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Effect of land-use on lichen diversity in the transboundary region of Lithuania and northeastern Poland

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Twelve transects, each 7 km long and 10 m wide (in groups of six in Lithuania and Poland), and additional five areas (three on the Lithuanian side and two on the Polish side) were chosen for the evaluation of lichen diversity along the Via Baltica highway in the segment between Marijampolë and Suwalki towns. The study area was similar geographically, but had a different history of land-use practices determined by different human activities in both countries.

A total of 194 species of lichens were registered during the present study in the whole investigated area; 165 species were reported from the Lithuanian part and 136 from the Polish part.

In the Polish part of the study area, among the commonest species acidophilous lichens were more frequently registered, meanwhile on the Lithuanian side nitrophilous species were more common. On the other hand, most of the lichens characteristic of forests with a long ecological continuity were registered only in the Lithuanian part of the study area. The large-scale totally replacing sylviculture combined with relatively intensive agriculture affected lichen diversity more adversely than the agricultural landscape intermixed with surviving islands of natural biotopes. The differences in lichen diversity were caused by a decrease of landscape/ biotope diversity on the Polish side and maintenance of landscape/biotope diversity through a more traditional land-use on the Lithuanian side.

Key words: lichens, diversity, land-use, Lithuania, NE Poland

INTRODUCTION

Man is one of the most important factors influencing the modern patterns of lichen diversity all over the world and especially in the areas with a long history of human activities like Europe, where nature has been shaped by humans for millennia. Though it is impossible to track all changes in lichen flora due to deforestation, industrial re-forestation, agriculture, urbanization, environmental pollution and mining activities, at least some mirroring of not too remote land-use history can be observed.

It is reasonably well known how species diversity dwindle to rather simplified flora due to habitat destruction, especially destruction of forest habitats (Hawksworth et al., 1974; Gilbert, 1980; 2000, etc.), environmental pollution (see, *e. g.*, bibliography by A. Hendersson in http://www.nhm.uio.no/botanisk/lav/RLL/RLL.HTM), agriculture (Brown, 1992; 1996; Loppi, De Dominicis, 1996; van Dobben, 1996, etc.), and forestry (Kuusinen, Siitonen, 1998; Gilbert, 2000; etc.). There is also certain amount of data on lichens spreading through new substrates or habitats created by man (Alstrup, 1977; Aptroot, James, 2002; Gilbert, 1990, 2000; Daniels, Harkema, 1992; Ceynowa-Gieùdon, 2001; Ernst, 1995; Wirth, 1976; Motiejûnaitë, 1999; etc.). All these factors are important, and often it is difficult to tell which of them has played the key role in the formation of the existing pattern of lichen diversity in one or another locality.

Documenting of lichen flora in various areas usually does not answer this question, because subjectively more often protected or at least less human-affected areas are chosen for lichen inventory and then mainly the influence of natural factors on lichen diversity are discussed, if at all, or only a human-influenced decrease of diversity is mentioned (*e. g.*, Arup et al., 2001; Czyýewska et al., 2002; Faùtynowicz, 1996; Motiejûnaitë, Piterâns, 1998; Piðut, Guttovc, 1998; Randlane, Jüriado, 1999; Woods, 2003; etc.) or, if ecological surveys are carried out, they are targeted either to one environmental factor or to one ecological group of lichens (Dietrich, Scheidegger, 1996, 1997; Giordani et al., 2001; Holien, 1998; Arup et al., 2003; etc.). Therefore analyses of lichen diversity in a mosaic landscape are quite sparse.

In 1999, an international project was launched in the transboundary region of Lithuania (Marijampolë district) and Poland (Suwalki region), aiming to evaluate the diversity of target organism groups in the vicinity of the important international highway Via Baltica, where the transport and urbanisation load is expected to increase significantly in the nearest future. The results of the investigation not only highlighted the present situation of lichen diversity in the study area, but also revealed certain patterns that can be explained by differences in human activities on both sides of the state border. In the present paper, we attempted to elucidate the factors influencing lichen diversity and to link the variability of diversity patterns to different land-use practices in the region.

