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The occurrence of epigeic lichens in different habitats around the Siemianowka Lagoon in the Upper Narew Valley

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Abstract. This study examines the occurrence of epigeic lichens on study plots located within different types of habitat near the Siemianowka retention reservoir in the Upper Narew Valley. The outcome of this research is a better understanding of epigeic lichens and the problems associated with their distribution and conservation.

The investigation of the less common and hence more interesting taxa found within the study area was based on species composition analyses of lichens in different habitats, the degree of recognition in North Eastern Poland and their conservation status as well as threats within the country. A total of 48 lichen species, mainly from the genus of Cladonia, were identified, which is a typical number for these types of habitat. 19% of the species growing on soil are classified as threatened and some of them have been recorded only within this study area. In total, 15 lichen species are under the strict or partial protection.

Keywords: lichenised fungi, epigeic, habitat

1. Introduction

Human activity enables many lichen species to spread, including ground lichens. Many species of epigeic lichens have found their niche on slopes, in roadsides, ditches, and the edges of pine thickets. The secondary communities of anthropogenic origin, such as xerothermic and psammophilous grasslands, are also the habitat of numerous ground lichen species. Sometimes, they are ephemeral and disappear as succession progresses (Cieśliński 2003a). Also, the degeneration of forest and non-forest communities or the abandonment of farmland encourages and facilitates the spread of ground species, especially the *Cladonia* genus cup lichens, *Cetraria* lungworts and *Stereocaulon* snow lichens (Fałtynowicz 1997). Ground lichens, mainly represented by many species of the genus *Cladonia*, are found in forest communities, on the forest floor of *Cladonio-Pinetum*, a form of dry pine forests, or in the pine forests in various successional stages growing on sandy soils and the poor soils of post-agricultural lands. In forest communities, especially in Scots pine plantations, many lichens preferring rich humus conditions spread on the open soil.

Fałtynowicz (1980, 1986) and Czyżewska (1992) investigated the issues of secondary succession, where large proportions of lichens are found on poor soils. Cieśliński (1993) analysed the share of ground lichens found in the process of secondary forest formation on the abandoned agricultural fields.

The clear cuts in fresh pine forests promote the species diversity of ground lichens, and pine thickets can be regarded as a mainstay of these species in the managed pine forests (Stefańska-Krzaczek, Fałtynowicz 2013).

The best preserved populations of cup lichens are found in northern Poland, and the condition of such populations deteriorates, the further south one goes. This trend also characterises the *Cladonio-Pinetum* forest community (Węgrzyn 2012). An analysis of the occurrence of lichens, including epigeic ones, in the pine forests of north-eastern Poland was conducted by Kolanko (2013).

The main objective of this study was to present the diversity of epigeic lichen species occurring on the soil of different types of habitats in and around the Siemianówka reservoir in the Upper Narew River valley.

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2. Study area

The area surrounding the Siemianówka reservoir (52°55'34"N, 23°49'39"E) lies in the Upper Narew Valley in the Podlasie region on the border of the Białystok plateau and Bielsko plains. It borders the Białowieża forest to the west and south-west. The eastern part of the reservoir is adjacent to the national border of Belarus, the south-eastern part to the Natura 2000 area of the Białowieża forest, the western part to the Natura 2000 area of the Upper Narew Valley, while several kilometres north of the reservoir is another Natura 2000 area – the Gródecko-Michałowska basin. This area changed with the construction of the reservoir and is completely subordinated to it. The Siemianówka reservoir was built between 1977–1990 as a result of damming the water with an earthen dam built in the throat of the valley at the 367.38 km of the Narew river's course in the vicinity of Łuka and Rybaki. After construction of the dam, the reservoir was filled for 5 years, reaching its final water level of approximately 7 m in 1993. The catchment area is 1,094 km². The reservoir is located in the townships of Michałowo and Narewka – an area that is included in the 'Polish Green Lungs' project. It is the third largest artificial reservoir in Poland, with an area of over 32 km². The length of the reservoir is 13.5 km, while its width ranges from 0.8 km to 4.5 km. The Siemianówka reservoir is divided into a main pool (west), where its maximum depths occur, and an eastern pool – shallow, periodically flooded. The border between the two pools is a railway line (two tracks: a narrow one, which is Polish and a wide one, which is Russian) placed on a high, artificial, reinforced railway embankment (railway line of Siedlce–Czeremcha–Hajnówka–Siemianówka–Cisówka–Swisłaczin Belarus). The shoreline is deeply indented in the north near the village of Bachury, while the remaining shoreline is shallow and variable, depending on the water level (Górniak 2006).

