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Contributions to the lichen flora of Slovenia IX. Lichenized and lichenicolous fungi from Črni Kal (Kras)

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A b s t r a c t : WILFLING A. & H. MAYRHOFER (2002): Contributions to the lichen flora of Slovenia IX. Lichenized and lichenicolous fungi from Črni Kal (Kras). — Stapfia **80**: 293-310.

The lichens and lichenicolous fungi of the cliffs of Črni Kal, on the border of the Slovenian Karst was investigated for the first time. 124 taxa (120 species including 110 lichens and 10 lichenicolous fungi) are recorded. 56 taxa are reported for the first time for Slovenia, and a further 16 are new to the submediterranean phytogeographical region of Slovenia. A short overview on the history of lichenological research, on climate, geology, soils and vegetation in the karst area is given. Floristic composition and phytogeographical charcteristics are discussed.

P o v z e t e k : Flora lišajev in lišajskih gliv je bila prvič sistematično preučevana na skalah kraškega roba nad Črnim Kalom. Zabeleženih je bilo 124 taksonov, ki vključujejo 110 vrst lišajev in 10 vrst lišajskih gliv. 56 taksonov je novih za Slovenijo, nadalnjih 16 je novih za submediteransko fitogeografsko območje Slovenije. Za obravnavano kraško območje je podan kratek pregled zgodovine lihenoloških raziskav, podnebja, geologije, tal in vegetacije. Prispevek kritično obravnava floristično sestavo in fitogeograske značilnosti preučene lišajske flore.

Z u s a m m e n f a s s u n g : WILFLING A. & H. MAYRHOFER (2002): Beiträge zur Lichen-Flora von Slovenien IX. Flechten und flechtenbewohnende Pilze aus Črni Kal (Kras). — Stapfia **80**: 293-310.

Eine erste Untersuchung zur Flora der Flechten und flechtenbewohnenden Pilze der Felsabbrüche von Črni Kal, am Rande des slowenischen Karst wird vorgelegt. Es konnten insgesamt 124 Taxa (120 Arten davon 110 Flechten und 10 lichenicole Pilze) nachgewiesen werden. 56 Taxa sind Erstnachweise für Slowenien, weitere 16 Arten sind neu für die submediterrane phytogeographische Region Sloweniens. Es wird ein kurzer Abriss zur historischen Flechtenforschung im Karst, sowie zu Klima, Geologie, Böden und Vegetation gegeben. Die floristische Zusammensetzung und pflanzengeographische Besonderheiten werden diskutiert.

K e y w o r d s : Lichens, lichenicolous fungi, Flora of Slovenia, biodiversity, Karst, Črni Kal.

Introduction

Historical retrospective to the lichenological exploration of the area

The publication of the 'Catalogue of the lichenized and lichenicolous fungi of Slovenia' (SUPPAN et al. 2000) was an important step in the investigation of the lichen flora of Slovenia. This annotated catalogue is based on the literature of nearly 230 years,

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beginning with Scopoli's 'Flora Carniolica' (SCOPOLI 1772). Recently a new reference, unknown when the catalogue was completed, emerged. SCOPOLI (1769: 110) mentions '*Lichen islandicus*' from 'alpibus Carnioliae superioris' and 'in Comitatu Tolminensi' in his work on the medical use of *Cetraria islandica*. So far known this is the oldest report of a lichen for the area of today's Slovenia.

However, even the existence of such a comprehensive catalogue cannot allow us to lean back in contentment. On the contrary it shows us that there is still much work to undertake and a wide field for new investigations. From 177 species reported from Veliki Snežnik (ARUP et al. 2001) 36 are new to Slovenia. The high number of new records (56) for Slovenia in the present study is a further indicator for this. In Črni Kal we have to consider that the rocks investigated are restricted to only one main aspect (south-west).

GLOWACKI (1871) also investigated the lichen flora of the Kras region ('Das niedere Kalkgebiet'). In a list of lichens collected by Tommasini, GLOWACKI (1874) also reports saxicolous, terricolous and muscicolous species from the Karst. SCHULER (1893) lists several saxicolous species from the surroundings of Trieste (Val Rosandra, Kras etc.). CLERC (1983) added five further species to the comprehensive list given by NIMIS & LOI (1982) from Val Rosandra (Italy).

Kras and the karst – geography and historical exploration

The following introduction to the geography of Kras and to the origin of its name is based mainly on KRANJC (1997). Kras is a limestone plateau above Trieste Bay, the northernmost part of the Adriatic Sea. The plateau stretches NW to SE and is about 40 km long and up to 13 km wide, covering about 440 km^2. Although the Kras plateau is not very high (200-500 m.s.m.) when approaching from the sea side it has an very impressive border with steep limestone slopes and vertical limestone cliffs as around Črni Kal. It is physiographically delimited by Trieste Bay to the SW, the alluvial Friuli plain (river Soča, Isonzo) to the NW, the broad alluvial Vipava valley (flysch) to the NE and by the Brkini hills (flysch) and the Reka river valley to the SE. The transition from Kras towards the limestone ridges of Čičarija, Podgorski Kras and Materija valley is not clearly defined. The german word 'Karst' derives from the name of the country Kras (ital. Carso), not to be confused with 'karst' as a phenomen widely distributed in Slovenia (43% of the total surface) and the whole Balkan region. It is not known exactly why just Kras gave the general term to karst phenomena but a reason can be found in the geopolitical conditions from the 16th to the 19th century and the work of the scientists (geographers, cosmographers, cartographers and topographers) of that time. Karst became a common term for a special type of landscape. The term 'Kras' derives from the ancient roman name for the region 'carsus' and includes the pre-Indo-European stem 'kara' or 'gara' meaning 'stone'.

