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The lichen flora of Risnjak National Park (Croatia)

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This paper lists 80 lichen taxa recorded for Risnjak National Park. Among the listed species, *Candelariella reflexa, Chaenotheca brunneola, Placynthiella icmalea, Usnea diplotypus* and *Usnea subfloridana* have been already first reported for Croatia. The field survey was carried out at 14 collection sites in the periods 1997–1998 and 2001–2002. Floristic composition, life form spectrum and substrate preferences are described. The most numerous genera are *Cladonia*, *Pertusaria*, *Lecanora* and *Peltigera*. Lichens growth on 16 various substrates, among which the deciduous trees, *Acer pseudoplatanus* and *Fagus sylvatica* dominate. The alliance *Lobarion pulmonariae*, consisting of some rare and old-forest indicator species, is present within the area.

Key words: Lichen, taxonomic list, life form, substrate, Risnjak, Croatia

Introduction

The first botanical research in the area of Risnjak and Snježnik mountains was undertaken more than 180 years ago. Comprehensive botanical research including phytosociology and vegetation mapping in Gorski kotar region was started by Ivo Horvat in 1927 (Horvat 1930, 1931). The results of his thirty-five-year long investigation are described in the publication »Vegetation of the Mountains in Western Croatia« (Horvat 1962). Lichenological researches in Croatia date back to the second part of the 19th century in the North Adriatic coastal area and the nearby hinterland of Gorski kotar (Matković 1879). A major contribution to the knowledge of lichen flora of Rijeka and Gorski kotar was made by Johann Schuler, who published a list of 329 taxa (Schuler 1902). The lichens collected by Schuler were discussed by Zahlbruckner, whose important contribution is the description of several new lichen species (Zahlbruckner 1905). The Croatian natural scientist Dragutin Hirc, in a description of the path to Mali Risnjak recorded that the moss was densely overgrown by *Cetraria islandica* (Hirc 1898). During research into the vegetation

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of the massifs of Risnjak and Snježnik, HORVAT (1930, 1962) recorded the presence of *Cetraria islandica* and *Cladonia* sp. in phytocoenological relevés of the grassland alliance *Seslerion tenuifoliae.* Lichen vouchers collected during this research in 1927, 1948 and 1949 year are deposited in the Ivo and Marija Horvat Herbarium (ZAHO) in Zagreb. The outstanding Croatian lichenologist Fran Kušan has visited Risnjak and many other localities in Gorski kotar in 1947 (BERTOVIĆ 1994). However, there is no evidence of specimens collected or any references in Kušan's compilation on lichens from the former Yugoslavia (KUŠAN 1953). Lichenological research in the area of Risnjak National Park was renewed in the periods 1997–1998 and 2001–2002, as presented in this paper.

Study area

Lichenological research was carried out in Gorski kotar, a mountainous region in western Croatia, which is, with 60% forest cover, the most wooded part of the country. Risnjak National Park (Fig. 1.) extends over 64 sq. km, including the massifs of Risnjak (1528 m) and Snježnik (1506 m), part of the western branch of the Dinaric Mountains, and the source area of the Kupa River up to the village Hrvatsko (287 m). The area of the Risnjak massif was proclaimed a national park in 1953, being extended in 1997 to Snježnik and the source of the Kupa River.