The area around the reservoir is poorly developed. The soils of the grasslands, forests, meadows, and arable lands are of low quality. The areas located to the north and south-west of the reservoir system are characterised by a mosaic of vegetation. These areas are used as grasslands (meadows, pastures), farmlands, and forest patches of various sizes belonging mainly to the State Forests National Forest Holding. Pine, hornbeam, and alder forests of a natural character, part of the Białowieża forest, border the south-eastern part of the reservoir. Village buildings and their accompanying ruderal assemblages represent a small proportion of the area. Many lichenological studies have been carried out in the vicinity of the Siemianówka reservoir, for example, Czyżewska (1992), who lists the species from the rich ground lichen patches of the *Spergulo-Corynephoretum* grasslands close to Juszkowy Gród. Cieśliński and Tobolewski (1988) and Cieśliński (2003a) reported 49 species of ground lichens from five sites (pine thickets and young stands around the villages of Bondary, NowaŁuka, Tarnopol, Mostki, and Łozowe).

3. Materials and methods

The lichenological research was conducted in 2011 in the areas surrounding the Siemianówka reservoir. The study included sites with different habitat conditions, that is, *Peucedano-Pinetum* fresh pine forest community and *Cladonio-Pinetum* dry pine forest, *Spergulo-Corynophoretum* grasslands, pine thickets and their edges, roadsides, and fallow agricultural lands. Five plots were chosen in each type of habitat, and one survey was conducted for each plot.

In total, data were collected from 30 study plots. The study plots were rectangular in shape with dimensions of 10 × 15 m (150 m²). All species of lichens found on the ground cover of the plots were recorded. Next, the species coverage was estimated by using a 7-point scale of abundance (Braun–Blamquet 1928), that is, 5 – the species cover 75.1–100% of the surface, 4 – the species cover 50.1–75% of the surface, 3 – the species cover 25.1–50% of the surface, 2 – the species cover 10.1–25% of the surface, 1 – the species cover 1.1–10% of the area, + – the species cover up to 1% of the surface, r – a single specimen in the sample.

By using thin-layer chromatography (TLC), *Cladonia chlorophaea*, *C. fimbriata*, *C. novochlorophaea*, and *C. pyxidata* (Orange et al., 2003) were verified to species. The Latin nomenclature of lichens according to Diederich et al. (2015) and the list of the Index Fungorum were used.

In order to compare the overall percentage of lichens for each habitat, the average number of species for the five study plots and the average cover of species in various communities using the Tuxen and Ellenbergmethod (1937) were calculated. The existence of differences between the number of species in the study plots for the different types of communities was verified by using the Kruskal–Wallis test in the PAST software (Hammer et al. 2001). The percentage of endangered and protected lichens was also calculated for different types of habitats in relation to the total number of recorded lichens in the study plots of a given type of habitat in the study area.

The incidence of species was estimated on the basis of five distinct classes of prevalence: very rare – 1–2 plots, rare – 3–6 plots, fairly frequent – 7–12 plots, frequent – 13–20 plots, common > 20. The collected specimens were deposited in the 'Lichen Herbarium' of the Institute of Biology at the University of Białystok.

4. Results

48 species of lichens of 7 genera were recorded as growing on the soil of the study area. The most numerous gene-

ra were: *Cladonia* (33 species), *Cetraria* and *Stereocaulon* (3 species of each).

