

**THE LICHEN BIOTA OF “SKAŁKI PIEKŁO POD
NIEKŁANIEM” NATURE RESERVE – CURRENT STATE
AND CHANGES IN SPECIES COMPOSITION OVER
THE PAST 100 YEARS**

Anna Łubek

Institute of Biology
Jan Kochanowski University in Kielce

Key words: lichenized fungi, lichenicolous fungi, rare species, species diversity, Świętokrzyskie Mountains, Central Poland.

A b s t r a c t

The lichenological study was conducted in the “Skalki Piekło pod Nieklaniem” Nature Reserve and its surroundings in the Świętokrzyskie Mts. The aim of the study was to present the current state of lichen biota and changes that have occurred in the species composition in the last 100 years. A total of 168 species of lichens and lichenicolous fungi were found in the investigated area. There are currently 20 unconfirmed species of lichens and lichenicolous fungi.

**BIOTA POROSTÓW REZERWATU „SKAŁKI PIEKŁO POD NIEKŁANIEM”
– STAN OBECNY I ZMIANY W SKŁADZIE GATUNKOWYM
W CIĄGU OSTATNICH STU LAT**

Anna Łubek

Instytut Biologii
Uniwersytet Jana Kochanowskiego w Kielcach

Słowa kluczowe: grzyby zlichenizowane, grzyby naporostowe, gatunki rzadkie, różnorodność gatunkowa, Góry Świętokrzyskie, Polska Centralna.

A b s t r a k t

Badania lichenologiczne przeprowadzono w rezerwacie przyrody „Skalki Piekło pod Nieklaniem” i w jego otoczeniu w Górach Świętokrzyskich. Celem badań było przedstawienie aktualnego stanu bioty porostów oraz zmian, jakie zaszły w jej składzie gatunkowym na przestrzeni ponad 100 lat. Na badanym terenie stwierdzono łącznie 168 gatunków porostów oraz grzybów naporostowych. Obecnie nie potwierdzono 20 gatunków porostów i grzybów naporostowych.

Address: Anna Łubek, Jan Kochanowski University, ul. Świętokrzyska 15, 25-406 Kielce, Poland,
phone: +48 (41) 349 63 47, e-mail: alubek@ujk.edu.pl

Introduction

On the north-western rim of the Świętokrzyskie Mountains at the top of Piekło Mt., is a large outcrop of rock accumulation built of Lower Jurassic sandstone. The rocks are of various and interesting forms, such as: thresholds, pulpits, towers, mushrooms, etc., as a result of various factors of erosion. This area was, and still is, attractive to many researchers, mainly geologists (LINDNER 1972, URBAN 1996) and botanists (BŁOŃSKI 1890, MASSALSKI, KAZNOWSKI 1928). The first accounts of lichens of the area date back to works of BŁOŃSKI (1890) and BERDAU (1876). These historic studies are at present the only source of information about the occurrence of lichens in the whole region of the Świętokrzyskie Mts in the late 19th century. Lichenological research in this area was resumed only one hundred years later. A short report on the lichens of the “Skałki Piekło pod Niekłaniem” reserve includes the work of TOBOROWICZ (1992). At present the study on the state of conservation of lichen biota and changes in the species composition has been carried out at the top of Piekło Mt. and the neighbouring areas. Preliminary results of the research on the species that have disappeared from the area since the late 19th century include the work of CIEŚLIŃSKI and CZYŻEWSKA (2006). This work complements the previous report. The historic study (BŁOŃSKI 1890) documented the species composition of lichens from the late 19th century in the region of Niekłań, and especially about natural sandstone rocks located in this area. This is a very suitable location for following the dynamics of lichen biota over a long time period.

The aim of this study is to characterize the current state of lichen biota in positions that BŁOŃSKI (1890) investigated, and to trace its degree of extent and direction of change that have occurred during more than one hundred years. Particular attention was paid to population changes of rare and endangered species in the region of the Świętokrzyskie Mts and in Poland.

Characteristics of the research area

The elevation called Piekło Mt. (368 m asl), with a vast hilltop, is distinguished by large accumulations of natural rock outcrop. These rocks are composed of Lower Jurassic sandstone. In total there are over 70 separate rocks (URBAN 1996). The height of some of them is from 5 up to 8 meters, not counting a sandy cone line surrounding their foothills. The surface of the rocks is very diverse with interesting microrelief in the form of slats, grooves, ribs, cornices, cavities, etc., shaped by various processes of chemical and physical

weathering. Sandstone, which is the basic building material for the rocks, especially yellow sandstone, crumbles easily, making plant and lichen settlement difficult. The unequal size of the rocks, their diverse formation, and varied exhibition create a wide variety of habitats. Moreover, forest communities surrounding them affect their further differentiation, especially in the scope of moisture and light relations. The high humidity of the rocks, especially their northern area of exposure, favours the occurrence of only a few species of lichens. Mosses prevail in the area. The flat tops of the rocks are covered by a coat of silicate-ferruginous mineral, a few millimetres thick. The coat is mostly covered by mosses, with the rare appearance of vascular plants, and even more rarely spotted with some species of lichens of the *Cladonia* genus.

