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Lichen flora of Žumberak-Samoborsko gorje Nature Park, NW Croatia

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Abstract – During 2007 and 2008 epiphytic and terrestrial lichen communities were surveyed in the Žumberak-Samoborsko gorje Nature Park (NW Croatia); 84 taxa were recorded including, *Lecanora thysanophora*, which was new to Croatia, and four, *Bryoria fuscescens*, *Lobaria pulmonaria, Usnea subfloridana* and *Usnea hirta*, which are red data species in Croatia.

Keywords: Lichen, check list, Žumberak, Samoborsko gorje, Croatia

Introduction

Most research into lichens in Croatia was done in the late 19th and the first part of the 20th century, and summarised in KUŠAN (1953). Few works were published until the 1990s after recommendations for lichenological research were made (CHRISTENSEN 1987, 1988; CHRISTENSEN and HANSEN 1994; OZIMEC 2000; PARTL and ASTA 2003; OZIMEC et al 2009). In 2007 the first check list and red list of Croatian lichens were published, later revised in 2009 (OZIMEC and PARTL 2009a, b). The distribution of most species in Croatia is still not well known. This paper is an attempt to contribute to a broader understanding of lichen flora in the north Croatian mountain region. This area had previously been visited once before (KUŠAN 1928), resulting in the recording of 67, mostly saxicolous, taxa.

Study area

The lichen survey was carried out in the Žumberak-Samoborsko gorje Nature Park. This is situated in NW Croatia, on the border with Slovenia. It includes parts of Žumberačko and Samoborsko gorje mountains, between the rivers Sava and Kupa, in Croatia, and the river Krka in Slovenia. Altitudes range from 180m in the Kupa river valley increasing to 1178m at the summit of Sveta Gera, which is the highest peak of Žumberačko gorje mountain range. In this paper, previous lichen records for the mountains are also mentioned, and all the localities visited are marked on the enclosed map (Fig.1).

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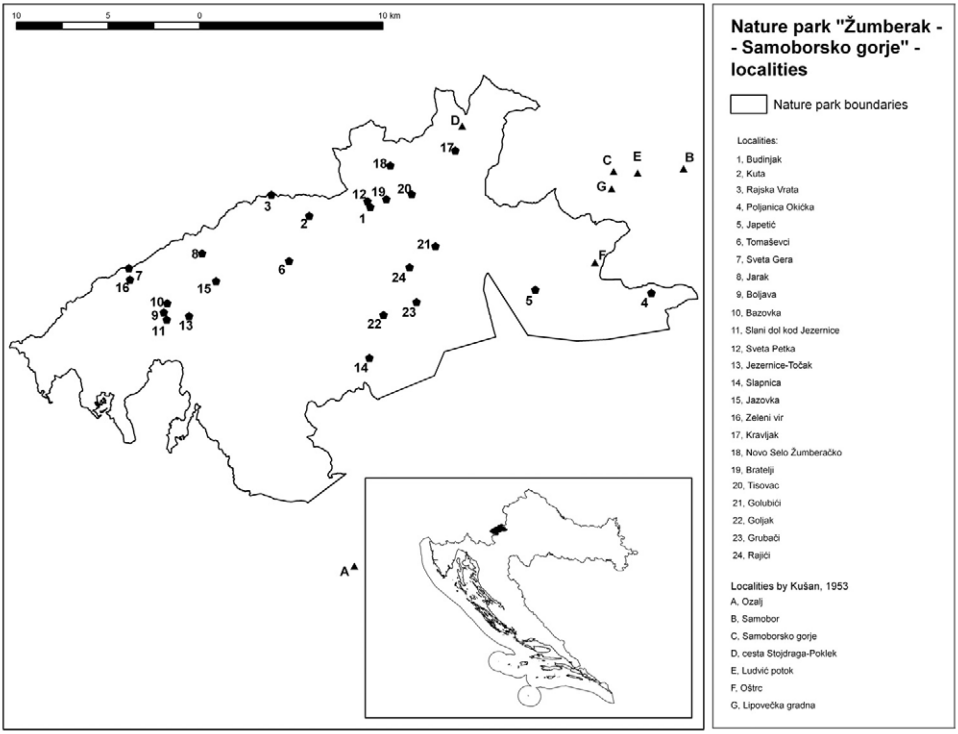

Fig. 1: Map of the study area in Croatia with sampling sites.

