical and chemical analyses in order to determine 28 characteristics of water and 23 characteristics of substrate (heavy metal concentration included) were determined immediately after sample collection and the material collected was stored in a refrigerator. The analytical procedure proposed by Siepak was applied [15]. All determinations were performed twice and the mean value was taken as a result. The determinations were verified on the basis of the ionic balance of water.

In order to divide the phytocoenoses studied into groups subjected to different influence of wind (waves) different criteria can be applied, e.g. those related to the morphometry of the lake. The criterion assumed in this work was based on the fact that dominant in Wielkopolska are the western and southwestern winds and the exposition of phytocoenoses to their effect was considered [16]. Consequently, the phytocoenoses in the number of 32, localized along the eastern and northeastern and northern shore of the lakes were assumed as subjected to a greater influence of wind and waves. The group of 28 phytocoenoses localized along the western, northwestern, southern and southeastern shores was treated as subjected to a much weaker effect of wind. The parameters of water and substrate in the two groups of phytocoenoses were compared. Statistical significance of the comparison was tested by U Mann-Whitney test [17], for the zero hypothesis of the lack of statistically significant habitat differences between the groups.

The phytocoenoses studied were also divided into two groups (N=30 each) according to the intensity of anthropopressure to which they were subjected. The criterion of the degree of anthropopressure was based on the morphometric and catchment data (estimated annual loading with nitrogen and phosphorus, catchment area and the percent contribution of particular types of catchment etc.). The information on the anthropopressure was taken from the lake monitoring study and assessment of the lake's susceptibility to degradation [18-30], and our own observations. Statistical significance of the differences between the habitats of the two groups of phytocoenoses was checked by the U Mann-Whitney test [17] for the zero hypothesis of the lack of significant differences between the two groups. The use of a non-parametrical test in this case as well as above was caused by the inconsistency between the empirical distributions of abundance and the normal distribution. The statistically significant differences were illustrated by box and whisker type diagrams.