Part of the top of the Piekło Mt., with the greatest accumulation of rocks, with the most prominent forms and all features of natural beauty, has been under legal protection as a nature reserve since 1959 under the name of "Skalki Piekło pod Niekłaniem" ("Hell Rocks under Niekłań"). The reserve's area is 6.3 hectares. The subjects of protection are sandstone rocks and the rare relict fern *Asplenium septentrionalne*, which grew abundantly in the past, forming dense turfs in the crevices of rock outcrops (MASSALSKI, KAZNOWSKI 1928). In recent years, the fern has been found only in a single specimen. Outside the reserve, inside the forest communities are also found less imposing sandstone outcrops of rocks.

Forest communities in the reserve surrounding the rocks belong to two groups: fresh pine forest *Leucobryo-Pinetum* and mixed pine-oak forest *Quercu-Pinetum*. Forest communities surrounding the reserve are commercial forests, with a floristic composition and structure similar to those that are inside the reserve. Some specimens of *Quercus petraea* and *Pinus sylvestris* in the reserve reach the age of 140–150 years, so they were already growing in the late 19th century. In addition, frequent tree species found in the reserve and outside are *Betula pendula*, more seldom *Abies alba*, *Fagus sylvatica* and *Larix decidua*. However, the trees in the village of Niekłań (hamlet of Kałuża), along the road leading to Szydłowiec, are venerable trees: *Betula pendula*, *Tilia cordata* and *Acer platanoides*. These old specimens of trees are being removed at the moment.

Materials and Methods

Field studies carried out in the reserve "Skalki Piekło pod Niekłaniem" and its surroundings were focused on as accurate a reference to the work of BŁOŃSKI (1890) as possible. The author mentions the following name of sites: "Niekłań", "Piekło pod Niekłaniem", and "Piekło", but still, the most com-

monly mentioned name is “Niekłań”. Of all these sites BŁOŃSKI listed 45 species of lichens and one species of lichenicolous fungus. It is assumed that the author conducted the research on: the top of Piekło Mt, where there are numerous natural outcrops, in the village of Niekłań and probably along the forest road leading from Niekłań (Kałuża) to the top of Piekło Mt. The ecological character of some lichen species mentioned by BŁOŃSKI (1890) confirms the assumption that the author conducted the research outside forest communities, and thus in Niekłań. Therefore, four sites in the field were chosen. They could most likely have been places of BŁOŃSKI'S (1890) research:

- “Skałki Piekło pod Niekłaniem” reserve, within the limits laid down in the regulation establishing the reserve. The reserve area does not include all rocks;

- forest communities and sandstone rocks around the reserve. In the late 19th century, when there was no reserve outlined, BŁOŃSKI (1890) was able to conduct the research on the hilltop across the top of Piekło Mt., where outcrops of rocks are found;

- forest communities along the forest road leading from Niekłań to the reserve. Heavily eroded rocks overgrown with young pine trees, with a large amount of terrestrial lichen of the *Cladonia* genus are found here;

- trees by the road in Niekłań.

Only a few herbarium specimens have been preserved that were collected from this area by BŁOŃSKI in 1889. They are: *Cladonia squamosa* var. *squamosa*, *Dibaeis baeomyces*, *Hypogymnia physodes*, *Parmelia saxatilis*, *Platismatia glauca*, *Pseudevernia furfuracea* and *Umbilicaria polyphylla*.

The study included, as in the work of BŁOŃSKI (1890), all ecological groups of lichens, such as epiphytes, epixylithes, epilythes and epigeithes. Field studies were conducted between 2005–2007 (compare CIEŚLIŃSKI, CZYŻEWSKA 2006) and supplemented in 2010. Sterile lichens were determined by thin layer chromatography (TLC) in accordance with the procedures set out in the work of ORANGE et al. (2001).

A list of lichen species found in the past and present in the above sites is presented in Table 1.

Categories of threats to species in Poland were taken from CIEŚLIŃSKI et al. (2006) and in the Świętokrzyskie Mts from CIEŚLIŃSKI and LUBEK (2003). Nomenclature of lichen species follows SMITH et al. (2009) (compare FAŁTYNOWICZ 2003), KUKWA (2009) and lichenicolous fungi: CZYŻEWSKA and KUKWA (2009).

All sites are located in the large Ee34 square of the ATPOL system (compare CIEŚLIŃSKI, FAŁTYNOWICZ 1993). The specimens are deposited in the herbarium at Jan Kochanowski University in Kielce. The specimens collected by BŁOŃSKI are deposited in the herbarium at University of Warsaw.

Table 1
List of species of lichens and lichenicolous fungi found in the "Piekło pod Nieklaniem" reserve and its surroundings

