THE LICHENS IN THE AGRICULTURAL LANDSCAPE OF
PODLASIE, NORTH EAST POLAND

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Abstract

This paper carries information for diagnosis lichenobiota in the agricultural landscape of Poland NE. The research led to a better understanding of the problem of occurrence of lichens in the agricultural landscape. The functional groups of lichens, which were used to characterize lichen biota taking into account the morphological forms, frequency of occurrence and habitat requirements were determined. The basis for the specification of the more interesting taxa in the study area was to analyze the species composition of lichens in relation to the data on their previous records in rural areas, the degree of recognition in Poland NE and conservation status and threats in the country.

Key words: Lichens, Distributions, Agricultural landscape, Poland.

Introduction

Agricultural landscape is one of the types of cultural landscapes resulting from anthropogenic activities (Szczesny, 1971). In Poland, according to official data from 2011 (Anon., 2011) farmland occupied 60.3% of the total area of the country. Arable land (44.5%) prevailed within it; meadows, pastures and orchards covered respectively 7.3%, 5.2% and 0.9% of the total area of the country. Vertical shape of the surface of Poland determined the concentration of arable land in Middle Poland Lowlands. In contrast, the least of it can be found in the wooded lake districts and in the mountains. Meadows and pastures in Poland are distributed more or less evenly, although a larger share of them is marked in the eastern part of the country - in Mazury, Podlasie, Polesie and Carpathian mountains.

Lichens in the agricultural landscape: Polish literature is clearly characterised by a lack of cross-cutting studies on the occurrence of lichens in the agricultural landscape. Interesting information in this regard comes only from rural north-west (Lipnicki, 1990), north (Szymczyk & Zalewska, 2008) and central (Zarabska, 2011) part of the country. The degree of diversity of lichens was demonstrated at the level of 174 taxa in the Choszczno Lake District (Lipnicki, 1990), 96 species in the selected passage of Warmia Plains (Szymczyk & Zalewska, 2008) and 175 taxa in the agricultural landscape of Sandr Nowotomyski (Zarabska, 2011). Among the habitats most commonly occupied by lichens in the agricultural landscape of these mesoregions were plantings of roadside trees and artificial substrates. In both statements there appeared lichens typical of open habitats, including those interesting ones due to the rarity of their quotations from the region and the country, conservation status and the degree of danger in Poland (Lipnicki, 1990; Szymczyk & Zalewska, 2008; Zarabska, 2011).

Limited information about lichens present in the agricultural landscape has highlighted the need to try to characterize lichen biota occurring in rural areas of Podlasie. Implementation plans were undertaken to serve the following objectives: 1 determination of the species composition of lichens, 2 distinction of species particularly associated with areas covered by agricultural use and valuable in the Podlasie region in relation to the rarity of their listing on the area of NE Poland and/or conservation status and the degree of risk in the country, 3 determination of the degree of diversity of lichen species in communities characterized by different levels of anthropogenic transformation, including those mainly caused by agricultural activities, 4 characterization of the functional groups of lichens typical of rural areas.

Study area: Location and topography of the region of Podlasie is extremely beneficial for agriculture because of the small undulation and lowland character of the land. The region is located in the north-eastern part of the country, in the area of Podlasie Lowland, Suwałki Lakeland and Mazowsze Lowland. It borders on Masovian Voivodeship to the west, Warmian-Masurian Voivodeship to the northeast, Lublin Voivodeship to the east, the Lithuanian Counties of Alytus and Marijampole to the northeast, and the Kaliningrad Oblast of Russia to the north (Fig. 1). Its capital is Białystok. Białystok is, and has been for centuries, the main hub of transportation for the Podlaskie Voivodeship and the entire northeastern section of Poland. It is a major city on the European Union roadways (Via Baltica) and railways (Rail Baltica) to the Baltic Republics and Finland. It is also a main gateway of trade with Belarus due to its proximity to the border and its current and longstanding relationship with Hrodno, Belarus.

Podlasie is the land of the confluence of cultures – Polish, Belarusian, Ukrainian and Lithuanian – and is indicative of the ethnic territories limits. At the end of 2009 in Podlaskie Voivodeship there were 1192.7 thousand inhabitants, 3.1 per cent of the total population of Poland. The average density of the population, the number of the population per 1 km², was 59. The urban population in the same period was 60.2 per cent of the total number of inhabitants of the voivodeship (Anon., 2010).

Favourable topography of the land is the basis for the development of agricultural activities. In the structure of agricultural land in the Podlaskie Voivodeship meadows and pastures constitute a far greater share than in other regions of the country. A characteristic feature of Podlasie countryside is a higher than average share in Poland of agricultural land in total area (Regional Operational Program).
Agriculture in Podlaskie Voivodeship functions in harsh natural, both climatic and soil conditions – a very short vegetation period, record temperature lows, poor soil and periodic water deficits. Podlaskie has a Warm Summer Continental or Hemiboreal climate (Dfb) according to the Köppen climate classification system, which is characterized by warm temperatures during summer and long and frosty winters. It is substantially different from most of the other Polish lowlands. The region is one of the coldest in Poland, with the average temperature in January being $-5^\circ$C. The average temperature in a year is 7$^\circ$C. The number of frost days ranges from 50 to 60, with frost from 110 to 138 days and the duration of snow cover from 90 to 110 days. Mean annual rainfall values oscillate around 550 millimetres (21.7 in), and the vegetation period lasts 200 to 210 days. Podlaskie is the coldest region of Poland, located in the very northeast of the country near the border with Belarus and Lithuania. The region has a continental climate which is characterized by high temperatures during summer and long and frosty winters. The climate is affected by the cold fronts which come from Scandinavia and Siberia. The average temperature in the winter ranges from $-15^\circ$C to $-4^\circ$C (Górniak 2000).

Despite this, there are over 100000 rural farms in the region, using an average surface of about 13 hectares. The structure of rural areas makes good conditions for further development of the production of milk and beef. Potatoes are mainly cultivated in the area of the province of Podlasie, as well as cereals (rye, oats, wheat, corn) and sugar beets. In the last years, the owners of rural farms have seen more and more success in their agrotouristic activities (Regionaly Operational Program).
Materials and Methods

Fieldwork research. Fieldwork research was conducted in the area of Podlasie in 2010-2013. In order to obtain a large number of data on lichen biota diversity in the agricultural landscape in Podlasie positions were set using the "counsel" method. In total, 35 research plots were determined. These surfaces were established within the following communities differing in the degree of anthropogenic transformation: natural communities (fresh mixed forests, fresh forests, fresh mixed coniferous forests, fresh coniferous forests), semi-natural communities (meadows and pastures, woodlands, grasslands) and anthropogenic communities (ruderal, segetal). A habitat was considered a stand within which the census of lichens was made from all available substrates. Names of trees, which were the source of epiphytic lichens observations are given in accordance with the development of Mirek et al. (2002). For each habitat coordinates are specified.

Taxonomic identification: For most taxa, taxonomic identification was carried out in laboratory conditions. Downloaded specimens were determined on the basis of morphological and anatomical (macroscopic and microscopic analysis). Lichens were also determined based on the presence of fouling compounds (secondary metabolites) - test reactions. Thin-layer chromatography (TLC) was used to identify the types of secondary metabolites, mainly from the genus Cladonia and Lepraria. This method was conducted in accordance with the guidelines from Culberson & Ammann (1979) and Orange et al. (2001). Lichen naming was adopted from Diederich et al. (2015) except for the following taxa: Circinaria calcarea, C. caesiocinerea, C. contorta, C. gibbosa (Nordin et al., 2010), Lecanora saxicola (Laundon, 2010) oraz Calogaya decipiens, C. pusilla, Flavoplaca citrina, F. oasis, Polycauliona polycarpa, Rusavskia elegans (Arup et al., 2013).

Characteristic of species:

In order to characterize recorded taxa the following data were included: 1. morphological forms of thallus by Nimis & Martellos, (2008), 2. habitat group, 3. degree of prevalence - based on the frequency of occurrence in the study area (Table 1).