Most rock exposures are limestone and dolomites that weather to form a karst landscape. Locally, other rock type outcrops are present, such as sandstone and clay, whilst magmatic rocks can be found in the southeast part of the park. Over three hundred freshwater springs are recorded in the region and most of the permanent streams run in rather deep valleys.

Climate is moderate-continental, with a Mediterranean influence. Average annual temperature is from 7–10 °C, and average annual precipitation in the region exceeds 1100mm, and may reach 1300mm in the highest parts.

The area is mostly covered with forests in which the major types are beech (*Fagus silvatica*) forests, and, in the lower parts, oak (*Quercus* spp) and hornbeam (*Carpinus betulus*) forests. Semi-natural and anthropogenic habitats include planted conifers, old orchards, and meadows.

Materials and methods

The lichens found during this survey were collected from 24 sites (Fig. 1). Old records, referenced by toponyms (KUŠAN 1928, 1953), were grouped and recorded from 7 additional sites. These should be considered as approximate locations as in the original studies the records were from quite wide areas. Stations indicated by numbers were those examined in this research; old records by KUŠAN (1928) are indicated by letters.

Lichens were collected in paper bags labelled with site number and substratum. After drying, specimens were identified using both stereo and compound microscopes, and by chemical spot tests. Several keys were used (CLAUZADE and ROUX 1985, DOBSON 1992, PURVIS et al 1992, WIRTH 1995). Nomenclature mostly follows NIMS and MARTELLOS (2008).

Results

Lichen taxa recorded in this survey, together with older records, are listed alphabetically (Tab. 1), showing stations where they were found. In the present research done during 2007 and 2008, 84 taxa were recorded; previous research from 1928 recorded 67 taxa. Only 10 taxa from 1928 were re-discovered during the present survey. This is probably due to the focus of the earlier survey being on saxicolous lichens, whilst this study concentrated on epiphytic and terrestrial taxa. In further analyses, only taxa recorded in this research were used, as old records could not be properly geo-referenced or verified.

Tab. 1: Lichens from Žumberak-Samoborsko gorje National Park

SPECIES	STATIONS
Amandinea punctata (Hoffm.) Coppins et Scheid.	2, 6, 7, 8
Anaptychia ciliaris (L.) Körb.	7
Arthonia spadicea Leight.	E
Aspicilia calcarea (L.) Mudd	G
Bacidia bagliettoana (A.Massal. et De Not.) Jatta	E
Baeomyces rufus (Huds.) Rebent.	C
Bagliettoa limborioides A.Massal.	C
Bagliettoa parmigera (J.Steiner) Vìzda et Poelt	D
Bilimbia sabuletorum (Schreb.) Arnold	E
Bryoria fuscescens (Gyeln.) Brodo et D. Hawksw.	1, 19, 21, 23
Buellia leptocline (Flot.) A. Massal.	E
Caloplaca cerinella (Nyl.) Flagey	7
Caloplaca ferruginea (Huds.) Th. Fr.	7
Caloplaca flavovirescens (Wulfen) Dalla Torre et Sarnth.	C
Caloplaca holocarpa (Ach.) A. E. Wade	18, 19
Candelaria concolor (Dicks.) Stein	12
Candelariella reflexa (Nyl.) Lettau	10
Candelariella vitellina (Hoffm.) Müll. Arg.	E
Candelariella xanthostigma (Ach.) Lettau	1, 2, 4, 7, 10, 12, 17, 18, 19, 21
Catillaria lenticularis (Ach.) Th. Fr.	C
Cetrelia olivetorum (Nyl.) W. L. Culb. et C. F. Culb.	4, 5, 7, 12
Cladonia caespiticia (Pers.) Flörke	C
Cladonia coniocraea (Flörke) Spreng.	1, 10, E, G