When significant differences in the habitat were

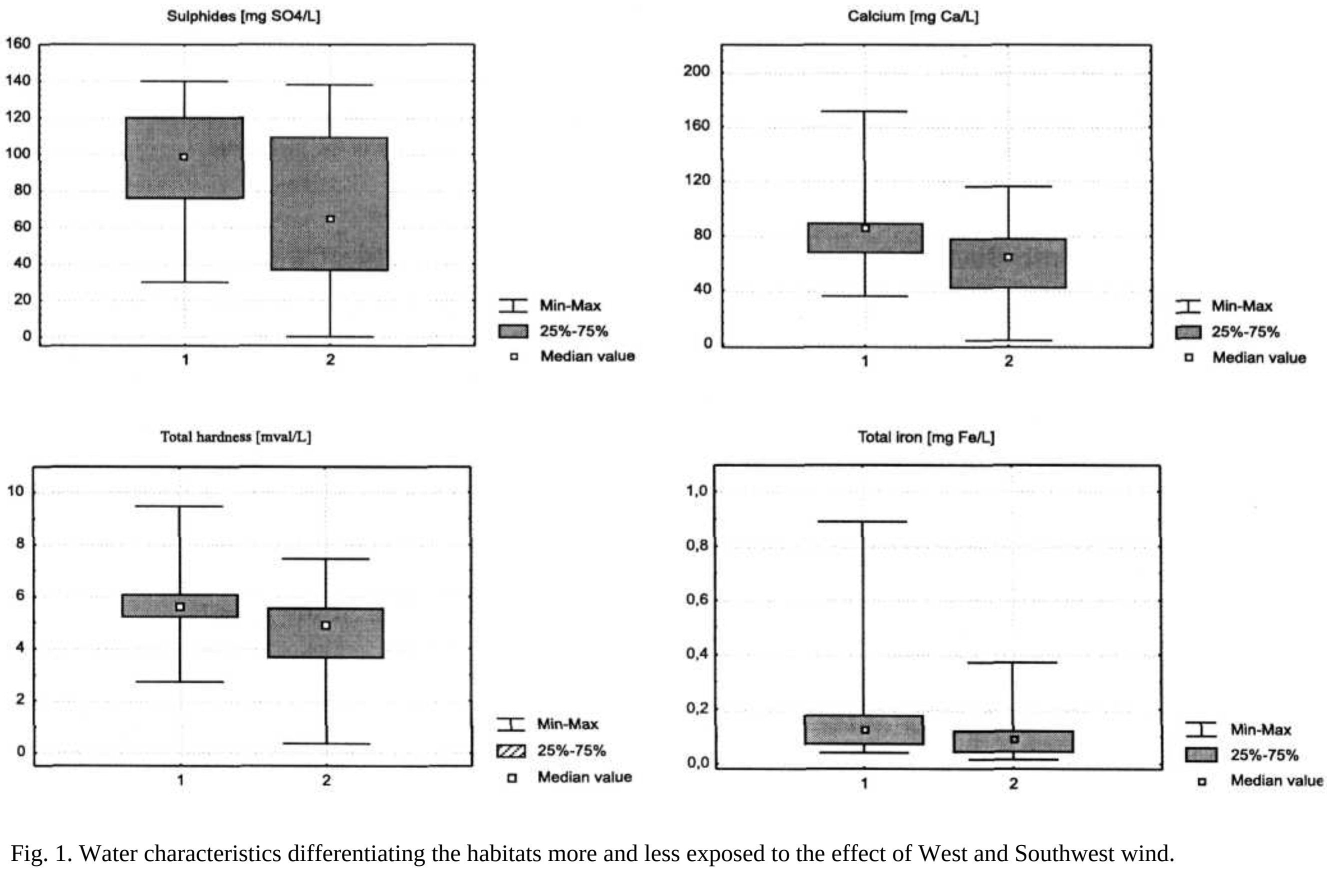


Fig. 1. Water characteristics differentiating the habitats more and less exposed to the effect of West and Southwest wind. Group 1 - phytocoenoses subjected to a weaker effect of wind and waves, N=28. Group 2 - phytocoenoses subjected to a stronger effect of wind and waves, N=32.

Table 1. The effect of wind and waves on the habitats of the lake littoral; a comparison of the properties of water in *Phragmitetum communis* phytocoenoses subjected to a weaker effect of wind and waves (group 1, N=28) and subjected to a stronger effect of wind and waves (group 2, N=32); the dominant direction of wind in Wielkopolska was assumed from the West and Southwest. For the properties contained in the table the zero hypothesis of the lack of significant differences was rejected.

Mann-Whitney U Test									
	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-level	Z adjusted	p-level	Valid N Group 1	Valid N Group 2
SO_4	997.5	832.5	304.5	– 2.1263	0.033486	– 2.12689	0.033437	28	32
Ca	1062	768	240	– 3.08202	0.002058	– 3.08343	0.002048	28	32
total hardness	1046.5	783.5	255.5	– 2.85235	0.004343	– 2.85302	0.004333	28	32
total Fe	993	837	309	– 2.05962	0.039443	– 2.0624	0.039178	28	32

Table 2. A comparison of the water properties in two groups of phytocoenoses subjected to weaker (group 1, N=30) and stronger anthropopressure (group 2, N=30). The zero hypothesis of the lack of significant habitat differences between the two groups was rejected for the properties contained in the table.

Mann-Whitney U Test									
Properties:	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-level	Z adjusted	p-level	Valid N Group 1	Valid N Group 2
BOD_5	692.5	1137.5	227.5	– 3.28953	0.001005	– 3.29049	0.001001	30	30
$N\text{-}NO_3$	782	1048	317	– 1.96633	0.049269	– 2.73271	0.006285	30	30
total phosphates	692.5	1137.5	227.5	– 3.28953	0.001005	– 3.29632	0.000981	30	30
SiO_2	681	1149	216	– 3.45956	0.000542	– 3.47738	0.000507	30	30