Karst caves were always the symbol of Kras and the first reports of this phenomenon go back to Posidonius of Apameia (135-50 B.C.) and Vergil (70-19 B.C.). Today the famous caves of Škocjanske jame belong to UNESCO's World's Heritage.

Geology and soils

Kras, part of the Adriatic-Dinaric plate, is dominated by limestones and dolomites which are cretaceous and tertiary carbonate deposits of shallow warm-water shelf environments (KNEZ et al. 1997). The carbonate rocks are very variable. The people

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inhabiting Kras used some for building, others as decorative stone, whereas others were the base for the soil on which thrives the cultivar of wine plant called 'Refošk' for making Teran, the famous Kras vine.

Kras' cretaceous rocks can be related to six different geological formations (KNEZ et al. op. cit). Within the tertiary rocks the alveolinid-nummulithic limestone of the Liburian formation are common in southwestern Slovenia. The medium to thick-bedded limestone is usually of grey or white colour. Its name derives from the abundance of fossils and remnants of various Foraminifereae namely from the families Alveolinidae and Nummulitidae. The investigated cliffs near Črni Kal are part of the highest embankments of Istria's Karst and contain also lithotypes of nummulithic limestones ("Calcari ad Alveoline e Nummuliti") of the lower Eocene. These limestones are extremely pure containing 91% calcite, 2,5% dolomite and 6,4% insoluble residues. Typical for the karst is the high rock solubility and well developed secondary porosity. The fracturation rate of the compact rock varies from a decimeter to a meter, stratification is often indistinct.

In most cases carbonate rocks are the parent material for soils in Kras (CULIBERG et al. 1997), which are determined mainly by inclination, micro forms of the relief and climate. Soils are often exposed to erosion by wind and water due to anthropogenic removing of the natural vegetation. In Kras three main types of soils are known: jerovica, rendzina and brown chromic cambisol. Jerovica has developed from insoluble residues of the weathered limestone and dolomites and is a shallow (0-40 cm) to medium deep (40-80 cm) soil. Due to the warm winter climate in this region, organic remnants tend to decompose very fast and so jerovica is extremly poor in organic content. Grapes, especially the sort 'Refošk', from which the famous 'Teran' is made, are cultivated particularly on the characteristic red to red brown soil (ital. terra rossa, slov. jerovica). Rendzina, also appearing on dolomite and limestone, is shallower (0-40 cm) than jerovica. It is characterized by an upper humus horizon. Brown chromic cambisols are deeper than rendzinas (up to 90 cm) and are characterized by many horizons. The upper part can contain a considerable amount of silt particles interwoven by roots, whereas the middle and the lower part consists of red brown clay.

Climate

The climate of Kras has a Mediterranean character with hot, dry summers and cold winters with most of the precipitation. The average annual precipitation for Kras is from 1417 to 1683 mm with two maxima and two minima in the precipitation regime. A first spring maximum occurs in June, but most of the rainfall occurs in November (KOGOVŠEK et al. 1997). February is the driest month and in July there is a further minimum of rainfall. Average annual temperatures range between 10,6 and 11,7°C. July is the warmest month with an average monthly temperature of 19,8 to 21°C and January is the coldest month with average temperatures between 1,6 and 2,8°C.

The most famous phenomenon (MIHEVC 1997) is the influence of very cold fallwinds from the NE called bora (slov. 'burja'). In earlier times, when Kras was bare landscape without trees and forests, bora was a severe problem for the people living there. The air warms and dries simultaneously when descending from the mountains nearby and so bora brings dry, sunny but harsh weather. Bora appears most frequently in the winter months when the temperature difference between littoral and continental areas are the highest. The influence of bora with maximum velocities of up to 170 km/h, average hourly velocities of about 19 km/h and average intensities of gusts of 70-

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94,5 km/h is enormous. This effects nearly every part of the life and can result in broken trees, unroofed houses, snow-drifts, closed roads or overturned cars. Also Kras architecture was strongly influenced by bora, resulting in stone-laid roofs, small windows and other features.

Flora and Vegetation

150 years ago a large part of Kras (between Trieste and Postojna) was still a stone desert comparable to today's stony Dalmatian islands (CULIBERG et al. 1997). Contrary to this 'low Kras' 'high Kras' was covered by forest vegetation. Successful plantings of the 'Austrian pine' (*Pinus nigra*) 150 years ago made 'low Kras' green again. However, as palynological investigations indicated 'low Kras' was not always a desert, and the same type of vegetation grew there in past millenia as grows in today's 'high Kras'. Mainly human factors like cattle-breeding and deforestation of the natural forests, and not climatic reasons caused the desertification of this area.

Today's Kras is a colourful mosaic of stony grasslands, shrubs and forests. Forests, mainly monocultures of planted Austrian pine, cover one half of Kras' area. One tenth is covered by fields, the rest is overgrown with grassland. Laymen often think that karst also implies dry rocky conditions and inhospitality and are often surprised when finding green meadows and dense pine forests. More recently, the picture of Kras has changed rapidly again, and no longer corresponds to the 'Karst' as we are used to. The almost complete abandonment of pasture and the disappearance of mowing on more skeletous soils and on steep slopes has caused a rapid 'comeback' of shrub vegetation and eventually of forests.