No	Species	Data from BŁOŃSKI (1890)	Data from 2006 and 2010, number of sites (substrate)	Status of threat in Świętokrzyskie Mts/Poland
1	2	3	4	5
1.	* <i>Abrothallus parmeliarum</i> (Sommerf.) Arnold	+ on the thallus of <i>Parmelia saxatilis</i>	-	-
2.	<i>Absconditella lignicola</i> Vězda & Pišút	-	1 (l)	-/DD
3.	<i>Acarospora fuscata</i> (Nyl.) Arnold	-	1 (r)	-
4.	<i>Agonimia repleta</i> Czarnota & Coppins	-	1 (Q)	-
5.	<i>Amandinea punctata</i> (Hoffm.) Coppins & Scheid.	-	1 (Q), 4 (A, B, Pt, Ti)	-
6.	<i>Anaptychia ciliaris</i> (L.) Körb. ex A. Massal.	+	-	CR/EN
7.	<i>Arthonia spadicea</i> Leight.	-	2 (Q)	-
8.	<i>A. vinosa</i> Leight.	-	1 (Q), 2 (Q)	CR/NT
9.	<i>Arthothelium ruanum</i> (A. Massal.) Körb.	-	3 (F)	VU/NT
10.	<i>Aspicilia gibbosa</i> (Ach.) Körb.	+	-	DD/EN
11.	<i>A. caesiocinerea</i> (Nyl. ex Malbr.) Arnold	-	1 (r)	DD/-
12.	<i>Bacidia phacodes</i> Körb.	-	1 (Q), 4 (A)	LC/-
13.	<i>B. rubella</i> (Hoffm.) A. Massal.	+	4 (Ti)	EN/VU
14.	<i>B. subincompta</i> (Nyl.) Arnold	-	3 (F)	CR/EN
15.	<i>Baeomyces rufus</i> (Huds.) Rebert.	-	1 (r), 2 (r), 3 (r)	-
16.	<i>Bryoria fuscescens</i> (Gyeln.) Brodo & D. Hawksw.	-	1 (Q)	CR/VU
17.	<i>Bryoria jubata</i> auct. [<i>Bryopogon jubatum</i> (L.) α <i>prolixum</i> (Ach.)]	+	-	RE/RE
18.	<i>Buellia griseovirens</i> (Turner & Borrer ex Sm.) Almb.	-	1 (Q), 2 (Q, B), 4 (A, B, Pt, Ti)	-
19.	<i>Calicium adpersum</i> Pers.	-	2 (Q)	-
20.	<i>C. glaucellum</i> Ach.	-	3 (Q)	EN/VU
21.	<i>C. salicinum</i> Pers.	-	1 (Q), 3 (Q)	EN/VU
22.	! <i>Caloplaca chrysodeta</i> (Vain. ex Räsänen) Domb.	-	1 (r)	-
23.	<i>C. holocarpa</i> (Hoffm.) A.E. Wade	-	4 (A, B, Ti)	-
24.	<i>Candelariella vitellina</i> (Hoffm.) Müll. Arg.	(+)	4 (B, Ti)	-
25.	<i>C. xanthostigma</i> (Pers. ex Ach.) Lettau	-	4 (A, Fr, Ti)	-
26.	<i>Cetraria aculeata</i> (Schreb.) Fr.	+	3 (s)	-
27.	<i>C. sepincola</i> (Ehrh.) Ach.	+	-	CR/EN
28.	! <i>Cetrelia monachorum</i> (Zahlbr.) W.L. Culb. & C.F. Culb.	-	1 (Q)	-

cont. table 1

1	2	3	4	5
29.	<i>Chaenotheca chrysocephala</i> (Turner ex Ach.) Th. Fr.	-	1 (Q)	-
30.	<i>Ch. ferruginea</i> (Turner ex Sm.) Mig.	-	1 (Q)	-
31.	<i>Ch. furfuracea</i> (L.) Tibell	+	-	CR/NT
32.	<i>Cladonia cervicornis</i> (Ach.) Flot. subsp. <i>verticillata</i> (Hoffm.) Ahti	-	3 (s)	-
33.	<i>C. coccifera</i> (L.) Willd.	+	-	NT/-
34.	<i>C. coniocraea</i> (Flörke) Spreng.	-	1 (Q, r, s, l), 2 (Q), 3 (Ti)	-
35.	<i>C. deformis</i> (L.) Hoffm.	-	3 (s)	-
36.	<i>C. digitata</i> (L.) Hoffm.	+	1 (Q, r), 3 (T)	-
37.	<i>C. fimbriata</i> (L.) Fr.	+	1 (r), 3 (s, l), 4 (B)	-
38.	<i>C. floerkeana</i> (Fr.) Flörke	-	3 (s)	-
39.	<i>C. furcata</i> (Huds.) Schrad.	-	1 (r), 3 (s)	-
40.	<i>C. grayi</i> G. Merr. ex Sandst.	-	3 (s, l)	-
41.	<i>C. gracilis</i> (L.) Willd.	+	3 (s)	-
42.	<i>C. macilenta</i> Hoffm.	+	1 (s), 4 (B)	-
43.	<i>C. mitis</i> Sandst.	-	3 (s)	-
44.	<i>C. ochrochlora</i> Flörke	-	1 (B, Q, s)	-
45.	<i>C. phyllophora</i> Hoffm.	-	3 (s)	-
46.	<i>C. pleurota</i> (Flörke) Schaer.	-	1 (r), 3 (s)	-
47.	<i>C. polydactyla</i> (Flörke) Spreng.	-	1 (s)	DD/-
48.	<i>C. pyxidata</i> (L.) Hoffm.	+	3 (s)	-
49.	<i>C. rangiferina</i> (L.) F.H. Wigg.	+	3 (s)	-
50.	<i>C. squamosa</i> (Scop.) Hoffm. var. <i>squamosa</i>	+	1 (br, s), 3 (s)	-
51.	<i>C. subulata</i> (L.) F.H. Wigg.	-	3 (s)	-
52.	<i>C. uncialis</i> (L.) F.H. Wigg.	(+)	3 (s)	-
53.	* <i>Clypeococcum hypocenomycis</i> D. Hawksw.	-	on the thallus of <i>Hypocenomyce scalaris</i> 1 (P, l)	-
54.	<i>Cornicularia normoerica</i> (Gunn.) Du Rietz	+	-	absent/VU
55.	<i>Dibaeis baeomyces</i> (L. f.) Rambold & Hertel	+	-	EN/NT
56.	<i>Dimerella pineti</i> (Ach.) Vězda	-	1 (P, Q), 3 (F)	-
57.	<i>Diploschistes scruposus</i> (Schreb.) Norman	+	1 (r)	-
58.	<i>Evernia divaricata</i> (L.) Ach.	+	-	RE/CR
59.	<i>E. prunastri</i> (L.) Ach.	+	1 (Q), 4 (Ti)	VU/NT
60.	<i>Graphis scripta</i> (L.) Ach.	+	1 (F)	NT/NT
61.	<i>Hypocenomyce anthracophila</i> (Nyl.) P. James & Gotth. Schneid.	-	1 (P, Q)	LC/-
62.	<i>H. scalaris</i> (Ach. ex Lilj.) M. Choisy	-	1 (B, l, P), 4 (B)	-

