Biodiv. Res. Conserv. 5-8: 61-69, 2007

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Comparison of the habitat conditions of peat-moss phytocoenoses dominated by *Eriophorum angustifolium* Honck. or *Carex rostrata* Stokes from mires in Western Poland

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Abstract: The presented phytosociological and habitat study concentrates on the moss phytocoenoses dominated by *Eriophorum angustifolium* or *Carex rostrata*, from 26 *Sphagnum* dominated peatlands adjacent to the lakes of the Wielkopolska region in Western Poland. Associations with these species dominate in the vegetation of the analysed mire configurations. 19 chemical parameters of surface water were analysed. Particular attention was paid to the determination of the habitat trophy and its indicators, the concentration of factors connected with the hardness of water, and the content of humic substances.
Phytocoenoses with *E. angustifolium* appeared in habitats where the analysed water parameters took lower values and more narrow amplitudes than those of the phytocoenoses with *C. rostrata*. The most important factors differentiating these two types of phytocoenoses, turned out to be the following: water colour, conductivity, Mg, Na and dissolved SiO_4. In conclusion, the appearance of phytocoenoses with *C. rostrata* was connected with habitats richer in nutrients and more advanced in the process of mineralisation than those of *E. angustifolium*.

Key words: *Carex rostrata*, *Eriophorum angustifolium*, mires vegetation, habitat conditions, habitat indicators, water chemistry, phytocoenoses

1. Introduction

Because of their transitional character and location between land and water, *Sphagnum* dominated peatlands play an essential role in the functioning of humic lakes. Physico-chemical character and biocenotic conditions of these lakes are conditioned by the constant flow of humic substances and nutrients provided by the direct catchment basin, and in particular by the zone of mires (e.g. Wojciechowski 1970, 1990; Górniak 1996, 1997; Górniak *et al*. 1999; Kruk 1997, 1999; Carpenter & Pace 1997; Williamson *et al*. 1999; Szmeja 2000; Wojtuń 2006).

Therefore, in order to determine the role of a given community in the accumulation, or in the transfer of particular elements of a habitat, it is essential to determine first the mutual relationships between habitat parameters of different phytocoenoses occupying the mires. The results of such a study may help to determine the role of vegetation in the diagnosis of abiotic conditions in mires and their impact on physico-chemical parameters of lake water (e.g. Wojciechowski 1990; Wojciechowski & Górniak 1990; Górniak 1996, 1997; Górniak *et al*. 1999; Kruk 1997, 1999; Gąbka *et al*. 2002, 2004).

The paper presents detailed characteristics of habitat conditions of phytocoenoses dominated by either *Eriophorum angustifolium* Honck. or *Carex rostrata* Stokes, located on peatlands adjacent to natural humic lakes. These species are considered characteristic of the associations (Brzeg *et al*. 2000; Brzeg & Wojterska

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2001): *Sphagno recurvi-Eriophoretum angustifolii* Hueck 1925 *nom. invers. et nom. mut*. (syn. *Eriophoro angustifolii-Sphagnetum recurvi* M. Jasnowski *et al.* 1968 *em.* Succow 1974 *p.p. nom. illeg.*) and *Sphagno apiculati-Caricetum rostratae* Osvald 1923 *em.* Steffen 1931 (syn. *Sphagno-Caricetum rostratae* Steffen 1931 *em.* Dierssen 1982) from the *Scheuchzerio-Caricetea fuscae* (Nordhagen 1936) R.Tx. 1937 class. Despite their wide presence in the territory of Poland and Central Europe, these associations are relatively little known and ambiguously presented in literature (e.g. Succow 1974; Jasnowska & Jasnowski 1983a, 1983b; Borysiak *et al.* 1998; Brzeg *et al.* 1996; Timmermann 1993; Matuszkiewicz 2001). In the case of *Sphagnum* dominated peatlands ecosystems of western Poland, these associations are the basic element of the mire vegetation. The aim of the study was to determine the differences between the ecological amplitudes of phytocoenoses dominated by *E. angustifolium* and those with *C. rostrata*.

2. Materials and methods

2.1. Study area

For the analysis, 26 *Sphagnum* dominated peatlands were selected (Table 1), all of them adjacent to the humic lakes distributed in the lake districts of the Wielkopolska region and of the Southern Pomerania (Kondracki 1998), both in western Poland. These mires are placed around small natural lakes (<10 ha), mostly very shallow (<5 m) and in the majority of cases situated in forests with the domination of a pine forest in a drainage basin. As far as the appearance of this type of ecosystems in Poland is concerned, these lakes are a bit off-centre, being mostly associated with the Pomerania region (e.g. Hutorowicz *et al.* 1999; Kraska *et al.* 1999). In the analysed region, such bog-lake ecosystems are a very rare element of the lakeland landscape.