The Psammophilous grasslands of the *Spergulo-Corynephoretum* association were a widespread plant community. They occurred in the secondary habitats: sand pits, clear cuts, and deforested areas. They were characterised by the richest biota of lichens, numbering 27 species. Dominant among them were *Placynthiella uliginosa* – the initial species, *Cetraria aculeata* and *Cladonia furcata*, *C. gracilis*, *C. macilenta*, *C. phyllophora*, and *C. verticillata*. The accompanying species included *Cladonia cornuta*, *C. rangiferina*, *C. subulata*, *Trapeliopsis granulosa*, *Pycnothelia papillaria*, and *Stereocaulon condensatum* (Table 1).

In the study plots of pine thickets and their edges, 27 species of ground lichens were found. Growing massively were *Cetraria islandica, Cladonia arbuscula, C. cornuta, C. phyllophora, C. crispata, C. furcata, C. subulata,* and *C. fimbriata*. There was a significant amount of *Placynthiela uliginosa, Trapeliopsis granulose,* and *Stereocaulon incrustatum*. *Peltigera canina, P. rufescens, P. horizontalis,* and *Cetraria aculeata* were found at the edges. The pine thickets revealed the presence of small clumps of *Cladonia rangiferina, C. cilliata, C. portentosa,* as well as *C. botrytes, C. pyxidata, C. Macilenta,* and *C. chlorophaea.*

Epigeic lichens (23 species) were also noted in the *Cladonio-Pinetum* inland dry pine forest. This habitat contained many characteristic species of lichens, such as *Cladonia furcata, C. phyllophora, C. squamosa, C. arbuscula, C. crispata, C. ciliata, C. uncialis, C. portentosa, C. cenotea, C. rei, C. verticillata, C. pyxidata, C. deformis, C. Chlorophaea,* and *C. rangiferina.*

Favourable habitats for the development of ground lichens are roadside verges and sandy roadside slopes. 20 lichen taxa and species of the genus *Peltigera* (*P. canina, P. horizontalis, P. praetextata*), *Cladonia* (*C. arbuscula, C. rangiferina*), and *Cetraria islandica* were found there. Thalli of *Cladonia furcata* and *C. Phyllophora* were noted at the edges of the pine forests along the roads.

Another habitat for the development of ground lichens (12 species) are the fallow agricultural lands. These areas provided optimal development conditions for *Cladonia glauca, C. arbuscula, C. furcata, C. squamosa, C. verticillata*, *C. cornuta,* and *C. fimbriata*.

A considerable percentage of ground lichens (12 species) is found in the *Peucedano-Pinetum* continental fresh pine forest. Among the lichens occurring in such forests were *Cladonia uncialis, C. arbuscula, C. phyllophora, C. glauca, C. gracilis, C. furcata, C. Novochlorophaea,* and *C. rangiferina.*

List of study plots:

1. Pine thickets by a dirt road in the forest in the village of Nowa Łuka.

2. Pine forest between Nowa Łuka and Nowe Lewkowo, about 2 km NE of Nowe Lewkowo.

3. Pine thickets on the western side of the road linking Nowa Łuka and Lewkowo, about 3 km NW of Nowe Lewkowo.

4. *Peucedano-Pinetum* pine forest on both sides of the road leading to the village of Stara Łuka, branching off of the main road linking Nowa Łuka and Lewkowo, about 1.5 km SE of the village of Nowa Łuka.

5. Fallow agricultural land at the edge of the village of Stara Łuka.

6. Fallow agricultural land on both sides of the road leading to the village of Łozowe from the main Bondary-Lewkowo road, about 2 km NE of the village of Nowe Lewkowo.

7. Pine thickets at the edge of the village of Mostki, about 1.2 km NE of the village of Tarnopol.

8. Pine thickets by the reservoir, east of the village of Stara Łuka

9. Pine forest at the intersection of the Tarnopol and Nowa Łuka – to – Lewkowo roads.

10. Pine forest along the western side of the road connecting Tarnopol and the village of Siemianówka, about 1.3 km E of the village of Tarnopol.

11. *Peucedano-Pinetum* pine forest along the road connecting Tarnopol and the village of Siemianówka, about 2 km SW of the village of Siemianówka.

