

# DISTRIBUTION OF LICHEN SPECIES OF THE GENUS *LEPRARIA* IN THE KNYSZYN FOREST (NE POLAND) IN DIFFERENT FOREST PLANT COMMUNITIES

ANNA MATWIEJUK

**Abstract.** The aim of the study was to evaluate the distribution of lichen species of the genus *Lepraria* in Knyszyn Forest (NE Poland) to different forest plant communities. Six species of *Lepraria* [*L. eburnea* J. R. Laundon, *L. elobata* Tønsberg, *L. incana* (L.) Ach., *L. jackii* Tønsberg, *L. lobificans* Nyl. and *L. vouaxii* (Hue) R. C. Harris] recorded from Knyszyn Forest. *Lepraria eburnea* is a new species for the studied area. The most common species were *Lepraria incana* and *L. lobificans*. Among the studied forest communities the richest in species (5 species of *Lepraria*) were oak-hornbeam forest (*Tilio-Carpinetum*), and the least species-rich (2 species) were maple-linden slope forest (*Aceri-Tilietum*), alder carr (*Carici elongatae-Alnetum*) and spruce forest (*Sphagno girgensohnii-Piceetum*). The richest lichen diversity in the Knyszyn Forest was found on deciduous trees such as *Carpinus betulus* L. and *Quercus robur* L. (4 species), *Tilia cordata* Mill. (3 spp.), and conifers such as *Picea abies* (L.) H. Karst. and *Pinus sylvestris* L. (3 spp.).

**Key words:** biodiversity, lichenized fungi, sterile lichens, secondary substances, lowland forests, new records

*Anna Matwiejuk, Department of Plant Ecology, Institute of Biology, University of Białystok, Konstanty Ciolkowski 1J street, 15-234 Białystok, Poland; e-mail: matwiej@uwb.edu.pl*

## INTRODUCTION

The species of the genus *Lepraria* Ach. are lichenized fungi consisting of a persistently sterile crustose sorediate thallus. *Lepraria* is an evolutionarily successful genus of 61 species with a worldwide distribution (Saag *et al.* 2009). Reduced morphology in *Lepraria* has made species difficult to define; consequently, secondary metabolites have played a central role in species delimitation (Nelsen & Gargas 2008). Molecular studies by Ekman and Tønsberg (2002) confirmed that it belongs to the family Stereocaulaceae. The genus *Lepraria* has been examined for the British Isles (Laundon 1992; Orange 1995), Norway (Tønsberg 1992, 2002), Finland (Lohtander 1994, 1995), Sweden (Lindblom 1995), Germany (Wirth & Heklau 1995), Estonia (Saag & Saag 1999), North America (Tønsberg 2004, 2007), Australia (Elix 2006), Belarus (Golubkov & Kukwa 2006; Tsurukau *et al.* 2016), Italy (Zedda 2000, Baruffo *et al.* 2006), South America (Flakus & Kukwa 2007, Bungartz *et al.* 2013), Greenland (Saag *et al.*

2007), South Korea (Joshi *et al.* 2010) and Latvia (Mežaka *et al.* 2012).

In Poland the genus *Lepraria* is represented by 17 species (Kukwa 2006). It has been studied in detail by Czarnota and Kukwa (2001), Kukwa (2001, 2002a, b, 2003, 2004a, b, 2006), Kukwa and Śliwa (2005), Osyczka and Stolarczyk (2005) and Osyczka *et al.* (2010). The data came from lowland (Gdansk region, Białowieża Primeval Forest) and the Western Carpathians (Gorce Mts, Tatry Mts, Beskid Sądecki Mts, Pieniny Mts, Jasło-Sanok Basin).

About 350 lichen species are known from the Knyszyn Forest (e.g., Bystrek & Kolanko 2000; Cieśliński 2003). The lichen biota was thoroughly investigated by Bagińska and Motyka-Zgłobicka (1979), Bystrek and Anisimowicz (1981), Bystrek and Chwojko (1982), Cieśliński and Zielińska (1994), Cieśliński (1995, 2003), Bystrek and Kolanko (1996, 2000), Kolanko and Matwiejuk (1999, 2001a, b), Kolanko (2000, 2001, 2008,

2009), Czyżewska *et al.* (2002) and Motiejūnaitė and Czyżewska (2008). Five *Lepraria* species [*L. elobata* Tønsberg, *L. incana* (L.) Ach., *L. jackii* Tønsberg, *L. lobificans* Nyl., *L. vouaxii* (Hue) R. C. Harris as *Leproloma vouauxii* (Hue) J. R. Laundon] were previously reported from the area but the species were treated without attention to secondary metabolites. Also, their records were limited to single localities.