cont. table 1

1	2	3	4	5
63.	<i>Hypogymnia physodes</i> (L.) Nyl.	+	1 (B, P, Q), 2 (Q), 4 (B, Ti)	-
64.	<i>H. tubulosa</i> (Schaer.) Hav.	-	1 (Q)	NT/NT
65.	<i>Icmadophila ericetorum</i> (L.) Zahlbr.	+	-	RE/EN
66.	<i>Imshaugia aleurites</i> (Ach.) S.L.F. Meyer	(+)	1 (l)	-
67.	<i>Lecania cyrtella</i> (Ach.) Th. Fr.	-	4 (A)	-
68.	<i>Lecanora albella</i> (Pers.) Ach.	+	-	RE/EN
69.	<i>L. albellula</i> (Nyl.) Th. Fr.	-	4 (A)	-
70.	<i>L. carpinea</i> (L.) Vain.	+	4 (A)	-
71.	<i>L. chlarotera</i> Nyl.	-	4 (Ti)	-
72.	! <i>L. compallens</i> Herk & Aptroot	-	4 (Ti)	-
73.	<i>L. conizaeoides</i> Nyl. ex Cromb.	-	1 (P), 4 (B)	-
74.	<i>L. dispersa</i> (Pers.) Sommerf.	-	4 (B)	-
75.	<i>L. expallens</i> Ach.	-	4 (Ti)	-
76.	<i>L. glabrata</i> (Ach.) Malme	+	-	-
77.	<i>L. hagenii</i> (Ach.) Ach.	-	4 (A)	-
78.	<i>L. muralis</i> (Schreb.) Rabenh.	(+)	1 (r), 3 (r)	-
79.	<i>L. persimilis</i> (Th. Fr.) Nyl.	-	4 (Ti)	-
80.	<i>L. pulicaris</i> (Pers.) Ach.	-	1 (Q), 4 (B)	-
81.	<i>L. saligna</i> (Schrad.) Zahlbr.	-	4 (Ti)	-
82.	<i>L. swartzii</i> (Ach.) Ach.	-	1 (r)	-
83.	<i>L. varia</i> (Hoffm.) Ach.	-	4 (B)	-
84.	<i>Lecidea fuscoatra</i> (L.) Ach.	-	1 (r)	-
85.	<i>L. plana</i> (J. Lahm) Nyl.	-	3 (r)	NT/-
86.	<i>Lecidella elaeochroma</i> (Ach.) M. Choisy	(+)	4 (A, B, Pt, Ti)	-
87.	! <i>L. flavosorediata</i> (Vězda) Hertel & Leuckert	-	4 (A, Ti, Pt, Fr)	-
88.	! <i>Lepraria crassissima</i> (Hue) Lettau	-	1 (r)	-
89.	! <i>L. eburnea</i> J.R. Laundon	-	1 (Q), 2 (Q), 4 (Ti)	-
90.	<i>L. elobata</i> Tørnberg	-	4 (Ti)	-
91.	<i>L. incana</i> (L.) Ach.	-	1 (r, s, Q, B), 2 (Q), 3 (F, Q), 4 (Ti)	-
92.	<i>L. jackii</i> Tørnberg	-	1 (r), 2 (r)	-
93.	<i>L. lobificans</i> Nyl.	-	1 (r), 2 (Q)	-
94.	<i>L. membranacea</i> (Dicks.) Vain.	-	1 (r)	-
95.	<i>L. neglecta</i> (Nyl.) Lettau	-	1 (r)	-
96.	<i>L. rigidula</i> (B. de Lesd.) Tørnberg	-	4 (Ti, Pt)	-
97.	<i>L. vouauxii</i> (Hue) R.C. Harris	-	1 (Q, B), 2 (Q), 4 (Ti)	-

