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Lichens as indicators of bog-community degeneration

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The lichen flora of raised and transition-bogs in West Pomerania (N Poland) is poor and characterized by dominance of acidophilous epiphytes associated with pine bark, and of humus-loving lichens. Lichens are not good indicators of the degradation of transition and raised-bog phytocoenoses, mainly because it is difficult to properly determine their response – whether it is caused by natural or anthropogenic factors. It does not seem possible to create a lichenoindicative system for bogs, similar to that used in studies of the pollution of the atmospheric air. Lichens can successfully be used in analyses of changes in the vegetation of isolated bogs; this should, however, be done at the most in addition to other procedures used to determine the degree of naturalness of plant communities.

Key words: lichens, bog-communities, degeneration, bioindicators, Poland.

INTRODUCTION

The use of lichens as indicators of changes taking place in plant communities during a secondary succession has, so far, been poorly documented in the literature (cf. F a b i s z e w s k i 1975; C z y ż e w s k a 1976, 1992; D ä n i e l s 1983; F a ł t y n o w i c z 1986a, 1988; F a l i ń s k i et al. 1993; C i e ś l i ń s k i et al. 1995a, b). There have also been very few studies dealing with the proportion and role of lichens in bog communities (F a b i s z e w s k i 1975; W o o d s 1991; F a ł t y n o w i c z 1996); in most of them the authors only enumerate several or a dozen or so lichens taxa in phytosociological tables (W o j t e r s k i 1963; C z e r w i ń s k i 1970; F a b i s z e w s k i 1981; S o k o ł o w s k i 1980; F a ł t y n o w i c z et al. 1986b).

The aim of this studies is to:
- analyse qualitatively and quantitatively the lichen flora of selected transition and raised bogs in northern Poland;
- ascertain whether there exists any relationship between the occurrence of lichens and degree of naturalness of bog ecosystems.

The specification of the objectives resulted from the assumption that, as suggestion by K r a w i e c (1936) and F a b i s z e w s k i (1975), the role of lichens on bogs grows with the advancing degradation of these ecosystems.

Northern Poland is an area particulary suitable for such studies because of the presence there of still numerous natural raised and transition-bogs (cf. J a s n o w s k i 1975) and occurrence over considerable areas of raised-bog and transition-bog phytocoenoses degenerated to a various degree as a result of human activity (J a s n o w s k i 1972; J a s n o w s k i et al. 1968).

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METHODOLOGICAL COMMENTS

From each bog lichens were collected on every habitat and substrate. Estimates were also made of the quantitative proportions of particular taxa. At the same time the plant communities, the kind and degree of their deformation were described and defined, and the anthropogenic factors causing changes in the habitat conditions in every bog under study were determined.

The nomenclature of lichen species has been adopted after F a ł t y n o w i c z (1993). Names of plant communities has been given according to M a t u s z k i e w i c z (1981). The method used for carrying out Feret's triangle has been taken from the paper of K o c i m o w s k i and K w i a t e k (1977). Herbarium specimens of lichens can be found at the herbarium UGDA.

CHARACTERISTICS OF THE BOGS UNDER STUDY

The field studies covered 15 raised bogs located in areas where the harmful effect of air pollution can be considered insignificant. Five of the bogs are situated in the lowland belt of the Baltic Shore and South-Baltic Coast, four — among elevations in the Kaszuby Lakeland, six — on the outwash plains of the Tuchola Forests (Fig. 1).