12. Open terrain lowering in the direction of a basin, roadsides leading to the Siemianówka train station.

13. Pine forest by the road leading to the Siemianówka train station.

14. *Peucedano-Pinetum* pine forest on the right side of the road connecting Siemianówka and Olchówka, about 2 km S of the village of Siemianówka.

15. Roadsides in the open terrain north of the village of Rybaki, near the road to the Bondary Hotel.

16. *Spergulo-Corynophoretum* community, grassland Corynophoretum about 1 km N of the village of Rybaki.

17. Pine thickets about 1 km NW before the village of Rudnia.

18. *Peucedano-Pinetum* pine forest behind the village of Babia Góra, about 1 km SE.

19. *Spergulo-Corynophoretum* community, grassland Corynophoretum in the area of Bondary, about 1 km SE of the village.

20. Fallow agricultural land, Mostki, about 1.5 km ES from the village.

21. Fallow agricultural land, Łozowe, about 1 km WS from the village.

22. The edges of pine thickets and *Spergulo-Corynophoretum* community, grassland Corynophoretum before the village of Słobódka.

23. The area of the Narew river, Narew township, the roadsides of the Narew –Juszkowy Gród road, about 2.5 km NE of Narew.

24. Open terrain, edge of pine thickets, *Spergulo-Corynophoretum* community, grassland Corynophoretum, Bagniuki.

25. Open terrain, *Spergulo-Corynophoretum* community, grassland Corynophoretum, Bondary.

26. Roadsides of the road between Juszkowy Gród and Bondary, about 1 km S past Juszkowy Gród.

27. Fallow agricultural land, Tarnica Górna, 1 km NW from the village.

28. Pine forest, Rudnia, about 1 km W of the village.

29. Roadsides before the village of Leonowicze, on the road to Szymek from Juszkowy Gród.

30. Pine forest about 1 km N from the village of Bachury.

Table 1. List of epigeic lichen species found in different types of habitats

No	Species	The prevalence of frequency	Habitat					
			Spergulo-Coryne-phoretum	*Peucedano-Pinetum*	*Cladonio-Pinetum*	Road sides	Fallow lands	Pine thickets and surrounding area
1.	*Cetraria aculeata* (Schreb.) Fr.	frequent	+		+	+		+
2.	*Cetraria ericetorum* Opiz	rare	+					
3.	*Cetraria islandica* (L.) Ach.	fairly frequent	+		+	+		+
4.	*Cladonia arbuscula* (Wallr.) Flot. subsp. *mitis* (Sandst.) Ruoss	common	+	+	+	+	+	+
5.	*Cladonia botrytes* (K. G. Hagen) Willd.	very rare						+
6.	*Cladonia caespiticia* (Pers.) Flörke	very rare					+	
7.	*Cladonia cariosa* (Ach.) Spreng.	rare	+			+		
8.	*Cladonia cenotea* (Ach.) Schaer.	rare			+			
9.	*Cladonia chlorophaea* (Sommerf.) Spreng.	frequent	+		+	+	+	+
10.	*Cladonia ciliata* Stirt.	rare			+			+
11.	*Cladonia coccifera* (L.) Willd.	rare	+					
12.	*Cladonia coniocraea* (Flörke) Spreng., nom. cons.	rare		+				
13.	*Cladonia cornuta* (L.) Hoffm.	fairly frequent	+		+		+	+
14.	*Cladonia crispata* (Ach.) Flot.	rare			+			+
15.	*Cladonia deformis* (L.) Hoffm.	rare	+		+			
16.	*Cladonia digitata* (L.) Hoffm.	rare			+			
17.	*Cladonia fimbriata* (L.) Fr.	fairly frequent		+	+			+
18.	*Cladonia floerkeana* (Fr.) Flörke	rare	+					
19.	*Cladonia furcata* (Huds.) Schrad. subsp. *furcata*	common	+	+	+	+	+	+