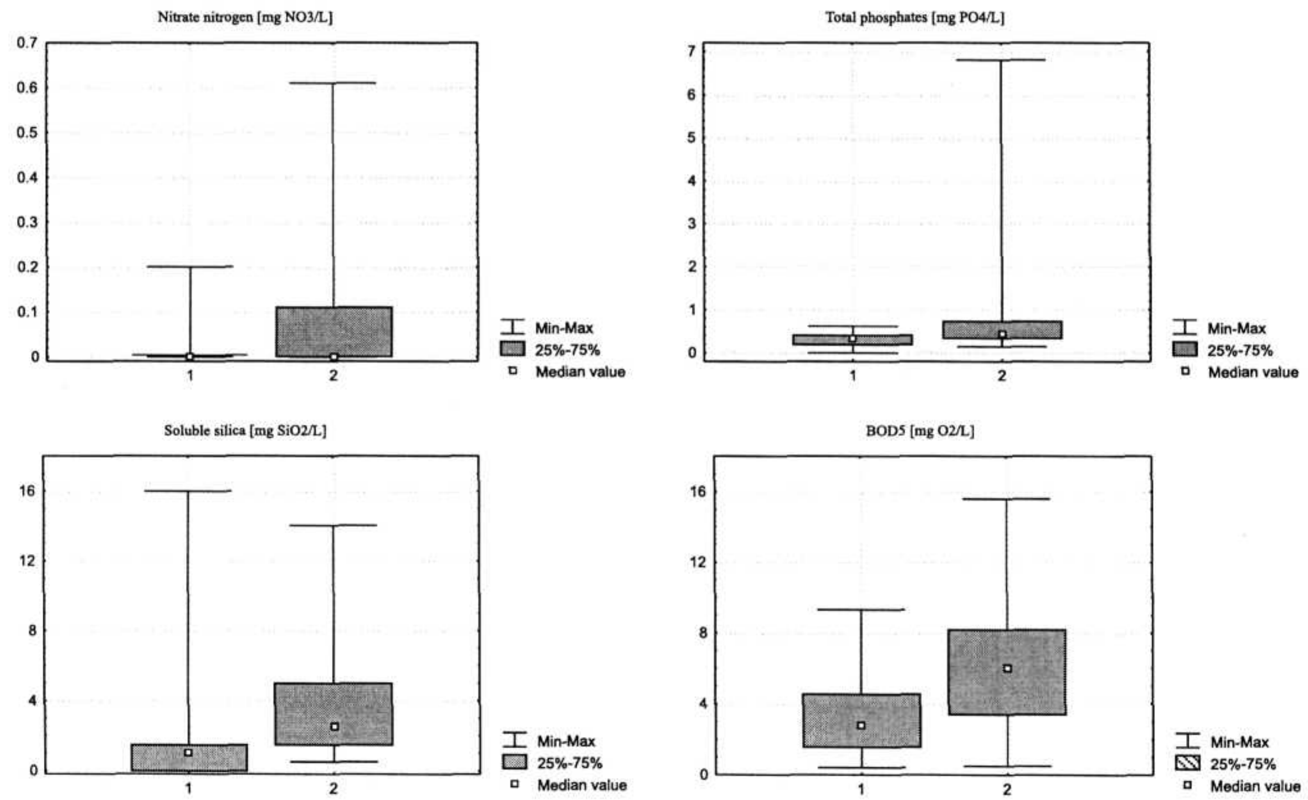
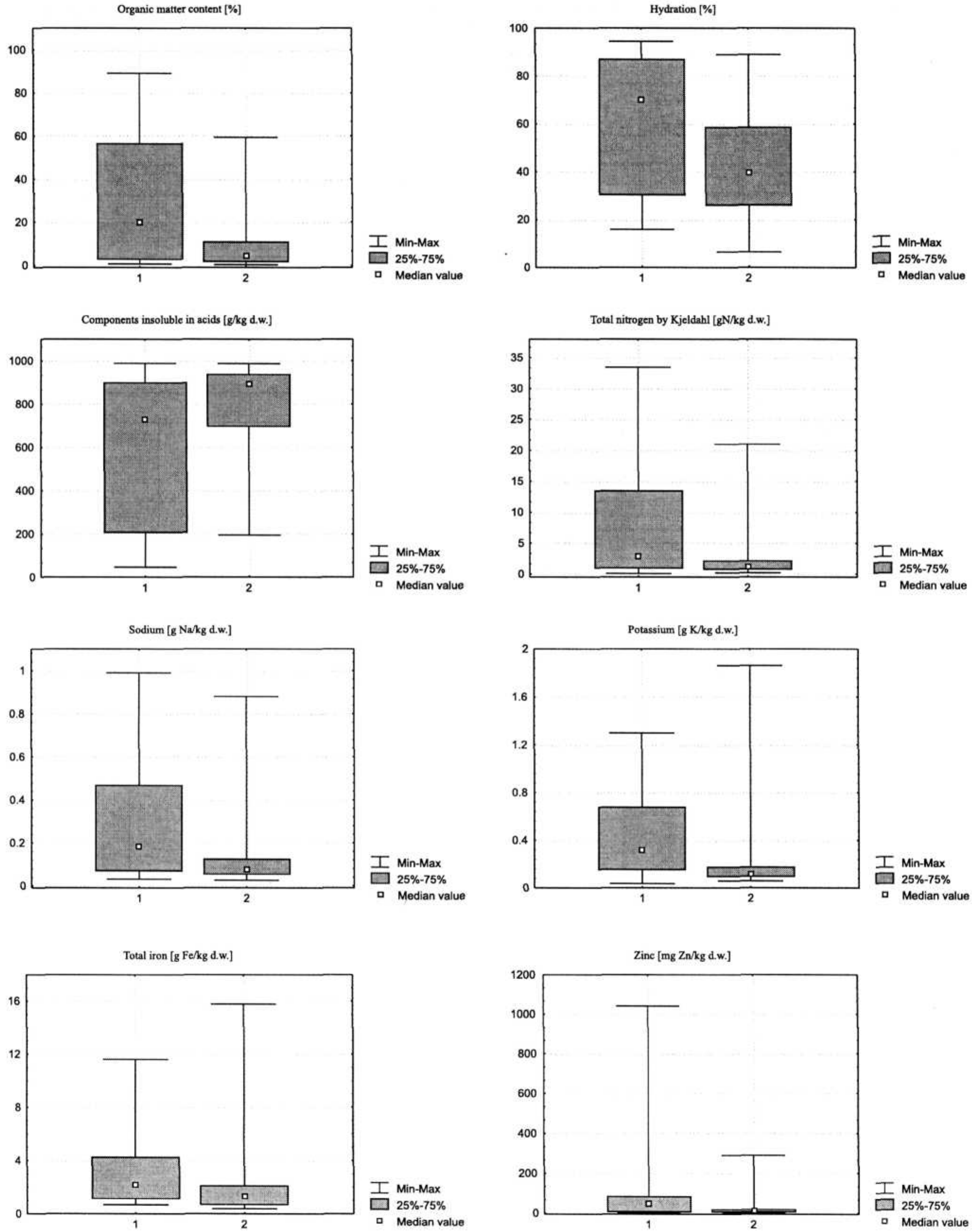