Within the grassland the Carici humilis-Centaureetum rupestris and the Danthonio alpinae-Scorzoneretum villosae are most frequent (SELIŠKAR 1994). The former association can be found on shallow skeletous soil and belongs to the floristically richest grasslands in Europe. The latter community thrives on deeper soil in flat areas of Kras, and therefore appears more green, less stony and with taller vegetation.

The predominant forest associations of Kras are the floristically very rich Ostryo-Quercetum pubescentis which is often degraded by human influence (mainly pasture) to Seslerio autumnalis-Ostryetum or Carici humilis-Centaureetum rupestris and the Seslerio autumnalis-Quercetum petraeae (ZUPANČIČ 1994). At higher altitudes (above 800 m) the Seslerio autumnalis-Fagetum appears.

Within the Submediterran region island-like extrazonal Mediterranean patches (maquis) restricted mainly to southerly exposed slopes or cliffs can be found. WRABER (1977, 1994) gives a description of the climate, relict flora and vegetation from Osp, a village with weakly oceanic conditions not far from Črni Kal. The Eumediterranean evergreen sclerophyll vegetation (Ostryo-Quercetum ilicis) contains many rare species and Osp is the only autochtonous locality where *Laurus nobilis* can be found in Slovenia. In general, truly Mediterranean species are rare in Kras.

Tommasini collected already in 1843 'on the cliffs overhanging S. Sergio/Černikal (TSM)' the stenoendemic chasmophytic *Moehringia tommasinii* (sub *M. muscosa* var. *firma)* (MARTINI 1990). This species has its highest frequency on slopes exposed to the south-west like in Črni Kal, where it is sheltered from the bora wind. MARTINI (op. cit.) described a new phytocoenosis, the Asplenio-Moehringietum tommasinii. There the *Moehringia* grows constantly accompanied by *Asplenium lepidum*,

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Campanula pyramidalis and *Sesleria juncifolia* var. *interrupta*. On the cliffs of Črni Kal in this association *Alyssum montanum*, *Coronilla emerus* ssp. *emeroides*, *Micromeria thymifolia*, *Parietaria ramiflora*, *Petrorhagia saxifraga*, *Satureja montana* ssp. *variegata* and *Seseli gouanii* were also found. Sporadic species were *Chondrilla juncea*, *Lathyrus sphaericus*, *Parietaria officinalis* and *Pinus nigra*. Within the Asplenio-Moehringietum tommasinii, the Mediterranean element (40%) prevails in the floristic composition, followed by Southern-Illyric (25%) and Oromediterranean (10%) elements. Illyric elements are less frequent compared to their important position in Northern Adriatic Karst territories. Central-european and Eurosiberian phytogeographical elements are absent in this community. This confirms the 'island situation' and refugial importance of this locality concerning (even endemic) phanerogams.

MARTINI (op. cit.) refers also to the importance of the presence of some xerothermic lichens with an essentially steppic distribution, like *Fulgensia fulgida*, *Gonohymenia nigritella*, *Mycobilimbia* (=*Lecidea*) *lurida*, *Squamarina cartilaginea* and *S. gypsacea* typical for this habitat, reported by NIMIS & LOI (1982) from Val Rosandra (Italy).

Phytogeographically Kras is a transitional Submediterranean area (with an strong Illyrian-Dinaric influence) between the North-American-Euro-Siberian region of Central Europe and the Mediterranean region (WRABER 1969). The region is characterized mainly by thermophilous deciduous trees, especially oak and hop hornbeam (CULIBERG et al. 1997). The floristic composition is determined by Submediterranean, South-European, Mediterranean-Pontic and thermophilous Illyrian species. Besides these Central European, Atlantic, Eurasian, Eurosiberian and Cosmopolitan species can be found.

Investigated localities

The specimens are deposited in the herbarium of the Institut für Botanik (GZU) or in the first authors private herbarium (aw). Locality names are given in German according to the labels. ANONYMOUS (1992) was used for orientation in the field and locality names are based on this atlas.





Figs 1-2: **1** – the village Črni Kal with the investigated cliffs from the Rižana valley; **2** – vertical cliffs above Črni Kal.

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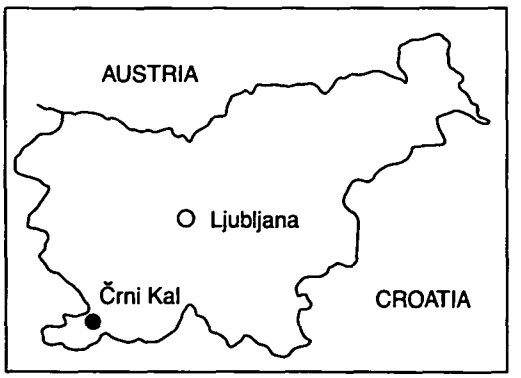


Fig. 3: Map of Slovenia with the investigated area. Slowenien, Kras, SW-exponierte Felsabbrüche SE über Črni Kal ...