The analysed region is characterised by small annual precipitation, ca. 500 mm per year. Mean annual temperatures range from 7.2°C in the north-eastern part of the region to 8.2°C in the west. The coldest season coincides with January (-1.5 – -2.5°C), the warmest weather is, over the years, traditionally noted in July (17.5 – 19.0°C) (Woś 1994).

2.2. Vegetation data

Phytosociological and habitat observation concerned mire phytocoenoses dominated by *Eriophorum angustifolium* or *Carex rostrata*. Phytosociological specificity of patches classified as *Sphagno recurvi-Eriophoretum angustifolii* and *Sphagno apiculati-Caricetum rostratae* was based on considerable density and abundance of characteristic species, i.e., *E. angustifolium* and *C. rostrata*, respectively.

Field investigations were carried out in the summer during the period of maximal growth (July, August) between 2001-2004. Phytosociological relevés were taken according to the Braun-Blanquet method (Braun-Blanquet 1951). Altogether, 18 patches with *Eriophorum*

Table 1. The location of mires with patches of *Eriophorum angustifolium* (EA) and *Carex rostrata* (CR) and number of relevés investigated in the study

No.	Lakes	Administrative unit	Geographical coordinates	EA	CR
1	Święte	Wieleń	N 52°48’5’’ E 16°12’3’’	.	1
2	Moczydło	Drawsko	N 52°49’8’’ E 16°00’0’’	.	2
3	Perskie	Drawsko	N 52°45’6’’ E 16°01’8’’	.	1
4	Rzecińskie	Wronki	N 52°45’7’’ E 16°45’7’’	1	1
5	Pokraczyn	Wronki	N 52°46’2’’ E 16°21’2’’	2	.
6	Pustelnik I	Wronki	N 52°46’7’’ E 16°19’1’’	3	.
7	Pustelnik II	Wronki	N 52°46’8’’ E 16°19’1’’	3	.
8	Wilcze Błoto	Wronki	N 52°49’4’’ E 16°22’8’’	1	2
9	Mnich Mały	Sieraków	N 52°39’0’’ E 16°01’9’’	1	.
10	Zamorze	Pniewy	N 52°30’6’’ E 16°12’6’’	.	1
11	Skrzynka	Mosina	N 52°15’3’’ E 16°47’2’’	.	2
12	Niewiemko	Budzyń	N 52°53’7’’ E 16°45’8’’	.	1
13	Czarne Małe	Murowana Goślina	N 52°31’8’’ E 17°05’3’’	.	1
14	Kańskie	Powidz	N 52°24’8’’ E 18°01’5’’	.	1
15	Czarne	Witkowo	N 52°28’6’’ E 17°53’4’’	.	1
16	Święte	Przemęt	N 51°57’7’’ E 16°46’3’’	2	.
17	Żurawin	Rychwał	N 52°02’0’’ E 18°05’5’’	1	.
18	Modre	Sępólno Krajeńskie	N 53°25’6’’ E 17°20’3’’	1	.
19	Czarne	Kaczory	N 53°08’1’’ E 16°55’2’’	.	1
20	Smolary	Szydłowo	N 53°17’8’’ E 16°44’0’’	1	.
21	Kuźnik Mały	Piła	N 53°11’9’’ E 16°44’4’’	.	1
22	Kuźniczek	Piła	N 53°11’5’’ E 16°44’3’’	.	2
23	Kuźnik Bagienny	Szydłowo	N 53°12’5’’ E 16°44’0’’	1	.
24	Kuźnik Olszowy	Szydłowo	N 53°12’4’’ E 16°43’5’’	1	1
25	Czapla	Dobrzyca	N 53°11’3’’ E 16°48’1’’	.	1
26	Okoniowe	Piła	N 53°11’1’’ E 16°48’2’’	.	2

angustifolium from 12 mires and 22 patches with *Carex rostrata* from 17 mires were sampled (Table 1). The floristic composition under study was collected in one synthetic table of shortened form. Abundance, constancy and coefficient of cover were worked out. Abundance was determined according to a modified six-degree scale by Braun-Blanquet. Constancy was determined according to the following scale on the basis of species abundance: V – species occurring in 80.1-100% of relevés taken in the phytocoenoses; IV – species present in 60.1-80.0%; III – species present in 40.1-60.0%; II – species present in 20.1-40.0%; I – species present in 10.1-20.0%; + – species present in 5.1-10.0% and r – $\leqslant$ 5.0%.