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<th>Characteristic</th>
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| Growth and life forms | C – Crustose  
S – Squamulose  
Fw – Wide foliose type Parmelia  
Fn – Narrow foliose type Physcia  
F – Fruticose |
| Substrate type | Epiphytic: Growing on the bark of trees  
Epigeic = Terricolous: growing on soil  
Epixylic = Lignicolous: growing on rotten, decayed and dead wood  
Epilithic = Saxicolous: growing on rocks and concrete  
Epibryophytic = Growing on mosses: found on terricolous mosses |
| Degree of prevalence | Very – Taxon occurring for 1 – 2 stands  
Rare – Taxon occurring for 3 – 5 stands  
Frequent – Taxon occurring for 6 – 15 stands  
Common – Taxon occurring for > 15 stands |

Statistical development: The collected data on the degree of differentiation of lichen species and species richness of particular morphological forms were subjected to basic statistical analysis (mean, standard deviation, range of variation).

Nonparametric ANOVA rank Kruskal Wallis test was used to test the significance of differences between the average of the degree of variation in lichen species and richness of various morphological forms of lichens. Lichens are assigned to various morphological forms, taking into account the type of communities with different degrees of anthropogenic transformation, in which they were listed. The results were gathered in the framework of research on the diversity of lichens and their functional groups conducted in a completely randomized design.

The dependent variable was defined as the degree of variation of lichen species and species richness of various morphological forms. The degree of variation in lichen species is defined as the total number of species (Nalls) reported on the test area. Species are assigned to functional groups distinguished on the basis of the type of morphological forms of fronds: crustose lichens (NsC), squamose (NsS), wide foliose type of Parmelia (NsFW) narrow foliose type Physcia (NsFn), fruticose (NsF). As an explanatory variable a kind of community was assumed (Type of habitat).

Selected types of communities, which are assigned to research areas are:

Natural: 1. Deciduous forests: fresh mixed forest, fresh forest, moist forest; 2. Coniferous forests: fresh mixed coniferous forest, fresh coniferous forest, moist coniferous forest;

Semi-natural: 3. Meadows and pastures; 4. Plantings (mid-field, at watercourse); 5. Grasslands;

Anthropogenic: 6. Ruderal (on roadsides and within dense rural and urban built-up), 7. Segetal (cultivated fields and associated field margins);
List of research stands


2. Sokole (53°05′09″N 23°30′59″E), 2.5 km to the SSE, fresh pine forest, *Pinus sylvestris, Betula pendula*, soil, bryophytes and remains of vascular plants, wood, 2011.09.15.


5. Korycin (53°27′00″N 23°05′00″E), 1 km to the N, open area, pasture, artificial bedrock containing calcium carbonate, *Fraxinus cfr. excelsior, Populus tremula, Salix spp.*, 2011.09.25.

6. Baciuty (53°03′11″N 22°58′59″E), 1.5 km to the SSW, venerable tree in the meadows by the river Narew, artificial bedrock containing calcium carbonate, *Fraxinus cfr. excelsior, Salix spp.*, *Quercus robur*, 2012.09.09

7. Suraż (52°57′00″N 22°57′00″E), 1 km to the SSE, agricultural landscape, pasture, boulders, artificial bedrock containing calcium carbonate, *Populus tremula, Salix spp.*, 2012.09.09.

8. Doktorce (52°54′53.50″N 23°05′01.75″E), 2.5 km to the E, fresh coniferous forest, soil, bryophytes and remains of vascular plants, wood, *Pinus sylvestris*, 2012.09.09.


10. Siemianówka (52°53′58″N 23°50′21″E), fresh pine forest, *Betula pendula, Padus serotina, Pinus sylvestris*, soil, wood, 2013.06.16.

11. Surroundings of Serpelice (52°16′40″N 23°03′11″E), pine forest, *Juniperus communis, Pinus sylvestris*, soil, 2010.05.22.

12. Forestry Mierzwice (52°19′50″N 22°59′09″E), pine forest, *Juniperus communis, Picea abies, Pinus sylvestris*, soil, wood, 2010.05.22.

13. Bočki (52°39′00″N 23°02′00″E), road to the village Engines, roadside trees, 2011.04.15.

14. Mielnik (52°19′38″N 23°02′55″E), around chalk mine, open area and grasslands, stones, artificial bedrock containing calcium carbonate, soil, *Fraxinus cfr. excelsior, Populus tremula, Salix spp.*, *Sambucus nigra, Sorbus aucuparia, Tilia platyphyllos*, 2012.05.14.


17. Białowieża (52°42′04″N 23°52′10″E), open area, trees, *Fraxinus cfr. excelsior, Pinus sylvestris, Quercus robur*, artificial bedrock containing calcium carbonate, 2012.07.15.


25. Krynice (53°13′53″N 23°01′35″E), 0.5 km to the W, small forest in an agricultural landscape, stones, artificial bedrock containing calcium carbonate, soil, wood, *Frangula alnus, Fraxinus cfr. excelsior, Populus tremula, Salix spp.*, 2011.05.04.
26. Zagruszany (53°02′00″N 23°17′00″E), small-field forests, concrete pole, artificial bedrock containing calcium carbonate, soil, *Pinus sylvestris, Populus tremula*, 2011.05.14

27. Koryciny (52°38′53″N 22°44′45″E), 1 km to the W, oak forest as nature park, *Carpinus betulus, Euonymus europaea, Quercus robur, Pinus sylvestris*, 2011.04.15

28. Glinnik (52°48′22″N 22°48′05″E), 2 km to the S, regenerating forest hail, *Padus serotina, Populus tremula*, 2011.06.02

29. Mielecze (52°31′10.4″N 23°07′54.1″E), 2 km to the W, sand calcareous grasslands turf, brushwood pine, soil, *Juniperus communis, Pinus sylvestris*, 2011.09.09

30. Jaginty on the river Biebrza (53°40′13″N 23°38′48″E), cultivation of pine trees, xerothermic grass, boulder, artificial bedrock containing calcium carbonate, soil, *wood, Pinus sylvestris*, 2012.08.14

31. Brzeziny Kapickie (53°33′10″N 22°39′38″E), swamp forest, wood (stump), *Betula pendula, Populus tremula*, 2011.08.14

32. Kuźnica Biłostocka (53°30′35″N 23°38′37″E), 0.5 km to the S, xerothermic grass, boulder, artificial bedrock containing calcium carbonate, soil, *Populus tremula, Quercus robur*, 2013.09.15

33. Krynki (53°15′55″00″N 23°46′19″89″E), 1 km to the S, xerothermic grass, lonely tree, artificial bedrock containing calcium carbonate, soil, *Betula pendula, Populus tremula, Quercus robur*, 2013.09.15

34. Góra (53°12′54″66″N 23°40′41″82″E), on the edge of mixed forest, *Carpinus betulus, Quercus robur*, 2012.04.18

35. Stanisławowo (53°04′42″81″N 23°12′23″76″E), on the edge of mixed forest, *Quercus robur, Pinus sylvestris, Populus tremula*, 2010.09.15.

Research areas are assigned to the following communities.

**Natural communities:** 1. Deciduous forest – stands: 27, 28, 31, 34, 35; 2. Coniferous forest – stands: 2, 8, 10, 11, 12.


**Anthropogenic communities:** 6. Ruderal (on roadsides and within dense rural and urban built-up) – stands: 9, 13, 15, 16, 17; 7. Segetal (cultivated fields and associated field) – stands: 1, 3, 4, 21, 24.

**List of taxa**

The list presented below includes 156 lichen taxa found in the study area. For each taxon the following information is given: a substrate, the number of quotations and a list of posts.

**Acarospora fuscata** (Schrad.) Th. Fr. – Loc. 1, 7, 16, 19, 20, 21: on stones, frequent species, 6: stones


**Aspicilia cinerea** (Ach.) Körb. – Loc. 4, 14, 20, 21, 25, 32: on stones, frequent species, 6 stands: stones


**Circinaria calcarea** (L.) A. Nordin, S. Savić & Tibell – Loc. 9, 14, 16, 30: on artificial bedrock containing calcium carbonate (building, fence), rare species, 4: artificial bedrock containing calcium carbonate.

**Circinaria caesiciocinerea** (Nyl. ex Malbr.) A. Nordin, S. Savić & Tibell – Loc. 1: on boulder, very rare species, 1: boulder.

**Circinaria contorta** (Hoffm.) A. Nordin, S. Savić & Tibell – Loc. 16: on artificial bedrock containing calcium carbonate (fence), very rare species, 1: artificial bedrock containing calcium carbonate (fence).