MATERIALS AND METHODS

Twelve transects (7 km long and 10 m wide) and five additional localities of slightly varying area in both countries were chosen for the field studies in the environs of the Via Baltica highway. In the Lithuanian part of the area six transects were chosen. Two were in the segment between Marijampolë and Kalvarija towns (Valavièiai (L1) and Zapalimai (L2) transects); this segment is especially heavily anthropogenized, and any forested areas are absent; agricultural fields prevail, therefore lichen diversity is especially low here. In the segment between Kalvarija and the state border, four transects were chosen: Sangrûda (L3), Reketija (L4), Brazavas (L5) and Palucmargiai (L6). Three additional areas were the Trakënai forest (L7), the forest in the environs of the Barkai farmstead in the valley of the Šarkyèia rivulet (L8), and the territory around the Reketija cordon (L9).

Six transects were chosen between Suwalki and the Polish–Lithuanian state border in the Polish part of the study area: Sadzawki (P1), Becejy (P2), Zaboryszki (P3), Jeleniewo (P4), Prudziszki (P5) and Osinki (P6). Two additional areas were chosen in Szymanowizna (P7) and Studzieniczne (P8) forests.

Material for the study was collected or registered from all available substrates and habitats. The collected specimens were identified following routine lichenological methods. In the present analysis lichenicolous fungi were omitted, as they were registered only on the Lithuanian side. These findings were published earlier (Motiejûnaitë, 2002).

Hierarchical cluster analysis was performed with PC-ORD 4 (McCune, Mefford, 1999) to estimate the similarity of lichen species composition in transects and study areas. The relative S¸rensen distance measure and the farthest neighbourhood linkage method were employed in cluster analysis. The analysis was based on presence of species; species abundance was not taken into account.

HISTORICAL BACKGROUND OF LICHENOLOGICAL STUDIES IN THE STUDY AREA AND SURROUNDING REGION

No baseline of lichenological studies for the investigation area exists in either of the countries. In the Lithuanian part, as in the whole previous district of Marijampolë in general, lichens are generally very much understudied: historical data are almost absent. There are only several collections from this region, mainly common species like *Xanthoria parietina, Hypogymnia physodes, Cladonia rangiferina* in the herbarium of Vilnius University (WI) (Motiejûnaitë, 1992). The closest better-investigated area is the Bagotoji military forestry, northwards of the present study area, which was studied in 1995 (Motiejûnaitë, 1996); besides, there is a small collection of lichens from the close-laying Bukta forest in the herbarium of the Institute of Botany (BILAS). A small recent lichenological collection containing several specimens from the area of the present study is kept in the herbarium of the Marijampolë Ecological Education Station. Almost all species of this collection were recorded during the present study as well: *Physcia tenella, Evernia prunastri, Xanthoria parietina, Ramalina fraxinea, R. farinacea, Parmelia sulcata, Platismatia glauca, Vulpicida pinastri, Hypogymnia physodes, Pseudevernia furfuracea* and *Cladonia furcata.* Only two species (*Cladonia botrytes* and *C. rangiformis*) were not found on the Lithuanian side of the area.

There are no historical data on the lichens from the Polish part of the study area either, except for several lichenological works concerning the Suwalki region in general. Information concerning lichens of the neighbouring Wigierski National Park can be found in the articles by Bystrek and Matwiejuk (1994); Bystrek and Przepiórkowska (1994); Faùtynowicz (1994). Some data on lichens from the vicinity of the study area can be found in papers by Ñàâè÷ (1923); Bystrek (1964, 1964, 1974); Faùtynowicz (1981) and Cieúliñski, Tobolewski (1989).

INVESTIGATION AREA

The investigated area is a belt of *ca*. 90 km long, starting at the outskirts of the Marijampolë town in Lithuania, crossing the state border and ending in the outskirts of the Suwalki town in Poland. Its direction coincides with the Via Baltica highway.

Geographically, the Lithuanian part of the study area belongs to two districts of the biogeographical

Eastern Baltic province's Atlantic belt: the segment from Marijampolë to Kalvarija belongs to the Sûduva lowland district, and the segment between Kalvarija and the State border belongs to the Sûduva highland district. The Sûduva lowland district is characterized by argillaceous and wavy loam plains with biocenoses of mixed spruce-hardwood as well as deciduous forests intermixed with dry meadows and mires under conditions of agrarian and agrarian-forested landscape. This part is characterized by rich soils and subsequently by intensive agriculture. Most areas are occupied with arable fields, cultured meadows and pastures, farms and gardens with very sparse areas of forest plantations (*Pinus sylvestris*). The Sûduva highland district is characterized by loamy hills with biocenoses of mixed spruce-hardwood as well as deciduous forests intermixed with lowland meadows and lakes under conditions of agrarian and agrarian-forested landscape (Anonimas, 1997). In this part, more fragments of natural landscape survived: small patches of semi-natural deciduous forests, fragments of dry grasslands with numerous boulders. Forest plantations occupy larger areas as well.