The present paper includes data on six species of *Lepraria* (*L. eburnea* J. R. Laundon, *L. elobata*, *L. incana*, *L. jackii*, *L. lobificans*, *L. vouaxii*) recorded from the Knyszyn Forest. One species, *L. eburnea*, is newly reported for the studied area. All species were analyzed for the presence of lichen substances (TLC) and for their forest community and phorophyte type preferences. Seven lowland forest communities were included in the study.

#### STUDY AREA

The Knyszyn Forest is situated in Podlaskie Province, NE Poland (Fig. 1). It covers a large part (1260 km<sup>2</sup>) of the Wysoczyzna Białostocka upland. This forest is the second biggest forest complex in the Podlasie lowland, after the Białowieża Forest. Over 60% of the forested area in the studied region is occupied by coniferous forest communities.

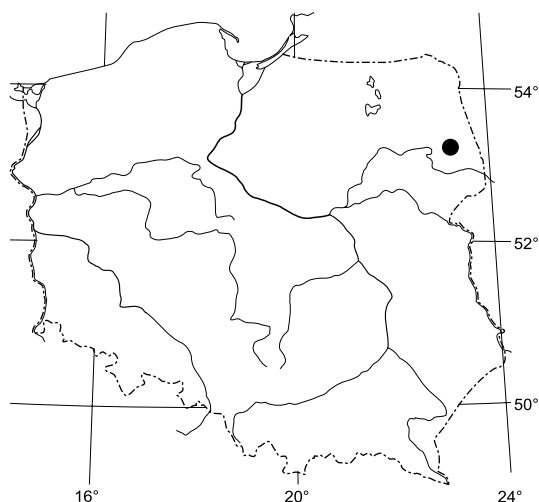


Fig. 1. Location of the study area.

Czerwiński (1995) described 15 forest communities and several supplementary communities from the Knyszyn Forest. The forest area is protected as Knyszyn Forest Landscape Park, established in 1988, and is a Nature 2000 EU Special Protection Area. The landscape park contains 20 nature reserves (Sokołowski 1991). The study was carried out in eight of them.

#### MATERIAL AND METHODS

In 2014–2015 I investigated the lichens of the Knyszyn Forest in eight nature reserves: Budzisk, Góra Pieszczana, Jesionowe Góry, Krzemianka, Krasne, Las Cieliczański, Stare Biele and Woronicza. The study was done in communities representing four types of deciduous forest (oak-hornbeam forest *Tilio-Carpinetum* Tracz. 1962, maple-linden slope forest *Aceri-Tilietum* Faber 1936, riparian alder forest *Circaeo-Alnetum* Oberd. 1953, alder carr *Carici elongatae-Alnetum* Koch 1926) and three types of coniferous forest: mixed oak-spruce forest *Quercu-Piceetum* (W. Mat. 1952) W. Mat. & Polak. 1955, subcontinental pine forest *Peucedano-Pinetum* W. Mat. (1962) W. Mat. & J. Mat. 1973 and bog-spruce forest *Sphagno girgensohnii-Piceetum* Polak. 1962. Geographical coordinates were obtained from a GPS.

The research was done in two plots (each 20 × 20 m) demarcated in each forest plant community in the nature reserves, as follows:

- 1 – Budzisk Reserve (53°16'44"N 23°22'50"E), forest plant communities: *Aceri-Tilietum*, *Tilio-Carpinetum*, *Circaeo-Alnetum*, *Quercu-Piceetum*, *Sphagno girgensohnii-Piceetum*
- 2 – Jesionowe Góry Reserve (53°20'47"N, 23°17'28"E), forest plant communities: *Aceri-Tilietum*, *Quercu-Piceetum*
- 3 – Las Cieliczański Reserve (53°10'23"N, 23°22'17"E), forest plant community: *Tilio-Carpinetum*
- 4 – Góra Pieszczana Reserve (53°12'19"N, 23°34'58"E), forest plant community: *Peucedano-Pinetum*
- 5 – Krasne Reserve (53°11'44"N, 23°18'14"E), forest plant communities: *Peucedano-Pinetum*, *Carici elongatae-Alnetum*
- 6 – Stare Biele Reserve (53°18'38"N, 23°39'23"E), forest plant community: *Carici elongatae-Alnetum*
- 7 – Krzemianka Reserve (53°17'71"N, 23°06'72"E), forest plant community: *Circaeo-Alnetum*
- 8 – Woronicza Reserve (53°15'22.11"N, 23°29'18.29"E), forest plant community: *Sphagno girgensohnii-Piceetum*.