No	Species	The prevalence of frequency	Habitat					
			Spergulo-Coryne-phoretum	*Peucedano-Pinetum*	*Cladonio-Pinetum*	Road sides	Fallow lands	Pine thickets and surrounding area
20.	*Cladonia glauca* Flörke	fairly frequent		+			+	+
21.	*Cladonia gracilis* (L.) Willd.	frequent	+	+	+	+		
22.	*Cladonia macilenta* Hoffm.	fairly frequent	+		+			+
23.	*Cladonia novochlorophaea* (Sipman) Brodo & Ahti	very rare		+				
24.	*Cladonia ochrochlora* Flörke	rare		+				
25.	*Cladonia phyllophora* Hoffm.	common	+	+	+	+		+
26.	*Cladonia portentosa* (Dufour) Coem.	rare			+	+		+
27.	*Cladonia pyxidata* (L.) Hoffm.	very rare			+			+
28.	*Cladonia ramulosa* (With.) J. R. Laundon	very rare		+				
29.	*Cladonia rangiferina* (L.) F. H. Wigg.	common	+	+	+	+		+
30.	*Cladonia rangiformis* Hoffm.	very rare	+					
31.	*Cladonia rei* Schaer.	very rare			+			
32.	*Cladonia scabriuscula* (Delise) Nyl.	very rare						+
33.	*Cladonia stellaris* (Opiz) Pouzar & Vězda	very rare			+			
34.	*Cladonia squamosa* Hoffm.	rare	+		+			
35.	*Cladonia subulata* (L.) F. H. Wigg.	rare	+			+	+	+
36.	*Cladonia uncialis* (L.) F. H. Wigg.	frequent	+	+	+	+		
37.	*Cladonia verticillata* (Hoffm.) Schaer.	frequent	+		+		+	+
38.	*Peltigera canina* (L.) Willd.	very rare				+		+
39.	*Peltigera didactyla* (With.) J. R. Laundon	very rare				+		+
40.	*Peltigera horizontalis* (Huds.) Baumg.	very rare			+	+		+
41.	*Peltigera polydactylon* (Neck.) Hoffm.	very rare						+
42.	*Peltigera praetextata* (Sommerf.) Zopf	very rare				+		+

No	Species	The prevalence of frequency	Habitat					
			Spergulo-Coryne-phoretum	*Peucedano -Pinetum*	*Cladonio -Pinetum*	Road sides	Fallow lands	Pine thickets and surrounding area
43.	*Peltigera rufescens* (Weiss) Humb.	rare	+			+		+
44.	*Placynthiella uliginosa* (Schrad.) Coppins & P. James	fairly frequent				+	+	+
45.	*Pycnothelia papillaria* (Ehrh.) Dufour	very rare					+	
46.	*Stereocaulon condensatum* Hoffm.	very rare				+		
47.	*Stereocaulon incrustatum* Flörke	very rare						+
48.	*Stereocaulon tomentosum* Fr.	very rare						
49.	*Trapeliopsis granulosa* (Hoffm.) Lumbsch	fairly frequent	+			+		+

Table 2. The number of species of epigeic lichens and their coverage in different types of habitats

The type of habitat	Average	Minimum	Maximum	**SD**
The number of species				
Spergulo-Corynephorotem	17.40	10	23	4.67
Peucedano-Pinetum	8.80	8	12	1.79
Cladonia-Pinetum	14.40	11	17	2.19
Pine thickets surrounding area	16.00	8	27	6.86
Road sides	15.20	9	20	4.65
Fallow lands	8.40	3	12	4.09
Coverage [%]				
Spergulo-Corynephorotem	23.00	10	39	10.84
Peucedano-Pinetum	10.40	8	14	2.30
Cladonio-Pinetum	28.80	19	54	14.25
Road sides	25.60	11	45	14.42
Fallow lands	24.40	18	35	7.70
Pine thickets surrounding area	17.00	10	27	6.89

Rare species, known from a single or a few localities in north-eastern Poland, included, among others: *Cladonia scabriuscula, C. stellaris, Peltigera praetextata, P. polydactylon, Pycnothelia papillaria, Stereocaulon incrustatum, S. Condensatum,* and *S. tomentosum.*

The average number of lichen species was the highest on the surfaces of the psammophilous *Spergulo-Corynophoretum* grasslands, while the smallest average was found in the *Peucedano-Pinetum* fresh pine forest. The average percentage of coverage of ground lichen species was the highest in the areas of the *Cladonio-Pinetum* inland dry pine forest, the lowest in the *Peucedano-Pinetum* community. Despite these differences, both the number and coverage of lichens were relatively high (Table 2).