cont. table 1

1	2	3	4	5
98.	* <i>Lichenocodium erodens</i> M.S. Christ. & D. Hawksw.	-	on the thallus of <i>Platismatia glauca</i> , on apothecia of <i>Lecanora conizaeoides</i> 1 (Q), 4 (B)	-
99.	* <i>Lichenocodium lecanorae</i> (Jaap) D. Hawksw.	-	on the apothecia of <i>Lecanora conizaeoides</i> 1 (P)	-
100.	! <i>Lichenomphalia umbellifera</i> (L.: Fr.) Redhead, Lutzoni, Moncalvo & Vilgalys	-	1 (l)	-/NT
101.	<i>Melanelixia fuliginosa</i> (Fr. ex Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	-	2 (Q), 4 (A, Ti)	-
102.	<i>M. subaurifera</i> (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	-	4 (A)	-
103.	<i>Melanohalea exasperatula</i> (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	-	4 (A, Ti)	-
104.	<i>M. olivacea</i> (L.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	+	-	RE/CR
105.	<i>Micarea botryoides</i> (Nyl.) Coppins	-	1 (r, s)	-
106.	! <i>M. lignaria</i> (Ach.) Hedl.	-	1 (B, r)	-
107.	<i>M. melaena</i> (Nyl.) Hedl.	-	1 (l)	VU/NT
108.	<i>M. micrococca</i> (Körb.) Gams ex Coppins	-	1 (Q, br), 2 (Q)	-
109.	<i>M. peliocarpa</i> (Anzi) Coppins & R. Sant.	-	1 (r)	DD/-
110.	<i>M. prasina</i> Fr.	-	1 (l, Q), 2 (Q)	-
111.	! <i>M. viridileprosa</i> Coppins & van den Boom	-	2 (br)	-
112.	<i>Miriquidica leucophaea</i> (Flörke ex Rabenh.) Hertel & Rambold	-	1 (r)	DD/VU
113.	! * <i>Monodictys epilepraria</i> Kukwa & Diederich	-	on the thallus of <i>Lepraria incana</i> 1 (r, Q)	-
114.	! <i>Mycobilimbia epixanthoides</i> (Nyl.) Vitik., Ahti, Kuusinen, Lommi & T. Ulvinen	-	1 (Q, br)	-
115.	<i>Mycoblastus fucatus</i> (Stirt.) Zahlbr.	-	4 (B)	-
116.	<i>Nephroma resupinatum</i> (L.) Ach.	+	-	RE/CR
117.	! <i>Ochrolechia bahusiensis</i> H. Magn.	-	1 (Q)	EN/VU
118.	<i>O. microstictoides</i> Räsänen	-	1 (Q), 2 (Q)	-
119.	<i>Opegrapha varia</i> Pers.	-	2 (Q)	VU/NT
120.	<i>Parmelia omphalodes</i> (L.) Ach.	+	1 (r)	-/EN
121.	<i>P. saxatilis</i> (L.) Ach.	+	1 (B, Q, r), 4 (B, Ti)	-

cont. table 1

1	2	3	4	5
122.	<i>P. sulcata</i> Taylor	+	1 (Q), 4 (Ti)	-
123.	<i>Parmelina tiliacea</i> (Hoffm.) Hale	-	4 (Ti)	CR/VU
124.	<i>Parmeliopsis ambigua</i> (Wulfen) Nyl.	-	1 (Q, l, r)	-
125.	<i>Peltigera canina</i> (L.) Willd.	+	-	CR/VU
126.	<i>Pertusaria albescens</i> (Huds.) M. Choisy & Werner	-	3 (Q), 4 (Ti)	LC/-
127.	<i>P. amara</i> (Ach.) Nyl.	-	3 (F)	LC/-
128.	<i>P. coccodes</i> (Ach.) Nyl.	-	1 (Q), 4 (Ti)	VU/NT
129.	<i>P. coronata</i> (Ach.) Th. Fr.	-	1 (Q), 2 (Q)	CR/VU
130.	<i>P. pertusa</i> (Weigel) Tuck.	+	1 (r), 2 (Q)	CR/VU
131.	<i>Phaeophyscia nigricans</i> (Flörke) Moberg	-	4 (A, Ti)	-
132.	<i>P. orbicularis</i> (Neck.) Moberg	+	4 (A)	-
133.	<i>Phlyctis argena</i> (Spreng.) Flot.	-	3 (F), 4 (B, Ti)	-
134.	<i>Physcia adscendens</i> H. Olivier	-	4 (A, B, Ti)	-
135.	<i>P. caesia</i> (Hoffm.) Fűrnr.	(+)	4 (A)	-
136.	<i>P. dubia</i> (Hoffm.) Lettau	-	4 (B, Ti)	-
137.	<i>P. tenella</i> (Scop.) DC.	-	4 (A, B, Ti)	-
138.	<i>Physconia eneteroxantha</i> (Nyl.) Poelt	-	4 (A)	-
139.	<i>P. grisea</i> (Lam.) Poelt	-	4 (A, Fr)	-
140.	<i>Placynthiella dasaea</i> (Stirt.) Tørnsberg	-	1 (l)	-
141.	<i>P. icmalea</i> (Ach.) Coppins & P. James	-	1 (Q, l, br), 3 (s)	-
142.	<i>P. oligotropha</i> (J.R. Laundon) Coppins & P. James	-	3 (s)	-
143.	<i>Platismatia glauca</i> (L.) W.L. Culb. & C.F. Culb.	+	1 (P, Q, r)	NT/-
144.	<i>Pleurostica acetabulum</i> (Neck.) Elix & Lumbsch	-	4 (Ti)	CR/EN
145.	<i>Porina aenea</i> (Wallr.) Zahlbr.	-	3 (F)	-
146.	<i>Porpidia cinereoatra</i> (Ach.) Hertel & Knoph	-	1 (r)	LC/LC
147.	<i>P. crustulata</i> (Ach.) Hertel & Knoph	+	3 (r)	-
148.	<i>P. macrocarpa</i> (DC.) Hertel & A.J. Schwab	+	1 (r)	VU/LC
149.	<i>P. soredizodes</i> (Lamy ex Nyl.) J.R. Laundon	-	1 (r), 2 (r)	-
150.	<i>Pseudevernia furfuracea</i> (L.) Zopf	+	1 (Q), 2 (Q), 4 (B)	-
151.	<i>Psilolechia clavulifera</i> (Nyl.) Coppins	-	1 (r)	-/NT
152.	<i>Pycnothelia papillaria</i> Dufour	+	-	EN/EN
153.	<i>Ramalina farinacea</i> (L.) Ach.	-	1 (Q)	EN/VU
154.	<i>R. pollinaria</i> (Westr.) Ach.	+	1 (Q), 4 (Ti)	CR/VU
155.	<i>Scoliosporum chlorococcum</i> (Graewe ex Stenh.) Vězda	-	4 (A, Ti)	-