**Circinaria gibbosa** (Hoffm.) A. Nordin, S. Savić & Tibell – Loc. 1, 4, 32: on stones, rare species, 3: stones.

**Bacidia bagliettoana** (A. Massal. & De Not.) Jatta – Loc. 14, 30, 32, on soil, rare species, 3: soil

**Bacidia rubella** (Hoffm.) A. Massal. – Loc. 27, on bark of *Quercus robur*, very rare species, 1: *Quercus robur*

**Baemomyces rufus** (Huds.) Re bent. – Loc. 2, 10, on soil, very rare species, 2: soil

**Bryoria fuscescens** (Geyln.) Brodo & D. Hawksw. – bark of *Betula pendula*, very rare species; 1 stand: 31.
Buellia griseovirens (Sm.) Almb. – Loc. 27, 34, 35, on bark of Quercus robur, rare species, 3: Quercus robur

Calogaya decipiens (Arnold) Arup, Frödén & Sochting – Loc. 3, 9, 14, 16, 21, 24, 26, 32, 33, on artificial bedrock containing calcium carbonate (building, fence, pole), common species, 9: artificial bedrock containing calcium carbonate

Calogaya pusilla (A. Massal.) Arup, Frödén & Sochting – Loc. 1, 3, 5, 6, 7, 9, 17, 19, 21, 22, 25, 26, 32, on artificial bedrock containing calcium carbonate (fence pole), common species, 13: artificial bedrock containing calcium carbonate

Caloplaca cerina (Hedw.) Th. Fr. – Loc. 14, 32, on bark of Populus tremula, very rare species, 2: Populus tremula

Caloplaca teicholyta (Ach.) J. Steiner – Loc. 3, 4, 33, on artificial bedrock containing calcium carbonate (fence), rare species, 3: artificial bedrock containing calcium carbonate (fence).


Candelariella aurella (Hoffm.) Zahlbr. – Loc. 1, 3, 5, 6, 7, 9, 14, 19, 22, 24, 25, 26, 32, 33, on artificial bedrock containing calcium carbonate (fence, pole), frequent species, 14: artificial bedrock containing calcium carbonate.

Candelariella coralliza (Nyl.) H. Magn. – Loc. 4, 19, 20, on stone, rare species, 3: on stone.

Candelariella reflexa (Nyl.) Lettau – Loc. 21, on bark of Malus spp., Robinia pseudoacacia, Salix spp., very rare species, 1: Malus spp., 1: Robinia pseudoacacia, 1: Salix spp.

Candelariella vitellina (Hoffm.) Müll. Arg. – Loc. 1, 4, 9, 19, 20, 30, 32, on stone, artificial bedrock containing calcium carbonate (fence, pole), frequent species, 7: on stone, 7: artificial bedrock containing calcium carbonate.


Cetraria aculeata (Schreb.) Fr. – Loc. 8, 9, 33, on soil, rare species, 3: Quercus robur

Cetraria ericetorum Opiz – Loc. 8, 10, 12, 30, 33, on soil, rare species; 5: soil

Cetraria islandica (L.) Ach. – Loc. 8, 10, 11, 12, 30, 33, on soil, rare species, 6: soil

Cladonia arbuscula (Wallr.) Flot. – Loc. 2, 3, 8, 10, 12, 25, 30, 33, on soil, frequent species, 8: soil

Cladonia arbuscula (Wallr.) Flot. subsp. mitis (Sandst.) Ruoss – Loc. 10, on soil, very rare species; 1: soil

Cladonia botrytes (K. G. Hagen) Willd. – Loc. 2, on wood (snag), very rare species, 1: wood (snag)

Cladonia cariosa (Ach.) Spreng. – Loc. 10, 30, 33, on soil, rare species, 3: soil

Cladonia cenueta (Ach.) Schaar. – Loc. 2, 3, 8, 12, on wood (pieces of bark, stump), rare species, 4: wood

Cladonia cervicornis ssp. verticillata (Hoffm.) Ahti – Loc. 2, 8, 10, 12, 29, 33, on soil, frequent species, 6: soil

Cladonia chlorophaea s.lat. (Sommerf.) Spreng. – Loc. 2, 8, 9, 10, 12, 14-26-28, 30, 33, on wood (pieces of bark, snag), soil, bark of Betula pendula, Quercus robur, Salix spp., bryophytes and remains of vascular plants, frequent species, 2: on wood (pieces of bark, snag), 3: soil, 3: Betula pendula, 2: Quercus robur, 1: Salix spp., 5: bryophytes and remains of vascular plants.

Cladonia ciliata var. tenuis (Flörke) Ahti – Loc. 8, 10, on soil, very rare species, 2: soil

Cladonia cocciifera (L.) Willd. – Loc. 10, on soil, very rare species, 1: soil


Cladonia cornuta (L.) Hoffm. – Loc. 2, 8, 10, 12, 25, 30, on wood (branches, pieces of bark, stump), soil, bark of Pinus sylvestris, frequent species, 2: on wood, 4: soil, 1: Pinus sylvestris.

Cladonia crispata (Ach.) Flot. – Loc. 12, on soil, very rare species, 1: soil
**Cladonia deformis** (L.) Hoffm. – Loc. 8, 10, 11, 12, on wood (pieces of bark, stump), soil, rare species, 1: on wood (pieces of bark, stump), 4: soil.

**Cladonia digitata** (L.) Hoffm. – Loc. 2, 10, 12, on wood (branches, pieces of bark, stump), soil, bryophytes and remains of vascular plants, rare species, 1: on wood, 2: soil, 1: bryophytes and remains of vascular plants.


**Cladonia floerkeana** (Fr.) Flörke – Loc. 10, 11, 12, on wood (pieces of bark, stump), soil, rare species, 2: on wood, 1: soil

**Cladonia furcata** (Huds.) Schrad. – Loc. 2, 8, 10, 11, 12, 25, 26, 29, 30, 33, on soil, frequent species, 10: soil

**Cladonia glauca** Flörke – Loc. 2, 8, 10, 12, 25, 26, 28-33, on wood (branches, pieces of bark, stump), soil, frequent species, 3: on wood, 8: soil

**Cladonia gracilis** (L.) Willd. – Loc. 2, 8, 10, 12, on wood (pieces of bark, stump), soil, bryophytes and remains of vascular plants, rare species, 1: on wood, 2: soil, 2: bryophytes and remains of vascular plants

**Cladonia grayi** Sandst. – Loc. 12, on soil, very rare species, 1: soil

**Cladonia macilenta** Hoffm. – Loc. 2, 8, 10, on wood (branches, pieces of bark, stump), soil, rare species, 1: on wood, 2: soil

**Cladonia macilenta** Hoffm. var. bacillaris (Genth) Schauer. – Loc. 10, on wood (pieces of bark, stump), soil, bark of *Betula pendula*, *Pinus sylvestris*, very rare species, 1: on wood, 1: soil, 1: *Betula pendula*, 1: *Pinus sylvestris*

**Cladonia merochlorophaea** Asahina – Loc. 12, on soil, very rare species, 1: soil

**Cladonia merochlorophaea** var. novochlorophaea Sipman – Loc. 12, on soil, very rare species, 1: soil

**Cladonia ochrochlora** Flörke – Loc. 10, 25, on wood (pieces of bark, fence, stump), soil, very rare species, 1: on wood, 2: soil