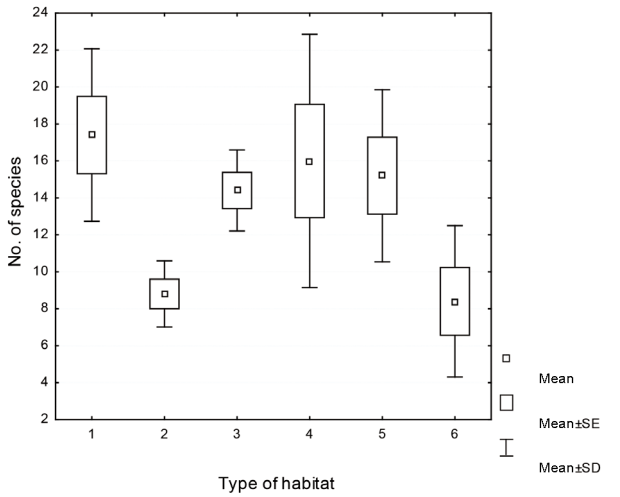

Figure 1. The range of variation of the number of lichen species found on the research surfaces, depending on their belonging to the type of habitat (1 – *Spergulo-Corynophoretum*, 2 – *Peucedano-Pinetum*, 3 – *Cladonio-Pinetum*, 4 – pine thickets and surrounding area, 5 – road sides, 6 – fallow lands)

The percentage of endangered and protected lichens

Of the 48 species of lichens identified in the study area, 9 species are included in the 'Red List of Lichens in Poland' (Cieśliński et al. 2006), including 6 species for the category of endangered – EN (*Cladonia caespiticia, C. stellaris, Peltigera horizontalis, Pycnothelia papilaria, Stereocaulon incrustatum,* and *S. tomentosum*), 2 in the category of vulnerable – VU (*Peltigera canina*, *Stereocaulon condensatum*), 1 in the category of data deficient – DD (*Peltigera polydactylon*), and 7 species listed in the 'Red List of Lichens Threatened in North-eastern Poland' (Cieśliński 2003b), including 1 listed as critically endangered – CR (*Pycnothelia papillaria*), 3 in the EN category (*Cladonia stellaris, Stereocaulon incrustatum,* and *S. tomentosum*), 1 in the VU category (*Peltigera polydactylon*), 1 in the category of near threatened – NT (*Cladonia portentosa*), and 1 in the DD category (*Cladonia rei*).

15 species of lichenised fungi are protected by law (Regulation 2014), of which 5 are under strict protection (*Cladonia stellaris, Peltigera horizontalis, P. praetextata, Pycnothelia papillaria,* and *Stereocaulon tomentosum*) and 10 are partially protected (*Cetraria ericetorum, C. islandica, Cladonia arbuscula, C. ciliata, C. portentosa, C. rangiferina, Peltigera canina, P. polydactylon, Stereocaulon condensatum,* and *S. incrustatum*).

The strictly protected species were found in the pine thicket edges, psammophilous grasslands, roadsides and *Cladonio-Pinetum* inland dry pine forests, while the endangered species from various categories were noted in the psammophilous grassland and pine thicket edges (Table 3).