Loc. 1: am Fuß der Abbrüche, am Weg von der Eisenbahntrasse zum gesicherten Klettersteig nahe der Ruine; stark geneigte und vertikale Kalkfelsflächen; ca. 370-390 m, 45°33'N/13°53'E, MTB 0449/3, 09.04.1999, leg. A. Wilfling & H. Mayrhofer

Loc. 2: nordöstliches Ende der Abbrüche; beim Wasserspeicher neben der Bergstraße Črni Kal – Črnotiče;, Schräg- und Vertikalflächen an der oberen Kante der Abbrüche; ca. 360 m; 45°33'13"N/13°53'05"E, y=5412940, x=5046070, MTB 0449/1, 28.10.2000, leg. A. Wilfling & J. Prügger

Loc. 3: oberer Rand der Abbrüche zwischen Wasserspeicher und einer Ruine, vertikale Abbrüche und Überhangflächen; ca. 370-380 m; 45°33'11"N/13°53'07"E; y=5413000, x=5046030; MTB 0449/1; 28.10.2000, leg. A. Wilfling & J. Prügger

Loc. 4: obere Kante der Abbrüche von der Ruine bis ca. 100 m südöstlich;, ca. 370-380 m; 45°33'08"N/13°53'11"E; y=5413080, x=5045920; MTB 0449/1, 28.10.2000, leg. A. Wilfling & J. Prügger

Loc. 5: Kante der Felsabbrüche unmittelbar W über der Eisenbahntrasse, auf niederen Felsen; ca. 370-380 m; 45°33'00"N/13°53'20"E; y=5413270, x=5045680; MTB 0449/1, 28.10.2000, leg. A. Wilfling & J. Prügger

Loc. 6: Weg von der Eisenbahntrasse zum gesicherten Klettersteig nahe der Ruine; am Fuße der Abbrüche ca. 20-50 m nach der Bahntrasse; sehr trockene, vertikale Felswände; ca. 350-360 m; 45°32'58"N/13°53'22"E; y=5413300, x=5045600; MTB 0449/3; 28.10.2000, leg. A. Wilfling & J. Prügger

Loc. 7: Weg von der Eisenbahntrasse zum gesicherten Klettersteig nahe der Ruine; am Fuße der Abbrüche, extrem trockene, steile Schrägflächen am Fuß der vertikalen Wände; ca. 350-360 m; 45°33'07"N/13°53'10"E; y=5413050, x=5045880; MTB 0449/1; 28.10.2000, leg. A. Wilfling & J. Prügger

List of taxa

The nomenclature follows HAFELLNER & TÜRK (2001), SANTESSON (1993) and WIRTH (1995). For determination of the material CLAUZADE & ROUX (1985), POELT & LEUCKERT (1995), BREUSS (1985, 1996a,b), TIMDAL (1991), ZEHETLEITNER (1978), CLAUZADE et al. (1989) and HAFELLNER (1987, 1994) were used. For some rare, badly

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known or easily overlooked species which are often only found under the stereo microscope the accompanying species (on the sample) are mentioned in order to get a better picture of their ecological demands and to be able to focus the search on them in the field.

Species new to Slovenia are indicated with an asterisk*; species new to the Submediterranean phytogeographical region of Slovenia with a ring°.

Lichenized fungi

***Acarospora cervina* A. MASSAL.: 2 (aw, GZU)**

Both samples are overgrown by the parasitic *Caloplaca inconnexa.*

***Agonimia opuntiella* (POELT & BUSCHARDT) V ZDA: 3 (aw)**

The specimen only contains sterile material, but due to the squamulose thallus with the typical hyaline setae we are sure it belongs to this rarely collected, often misinterpreted taxon.

***Anema decipiens* (A. MASSAL.) FORSSELL: 1 (aw, GZU)**

***Anema nummularium* (DURIEU & MONT.) NYL.: 6 (aw, GZU)**

***Anema tumidulum* HENSSEN ined.: 6 (aw, GZU)**

Single thalli (never in groups) of this umbilicate species with its typical globose-isidiate surface are common on this locality.

***Aspicilia calcarea* (L.) MUDD: 1 (aw), 2 (aw), 5 (aw)**

At loc. 1 *A. calcarea* was the host for *Verrucaria* sp.; at loc. 2 for *Verrucaria aspiciliicola.*

***Aspicilia cheresina* (MÜLL. ARG.) HUE var. *cheresina*: 4 (aw)**

***Aspicilia contorta* (HOFFM.) KREMP.: 1 (aw), 2 (GZU), 3 (aw), 5 (aw)**

This common species is parasitised by *Muellerella pygmaea*, *Opegrapha parasitica* and *Weddellomyces pachyosporicola.*

***Bagliettoa parmigera* (J. STEINER) V ZDA & POELT: 1 (aw)**

B. parmigera is much rarer than the very common *B. steineri.*

***Bagliettoa steineri* (KUŠAN) V ZDA: 1 (aw), 3 (aw), 4 (aw)**

Two specimens are infected by the parasitic *Opegrapha rupestris.*

***Caloplaca agardhiana* (A. MASSAL.) CLAUZADE & Cl. ROUX: 4 (aw)**

It was found on low vertical rocks near the upper edge of the cliffs.

***Caloplaca alociza* (A. MASSAL.) MIG.: 2 (aw), 3(aw)**

It was found on vertical to overhanging rocks.