**Cladonia phyllophora** Hoffm. – Loc. 2, 8, 10, 11, 12, 26, 30, 33, on soil, frequent species, 8: soil

**Cladonia pleurota** (Flörke) Schaerer – Loc. 10, on soil, very rare species, 1: soil

**Cladonia portentosa** (Dufour) Coem. – Loc. 10, 12, on soil, very rare species, 2: soil

**Cladonia pyxidata** (L.) Hoffm. – Loc. 10, 30, 33, on soil, very rare species, 3: soil

**Cladonia pyxidata** subsp. pocillum (Ach.) Schaer. – Loc. 14, on soil, very rare species, 1: soil

**Cladonia ramulosa** (With.) J. R. Laundon – Loc. 10, 12, on soil, very rare species, 2: soil

**Cladonia rangiferina** (L.) F. H. Wigg. – Loc. 8, 10, 11, 12, 30, on soil, rare species, 5: soil

**Cladonia rangiformis** Hoffm. – Loc. 33, on soil, very rare species, 1: soil

**Cladonia rein** Schaer. – Loc. 12, on wood (pieces of bark), soil, very rare species, 1: on wood, 1: soil

**Cladonia squamosa** Hoffm. – Loc. 10, 12, on soil, very rare species, 2: soil

**Cladonia subulata** (L.) F. H. Wigg. – Loc. 2, 8, 10, 25, 29, 30, 33, on soil, frequent species, 7: soil

**Cladonia sulphurina** (Michx.) Fr. – Loc. 10, on soil, very rare species, 1: soil

**Cladonia uncialis** (L.) F. H. Wigg. – Loc. 8, 10, 11, 12, on soil, rare species, 4: soil

**Collema limosum** (Ach.) Ach. – Loc. 14, on soil, very rare species, 1: soil

**Collema tenax** (Sw.) Ach. – Loc. 14, 30, 33, on soil, rare species, 3: soil

**Dibaeis baemoyces** (L. f.) Rambold & Hertel – Loc. 33, on soil, very rare species, 1: soil

**Diploschistes muscorum** (Scop.) R. Sant. – Loc. 30, 32, 33, on soil, organic debris, rare species, 3: on soil, 2: organic debris

**Endocarpon pocillum** Hedw. – Loc. 14, on soil, very rare species, 1: soil


**Flavopla citrina** (Hoffm.) Arup, Frödén & Sechting – Loc. 7, 9, 19, 21, 26, on artificial bedrock containing calcium carbonate (building, curb, fence, pole, well), rare species, 5: on artificial bedrock containing calcium carbonate.


Hypogymnia tubulosa (Schae.) Hav. – Loc. 31, 35, on wood (branches), bark of Betula pendula, very rare species, 1: on wood (branches), 1: Betula pendula.

Imshaugia aleurites (Ach.) S. L. F. Meyer – Loc. 2, 10, 12, 27, on wood (pieces of bark), bark of Pinus sylvestris, rare species, 2: on wood, 3: Pinus sylvestris.

Lecania cyrtella (Ach.) Th. Fr. – Loc. 9, 12, 21, 32, on bark of Alnus glutinosa, Fraxinus cfr. excelsior, Malus spp., Populus tremula, Tilia cordata, rare species, 1: on Alnus glutinosa, 2: Fraxinus cfr. excelsior, 1: Malus spp., 2: Populus tremula, 1: Tilia cordata.

Lecanora albescens (Hoffm.) Flörke – Loc. 1, 3, 9, 17, 26, on artificial bedrock containing calcium carbonate (building, fence), rare species, 5: on artificial bedrock containing calcium carbonate.

Lecanora allophana Nyl. – Loc. 4, 7, 25, 26, 28, 29, 33, on bark of Populus tremula, frequent species, 7: Populus tremula.

Lecanora argentata (Ach.) Malme – Loc. 9, 16, on bark of Acer platanoides, very rare species, 2: on Acer platanoides.


Lecanora dispersa s.lat. (Pers.) Sommerf. – Loc. 1, 3, 5, 6, 9, 16, 17, 22, 24, 25, 32, on artificial bedrock containing calcium carbonate (building, pole, fence), frequent species, 11: on artificial bedrock containing calcium carbonate.

Lecanora expallens Ach. – Loc. 5, 9, 22, 26, 32, on wood (pieces of bark, fencing), bark of Acer platanoides, Aesculus hippocastanum, Alnus glutinosa, Betula pendula, Fraxinus cfr. excelsior, Malus spp., Populus spp., Quercus robur, Robinia pseudoacacia, Salix spp., Sorbus aucuparia, Tilia cordata, rare species, 1: on artificial bedrock containing calcium carbonate.

Lecanora hagenii (Ach.) Ach. – Loc. 3, 9, 16, 18, 24-26, 32, on wood (branches, pieces of bark, stump), bark of Alnus glutinosa, Betula pendula, Carpinus betulus, Frangula alnus, Fraxinus cfr. excelsior, Malus spp.,
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**Lecanora saxicola** (Pollich) Ach. – Loc 1, 3, 4, 7, 9, 16, 19, 24, 25, 32, on artificial bedrock containing calcium carbonate (sidewalk, fencing, wells, pole), frequent species, 10: on artificial bedrock containing calcium carbonate.

**Lecanora polytricha** (Hoffm.) Rabenh. – Loc 4, 9, 19, 32, on stone, rare species, 4: stone.


**Lecanora rupicola** (L.) Zahlbr. – Loc 1, 9, 20, 32, on stone, rare species, 4: stone.


**Lecanora symmicta** (Ach.) Ach. – Loc 10, 18, 31, on wood (stump), bark of *Malus* spp., *Quercus robur*, *Populus* spp., rare species, 1: on wood (stump), 1: bark of *Malus* spp., 1: *Quercus robur*, 1: *Populus* spp.

**Lecanora umbrina** (Ach.) M. Massal. – Loc 4, 7, 16, on bark of *Populus tremula*, *Salix* spp., rare species, 2: on *Populus tremula*, 2: *Salix* spp.

**Lecanora varia** (Hoffm.) Ach. – Loc 3, 9, 24, 26, 28, 29, 31-33, on wood (fence), bark of *Fraxinus cfr. excelsior*, *Pyrus communis*, *Tilia cordata*, frequent species, 7: on wood (fence), 2: *Fraxinus cfr. excelsior*, 1: *Pyrus communis*, 1: *Tilia cordata*.

**Lecedida fuscocra** (L.) Ach. – Loc 9, 19, 20, on stone, rare species, 3: stone.


**Leclidella stigmata** (Ach.) Hertel & Leuckert – Loc 9, 16, 19, 25, 26, on stone, artificial bedrock containing calcium carbonate (pole), rare species, 4: on stone, 2: artificial bedrock containing calcium carbonate.

**Lepraria elobata** Tønsberg – Loc 11, 12, on wood (stump), bark of *Pinus sylvestris*, very rare species, 1: on wood, 2: *Pinus sylvestris*.


**Melanelixia subargentifera** (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch – Loc 6, 33, on bark of *Quercus robur*, very rare species, 2: *Quercus robur*.


**Micarea denigrata** (Fr.) Hedl. – Loc 12, 26, on wood (branches, pieces of bark, stump), bark of *Betula pendula*, very rare species, 1: on wood, 2 *Pinus sylvestris*.

**Micarea prasina** s.lat. Fr. – Loc 9, 31, on wood (branches, pieces of bark, stump), bark of *Betula pendula*, very rare species, 1: on wood, 2: *Betula pendula*.

**Parmelia saxatilis** (L.) Ach. – Loc 1, on wood (pieces of bark), stone, very rare species, 1: wood, 1: stone.
*Parmeliopsis ambigua* (Wulfén) Nyl. – Loc. 2, 8, 10, 12, 31, on wood (fence), bark of *Betula pendula*, *Quercus robur*, *Pinus sylvestris*, rare species, 1: on wood, 1: *Betula pendula*, 1: *Quercus robur*, 2: *Pinus sylvestris*.

*Peltigera canina* (L.) Willd. – Loc. 12, 33, on soil, very rare species, 2: soil.

*Peltigera didactyla* (With.) J. R. Laundon – Loc. 10, 12, 30, 33, on soil, rare species, 4: soil.

*Peltigera rufescens* (Weiss) Humb. – Loc. 4, 5, 9, 11, 12, 30, 33, on soil, bryophytes and remains of vascular plants, frequent species, 7: on soil, 3: bryophytes and remains of vascular plants.


*Physcia aipolia* (Humb.) Fürn. – Loc. 9, 16, bark of *Fraxinus cfr. excelsior*, very rare species, 2: on *Fraxinus cfr. excelsior*.

*Physcia caesia* (Hoffm.) Fürn. – Loc. 1, 3, 4, 5, 7, 9, 19, 22, 24, 25, 32, on artificial bedrock containing calcium carbonate (outbuildings, pole, fence), stone, frequent species, 11: on artificial bedrock containing calcium carbonate (outbuildings, pole, fence), 6: stone.


