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Dedicated to Professor Alina Skirgiełło on the occasion of her ninety-fifth birthday

Lichens of red oak *Quercus rubra* in the forest environment in the Olsztyn Lake District (NE Poland)

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A list of 63 species of lichens and 4 species of lichenicolous fungi recorded on the bark of red oak (*Quercus rubra* L.) in Poland is given. Literature data and the results of field studies conducted in the forest in the Olsztyn Lake District between 1999 and 2005 are used in the report. Fifty-five taxa, including lichens rare in Poland, for instance *Lecanora albella*, *Lecidella subviridis*, *Ochrolechia turneri*, were recorded.

Key words: lichens (lichenized fungi), lichenicolous fungi, red oak (*Quercus rubra*), Poland

INTRODUCTION

Rich lichen biotas, usually comprising numerous specific species, are associated with the genus *Quercus* L. both in Poland (Cieśliński, Tobolewski 1988; Rutkowski 1995) and in other parts of Europe (Alvarez, Carballal 2000; Zedda 2002; Engel et al. 2003). Many rare or very rare lichen species in Poland and taxa considered to be extinct have been found to colonise oak bark in Poland (Cieśliński, Tobolewski 1988; Rutkowski 1995; Rutkowski, Kukwa 2000; Fałtynowicz 1991). Its diversified texture provides niches suitable for different lichen species while the phorophyte's longevity influences the richness and diversity of its lichen biota. The occurrence of native oak species (*Quercus robur*, *Q. petraea*) in various forest communities is also significant (Matuszkiewicz 2001; Modrzyński et al. 2006; Danielewicz, Pawlaczyk 2006). However, despite abundant data on the occurrence of lichens on oak bark, the lichen biota of this phorophyte has not been studied thoroughly and extensively.

In Poland, the genus *Quercus* is represented by three native species (*Q. robur*, *Q. petraea*, *Q. pubescens*) and several alien, mostly North American, species. *Quercus rubra* L. is the only taxon of many introduced species to have acclimatised in natural forest habitats in Poland (Król 1967; Hereźniak 1992). At the same time, the number of introduction sites and its total cultivation area exceed those of all other

deciduous species introduced in Polish forests (Danielewicz, Pawlaczyk 2006). *Quercus rubra* is native to eastern parts of North America. It usually grows in lowland and submontane areas, and reaches 1600 m above sea level in the mountains (Browicz 1953). Its native range covers the area from Nova Scotia in the north to Alabama and Texas in the south, reaching the belt of Central American prairies in the west, and it generally corresponds to the eastern (Appalachian) forest region where deciduous forests that lose their leaves for winter are the basic type of vegetation (Appalachian oak forest region) (Podbielkowski 1995). In the native range, *Quercus rubra* grows on a variety of soils and in topographically diversified areas, often forming pure stands.

Species of the genus *Quercus*, both native and acclimatised, have usually been treated inclusively in lichenological research in Poland. Although some authors draw attention to the interesting lichen biota of red oak (Zalewska et al. 2004), only few provide extensive relevant information (Tyszkiewicz 1935; Dziabaszewski 1962; Glanc 1969; Glanc, Kapuściński, Król 1971; Kukwa 2002; Kubiak 2005). The lack of detailed studies on species diversity, particularly important in the case of *Q. rubra*, the most widespread of alien species, encouraged the present author to examine the lichen biota of this phorophyte in depth.

STUDY AREA

Quercus rubra sites located in the Olsztyn Lake District in the municipal forests of the city of Olsztyn, in the Las Warmiński reserve and the Kamienna Góra reserve as well as in forest sections 51, 104 and 523 of the Nowe Ramuki forest district were examined. The sites are usually mid-forest cultivations covering a total surface area of 0.10-0.05 ha. The tree forms avenues, and occurs along section lines or forest roads less frequently. Single trees, probably self-sown, are also noted. The oldest sites of *Quercus rubra* in the area date back to the 1880s and are mostly the remains of Experimental Forest Areas established by German foresters (cf. Tumiłowicz 1965, 1967). The majority of the study sites come from this period.