**Table 1.** Occurrence of the *Lepraria* species in Knyszyn Forest, by tree substrate and forest plant community type (Ag – *Alnus glutinosa*, Bp – *Betula pendula*, Cb – *Carpinus betulus*, Fe – *Fraxinus excelsior*, Qr – *Quercus robur*, Pa – *Picea abies*, Ps – *Pinus sylvestris*, Pt – *Populus tremula*, Tc – *Tilia cordata*).

Forest plant community	Locality	Species					
		<i>Lepraria eburnea</i>	<i>Lepraria elobata</i>	<i>Lepraria incana</i>	<i>Lepraria jackii</i>	<i>Lepraria lobificans</i>	<i>Lepraria vouaxii</i>
<i>Tilio-Carpinetum</i>	1, 3	Qr	Cb, Tc	Cb, Pt, Tc, Qr		Cb, Qr, Pt, Tc	Cb, Qr
<i>Aceri-Tilietum</i>	1, 2		Cb	Qr, Tc		Cb, Fe, Qr, Tc	
<i>Carici elongatae-Alnetum</i>	5, 6			Ag		Ag	
<i>Circaeo-Alnetum</i>	1, 7			Ag	Pa	Ag	
<i>Quercu-Piceetum</i>	1, 2		Pa	Bp, Qr, Pa	Bp, Pa		
<i>Peucedano-Pinetum</i>	4, 5		Ps	Ps	Ps	Ag	
<i>Sphagno girgensohnii-Piceetum</i>	1, 8			Bp, Pa		Pa	

Data were collected from 14 study plots. The plots were sampled in the middle of the forest stands. In each plot, 10 trees with DBH > 0.05 m were selected randomly. The specimens were studied morphologically and anatomically by microscopy. Chemical analyses employed thin-layer chromatography (TLC) as described by Orange *et al.* (2001) and Flakus and Kukwa (2007). Lichen samples were extracted in acetone and the extract was spotted onto glass TLC plates pre-coated with Merck silica gel 60 F 254, in solvent systems A (Culberson & Ammann 1979) and C (Mietsch *et al.* 1994). Lichen species nomenclature follows Kukwa (2006), and forest plant community names follow Czerwiński (1995). Specimens are stored in the Herbarium of the Institute of Biology of the University of Białystok.

## RESULTS AND DISCUSSION

I recorded six species of *Lepraria* (*L. eburnea*, *L. elobata*, *L. incana*, *L. jackii*, *L. lobificans*, *L. vouaxii*) from the Knyszyn Forest (Table 1). *Lepraria eburnea* is a new species for the studied area. The most common species were *Lepraria incana* and *L. lobificans*. The richest lichen species diversity in the Knyszyn Forest was found on deciduous trees such as *Carpinus betulus* L. and *Quercus robur* L. (4 species), *Tilia cordata* Mill. (3 species) and on conifers such as *Picea abies* (L.) H. Karst. and *Pinus sylvestris* L. (3 species). The fewest *Lepraria* species were recorded on *Alnus glutinosa* (L.) Gaertn., *Betula pendula* Roth., *Populus tremula* L. and *Fraxinus excelsior* L. (1 sp.) (Table 1).

The forest community richest in species was oak-hornbeam *Tilio-Carpinetum* (5 species). Four species were found in pine *Peucedano-Pinetum*. Three taxa each were found in riparian alder *Circaeo-Alnetum* and mixed oak-spruce *Quercu-Pinetum*. The fewest (2 species each) were found in maple-linden slope forest *Aceri-Tilietum*, alder carr *Carici elongatae-Alnetum* and spruce *Sphagno girgensohnii-Piceetum* (Table 2).