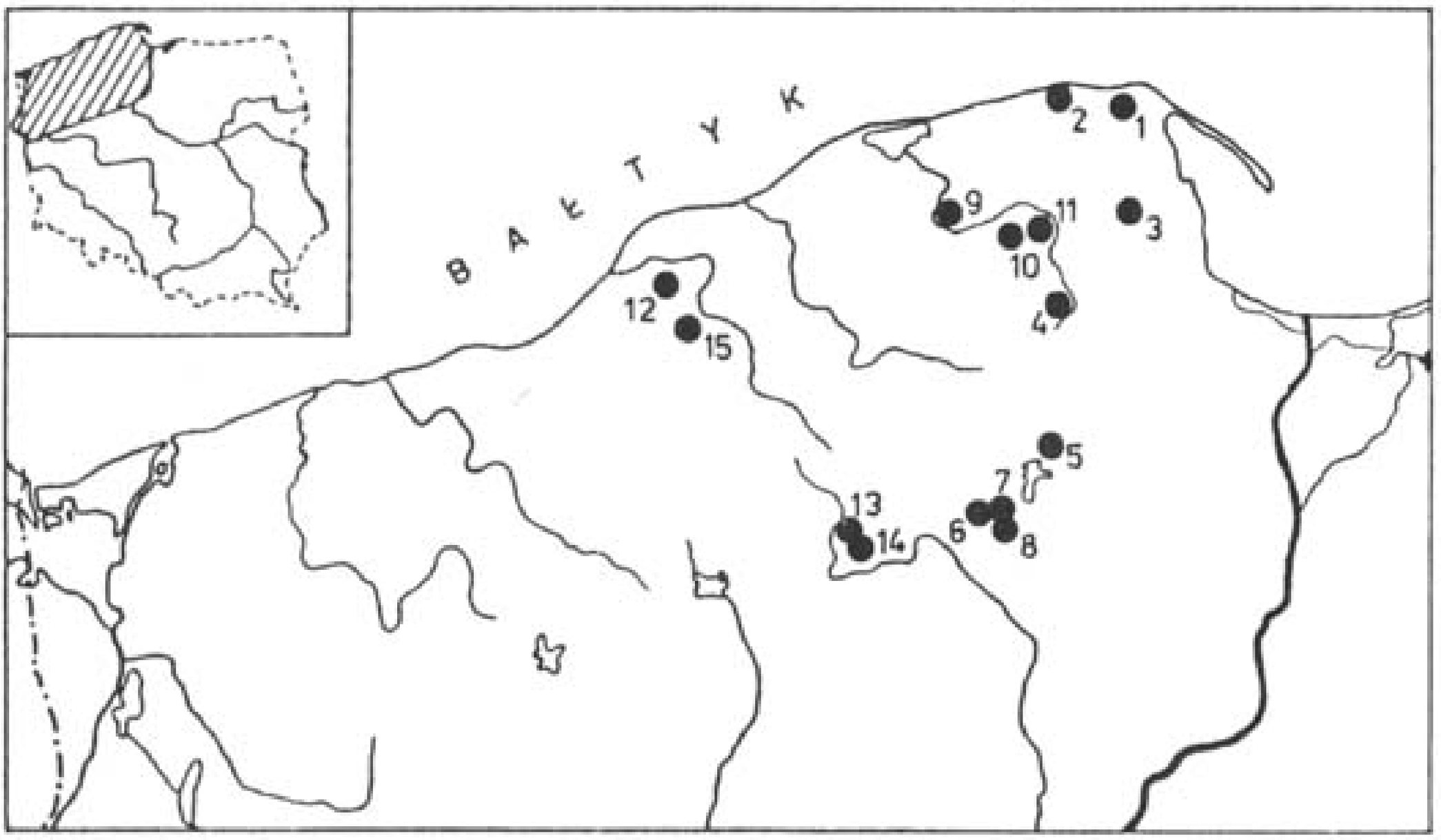

Fig. 1. Distributon of the investigated peat-bogs
1 — Bielawskie Błoto (Marsh Bielawskie), 2 — Białogóra, 3 — Bagno Biała (Biała Bog), 4 — Staniszewskie Błoto (Staniszewskie Bog), 5 — a bog on lake Drzędno, 6 — a bog on lake Moczydło, 7 — a bog on lake Kły, 8 — a bog SE of lake Kły, 9 — Czarne Bagno (Czarne Bog), 10 — Białe Błoto (Białe Marsh), 11 — Żurawiec, 12 — Słowińskie Błoto (Marsh Słowińskie), 13 — Bagnisko Niedźwiady (Swampland Niedźwiady), 14 — Bagno Biel (Biel Bog), 15 — Janiewickie Bagno (Janiewickie Bog)

Bielawskie Błoto (Marsh Bielawskie). A vast bog (about 700 ha), located about 2 km from the sea-shore. The largest part of the area is covered with heathland phytocoenoses. On the fringes, pine monocultures, small fragments of natural swamp pine forest and birch and willow scrub are found. Patches of the following associations are found on Bielawskie Błoto: *Ericetum tetralicis*, *Junco-Trichophoretum*, *Myricetum gale*, *Rhynchosporetum fuscae* and *Vaccinio uliginosi-Pinetum*. A large proportion of the bog is deprived of trees; only isolated dwarf pine and birch trees occur here. Bielawskie Błoto has for many years been managed (draining, exploitation, ploughing). Management has caused great changes in the water relations and vegetation. Of great importance, too, were fires which occurred here every several years. Bielawskie Błoto has long been the subject of interest for botanists (cf. C z u b i ń s k i 1954; H e r b i c h o w a 1972, 1976, 1979; P i o t r o w s k a and H e r b i c h 1974; F a ł t y n o w i c z 1986a). In 1983 a large part of it was destroyed by fire.

Białogóra. A bog reserve, 55.27 ha in surface area, located about 1 km from the sea-shore. It includes several inter-dune depressions and low dune ridges which separate them. Very diverse natural plant communities from here

a unique, in Europe, bog-forest complex. The following plant associations and communities have been described from the reserve: *Rhynchosporetum fuscae*, *Junco-Trichophoretum*, *Sphagnetum magellanici boreale*, *Caricetum lasiocarpae*, *Ranunculo-Juncetum bulbosi*, *Eleocharetum multicaulis*, *Myricetum gale*, a community with *Lycopodiella inundata* and *Empetro nigri-Pinetum* (*cladonietosum*, *piroletosum*, *typicum* and *ericetosum*). Over the half of the reserve surface area bears forest and scrub communities. This entirely natural bog has been studied and described by Herbichowa (1979).

Bagno Biała (Biała Bog). A reserve of 5.33 ha in surface area; it comprises a depression in a broadleaved-forest complex. The phytocoenoses found here are: *Sphagnetum magellanici boreale*, *Caricetum limosae*, *Vaccinio uliginosi-Pinetum* and *Betuletum pubescentis*. Trials for draining the bogs and exploiting the peat have soon been abandoned and have not had any visible impact on the water relations and vegetation of the area. The only data on Bagno Biała can be found in the paper Fałtynowicz et al. (1982).

Staniszewskie Błoto (Staniszewskie Bog). Set up in 1916, this reserve has an area of about 100 ha. Almost all the area is occupied by *Vaccinio uliginosi-Pinetum* phytocoenoses with pine-trees over a 100 years old and a small admixture of birch; only an insignificant fragment is covered with a patch of *Sphagnetum magellanici boreale pinetosum*. The terrain of the reserve is intersected by drainage ditches which contribute to the drying of the upper peat layers. Information on the vegetation of the bog can be found in the papers of Krawiec (1936), Lubliner–Mianowska (1961), Herbich (1982) and Fałtynowicz and Tobolewski (1989).

A bog on Lake Drzędno. It is a mid-forest bog located on a lobelia lake south of Kościerzyna. Over an area of 4.24 ha phytocoenoses of *Calamagrostietum neglectae*, *Vaccinio uliginosi-Pinetum*, *Sphagnetum magellanici boreale*, *Caricetum rostratae* and a community with *Juncus effusus* are found. The bog shows a high degree of naturalness. Data on the vegetation of this area can be found in the paper Jasińska-Łukaszewicz (1976).

A bog on Lake Moczydło. A small (about 5 ha) mid-forest bog situated on a dystrophic lake (cf. Fałtynowicz and Szmeja 1978). It is occupied primarily by *Vaccinio uliginosi-Pinetum* phytocoenoses; only along the lake-shore does a narrow strip of *Caricetum limosae* (2-3 m wide) extend. In the past the bog was exploited, as indicated by the presence of old peat-pits now overgrown; this has not had any visible effect on the vegetation.

A bog on Lake Kły. This is peat-filled former bog of the lake about 4 ha in surface area. On the side of the lake a narrow belt of scrub with *Alnus glutinosa* and *Salix aurita* is found. A small area is occupied also by *Calamagrostietum neglectae* phytocoenoses; the remainder of the bog bears patches of *Vaccinio uliginosi-Pinetum*. In the past peat was exploited here, which is indicated by vegetation-grown old peat-pits and partly dry dikes

among them. The natural state of the plant communities that still endures here can be estimated as good.

A bog SE of Lake Kły. It lies in a small (about 4 ha) depression and is surrounded by a dry pine forest. In its central part a little lake is found (about 15x10 m) with *Caricetum limosae*, *Sphagnetum magellanici boreale* and *Vaccinio uliginosi-Pinetum* phytocoenoses developing in zones around it; the largest area is occupied by swamp pine forest. In the past the bog was exploited; pits from which peat has been removed are in the early phase of becoming overgrown with vegetation. The plant communities show a high degree of naturalness.