The Olsztyn Lake District belongs to the western part of the Masurian Lake District (Kondracki 1998). The region is characterised by significant terrain diversification. Rolling uplands of the clayey ground moraine constitute the northern part of the Olsztyn Lake District, while hilly uplands and kettles in outwash plains, built from sands and gravels covered by expansive forests called the Nidzica Forest (Zaręba 1978), abundant in lakes, form the southern part. The altitudes of moraine hills along the peripheries of the mesoregion slightly exceed 200 m above sea level and are significantly lower in the central part.

A greatly diversified plant cover is a feature of the Olsztyn Lake District, located in the transitional zone where elements of the oceanic and continental climates clash. Occurrence ranges of numerous plants, including forest-forming trees, characteristic both of central and western Europe (Atlantic flora) and of northern Europe (subboreal and boreal species), run and cross in the area. Durmast oak *Quercus petraea* (Boratyńska 1979), sycamore *Acer pseudoplatanus* (Boratyński 1979) and beech *Fagus sylvatica* (Tokarz 1971) reach their north-eastern limits of occurrence ranges in the Olsztyn Lake District. Norway spruce *Picea abies* (Jutrzenka-Trzebiatowski, Fenyk 2001) reaches the south-western limit of the boreal

range. The ranges of main forest-forming species determine the shape and character of entire forest communities. Associations characterised by the continental type of range: *Peucedano-Pinetum*, *Seratulo-Pinetum* and *Tilio-Carpinetum* (subboreal variety), reach their western limits in the area while associations characterised by the subatlantic range or similar to it: *Fago-Quercetum*, *Luzulo pilosae-Fagetum*, *Stellario-Carpinetum*, *Galio odorati-Fagetum* or *Leucobryo-Pinetum*, reach their eastern limits (Matuszkiewicz 2001).

MATERIAL AND METHODS

Detailed field studies were conducted in 2005. Data collected by the author in the period between 1999 and 2005 were additionally used. In total, 16 *Querqus rubra* sites located within forest complexes previously studied lichenologically were analysed. Critical taxa (sterile sorediate lichens, species of the genus *Usnea*) were determined using chromatography methods (TLC), performed according to the procedures specified by Orange, James and White (2001), in the Department of Mycology, University of Warmia and Mazury in Olsztyn, and the Department of Plant Taxonomy and Nature Protection, University of Gdańsk. Names of lichens and lichnicolous fungi are given after Fałtynowicz (2003) and Kukwa and Diederich (2005), red list categories of lichens after Cieśliński, Czyżewska and Fabiszewski (2003) and Cieśliński (2003b).

The collected herbarium material is deposited in the Herbarium of the Department of Mycology, University of Warmia and Mazury in Olsztyn (OLTC-L). The taxa are listed alphabetically. Source studies are specified in the case of taxa reported in earlier publications. The number of sites and their general location is given for the taxa recorded in the present study (Tab. 1).

RESULTS

A total of 55 species of lichens and 4 species of lichenicolous fungi were recorded in the study sites (Tab. 1). Between 11 and 25 species were recorded in individual sites, and 19 species on average. Taxa with crustose thalli dominate (39 species); lichens with foliose thalli (8 species) or with fruticose thalii (5 species) and dimorphic species (*Cladonia* spp.; 4 species) are less numerous. The following species were recorded most frequently: *Hypogymnia physodes, Cladonia coniocraea, Platismatia glauca, Lepraria incana, Mycoblastus fucatus, Pertusaria amara, Parmelia sulcata, Phlyctis argena, Buellia griseovirens, Lecanora pulicaris, Melanelia fuliginosa, Parmeliopsis ambiqua* and *Ochrolechia androgyna*. Except *Ochrolechia androgyna*, these thalli are frequent or common, moderately or significantly ubiquitous. This group is responsible for the formation of crustose or crusote-foliose epiphytic communities, typical of this phorophyte, where taxa with fruticose thalli are recorded only sporadically. Twelve taxa (23.2% of the biota) were recorded in single sites, mostly on single trees. These are: *Amandinea punctata, Anisomerydium polyporii, Arthonia spadicea, Bacidina arnoldiana, Chaenotheca ferruginea, Chaenothecopsis pusilla, Lecanora albella, L. carpinea, Lecidella subvirdis, Ochrolechia turneri, Placynthiella icmalea*, *Scoliciosporum chlorococcum* and *Xanthoria polycarpa*. Both common species, characterised by a broad ecological scale, and rare or very rare species