Vascular plants names are those used by Mirek *et al.* (2002), of mosses by Ochyra *et al.* (2003), and the nomenclature of the syntaxa follows Brzeg and Wojterska (2001).

2.3. Environmental data

For each of the phytocoenoses in which phytosociological relevé was made, water samples were taken, too, from the central parts of each patch (Kłosowski & Tomaszewicz 1993; Kłosowski 1999). Each of the analysed water samples consisted of three sub-samples taken from the patches up to 0.5 m deep. The samples were taken from shallow piezometric wells in the centre of each patch. Water samples were poured into three plastic containers, two of which were immediately preserved: one by addition of 1 ml of nitrate acid, the other with 1 ml of 95% chloroform; the third sample was not treated with any preservatives. Water pH and temperature, conductivity, dissolved oxygen and water oxygenation were measured directly on the site; the remaining parameters were measured after the samples had been taken to the laboratory.

Physical and chemical analysis were performed according to the Siepak (1992) and Hermanowicz *et al.* (1998) methods. 19 physical-chemical parameters of water were analyzed: colors (platinum-cobalt standard method), pH (with pH-meter), dissolved organic carbon (DOC, with organic carbon analyzer), conductivity (electrolytic method), NH_4^+ (by Nessler's colorimetric method), O_2 dissolved, saturation with O_2 (electrometric method), NO_3^- (by cadmium reduction method), PO_4^{3-} (by the colorimetric ascorbic acid method), SO_4^{2-} (by nephelometric method), Cl^- (by Mohr's argentometric method), total hardness, carbonate hardness, Ca^{2+}, Mg^{2+} (wersenian method), SiO_2 dissolved (heteropoly blue method), Na^+, K^+ and total Fe (by atomic absorption spectrometry method).

In order to compare the habitats, average values and ecological amplitudes of particular water parameters were taken into consideration. The significance of differences in water properties between groups of samples from the sites dominated by *Eriophorum angustifolium* and by *Carex rostrata* was tested by Mann-Whitney *U* test.

3. Results

3.1. Phytosociological characteristics of the phytocoenoses

Phytosociological analysis of phytocoenoses dominated by *Eriophorum angustifolium* and by *Carex rostrata* suggests that these species often tend to form dense compact stands (cover-abundance coefficient mostly 4). The species composition and phytosociological data are contained in Table 2. Phytocoenoses whose herb layer was dominated by *C. rostrata* were floristically richer than those with *E. angustifolium*. Patches of the analysed associations were clearly marked with the constant presence of species belonging to the class *Oxycocco-Sphagnetea*. In dryer conditions, the share of shrubs and low trees was visibly greater especially *Pinus sylvestris* and *Betula pubescens*.

In the observed group of phytocoenoses with *E. angustifolium* (Table 2, EA) the most constant taxons appear to be such species as *Carex limosa* and *Menyanthes trifoliata*. Among vascular plants which were present in the patches, the most numerous was *Rhynchospora alba* (III constancy class). The moss layer was dominated mostly by *Sphagnum fallax* (V constancy class) and less often by *Sphagnum magellanicum* (III constancy class). In several patches only it was *Sphagnum flexuosum* that exhibited the greatest coverage in the moss layer. In a number of analysed phytocoenoses with *E. angustifolium* we could notice a considerable participation of other mosses of the classes *Oxycocco-Sphagnetea* and *Scheuchzerio-Caricetea fuscae*, i.e. *Aulacomnium palustre*, *Polytrichum strictum*, *Calliergon stramineum* and *Warnstorfia exannulata*.

In the patches dominated by *Carex rostrata* most constant were species of the class *Scheuchzerio-Caricetea fuscae*, such as *Menyanthes trifoliata, Comarum palustre* and *Eriophorum angustifolium*, then the class *Oxycocco-Sphagnetea*. Relatively larger, too, was the share of *Thelypteris palustris* and *Lysimachia vulgaris* (III constancy class), as well as some species with constancy II (Table 2, CR). The moss layer, in turn, was most often dominated by *Sphagnum fallax* (V constancy class); noticeable, too, was a higer constancy of such species as *Sphagnum palustre* and *Calliergon stramineum*. In the structure of these phytocoenoses, larger participation of tree species was visible, mainly of *Betula pubescens*, than it was in the case of phytocoenoses with *Eriophorum angustifolium*.