**Table 2.** Number of *Lepraria* species in different forest plant community types in the Knyszyn Forest.

Forest plant community	Average	Min.–Max.	SD
<i>Tilio-Carpinetum</i>	3.05	1–5	1.28
<i>Aceri-Tilietum</i>	1.85	1–3	0.79
<i>Carici elongatae-Alnetum</i>	1.45	1–2	0.50
<i>Circaeo-Alnetum</i>	1.90	1–3	0.78
<i>Quercu-Piceetum</i>	1.95	1–3	0.82
<i>Peucedano-Pinetum</i>	2.10	1–3	0.72
<i>Sphagno girgensohnii-Piceetum</i>	1.50	1	0.51

## THE TAXA

### *Lepraria eburnea* J. R. Laundon

New for the Knyszyn Forest. *Lepraria eburnea* is a very rare species in this forest, growing on bark of deciduous trees in oak-hornbeam forest.

LICHEN SUBSTANCES: Chemotype (1) alectorialic acid ± with associated substances, and with protocetraric acid.

OCCURRENCE THE STUDIED FOREST PLANT COMMUNITIES: *Tilio-Carpinetum*.

TYPE OF PHOROPHYTE: *Quercus robur*:

LOCALITY: 3.

NOTES. *Lepraria eburnea* is not very common in Poland (Kukwa 2003, 2006). The species has a rather wide habitat amplitude but prefers medium-acidic to basic substrates (Kukwa 2003, 2006); it grows on tree bark, concrete and rocks. The species has a boreal distribution (Tsurykau *et al.* 2016). It is common lichen in Estonian old-growth forests (Saag 2007). In the Knyszyn Forest this species is here reported for the first time, on bark of *Quercus robur* in oak-hornbeam forest. Wirth and Heklau (1995) reported *L. eburnea* mostly on *Quercus*, but Tønsberg (1992) found it more common on *Alnus incana* and *Sorbus aucuparia*, and rare on *Populus tremula* and *Quercus* spp.

### *Lepraria elobata* Tønsberg

*Lepraria elobata* is a relatively common corticolous species in the Knyszyn Forest. It grows frequently on bark of deciduous trees but also was found on bark of coniferous trees. It grows in coniferous, deciduous and mixed forest.

LICHEN SUBSTANCES: Atranorin, stictic acid complex and zeorin.

OCCURRENCE THE STUDIED FOREST PLANT COMMUNITIES: *Tilio-Carpinetum*, *Aceri-Tiletum*, *Quercu-Piceetum* and *Peucedano-Pinetum*.

TYPE OF PHOROPHYTES: *Carpinus betulus*, *Picea abies*, *Pinus sylvestris* and *Tilia cordata*.

LOCALITIES: 1, 2, 3, 4, 5.

NOTES. In Poland, *Lepraria elobata* is considered to be one of the most common species of the genus *Lepraria*, especially in mountain regions (Kukwa 2003, 2006). It prefers acidic, meso- to oligotrophic bark of trees. It occurs almost exclusively in forests (Kukwa 2003).

### *Lepraria incana* (L.) Ach.

*Lepraria incana* is relatively common in the Knyszyn Forest, found most often on bark of coniferous trees and bark of deciduous trees. This species prefers coniferous and mixed forests.

LICHEN SUBSTANCES: Divaricatic acid and zeorin.

OCCURRENCE IN THE FOREST PLANT COMMUNITIES: *Tilio-Carpinetum*, *Aceri-Tiletum*, *Carici elongatae-*

*Alnetum*, *Peucedano-Pinetum*, *Quercu-Piceetum* and *Sphagno girgensohnii-Piceetum*.

TYPE OF PHOROPHYTES: *Alnus glutinosa*, *Betula pendula*, *Carpinus betulus*, *Quercus robur*, *Picea abies*, *Pinus sylvestris*, *Populus tremula* and *Tilia cordata*.

LOCALITIES: 1, 2, 3, 4, 5, 6, 7, 8.

NOTES. *Lepraria incana* is a common species in Europe (Tønsberg 2002; Mežaka *et al.* 2012, Kukwa 2006), occurring on many phorophytes (Kukwa 2006; Mežaka *et al.* 2012). Mežaka *et al.* (2012) found this species to prefer trees with relatively low bark pH. Jüriado *et al.* (2009) also observed *L. incana* on more acidic substrates such as *Betula* spp. and *Alnus glutinosa*. Tsurykau *et al.* (2016) recorded *L. incana* mostly in coniferous forests (96% of the studied material) of varying insolation and humidity. In Estonia the old spruce-dominated forests may be especially suitable for *L. incana* on account of the shade, relatively high humidity, and low pH of spruce bark (Saag 2007).