Table 1
Lichens and lichenicolous fungi recorded on *Quercus rubra* in Poland

Species	Literature data	Olsztyn Lake District	
		Number of sites	Site location
Lichenized fungi (lichens)			
Amandinea punctata (Hoffm.) Coppins et Scheid.		1	NR
Anisomerydium polypori (M.B. Ellis et Everh.) M.E. Barr		1	OL
Arthonia radiata (Pers.) Ach.	Tyszkiewicz (1935), as *A. vulgaris* Schaer f. *astroidea* Ach.		
Arthonia spadicea Leight.		1	OL
Bacidina arnoldiana (Körb.) V. Wirth et Vězda		1	OL
Bacidina phacodes (Körb.) Vězda	Kubiak (2005)	4	NR, OL
Biatora efflorescens (Hedl.) Erichsen		2	OL
Buellia griseovirens (Turner et Borrer ex Sm.) Almb.		11	LW, NR, OL
Chaenotheca chrysocephala (Ach.) Th. Fr.		4	OL
Chaenotheca ferruginea (Turner ex Sm.) Mig.		1	OL
Cladonia coniocraea auct.		16	KG, LW, NR, OL
Cladonia digitata (L.) Hoffm.		1	OL
Cladonia fimbriata (L.) Fr.		6	KG, LW, OL
Dimerella pineti (Ach.) Vězda		9	LW, OL
Evernia prunastri (L.) Ach.	Tyszkiewicz (1935), Glanc (1969)	9	LW, NR, OL
Fuscidea arboricola Coppins et Tønsberg		8	NR – c.ap., OL
Fuscidea pusilla Tønsberg		2	OL
Graphis scripta (L.) Ach.	Tyszkiewicz (1935)	4	LW, OL
Hypocenomyce scalaris (Ach.) Choisy		9	KG, LW, NR, OL
Hypogymnia physodes (L.) Nyl.	Tyszkiewicz (1935), as *Parmelia physodes* f. *labrosa* (L.) Ach.; Kukwa (2003)	16	KG, LW, NR, OL
Lecanora albella (Pers.) Ach.	Tyszkiewicz (1935), as *L. albella* (Pers.) Ach. var. *subalbella* Nyl., Kubiak (2005)	1	OL
Lecanora argentata (Ach.) Malme		1	LW
Lecanora carpinea (L.) Vain.		1	LW
Lecanora conizaeoides Nyl. ex Crombie	Glanc et al. (1971), as *L. conizea* (Ach.) Nyl.	3	KG, OL
Lecanora expallens Ach.	Kukwa (2002)	3	NR, OL
Lecanora pulcaris (Pers.) Ach	Glanc et al. (1971), as *L. chlarona*	10	KG, LW, OL
Lecidella subviridis Tønsberg		1	OL
Lecidella eleaochroma (Ach.) Choisy	Tyszkiewicz (1935), as *Lecidea parasema* Ach.		
Lepraria elobata Tønsberg		5	LW, OL
Lepraria incana (L.) Ach.		13	LW, NR, OL
Lepraria jackii Tønsberg		3	KG, OL
Lepraria lobificans Nyl.		4	OL
Lepraria rigidula (B. de Lesd.) Tønsberg		4	KG, LW, NR, OL
Melanelia fuliginosa (Fr. ex Duby) Essl.	Tyszkiewicz (1935), as *Parmelia fuliginosa* (E.Fr.) Nl.; Dziabaszewski (1962), as *Parmelia fuliginosa* (Fr.) Nyl.	11	LW, KG, OL