Fig. 2. Statistically significant habitat differences between two groups of phytocoenoses occurring in lakes subjected to stronger and weaker anthropopressure - water properties.
1 - phytocoenoses in the lakes subjected to weaker anthropopressure, N = 30.
2 - phytocoenoses in the lakes subjected to stronger anthropopressure, N=30.



Organic matter content [%]
0
20
40
60
80
100
1
2
Min-Max
25%-75%
Median value
Hydration [%]
0
20
40
60
80
100
1
2
Min-Max
25%-75%
Median value
Components insoluble in acids [g/kg d.w.]
0
200
400
600
800
1000
1
2
Min-Max
25%-75%
Median value
Total nitrogen by Kjeldahl [gN/kg d.w.]
0
5
10
15
20
25
30
35
1
2
Min-Max
25%-75%
Median value
Sodium [g Na/kg d.w.]
0
0.2
0.4
0.6
0.8
1
1
2
Min-Max
25%-75%
Median value
Potassium [g K/kg d.w.]
0
0.4
0.8
1.2
1.6
2
1
2
Min-Max
25%-75%
Median value
Total iron [g Fe/kg d.w.]
0
4
8
12
16
1
2
Min-Max
25%-75%
Median value
Zinc [mg Zn/kg d.w.]
0
200
400
600
800
1000
1200
1
2
Min-Max
25%-75%
Median value