The Polish part of the study area belongs to the physicogeographical Eastern Suwalki Lakeland mesoregion (Kondracki, 1978). In the sense of phytogeographic division it belongs to the Suwalki–Augustów region (Szafer, 1972). Most of the Polish part of the area is arable land. In this agricultural landscape, small patches of forests (not exceeding several square kilometres) have survived. Woodland communities with the dominant *Pinus sylvestris* prevail. *Picea abies* is another important tree species. Monocultures of both conifers often replace forest habitats, formerly occupied by deciduous and mixed woodland. Only small fragments of rich deciduous forests with *Quercus petraea*, *Carpinus betulus*, *Tilia cordata* and *Corylus avellana* have survived on slopes above streams, as well as narrow patches of forests with *Alnus glutinosa* in tree-stands along streams and small rivers. The age structure of the tree-stands is outstandingly poor: most of them are post-war plantations (*ca.* 55 years old).

The whole territory is characterised by a rather low annual precipitation (550–600 mm). Local industrial pollution is low on both sides of the border, as there is no large industrial objects in the whole region.

RESULTS AND DISCUSSION

Lichen frequency and diversity

In total, 194 species of lichens were registered during the present study in the whole investigated area. As the genus *Lepraria* was identified to the species level only in part of the collections, all species were united under *Lepraria* spp. All "chemical" species of the *Cladonia chlorophaea* group were united under *C. chlorophaea* coll., the same as the *Xanthoria candelaria* and in part *Lecanora dispersa* groups. The taxa identified only to the genus level were not taken into account in the present paper, except a sterile species probably belonging to the genus *Biatora*, which is widespread and common in hardwood forests of Lithuania.

Lichen frequency analysis showed that most lichens were of the lowest frequency (Table 1), found in one or two transects or study areas (76 species, 39% of

Table 1. **List of species in four classes of frequency (with indicating the number of transects and study areas they occurred in)**

Rare	Rather rare	Rather frequent	Frequent
Acarospora heppii 2	*Acarospora veronensis* 4	*Aspicilia cinerea* 7	*Acarospora fuscata* 14
Acrocordia gemmata 2	*Anaptychia ciliaris* 5	*Buellia griseovirens* 8	*Amandinea punctata* 14
Agonimia allobata 2	*Arthonia spadicea* 4	*Caloplaca citrina* 6	*Caloplaca decipiens* 10
Arthonia dispersa 1	*Aspicilia moenium* 3	*Cetraria chlorophylla* 7	*Caloplaca holocarpa* 14
Arthonia radiata 1	*Bacidia bagliettoana* 3	*Chaenotheca ferruginea* 7	*Caloplaca saxicola* 11
Arthothelium ruanum 2	*Bacidia rubella* 5	*Cladonia chlorophaea* aggr. 8	*Candelariella aurella* 13
Aspicilia caesiocinerea 2	*Bacidina arnoldiana* 3	*Cladonia furcata* 8	*Candelariella vitellina* 13
Aspicilia calcarea 2	*Candelaria concolor* 3	*Cladonia ochrochlora* 6	*Candelariella xanthostigma* 14
Bacidina chloroticula 1	*Chaenotheca furfuracea* 3	*Cladonia subulata* 7	*Cladonia coniocraea* 10
Bacidina egenula 1	*Chaenotheca trichialis* 4	*Dimerella pineti* 6	*Cladonia fimbriata* 13
"*Biatora*" sp. 1	*Cladonia arbuscula* 3	*Lecania cyrtella* 7	*Evernia prunastri* 16
Bryoria fuscescens 1	*Cladonia glauca* 4	*Lecanora argentata* 8	*Hypocenomyce scalaris* 11
Buellia badia 1	*Collema limosum* 3	*Lecanora crenulata* 6	*Hypogymnia physodes* 16
Caloplaca cerinella 1	*Collema tenax* 5	*Lecanora saligna* 7	*Hypogymnia tubulosa* 11
Candelariella coralliza 2	*Graphis scripta* 3	*Lecanora symmicta* 6	*Lecanora albescens* 13