cont. table 1

1	2	3	4	5
156.	<i>S. umbrinum</i> (Ach.) Arnold	-	1 (r)	-
157.	<i>Strangospora pinicola</i> (A. Massal.) Körb.	-	4 (A, Ti)	LC/LC
158.	<i>Trapelia obtegens</i> (Th. Fr.) Hertel	-	1 (r)	-
159.	<i>T. placodioides</i> Coppins & P. James	-	1 (r)	-
160.	<i>Trapeliopsis flexuosa</i> (Fr.) Coppins & P. James	-	1 (B, Q, P, s, l), 3 (s)	-
161.	<i>Tuckermanopsis chlorophylla</i> (Willd.) Hale	-	1 (Q)	EN/VU
162.	<i>Umbilicaria polyphylla</i> (L.) Baumg.	+	-	NT/LC
163.	<i>Usnea florida</i> (L.) Weber ex F.H. Wigg.	+	-	absent/CR
164.	<i>Vulpicida pinastri</i> (Scop.) J.E. Mattsson & M.J. Lai	+	-	VU/NT
165.	<i>Xanthoparmelia conspersa</i> (Ehrh. ex Ach.) Hale	+	1 (r)	-
166.	<i>Xanthoria candelaria</i> (L.) Th. Fr.	-	4 (B, Ti)	-
167.	<i>X. parietina</i> (L.) Th. Fr.	+	1 (Q), 4 (A, P, B)	-
168.	<i>X. polycarpa</i> (Hoffm.) Th. Fr. ex Rieber	-	4 (Ti)	-

Explanations: * – lichenicolous fungus; + – the species given by BŁOŃSKI (1890) from the following sites: Niekłań, Piekło pod Niekłaniem, Piekło; (+) – species given by BŁOŃSKI (1890) from neighbouring positions: Staporków, Końskie; ! – species new to the Świętokrzyskie Mts; A – *Acer platanoides*; B – *Betula pendula*; F – *Fagus sylvatica*; Fr – *Fraxinus excelsior*; P – *Pinus sylvestris*; Pt – *Populus tremula*; Q – *Quercus* sp.; Ti – *Tilia cordata*; br – bryophytes; l – lignum; r – rocks of natural origin; s – soil.

Results and Discussion

Following the outcome of the study it was found that biota of the research area includes 168 species of lichens and lichenicolous fungi (Table 1). This area is distinguished by high species diversity of lichen biota in relation to other areas in Central Poland.

Currently, at the four researched sites, 148 species of lichens and lichenicolous fungi have been found. The biota is dominated by epiphytes – 95 species, including 78 found only on the bark of trees. Apart from forest communities on the bark of trees (site no 4) 57 species were found. On the outcrops of sandstone rocks 39 species (27 exclusively) grow. Terrestrial lichens include 24 species, lignicolous – 12 and bryophilous – 4. The biota is dominated by widespread and even common lichens, although species which are rare and endangered, both in the region and in the country, are also found there.

In comparison to the data provided by BŁOŃSKI (1890) the occurrence of 19 species of lichens – *Anaptychia ciliaris*, *Aspicilia gibbosa*, *Bryoria jubata*, *Cetraria sepincola*, *Chaenotheca furfuracea*, *Cladonia coccifera*, *Cornicularia normoerica*, *Dibaeis baeomyces*, *Evernia divaricata*, *Icmadophila ericetroum*, *Lecanora albella*, *L. glabrata*, *Melanohalea olivacea*, *Nephroma resupinatum*, *Peltigera canina*, *Pycnothelia papillaria*, *Umbilicaria polyphylla*, *Usnea florida*, and *Vulpicida pinastri*, and one species of lichenicolous fungus – *Abrothallus parmeliarum* has not been confirmed. Considering the number of lichen species (46) given by BŁOŃSKI (1890) it can be concluded that in the lichen biota unfavourable changes have taken place. Almost 44% of the species have disappeared from the study area within the last 100 years. Among them there are 6 species which currently belong to the category Regionally Extinct (RE) in the Świętokrzyskie Mts, and 4 to the category Critically Endangered (CR). Most of the species mentioned above belong to the high risk of extinction threat category in Poland (compare CIEŚLIŃSKI, CZYŻEWSKA 2006, CIEŚLIŃSKI et al. 2006).

The threat to the biota of lichens in the study area is a result of the general worsening of environmental conditions, mainly air pollution, and a reduction in moisture conditions. The condition of epiphytic lichen biota is negatively affected by cutting down old trees. Local threats to the nature reserve also arise from the high activity of tourists in the area. Their negative impact comes from excessive trampling of flora, even on the rock tops, and from the destruction of the rocks' surface by mechanically scratching inscriptions and drawings in soft sandstone, which had already been strongly emphasized by earlier investigators (MASSALSKI, KAZNOWSKI 1928).