Phytocoenoses dominated by *Eriophorum angustifolium* or *Carex rostrata* were the most important peat-forming communities in the analysed mires. In the beltlike configuration of vegetation, phytocoenoses with *E. angustifolium* were either adjacent to the lakes water table, or they were preceded by patches of *Caricetum limosae* (Beger 1922) Osvald 1923 em. Dierßen 1982,

Table 2. A synoptic table of the vegetation data studied. EA – community of *Eriophorum angustifolum*, CR – community of *Carex rostrata*

Community type	EA	CR
Number of relevés	18	22
Number of mires	13	22
Average relevé area [m^2]	29	28
Total number of species	59	88
Mean number of species in one relevé	15	18
I. Dominant species		
Eriophorum angustifolium	V $^{3-4}$	IV $^{+-1}$
Carex rostrata	IV $^{r-2}$	V $^{3-4}$
II. Characteristic species of the order *Scheuchzerietalia palustris*		
Sphagnum fallax	V $^{3-5}$	V $^{1-5}$
Carex limosa	IV $^{+-1}$	II $^{+}$
Rhynchospora alba	III $^{+-1}$	r $^{+}$
Scheuchzeria palustris	I $^{+-1}$	r $^{+}$
Carex lasiocarpa	I $^{+-1}$	I $^{+-1}$
Sphagnum flexuosum	I $^{1-3}$	II $^{+-4}$
Sphagnum teres	r ^{2}	II $^{1-2}$
Carex diandra	r $^{+}$	I $^{+-1}$
Sphagnum warnstorfii	r $^{+}$	I $^{+-1}$
III. Characteristic species of the order *Caricetalia fuscae*		
Carex canescens	II $^{+}$	.
Carex echinata	II $^{+-1}$	I $^{+}$
Agrostis canina	II $^{+-1}$	II $^{+-1}$
Carex nigra	I $^{+}$	.
Epilobium palustre	I $^{+}$	II $^{r-+}$
Calamagrostis stricta	+ $^{+-1}$	II $^{r-1}$
Hydrocotyle vulgaris	r $^{+}$	II $^{+}$
IV. Characteristic species of the class *Scheuchzerio-Caricetea fuscae*		
Menyanthes trifoliate	IV $^{r-1}$	IV $^{r-3}$
Calliegon stramineum	IV $^{+-2}$	IV $^{+-2}$
Warnstorfia exannulata	II $^{+-1}$	.
Comarum palustre	II $^{r-1}$	III $^{r-+}$
Calla palustris	r $^{+}$	+ $^{r-+}$
Sphagnum riparium	.	+ $^{3-4}$
V. Characteristic species of the class *Oxycocco-Sphagnetea*		
Drosera rotundifolia	V $^{+}$	IV $^{+-1}$
Oxycoccus palustris	V $^{+-4}$	III $^{+-3}$
Aulacomnium palustre	IV $^{+-1}$	III $^{+-2}$
Sphagnum magellanicum	III $^{1-3}$	I $^{+-1}$
Eriophorum vaginatum	II $^{+-2}$	II $^{+}$
Polytrichum strictum	II $^{+-1}$	III $^{+-2}$
Sphagnum capillifolium	r $^{+}$	I $^{+-2}$
Andromeda polifolia	r $^{+}$	I $^{+-1}$
VI. Others		
Pinus sylvestris juv.	IV $^{+}$	II $^{r-+}$
Pinus sylvestris fo. *turfosa* b	III $^{+-2}$	III $^{+-2}$
Juncus effusus	II $^{r-+}$	II $^{+-2}$
Sphagnum denticulatum	II $^{+-1}$	r ^{1}
Betula pubescens b	II $^{+-2}$	IV $^{+-3}$
Betula pubescens juv.	II $^{r-+}$	III $^{r-+}$
Sphagnum palustre	II $^{+-2}$	III $^{+-2}$
Lysimachia thyrsiflora	II $^{r-+}$	I $^{+}$
Lycopus europaeus	I $^{r-+}$	II $^{r-+}$
Molinia caerulea	I $^{r-+}$	+ $^{+}$
Calliergonella cuspidata	I $^{+}$	I $^{+-1}$
Lysimachia vulgaris	I $^{+}$	III $^{+}$
Thelypteris palustris	r ^{r}	III $^{+-1}$
Salix aurita b	r $^{+}$	II $^{+-1}$
Frangula alnus b	r $^{+}$	I $^{+-1}$
Frangula alnus juv.	r ^{r}	I $^{+}$
Typha latifolia	r ^{1}	I $^{r-+}$.
Salix cinerea b	r $^{+}$	+ $^{+}$
Carex disticha	r $^{+}$	r $^{+}$
Phragmites australis	.	II $^{+}$
Peucedanum palustre	.	II $^{r-+}$
Alnus glutinosa b	.	II $^{+-1}$
Alnus glutinosa juv.	.	II $^{r-+}$
Dryopteris cristata	.	II $^{r-+}$
Galium palustre	.	II $^{r-+}$