***Calopaca areolata* (ZAHLBR.) CLAUZADE: 1 (GZU), 3 (aw)**

***Caloplaca aurantia* (PERS.) HELLB.: 1 (aw, GZU)**

Accompanying species: *Rinodina lecanorina*, *Psorotichia montinii* and *Verrucaria fuscula.*

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****Caloplaca biatorinoides* (CLAUZADE & Cl. ROUX) GAYA, NAV.-ROS. & Cl. ROUX ined.: 1 (aw, GZU), 3 (aw)**

Based on spore morphology, distribution pattern and ecology, the former subspecies of *C. saxicola* was given species rank by GAYA et al. (2000). In Črni Kal the species grows on large dry vertical faces underneath overhanging rocks, sheltered from rain, mainly together with *Lecanora reuteri* but also with *Caloplaca granulosa*, *Peltula euploca* and *Verrucaria latericola*.

***Caloplaca chalybaea* (FR.) MÜLL. ARG.: 3 (aw)**

***Caloplaca cirrochroa* (ACH.) TH. FR.: 1 (aw), 3 (aw), 4 (aw)**

Accompanying species: *Caloplaca granulosa*, *Lecanora pruinosa*, *Toninia athallina* and *T. tumidula*.

***Caloplaca coronata* (KREMP. ex KÖRB.) J. STEINER: 2 (aw)**

***Caloplaca decipiens* (ARNOLD) BLOMB. & FORSSELL: 1 (aw)**

***Caloplaca dolomiticola* (HUE) ZAHLBR.: 5 (aw)**

***Caloplaca erythrocarpa* (PERS.) ZWACKH: 5 (aw)**

***Caloplaca flavescens* (HUDS.) J.R. LAUNDON: 1 (aw, GZU), 2 (aw, GZU), 3 (aw), 4 (aw), 6 (aw)**

At loc. 3 the specimen is infected by *Weddellomyces epicallopisma*. It is common on vertical rocks together with *Solenopsora candicans* and *Lecanora pruinosa*.

***Caloplaca granulosa* (MÜLL. ARG.) JATTA: 1 (aw, GZU), 3 (aw), 4 (aw), 6 (aw)**

This species occurs at places sheltered from rain on the bottom of dry vertical rocks. It is often overgrown by the parastic *Verrucaria latericola*; associated with *Caloplaca biatorinoides*, *Lecanora agardhiana* ssp. *agardhiana*, *L. pruinosa*, *Rinodina lecanorina*, *Rinodinella controversa* and *Toninia athallina*.

°*Caloplaca inconnexa* (NYL.) ZAHLBR.: 1 (aw, GZU), 2 (aw, GZU)

The species overgrows *Acarospora cervina*, *Placocarpus schaereri* and *Rinodina lecanorina* on low rocks.

***Caloplaca ochracea* (SCHAER.) FLAGEY: 1 (aw), 3 (aw)**

***Caloplaca polycarpa* (A. MASSAL.) ZAHLBR.: 1 (aw), 3 (aw)**

This species grows on an endolithic *Verrucaria*-thallus and is partly overgrown by the parasitic *Verrucaria latericola*.

***Caloplaca saxicola* (HOFFM.) NORDIN: 1 (aw, GZU)**

Accompanying species: *Lecanora crenulata* and *Sarcogyne regularis*.

***Caloplaca variabilis* (PERS.) MÜLL. ARG.: 6 (aw)**

***Caloplaca velana* (A. MASSAL.) DU RIETZ: 1 (aw)**

***Caloplaca xantholyta* (NYL.) JATTA: 3 (aw)**

***Candelariella medians* (NYL.) A.L. SM.: 1 (aw, GZU), 2 (aw), 3 (aw), 6 (aw)**

This species is common at loc. 1; accompanying species: *Caloplaca flavescens*, *Lobothallia radiosa*, *Peltula euploca*, *Placocarpus schaereri*, *Rinodinella controversa*, *Toninia cinereovirens* and *Verrucaria* sp.

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Catillaria lenticularis **(ACH.) TH. FR.: 2 (aw), 3 (aw)**

Cladonia convoluta **(LAM.) ANDERS: 4 (aw)**

Cladonia rangiformis **HOFFM.: 1 (aw)**

°*Cladonia symphycarpa* (FLÖRKE) Fr.: 4 (aw)

Clauzadea immersa **(HOFFM.) HAFELLNER & BELLEM.: 1 (aw, GZU), 2 (aw)**

****Clauzadea metzleri*** **(KÖRB.) CLAUZADE & Cl. ROUX ex D. HAWKSW.: 1 (aw)**

Collema auriforme **(WITH.) COPPINS & J.R. LAUNDON: 2 (aw)**

Collema cristatum **(L.) WEBER ex F.H. WIGG.: 1 (aw), 3 (aw)**

Collema undulatum **LAURER ex FLOT.: 2 (aw)**

Dermatocarpon miniatum **(L.) W. MANN: 1 (aw)**

Diplotomma epipolium **(ACH.) ARNOLD: 2 (aw)**

****Diplotomma nivalis*** **(BAGL. & CARESTIA) HAFELLNER: 2 (aw), 3 (aw, GZU), 4 (aw)**

At loc. 2 *D. nivalis* grows on the thalli of *Lecanora muralis* and even overgrows the thick thalli of the parasitic *Placocarpus schaereri*. It is known as a parasite on various species of Teloschistaceae.

Diplotomma scheideggerianum **(BRICAUD & Cl. ROUX) NIMIS: 1 (aw)**

BRICAUD & ROUX (1991: 170) mention that this parasitic species (on *Caloplaca xantholyta*) was observed near Škocjanske jame (Matavum) in Kras.