The historic study of BŁOŃSKI (1890) provides information about 26 species, the presence of which has been confirmed. They have invariably been at their sites for over 100 years. Lichens which dominate here are now widespread, both in forest communities, as well as in open areas. In this group of species, among others, is *Parmelia omphalodes*, which grows on sandstone rocks in the reserve (site no 1). This is a very rare species in Poland. Its sites are known mainly from the 19th century, from the mountain areas and the Południowobałtyckie Lake District (FAŁTYNOWICZ 2003, BIELCZYK 2003). In the "Piekło pod Nieklaniem" reserve it is a very rare lichen nowadays. This species has been found only on one rock, and its thallus demonstrates decreased vitality. It is probably now disappearing from the area. At present a very rare species growing on sandstone rocks is *Xanthoparmelia conspersa*, mentioned by BŁOŃSKI (1890). A small residual lichen thallus was found on only one outcrop of rock. Among epiphytic lichens which are currently rare and threatened in the Świętokrzyskie Mts are: *Bacidia rubella*, *Graphis scripta*, *Pertusaria pertusa* and *Ramalina pollinaria*, which are reported in the historic study.

At the investigated sites 123 species that were not mentioned by BŁOŃSKI (1890) from “Skałki Piekło pod Niekłaniem” reserve and its surroundings (Table 1) were found. The author found some of them at sites in the neighbouring areas, i.e. Staporków, and Końskie, without giving their exact location. They must have been widespread lichens in the region at the time, and with few exceptions must have had the same character they have at present. Among these species are: *Candelariella vitellina*, *Cladonia uncialis*, *Imshaugia aleurites*, *Lecidella elaeochroma*, *Physcia caesia* and *Lecanora muralis*.

Lichens new to the study area can be divided into two groups of species. The first group are the lichens (about 100 species) with a long-established and well-known place in taxonomic studies. It is difficult to determine whether these species occurred here in the late 19th century. Some species from this group were mentioned by BERDAU (1876) in other parts of the Świętokrzyskie Mts, mainly in the so-called “Łyse Mts”. It cannot be stated clearly whether some of the species did not appear later in time than the study conducted by BŁOŃSKI (1890). Among them are species that are expansive, spreading especially in habitats with heavy anthropogenic factors e.g. *Amandinea punctata*, *Buellia griseovirens*, *Caloplaca holocarpa*, *Dimerella pineti*, *Lecanora conizaeoides*, *L. hagenii*, *L. pulicaris* and others. At present in this group are also interesting and rare species having the status of threatened and endangered lichens in the country. This group includes species which grow in forest communities, e.g. *Bacidia subincompta*, *Calicium adpersum*, *C. salicinum*, *C. glaucellum*, *Arthonia vinosa*, *Ramalina farinacea*, and *Pertusaria coronata*, and on aged lime trees in the village of Niekłań: *Parmelina tiliacea* and *Pleurosticta acetabulum*. These are very rare lichens, forming very small populations and growing only on old trees, mostly oaks and beeches. Their small size and residual thallus shows that these lichens are slowly disappearing from the studied area. With regard to rare species, even small environmental changes, or cutting down trees, lead to a complete disappearance of species in the area. The persistence of small populations of these species raise the natural values of the study area, particularly that of the, “Skałki Piekło pod Niekłaniem” reserve. The study of BŁOŃSKI (1890) also lacks a very interesting lichen *Lecanora swartzii*. It is now growing on sandstone rocks in the reserve (site no 1). This species probably appeared in this area some time later than when BŁOŃSKI’S study was conducted (compare CIEŚLIŃSKI, CZYZEWSKA 2006).

The second (and large) group of species new to the investigated area are lichens which were not identified in the past and which have been listed in Poland only recently. This group includes about 20 species, mainly of the genera: *Lepraria* (*L. crassissima*, *L. eburnea*, *L. elobata*, *L. incana*, *L. jackii*, *L. lobificans*, *L. rigidula*, *L. vouauxi*, *L. membranacea*, *L. neglecta*), *Micarea*

(*M. botryoides*, *M. viridileprosa*) and *Placynthiella* (*P. dasaea*, *P. icmalea*), and also *Absconditella lignicola*, *Agonimia repleta*, *Cetrelia monachorum*, *Lecanora compallens*, *Lecidella flavosorediata*, *Mycobilimbia epixanthoides*, *Ochrolechia bahusiensis* and lichenicolous fungi: *Clypeococcum hypocenomyces*, *Lichenocodium erodens*, *L. lecanorae* and *Monodictys epilepraria*.

Particular attention should be put on the species of the genus *Lepraria* that occur on the bark of trees and highly overgrown sandstone rocks, creating specific layouts on them. On the bark of trees the following species have been recorded: *Lepraria eburnea*, *L. elobata*, *L. rigidula*, *L. vouauxi*, *L. incana* and *L. lobificans*. On the rocks, depending on the exhibition, various species of this genus occur with different abundance. On southern rocks grow: *Lepraria incana*, *L. jackii*, and *L. membranacea*, and on the north side: *L. crassissima*, *L. incana*, *L. jackii*, *L. lobificans*, and *L. membranacea*. These leprose lichens are often the only species which colonize the smooth, vertical walls of rocks. A specific habitat is occupied by *Lepraria neglecta*. The species has been recorded only on the top of rocks. The variety of epilithic lichens of the genus *Lepraria* enriches other crustaceous species such as *Caloplaca chrysodeta*, *Psilolechia clavulifera*, *Trapelia obtegens* and *T. placodioides*. Most of the species are mixed together, which often makes it difficult to identify them.