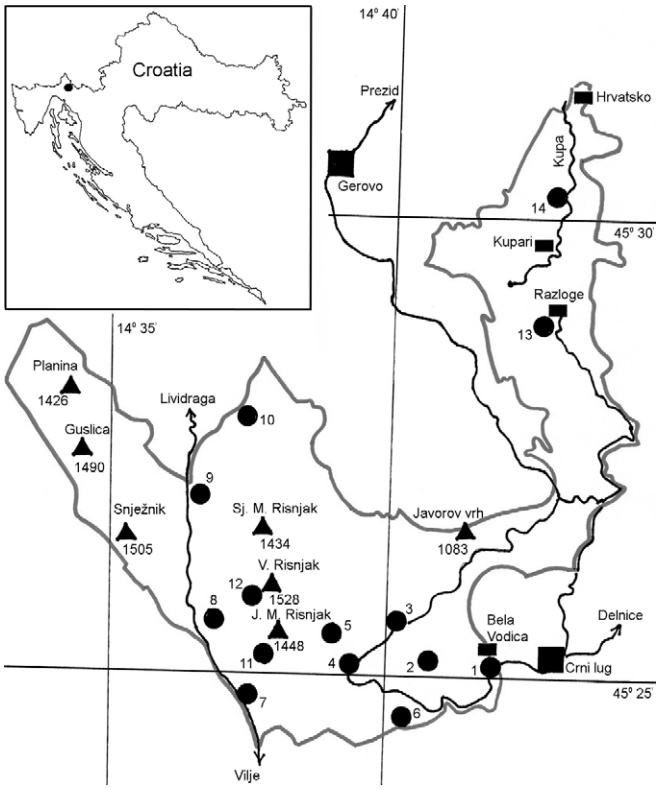

Fig. 1. Map of the study area with indicated collection sites

According to data from the meteorological station in Lividraga (939 m), the climate is perhumid and moderately cold. Mean annual temperature is 5.4 °C, the lowest in January (–2.0 °C) and the highest, 14.2 °C, in July. Rainfall averages 3770 mm per year, the highest amount occurring in November (488 mm), and lowest in August (166 mm). Air humidity is high (94%). Due to the prevailing limestone bedrock a typical karst relief with its specific morphology has developed.

The vegetation of Risnjak National Park consists of around 30 plant communities, among which 14 are forest associations. Due to their inaccessibility, some parts of the forests are still in primeval condition. Mixed beech and fir forests of the Dinaric vegetation zone (*Omphalodo-Fagetum*) cover the largest part of the area up to 1240 m (TRINAJSTIĆ 1995). At the altitude of 1200–1400 m this zone is replaced by prealpine beech forest (*Ranunculo platanifolii-Fagetum*). The upper boundary of the forest vegetation above 1450 m makes a special Dinaric association of mountain pine forest (*Lonicero borbasianae-Pinetum mugi*). The steep and warmer limestone blocks at 950–1350 m are covered by fir forests (*Calamagrosti-Abietetum*). In the lower parts of the Park, subalpine spruce forest (*Listero-Piceetum abietis*) grows in wet and cold locations in the shallow depressions, and on the edge of dolines. Acidophilous fir forest (*Blechno-Abietetum*) grows on acid soil at 680–800 m. The warmer climatic influence of the Kupa valley favours the occurrence of thermophilous forest associations such as hop hornbeam forests (*Erico-Ostryetum* and *Ostryo-Fagetum)*, while pure Illyrian beech forests (*Lamio orvalae-Fagetum*) grow on heights between 450 and 700 m. On the western boundary of the Park, in area of Lazac and Šegine, and in the Leska valley, meadows of calcareous grasslands (*Bromo--Plantaginetum* and *Festuco-Agrostietum)* are surround by old forests. The peaks of Risnjak and Snježnik are covered by alpine grasslands belonging to the endemic alliance *Seslerion tenuifoliae*.

Material and methods

Lichen samples were collected in the periods 1997–1998, and 2001–2002 at 14 collection sites within the area of the Risnjak National Park, as listed below:

1. Bijela Vodica, 700 m, MTB 0554/3 (14.–15.11.1997, 13.8.1998, 10.6.2001, 27.9.2001)
2. Leska, 700 m, MTB 0554/3 (15.–17. 11.1997, 13.8.1998)
3. Podi, 960 m, MTB 0553/4 (17. 11. 1997)
4. Markov Brlog, 940 m, MTB 0553/4 (16. 11.1997)
5. Smrekovac, 1140 m, MTB 0553/4 (16. 11.1997)
6. Risnik, 800 m, MTB 0554/3 (15.11.1997)
7. Vilje, 1180 m, MTB 0553/4 (4.10.1997)
8. Cajtige, 1240–1380 m, MTB 0553/4 (4.10.1997)
9. Lazac, 1100 m, MTB 0553/2 (12.8.1998)
10. Japetova Šegina, 940 m, MTB 0553/2 (12.8.1998)
11. Medvjeđa vrata, 1120–1300 m, MTB 0553/4 (4.10.1997, 16.11.1997)
12. Veliki Risnjak and Južni Mali Risnjak, 1360–1528 m, MTB 0553/4 (4.10.1997, 17.–18.11.1997, 23.7.1998, 30.4.2002)
13. Razloge village, 500 m, MTB 0554/1 (24.6.1998, 11.8.1998, 10.6.2001)
14. Between the source of the Kupa River and village Kupari, 321–500 m, MTB 0454/3, 0554/1 (24.6.1998, 11.8.1998, 2.5.2002)