Czarne Bagno (Czarne Bog). A large bog (about 300 ha) located in the Łeba valley. Most of the area is grown up with *Ledo-Ericetum tetralicis* phytocoenoses. On the fringes the latter pass into *Vaccinio uliginosi-Pinetum.* A large area is occupied by planted pine in a swamp-forest habitat. The history of Czarne Bagno is similar to that of Bielawskie Błoto: the bog has for a long time been drained and reclaimed, and fires also occurred on it frequently. Since 1987 industrial exploitation of peat has been continued on the bog, and many of the localities from which lichens had been collected earlier must now be considered historical. The plant cover of Czarne Bagno has been described by H e r b i c h o w a (1979).

Białe Błoto (Białe Marsh). A small (about 9 ha), very well preserved, mid-forest bog in a kettlehole surrounded with a fresh pine forest. *Caricetum limosae*, *Caricetum rostratae*, *Caricetum nigrae* and *Sphagnetum magellanici boreale* phytocoenoses occur here. The contribution of trees is insignificant; few dwarf pines grow on the bog. Some of them died in recent years because of heavy waterlogging. The vegetation has been studied and described by G o s and H e r b i c h o w a (1993); these authors think that Białe Błoto is at the stage of transition from a transition-bog into a raised bog.

Żurawiec. A small bog (17 ha) amidst fields and meadows. As a result of an intensive peat exploitation, the bog has been badly damaged, its water relations have been disturbed, and its plant cover strongly altered. In numerous old peat-pits *Caricetum rostratae* phytocoenoses are present. There also occur degenerated patches of *Sphagnetum magellanici boreale* and partly dry fragments of swamp pine forest. On mucky peat on the fringes heath communities form. The vegetation of Żurawiec has been described by G o s and H e r b i c h o w a (1993).

Słowińskie Błoto (Marsh Słowińskie). A large bog (over 200 ha), physionomically and floristically divisible into two parts: eastern from which all peats was exploited in the past down to the underlying floor, central and western – not damaged. The eastern part is grown up with planted pine and spruce, degenerate patches of *Betuletum pubescentis* and heath communities with *Molinia caerulea*. Other parts of the bog are occupied by phytocoenoses of

Sphagnetum maellanici boreale (mainly of the subassociation *S. m. b. pinetosum*) and *Vaccinio uliginosi-Pinetum* in whose complex patches of *Rynchosporetum albae* form. Drainage ditches have been built across the whole bog. Along them a *Calluna vulgaris* community develops on the partly dry muck; the community introduces many species, of plants and lichens, which do not grow on bogs naturally. The plant communities of Słowińskie Błoto have been studied and described by H e r b i c h o w a (1986).

Bagnisko Niedźwiady (Swampland Niedźwiady). A large bog (about 300 ha) situated in a complex of fresh pine forests; a part of it (about 48 ha) is a nature reserve. Almost the whole area is covered by *Vaccinio uliginosi-Pinetum* phytocoenoses; only in the northern part are small patches of *Sphagnetum magellanici boreale* and *Caricetum limosae* found, forming a narrow belt around a small dystrophic lake. In addition to pine, in the edge parts of the bog isolated birch-trees, *Betula pendula*, grow. This is an area of a high degree of naturalness (F a ł t y n o w i c z 1996).

Bagno Biel (Biel Bog). A large bog complex (about 400 ha), located 4 km to the south-west from Bagnisko Niedźwiady. The whole area is grown up with *Vaccinio uliginosi-Pinetum* phytocoenoses. Across the southern part of the bog an electrical supply line has been constructed and a large drainage ditch has been dug; this has caused drastic floristic changes in the surroundings, manifested among other things by the extinction of *Vaccinium uliginosum* and *Ledum palustre* over considerable areas and growth in great numbers of *Molinia caerulea*. Dominant on the bog is pine; isolated *Betula pendula* and *Alnus glutinosa* trees are only found in the northern part of the area (F a ł t y n o w i c z 1996).

Janiewickie Bagno (Janiewickie Bog). A bog reserve, 100 ha in surface area, 10 km south of Sławno. The whole area is grown up with forests, mainly *Vaccinio uliginosi-Pinetum* phytocoenoses, as well as fragments of beech-pine forest and a community intermediate between a carr and an alder swamp. The state of the reserve vegetation that endures is poor. This is the result of reclamation work continued for over 100 years, strong variations of ground water level and repeated insect outbreaks. Over large areas dead pines can be seen, standing or fallen by strong winds, which intensifies the impression of devastation. The reserve has been described from the phytosociological viewpoint by K r ó l (1968).

RESULTS

Lichen habitats on natural bogs

Natural raised and transition-bogs in northern Poland are ecosystems in which lichens occur rarely and in small numbers. Epigeic are only found on the tops of partly dry hummocks, and where the hummock-hollow structure does

not exist – they do not occur at all because the soil moisture is too high. Epiphytic and epixylous lichens occur in larger numbers only if suitable substrates are present. On undisturbed bogs in northern Poland conditions suitable for them arise as a result of the formation of plant association including trees, shrubs and dwarf shrubs, first of all *Vaccinio uliginosi-Pinetum*, *Sphagnetum magellanici boreale pinetosum*, *Betuletum pubescentis* and – to a lesser extent – *Ledo-Ericetum tetralicis* and *Myricetum gale*. A factor limiting the qualitative diversity of the epiphytic and epixylous lichenoflora is the poverty of phorophyte species; here absolutely dominant is *Pinus sylvestris*, a tree with a very acid bark which flakes off intensively. Birch-trees (*Betula pendula* and *B. pubescens*) are rare on bogs, and rarer still is *Alnus glutinosa*. As a habitat of epiphytes, shrubs play hardly any role on bogs. Of greater importance are dwarf shrubs (especially *Ledum palustre* and *Vaccinium uliginosum*) on whose twigs the same lichens grow as on the bark of *Pinus sylvestris*.

The wood of the above-mentioned species provides the substrate for epixylous lichens; like the bark, it has an acid reaction, being therefore inaccessible to many taxa which are more particular about this. The wood is often heavily soaked with water, due to which the presence of lichens is limited and a mass-growth of bryophytes and algae is favoured.

Undisturbed bogs lack habitats for epilithic lichens.

