

Białe Ługi Reserve: a refuge of the forest lichen flora of the Góry Świętokrzyskie Mts

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ABSTRACT: The study presents the state of lichen flora in the Białe Ługi peatbog reserve, with special attention to very rare and engendered lichens species of Poland persisting in the reserve. The reserve has been protected since 1959, and is a refuge of forest lichen flora.

KEY WORDS: lichens, relicts of primeval forest, Poland

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INTRODUCTION

The Góry Świętokrzyskie Mts are among the regions whose lichen flora are relatively well known. Lichenological studies have been carried out in this area for over 100 years, with some interruptions. Research recently has focused on anthropogenic changes in the lichen flora of the region in view of the scale of its impoverishment and the destruction of biocenotic inter-linkages with the participation of lichens. Unfavorable changes have affected all ecological groups of lichens but particularly epiphytes occurring both in forest communities and on trees in open habitat. The research has so far been concerned mainly with the range, rate and causes of impoverishment of the lichen flora. However, factors governing the extinction of species have not been sufficiently examined. The rate of withdrawal of lichens is uneven in terms of both time and space. In specific environmental conditions many species persist at their stations. An analysis of species composition and environmental conditions at such sites permits a more precise determination of the sensitivity of many species to human pressure and provides a better understanding of the process of their decline. The results may also be important for practical nature and environmental conservation.

This paper describes the present state of lichen flora in the ecosystems of the Białe Ługi Reserve, which have been protected for forty years. Particular attention was paid to the presence of species typical of primeval forest. Field studies were carried out in 1998–1999.

LICHENOLOGICAL STUDIES IN THE RESERVE

The Białe Ługi Reserve has been neglected in lichenological research, probably because it is difficult to access. Some phytosociological relevés with the participation of lichens, made at the margins of the reserve, were presented in papers by Cieśliński and Halicz (1971). Stations of some common species belonging to the genera *Usnea* and *Bryoria* were reported from the reserve (Bystrek & Cieśliński 1976; Cieśliński & Bystrek 1982). The few herbarium specimens collected in the seventies, among others *Lobaria pulmonaria*, are kept in the herbarium of the Department of Botany of the Świętokrzyska Academy in Kielce (KTC).

STUDY AREA

The Białe Ługi Reserve, covering an area of 408.4 ha, was established in 1959 to protect a bog complex. It is the only large site of this kind on the Wyżyna Środkowomałopolska upland. It is situated in the extensive forest area of the Cisowsko-Orłowiński Landscape Park. The site comprises part of a peat-covered valley which is limited to the north by the Pasma Cisowskie range and to the south by the massif of Góra Kamień (302 m a.s.l.). The bog is drained by two small rivers which originate here: Trupień stream on the northwest, which discharges to the Belnianka river near the village of Słopiec and the Czarna Staszowska river on the southeast. The reserve is surrounded mostly by forest communities. Only small fragments border on meadow communities (Fig. 1).

VEGETATION OF THE RESERVE

The cover vegetation of the reserve, according to Bróz and Przemyski's unpublished observations, is much differentiated. Plant communities occur in small patches forming a mosaic-like arrangement. The central part of the site, which comprises about 70% of its total area, is occupied by forest and non-forest forms of raised and transitional bogs, identified as *Caricetum lasiocarpae*, *Sphagnetum magellanicum boreale* and *Ledo-Sphagnetum magellanicum*. Forest forms are characterized by the presence of low-growing *Pinus sylvestris* (often dead) and sporadic *Betula pubescens* which are a habitat for epiphytes.