Identification in the field was made with a hand lens, and in the laboratory using a dissecting microscope, a light microscope and the usual spot test, according to the reference books: CLERC (1998), PURVIS et al. (1994), VITIKAINEN (1994) and WIRTH (1995). Some specimens were analysed by thin-layer chromatography according to ORANGE et al. (2001). The lichen collections from the herbaria: ZA, ZAHO, EDI and GZU have been studied. Data on locality and substrate for each species are given. Nomenclature follows WIRTH (1995), SUPPAN et al. (2000) and MAYRHOFER (2006).

Results

According to literature sources, collection records at herbaria and field survey results, the currently known lichen flora of the Risnjak National Park comprises 80 species belonging to 53 genera. The lichen species are listed alphabetically (Tab. 1). Among the listed species, *Candelariella reflexa, Chaenotheca brunneola, Placynthiella icmalea, Usnea diplotypus* and *Usnea floridana* were first reported for Croatia by OZIMEC (2000).

Tab. 1. The lichen species recorded in Risnjak National Park in the period 1997–1998, and 2001–2002.

Species	Site	Substrata	Identified lichen compounds
Arthonia radiata (Pers.) Ach	14	*Fraxinus excelsior*	
Bilimbia lobulata (Sommerf.) Hafellner et Coppins	12	calcareous rock	
Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr. v. *cerina*	1 12	*Salix* sp., *Acer pseudoplatanus* *Fagus sylvatica*	
Caloplaca flavovirescens (Wulfen) Dalla Torre et Sarnth.	12	calcareous rock	
Caloplaca herbidella (Hue) H. Magn.	11 14	*Acer pseudoplatanus* *Prunus* sp.	
Candelariella reflexa (Nyl.) Lettau	1, 2, 4	*Acer pseudoplatanus*	
Cetraria islandica (L.) Ach.	Risnjak and Snježnik; vauchers in ZAHO		
Cetrelia olivetorum (Nyl.) W. L. Culb. et C. F. Culb.	9 14	*Acer pseudoplatanus* *Fagus sylvatica*	
Chaenotheca brunneola (Ach.) Müll. Arg.	8	on the mosses	
Cladonia coniocraea (Flörke) Spreng.	2 6 9 11 14	on the mosses *Abies alba* *Fagus sylvatica, Picea abies* *Abies alba* *Prunus* sp.	fumarprotocetraric acid