Tab. 1 – continued

SPECIES	STATIONS
Cladonia digitata (L.) Hoffm.	E, G
Cladonia fimbriata (L.) Fr.	1, G
Cladonia furcata (Huds.) Schrad.	E, G
Cladonia macilenta Hoffm. subsp. *macilenta*	C
Cladonia pyxidata (L.) Hoffm.	15, C, E, F
Cladonia rangiferina (L.) F. H. Wigg.	C, G
Cladonia rangiformis Hoffm.	F
Cladonia squamosa Hoffm. var. *squamosa*	E, G
Clauzadea monticola (Schaer.) Hafellner et Bellem.	D
Collema flaccidum (Ach.) Ach.	2, 13
Collema fuscovirens (With.) J. R. Laundon	13
Collema tenax (Sw.) Ach.	E, F
Dermatocarpon intestiniforme (Körb.) Hasse	D
Dermatocarpon miniatum (L.) W. Mann	13, A
Dibaeis baeomyces (L.) Rambold et Hertel	D
Diploschistes muscorum (Scop.) R. Sant.	E
Diplotomma alboatrum (Hoffm.) Flot.	G
Evernia prunastri (L.) Ach.	1, 2, 7, 12, 17, 18, 20, 21, 22, 23, 24
Farnoldia jurana (Schaer.) Hertel subsp. *jurana*	E
Flavoparmelia caperata (L.) Hale	1, 4, 6, 8, 10, 18, 19, 20, 22, 24, E
Fuscidea stiriaca (A.Massal.) Hafellner	8, E
Graphis scripta (L.) Ach.	2, 4, 8, 10, B
Gyalecta hypoleuca (Ach.) Zahlbr.	E
Gyalecta jenensis (Batsch) Zahlbr.	C
Hypocenomyce scalaris (Ach.) M. Choisy	1
Hypogymnia physodes (L.) Nyl.	1, 3, 7, 10, 12, 17, 18, 19, 20, 21, 22, 24
Hypogymnia tubulosa (Schaer.) Havar.	1, 7, 10, 12, 17, 18, 19, 20, 21, 23
Lecanora allophana Nyl.	2, 7, 10
Lecanora argentata (Ach.) Malme	7, 10
Lecanora carpinea (L.) Vain.	10, 12, 18
Lecanora chlarotera Nyl.	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 17
Lecanora conizaeoides Cromb.	4
Lecanora dispersa (Pers.) Sommerf.	D
Lecanora expallens Ach.	7
Lecanora leptyrodes (Nyl.) Degel.	4, 9
Lecanora thysanophora R. C. Harris	10
widctlpar*Lecanora saligna* (Schrad.) Zahlbr.	1, 10
Lecidella elaeochroma (Ach.) M. Choisy	1, 2, 4, 5, 7, 8, 10, 11, 20
Lepraria nivalis J. R. Laundon	5
Leptogium lichenoides (L.) Zahlbr.	B

Tab. 1 – continued

SPECIES	STATIONS
Leptogium saturninum (Dicks.) Nyl.	2, 14
Lobaria pulmonaria (L.) Hoffm.	2, 7, 10, C
Melanelia elegantula (Zahlbr.) Essl.	7
Melanelia exasperata (De Not.) Essl.	1, 7, 18, 10, 21
Melanelia exasperatula (Nyl.) Essl.	6
Melanelia fuliginosa (Duby) Essl. subsp. *glabratula*	1, 2, 4, 5, 7, 8, 10, 14, 17, 18, 19, 20, 22, 23, 24
Melanelia glabra (Schar.) Essl.	1
Melanelia subaurifera (Nyl.) Essl.	2, 7, 10, 12
Menegazzia terebrata (Hoffm.) A. Massal.	E
Micarea peliocarpa (Anzi) Coppins et R. Sant.	G
Mycobilimbia lurida (Ach.) Hafellner et Türk	F
Ochrolechia turneri (Sm.) Hasselrot	5, 7
Opegrapha calcarea Sm.	D
Opegrapha rupestris Pers.	D, E
Parmelia omphalodes (L.) Ach.	G
Parmelia saxatilis (L.) Ach.	1, 2, 4, 7, 10
Parmelia sulcata Taylor	1, 2, 4, 6, 7, 8, 9, 10, 12, 17, 18, 18, 20, 21, 24
Parmelina pastillifera (Harm.) Hale	4, 6, 7, 10
Parmelina quercina (Willd.) Hale	18
Parmelina tiliacea (Hoffm.) Hale	1, 2, 4, 6, 7, 8, 17, 18, 19, 20, 21, 22, 23, 24
Parmeliopsis ambigua (Wulfen) Nyl.	1, 3, 10
Parmotrema crinitum (Ach.) M. Choisy	G
Parmotrema perlatum (Huds.) M. Choisy	7, 10, 14
Peltigera canina (L.) Willd.	E
Peltigera didactyla (With.) J. R. Laundon	16
Peltigera horizontalis (Huds.) Baumg.	2, 15, G
Peltigera membranacea (Ach.) Nyl.	2
Peltigera polydactyla (Neck.) Hoffm.	2, 10, 13, 16
Peltigera praetextata (Sommerf.) Zopf	14, 15, 16, E
Peltigera rufescens (Weiss) Humb.	2
Peltigera venosa (L.) Hoffm.	D
Pertusaria albescens (Huds.) M. Choisy et Werner	2, 4, 7, 10, 22
Pertusaria amara (Ach.) Nyl.	7, 22
Pertusaria coccodes (Ach.) Nyl.	7, 10
Pertusaria corallina (L.) Arnold	G
Pertusaria flavida (DC.) J. R. Laundon	20
Pertusaria leioplaca DC.	E