Anthropogenic processes on the bogs under study and their impact on lichens

On the bogs under study 132 lichen species have been found of which 61 (46%) occurred at least in four localities, and 19 – on eleven or more bogs (Tab. 1). They are acidophilous lichen, common throughout Poland; only *Lecanora pulicaris* is a neutrophilous lichen, although it tolerates acid substrates. Those 19 species can be considered representative and characteristic of undisturbed raised and transition-bogs in northern Poland. Most numerous among them are epiphytes (12 species) of which 11 are typical of pine bark, and one – *Tuckermannopsis sepincola* – grows primarily on birch-trees.

On the bogs under study changes in the lichen flora are brought about mainly by two forms of anthropopressure: draining and introduction of a foreign substrate.

Bog reclamation in northern Poland was begun as early as over a 100 years ago. The effect of this form of anthropopressure is most conspicuous on large bogs (Bielawskie Błoto, Staniszewskie Błoto, Czarne Bagno, Bagno Biel, Janiewickie Bagno), and is manifested by the drying of the top layers of peat and its turning into muck. Over large areas equivalent communities, e.g.

Table 1
List of lichen species from the investigated peat-bogs

Species — Gatunki	Investigated peat-bogs														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Cladonia chlorophaea (Flk. ex Sommerf.) Sprengel s.l.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
C. macilenta Hoffm. ssp. *bacillaris* Nyl.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Hypocenomyce scalaris (Ach.) Choisy	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Lecanora conizaeoides Nyl. in Crombie	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Lepraria sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Pseudevernia furfuracea (L.) Zopf	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Trapeliopsis granulosa (Hoffm.) Lumbsch	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cladonia glauca Flk.	+	+	+	+	+	+	+	+	+		+	+	+	+	+
Parmeliopsis ambigua (Wulfen in Jacq.) Nyl.	+	+	+	+	+	+	+	+	+		+	+	+	+	+
Platismatia glauca (L.) W. Culb. et C. Culb.	+	+	+	+	+	+	+	+	+		+	+	+	+	+
Usnea hirta (L.) Weber in Mot.	+	+	+	+	+	+	+	+			+	+	+	+	+
Cladonia digitata (L.) Hoffm.	+	+	+	+	+	+	+	+			+	+	+	+	+
Lecanora symmicta (Ach.) Ach.	+	+	+	+	+	+	+	+		+	+	+	+	+	
Cladina portentosa (Dufour) Follmann	+	+	+	+			+	+	+		+	+	+	+	+
Imshaugia aleurites (Ach.) Fricke Meyer	+	+	+	+	+		+	+			+	+	+	+	+
Cladonia cornuta (L.) Hoffm.	+	+	+	+	+	+		+	+	+	+		+	+	
Tuckermannopsis sepincola (Ehrh.) Hale	+	+	+	+	+	+	+	+	+		+		+	+	+
Vulpicida pinastri (Scop.) J.E. Mattson et M.J. Lai	+		+	+	+	+	+	+	+		+		+	+	
Lecanora pulicaris (Pers.) Ach.	+	+	+	+	+	+	+		+		+		+	+	

Cladonia ochrochlora Flk.	+		+	+		+		+			+	+	+	+	+
Cladina rangiferina (L.) Nyl.	+	+	+	+		+	+		+	+			+	+	
Parmelia sulcata Taylor	+	+	+	+	+		+		+		+	+		+	
Scoliciosporum chlorococcum (Graeve et Stenham.) Vězda	+	+	+	+	+				+			+	+	+	+
Pertusaria albescens (Huds.) Choisy et Werner		+	+	+	+	+	+					+	+	+	+
Cladonia cenotea (Ach.) Schaerer	+		+	+	+		+		+				+	+	+
C. floerkeana (Fr.) Flk.	+	+			+		+		+	+	+	+	+		
Hypogymnia tubulosa (Schaerer) Havaas	+	+	+	+			+		+		+	+			
Cladonia coniocraea (Flk.) Vainio	+	+	+	+					+			+		+	+
Cladina arbuscula (Wallr.) Hale et W. Culb.	+	+	+	+				+					+	+	+
Placynthiella uliginosa (Schrader) Coppins et P. James	+	+	+	+	+				+				+	+	
Chaenotheca ferruginea (Turner ex Sm.) Migula	+	+			+	+						+	+	+	+
Cladonia fimbriata (L.) Fr.	+	+							+	+	+	+	+	+	
Trapeliopsis flexuosa (Fr.) Coppins et P. James			+	+	+				+		+		+	+	+
Placynthiella oligotropha (Vainio) Coppins et P. James	+			+			+				+	+		+	+
Lecanora varia (Ehrh.) Ach.	+	+	+		+				+		+	+			
Pertusaria amara (Ach.) Nyl.	+	+		+			+					+		+	+
Cladonia deformis (L.) Hoffm.	+			+		+			+			+	+	+	
C. gracilis (L.) Willd.	+	+		+		+	+		+			+			
C. macilenta Hoffm. ssp. *macilenta*	+	+		+		+			+			+	+		
C. subulata (L.) Weber in Wigg.	+	+		+		+			+	+				+	
Lecanora argentata (Ach.) Malme	+	+		+					+		+	+			

cont. Table 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Phlyctis argena (Ach.) Flotow	+	+		+					+		+	+			
Bryoria fuscescens (Gyeln.) Brodo et D. Hawksw.	+	+		+	+								+	+	
Evernia prunastri (L.) Ach.	+	+							+		+	+		+	
Tuckermannopsis chlorophylla (Willd.) Hale	+					+	+		+					+	+
Micarea denigrata (Fr.) Hedl.	+	+		+	+						+				
* *Physcia tenella* (Scop.) DC.	+	+		+					+		+				
Cladina ciliata (Stirton) Trass	+	+	+						+				+		
Cladonia pyxidata (L.) Hoffm.	+		+	+							+		+		
Chaenotheca chrysocephala (Ach.) Th. Fr.		+	+	+									+	+	
Cladonia crispata (Ach.) Flotow	+								+	+	+		+		
C. furcata (Huds.) Schrader	+	+							+		+				
* *Lecidella elaeochroma* (Ach.) Choisy	+	+							+		+				
* *Lecanora carpinea* (L.) Vainio	+	+							+			+			
* *Xanthoria parietina* (L.) Th. Fr.	+	+							+					+	
Cetraria islandica (L.) Ach.	+	+		+							+				
Cladonia uncialis (L.) Wigg.	+	+		+							+				
C. pleurota (Flk.) Schaerer	+	+									+	+			
Usnea subfloridana Stirton	+										+	+	+		
Parmelia saxatilis (L.) Ach.		+		+										+	+
Buellia griseovirens (Turner et Borr.) Almb.					+							+		+	+