Bog communities are surrounded by forest communities dominated by pine woods. The largest area is covered by pine bog wood *Vaccinio uliginosi-Pinetum*. It has the character of a fully natural forest community with typical structure and species composition. *Vaccinio myrtilli-Pinetum* occupies higher-situated fragments of the reserve. In many places they are pine monocultures of different ages. At the southwestern border of the reserve there is a small stretch of dunes with patches of dry pine wood *Cladonio-Pinetum*. Along the streams are fragments of deciduous forest. There are small but well-developed patches of *Circaeo-Alnetum* with a fair share of old trees, *Sphagno squarrosi-Alnetum* and *Ribo nigri-Alnetum*. The species composition of the tree layer in these

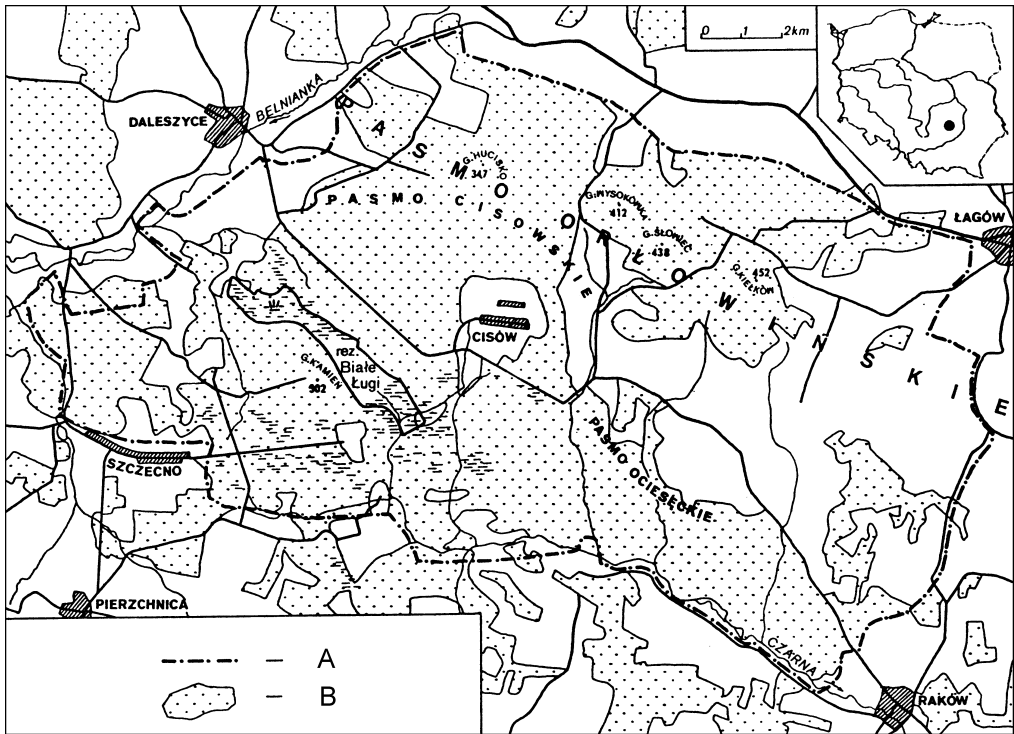


Fig. 1. Location of the Białe Ługi Reserve. A – border of Cisowsko-Orłowski Landscape Park; B – forests.

communities is much differentiated. The dominating species are pine, alder, verrucose birch and downy birch. Ash, aspen and spruce constitute a regular admixture, while lime, sycamore, two oak species, fir and willow are less frequent. Trees in the middle and older age classes prevail.

LICHEN FLORA OF THE RESERVE

The lichen flora of the Białe Ługi Reserve comprises 114 species. The occurrence of 110 was confirmed by the present studies. The most numerous is the genus *Cladonia* with 21 species, followed by *Lecanora* (8), *Pertusaria* (5) and *Chaenotheca* (5). Rare and very rare species noted from single stations are in the majority. This group includes lichen species very interesting in respect to both ecology and geography. There are only a few frequent and common species, and these are mainly ubiquitous taxa such as *Hypogymnia physodes*, *Lepraria* sp., *Cladonia coniocraea*, *C. digitata*, *Lecanora conizaeoides*, *Phlyctis argena* and others, occurring for the most part in forest communities. *Hypoceno-myce scalaris*, *Pseudevernia furfuracea* and *Imshaugia aleurites* are also frequent in pine

woods. The last one occurs abundantly on pines and decaying wood in marshy and dry coniferous forests.