Sphagno tenelli-Rhynchosporetum albae Osvald 1923 nom. invers. or *Caricetum lasiocarpae* Osvald 1923. In turn, phytocoenoses with *Carex rostrata* most often came either next to the patches with *Thelypterido-Phragmitetum* Kuiper 1958 or *Cladietum marisci* Allorge 1922 ex Zobrist 1935 on the water side, or developed behind other *Sphagnum* communities.

3.2. Habitat conditions of the phytocoenoses

Phytocoenoses with *Eriophorum angustifolium* were connected with complex peat habitats, usually highly hydrated, yet, without the stagnant water in the patches. In contrast, most of the patches with *Carex rostrata* showed low levels of ground water.

Differences in the physico-chemical parameters of water between the two types of analysed phytocoenoses were observed in the case of most of the parameters, especially those connected with the hardness of water, and with the concentration of humic substances and nutrients. One of the characteristic features of the habitats of the analysed species is the high content of nutrients and considerable habitat oxygenation, higher in the patches dominated by *Carex rostrata*. Yet, no significant difference between the habitats of the two communities was noted as far as the water pH is concerned. In the case of the habitats with *Carex rostrata*, the pH value had a wider range and higher maximum than in the case of the habitats with *Eriophorum angustifolium*.

Standardised data on all the water parameters suggest that most of the phytocoenoses with *E. angustifolium* exhibited low range of values (Fig. 1). Only the average values of specific acidity (pH) and PO_4^{3-} exceeded the line of general average values. Groups of phytocoenoses dominated by the analysed species developed in wide ranges of water characteristics; their values, however, were considerably lower in the case of phytocoenoses with the domination of *E. angustifolium*.

The water in the phytocoenoses with *E. angustifolium* exhibited lower values of the colour of water and conductivity; moreover, in comparison to the patches with *C. rostrata*, it was also poorer in Ca^{2+}, Na^{+}, K^{+}, NO_3^{-}, N-NH_4^{+} and dissolved SiO_2. Yet, the habitats with *E. angustifolium* were more abundant as far as the content of PO_4^{3-} and total Fe is concerned. With reference to such parameters as water colour, specific acidity (pH),

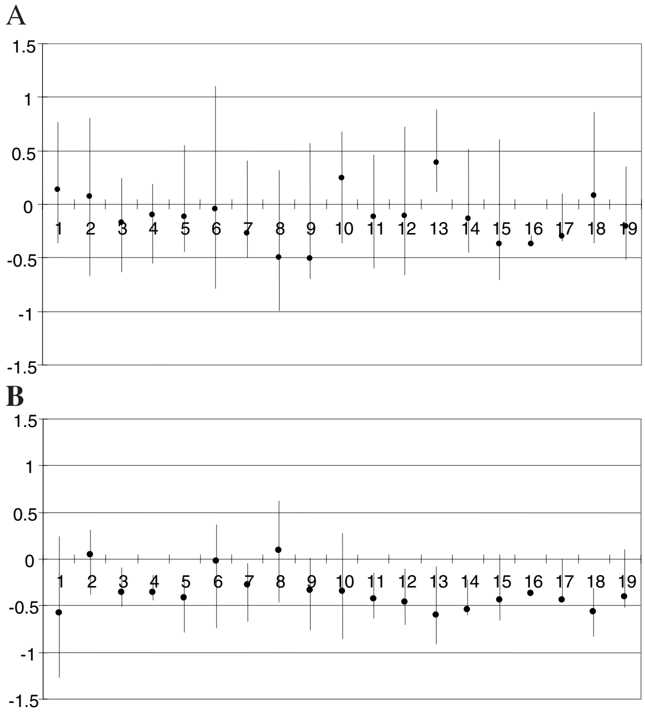

Fig. 1. The water properties in the habitat of phytocoenoses dominated by *Eriophorum angustifolium* (A) and *Carex rostrata* (B). Median value, lover and upper quartile based on the standardized data