Melanelia olivacea (L.) Essl.	Tyszkiewicz (1935), as *Parmelia olivacea* (L.) Nyl.		
Melanelia subarifera (Nyl.) Essl.	Glanc (1969), as *Parmelia subarifera* Nyl.		
Micarea prasina Fr.	Glanc (1969), as *Catillaria prasina* (Fr.) Th.Fr.; Kukwa (2002)	9	LW, NR, OL
Mycoblastus fucatus (Stirt.) Zahlbr.		14	KG, LW, NR, OL
Ochrolechia androgyna (Hoffm.) Arnold		10	NR, LW, OL
Ochrolechia microstictoides Räs.		3	NR, OL
Ochrolechia turneri (Sm.) Hasselrot		1	LW
Parmelia saxatilis (L.) Ach.		3	LW, OL
Parmelia sulcata Taylor	Tyszkiewicz (1935), Kukwa (2002)	12	LW – c.ap., OL
Parmeliopsis ambigua (Wulfen ex Jacq.) Nyl.	Dziabaszewski (1962), Kukwa (2002)	1	OL
Pertusaria amara (Ach.) Nyl.	Dziabaszewski (1962), Kukwa (2002)	14	LW, NR, OL
Pertusaria coccodes (Ach.) Nyl.		7	KG, LW, NR, OL
Pertusaria pertusa (Weigel.) Tuck. var. *pertusa*	Tyszkiewicz (1935), as *P. communis* D.C.		
Phlyctis argena (Ach.) Flot.	Kukwa (2002)	12	LW, NR, OL
Physcia adscendens (Fr.) H. Olivier	Tyszkiewicz (1935)		
Physconia distorta (With.) J.R. Laundon	Tyszkiewicz (1935), as *Physcia pulverulenta* (Hoffm.) Nyl.		
Placynthiella icmalea (Ach.) Coppins et P. James		1	KG
Platismatia glauca (L.) W.L. Culb. et C.F. Culb.	Kukwa (2002)	15	LW, NR, OL
Pseudevernia furfuracea (L.) Zopf.		3	KG, LW, NR
Pseudosageda aenea (Wallr.) Hafellner et Kalb		2	OL
Ramalina farinacea (L.) Ach.	Tyszkiewicz (1935)	2	OL
Ramalina fraxinea (L.) Ach.	Tyszkiewicz (1935)		
Ramalina pollinaria (Westr.) Ach.	Tyszkiewicz (1935), Glanc (1969)		
Ropalospora viridis (Tønsberg) Tønsberg		7	LW, OL
Scoliciosporum chlorococcum (Graeve ex Stenh.) Vězda	Glanc (1969), as *Bacidia chlorococca* (Graeve) Lett.	1	KG
Usnea filipendula Stirt.		2	LW, OL
Usnea subfloridana Stirt.		3	LW, OL
Vulpicidia pinastri (Scop.) J.-E. Mattson et M.J. Lai		2	LW, OL
Xanthoria polycarpa (Hoffm.) Rieber		1	KG
Lichenicolous fungi			
Chaenothecopsis pusilla (Ach.) A. F.W. Schmidt (on wood)		1	OL
Clypeococcum hypocenomycis D. Hawksw. (on *Hypocenomyce scalaris*)		1	KG
Lichenoconium erodens M.S. Christ. et D. Hawksw. (on *Lecanora conizaeoides* and *Hypogymnia physodes*)		1	KG
Monodictys epilepraria Kukwa et Diederich (on *Lepraria* sp.)	Kukwa (2004)	1	OL

Abbreviations: KG – Kamienna Góra reserve; LW – Las Warmiński reserve; OL – Olsztyn city forests; NR – Nowe Ramuki Forest District; c. ap. – cum apotheciae

whose ecological preferences are poorly known belong to this group. One of the first records of *Lecidella subviridis* in Lowland Poland was also identified (cf. Czarnota, Kukwa 2003; Kukwa 2006).