****Dirina stenhammari*** **(FR. ex STENH.) POELT & FOLLMANN: 1 (GZU)**

This species is recorded only as one large thallus on vertical rocks.

Fulgensia fulgens **(SW.) ELENKIN: 1 (aw)**

****Gonohymenia nigritella*** **(LETTAU) HENSSEN: 1 (aw)**

****Gonohymenia schleicheri*** **(HEPP) HENSSEN: 1 (aw)**

This species occurs together with *Rinodina lecanorina*.

****Lecania inundata*** **(HEPP ex KÖRB.) M. MAYRHOFER: 1 (aw)**

****Lecania sylvestris*** **(ARNOLD) ARNOLD: 1 (aw)**

****Lecania turicensis*** **(HEPP) MÜLL. ARG.: 1 (aw)**

°*Lecanora agardhiana* ACH. ssp. *agardhiana*: 1 (aw, GZU)

According to POELT & LEUCKERT (1995: 309) ssp. *agardhiana* is frequent on the southern slopes of the Alps but at the same time they refer to the heterogeneous nature of this taxon.

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***Lecanora agardhiana* ssp. *sapaudica* CLAUZADE & Cl. ROUX var. *sapaudica*: 1 (aw, GZU)**

°*Lecanora crenulata* HOOK.: 1 (GZU)

***Lecanora dispersa* (PERS.) SOMMERF.: 2 (aw)**

***Lecanora muralis* (SCHREB.) RABENH.: 1 (GZU), 2 (aw), 5 (aw)**

This species is the host for *Diplotomma nivalis* and *Placocarpus schaereri*.

°*Lecanora pruinosa* CHAUB.: 1 (aw, GZU), 2 (aw), 3 (aw)

This species is common on vertical to overhanging walls and occurs sometimes close together with *Lecanora reuteri*. Further accompanying species: *Caloplaca cirrochroa*, *C. flavescens*, *C. granulosa*, *Lecanora agardhiana* ssp. *agardhiana*, *Rinodinella controversa*, *Solenopsora candicans*, *Toninia athallina*, *T. tumidula* and *Verrucaria latericola*.

***Lecanora reuteri* SCHAER.: 1 (aw), 3 (aw)**

This species covers on the vertical to overhanging rocks of loc. 3 large areas together with *Caloplaca biatorinoides*.

°*Leptogium intermedium* (ARNOLD) ARNOLD: 4 (aw)

***Leptogium lichenoides* (L.) ZAHLBR.: 4 (aw)**

***Lobothallia radiosa* (HOFFM.) HAFELLNER: 1 (aw, GZU), 4 (aw)**

***Mycobilimbia lurida* (ACH.) HAFELLNER: 1 (aw), 2 (GZU), 3 (aw), 6 (aw)**

***Opegrapha rupestris* PERS.: 1 (aw)**

This species is common on *Baglietoa steineri*.

***Peltula euploca* (ACH.) POELT: 1 (GZU)**

Single scattered squamules of *P. euploca* were found together with *Caloplaca granulosa*, *C. biatorinoides* and *Rinodinella controversa* in very dry places.

***Petractis clausa* (HOFFM.) KREMP.: 1 (aw)**

***Phaeophyscia cernohorskyi* (NADV.) ESSL. 1 (aw)**

°*Phaeophyscia chloantha* (ACH.) MOBERG: 1 (GZU)

According to WIRTH (1995) this mainly corticolous species does not often grow on rock.

***Physcia caesia* (HOFFM.) FÜRNR.: 1 (GZU)**

***Placidiopsis* sp.: 1 (aw)**

This is a small saxicolous species.

***Placidium rufescens* (ACH.) BREUSS: 1 (aw)**

This species is recorded as only a few scattered squamules growing directly on rock.

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Placocarpus schaereri **(FR.) BREUSS: 1 (aw, GZU), 2 (aw) 5 (aw)**

This species grows mainly on low rocks on *Lecanora muralis* or even on *Rinodina lecanorina* (aw 3774); serving as a host for *Caloplaca inconnexa* and *Diplotomma nivalis*.

****Placolecis opaca*** **(FR.) HAFELLNER: 1 (aw)**

Placynthium nigrum **(HUDS.) GRAY: 1 (aw, GZU)**

Placynthium subradiatum **(NYL.) ARNOLD: 1 (aw)**

Protoblastenia incrustans **(DC.) J. STEINER: 1 (aw), 2 (aw)**

This species occurs as single apothecia dispersed between other thalli.

Protoblastenia rupestris **(SCOP.) J. STEINER: 2 (aw)**

Psora decipiens **(HEDW.) HOFFM. 6 (aw)**

****Psorotichia diffracta*** **(NYL.) FORSSELL: 1 (aw)**

It grows together with *Thyrea confusa*.

****Pyrenocollema*** **sp.: 1 (aw)**

°*Rinodina dubyana* (HEPP) J. STEINER: 1 (aw)

Rinodina immersa **(KÖRB.) ZAHLBR.: 1 (aw, GZU)**

Rinodina lecanorina **(A. MASSAL.) A. MASSAL.: 1 (aw, GZU)**

This is one of the most common species on the inclined areas at the foot of the cliffs, overgrowing *Caloplaca aurantia*, *Rinodinella controversa*, *Verrucaria fuscula* and other species.