Explanations: 1 – colors, 2 – pH, 3 – saturation with O_2, 4 – O_2 dissolved, 5 – conductivity, 6 – N-NH_4^{+}, 7 – N-NO_3^{-}, 8 – P-PO_4^{3-}, 9 – total Fe, 10 – total hardness, 11 – carbonate hardness, 12 – Ca^{2+}, 13 – Mg^{2+}, 14 – Na^{+}, 15 – K^{+}, 16 – SO_4^{2-}, 17 – Cl^{-}, 18 – SiO_2 dissolved, 19 – DOC

general hardness, Mg^{2+} and dissolved SiO_2, in the case of the phytocoenoses with *C. rostrata* they were shifted above the general average values (Fig. 1). Waters of these patches were richer in the compounds of Ca^{2+} and Mg^{2+}, as well as in SO_4^{2-} and Cl^{-}. Especially wide amplitudes of values were visible in the case of parameters connected with the concentration of humic substances (colour, DOC), water fertility (NH_4^{+}) and habitat mineralization (conductivity, saturation with O_2 and O_2 dissolved).

Most important differences between water parameters of phytocoenoses with *Eriophorum angustifolium* and those of *Carex rostrata* were observed as far as the colour of water and conductivity are concerned, as well as the concentration of Mg^{2+}, K^{+} and dissolved SiO_2 (Table 3). These parameters essentially differentiated the phytocoenoses with *E. angustifolium* from those with *C. rostrata*.

Sporadic species: II. *Sphagnum subnitens* SCR (r $^{+}$); *Sphagnum obtusum* SCR (r ^{2}); III. *Triglochin palustre* SCR (r ^{r}); *Ranunculus flammula* SCR (r $^{+}$); *Veronica scutellata* SCR (I $^{r-+}$); *Viola palustris* SCR (I $^{+}$); *Eleocharis quinqueflora* EA (r $^{+}$), SCR (r $^{+}$); *Sphagnum fimbriatum* SCR (+ ^{2}); V. *Polytrichum commune* SCR (r $^{+}$); *Sphagnum fuscum* EA (r $^{+}$); *Sphagnum angustifolium* EA (r ^{1}); VI. *Picea exelsa* b SCR (+ ^{r}); *Pinus sylvestris* fo. *turfosa* a SCR (I ^{2}); *Vaccinium myrtillus* SCR (r $^{+}$); *Plagiomnium elatum* EA (r $^{+}$); *Salix aurita* juv. SCR (II $^{+-1}$); *Alnus glutinosa* a SCR (+ $^{+}$); *Empetrum nigrum* SCR (r ^{1}); *Equisetum fluviatile* SCR (+ $^{+-1}$); *Potentilla erecta* SCR (+ $^{+}$); *Stellaria palustris* SCR (r ^{r}); *Quercus robur* juv. SCR (I $^{r-+}$); *Juncus inflexus* SCR (r $^{+}$); *Salix repens* subsp. *rosmarinifolia* juv. SCR (r ^{2}); *Betula pubescens* a SCR (1 $^{1-2}$); *Ledum palustre* SCR (+ $^{+-1}$); *Dryoptheris cartusiana* SCR (r $^{+}$); *Cladium mariscus* SCR (r $^{+}$); *Typha angustifolia* EA (r $^{+}$); *Polytrichum longisetum* EA (r ^{1}), SCR (r ^{1}); *Bidens cernua* EA (r $^{+}$); *Utricularia minor* EA (r ^{1}); *Lythrum salicaria* SCR (+ ^{r}); *Scutellaria galericulata* EA (r $^{+}$); *Epilobium parviflorum* SCR (+ $^{r-+}$); *Salix repens* subsp. *repens* b SCR (r $^{+}$); *Sphagnum squarosum* SCR (r ^{1}); *Salix repens* subsp. *rosmarinifolia* SCR (+ ^{2}); *Cirsium palustre* (r ^{r}); *Utricularia intermedia* (r $^{+}$)

Table 3. Physical and chemical properties of water found in habitats of phytocoenoses studied. Ranges and mean values and the significance of differences in water properties between groups phytocoenoses obtained from Mann-Whitney *U* test