Tab. 1. – continued

Species	Site	Substrata	Identified lichen compounds
Cladonia fimbriata (L.) Fr	1	on the mosses	
Cladonia furcata (Huds.) Schrad.	Risnjak; vauchers in ZAHO		fumarprotocetraric acid
Cladonia macilenta ssp. *floerkeana* (Fr.) V. Wirth	2	on the mosses	
Cladonia pyxidata (L.) Hoffm.	2 8 12	*Acer pseudoplatanus* on the mosses, *Fagus sylvatica, Pinus mugo* on the soil, *Pinus mugo*	
Cladonia rangiferina (L.) Weber ex F.H. Wigg.	Risnjak; vauchers in ZAHO		atranorin
Collema auriforme (With.) Coppins et J.R. Laundon	9	on the mosses	
Collema cristatum (L.) F. H. Wigg.	12	calcareous rock	
Collema subflaccidum Degel.	1 8	on the mosses calcareous rock	
Degelia plumbea (Lightf.) P. M. Jørg. et P. James	1	*Tilia platyphyllos*	
Dermatocarpon miniatum (L.) W. Mann	3,5	calcareous rock	
Evernia prunastri (L.) Ach.	1,10 14	*Acer pseudoplatanus* *Prunus* sp.	
Flavoparmelia caperata (L.) Hale	1 2 13	*Acer pseudoplatanus* *Fagus sylvatica* *Ulmus glabra*	
Fuscidea stiriaca (A. Massal.) Hafellner	2	*Fagus sylvatica*	
Graphis scripta (L.) Ach.	2,4,6 6 14	*Acer pseudoplatanus* *Corylus avellana* *Fagus sylvatica, Fraxinus excelsior, Prunus* sp.	
Hypogymnia physodes (L.) Nyl.	1, 3 9 14	*Acer pseudoplatanus Picea abies* *Prunus* sp.	
Hypogymnia tubulosa (Schaer.) Hav.	2	*Abies alba*	
Lecania cyrtella (Ach.) Th. Fr.	1	*Acer pseudoplatanus*	
Lecanora argentata (Ach.) Malme	14	*Fraxinus excelsior*	
Lecanora carpinea (L.) Vain.	4	*Acer pseudoplatanus*	

Tab. 1. – continued

Species	Site	Substrata	Identified lichen compounds
Lecanora chlarotera Nyl.	4, 6, 7, 11, 12	*Acer pseudoplatanus*	
Lecanora subcarpinea Szatala	14	*Fagus sylvatica*	psoromic acid
Lecidella elaeochroma (Ach.) Massal.	1,12 4,12 12 14	*Salix* sp. *Acer pseudoplatanus* *Fagus sylvatica* *Fraxinus excelsior*	
Lepraria incana (L.) Ach.	8 11 12	F*agus sylvatica* *Abies alba* *Acer pseudoplatanus, Pinus mugo*	
Leptogium lichenoides (L.) Zahlbr.	9	on the mosses	
Lobaria amplissima (Scop.) Forssell	1	*Tilia platyphyllos*	
Lobaria pulmonaria (L.) Hoffm.	2, 5, 10,14 14	*Acer pseudoplatanus* *Fagus sylvatica, Fraxinus excelsior*	
Lobarina scrobiculata (Scop.) Nyl.	1	*Acer pseudoplatanus*	
Megalaria laureri (Th.Fr.) Hafellner	4 14	*Acer pseudoplatanus* *Fagus sylvatica*	
Melanelixia fuliginosa (Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. et Lumbsch	1 2 4,7 14	*Corylus avellana* *Fagus sylvatica* *Acer pseudoplatanus* *Fraxinus excelsior, Prunus* sp	
Menegazzia terebrata (Hoffm.) A. Massal.	2, 14 9	*Fagus sylvatica* *Picea abies*	
Mycobilimbia lurida (Ach.) Hafellner et Türk	8, 12	calcareous rock	
Nephroma parile (Ach.) Ach.	12	*Fagus sylvatica*	
Normandina pulchella (Borrer) Nyl.	13	*Ulmus glabra*	
Ochrolechia androgyna (Hoffm.) Arnold	13	*Ulmus glabra*	gyrophoric acid
Pannaria conoplea (Ach.) Bory	13	*Ulmus glabra*	
Parmelia saxatilis (L.) Ach.	1, 2, 4, 7, 9, 11, 12	*Abies alba, Acer pseudoplatanus*, *Fagus sylvatica*, *Picea abies*	
Parmelia submontana Hale	14	*Prunus* sp.	
Parmelia sulcata Taylor	1, 4, 11, 12, 14	*Acer pseudoplatanus* *Prunus* sp., *Salix* sp.	