*Physconia enterocantha* (Nyl.) Poelt – Loc. 6, 16, 21, 23, 26, 32, on bark of *Fraxinus cfr. excelsior*, *Populus* spp., *Salix* spp., frequent species, 3: on *Fraxinus cfr. excelsior*, 3: *Populus* spp., 2: *Salix* spp.
Physconia distorta (With.) J. R. Laundon – Loc. 17, on bark of Betula pendula, very rare species, 1: on Betula pendula


Physconia perisidiosa (Erichsen) Moberg – Loc. 1, on bark of Salix spp., very rare species, 1: Salix spp.

Placynthiella oligotropha (J. R. Laundon) Coppins & P. James – Loc. 8, 30, on wood (pieces of bark, stump), soil, very rare species, 1: on wood, 1: soil.

Placynthiella uliginosa (Schrad.) Coppins & P. James – Loc. 9, 10, 12, on wood, pieces of bark, fence drewniane, stump), soil, rare species, 2: on wood, 3: soil.

Platysmatia glauca (L.) W.L. Cubl. & C. F. Cubl. – Loc. 31, on bark of Betula pendula, wood (branches, pieces of bark, stump), very rare species, 1: on Betula pendula, 1: wood.

Pleurosticta acetabulum (Neck.) Elix & Lumbsch – Loc. 6, on bark of Fraxinus cfr. excelsior, very rare species, 1: Fraxinus cfr. Excelsior.


Polysporina simplex (Davies) Vězda – Loc. 6, on stone, very rare species, 1: on stone.

Porpidia crustulata (Ach.) Hertel & Knoph – Loc. 9, 30, 32, on stone, rare species, 3: on stone.

Pseudovernia furfuracea (L.) Zopf – Loc. 2, 6-8, 10, 17, 25-27, 29, 30, 31, 33, on wood (branches), bark of Alnus glutinosa, Pinus sylvestris, Quercus robur, frequent species, 2: on wood, 1: Alnus glutinosa, 10: Pinus sylvestris, 4: Quercus robur.


Ramalina fraxinea (L.) Ach. – Loc. 1, 4-7, 9, 13, 15, 17, 18, 22, 25, 26, 28, 32, 33, on bark of Fraxinus cfr. excelsior, Quercus robur, Salix alba, common species, 10: on Fraxinus cfr. excelsior, 4: Quercus robur, 5: Salix alba.

Ramalina pollinaria (Westr.) Ach. – Loc. 17, on bark of Fraxinus cfr. excelsior, very rare species, 1: Fraxinus cfr. excelsior.

Rhizocarpon distinctum Th. Fr. – Loc. 7, 9, 30, 32, on stone, rare species, 4: stone.

Rhizocarpon reductum Th. Fr. – Loc. 20, on stone, very rare species, 1: stone.

Rinodina pyrina (Ach.) Arnold – Loc. 32, 33, on bark of Quercus robur, very rare species, 2: Quercus robur.

Rusavskia elegans (Link) S. Y. Kondr. & Kärnefelt. – Loc. 1, 3, 6, 9, 16, 24, on artificial bedrock containing calcium carbonate (fence, pole), frequent species, 6: artificial bedrock containing calcium carbonate.

Sarcogynae regularis Körb. – Loc. 32, on artificial bedrock containing calcium carbonate (fence), very rare species, 1: artificial bedrock containing calcium carbonate.


Scolicosporum umbrinum (Ach.) Arnold – Loc. 4, 5, 7, 32, 35, on stones, rare species, 5: stones.

Stereocaulon condensatum Hoffm. – Loc. 10, on soil, very rare species, 1: soil.

Stereocaulon incrustatum Flörke – Loc. 10, on soil, very rare species, 1: soil.
Trapeliopsis flexuosa (Fr.) Coppins & P. James – Loc. 2, 4, 5, 8, 9, 12, 25, on wood (branches, pieces of bark, stump), soil, bark of Alnus glutinosa, Betula pendula, Fraxinus cfr. excelsior, Pinus sylvestris, frequent species, 3: on wood, soil, 1: Alnus glutinosa, 2: Betula pendula, 2: Fraxinus cfr. excelsior, 1: Pinus sylvestris.

Trapeliopsis granulosa (Hoffm.) Lumbsch – Loc. 8, 9, 10, 12, 29, on wood (branches, pieces of bark, fence, stump), soil, bark of Alnus glutinosa, Betula pendula, Fraxinus cfr. excelsior, Quercus robur, Pinus sylvestris, bryophytes and remains of vascular plants, rare species, 2: on wood, 2: soil, 1: Alnus glutinosa, 1: Betula pendula, 1: Fraxinus cfr. excelsior, 1: Quercus robur, 1: Pinus sylvestris, 1: bryophytes and remains of vascular plants.

Tuckermannopsis flexuosa (Fr.) Lumbsch – Loc. 2, 8, 10, 12, 29, on wood (branches, pieces of bark, fence, stump), soil, bark of Alnus glutinosa, Betula pendula, Fraxinus cfr. excelsior, Pinus sylvestris, frequent species, 3: on wood, soil, 1: Alnus glutinosa, 2: Betula pendula, 2: Fraxinus cfr. excelsior, 1: Pinus sylvestris.

Tuckermanopsis granulosa (Hoffm.) Lumbsch – Loc. 8, 9, 10, 12, 29, on wood (branches, pieces of bark, fence, stump), soil, bark of Alnus glutinosa, Betula pendula, Fraxinus cfr. excelsior, Quercus robur, Pinus sylvestris, bryophytes and remains of vascular plants, rare species, 2: on wood, 2: soil, 1: Alnus glutinosa, 1: Betula pendula, 1: Fraxinus cfr. excelsior, 1: Quercus robur, 1: Pinus sylvestris, 1: bryophytes and remains of vascular plants.

Usnea hirta (L.) F. H. Wigg. – Loc. 2, 8, 11, 27, 35, on bark of Pinus sylvestris, rare species, 5: Pinus sylvestris.

Usnea subfloriana Sturt. – Loc. 10, 17, on bark of Pinus sylvestris, Quercus robur, very rare species, 1: Pinus sylvestris, 1: Quercus robur.

Verrucaria muralis Ach. – Loc. 33, on artificial bedrock containing calcium carbonate (fence, pole), very rare species, 1: on artificial bedrock containing calcium carbonate.

Verrucaria nigrescens Pers – Loc. 9, 26, on artificial bedrock containing calcium carbonate (fence, pole), very rare species, 2: on artificial bedrock containing calcium carbonate.

Vulpicida pinastri (Scop.) J.–E. Mattson & M. J. Lai – Loc. 31, on wood (stump), bark of Betula pendula, very rare species, 1: on wood, Betula pendula.

Xanthoparmelia conspersa (Ach.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch – Loc. 20, on stone, very rare species, 1: stone.

Xanthoparmelia loxodes (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch – Loc. 20, on stone, very rare species, 1: stone.

Xanthoparmelia pulla (Ach.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch – Loc. 1, 4, 7, 19, 20, 30, on stone, frequent species, 6: stone.

Xanthoparmelia verruculifera (Nyl.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch – Loc. 20, on stone, very rare species, 1: stone.


Characteristics of lichens in agricultural landscape:
Lichens found in the agricultural landscape of the Podlasie region represented the following habitat groups: epiphytic (72 species), epigeic (53), epixylic (45), epilithic (45) and epiphytrophic (7). Most species were found on the bark of trees. Less variation was observed among the lichens that inhabit soil and bedrock. Lichens growing on bryophytes and remain of vascular plants remain very rarely reported. These include: Cladonia chlorophaea, C. coniocraea, C. fimbriata, C. gracilis, Hypogymnia physodes, Lepraria incana and Peltigera rufescens.

Epiphytes: Among the habitat groups occurring in the rural landscape of Podlasie the greatest differentiation was demonstrated for epiphytes. In total, 72 species were found. Their records come from the bark of trees growing along the roads alone, in the fields, meadows and pastures or within the countryside buildings and on the edge of forests.