Property		EA		SCR		Significance
		Range	Mean	Range	Mean	EA-SCR
Colour	mg Pt/l	37-469	191.44	79-535	288.86	+
DOC	mg C/l	24.49-121.47	54.2	15.04-102.39	51.16	ns
pH		3.4-4.9	4.36	3.52-5.94	4.45	ns
O_2 dissolved	mg O_2/l	0.51-10.1	2.44	0.64-20	3.65	ns
Saturation with O_2	%	6.9-126	28.60	6.43-200	39.71	ns
Conductivity	µS/cm	33.3-413	104.35	40.3-369	134.88	+
$N\text{-}NH_4^+$	mg N/l	0.47-3.2	2.12	0.4-5.1	2.44	ns
$N\text{-}NO_3^-$	mg N/l	0.1-1.5	0.55	0.1-2.1	0.67	ns
$P\text{-}PO_4^{3-}$	mg PO_4/l	0.24-5.16	1.94	0-5.12	1.33	ns
Total Fe	mg Fe/L	0.01-1.07	0.33	0.01-1.45	0.4	ns
Total hardness	mval/l	0.02-0.6	0.26	0.03-0.85	0.33	ns
Carbonate hardness	mval/l	0.01-0.5	0.14	0.01-0.9	0.24	ns
Ca^{2+}	mg Ca/l	0.26-7.43	2.36	0.26-13.21	4.1	ns
Mg^{2+}	mg Mg/l	0.09-3.17	1.156	0,26-4.03	1.861	+
Na^+	mg Na/l	0.27-6.29	1.95	0.4-23.4	4.43	+
K^+	mg K/l	1.46-19.12	7.58	0.47-21.4	8.05	ns
SO_4^{2-}	mg SO_4/l	0-34	1.94	0-35	4.64	ns
SiO_2 dissolved	mg SiO_2/l	0.01-1.72	0.55	0.17-2.90	1.11	+
Cl^-	mg Cl/l	3-16	6.4	4-62	10.59	ns

Explanations: EA – community of *Eriophorum angustifolium* (*n*=18), CR – community of *Carex rostrata* (*n*=22), ns – non-significant

4. Discussion

Analyses of habitat requirements of the species, and their communities, occupying mires suggest mutual relationships between the species and the parameters of their habitats (e.g. Hájková & Hájek 2004a, 2004b; Navrátilová & Navrátil 2005; Hájková *et al.* 2002). Ground water level, reaction and conductivity have been regarded as the most important abiotic factors influencing the appearance of species and their communities in mires (e.g. Miserere *et al.* 2003; Tahvanainen & Tuomala 2003; Hájková & Hájek 2004a, 2004b). Numerous studies have suggested that species diversity and the presence of specific associations could be used as indicators of environmental characteristics and of anthropogenic impact (e.g. Hájková & Hájek 2004a, 2004b; Bragazza *et al.* 2005; Navrátilová & Navrátil 2005). Sometimes it is noticed, too, that regional habitat differences, observable in the case of the vegetation of waterlogged areas, may to some extent limit the indicative value of particular associations (e.g. Pełechaty 2004).

The analysed phytocoenoses dominated by *Eriophorum angustifolium* or *Carex rostrata*, which form the most important parts of the vegetation of the observed mires, were connected with different habitat requirements. It might suggest their bioindicative value. Phytocoenoses with *E. angustifolium* appear in habitats characterised by lower values of most of the analysed water parameters than those of phytocoenoses with *C. rostrata*. The most important elements differentiating these two groups of analysed phytocoenoses were the following water parameters: colour, conductivity, Mg^{2+}, Na^+ and dissolved SiO_2. In comparison to phytocoenoses with *C. rostrata*, those with *E. angustifolium* were connected with the waters poorer in Ca^{2+}, with smaller concentration of NH_4^+ and NO_3^-, and higher content of PO_4^{3-}. The analysed habitats with *C. rostrata* were more fertile both as far as the content of nutrients is concerned, and with regard to such substances as Na^+, K^+, Ca^{2+} and SO_4^{2-}.

It has to be pointed out that in the case of the analysed phytocoenoses of peat-bogs adjacent to the humic lakes in the Wielkopolska region, the water reaction was not an essential differentiating factor. The features analysed above can be regarded as characteristic for communities dominated by these mires species and present in the bog-lake ecosystems of western Poland.