Bacidina arnoldiana, *Cladonia caespiticia*, *Gyalecta flotowii*, *Hypocenomyce caradocensis*, *Placynthiella icmalea*, *Trapeliopsis pseudogranulosa* and *Lepraria jackii*, growing in the reserve, are new species for the lichen flora of the Góry Świętokrzyskie Mts.

BIOLOGICAL, ECOLOGICAL AND SPATIAL DIFFERENTIATION OF THE LICHEN FLORA

The three main biological-ecological groups of lichens – epiphytic, epixylic and epigeic – are represented in the Białe Ługi Reserve. Natural rocky substratum (stones, boulders) or that of anthropogenic character (concrete, plaster) are not found in the reserve. The groups mentioned are represented mainly by typical forest species. The share of heliophilous species, nitrophilous species or species preferring trees beyond forest communities (apophytes) is very small. Only a pear tree growing at the southwest border of the reserve, an anthropogenic element in the local forest communities, supports some species of the genera *Physcia*, *Physconia* and *Candelariella xanthostigma*. *Xanthoria parietina* was found in the crown of an aspen.

Epiphytes are the most numerous habitat group in the reserve. It comprises 84 species, including 58 only on the bark of trees. Their cover on the bark of particular tree species is quite varied. Lichens occur more abundantly on the bark of deciduous than coniferous trees. In the reserve the largest number of species was found on alder bark (41 species).

Epixylic species are represented by 42 taxa. They form a small specific habitat group. Most of them also occur on the bark of trees and on soil. Ten species were found only on decaying wood.

The occurrence of most epigeic species is limited to patches of *Cladonio-Pinetum*. They are very rare in *Vaccinio myrtilli-Pinetum* and only sporadic in *Vaccinio uliginosi-Pinetum*. Some species were found at a road adjacent to the southwestern border of the reserve: *Cladonia turgida*, *C. furcata*, *Peltigera didactyla*, *P. rufescens*, *P. hymenina* and *Cetraria islandica*. Altogether there were 27 species found on soil, including 13 only on this substratum.

The spatial distribution of lichen species varies depending on the type of higher plant community. The flora of bog communities is very poor. The bark of low-growing pines, and rarely birches, is overgrown by only a few lichen species: *Lecanora conizaeoides*, *L. pulicaris*, *L. expallens*, *Hypogymnia physodes*, *Pseudevernia furfuracea*, *Trapeliopsis granulosa* and *T. flexuosa*. More interesting species grow on the wood of dead pines after the cork has peeled off. At the bog surface at the base of tree trunks one may find, in addition to common species of the genus *Cladonia* (*C. coniocraea*, *C. chlorophaea*, *C. macilenta*), species of the genus *Chaenotheca* (*C. ferruginea* and rarely *C. xyloxena* and *C. brunneola*), *Calicium glaucellum*, *Chaenothecopsis pusilla* and *Micarea melaena*.

The lichen flora of pine woods is also poor and uniform. The most frequent species overgrowing the bark of pines are *Hypogymnia physodes*, *Hypocenomyce scalaris*,

Pseudevernia furfuracea, *Cladonia digitata* and rarely *Platismatia glauca* and *Chaenotheca ferruginea*. The reserve's pine wood communities are distinguished by the abundant occurrence of *Imshaugia aleurites*. The lower parts of pine trunks are overgrown by species of the genus *Cladonia* and more rarely by *Micarea melaena*. Birches have a similar composition of lichen flora. More frequent on birch bark are *Scoliciosporum chlorococcum*, *Mycoblastus fucatus* and *Buellia griseovirens*. *Usnea hirta*, *Hypocenomyce anthracophila* and *H. caradocensis* occur only on pines in *Cladonio-Pinetum*.

In terms of lichen flora, the most interesting are the communities of deciduous forests, that is, riparian forests situated on the SE and NW margins of the reserve along the Trupień and Czarna Staszowska streams. The bark of alders, ashes, and rarely other tree species, supports an exceptionally rich epiphytic lichen flora, comprising many very interesting species typical of a primeval forest. Their characteristics are given below.