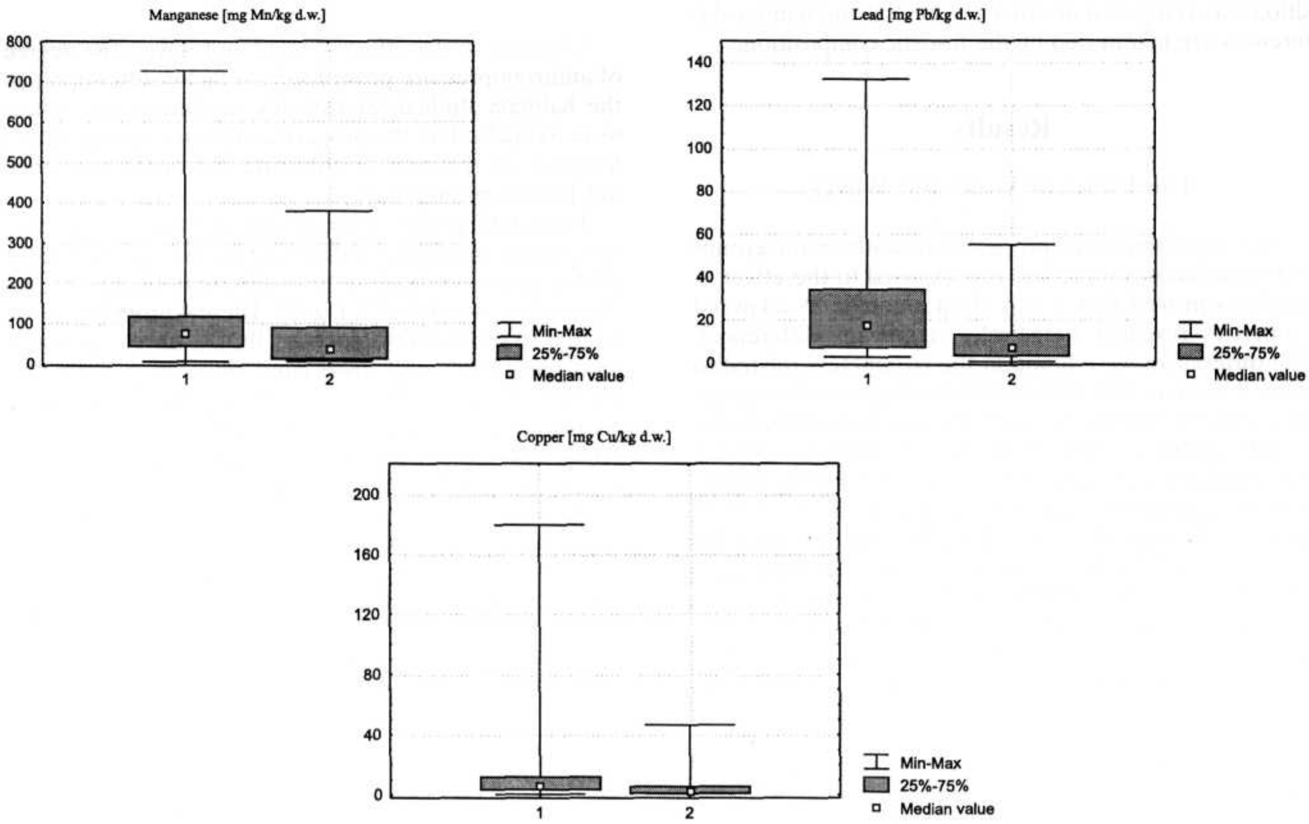


Fig. 3. Statistically significant habitat differences between two groups of phytocoenoses occurring in lakes subjected to weaker and stronger anthropopressure - substrate properties.
1 - phytocoenoses in the lakes subjected to weaker anthropopressure, N=30.
2 - phytocoenoses in the lakes subjected to stronger anthropopressure, N=30.

Table 3. A comparison of the substrate properties in two groups of phytocoenoses subjected to weaker (group 1, N=30) and stronger anthropopressure (group 2, N=30). The zero hypothesis of the lack of significant habitat differences between the two groups was rejected for the properties contained in the table.

Mann-Whitney U Test									
Properties:	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-level	Z adjusted	p-level	Valid N Group 1	Valid N Group 2
hydration	1084.5	745.5	280.5	– 2.50596	0.012217	– 2.506	0.012216	30	30
organic matter content	1092	738	273	– 2.61684	0.008879	– 2.61688	0.008878	30	30
components insoluble in acids	765	1065	300	– 2.21766	0.026585	– 2.21769	0.026583	30	30
total Kjel. nitrogen	1089	741	276	– 2.57249	0.010101	– 2.57274	0.010094	30	30
Na	1094.5	735.5	270.5	– 2.6538	0.007963	– 2.65395	0.007959	30	30
K	1133	697	232	– 3.223	0.00127	– 3.22368	0.001267	30	30
total Fe	1074	756	291	– 2.35072	0.018743	– 2.35079	0.01874	30	30
Pb	1109	721	256	– 2.86818	0.004131	– 2.86926	0.004117	30	30
Cu	1084	746	281	– 2.49857	0.012475	– 2.49892	0.012462	30	30
Zn	1072.5	757.5	292.5	– 2.32855	0.019889	– 2.32884	0.019874	30	30
Mn	1055.5	774.5	309.5	– 2.07721	0.03779	– 2.07747	0.037766	30	30

found between the phytocoenoses, their floristic composition was compared in order to check if the habitat differences are manifested by the floristic composition.