The richest epiphytic biota is exhibited by Quercus robur, Populus spp., Fraxinus cfr. excelsior, Salix spp., Alnus glutinosa, which are colonized by respectively 43, 40, 38, and 37 species respectively. Quite a large variation was also observed on the bark of Alnus spp. (30 species) and Tilia cordata (28). In the lists of coniferous phorophytes the individual registers are dominated by Pinus sylvestris, the bark of which showed the presence of 23 species. Among trees of foreign origin most epiphytic species (16) belong to Robinia pseudoacacia. Apple tree was singled out in a group of fruit trees in connection with the greatest diversity of lichens found on its bark (25 species), much fewer of them were found on bark of Pyrus communis (15) and Prunus spp. (9). Single records of common lichens are registered from shrubs. Here a richer record appears to belong to Sambucus nigra only, whose bark was colonized by 17 species.

Most epiphytes were found on the trunk and in crown of trees, and the fewest at the base of the trunk. On the trunk, along with his height, changing the share morphological forms of lichen. At the base of the trunk strongly dominated by crustose thallus of lichens (eg. Lecanora carpinea, L. expallens, Scoliciosporum chlorococcum), at the trunk and crown dominated foliose (eg. Melanohalea exasperatula, Parmelia sulcata, Physcia dubia, Ph. tenella, Physconia enteroxantha, Ph. grisea, Polycauliona polycarpa, Xanthoria parietina) and fruticose thallus (Ramalina farinacea, R. fraxinea, R. pollinaria).
The most numerous in species is genus _Lecanora_ (12 species). The following species were found on the largest number of phorophytes: _Lecanora conizaoides_ (19), _Buellia punctata_ (16), _Physcia adscendens_ (16) and _Polycodium polyacarpa_ (15). Among the epiphytic lichens there dominate lichens with crustose thalli - 31 species. Next group of lichens is represented by foliose lichens (25 species: wide foliose - 10, narrow foliose - 15), fruticose (14) and squamulose (2). Most of the observed species are found in more sunlight and little shading.

On the bark of trees in rural landscape lichens under legal protection in Poland were noted, i.e. _Bryoria fuscescens, Hypogymnia tubulosa, Imshaugia aleurites, Pleurosticta acetabulum, Ramalina farinacea, Usnea hirta, Valpicida pinastri_, or threatened, i.e. _Anaptychia ciliaris, Bacidia rubella, Bryoria fuscescens, Evernia prunastri, Melanelia subargentifera, R. pollinaria, Usnea hirta, U. subfloridana_ (Regulation, 2014; Cieśliński et al., 2006).

**Epixylic lichens:** Typical substrates occupied by epixylic lichens in rural landscape are wooden walls and roofs of farm buildings and fences placed, inter alia, along meadows, pastures and buildings. In addition, members of this group can be seen on the wood of stumps, logs and branches of trees, poles (e.g. energy poles) standing in the meadows or within woodlots. The epixylic list consists of 46 species. The most numerous are genera _Cladonia_ (12 species) and _Lecanora_ (8 species). Other taxa are mainly crustose and foliose lichens.

Nearly half of the epixylic lichens are crustose taxa (19 species), followed by foliose (14: wide foliose type _Physcia_ – 7, narrow foliose type _Physcia_ – 7) and fruticose taxa (13).

Most of the observed epixylic lichens are common lichenized fungi. Only on wood there were registered _Cladonia botrytes, C. cenoteca, C. deiformis_; records of other species come also from other types of substrates. The value of these habitats increases due to the presence of a taxon rare in the area of NE Poland, i.e. _Cladonia botrytes_ and _Cladonia botrytes_ taxa included in the list of lichens protected by law (Regulation, 2014), i.e. _Usnea hirta_. Only two species, i.e. _Cladonia botrytes_ and _Usnea hirta_ are inscribed in the national red list (Cieśliński et al., 2006).

**Epigeic lichens:** In rural areas of the Podlasie region the presence of 53 species of lichens growing on soil was recorded. Favorable conditions for development are encountered by epigeic lichens, especially in grasslands and ruderal communities and in nearby coniferous forests. The largest differentiation was demonstrated for genus _Cladonia_, represented by 32 taxa. Furthermore, lichens of genera _Cetraria, Peltigera, Placynthiella_ and _Traneliopsis_ were also observed. What might be considered interesting is the occupation of the soil by species of genus _Bacidia, Baeomyces, Collema, Dibaeis, Diploschistes, Endocarpon, Stereocaulon_, inhabiting the soil on grasslands, including xerothermic grasses.

The epigeic lichen biota of meadows, pastures, woodlots and edges of fields is poor. It consists of single taxon of genus _Cladonia, Peltigera, Placynthiella uliginosa_ and _Traneliopsis granulosa._

In the listing of epigeic lichens taxa with fruticose thalli clearly prevail (41 species), which is associated with the dominance of lichens of genus _Cladonia_. A much smaller proportion is exhibited by foliose lichens (3 species: wide foliose type _Parmelia_ - 3) and crustose (9). Most epigeic lichens show preference for growth in natural habitats or those slightly transformed by human activity. Lichens occur mainly on substrates poor in nutrients. Only _Peltigera rufescens_ is tied to slightly eutrophic places.

Other interesting epigeic lichens occurring in the agricultural landscape of Podlasie include _Cladonia grayi, C. merochlorophaea, C. merochlorophaea var. novochlorophaea, C. subulata_ and _C. rei_ which were determined by thin layer chromatography. Notable is the presence of protected species in rural landscape (Regulation, 2014), i.e. _Cetraria ericetorum, C. arbuscula, C. portentosa, C. rangiferina, Peltigera canina_. Among the endangered species (Cieśliński et al., 2006), however, _Cladonia botrytes, Cetraria ericetorum, C. islandica, Endocarpon pusillum, Peltigera canina, Stereocaulon condensatum_ and _S. incrustatum_ can be found.

**Epilithic lichens:** The presence of rock lichens in rural landscape is marked, inter alia, on poles, fences and walls of farm buildings. Artificial anthropogenic substrate rich in calcium carbonate is mainly inhabited by calciphilous species. Quotations of epilithic lichens also come from natural substrates of rock, which in the study area are stones found in meadows, pastures, cultivated fields, within woodlots or the ones used to build such poles and fences. In total, 45 species were shown on rock substrates.

Among lichens observed on substrates of anthropogenic origin were: _Circinaria calcarca, C. contorta, Calogaya decipiens, C. fimbriata, Lecanora albescens, L. dispersa, Physcia adscendens, Ph. caesia, Sarcogyna regularis, Verrucaria muralis_ and others. On stones the following species were recorded: _Acarospora fuscata, Circinaria caesiocineria, Candelariella coralliza, C. vittelina, Parmelia saxatilis, Polyphysora simplex, Pseudoparmelia crustulata, Rhizocarpon distinctum, Xanthoparmelia compressa_, and others.

Most of the located epilithic lichens are taxa of crustose thalli (26 species), which outweigh those of foliose (17: wide foliose type _Parmelia_ – 7, narrow foliose type _Physcia_ – 10) and fruticose (2) thalli. A distinctive tendency of the discussed group of lichens to occupy places in direct sunlight has been shown.

Noteworthy is the presence of protected species in rural landscape (Regulation, 2014), i.e. _Xanthoparmelia pulla_ and _X verruculifera_. Among the epilithic lichens only _Circinaria contorta_ is a valuable record in connection with its few quotations in NE Poland.

**Synanthropic lichens:** Reported synanthropic lichens are grouped according to the classification of Faltynowicz (1994) marking off apophytic lichens (eu-apophytes, mesoautoapophytes, ephemeroapophytes) and anthropophytes (eu-anthropophytes). The species are assigned to the appropriate groups depending on the frequency of record (cf. Szczepańska, 2008; Zarab ska, 2011). In the study area 127 species of synanthropic
lichens were found, which included all the lichens having at least one quote habitat of anthropogenic origin (cf. Szczepańska 2008; Zarabska, 2011). Among apophytes mesoautoapophytes dominated, followed by ephemeroapophytes, eu-apophytes and eu-anthropophytes. The anthropophytization index for lichen biota of the study area, which determines the percentage of apolitical species of lichen biota, amounted to 81.4%. The largest group of synanthropic lichens, as many as 41% of the total, are mesoautoapophytes. Lichens which were classified as mesoautoapophytes were those whose half or fewer quotes came from anthropogenic positions. In the list lichens of crustose and fruticose thalli dominate. The largest participation is exhibited by lichens inhabiting tree bark, soil and dead matter. Many of the mesoautoapophytes are acidophilous rock lichens. They colonize rocks and stones used as building material.