THE RESERVE: A REFUGE OF PRIMEVAL FOREST FLORA

The lichen flora of the Białe Ługi Reserve has a typical forest character. Many epiphytic and some epixylic species have survived in the best-preserved patches of forest communities, mainly in riparian forests. They are very rare in the region or they are species which have withdrawn from both the Góry Świętokrzyskie Mts and many other regions of the country. Their occurrence is connected with forests of natural origin. Most of them are stenotopic and show exceptional sensitivity to human pressure (hemerophobous species). It is a long list of species comprising about 30% of the total epiphytic and epixylic flora of the reserve (Table 1).

The species listed in Table 1 were known previously from other parts of the Góry Świętokrzyskie Mts, and mainly from Świętokrzyski National Park. Most of them do not occur in the park any longer (Cieśliński 1985), but in the sixties some of them were frequent and even common in the Góry Świętokrzyskie Mts, such as *Graphis scripta*, *Flavoparmelia caperata*, *Opegrapha rufescens*, *O. varia*, *Calicium salicinum* or *Peltigera praetextata*. They are now strongly threatened; most have been reckoned among the category of endangered species (E). The nearest sites of certain species still growing in the reserve are tens or even hundreds of kilometers away from it. In other regions of the country they have become extinct or are rare species. Some species listed above are sometimes reported from intensively managed forests, considered there as remnants of the former ecological systems. The concentration of these species in such a small area is a characteristic feature of the Białe Ługi Reserve. Only a few of them are frequent and thriving species, such as *Graphis scripta*, *Arthothelium ruanum*, *Arthonia spadicea* and *Micarea melaena* (Table 1). In alder woods *Cladonia caespiticia* has well-developed thalli with developed podetia. However, most of these species are very rare, found in only one place in the reserve, and they have degenerated vestigial thalli; examples are *Bacidina arnoldiana*, *Cetrelia cetrarioides*, *Chrysothrix candelaris*, *Cladonia botrytes*, *C. incrassata* and *Opegrapha rufescens*. The lichen species mentioned add much to the diversity of the reserve flora, enriching it with the most valuable natural elements and

Table 1. List of the forest lichen flora of Białe Ługi Reserve.

Species	Substratum	Frequency	Treat in		Relict of primeval forest
			Góry Święto- krzyskie Mts	the country	
<i>Arthonia spadicea</i> Leighton	Al, Fr, L, Q	+++	V		
<i>Arthothelium ruanum</i> (Massal.) Zwackh	Al, Ap, Co, Fr	+++	V	V	
<i>Bacidia globulosa</i> (Flk.) Hafellner & V. Virth in V. Virth	Fr	+	V		
<i>Bacidina arnoldiana</i> Koerber	Fr	+!	E		*
<i>Calicium glaucellum</i> Ach.	L	+	V	V	
<i>Calicium salicinum</i> Pers.	Ap, Fr, Al	+	E	V	
<i>Cetrelia cetrarioides</i> (Delise & Duby) W. Culb. & C. Culb.	Al	+!	E	E	*
<i>Chaenotheca brachypoda</i> (Ach.) Tibell	L	+	E	E	*
<i>Chaenotheca brunneola</i> (Ach.) Müll. Arg.	L	+	E	V	*
<i>Chaenotheca xyloxena</i> Nádv.	L	+	E	E	*
<i>Chrysothrix candelaris</i> (L.) Laundon	Al	+!	E	E	
<i>Cladonia botrytes</i> (Hagen) Willd.	L	+!	E	V	
<i>Cladonia caespiticia</i> (Pers.) Florke	Al	+	E	E	
<i>Cladonia incrassata</i> Florke	L	+!	E	V	
<i>Flavoparmelia caperata</i> (L.) Hale	Al, Pt	+	E	E	
<i>Graphis scripta</i> (L.) Ach.	Al, B, Co, Fr, So, Ti	+++	V	V	
<i>Gyalecta flotowii</i> Korber	Fr	+	E	E	
<i>Haematomma ochroleucum</i> (Necker) Laundon var. <i>ochroleucum</i>	Al, Fr	+	E	V	
<i>Hypocenomyce caradocensis</i> (Leighton ex Nyl.) P. James	P	+	V	V	
<i>Hypotrachyna revoluta</i> (Flk.) Hale	Al	+!	E	E	
<i>Loxospora elatina</i> (Ach.) Massal.	Al	+!	E	E	
<i>Menegazzia terebrata</i> (Hoffm.) Koerber	Al	+	E	E	*
<i>Micarea melaena</i> (Nyl.) Hedl.	P, L	+	E	V	
<i>Opegrapha rufescens</i> Pers.	Fr	+!	E	V	
<i>Opegrapha varia</i> Pers.	Fr	+	V	V	
<i>Peltigera praetextata</i> (Flk.) Zopf	Fr	+	E	E	
<i>Pertusaria hemisphaerica</i> (Flk.) Erichsen	Al, Pt	+!	E	V	
<i>Usnea hirta</i> (L.) Weber in Mot.	P	+	E	V	