Lichens were observed not only on the bark of tree trunks but also on exposed dead trunk wood and branches fallen on the ground. The following taxa were recorded on dead wood: *Anisomerydium polyporii, Chaenotheca chrysocephala, Chaenothecopsis pusilla, Hypocenomyce scalaris, Lepraria incana* and *Cladonia* sp. It was the only occurrence substrate of two species: *Anisomerydium polyporii* and *Chaenothecopsis pusilla*. The following species occurred on fallen branches: *Hypogymnia physodes, Lecanora conizaeoides, L. pulicaris, Lichenoconium erodens* (on a thallus of *Lecanora conizaeoides*), *Pseudevernia furfuracea, Scoliciosporum chlorococcum* and *Xanthoria polycarpa*. Two of them, *Lichenoconium erodens* and *Xanthoria polycarpa*, were recorded exclusively on this substrate.

The recorded biota includes 11 species threatened with extinction in Poland (19.6%), including two endangered species (EN): *Lecanora albella* and *Usnea subfloridana*, four vulnerable species (VU): *Biatora efflorescens, Ochrolechia androgyna, Ramalina farinacea* and *Usnea filipendula*, and five near threatened species (NT): *Bacidina arnoldiana, Evernia prunatri, Graphis scripta, Pertusaria coccodes* and *Vulpicidia pinastri*. Four of them are threatened in North-Eastern Poland, including one endangered species: *Lecanora albella*, two vulnerable species: *Bacidina arnoldiana* and *Biatora efflorescens*, and one data deficient lichen (DD): *Fuscidea arboricola* (Fig. 4). Ten (17.9%) of the species given are protected in Poland, including one partially protected (*Evernia prunastri*) and 9 fully protected (*Melanelia fuliginosa, Parmelia saxatilis, Parmeliopsis ambiqua*, *Platismatia glauca, Pseudevernia furfuracea, Ramalina farinacea, Usnea filipendula, Usnea subfloridana, Vulpicidia pinastri)*.

DISCUSSION

Quercus rubra is mostly a large tree with a thick, straight, regular trunk and a wide, spreading crown. Outer bark in young red oaks, up to 40 years old, is smooth, steel-grey or dark grey, and furrowed or with flat-topped ridges in old trees. *Quercus rubra* differs from native oaks (*Q. robur*, *Q. petraea*) both by the habit as well as the structure and thickness of outer bark. The trunk of *Quercus robur*, which tends to branch out low above the ground (massive lateral boughs), is covered with thick, deeply furrowed, dark brown outer bark. Both these features as well as other factors influence species composition of lichens associated with this phorophyte. These differences are emphasised by Barkman (1969), who classifies *Quercus rubra* along such porophytes as *Fagus sylvatica* and young specimens of *Quercus robur* and *Q. petraea*. Chemical properties of *Fagus sylvatica* periderm (low pH) are similar to those of *Quercus robur* and *Q. petraea*; it differs from them, however, by the bark relief and the crown shape. These differences are not as pronounced in the case of red oak and beech.

The lichen biota of both oak and beech has not been studied extensively in Poland. Rutkowski and Kukwa (2000) list 88 taxa, including 51 beech epiphytes and 77 oak epiphytes, in their analysis of the lichen biota of beech trees (*Fagus sylvatica*) and native oaks (*Quercus robus* and *Q. petraea*) in 24 sites in Northern Poland. The list comprises 40 taxa common for both trees (45.4%).

As these findings show, the lichen biota of red oak seems to be quite diversified and is comparable with native oaks, and especially beech. It should be stressed, however, that the study by Rutkowski and Kukwa (2000) does not fully reflect species differentiation of its epiphytes in Northern Poland, particularly oak. It only includes a small number of sites in North-Eastern Poland, where, according to Cieśliński (2003a), 234 lichens of this phorophyte were recorded. Cieśliński (2003a), however, does not differentiate oak species, and the findings may concern various taxa. Therefore, the information provided by Rutkowski & Kukwa (2000) is of greater value in the assessment of lichen biotas of native oak species and beech and red oak. The similarity of lichen biotas (Jaccard's coefficient) of native oaks and beech, given in the study by Rutkowski and Kukwa (2000), and the lichen biota of red oak is 32% for red oak and native oaks, and is slightly higher and equals 34% for red oak and beech. The total, aggregated number of epiphytes of oak and beech equals 109, including 22 taxa recorded exclusively on the bark of *Quercus rubra*.