Quite frequently represented is an ephemeroapophytic group, which are transitional species dragged into habitats of anthropogenic origin. In the list taxa of crustose lichens dominate. The highest species diversity was demonstrated for epiphytes, epigeic and epilithic lichens. The species ranked as ephemerophytes were those whose number of record on anthropogenic habitats does not exceed three.

The smallest variation of apophytic lichens was observed among eu-apophytes, which include taxa occurring mainly in habitats of anthropogenic origin. The species were considered eu-apophytes when all or more than half of the quotations in the study area came from anthropogenic habitats. Among them lichens of foliose thalli dominate. The participation of epiphytes is clearly noticeable here.

Only three taxa (Melanelixia subargentifera, Melanohalea exasperatula, Pleurosticta acetabulum) were listed as eu-anthropophytes, or species alien to native lichen biota, however, both have been permanently established here. The records of these species, which are representatives of lichens of foliose thalli, are derived from the bark of trees.

The influence of the type of habitat on lichen biota: The values of the degree of species diversity for all species and for different morphological forms taking into account the type of habitat are presented in Table 2.

Table 2. The degree of variation in species and relative species richness of selected parameters X ± SD.

<table>
<thead>
<tr>
<th>Parametr</th>
<th>1</th>
<th>2</th>
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<tr>
<td>Nalls</td>
<td>16.6 ± 7.16</td>
<td>31.8 ± 16.05</td>
<td>19.4 ± 5.96</td>
<td>30.6 ± 7.16</td>
<td>30.2 ± 14.46</td>
<td>24.4 ± 22.06</td>
<td>25.2 ± 3.96</td>
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<td>NcC</td>
<td>5.6 ± 2.51</td>
<td>4.8 ± 3.27</td>
<td>8.0 ± 1.58</td>
<td>11.0 ± 4.06</td>
<td>14.8 ± 8.17</td>
<td>10.2 ± 12.37</td>
<td>10.8 ± 1.92</td>
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<tr>
<td>NsS</td>
<td>0.6 ± 0.55</td>
<td>1.0 ± 0.00</td>
<td>0.4 ± 0.55</td>
<td>0.8 ± 0.45</td>
<td>0.2 ± 0.45</td>
<td>0.4 ± 0.89</td>
<td>1.0 ± 0.71</td>
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<td>NsFn</td>
<td>2.6 ± 2.70</td>
<td>2.0 ± 1.57</td>
<td>5.4 ± 3.36</td>
<td>5.25 ± 1.14</td>
<td>4.6 ± 4.39</td>
<td>6.6 ± 5.24</td>
<td>9.2 ± 1.64</td>
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<tr>
<td>NsFw</td>
<td>3.8 ± 2.16</td>
<td>2.8 ± 1.64</td>
<td>4.0 ± 1.00</td>
<td>4.8 ± 0.83</td>
<td>4.0 ± 3.08</td>
<td>3.4 ± 2.19</td>
<td>3.0 ± 2.12</td>
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<tr>
<td>NsF</td>
<td>4.0 ± 1.58</td>
<td>19.2 ± 11.09</td>
<td>1.8 ± 1.64</td>
<td>5.6 ± 2.89</td>
<td>8.6 ± 5.68</td>
<td>3.4 ± 2.88</td>
<td>1.2 ± 0.83</td>
</tr>
</tbody>
</table>

Explanation: Natural communities: 1 – Deciduous forests, 2 – Coniferous Forest, Semi-natural communities: 3 – Meadows and pastures, 4 – Plantings, 5 – Grasslands, Anthropogenic communities: 6 – Ruderal, 7 – Segetal; Nalls – the number of all species; NsC – the number of crustose species, NsS – the number of squamulose species, NsFn – the number of narrow foliose species, NsFw – the number of wide foliose species, NsF – the number of fruticose species.

Diversity of species: The degree of species variation of lichens has developed at a higher level in natural communities (coniferous forests) compared with the seminatural and anthropogenic habitats (Fig. 2). In rural areas, a greater percentage of species was noted within woodlots and at watercourses, while a smaller number of taxa was observed in ruderal habitats. The total number of identified species did not differ significantly between the different types of habitats.

Morphological form of thallus: There was no effect of the covariate on the percentage of species of particular types of thallus. The share of crustose lichens is higher in habitats associated with agricultural landscape, however, statistically significant differences are marked within the same habitats assigned to the landscape (Fig. 3). For the most part, significantly lower values of the examined parameter were observed in communities of meadows and pastures as well as natural habitats.

In relation to the number of species of squamulose lichens the difference was reported only on surfaces of natural communities (forests), and anthropogenic communities (segetal) (Fig. 4). The value of the parameter examined was not statistically significant.

The average number of species of narrow foliose lichens differed significantly between the surfaces of the communities of trees and forests, ruderal communities and grassland, segetal communities and grassland, meadows and pastures, trees and ruderal communities (Fig. 5). A higher share of narrow foliose lichens was noted in selected communities in the agricultural landscape, i.e. segetal, ruderal, meadows and pastures and woodlots.

The share of lichens of wide foliose thalli of type Parmelia is higher in communities associated with agricultural landscape (woodlots, meadows and pastures, grasslands), but no statistically significant differences were found within the same communities assigned to the landscape (Fig. 6). The highest average number of species of wide foliose lichens was reported in the communities of trees.

The highest average number of fruticose lichen species was recorded in natural communities (forests) and seminatural communities (grasslands) (Fig. 7).
Fig. 2. The range of variation of the total number of lichen species found on the research surfaces, depending on their belonging to the type of habitat.

Fig. 3. The range of variation of the number of lichen species of crustose thalli found on research plots, depending on their belonging of the type of habitat.

Fig. 4. The range of variation of the number of lichen species of squamulose thalli found on research plots, depending on their belonging of the type of habitat.

Fig. 5. The range of variation of the number of lichen species of narrow foliose thalli found on research plots, depending on their belonging of the type of habitat.

Fig. 6. The range of variation of the number of lichen species of wide foliose thalli found on research plots, depending on their belonging of the type of habitat.

Fig. 7. The range of variation of the number of lichen species of fruticose thalli found on research plots, depending on their belonging of the type of habitat.
Discussion and Conclusions

In the 90s of the twentieth century NE Poland was cited among the regions best known in the lowlands for the presence of lichens (Faltnowicz, 2003; Cieśliński, 2003). Most of the data were collected in the late 90s, thus information on the contemporary presence of lichens in Podlasie is not sufficient. The works on lichens in the region are mainly on natural areas, forests (Cieśliński & Tobolewski, 1988; Faltnowicz, 1994; Bystrak & Kolanko, 2000 and others) and urban areas (Matwiejuk & Kolanko, 2007; Matwiejuk, 2007, 2008, 2009a, b). A need for lichenological research in agricultural areas is therefore justified to fill gaps in the knowledge of the distribution of lichens in the area. Cieśliński (2003) mentions 597 species of lichens from NE Poland. Taking into account the statement of lichens from this region of Poland (Cieśliński, 2003), approximately 26% of the total of lichens contained there were found in the Podlasie region, in rural areas. The obtained result on farmland of Podlasie was probably shaped by the specificity of the studied landscape covered by agricultural activities. The adopted way of collecting data, based mainly on the conduct of censuses within the randomly designated area of research probably also limited the possibility of finding a larger number of taxa.

The lichen biota of agricultural landscape of Podlasie consists of 156 species of lichens. This number is relatively large considering the results of research conducted in a similar type of landscape in other parts of the country. In north-eastern Poland, in a selected portion of Warmia plains covered by agricultural activity 98 species of lichens were observed (Szymczyk & Zalewska, 2008), in the area of Sandr Nowotomyski–175 taxa (Zarabska, 2011), in Choszczeńskie Lakeland – 184 species, but some of them were found only in the forest communities of the mesoregion (Lipnicki, 1990), Kalisz Upland (Krawiec, 1955) – 142 taxa. Taking into account the statements of lichens in areas of NE Poland undergoing anthropogenic activities the degree of lichen differentiation in the Podlasie region can be regarded as approximate to that of Białystok (Matwiejuk, 2007) – 151 species, in Bocki (Matwiejuk, 2009a) – 118. Among the lichens of the studied region epiphytic and epigeic lichens exhibit a significant share. The dominance of arboreal lichens and a large share of terrestrial lichens affect the nature of lichen biota occurring in this region of Poland (Cieśliński, 2003). A large abundance of epiphytes, compared with other habitat groups, is also observed in other parts of NE Poland (Cieśliński, 2003).