Candelariella efflorescens 1	*Lecania cyrtellina* 3	*Lecanora varia* 7	*Lecanora carpinea* 17
Candelariella reflexa 1	*Lecania naegelii* 4	*Lecidea fuscoatra* 6	*Lecanra chlarotera* 14
Cetraria aculeata 1	*Lecanora allophana* 5	*Neofuscella loxodes* 8	*Lecanora conizaeoides* 14
Cetraria islandica 1	*Lecanora piniperda* 4	*Neofuscella pulla* 7	*Lecanora dispersa* s. l. 13
Cetraria sepincola 1	*Lecanora populicola* 3	*Peltigera rufescens* 8	*Lecanora expallens* 13
Chaenotheca brachypoda 2	*Lecanora rupicola* 4	*Pertusaria amara* 6	*Lecanora hagenii* 13
Chaenotheca chrysocephala 1	*Lecanora umbrina* 4	*Physconia distorta* 7	*Lecanora muralis* 15
Chaenotheca xyloxena 2	*Lecidella stigmatea* 4	*Physconia perisidiosa* 6	*Lecanora polytropa* 14
Cladonia cariosa 2	*Leptogium biatorinum* 3	*Platismatia glauca* 6	*Lecanora pulicaris* 15
Cladonia cenotea 1	*Melanelia subaurifera* 4	*Pleurosticta acetabulum* 8	*Lecidella elaeochroma* 15
Cladonia cornuta 2	*Micarea denigrata* 4	*Tephromela atra* 6	*Lepraria* spp. 15
Cladonia digitata 2	*Micarea prasina* 4	*Trapeliopsis flexuosa* 9	*Melanelia exasperatula* 16
Cladonia gracilis 1	*Mycobilimbia sabuletorum* 3	*Verrucaria muralis* 8	*Melanelia fuliginosa* 10
Cladonia macilenta 2	*Opegrapha rufescens* 3	*Verrucaria nigrescens* 7	*Parmelia sulcata* 17
Cladonia rei 2	*Placynthiella icmalea* 3	*Vulpicida pinastri* 7	*Parmeliopsis ambigua* 10
Cladonia scabriuscula 1	*Placynthiella uliginosa* 5	*Xanthoria candelaria* s. l. 8	*Peltigera didactyla* 11
Cladonia subrangiformis 1	*Porpidia crustulata* 5	*Xanthoria elegans* 6	*Phaeophyscia nigricans* 14
Cladonia symphycarpa 1	*Rhizocarpon obscuratum* 5		*Phaeophyscia orbicularis* 14
Diploschistes scruposus 1	*Rinodina pyrina* 4		*Phlyctis argena* 17
Fuscidea pusilla 1	*Sarcogyne regularis* 4		*Physcia adscedens* 15
Imshaugia aleurites 2	*Sarcosagium campestre* 4		*Physcia caesia* 14
Lecania globulosa 2	*Scoliciosporum chlorococcum* 5		*Physcia dubia* 13
Lecanora glabrata 2	*Scoliciosporum umbrinum* 4		*Physcia stellaris* 12
Lecanora intricata 2	*Thelidium zwackhii* 3		*Physcia tenella* 16
Lecidea nylanderi 1			*Physconia enteroxantha* 15
Lecidea plana 1			*Pseudevernia furfuracea* 13
Lecidea variegatula 1			*Ramalina farinacea* 14
Melanelia exasperata 1			*Ramalina fastigiata* 10
Melanelia incolorata 2			*Ramalina fraxinea* 13
Melanelia olivacea 1			*Xanthoparmelia conspersa* 11
Melanelia sorediata 1			*Xanthoria parietina* 15
Melanelia subargentifera 1			*Xanthoria polycarpa* 17
Micarea melaena 1			
Opegrapha varia 1			
Parmelia submontana 1			
Peltigera neckeri 1			
Peltigera praetextata 1			
Pertusaria albescens 2			
Pertusaria coccodes 2			
Pertusaria leioplaca 1			
Phaeophyscia endophoenicea 1			
Physcia aipolia 1			
Physconia grisea 2			
Placynthiella oligotropha 1			
Polysporina simplex 1			

Table 1 (continued)