5. Discussion

The Białowieża forest and its western foreland have a very rich ground lichen biota in comparison with the entire Podlasie region. Cieśliński and Tobolewski (1988) and Cieśliński (2003a) identified 62 ground lichen species from this area, including many rare ones for the lowlands. They indicate the occurrence of 49 ground lichen species at five sites in the vicinity of the Siemianówka reservoir. This study revealed the presence of 48 species. The following species were not found again: *Cladonia foliacea* (Huds.) Willd., *C. symphycarpa* auct., *C. turgida* Hoffm., *Diploschistes muscorum* (Scop.) R. Sant., *Peltigera malacea* (Ach.) Funck, *Placynthiella oligotropha* (J. R. Laundon) Coppins & P. James, *Stereocaulon paschale* (L.) Hoffm. However, the thalli of new species were found in the study area: *Cladonia novochlorophaea, C. stellaris, Peltigera didactyla, P. horizontalis,* and *Stereocaulon tomentosum.*

Czyżewska (1992) lists 36 species of ground lichens at Juszkowy Gród in the *Spergulo-Corynephoretum* community, including several that are rarely encountered. However, *Cladonia floerkeana*, *C. foliacea*, *C. pleurota* (Flörke) Schaer., *C. rangiformis*, *C. scabriuscula*, *Diploschistes muscorum, Placynthiella oligotropha,* and *Stereocaulon condenstatum*, noted earlier by Czyżewska, were not found. The lower number of the recorded species may be evidence of the progressing succession. With succession, habitats colonised by lichens, such as grasslands and pine thicket edges, are transforming naturally, which also means the withdrawal of lichen species (Cieśliński 2003a).

The greatest richness of lichen species was found in the psammophilous grasslands of the *Spergulo-Corynephoretum* association, pine thickets, and their edges. This confirms the results of other research (Fałtynowicz 1980; Wilkoń–Michalska et al. 1998; Stefańska-Krzaczek 2012; Stefańska–Krzaczek, Fałtynowicz 2013) on the presence of the greatest number of ground lichen species, including *Cladonia* lichens, in young tree stands. The high intensity of light in such areas favours this. Lichens, mainly of the genus *Cladonia*, which are light-loving species (Ellenberg et al. 1992), prefer forests with a high level of sunlight. Lichens are able to grow in young tree stands, as the moss layer is just beginning to develop.

In Podlasie, the thermophilic grasslands of the *Koelerio glaucae-Corynephoretea canescentis* class occur, among others, among the grasslands of the southern Podlasie lowland within the 'Podlaski Bug River Gorge' landscape park (Sienkiewicz-Paderewska 2010). These are communities with rare and protected species of plants and animals. Cur-

Tabela 3. Udział (liczba i odsetek względem miejscowej bioty) porostów zagrożonych i chronionych w różnych typach siedlisk

Table 3. The participation (number and percentage of the local biota) of endangered and protected lichens in different types of habitats

Habitat	Status of protection		Category of threat							
			Cieśliński et al. (2006)			Cieśliński (2003b)				
	strictly	partially	EN	VU	DD	CR	EN	VU	NT	DD
Spergulo-corynophoretum	2 (7%)	7 (26%)	3 (11%)	1 (4%)	0	1 (4%)	2 (7%)	0	0	0
Peucedano-Pinetum	0	2 (17%)	0	0	0	0	0	0	0	0
Cladonio-Pinetum	1 (4%)	5 (22%)	2 (9%)	0	0	0	1 (4%)	0	0	1 (4%)
Road sides	1 (5%)	6 (30%)	0	2 (10%)	0	0	0	0	1 (5%)	1 (5%)
Fallow lands	1 (8%)	1 (8%)	2 (17%)	0	0	1 (8%)	0	0	0	0
Pine thickets	2 (7%)	8 (30%)	2 (7%)	1 (4%)	1 (4%)	0	1 (4%)	1 (4%)	0	1 (4%)

Explanations: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; DD – Data Deficient

rently, inland psammophilous grasslands and their associated natural elements are threatened, mainly by the abandonment of farming, increased building construction, and the operation of sand pits.

The thermophilic psammophilous grasslands in Poland are found in scattered sites, among others, in the Podlasie region and Mazury Lake District. *Cornicularia aculeatae-Corynephoretum canescentis* psammophilous grassland communities noted in the Mazury region (Juśkiewicz Swaczyna 2009) are characterised by a high proportion of lichens, mainly of the *Cladonia, Placynthiella, Trapeliopsis,* and *Peltigera* genera.