The provided data show that the phorophytic profile of *Quercus rubra* significantly differs from that of other, native oak species. The species has its own specific lichen biota which consists of many interesting taxa. As a result of the review of the Polish lichenological literature, additional 19 lichen species reported from the bark of red oak were recorded. Of those, 11 taxa were not observed in the Olsztyn Lake District. The list of lichens of red oak in Poland comprises in total 63 lichen species and 4 species of lichenicolous fungi. This biota should be considered to be rich, especially as its differentiation appears to be similar to that recorded in the areas of the native range of this phorophyte. The number of taxa colonising the bark of *Quercus rubra* in its native occurrence range is small although the fact that its trunks are often abundantly covered by lichens is stressed (cf. Stubbs 1989; May 2001). Hale (1955) reports 45 lichen species from the southern part of Wisconsin, and Culberson (1955) reports 41 species from the northern part of the state. Stubbs (1989) presents 32 taxa (15 fruticose and foliose and 17 crustose) from the sites in Main. The number of lichens of this important phorophyte in this region usually does not exceed 10 in numerous local studies on the north-western part of North America (Hyerczyk 1996, 1998; May 2001).

As the surface area covered by deciduous forests of the class *Querco-Fagetea*, associated with the richest lichen biotas in lowland regions, has been declining (Czyżewska 2003), *Quercus rubra*, a phorophyte characterised by a broad ecological scale and potentially rich lichen biota, may play an important role in the preservation of lichen species diversity in forest phytocoenoses. The biocoenotic function of red oak, underestimated so far, may be of certain use in cultivated forests located outside or on the limit of the native occurrence of beech. Special attention should be paid to the occurrence of *Lecanora albella*, a species belonging to a group of lowland old-growth forest indicators, on the bark of red oak (cf. Cieśliński, Czyżewska, Fabiszewski 2003). The phorophyte has been reported on the bark of red oak both in the Olsztyn Lake District and Gdańsk Pomerania (Tyszkiewicz 1935). According to Fałtynowicz (1991), *Lecanora albella* is in particular associated with beech bark in Western Pomerania. It occurs on a variety of deciduous species in North-Eastern Poland (Cieśliński 2003a) and exemplifies ecological vicarism (cf. Barkman 1969; Fałtynowicz 1991; Zalewska 2000). In the Olsztyn Lake

District, the species was recorded in the city forest in Olsztyn where many other lichen lowland old-growth forest indicators also occur (Kubiak 2005).

CONCLUSIONS

1. The epiphytic biota of *Quercus rubra* as a phorophyte is characteristic, diversified and rich, and it comprises 63 lichen species and 4 species of lichenicolous fungi.

2. Species of rare lichens, both threatened with extinction (*Lecanora albella, Melanelia olivacea, Ochrolechia androgyna, Usnea subfloridana*) and differentiated very rarely (*Fuscidea arboricola, F. pusilla, Lecidella subviridis, Ropalospora viridis*), were recorded on the bark of red oak in Poland.

3. As well as having many biocoenotic functions, red oak may play an important role in preserving lichen biodiversity in the forest environment in Poland.

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Porosty dębu czerwonego *Quercus rubra* w środowisku leśnym Pojezierza Olsztyńskiego

S t r e s z c z e n i e

W wyniku przeprowadzonych badań własnych oraz przeglądu krajowej literatury lichenologicznej odnotowano 63 gatunki porostów oraz 4 gatunki grzybów naporostowych występujących na korze *Quercus rubra*. Podczas szczegółowych badań nad porostami epifitycznymi tego forofitu, przeprowadzonych na 16 stanowiskach w lasach Pojezierza Olsztyńskiego, stwierdzono 56 taksonów, w tym szereg gatunków rzadkich. Wyróżniona na obszarze Pojezierza biota liczy 11 gatunków umieszczonych na krajowej „Czerwonej Liście" oraz 14 porostów objętych ochroną gatunkową. Do szczególnie interesujących taksonów zaliczyć należy: *Fuscidea arboricola, Lecanora albella, Lecidella subviridis, Ochrolechia androgyna* i *O. turneri*.