*

Lecanora expallens Ach.		+												+	+
Hypogymnia farinacea Zopf				+									+	+	
Cladonia botrytes (Hagen) Willd.	+											+	+		
C. incrassata Flk.	+								+			+			
* *Physcia stellaris* (L.) Nyl.	+								+		+				
* *Xanthoria polycarpa* (Hoffm.) Rieber	+								+		+				
* *Candelariella aurella* (Hoffm.) A. Zahlbr.	+				+									+	
* *Phaeophyscia orbicularis* (Necker) Moberg	+				+									+	
Cladonia coccifera (L.) Willd.	+	+									+				
Cetraria aculeata (Schreber) Fr.	+	+									+				
Melanelia fuliginosa (Fr. ex Duby) Essl.	+	+							+						
Cladonia phyllophora Hoffm.	+	+													
* *Ramalina farinacea* (L.) Ach.	+	+													
* *Caloplaca decipiens* (Arnold.) Blomb. et Forss.	+				+										
Lecanora saligna (Schrader) A. Zahlbr.	+								+						
* *Physcia caesia* (Hoffm.) Fürnrohr	+													+	
* *Lecanora dispersa* (Pers.) Sommerf.	+													+	
Candelariella xanthostigma (Ach.) Lettau		+							+						
* *Melanelia exasperatula* (Nyl.) Essl.		+									+				
Chaenotheca trichialis (Ach.) Th. Fr.		+										+			
Micarea melaena (Nyl.) Hedl.				+									+		
Ochrolechia androgyna (Hoffm.) Arnold				+										+	

cont. Table 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
O. subviridis (Höeg) Erichsen				+										+	
* *Lecanora albescens* (Hoffm.) Flk.					+									+	
Baeomyces roseus Pers.											+	+			
* *Trapelia involuta* (Taylor) Hertel											+				+
Hypocenomyce anthracophila (Nyl.) P. James et G. Schneider													+	+	
H. caradocensis (Leighton ex Nyl.) P. James et G. Schneider													+	+	
Calicium glaucellum Ach.													+		+
* *Caloplaca saxicola* (Hoffm.) Nordin	+														
* *Candelariella coralliza* (Nyl.) H. Magn.	+														
Cladina stellaris (Opiz) Brodo	+														
* *Cladonia cariosa* (Ach.) Sprengel	+														
* *C. cervicornis* (Ach.) Flotow	+														
C. grayi Merrill ex Sandst	+														
* *C. rangiformis* Hoffm.	+														
* *C. scabriuscula* (Delise) Leighton	+														
C. squamosa (Scop.) Hoffm.	+														
Melanelia exasperata (De Not.) Essl.	+														
M. olivacea (L.) Essl.	+														
Micarea peliocarpa (Anzi) Coppins et R. Sant.	+														
* *Physcia adscendens* (Fr.) Olivier	+														

* *Pycnothelia papillaria* (Ehrh.) Dufour	+														
* *Ramalina fastigiata* (Pers.) Ach.	+														
* *Cladonia foliacea* (Huds.) Willd.		+													
* *Lecanora subrugosa* Nyl.		+													
Pertusaria coccodes (Ach.) Nyl. var. *phymatodes* (Ach.) Almb.		+													
* *Verrucaria muralis* Ach.		+													
* *Candelaria concolor* (Dickson) B. Stein				+											
Cladonia sulphurina (Michx.) Fr.				+											
Lecidea turgidula Fr.				+											
* *Porpidia crustulata* (Ach.) Hertel et Knoph				+											
* *Trapelia coarctata* (Sm.) Choisy in Werner				+											
* *Caloplaca citrina* (Hoffm.) Th. Fr.					+										
* *Lecanora crenulata* Hook					+										
* *Phaeophyscia nigricans* (Flk.) Moberg					+										
* *Peltigera didactyla* (With.) Laundon									+						
* *Physconia distorta* (With.) Laundon									+						
* *P. grisea* (Lam.) Poelt									+						
* *Thelocarpon laureri* (Flotow) Nyl.											+				
* *Xanthoria candelaria* (L.) Th. Fr.											+				
Usnea filipendula Stirton													+		
Calicium viride Pers.														+	
Cyphelium inquinans (Sm.) Trevisan														+	

cont. Table 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lecanora hagenii (Ach.) Ach.														+	
* *Lecidea fuscoatra* (L.) Ach.														+	
Mycoblastus sanguinarius (L.) Norm.														+	
Pertusaria pertusa (L.) Tuck.														+	
Leproloma membranaceum (Dickson) Vainio															+
Mycoblastus affinis (Schaerer) Schauer															+
Opegrapha viridis Pers.															+
Number of species	**87**	**64**	**35**	**56**	**38**	**27**	**29**	**20**	**51**	**15**	**50**	**42**	**46**	**60**	**34**

1 – Bielawskie Błoto (Marsh Bielawskie); 2 – Białogóra; 3 – Bagno Biała (Biała Bog); 4 – Staniszewskie Błoto (Staniszewskie Bog); 5 – a bog on lake Drzędno; 6 – a bog on lake Moczydło; 7 – a bog on lake Kły; 8 – a bog SE of lake Kły; 9 – Czarne Bagno (Czarne Bog); 10 – Białe Błoto (Białe Marsh); 11 – Żurawiec; 12 – Słowińskie Błoto (Marsh Słowińskie); 13 – Bagnisko Niedźwiady (Swampland Niedźwiady); 14 – Bagno Biel (Biel Bog); 15 – Janiewickie Bagno (Janiewickie Bog). * – taxa foreign for bogs.

phytocoenoses with *Calluna vulgaris*, develop (Bielawskie Błoto, Czarne Bagno, Żurawiec). Also, raised-bog species retreat and are often replaced by *Molinia caerulea* (Bagno Biel and Czarne Bagno); peat-moss cover also decreases considerably, peat mosses being usually replaced by other mosses and lichens. On other bogs reclamation, if there was any, had no significant effect because its scope was small (e.g. on Bagno Biała).