The *Cladonio-Pinetum* pine habitat is currently a very unstable habitat, occurring within dry and fresh pine forests (Węgrzyn 2012). It is characterised by a large share of cup lichens on the forest floor. Due to the shortage of water and minerals, the poor soils of dry pine forests are places where herbaceous plants rarely occur (Węgrzyn 2012).

One of the reasons for the small number of lichen species in pine communities is the high level of shade there. More species of ground lichens occur at roadsides, in places lacking a compact tree stand. Lichens often withdraw from the structure of forest communities due to habitat regeneration or eutrophication, causing the regression of *Cladonio-Pinetum* pine habitats (Matuszkiewicz 2007; Matuszkiewicz, Lorens 2007).

Lichens are of particular importance in the pioneering stages of succession, when they begin growing in the developing phytocoenoses of poorer habitats, that is, dry and fresh pine forests. 37 species of lichens, mainly species of the genus *Cladonia*, are found in the pine forest stage of succession of fallow agricultural lands (Cieśliński 1993).

Compared with the other regions of Poland, the epigeic lichen biota of the pine forests in the study area (29 species, including 23 for *Cladonio-Pinetum,* and 12 for *Peucedano-Pinetum*) is poorer than in north-eastern Poland, which has 52 species (Kolanko 2013), the north-western part of the Tuchola forest with 150 species (Faltynowicz 1986; Lipnicki 1990), and the Kielce-Sandomierz uplands with 23 species for the *Vaccinio uliginoso-Pinetum* pine forest swamp community and 34 species for the *Cladonio-Pinetum* community (Cieśliński 1979). The taxonomic diversity of lichens in the pine forests, especially *Cladonio-Pinetum*, in north-eastern Poland does not fundamentally differ from those found in other Polish regions. Among the epigeic lichens, representatives of *Cladonia* dominate, often reaching high levels of coverage.

Among the recorded species of ground lichens in the study area, the presence of rare species was confirmed, such as *Cladonia botrytes*, a species associated with wood, *Peltigera praetextata* – an indicator species of old forests, and *Cladonia caespiticia*, which typically does not occur in fallow agricultural lands.

The rapid changes taking place in the forests due to logging strongly affect lichens. An example of this is *Cladonia botrytes*, an obligatory epixylous species, often occurring on stumps, and also noted in clear cuts on the soil. Thalli of this species were found in the soil in Sweden, where they grew on the exposed humus layer of the ground, in clearings of pine stands aged 10–12 years, in areas that were well-lit and ventilated, and where a thin layer of humus was left on boulders (Bogomazov 2012).

Pycnothelia papillaria, a species preferring sandy, sandy-gravelly soil in dry and sunny places was mainly recorded at sites located in the southern and south-western Poland (Zarabska, Rosadziński 2011).

Peltigera praetextata was most often found in well-preserved deciduous forests, on mosses and at the base of tree trunks in north-eastern Polish. Many of its sites have been confirmed in the Białowieża forest (Cieśliński 2003). The forest complex is a refuge for many relict species, including *Peltigera praetextata*.

Cladonia caespiticia is a rare and endangered species in Poland. It was last recorded in northern (Szymczyk, Zalewska 2008) and north-eastern Poland (Czyżewska et al. 2001; Cieśliński 2003; Czyżewska et al., 2005; Motiejūnaitė, Czyżewska 2008).

6. Summary and conclusions

The environs of the Siemianówka reservoir in north-eastern Poland have optimal and diverse conditions for the growth of many ground lichen species, including rare ones. Ground lichens occur there in different habitat conditions. Excellent habitats for lichen development are the psammophilous grasslands, pine thickets and their edges, roadsides, and the sandy slopes of roadsides. In terms of forest communities, epigeic lichens occur in dry pine forests. Researching the ground lichen biota of different habitats allows an accurate and complete determination to be made of the species composition of epigeic lichens in the study area.

Conflict of interest

The author declares no potential conflicts of interest.

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