The analysed habitats were characterised by wide ranges of ecological optima. They appeared in wide ranges in the case of acidic reaction of water acidity? (especially patches with *C. rostrata*), considerably coloured and rich in nutrients. Yet, some data present in the literature on the subject suggest the predilection of phytocoenoses with domination *E. angustifolium* or *C. rostrata* for habitats with moderate or slightly higher nutrient abundance (Matuła *et al.* 1997). In the peat-bogs of the Sudety Mountains, in the patches with these species a high concentration of nutrients was found, especially those of NO_3^- and NH_4^+ (Matuła *et al.* 1997). We have to bear in mind, however, that patches of the analysed phytocoenoses of the bog-lake ecosystems had their *Sphagnum* substratum less hydrated than it is described by the data found in literature (Pietsch 1976; Brzeg *et al.* 1996; Matuła *et al.* 1997). Smaller water volume in the habitats, together with the processes of *Sphagnum* peat mineralisation in the peak of the vegetative season, are reflected in the characteristics of water. In numerous patches, especially in those dominated by *C. rostrata*, high values were measured for such water parameters as: conductivity, oxygen concentration and oxygenation, or NH_4^+; together with low reaction, they all indicate the state of advanced mineralisation.

Wide ecological scale and the multi-facial character of communities created by *Carex rostrata* and by *Eriophorum angustifolium* have been pointed out in numerous studies (e.g. Hadač & Váňa 1967; Jasnowska & Jasnowski 1983a, 1983b; Matuła *et al*. 1997; Borysiak *et al*. 1998).

Most of the parameters, both in the case of phytocoenoses with *E. angustifolium* and those with *C. rostrata*, exhibited wide ranges of the occurrence. This fact may be connected with the domination of *Sphagnum fallax* in the moss layer of majority of the patches. We have to point out, though, that the habitat requirements and the diversity of ecological gradients in the case of *Sphagnum* peat mosses are different from those of vascular plants growing over peat-bogs (Hájková & Hájek 2004a, 2004b).

Sphagnum fallax is sometimes regarded as an indicator of advanced habitat trophism and particularly high concentration of N (Limpens *et al*. 2003). We may point to the important habitat-creating role of this dominating peatmoss, characteristic for wide expansion at the present state of habitat development (Jasnowska & Jasnowski 1983a, b; Limpens *et al*. 2003; Miserere *et al*. 2003). It has to be pointed, too, that the peat-bogs exhibiting a dense structure of *Sphagnum* peat, with *Sphagnum fallax* dominating in the moss layer, were very frequent in the analysed lake-bog ecosystems. Small floristic diversity of moss layer in the case of peat-bogs with *Sphagnum fallax*, despite the diversity of vascular species forming physiognomically separate patches within the limits of some *Sphagnum* bog objects, has been described by Jasnowska *et al*. (2000) and Hájková and Hájek (2004a, 2004b).

In the mosses layer of phytocoenoses dominated by *E. angustifolium* we could locally distinguish a greater participation of peatmoss *Sphagnum flexuosum*. This taxon is considered in Poland as a species regionally characteristic for the association *Sphagno recurvi-Eriophoretum angustifolii* (Brzeg *et al*. 1996; Borysiak *et al*. 1998), and as an indicator of waterlogged habitats (Borysiak *et al*. 1998). However, phytocoenoses with *E. angustifolium* and a considerable participation of *Sphagnum flexuosum* were rarely met in the mires of humic lakes. Indirectly, this can suggest the overdrying of organogenic habitats.

On numerous occasions, in the patches with analysed species, especially with *Carex rostrata*, we could meet low trees and shrubs. This fact may be connected with natural dynamic transformations of mires into forest communities, conditioned by small precipitation in the analysed region.

The diagnosis of habitat conditions of mires dominated by phytocoenoses with *Eriophorum angustifolium* or *Carex rostrata* in the lake-bog ecosystems may be of help in the determination of physico-chemical condition of lake waters. The appearance of patches dominated by *C. rostrata* was observed mainly in the case of lakes with humotrophic waters, fertile and rich in nutrients. Phytocoenoses with *C. rostrata*, in turn, tended to appear optimally in mires adjacent to lakes of strongly marked dystrophic character (Gąbka *et al*. 2004, 2005).

Acknowledgements. Scientific work financed from the resources earmarked for science in years 2001-2003 as the Research Project no. 6 P04F 037 29. We thank to Dr. Barbara Fojcik (University of Silesia) for help in identification of mosses. The anonymous reviewers are thanked for their helpful comments.

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