Ground-water level lowering many occur in a natural way at stagnant stages of bogs (F a b i s z e w s k i 1975), but in the study areas it is caused exclusively by management. On the partly dried peat which which turns into muck a mass-growth of lichens can be observed, mainly of the genera *Cladina*, *Cladonia* and *Placynthiella*. The sequence of appearance of the taxa is illustrated by the diagram below:

Placynthiella (mainly *P. uliginosa*, less abundantly *P. oligotropha*) → *Cladonia macilenta* → *C. chlorophaea* s.l., *C. pleurota* and *C. floerkeana* → *C. glauca* and *C. crispata* → *Cladina portentosa* and *C. mitis*

The abundance of the above species is variable and dependent on the degree of moisture in the muck and presence of vascular plants and bryophytes. At low substrate-moisture levels and lack of competition a mass-growth occurs of species of the genus *Placynthiella* and cup-mosses of the section *Cocciferae*. On very moist muck, grown up with *Calluna vulgaris* and *Erica tetralix*, the dominant species are *Cladonia glauca*, *C. crispata* and *C. chlorophaea s. l.*, sometimes very abundant, too, is *C. incrassata*. The succession stages described above were observed on Bielawskie Błoto, Białogóra, Żurawiec and Czarne Bagno, and to a lesser extent on Staniszewskie Błoto. In these areas a larger number of epigeic lichen species are found than in the remaining study areas (Tab. 1). On all the bogs, except on Białogóra, peat exploitation or large-scale reclamation had been carried out.

Traces of peat exploitation were found on most of the bogs. They could not be found only on Białogóra and Białe Błoto. The greatest changes in habitat and vegetation have been caused by this operation on Bielawskie Błoto, Żurawiec, Słowińskie Błoto and Czarne Bagno. In parts of the bogs, exploited in the past, secondary communities have now formed, or early regenerative succession stages of bog associations.

Fires have significantly contributed to the degradation of some bogs (Bielawskie Błoto, Czarne Bagno). A drastic example is Bielawskie Błoto, where over large areas peat was digested by a fire down to the underlying floor, and on the moist sand of the fire site heath communities have developed (F a ł t y n o w i c z 1986a).

The presence of *Pinus sylvestris* has a decisive effect on the quantitative relations in the epiphytic flora. On bogs grown up mainly with swamp pine

forest or *Sphagnetum magellanici boreale pinetosum* phytocoenoses there occur large numbers of lichens characteristic of pine bark, i.e., *Hypocenomyce scalaris*, *Hypogymnia physodes*, *Imshaugia aleurites*, *Lecanora conizaeoides*, *Lepraria sp.*, *Parmeliopsis ambigua*, *Pseudevernia fufuracea* and *Usnea hirta*. They are accompanied by *Lecanora pulicaris*, *L. symmicta*, *Platismatia glauca* and *Scoliciosporum chlorococcum* which are less numerous but highly constant. Other species occur on pine bark on bogs sporadically, except for some cup-mosses (*Cladonia*) which grow at the base of tree-trunks.

Qualitative diversity of epiphytes on bogs is higher when old birch-trees are present on them. Even isolated birch-trees enrich the epiphytic flora with several to a dozen or so species not found on pine-trees; this has been observed e.g. on Bagno Biel, Bagnisko Niedźwiady, Staniszewskie Błoto and Białogóra.

Changes in the water conditions and turning of peat into muck are the cause of the appearance of tree and shrub species foreign to natural raised-bog ecosystems, e.g. *Populus tremula*, *Salix spp.* and *Sorbus aucuparia*. These phorophytes, of which the bark is rich in inorganic compounds and has a weakly acid or neutral reaction, make possible the occurrence of those lichens which do not grow on bogs naturally. For instance, on Czarne Bagno and Bielawskie Błoto over 30% of the epiphyte species grew on aspen and alder-trees. On bogs on which the percentage of trees is low (Białe Błoto), or where only the pine is present in the treestand (bogs: SE of Lake Kły and on Lake Moczydło), the proportion of epiphytic lichens is the smallest of all the bogs areas under study.

The number of epixylous species on bogs is small, and their abundance depends on the amount of substrate; lichens of decaying wood were found to be most abundant on Bielawskie Błoto, Staniszewskie Błoto, Bagno Biel, Bagnisko Niedźwiady and Janiewickie Bagno.

In the lichen flora of the study bogs a species group has been found foreign to the habitat (Tab. 1). In addition to *Lecanora argentata*, *L. carpinea*, *Lecidella elaeochroma*, *Physcia tenella* and *Xanthoria parietina* they are sporadical taxa of which almost 60% have been recorded from one bog. Most numerous among them are epiphytes which grow on the bark of broadleaved trees rich in inorganic compounds, mainly on aspen-trees.

As a result of management, on bogs habitats for epilithical lichens appear. These include concrete and granite posts, concrete culverts, sometimes small stones, rubble, roofing-tiles, often brought to the bog together with the epilithical species growing upon them. In this way the lichenoflora of the following areas has been enriched: Bielawskie Błoto, Bagno Biel and the bog on Lake Drzędno. The presence of epilithic species indicates human activity, but is not an indicator of habitat degradation and plant-community degradation; on the bog on Lake Drzędno 6 epilithic species have been found

growing on dispersed pieces of concrete, while the plant communities of that area show a very high degree of naturalness.

Among the lichens foreign to the habitat the following epigeic species form a small group: *Cetraria aculeata*, *Cladonia cariosa*, *C. cervicornis*, *C. foliacea*, *C. rangiformis*, *C. scabriuscula* and *Peltigera didactyla*. They are taxa growing by nature on sand and humus; they were found in small numbers on sand on Bielawskie Błoto, and on small dunes in Białogóra.

The number of species foreign to the habitat is not directly proportional to the degree of bog degradation. For example, on the best-preserved bog in Białogóra over 20% of taxa are foreign to the habitat, and on the badly damaged Żurawiec – about 17%.

The proportions of species from the particular habitat groups in the flora of the bogs studied are presented in Fig. 2. Data concerning most of the areas are concentrated at a small distance from the mean. The smallest, proportionately, number of epiphytic taxa, and the smallest of epigeic ones