Rare	Rather rare	Rather frequent	Frequent
Porina aenea 1 *Ramalina pollinaria* 2 *Rhizocarpon geographicum* 2 *Steinia geophana* 2 *Thelidium minutulum* 1 *Thelomma ocellatum* 2 *Trapelia obtegens* 1 *Trapelia placodioides* 1 *Trapeliopsis granulosa* 1 *Usnea hirta* 1 *Verrucaria dolosa* 2 *Verrcaria hydrela* 2 *Verrucaria praetermissa* 2 *Verrucaria xyloxena* 2 *Xanthoparmelia somloensis* 2 *Xanthoria calcicola* 1			

the total species number). Frequent species, found in 10–17 transects or areas, comprised 24% of the total species number (47 species). Only four species were registered in all transects and study areas.

Notably, the "common" species of this study were generally common in Lithuania and NE Poland, meanwhile the case was different with "rare" species. Part of them are genuinely rare in both countries, *e. g.*, *Agonimia allobata, Arthonia dispersa, Bacidina egenula* (which is here reported for the first time for Lithuania and has not been known in NE Poland so far), *Chaenotheca brachypoda*, *Caloplaca cerinella*, etc. The other "rare" species were generally common to very common, but due to the scarcity of suitable biotopes in the study area fell into the "rare" category: *Cetraria aculeata*, *Cetraria islandica*, *Chaenotheca chrysocephala*, *Cladonia cornuta*, *Cladonia digitata*, *Cladonia macilenta*, etc.

Quantitatively, lichen diversity in the study areas of the Lithuanian and in Polish parts was not similar: 165 species were recorded in the Lithuanian part and 136 in the Polish part. This is explainable by more uniform, man-impacted biotopes on the Polish side. It is notable that two species, *Chaenotheca brachypoda* and *Micarea melaena*, which are assumed to be old-growth forest indicators in Lithuania and NE Poland (Motiejûnaitë et al., 2004), were found only on the Lithuanian side. Almost all calicioid species also were recorded on the Lithuanian side, meanwhile only one, very common *Chaenotheca ferruginea* was found on the Polish side. Richness of this group of lichens is known to be a good index of forest naturality (Selva, 2000). More of the species that are indicators of sites of conservational value in other European countries (Coppins A. M., Coppins B. J., 2002; Hallingbäck, 1995) were recorded only on the Lithuanian part: *Agonimia allobata*, *Opegrapha varia*, *Phaeophyscia endophoenicea*, *Porina aenea.* Only on the Polish side, *Melanelia incolorata* and *Parmelia submontana* which are indicators of biologically rich sites in Sweden (Hallingbäck, 1995) were noted. On both Lithuanian and Polish parts *Pleurosticta acetabulum*, an indicator of biologically rich sites in Sweden (Hallingbäck, 1995) and in Lithuania (Andersson, Kriukelis, 2002) was recorded. Aquatic lichens, which are characteristic of undisturbed streams, were recorded only on the Lithuanian part. Presence of these species along with saxicolous lichens (*Neofuscelia* spp., *Rhizocarpon* spp., *Candelariella coralliza, Diploschistes scruposus*, etc.) indicate a probable pattern of the former lichen diversty in the study area in both countries and the extent of losses in lichen flora over the last decades.

On the other hand, traditional human activities have created several ecological niches for specific lichen diversity, such as old gravel pits, road scarps along old gravel roads, and old timber constructions. The first two were more common and had a higher lichen diversity in the Lithuanian part, meanwhile timber constructions boasted of more diverse lichen flora on the Polish part. Notably, though old gravel pits and road scarps bear diverse and generally understudied lichen communities, they are pioneer ones consisting of spreading or invasive species. Besides, this type of human activity is continuous and does not tend to decrease in the area, though in Western Europe it is thought to be vanishing (see, *e. g.*, Jørgensen, Motiejûnaitë, 2005). Meanwhile old, untreated timber constructions belong to a decreasing lichen habitat which can often bear rare and vulnerable stenotopic species (Hawksworth et al., 1974; Faùtynowicz, Kukwa, 1999).

Another noteworthy pattern was revealed by analysis of the most common species on the both sides of the study area (Table 2). Though generally common species were common on the both sides of the study area, acidophilous lichens were more frequent in the Polish part and nitrophilous in the Lithuanian part. Common saxicolous lichens were more or less equally distributed on the both sides of the study area, *Verrucaria muralis* making an exception: it was found on calcareous pebbles, old brickwork and concrete in almost all transects and study areas in Lithuania and not recorded in the Polish part.