Epiphytes are the most numerous habitat group in rural areas. The number of 72 taxa found in Podlasie is comparable with the data from other parts of the country. The epiphytic biota from Choszczeńskie Lakeland consisted of 75 species (Lipnicki, 1990), from the Plain of Warmia – 60 (Szymczyk & Zalewska, 2008), from Sandr Nowotomyski – 92 (Zarabska, 2011). In the areas of Alpine foothills in Switzerland 84 species of epiphytes were recorded (Ruoss, 1999). Typical substrates for the development of this group in the agricultural landscape is the bark of roadside trees growing at farmhouses, fields, meadows and pastures, orchards, and rural parks (e.g. Lipnicki, 1990; Szczepańska, 2008; Szymczyk & Zalewska, 2008; Zarabska, 2011). Among the epiphytic lichens species common in the country dominate. Some of these species are nitrophilous and coniophilous lichens.

In rural areas of the study area, as in other parts of the country, the presence of epixylic lichens is marked on the wooden buildings, fences around fields, buildings, gardens, pillars (Szymczyk & Zalewska, 2008; Zarabska, 2011; Matwiejuk, 2009a, b). The list of this group is dominated by common lichen taxa and those exhibiting a wide range of ecological spectrum, developing both on the wood and the bark of trees and on soil.

The natural conditions of Podlasie favor the development of epigeic lichen biota, which could partially affect quite a number of quotations of this habitat group in this type of landscape. Among the epigeic lichens genus Cladonia is most abundantly represented in species. Rich epigeic lichen biota from rural Podlasie can be observed most often in communities of psammophilous grasslands occurring, among others, on the slopes of unwooded dunes or uncultivated agricultural lands, in the communities of xerothermic grasslands and pine plantings and on the edge of forests. Listing of lichens rare here in the lowlands, such as Endocarpon pusillum, Collema limosum, C. tenax confirm observations from other parts of NE Poland concerning the presence of interesting epigeic lichens within grasslands (Cieśliński, 2003). Despite the good diagnosis of the type of Cladonia in NE Poland, efforts to show the position of Cladonia merochlorophaea and C. merochlorophaea var. novochlorophaea, new taxa of Podlasie, failed (Cieśliński, 2003). The literature data on the occurrence of terrestrial lichens in areas undergoing agricultural activities are scarce, therefore it is difficult to distinguish a group of species typical of these areas.

Observations of epilithic lichens in this part of the country come from natural and anthropogenic habitats (e.g. Cieśliński, 2003). In agricultural areas of Podlasie boulders are often encountered, hence a relatively large number of epilithic lichens are found on natural habitats. There grow Acarospora fuscata, Apicilia cinerea, Candelariella coralliza, Lecanora polytropa, Porpidia crustulata, Rhizocarpon distinctum, Xanthoparmelia conspersa and X. pulla. In the discussed area the epilithic biota is rich in species growing in anthropogenic habitats. It consists mainly of common and widespread taxa found in other regions of Poland (Lipnicki, 1990; Cieśliński, 2003; Zarabska, 2011). A large part of the reported epilithic lichens is characterized as heliophilous, calciphilous, nitrophilous and coniophilous (cf. Faltnowicz, 1997). These properties, however, do not seem to be exclusive to the species found in rural landscape. They are also common in lichens listed in urban areas (cf. Matwiejuk, 2007, 2008, 2009a, b). Quotations of Cladonia merochlorophaea var. novochlorophaea from Podlasie is the first listing of this taxon in the region. The findings of this lichen are known mainly from the northern part of Poland (Kowalewska et al., 2008). In other parts of the country this lichen was very rarely recorded (Zarabska, 2011).
Rare species recorded during surveys in rural areas of Podlasie are *Caloplaca cerina*, a species showing preference for aspen bark growing on the edges of forests, clearings, *Cladonia grayi* – a terrestrial species listed on the outskirts of pine forests, *C. pocillum* – a species growing on soils rich in calcium carbonate in grasslands, *C. rei* - a species growing on grasslands, *Dibaeis baemoyces* and *Diploschistes muscorum* - species preferring humus - rich soil in grasslands. Most of the statements of *Cladonia rei* in Poland come from the eastern, south-eastern and central parts of the country (Syrek & Kukwa, 2008). *Diploschistes muscorum* was noted from a few localities in northern and central Poland (Lipnicki & Grochowski, 2011). Also *Candelariella reflexa* is known from a small number of positions in NE Poland (Cieśliński, 2003). Over the past several years the spread of this taxon has clearly been indicated (van Herk et al., 2002; Aptroot, 2008; van Herk, 2009).

In Podlasie, there has been found a high proportion of synanthropic taxa in the general statement of lichen biota of the study area. This indicates the importance of agricultural landscape in shaping the habitats occupied by lichens and its impact on the degree of differentiation of lichen biota. Most apophytic taxa were found among epiphytic lichens. Among the apophytes in the lichen biota of the study area mesoautoapophytes had the largest share. Some of these species are lichens of a wide range of organic farming, such as *Hypogymnia physodes, Melanelixia fuliginosa, Melanohalea exasperatula*, which grow in natural forest communities but can pass onto anthropogenic habitats, for example, on the bark of roadside trees, fruit trees and wooden structures. The large share is also exhibited by epheromoapophytes. Its characteristic large species richness in the Podlasie region is associated with broad participation of synanthropic species of lichens rarely quoted in the study area. Epheromoapophytes are defined as species occasionally appearing on the surfaces under the influence of human activities, while prevailing in the natural habitats. Considering, however, the composition of the species of the epheromoapophyte – forming group we can observe the advantage of taxa typical of open places. In the study area they are therefore associated with anthropogenic habitats, but poorly distributed. The dominance of arboreal lichens among eu-epiphytes was also observed in the agricultural landscape of the Plains of Warmia (Szymczyk and Zalewska, 2008), Sandr Nowotomyski (Zarabska, 2011). The advantage of epigeic lichens among mesoautoapophytes can be partially attributed to a high proportion of terrestrial lichens in forest communities in the studied region. Similarly, the high value of the anthropophytization index (81.4%) was found in the agricultural landscape of Sandr Nowotomyski – 84.9% (Zarabska, 2011). Lower values of this index are given for Massif Śnieżnik and Białoškie Mountains – 63% (Szczepańska, 2009), for the Bieszczady Low – approximately 60% (Kościelnik, 2004), and for the BNP – 4.26% (Cieśliński & Cyżyewska, 1998). The higher the human intervention in the area, the higher the result of synanthropisation of lichen biota.

The occurrence of lichens in habitats created by human activities is associated with their environmental requirements and morphological, chemical and physiological considerations of these organisms (cf. Faltyńowicz, 1992). Studies have shown a higher degree of differentiation among crustose lichens found in certain types of communities covered by agricultural use. The crustose lichens in rural areas fall mainly in the epiphytic and epitetic lichen biota. A higher share of narrow foliose lichens was marked in the segetal and ruderal communities and woodlots, as well as streams, meadows and pastures. This may be related to the fact of the composition of this group mainly by nitrophilous, coniophilous, heliophilous and xerophilic lichens of genus *Physcia, Phycosina, Phaeophyscia* and some *Xanthoria* particularly associated with rural areas. A higher share of foliose lichens in open areas is due to the favorable impact of higher intensity of light reaching the lower parts of the trunks of trees growing in open areas compared to phorophytes of forest communities (Dietrich & Scheidegger, 1997). Additionally, the presence of appropriate phorophytes of cracked bark is favourable for their development, e.g., of genus *Salix, Tilia, Fraxinus*, which allows effective anchoring of the lichen thalli to the substrate (Faltyńowicz, 1992). A significant share of fruticos lichens of grassland in comparison with other types of communities in the open landscape is probably related not so much to the impact of farming, as the natural determinants of the region. These lichens are represented primarily by epigeic lichens of genus *Cladonia* (Zarabska, 2011).

The lichen biota of this area, despite the various anthropogenic factors, has remained rich and varied, despite the multitude of anthropogenic factors.

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**References**