Tab. 1. – continued

Species	Site	Substrata	Identified lichen compounds
Parmelina pastillifera (Harm.) Hale	1 2 11	*Prunus* sp. *Fagus sylvatica* *Acer pseudoplatanus*	
Parmeliopsis ambigua (Wulfen) Nyl.	12	*Picea abies*	
Parmotrema perlatum (Huds.) M. Choisy	13 14	*Ulmus glabra* *Carpinus betulus, Fraxinus excelsior*	stictic acid atranorin
Peltigera collina (Ach.) Schrad.	1 2 13	*Acer pseudoplatanus* *Abies alba* *Ulmus glabra*	
Peltigera horizontalis (Huds.) Baumg.	8, 12	*Fagus sylvatica*	
Peltigera polydactyla (Neck.) Hoffm.	14	*Acer campestre*	
Peltigera praetextata (Sommerf.) Zopf.	5, 8 6, 8, 10, 12, 14	on mosses *Acer pseudoplatanus* *Fagus sylvatica*	
Pertusaria albescens (Huds.) M. Choisy et Werner	1, 10, 11	*Acer pseudoplatanus*	allo-pertusaric acid dihydropertusaric acid
Pertusaria amara (Ach.) Nyl.	13 14	*Ulmus glabra* *Prunus* sp.	picrolichenic acid protocetraric acid
Pertusaria hemisphaerica (Flörke) Erichsen	9	*Picea abies*	lecanoric acid
Pertusaria hymenea (Ach.) Schaer.	5	*Acer pseudoplatanus*	
Pertusaria pertusa (Weigel) Tuck.	4, 7, 11	*Acer pseudoplatanus*	
Phlyctis argena (Spreng.) Flot.	1	A*cer pseudoplatanus*	
Physcia aipolia (Humb.) Fürnr.	1	*Prunus* sp., *Salix* sp.	
Physconia distorta (With.) J. R. Laundon	1	*Prunus* sp.	
Placynthiella icmalea (Ach.) Coppins et P. James	11	*Abies alba*	
Platismatia glauca (L.) W.L. Culb. et C.F. Culb.	2 4 9,10	*Abies alba* *Fagus sylvatica* *Picea abies*	
Pleurosticta acetabulum (Neck.) Elix et Lumbsch	1	*Acer pseudoplatanus*	

Tab. 1. – continued

Species	Site	Substrata	Identified lichen compounds
Pseudevernia furfuracea (L.) Zopf.	1	*Acer pseudoplatanus*	
	4	*Fagus sylvatica*	
	2, 9	*Picea abies*	
Punctelia subrudecta (Nyl.) Krog	2	*Fagus sylvatica*	
Pyrenula nitida (Weigel) Ach.	14	*Fagus sylvatica*	
Ramalina farinacea (L.) Ach.	10	*Acer pseudoplatanus*	
	13	*Ulmus glabra*	
Ramalina fastigiata (Pers.) Ach.	1	*Acer pseudoplatanus*	
Ramalina fraxinea (L.) Ach.	14	*Malus* sp., *Prunus* sp.	
Squamarina cartilaginea (With.) P. James	12	calcareous rock	
Thelotrema lepadinum (Ach.) Ach.	2	*Acer pseudoplatanus, Picea abies*	
	4,14	*Fagus sylvatica*	
Toninia sedifolia (Scop.) Timdal	12	on the soil	
Usnea diplotypus Vain.	1	*Acer pseudoplatanus*	usnic acid alectoronic acid
Usnea filipendula Stirt.	1	*Acer pseudoplatanus*	
	2	*Abies alba*	
Usnea subfloridana Stirt.	2	*Abies alba*	usnic acid salazinic acid
Xanthoria parietina (L.) Th. Fr.	1	*Prunus* sp.	

Distribution of lichen life forms shows that the most numerous, 43%, are foliose, 36% are crustose, and 21% are fruticose lichens. The lichens were found living on 16 different organic (trees, shrubs, mosses) and inorganic (soil, calcareous rocks) substrata (Fig. 2). Ten deciduous trees and shrubs make 62.5% of all substrates, three conifers make 18.75%, while mosses, calcareous rock and soil make 6.25% each. The most frequent phorophytes are *Acer pseudoplatanus*, which supports 36 species, *Fagus sylvatica* with 26 species, *Prunus* spp. with 14, and *Fraxinus excelsior* and *Abies alba* supporting 10 species each. The major habitats for lichens are solitary trees in valleys, and forest fringes with favourable microclimatic conditions.