Table 2. **List of most frequent species in Polish and Lithuanian parts of the study area (registered in no less than 7 transects / study areas in the Lithuanian part or 6 transects/study areas in the Polish part). Acidophilous lichens are marked in bold type, nitrophilous lichens are marked with an asterisk (*)**

Lichen species	Frequency in Lithuanian part	Frequency in Polish part
Acarospora fuscata	7	7
**Amandinea punctata*	8	6
**Caloplaca holocarpa*	8	6
Candelariella aurella	7	6
**Candelariella vitellina*	9	6
Candelariella xanthostigma	8	7
Cladonia fimbriata	**6**	**7**
Evernia prunastri	**8**	**8**
Hypocenomyce scalaris	**3**	**8**
Hypogymnia physodes	**8**	**8**
Hypogymnia tubulosa	**4**	**7**
Lecanora albescens	7	6
Lecanora argentata	1	7
Lecanora carpinea	9	8
Lecanora conizaeoides	**6**	**8**
**Lecanora chlarotera*	7	6
**Lecanora dispersa*	7	6
Lecanora expallens	8	5
**Lecanora hagenii*	8	5
**Lecanora muralis*	8	7
Lecanora polytropa	7	7
Lecanora pulicaris	**7**	**8**
Lecidella elaeochroma	9	7
Melanelia exasperatula	9	7
Melanelia fuliginosa	4	6
Parmelia sulcata	9	8
Parmeliopsis ambigua	**3**	**7**
Peltigera didactyla	7	4
**Pheophyscia nigricans*	8	6
**Phaeophyscia orbicularis*	8	6
Phlyctis argena	9	8
**Physcia adscendens*	9	6
**Physcia caesia*	8	6
**Physcia dubia*	9	4
**Physcia stellaris*	9	3
**Physcia tenella*	9	7
**Physconia enteroxantha*	9	6
Ramalina farinacea	7	7
Ramalina fraxinea	7	6
Verrucaria muralis	8	0
**Xanthoria parietina*	9	6
**Xanthoria polycarpa*	9	8

Substrates

The study territory is mosaic and includes a variety of substrates suitable for lichens, however, different substrates bear a varying load of lichen diversity (Fig. 1). Gross part of the registered species make epiphytes, especially these of deciduous trees. Siliceous stones also bear numerous lichen species, though only in the case of a weaker human influence. Other substrate groups are considerably poorer in lichens. Different substrate types are distributed unevenly among the transects and study areas. When comparing the substrate groups bearing most of the rarest and the commonest (in this study) species, the highest numbers of rare species (1–2 findings) were noted for siliceous stones (15 species), deciduous trees in forests (20 species) and soil (14 species) (Fig. 2). Four substrate groups, wood, timber, pebbles and bryophytes-plant remnants, did not bear very common lichens at all. The first two substrates are scarce and unevenly distributed in transects. Wood is sparse due to the intensive sanitary cleaning of forests, even in transects with larger woodland areas. Bryophyte remnants and pebbles are often more common, but suitable conditions are rare for lichens to settle on them. In all substrate groups rare species were more abundant, repeating the general frequency pattern (Fig. 2, Table 1). An except was concrete-inhabiting lichens and the eurysubstrate lichen group (species found on more than three different types of substrate) where common lichens comprise a larger part than rare ones (Fig. 2).

Characteristics of the transects and study areas

Different numbers of lichen species were found in the transects and study areas (Fig. 3). The highest numbers on the Lithuanian side were found in the Sangrûda transect, Trakënai forest and the territory around Reketija cordon. The Sangrûda transect and Reketija cordon area are mosaic landscapes that provide variable conditions for lichens