Results

The Effect of Wind and Waves

A comparison of the properties of water in the groups of phytocoenoses more and less exposed to the effect of wind has proved that 4 only from amongst 28 analyzed properties revealed statistically significant differences. The differences were found in the parameters related to water hardness and mineralization degree, whereas no differences were found in properties characterizing water fertility. Analysis of the properties of substrate also did not reveal any significant differences between the groups of phytocoenoses studied, although such differences were expected. Results of the U Mann-Whitney test used for verification of the zero hypothesis about no significant differences and for verification of significance of potential differences are presented in Table 1 and in Fig. 1 for properties of water in case of which significant differences were found. This test was also used to check the differences in the depth of occurrence in the lake between the two groups, which could influence the result of the comparison. The difference was not statistically pronounced.

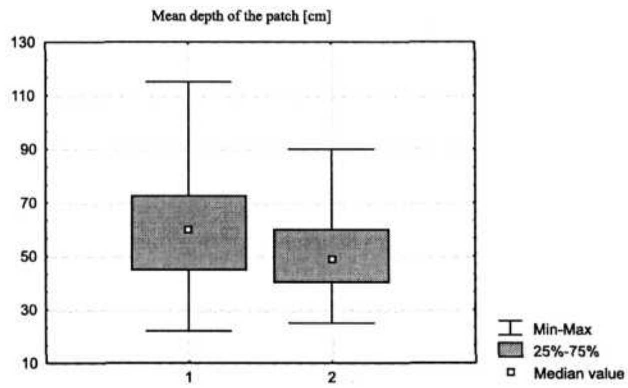


Fig. 4. Statistically significant habitat differences between two groups of phytocoenoses occurring in lakes subjected to weaker and stronger anthropopressure - mean depth of the patch.
1 - phytocoenoses in the lakes subjected to weaker anthropop ressure, N=30.
2 - phytocoenoses in the lakes subjected to stronger anthropop ressure, N=30.

The Effect of Anthropopressure

Contrary to the effect of wind and waves, the degree of anthropopressure proved to be a factor differentiating the habitats studied. Statistically significant differences were found both in the properties of water and substrate; however, in the case of substrate the differences were much more pronounced.

From among the 28 properties of water, 4 revealed statistically significant differences in the two groups of phytocoenoses subjected to a different degree of anthropopressure (Table 2, Fig. 2). These 4 properties were related to the fertility of water: BOD_5, nitrate nitrogen, total phosphates and dissociated silica. In general, the habitats of the phytocoenoses in the lakes subjected to greater anthropopressure were characterized by higher values of the water parameters, which was also manifested by higher values of electrolytic conductivity.

As far as substrate is concerned, 11 from among 23 of its properties revealed statistically significant differences between the two groups of phytocoenoses (Table 3, Fig. 3). However, contrary to the properties of water, the majority of values characterizing substrate in the group of phytocoenoses subjected to greater anthropopressure were lower than in the other group. Statistically significant differences were found in the properties describing the richness of substrate such as the content of organic matter, biogens and related characteristics. Moreover, the concentrations of metals - mainly sodium, potassium, total iron and the majority of heavy metals - were much lower.

The difference in the mean depth of the patch occurrence of the two groups of phytocoenoses was also statistically significant, (Table 4, Fig. 4), and the phytocoenoses in the water reservoirs subjected to greater anthropopressure occurred at lower depths.

In order to check if the habitat differences related to different intensity of anthropopressure are reflected by differences in floristic composition of the two groups of phytocoenoses, an appropriate comparison was made and the results are given in Table 5. As follows from Table 5, habitat differentiation was not reflected in significant differences in floristic composition. The floristic differences were in the absence or presence of a particular taxon or total number of species rather than in synthetic features such as the coefficient of cover or phytosociological constancy. A more pronounced difference was noted in the cover coefficient of *Typha angustifolia* L, which was much lower in the group of phytocoenoses subjected to greater anthropopressure, despite the same constancy.

Table 4. A comparison of the mean depth of patches in two groups of phytocoenoses subjected to weaker (group 1, N = 30) and stronger anthropopressure (group 2, N = 30). The zero hypothesis of the lack of significant differences was rejected.