Discussion

The number of 80 species reported for the lichen flora of the Risnjak National Park is lower than that in the lichen flora of the neighbouring areas in the Dinaric part of Slovenia. Although several rare microlichens have been found in the study area, a lot of especially crustose taxa are missing. For the Snežnik and Javorniki area, which is situated in southern Slovenia and bordering on Croatia, PRÜGGER (2005) reported a total of 409 species, among

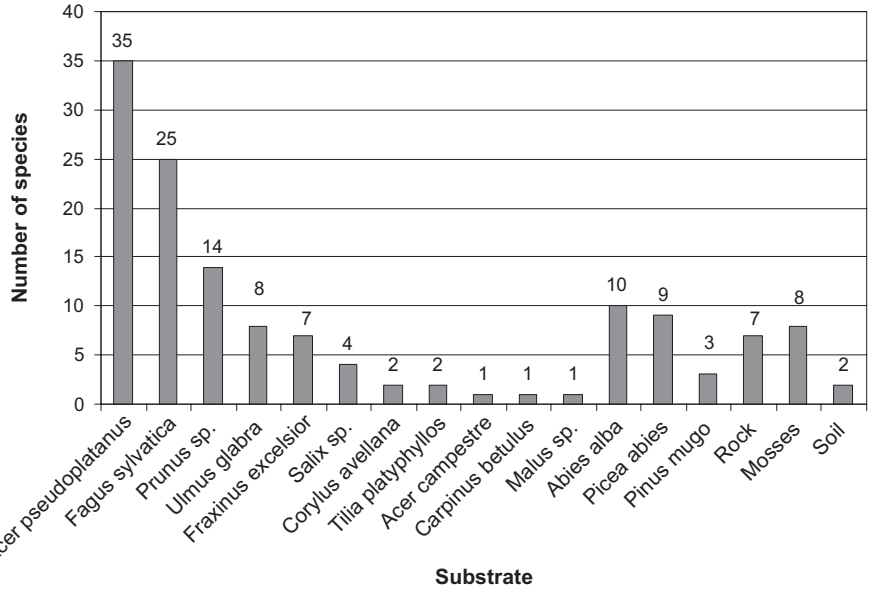

Fig. 2. Distribution of lichen species according to substrate

which 285 were described as being epiphytic. The area of Trnovski gozd, located at the extreme northwest of the Dinaric Mountains near the Italian-Slovenian border, holds 209 lichen species (PRÜGGER et al. 2000). This comparison emphasizes the necessity for taking a further, comprehensive lichen inventory within Risnjak National Park, and in the Dinaric region of Croatia, too.

Most of the lichens recorded are indicators of montane and subalpine belts, whose climazonal forests vegetation prevails in the area. Therefore, *Acer pseudoplatanus* and *Fagus sylvatica* are the common main trees supporting the lichens in the study area, as they are in Snežnik and Javorniki in Slovenia (PRÜGGER 2005).

Relief variety and climate characterized by high annual rainfalls, frequent fog and dew, and high air humidity enable the occurrence of lichen species classified into oceanic and suboceanic elements (SCHAUER 1965). The currently known lichen flora of Risnjak National Park includes 28 oceanic and suboceanic species, which makes 39% of the total. This is a reflection of the broader geographical position of the Gorski kotar and Kvarner region along the eastern coast of the Adriatic Sea, which is more humid than the western Adriatic coast. The scarcity of oceanic and suboceanic lichens in Adriatic Italy, with a percentage between 11.1 and 16.6% in total lichen flora, has been reported by NIMIS and TRETIACH (1999).

A certain number of epiphytic lichens depend among other factors on the age of the trees. Species from the *Lobarion pulmonariae* alliance are long been recognised as key epiphytic species associated with ancient woodlands of high conservation interest across Europe (WOLSELEY and JAMES 2000). Endangered and rare species like *Degelia plumbea, Lobaria amplissima, Lobaria pulmonaria, Lobarina scrobiculata* and *Pannaria conoplea* can still be found growing in good conditions on old sycamore, beech, linden and elm-trees within the Risnjak National Park.

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