### *Lepraria jackii* Tønsberg

*Lepraria jackii* is a common lichen in the Knyszyn Forest. It grows almost exclusively on tree bark, especially that of coniferous and deciduous trees. It prefers pine and spruce forest.

LICHEN SUBSTANCES: Atranorin, jackinic and roccelic acids.

OCCURRENCE THE STUDIED FOREST PLANT COMMUNITIES: *Circaeo-Alnetum*, *Quercu-Piceetum* and *Peucedano-Pinetum*.

TYPE OF PHOROPHYTES: *Betula pendula*, *Picea abies* and *Pinus sylvestris*.

LOCALITIES: 1, 2, 4, 5, 7.

NOTES. *Lepraria jackii* is widespread throughout Poland, and relatively common (Kukwa 2002, 2006). The species grows on acidic and oligotrophic bark of trees. It prefers forests, especially well-insolated and rather dry pine and spruce forests (Kukwa 2003). Similar ecology was also reported for Belarus by Tsurykau *et al.* (2016). In Estonia, *L. jackii* is mainly epiphytic, preferring neutral substrate, and *L. elobata* belongs to the epiphyte group together with *L. jackii* but is more often acidophytic (Saag 2007). I recorded *L. jackii*

mostly on bark of *Picea abies*, *Pinus sylvestris* and *Betula pendula*.

### *Lepraria lobificans* Nyl.

*Lepraria lobificans* is a common lichen in the Knyszyn Forest. It was found mainly on bark of deciduous trees and very rarely on bark of coniferous trees (*Picea abies*). It prefers deciduous forests.

LICHEN SUBSTANCES: Atranorin, stictic acid complex and zeorin.

OCCURRENCE IN THE STUDIED FOREST COMMUNITIES: *Tilio-Carpinetum*, *Aceri-Tilietum*, *Carici elongatae-Alnetum*, *Circareo-Alnetum*, *Peucedano-Pinetum* and *Sphagno girsensohnii-Piceetum*.

TYPE OF PHOROPHYTES: *Alnus glutinosa*, *Carpinus betulus*, *Fraxinus excelsior*, *Quercus robur*, *Picea abies*, *Populus tremula* and *Tilia cordata*.

LOCALITIES: 1, 2, 3, 4, 5, 6, 7, 8.

NOTES. In Poland, *Lepraria lobificans* is a common species and widely distributed, growing mainly on meso- to eutrophic, medium-acidic to basic substrates. It grows on bark of trees and also very often on rocks and saxicolous mosses. *Lepraria lobificans* is a hygrophilous lichen, growing usually in shade. As an epiphyte it prefers forest conditions, but also occurs in open areas, mostly near lakes or rivers. *Lepraria lobificans* very rarely occupies roadside trees (Kukwa 2003, 2006). In Scandinavia this species was recorded mostly in the European protected habitat known as 'Fennoscandian hemiboreal natural old broad-leaved forests rich in epiphytes' (Mežaka *et al.* 2012). In study area, *L. lobificans* prefers oak-hornbeam *Tilio-Carpinetum*. This suggests that *L. lobificans* prefers moderate humidity and moderately shady conditions.

### *Lepraria vouaxii* (Hue) R. C. Harris

*Lepraria vouaxii* is a rare species in the Knyszyn Forest. It was found on bark of deciduous trees in *Tilio-Carpinetum*.

LICHEN SUBSTANCES: Pannaric acid-6-methylester.

OCCURRENCE IN THE STUDIED FOREST COMMUNITIES: *Tilio-Carpinetum*.

TYPE OF PHOROPHYTES: *Carpinus betulus* and *Quercus robur*.

LOCALITIES: 1, 3.

NOTES. *Lepraria vouaxii* is not a common species in Poland; it is known mostly from open locations (Kukwa 2003). Most often it occupies well-insolated, meso- to eutrophic and medium-acidic to neutral bark of deciduous trees, and rarely other types of phorophytes (Kukwa 2006). Similar ecology was also reported for Belarus by Tsurykau *et al.* (2016), where the species grows on trees with medium-acidic to basic and nutrient-rich bark (Tsurykau *et al.* 2016). In Sardinia this species is considered to be a characteristic taxon of old oak woods (Zedda 2000).

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