Some interesting species of lichens and lichenicolous fungi

Some rare species in Poland, which have recently been distinguished in lichenological studies, deserve special consideration. New sites in the investigated area contribute new information about their occurrence and habitat preferences. Some of them are new to the area of Central Poland.

Agonimia repleta – the second recording in Central Poland. So far it has also been recorded in Chęcińsko-Kielecki Landscape Park (ŁUBEK 2012).

Caloplaca chrysodeta – Leprose species characterized by a diffuse, unlimited, powdery, grey-yellow to orange thallus. It is easily identified by the reaction of the thallus with K+ purple. Known in Poland from the Beskid Sądecki Mts (ŚLIWA 1998) and the Tatra Mts (ALSTRUP, OLECH 1992). New to the Świętokrzyskie Mts and Central Poland.

Cetrelia monachorum – the species separated from the group of *Cetrelia olivetorum*. Based on its secondary metabolites (imbricaric acid – major and perlatolic acid – minor) identified by TLC. New to the Świętokrzyskie Mts.

Cladonia polydactyla – in Central Poland known from Spalski Landscape Park (CZYŻEWSKA 1972) and Załęczański Landscape Park (CZYŻEWSKA 1986).

Lecanora swartzii – the site in the investigated reserve is the only one known in Central Poland. The other sites are located in mountain areas: the Tatra Mts, Góry Stołowe Mts, and Karkonosze Mts (compare CIEŚLIŃSKI, CZYŻEWSKA 2006).

Lichenomphalia umbellifera – one of only a few lichens in Poland in which the mycobiont is *Basidiomycota*. Characterized by a dark green, granulate thallus, *Botrydina*-type, which grows yellow-brown cap-fruiting bodies. New to the Świętokrzyskie Mts and Central Poland. Known from southern and northern parts of the country (FAŁTYNOWICZ 2003).

Lepraria crassissima – new to the Świętokrzyskie Mts. In Poland known mainly from mountainous areas (KUKWA 2006).

Lepraria eburnea – new to the Świętokrzyskie Mts. In Poland known from both mountainous and lowland areas (KUKWA 2006).

Micarea lignaria – new to the Świętokrzyskie Mts and Central Poland. In Poland known from mountainous areas (CZARNOTA 2007).

Micarea viridileprosa – in the Świętokrzyskie Mts so far known from Świętokrzyski National Park (ŁUBEK 2007).

**Monodictys epilepraria* – Lichenicolous fungus given for the first time from the Central Poland area, from Wysoczyzna Bełchatowska Upland Plain and Niecka Włoszczowska Basin (CZYŻEWSKA et al. 2008). New to the Świętokrzyskie Mts.

Ochrolechia bahusiensis – the species separated from the group of *Ochrolechia androgyna* s. lat. based on its secondary metabolites (gyrophoric acid, trace of lecanoric acids and 3 substances of murolic acid complex) separated by TLC. Known from the Świętokrzyskie Mts under the name *O. androgyna* C., from Świętokrzyski National Park and Świnia Góra Mt. reserve (JABŁOŃSKA, KUKWA 2007, compare KUKWA 2009). *Ochrolechia bahusiensis* is a typical lowland lichen with very few mountain records.

Parmelia omphalodes – new to the Świętokrzyskie Mts and Central Poland. In Poland known from the southern part of the country (FAŁTYNOWICZ 2003).

Psilolechia clavulifera – in the Świętokrzyskie Mts known from the Świętokrzyski National Park so far (ŁUBEK 2007). From Central Poland known from Spalski Landscape Park (ŁUBEK 2007).

Conclusions

1. The study of lichen biota changes in the same sites over more than a hundred years provides reliable data with which to determine the extent and trends of lichen biota impoverishment, as well as the sensitivity of selected species to changes in the natural environment.

2. The results of the present study of lichen biota in the area of Piekło Mt. confirms the legitimacy of the classification of many species to appropriate categories of endangered species, as accepted in the studies as red lists.

3. The degree of adverse change in lichen biota in the analyzed time interval is high. The losses are about 44% of the total species recorded in the late 19th century in the same area.

4. Investigated sites are distinguished by the presence of rare and endangered species not only in the region of the Świętokrzyskie Mts., but in many other areas of the Polish lowlands, for example, *Parmelia omphalodes*, *Lecanora shwartzii*, *Bacidia subincompta*, *Calicium adpersum*, *C. salicinum*, *C. glaucellum*, *Pleurosticta acetabulum*, *Arthonia vinosa*, *Pertusaria coronta*, *Ramalina farinacea*, and *Cetraria chlorophylla*. With the exception of *Lecanora shwartzii* these lichens are very rare in the investigated sites, forming small, isolated populations with clearly reduced viability, and showing signs of disappearing lichens.

5. Outcrops of sandstone rocks in the Piekło Mt. and the surrounding forest communities, currently under reserve protection, are a good subject for conducting research on the dynamics of lichen biota. Permanent monitoring of the inventory of lichens in the area is necessary.

6. The studies provide material with which to assess the threat to lichens in north-western parts of the Świętokrzyskie Mts, in the region of a large forested area in the Świętokrzyska forest. Due to the absence of adequate data, this area was not included in the study *Red list of threatened lichens in the Świętokrzyskie Mountains* (CIEŚLIŃSKI, ŁUBEK 2003).

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