Tab. 1 – continued

SPECIES	STATIONS
Pertusaria pertusa (Weigel) Tuck.	2, 4, 5, 7, 8, 10
Phaeophyscia orbicularis (Neck.) Moberg	1, 7, 18
Phlyctis argena (Spreng.) Flot.	4, 7
Physcia adscendens (Fr.) H. Olivier	2, 7
Physcia stellaris (L.) Nyl.	1, 3, 7, 12, 18, 19, 20, 21, 23
Physcia tenella (Scop.) DC.	1, 5, 7, 18, 21
Physcia tribacia (Ach.) Nyl.	7
Physconia distorta (With.) J. R. Laundon	1
Physconia grisea (Lam.) Poelt subsp. *grisea*	7
Physconia perisidiosa (Erichsen) Moberg	1, 2
Placynthium nigrum (Huds.) Gray	D
Platismatia glauca (L.) W. L. Culb. et C. F. Culb.	1, 7, 10, 19, 21, 24
Pleurosticta acetabulum (Neck.) Elix et Lumbsch	7
Porina lectissima (Fr.) Zahlbr.	C
Porpidia albocaerulescens (Wulfen) Hertel et Knoph	C
Porpidia crustulata (Ach.) Hertel et Knoph	D
Porpidia macrocarpa (DC.) Hertel et A. J. Schwab	E
Protoblastenia rupestris (Scop.) J. Steiner	D
Pseudevernia furfuracea (L.) Zopf var. *furfuracea*	1, 7, 10, 12, 17, 18, 19, 20, 21, 24
Punctelia subrudecta (Nyl.) Krog	2
Ramalina calicaris (L.) Fr.	7, 9
Ramalina farinacea (L.) Ach.	1, 2, 4, 6, 7, 9, 10
Ramalina fastigiata (Pers.) Ach.	7, 20
Ramalina fraxinea (L.) Ach.	1, 2, 7, 8
Rhizocarpon reductum Th. Fr.	E
Rinodina confragosa (Ach.) Körb.	E
Rinodina oxydata (A.Massal.) A. Massal.	E
Sarcogyne regularis Körb. var. *regularis*	D
Solorina saccata (L.) Ach.	D, F
Usnea hirta (L.) F. H. Wigg.	1, 12
Usnea subfloridana Stirt.	1, 7, 10, 12, 17, 18, 19, 20, 21, 22, 23, 24
Verrucaria margacea (Wahlenb.) Wahlenb.	E
Verrucaria muralis Ach.	D
Verrucaria nigrescens Pers.	C
Verrucaria saprophila (A. Massal.) Trevis.	D
Vulpicida pinastri (Scop.) J.-E. Mattsson	1, 19
Xanthoparmelia conspersa (Ach.) Hale	E
Xanthoria candelaria (L.) Th. Fr.	12, 18
Xanthoria parietina (L.) Th. Fr.	1, 3, 7, 12, 18, 19, 20, 21, 23, 24, C
Xanthoria polycarpa (Hoffm.) Rieber	7, 19, 21

Discussion

Lecanora thysanophora is the first Croatian record for this species, and out of 84 taxa recorded during the survey 74 are new records for the area.

Most lichens were epiphytes on birch (*Betula pendula*), oak (*Quercus* sp.) and, at the higher altitudes, beech (*Fagus silvatica*). Of particular importance as porophytes were veteran fruit trees in grassland orchards and planted larch trees at location 12.