Explanations. Bark of trees: Al – *Alnus glutinosa* (L.) Gaertn., Ap – *Acer pseudoplatanus* L., B – *Betula pendula* Roth and *B. pubescens* Ehrh., Co – *Corylus avellana* L., Fr – *Fraxinus excelsior* L., P – *Pinus sylvestris* L., Pt – *Populus tremula* L., Q – *Quercus* sp., So – *Sorbus aucuparia* L. em. Hedl., Ti – *Tilia cordata* Mill., L – wood.

“Red book” categories. E – endangered; V – vulnerable. Frequency: +! – rare species, remnant populations; + – rare species; ++ – frequent species; +++ – common species; * – relict of a primeval forest in the Białowieża National Park.

increasing the general natural value of the reserve. It should be stressed that among them there are species which in the Białowieża National Park are classed as relicts of primeval forest (Cieśliński *et al.* 1996). They are old forest indicator species evidencing the eco-

logical continuity of the forests (Hawksworth & Hill 1984). These species persist in the reserve owing to the specific micro-climate prevailing in its plant communities. Among the many factors contributing to the persistence of lichens are these:

- the location of the reserve in a valley shielded by hills (Góra Kamień, Pasma Cisowskie). Atmospheric pollutants, and particularly long-range emissions, may be transported over the reserve, shielded by the elevations;
- favorable humidity conditions prevailing in the reserve;
- the reserve's location within a large forest area buffering external influences of local human activity;
- the presence of trees in older age classes;
- the well-preserved natural character of plant communities, which is a result of their forty-year protection in the reserve. In the sixties, just after the reserve was established, the lichen flora of the Góry Świętokrzyskie Mts was still distinguished by high taxonomic and ecological diversity.

The forest communities of the reserve should be considered a refuge of the forest lichen flora of the Góry Świętokrzyskie Mts and evidence of its past high diversity. The persistence of isolated populations of stenotopic forest lichens in the reserve shows that ecological niches characteristic of natural forest ecosystems still exist. Not the only species composition but also the specific biocenotic features of habitats enabling the existence of stenotopic species have been preserved. These lichens do not show expansion as they have no ability to colonize new habitats. The life strategies of the majority of these species consist in persistence in places where they have found suitable habitat conditions. Small and isolated populations are at great risk of extinction. In the case of strictly stenotopic species, to which forest lichens belong, even large populations are threatened with extinction when habitat conditions undergo radical changes (Zarzycki 1976, 1992). The impoverishment of the flora in the reserve may intensify if habitat conditions are disturbed by management practices within the reserve or in the surrounding area. Stabilization of environmental conditions is a prerequisite for maintenance of the forest lichens listed in Table 1. The species with degenerated thalli now present in the reserve are probably at the final stage of decline.

In all probability the lichen flora of the Białe Ługi Reserve was much richer in the past. A precise estimate of the losses incurred by this flora is not possible because data from the past are lacking. There is fully reliable information for only four species: *Bryoria fuscescens*, *B. subcana*, *Lobaria pulmonaria* and *Usnea subfloridana*. Specimens representing them have been preserved in the herbarium. The occurrence of these species in the reserve has not been confirmed. They should be considered extinct.

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