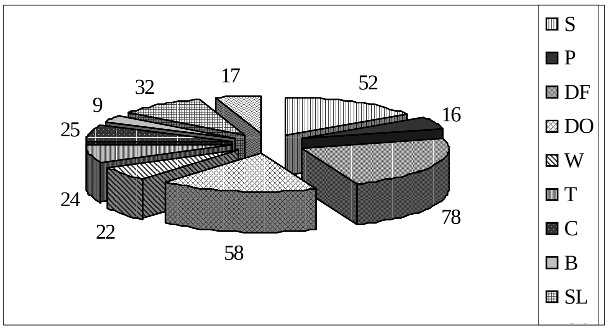

Fig. 1. Numbers of lichen species found on different substrate types. Abbreviations: S – siliceous stones, P – pebbles, DF – deciduous trees in forests, DO – deciduous trees in open places, W – natural wood, T – worked timber, C – concrete, B – bryophytes/plant remnants; SL – soil; CO – coniferous trees

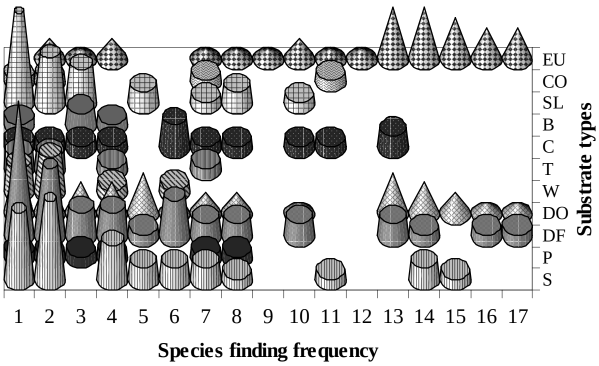

Fig. 2. Lichen frequency distribution on different substrate types. For abbreviations, see legend of Fig. 1. (Additional – EU – eurysubstrate lichens)

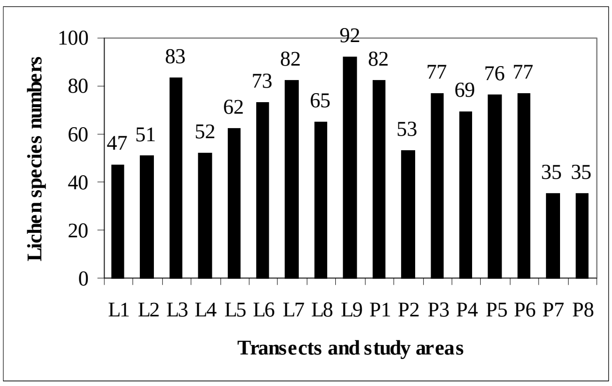

Fig. 3. Diversity of lichen species in the transects and study areas. For abbreviations, see Materials and Methods

to settle. Trakënai forest is an islet of semi-natural deciduous forest, native for the studied territory. The lowest diversity was found in the Valavièiai, Zapalimai and Reketija transects, which cross an anthropogenic landscape with prevailing pastures and arable fields. On the Polish side, the highest diversity was found in the Sadzawki transect which is also characterised by a mosaic landscape. The lowest diversity was found in the young and dense Szymanowizna and Studzieniczne forests, where conditions for lichens are rather adverse. Lichen diversity in the Polish transects and study areas was generally lower than in the Lithuanian part.

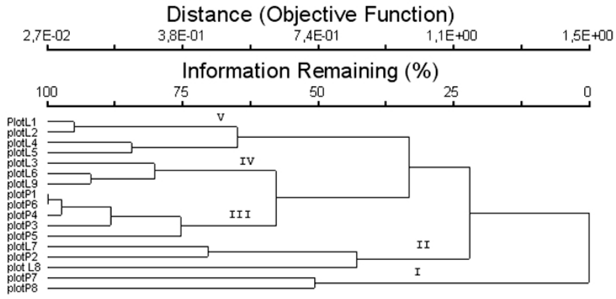

Fig. 4. Similarities of lichen species diversity in the transects and study areas according to cluster analysis. Designations I; II; III; IV; V indicate clusters. For abbreviations, see Materials and Methods