Mann-Whitney U Test									
Properties:	Rank Sum Group 1	Rank Sum Group 2	U	Z	p-level	Z adjusted	p-level	Valid N Group 1	Valid N Group 2
mean depth	1091	739	274	– 2.60206	0.009271	– 2.61874	0.00883	30	30

Table 5. A comparison of the species composition of *Phragmitetum communis* phytocoenoses occurring in the Wielkopolska lakes subjected to a different degree of anthropopressure.

Phragmitetum communis	In the lakes under weaker anthropopressure			In the lakes under stronger anthropopressure		
Number of releves:	30			30		
Total number of species:	47			36		
Mean number of species in one releve:	5.7			4.9		
	Constancy		Coeff. of cover	Constancy		Coeff. of cover
Ch. Phragmition						
Phragmites australis	V^{2-5}	100.0	6858	V^{3-5}	100.0	8000
Typha angustifolia	III^{r-3}	56.7	352	III^{r-1}	43.3	19
Typha latifolia	I^{+}	13.3	51	II^{r-2}	26.7	51
Sparganium erectum	I^{r-1}	20.0	9	I^{r-+}	16.7	<1
Acorus calamus	I^{r-2}	13.3	1	I^{+-2}	10.0	51
Schoenoplectus lacustris	I^{1}	3.3	8	I^{r-1}	10.0	8
Equisetum fluviatile	I^{+}	3.3	<1	I^{r}	6.7	<1
Rorippa amphibia	I^{r}	3.3	<1	I^{+}	6.7	<1
Glyceria maxima	.	.	.	I^{+}	3.3	<1
Ch. Phragmitetea						
Carex acutiformis	I^{r-+}	13.3	1	II^{r-1}	23.3	18
Lycopus europaeus	I^{+}	13.3	1	I^{r-+}	16.7	1
Rumex hydrolapathum	I^{r-+}	16.7	<1	I^{r-+}	10.0	<1
Sium latifolium	I^{r-+}	10.0	<1	I^{r-+}	10.0	<1
Mentha aquatica	I^{r-+}	16.7	<1	I^{r-+}	6.7	<1
Galium palustre	I^{r-+}	10.0	<1	I^{+}	3.3	<1
Phalaris arundinacea	.	.	.	I^{r}	3.3	<1
Carex pseudocyperus	I^{r-+}	10.0	<1	.	.	.
Eleocharis palustris	I^{+-1}	6.7	9	.	.	.
Epilobium hirsutum	I^{r-+}	6.7	<1	.	.	.
Alisma plantago-aquatica	I^{r}	6.7	<1	.	.	.
Stellaria palustris	I^{1}	3.3	8	.	.	.
Poa palustris	I^{+}	3.3	<1	.	.	.
Veronica anagallis	I^{+}	3.3	<1	.	.	.
Scutellaria galericulata	I^{r}	3.3	<1	.	.	.
Peucedanum palustre	I^{r}	3.3	<1	.	.	.
Accompanying species						
Ceratophyllum demersum	II^{+-3}	26.7	177	II^{r-+}	30.0	<1
Myriophyllum spicatum	I^{r-1}	16.7	17	II^{r-+}	30.0	<1
Solanum dulcamara	I^{r-1}	20.0	17	II^{r-+}	26.7	2
Fontinalis antipyretica	I^{+-3}	20.0	384	I^{+-4}	10.0	259
Bidens tripartitus	I^{r-1}	10.0	9	I^{r-+}	13.3	<1
Utricularia vulgaris	I^{r-4}	16.7	209	I^{+-3}	6.7	125
Lemna minor	I^{r-2}	16.7	53	I^{r}	3.3	<1
Najas marina	I^{r}	10.0	<1	I^{r-1}	6.7	8
Polygonum amphibium	I^{r-+}	10.0	<1	I^{r-+}	6.7	<1
Hydrocharis morsus-ranae	I^{r-3}	6.7	125	I^{4}	3.3	208
Calystegia sepium	I^{r-+}	6.7	<1	I^{r}	3.3	<1
Eupatorium cannabinum	I^{r}	3.3	<1	I^{+}	6.7	<1
Lysimachia nummularia	I^{r}	3.3	<1	I^{r}	3.3	<1
Potamogeton pectinatus	.	.	.	I^{r-+}	23.3	<1
Lysimachia vulgaris	.	.	.	I^{+}	3.3	<1
Nymphaea alba	.	.	.	I^{+}	3.3	<1
Nitellopsis obtusa	.	.	.	I^{+}	3.3	<1
Salix aurita	.	.	.	I^{+}	3.3	<1
Urtica dioica	.	.	.	I^{+}	3.3	<1
Lythrum salicaria	.	.	.	I^{r}	3.3	<1
Nuphar luteum	I^{+-2}	13.3	51	.	.	.
Lemna trisulca	I^{+-2}	6.7	50	.	.	.
Myriophyllum verticillatum	I^{r-+}	6.7	<1	.	.	.
Potamogeton natans	I^{3}	3.3	125	.	.	.
Chara tomentosa	I^{1}	3.3	8	.	.	.
Potamogeton perfoliatus	I^{+}	3.3	<1	.	.	.
Ranunculus repens	I^{+}	3.3	<1	.	.	.
Salix cinerea	I^{+}	3.3	<1	.	.	.
Spirodela polyrrhiza	I^{r}	3.3	<1	.	.	.
Ranunculus circinatus	I^{r}	3.3	<1	.	.	.
Sambucus nigra	I^{r}	3.3	<1	.	.	.