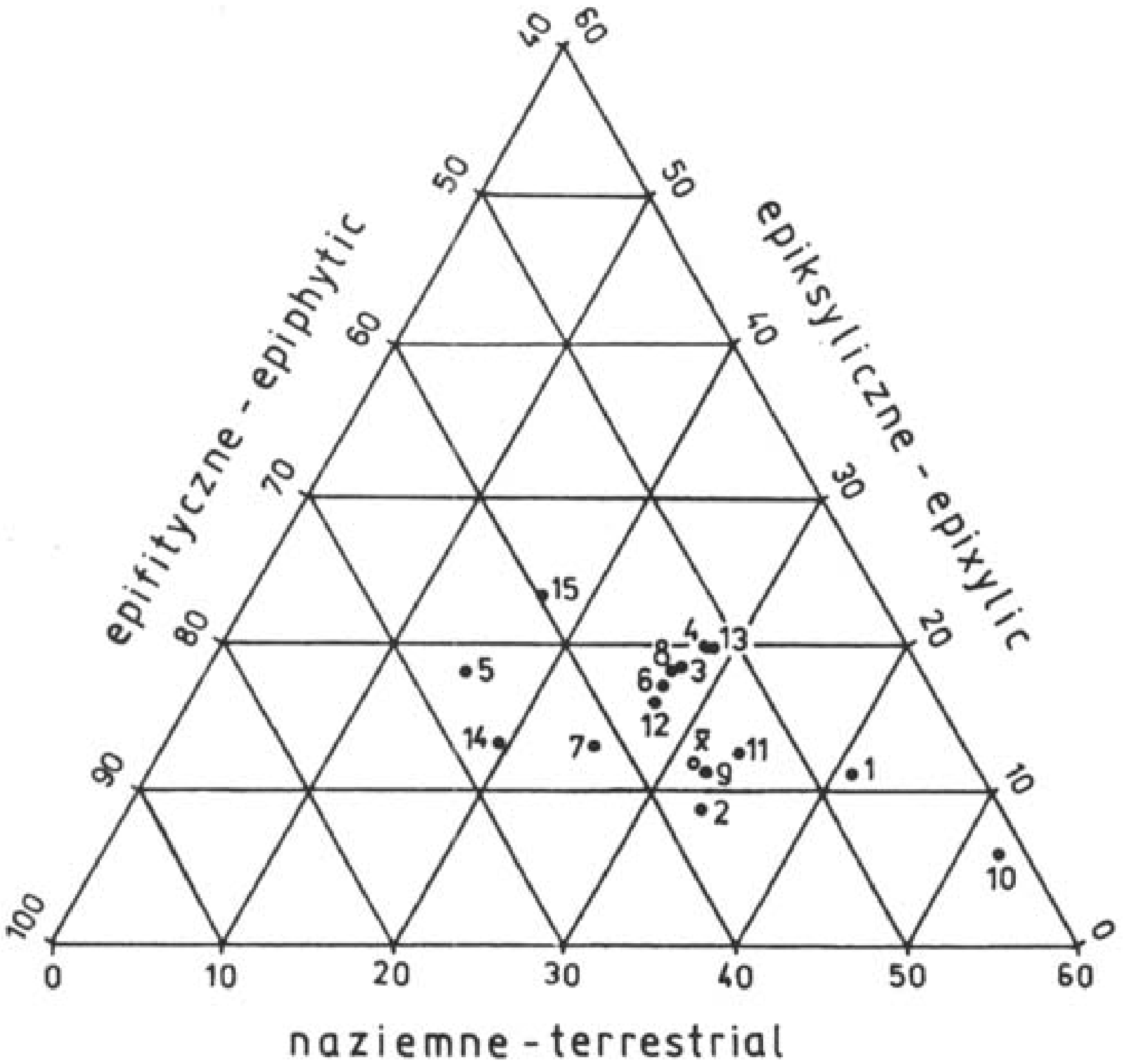

Fig. 2. The proportion of number of lichen species representing the more important habitat groups on the investigated peat-bogs (in %); x – mean; 1-15 – see Fig. 1

have been found for Białe Bagno (a bog of which the natural state that endures is very good) and Bielawskie Błoto (most degraded). On the reverse side of the diagram — the farthest from the mean value are: Janiewickie Bagno, Bagno Biel and the bog on Lake Drzędno, where the percentage of epigeic lichens is the lowest, and that of epiphytes the highest; this is the result of a fairly high water level on these bogs, and the presence on them, over large areas, of wet swamp pine forest. The degree of naturalness of the plant communities in these areas varies (cf. Chapter 2).

An analysis of the floristic similarity of the bogs studied (Fig. 3) has proved that the highest similarity coefficients (over 60%) are found for bogs of which the natural status enduring is good and which contain a large proportion of pine. Most different from other bogs are Białe Błoto and Białogóra (the least-degraded), as well as Bielawskie Błoto, Czarne Bagno and Żurawiec (the most damaged).