Based on the results of cluster analysis, the transects and study areas could be divided into five groups (Fig. 4). The first cluster (P7 and P8) unites similar areas with a rather dense, relatively young, lichen-poor woodland. The second cluster (L7, L8 and P2) is characterized by prevailing remnants of natural and semi-natural mixed broad-leaved forests, which are native for the region. The third cluster (P1, P3, P4, P5, P6) comprises the transects in Poland that are characterized by a relatively uniform landscape of intensive agriculture, intermixed with mainly planted forests. Fragments of seminatural mixed forests exert a rather insignificant impact on the differences in lichen flora of these areas. The fourth cluster (L3, L6, L9) comprises transects and areas in Lithuania with a less signficant human impact. Relatively natural forest communities have survived there, together with semi-natural dry calcareous grasslands with numerous erratics. Forest plantations, albeit present, do not occupy significat areas. Besides, these transects and study areas, close to the former well-guarded external border of the Soviet Union, were less exploited economically for several decades. The fifth cluster comprises two relatively distant subclusters (L1, L2 and L4, L5). The transects L1 and L2 are situated in the region of extremely intensive economic activities and of almost purely agricultural land. L4 and L5, though also characterized by intensive human activities, contain more natural elements; besides, these two subclusters belong to different geographical districts characterized by differing soils and relief.

CONCLUSIONS

The factors that most heavily affect lichen flora on the whole study area are:

1) intensive forest management, which replaces natural mixed deciduous forest communities with coniferous monocultures, thus destroying characteristic populations of epiphytic lichens; subsequent sanitary cleanings, which reduce coarse wood debris important to epixylic lichens;

2) agriculture, especially the use of fertilisers which increase the nutrient enrichment of the environment and the subsesequent lichen community impoverishment both on stones and trees;

3) destruction of old roadside trees;

4) direct destruction of boulders and stones (their number has decreased substantially, because they have been a cheap and accessible building material for a long time);

5) diversity of small-scale traditional human activities (gravel pit making, maintenance of gravel road scarps);

6) small-scale construction, creating new habitats for lichens (concrete and objects of worked, chemically untreated timber).

The present study clearly demonstrated the influence of different land-use history on the diversity of lichens in a geographically similar area. Intensive land exploitation for agricultural purposes together with an equally intensive replacement-type sylviculture in the Polish part of the study area lead to the uniformity and impoverishement of biotopes and lichen flora. In the Lithuanian part, lichen flora is in general equally severely influenced by human activities. However, more sustainable forest management, allowing preservation of albeit small but natural islets of native forest types, locally less intensive exploitation of erratics together with small-scale traditional human activities lead to survival of a richer lichen diversity, at least in part of the Lithuanian study area.

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ÞEMËNAUDOS ÁTAKA KERPIØ ÁVAIROVEI LIETUVOS IR LENKIJOS PASIENIO REGIONE

S a n t r a u k a

Via Baltica greitkelio aplinkoje, atkarpoje tarp Marijampolës ir Suvalkø miestø, vertinta kerpiø ávairovë. Tam tikslui buvo pasirinkta dvylika 7 km ilgio ir 10 m ploèio transektø (po ðeðias Lietuvos ir Lenkijos pusëje) ir penki papildomi tyrimø plotai (trys Lietuvos ir du Lenkijos pusëje). Juose registruotos visø rûðiø kerpës, surinktos nuo visø galimø substratø. Tyrimø teritorijai yra bûdingos panaðios geografinës sàlygos, taèiau kiekvienos transektos skiriasi þemënaudos pobûdis, kurá lëmë skirtinga þmoniø ûkinë veikla abiejose sienos pusëse.

Ið viso tyrimo metu uþregistruotos 194 rûðiø kerpës. Lietuvos pusëje aptiktos 165 rûðys, Lenkijos – 136 rûðys.

Lenkijos pusëje ið daþniausiai aptinkamø kerpiø daugiau pasitaikë acidofiliniø rûðiø, o Lietuvos pusëje – nitrofiliniø. Dauguma kerpiø, bûdingø miðkams, iðsiskiriantiems ilgu ekologiniu kontinumu, buvo aptiktos tik Lietuvos pusëje. Plataus masto intensyvi miðkininkystë, kai plynai iðkertami natûralûs miðkai ir uþsodinamos spygliuoèiø monokultûros, kartu su palyginti intensyvia þemdirbyste kerpiø ávairovæ paveikë neigiamai, stipriau negu þemës ûkio kraðtovaizdis, á kurá ásiterpia iðlikusios natûraliø miðkø salos. Kerpiø ávairovës skirtumus abiejose ðalyse nulëmë kraðtovaizdþio ir biotopø ávairovës sumaþëjimas Lenkijos pusëje ir dël labiau tradicinio ûkininkavimo iðlikusi kraðtovaizdþio ávairovë Lietuvos pusëje.

Raktaþodþiai: kerpës, ávairovë, þemënauda, Lietuva, ÐR Lenkija