****Rinodina zwackhiana*** **(KREMP.) KÖRB.: 1 (aw, GZU), 6 (aw)**

Rinodinella controversa **(A. MASSAL.) H. MAYRHOFER & POELT: 1 (aw, GZU), 6 (aw)**

R. controversa is often overgrown by *Rinodina lecanorina*.

Sarcogyne regularis **KÖRB. var. *regularis*: 1 (GZU)**

****Sarcogyne regularis*** **var. *intermedia*** **(KÖRB.) N.S. GOLUBK.: 1 (aw)**

****Sarcopyrenia beckhausiana*** **(LAHM) AGUIRRE, NAV.-ROS. & HLADUN: 1 (aw)**

Up to now *S. beckhausiana* was only reported from Germany and Spain (NAVARRO-ROSINES & HLADUN 1990). On the rocks of Črni Kal this species is accompanied by *Placynthium subradiatum*, *Staurothele immersa* and additional 'cyanolichens'.

****Solenopsora candicans*** **(DICKS.) J. STEINER: 2 (aw, GZU)**

The comparison with further material from the herbarium GZU showed that the colour of the apothecia is in many cases brown with a distinct pruina and not black like often mentioned in literature (CLAUZADE & ROUX 1985, WIRTH 1995).

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***Squamarina cartilaginea* (WITH.) P. JAMES: 3 (aw), 4 (aw)**

The sample from locality 3 is infected by *Clypeococcum epicrassum*.

****Staurothele immersa* (A. MASSAL.) DALLA TORRE & SARNTH.: 1 (aw)**

***Synalissa symphorea* (ACH.) NYL.: 1 (GZU), 3 (aw), 6 (aw)**

****Thelidium olivaceum* (FR.) KÖRB.: 1 (aw)**

****Thelochroa montinii* A. MASSAL.: 1 (GZU)**

Accompanying species: *Caloplaca aurantia*, *Rinodina lecanorina* and *Verrucaria fuscula*.

****Thyrea confusa* HENSSEN: 1 (aw)**

This species occurs on dry vertical rocks associated with *Psorotichia diffracta*.

***°Toninia athallina* (HEPP) TIMDAL: 1 (aw, GZU), 3 (aw)**

***Toninia candida* (WEBER) Th. FR.: 6 (aw)**

****Toninia cinereovirens* (SCHAER.) A. MASSAL.: 1 (aw, GZU), 6 (aw)**

At loc. 1 this species is partly overgrown by *Candelariella medians*; at loc. 6 it occurs together with different 'cyanolichens'.

****Toninia tristis* (Th. FR.) Th. FR. ssp. *asiae-centralis* (H. MAGN.) TIMDAL: 6 (aw)**

****Toninia tumidula* (SM.) ZAHLBR.: 3 (aw)**

This species occurs in vertical sunny rock crevices.

***Verrucaria aspiciliicola* R. SANT.: 2 (aw, on *Aspicilia calcarea*)**

****Verrucaria beltraminiana* (A. MASSAL.) TREVIS.: 1 (aw)**

***Verrucaria calciseda* DC.: 2 (aw), 4 (aw)**

***°Verrucaria cazzae* ZAHLBR.: 1 (aw)**

The only record of this species for Slovenia was given for the Dinarids (ARUP et al. 2001)

****Verrucaria compacta* (A. MASSAL.) JATTA: 1 (aw, GZU), 2 (aw), 3 (aw), 5 (aw)**

For the separation of *V. compacta* from *V. fuscula* see BREUSS (1994).

****Verrucaria fuscula* NYL.: 1 (aw, GZU), 5 (aw)**

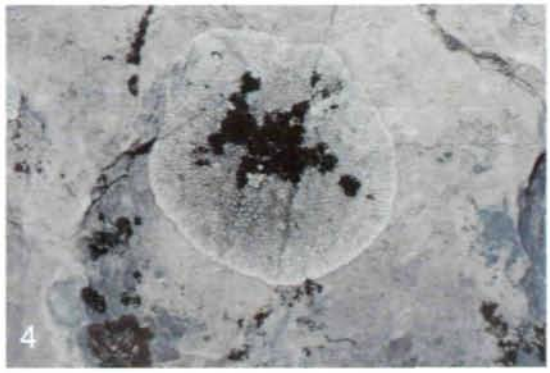
The well developed material of loc. 5 shows *V. fuscula* growing in the center of large thalli of *Aspicilia calcarea*.

***Verrucaria hochstetteri* FR. var. *obtecta* (MÜLL. ARG.) CLAUZADE & Cl. ROUX: 1 (aw), 2 (aw)**

The only record of this taxon for Slovenia was made in the Dinarids (ARUP et al. 2001).

****Verrucaria latericola* ERICHS.: 1 (aw, GZU), 3 (aw), 4 (aw)**

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Figs 4-5: **4** – *Verrucaria fuscula* growing in the center of *Aspicilia calcarea*; **5** – immersed perithecium of *Verrucaria hochstetteri* var. *obtecta*.

This parasitic species is infecting mainly *Caloplaca granulosa* (described as *V. granulosaria*, ZEHETLEITNER 1978) and is establishing it's own thallus there. Afterwards it can 'attack' further neighbouring thalli like that of *Rinodinella controversa*. MCCARTHY (1988) extended the 'host spectrum' of *V. latericola* to five further species. SPARRIUS et al. (2000) reported the species from basaltic rock in Friesland. JACOBSEN & COPPINS (1989) showed that the original material described by ERICHSEN (1943) is a parasite on *Caloplaca decipiens*. The specimen aw 3771, where the thallus of *Rinodinella controversa* was completely changed into the parasits thallus is a good examples for the host-unspecifity and aggressivity of this lichen. The parasite is quiet common on the cliffs of Črni Kal.