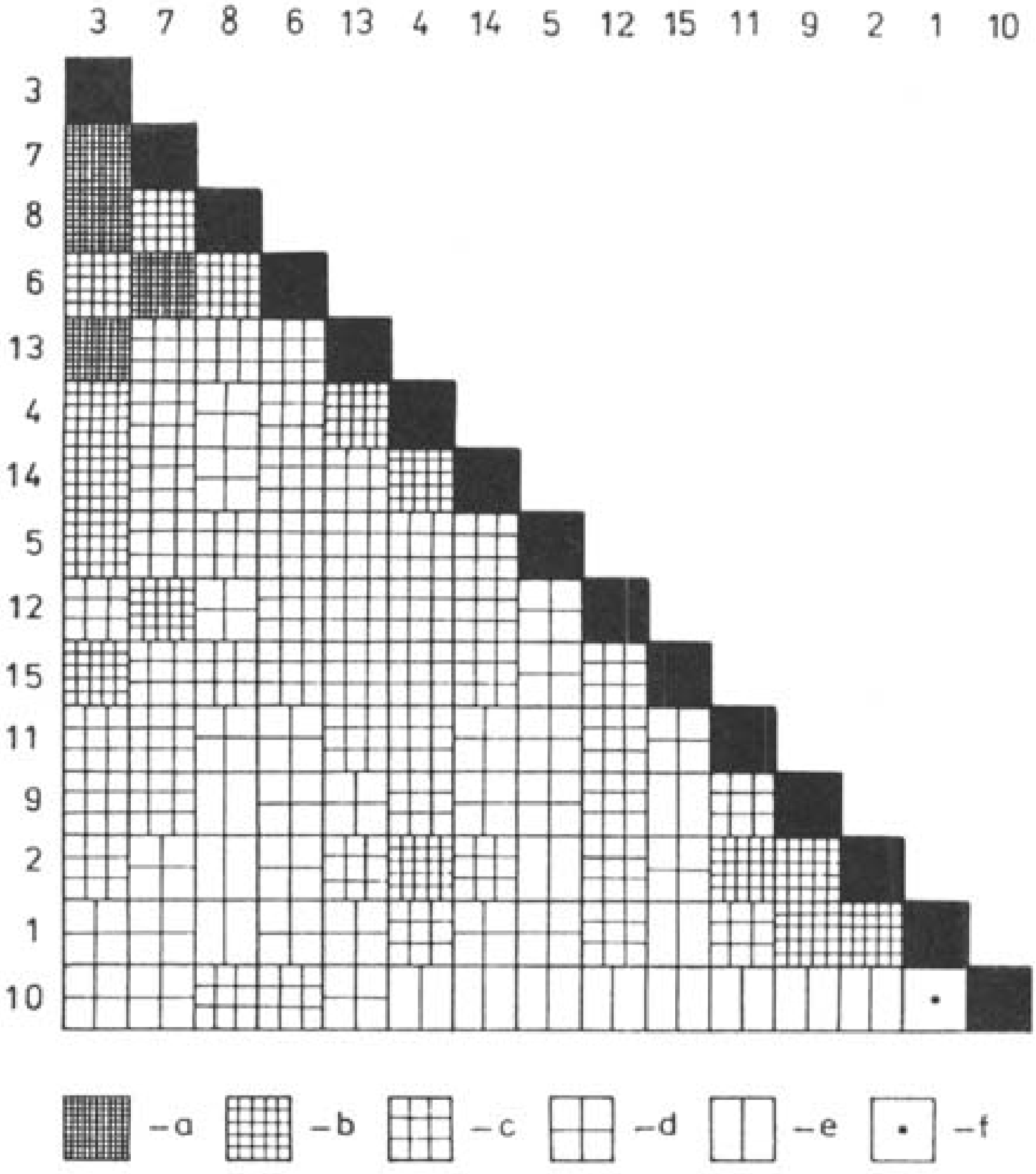

Fig. 3. The floristic similarity of investigated area (1-15 — see Fig. 1)
a — 60%, b — 50-59.9%, c — 40-49.9%, d — 30-39.9%, e — 20-29.9%, f — 10-19.9%

CONCLUSIONS

1. An analysis of the lichen flora of fifteen selected raised and transition-bogs in West Pomerania has shown that their lichenoflora is poor and characterized by dominance of acidophilous epiphytes associated with pine bark, and of humus-loving lichens growing on muck, wood and at the base of tree-trunks; in addition, it contains a very large percentage of sporadic (accidental) species.

2. Management operations on the bogs cause clear changes in the lichenoflora. However, these changes depend also on many other factors, e.g. on the geographical position (bogs in the seaside zone have a richer lichenoflora than inland bogs, which is due to the climatic conditions being more favourable for lichens in the former case) and on the immediate surroundings (possibilities of species passing from the surroundings into the bog ecosystems, this being particularly conspicuous in Białogóra). In some cases man-caused changes in the flora of lichens resemble those caused by natural factors.

3. The number of lichen species does not reflect anthropogenic changes in the vegetation; a detailed analysis of the floristic composition makes it possible to distinguish taxa which are foreign to the habitat, but their presence (except for epilithic species) may also be the result of the influence of natural factors, e.g. transition of bogs into a stagnant phase, or a rise in ground-water level. In the former case the number of epigeic species increases, in the latter — some epiphytes disappear, and the number of epixylous taxa increases.

4. Quantitative rations in the bog lichenoflora in most reflect anthropogenic changes, e.g. reclamation, turning of peat into muck, cause a rich (sometimes mass) growth of epigeic lichens, and the proportion also increases of some epiphytic species because of the appearance on the bogs of phorophytes which do not occur naturally on them.

5. The presence of epilithic lichens, entirely foreign to bogs, is a sign of human influence, but it has no importance for evaluation of the degree of naturalness of bog ecosystems. The „introduction" of substrates for epilithical lichens occurs at points, and does not affect the state of habitats and communities.

6. Lichens are not good indicators of the degradation of transition and raised-bog phytocoenoses, mainly because it is difficult to properly determine their response — whether it is caused by natural or anthropogenic factors. It does not seem possible to create a lichenoindicative system for bogs, similar to that used in studies of the pollution of the atmospheric air. Lichens can successfully be used in analyses of changes in the vegetation of isolated bogs; this should, however, be done at the most in addition to other procedures used to determine the degree of naturalness of plant communities.

7. Noteworthy is the presence upon many bogs of lichens which are very rare throughout Poland. Among those found during these studies the following are particularly interesting:

Cladonia incrassata
C. sulphurina
Cyphelium inquinans
Hypocenomyce anthracophila
H. caradocensis
Lecidea turgidula
Melanelia olivacea
Micarea melaena
Mycoblastus affinis
M. sanguinarius
Ochrolechia androgyna
Pycnothelia papillaria

Their occurrence raises the rank of bogs as ecosystems sustaining a particularly interesting relict flora.

(Translated by S. Kwieciński)

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Porosty jako wskaźniki degeneracji zbiorowisk torfowiskowych

Streszczenie

Flora porostów rosnących w ekosystemach torfowisk wysokich i przejściowych w warunkach naturalnych jest zwykle bardzo uboga. Występuje tutaj kilkanaście acydofilnych gatunków epifitycznych, a także niewielka liczba taksonów humusolubnych, które rosną u nasady pni sosen i brzóz, na murszejącym drewnie oraz na podsuszonych szczytach kęp.

Melioracje wodne na torfowiskach, których efektem z reguły jest znaczne obniżenie poziomu wody i przesuszenie powierzchniowych warstw torfu, powodują m.in.:

- zwiększenie liczby gatunków epifitycznych; jest to wynik pojawienia się na zmeliorowanych torfowiskach drzew i krzewów z natury na nich nie rosnących;
- wzrost liczby gatunków porostów naziemnych, czemu sprzyja przesuszenie i murszenie wierzchnich warstw torfu;
- bardzo obfity, a czasem wręcz masowy, rozwój naziemnych taksonów humusolubnych, takich jak *Placynthiella oligotropha, Trapeliopsis granulosa, Cladonia glauca, C. macilenta* i in. Zjawisko to występuje w kilku pierwszych latach po obniżeniu poziomu wody; później porosty naziemne na większości powierzchni ustępują przed silniejszymi konkurencyjnie roślinami kwiatowymi;
- częste pojawianie się w obrębie torfowiska porostów naskalnych, które są tutaj całkowicie obcym elementem siedliska; rosną one na betonowych słupkach, odkrytych fragmentach przepustów itp.

Zakres przedstawionych zmian zależy również m.in. od typu zbiorowisk otaczających torfowisko (są one źródłem diaspor) i od warunków klimatycznych (torfowiska w strefie przymorskiej mają bogatszą florę porostów od torfowisk śródlądowych).