Foliose lichens were the most abundant (42 species), followed by crustose taxa (23) and then fruticose lichens (13). Other growth forms were not common, and comprised three composite taxa (*Cladonia* type), two leprose, and one squamose lichen.

The most important habitats for lichens were open forests, old orchards, and old forests undisturbed by forestry management.

In terms of response to light intensity, most of the species recorded preferred well lit situations but were also able to tolerate shade. Orchards and open forests were the favoured habitats for such species. No extreme skiophytes were found, and very few species requiring direct solar irradiation. Species recorded from old forests favoured semi-shaded to shaded habitats.

As regards temperature tolerance, most of the lichens recorded were those favouring submontane to montane regions, which is consistent with the climate and terrain in the area. Extremely thermophilous lichens were not recorded. Tolerance to cold is a survival factor for a few montane to high montane species, such as *Bryoria fuscescens, Cetrelia olivetorum, Hypogymnia tubulosa, Melanelia exasperata, Parmeliopsis ambigua, Platismatia glauca* and *Usnea subfloridana* and one highmontane to subalpine species – *Vulpicida pinastri*, which inhabited valleys where cold air persists, or snow lays for longer periods.

Oceanity shows the tolerance of lichens to extreme climate changes during the year – oceanic species prefer milder climate with fewer variations and are more common in Western Europe: such are the most numerous in the region if we exclude species that are widespread. No continental species were found, which suggests the climate is mild continental with no extremes.

No extreme hygrophytes nor xerophytes were found – the 1000 mm yearly precipitation experienced by the area being sufficient to satisfy the water requirements of the species recorded.

Lichens are sensitive to pH and the substrata, which makes them good indicators of environmental quality. A number of species are epiphytes on certain tree types. Many species in this area grow on mildly acid substrata, but a few are able to tolerate more acid conditions: they can either tolerate pollution resulting from acid rain or prefer trees with more acid bark such as conifers and birch (which is the case in the study area).

For epiphytic lichens a further limiting factor is the nutrition value of the substratum. Some tree species have higher concentrations of important minerals in bark than others, such as ash (*Fraxinus excelsior*) and maples (*Acer* sp.) An absence of epiphytes on trees does not therefore necessarily indicate environmental pollution. Most of the lichens found in the study area were epiphytes on trees that indicated low nutrition requirements, with a smaller number (presumably requiring a higher mineral requirement) found on naturally richer bark. A number of species were usually recorded from the base of trees, where eutrophication is caused by animal excrements or by exhaust gases of vehicles at the roadsides.

Because of their sensitivity to certain anthropogenic chemicals lichens have long been used as indicators of environmental pollution. The presence of toxitolerant species does not necessarily signify pollution, but the appearance of sensitive taxa is a good signal. In the study area most of the species recorded a fall somewhere in the middle of the scale of tolerance; three species extremely sensitive to environmental pollution– *Leptogium saturninum, Lobaria pulmonaria* and *Melanelia exasperata* – and another 12 moderately sensitive taxa were recorded. This indicates that the area has experienced excellent air quality over a long time period. *Lobaria pulmonaria*, which is an old forest indicator, was found in several localities, showing that this area has remained undisturbed or minimally managed for some considerable time a factor that makes its protection of significant importance. To summarise; the presence of old forest indicators, together with species sensitive to environmental pollution indicates that this area should be protected.

Old orchards within the study area, in which agro chemicals have never been used, support high numbers of otherwise rare and sensitive species, including *Usnea subfloridana, U. hirta* and *Bryoria fuscescens*, which makes their continued, traditional management as grassland orchards of vital importance. Some areas shown a high number of interesting species, and should be protected as special reserves: Budinjak is a still a thriving village, and the nearby birch and oak forest, that have been minimally managed, should be conserved. In particular the locations where *Lobaria pulmonaria* was found, especially areas near the peak on the Slovenian border, should be protected as special forest reserves and left unmanaged or managed minimally. This lichen does not survive intensive commercial forestry, particularly when growing outside its normal oceanic climate range (which is the case within the Park). A number of rare species have been recorded near the summit in Slovenia, in two special forest reserves, Trdinov vrh and Ravna gora (HOČEVAR 1985).

Any future study should be performed in terms of various environmental factors, such as light requirements, temperature, oceanity, water requirements, pH and nutrition values of the substratum and toxitolerance, and should also compare relationships with other studies (WIRTH 1992).

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