Discussion

A comparison of the effect of two factors: wind (and waves) and degree of anthropopressure on littoral habitats was made. Wind proved to be a factor not differentiating significantly the habitats occupied by the studied phytocoenoses of *Phragmitetum communis.* Contrary to the lack of the differentiating effect of wind, the degree of anthropopressure was evidenced to differentiate the habitats.

The result of the lack of the differentiating effect of wind (through waves) on the habitats of phytocoenoses of *Phragmitetum communis* is not consistent with the literature reports on the subject [1-4]. However, our conclusion is based on statistical analysis of many phytocoenoses and their habitats and is therefore statistically sound. It confirms conclusions of some authors emphasising the stabilizing effect of phytocoenoses of *Phragmitetum communis* on littoral habitats. The dominant species - common reed - is not only important for habitat formation [31], but has a stabilizing effect on littoral habitats protecting substrate against water movements. It hinders any mechanical changes in the substrate and facilitates resedimentation of fine particles abstracted from the substrate [32-33], having an influence on the chemical composition of water. On one hand, rush communities play the role of a buffer zone modifying the organic matter during its migration to the reservoir and, on the other hand, a protective belt of the lake close to the shore against the erosive effect of waves [33].

Anthropopressure proved to be a factor significantly differentiating the habitats occupied by the communities studied. The differences were more pronounced in the properties of substrate than in those of water. Greater habitat differentiation by the substrate properties has been described in literature [34] and interpreted as a consequence of the fact that the species forming the community are more dependent on the resources from the substrate. Moreover, habitat differentiation in respect to water properties did not correspond to that in respect to the properties of substrate, which indicates that these two components of the habitat can be to a substantial degree independent [34]. From among the habitat properties, the greatest differentiating effect on macrophyte communities have those related to fertility, which has been confirmed by our results.

Depth as an ecological factor is important for the type of community and the method of its development. It is correlated with the properties of habitats occupied by water and rush communities [35-36]. The result of the comparison of the mean depth of occurrence of the two groups of phytocoenoses under study has confirmed the differentiating power of the morphometric and catchment features used as criteria for the phytocoenoses division. Shallow habitats (shallow bays or reservoirs) are more susceptible to unfavourable anthropogenic effect. Lake morphometry is one of the factors determining the negative influence of external factors and is considered in the context of assessment of a given reservoir's susceptibility to degradation.

The evident habitat differentiation of the two groups of phytocoenoses subjected to higher or lower anthropopressure was not accompanied by floristic differences. This observation suggests a wide ecological amplitude of macrophyte vegetation whose communities occurring in sometimes much different habitats are characterized by a similar floristic composition and physiognomy [4]. This fact can also suggest that anthropopressure as an ecological factor cannot be considered as directly affecting the phytocoenoses of the common reed association studied. Therefore, it can be concluded that these phytocoenoses do not show an internal ecological variability on a local scale which assumes not only habitat but also floristic differentiation of a community in a given area. A rather unexpected result of a comparison of the substrate properties between the two groups of *Phragmitetum communis* phytocoenoses, according to which the habitats of the phytocoenoses subjected to greater anthropopressure were characterized by lower values of their particular characteristics, indicates that the relation community -> habitat is more probable than habitat —> community. The need for further studies is also implied, e.g. in the context of the influence of anthropopressure on biomass production and its deposition on the substrate.

Acknowledgements

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