***Verrucaria macrostoma* DUF. ex. DC.: 1 (aw)**

***Verrucaria marmorea* (SCOP.) ARNOLD: 1 (aw), 4 (aw)**

***Verrucaria murina* LEIGHT.: 1 (aw)**

***Verrucaria nigrescens* PERS.: 1 (aw)**

***Verrucaria sphaerospora* ANZI: 3 (aw)**

***Xanthoria calcicola* OXNER: 1 (aw), 5 (aw)**

***Xanthoria parietina* (L.) TH. FR.: 1 (GZU)**

Lichenicolous fungi

***Cercidospora* cf. *caudata* KERNST.: 1 (aw), 6 (aw)**

host: *Caloplaca flavescens*.

***Clypeococcum epicrassum* (H. OLIVIER) NAV.-ROS. & CL. ROUX: 3 (aw)**

This species is parasitic on different species of the genus *Squamarina* (NAVARRO-ROSINES & al. 1994) in arid areas of the Mediterranean regions (here *S. cartilaginea*).

***Endococcus propinquus* (KÖRB.) D. HAWKSW.: 1 (aw)**

hosts: *Verrucaria* sp., *V. nigrescens*.

***Endococcus 'rugulosus'* NYL.: 1 (aw), 2 (aw)**

host: sterile endolithic crust.

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°*Muellerella pygmaea* (KÖRB.) D. HAWKSW.:

On thalli of *Aspicilia contorta* 1 (aw), *Caloplaca dolomiticola* 5 (aw), *C. granulosa* 1 (aw), *Protoblastenia rupestris* 2 (aw), *Rinodinella controversa* 6 (aw) and *Rinodina lecanorina* 1 (aw).

°*Opegrapha parasitica* (A. MASSAL.) H. OLIVIER: 1 (aw)

This species growing parasitically on *Aspicilia contorta* was determined according to HAFELLNER (1994).

***Polycoccum opulentum* (Th. FR. & ALMQ. ex Th. FR.) ARNOLD: 2 (GZU), 4 (aw), 5 (aw)**

hosts: sterile crust and *Verrucaria* sp.

***Stigmidium congestum* (KÖRB.) TRIEBEL: 3 (aw)**

host: *Lecanora reuteri*

***Weddellomyces epicallopisma* (WEDD.) D. HAWKSW.: 3 (aw)**

host: *Caloplaca flavescens*

***Weddellomyces pachyosporicola* NAV.-ROS. & Cl. ROUX: 2 (GZU)**

This species, parasitic on *Aspicilia contorta*, was previously only known from Spain (NAVARRO-ROSINÉS & ROUX 1995).

Discussion

With respect to higher plants, 2037 species were reported (MARTINČIČ et al. 1999) for the Submediterranean region of Slovenia. This is the highest number within Slovenia's phytogeographical regions and comprises two third of the whole autochthonous flora (2979 species). With respect to lichens, 196 taxa were reported in the checklist of SUPPAN et al. (2000) for the Submediterranean phytogeographical region of Slovenia, and 71 additional taxa are reported in this publication, making a total of altogether 267 taxa. However, this is still far from a comprehensive census for the region.

NIMIS & LOI (1982) reported about 250 species from Val Rosandra (a locality with Mediterranean character near Trieste), of which 127 were either saxicolous-calcicolous lichens (38%) or terricolous (13%). The rest were lichens on flysch or epiphytic lichens. The number of species recorded on these substrates in Črni Kal is somewhat lower (110). The reasons for this may be due to two factors. The area surveyed in Črni Kal is much smaller than that of Val Rosandra. The Italian part of Val Rosandra comprises about 0,5 km^2, whereas in Črni Kal only the narrow upper margin of the cliffs and some single sites on the bottom were investigated. The second reason why species diversity is lower in Črni Kal is that there exists no great diversity in habitats and microclimates. In Črni Kal we have only one significant steep wall exposed to the southwest, where we have relatively uniform climatic and hygrometric conditions, whereas Val Rosandra is a canyon with a great diversity in habitats.

For both localities we must state that the investigations are far from completed with the publication of data. In Val Rosandra the number of species has meanwhile gone beyond 300 (TRETIACH pers.com.) and two days of field work in Črni Kal can also bring only preliminary data.

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Phytogeographically 71% of the saxicolous-calcicolous species recorded in Val Rosandra had a southern European distribution of which 14% were strictly Mediterranean (NIMIS & LOI 1982). In Črni Kal, 72% are shared with southern Europe whereas the amount of Mediterranean species is lower (9%). The most remarkable Mediterranean lichens are *Anema nummularium*, *Caloplaca areolata*, *C. biatorinoides*, *Gonohymenia nigritella*, *Placolecis opaca*, *Rinodinella controversa* and *Verrucaria cazzae*. South European-Mediterranean species (19%) are represented by *Baglietoa parmigera*, *Caloplaca aurantia*, *C. erythrocarpa*, *C. granulosa*, *C. inconnexa*, *C. ochracea*, *Candelariella medians*, *Diplotomma scheideggeriana*, *Lecanora agardhiana* ssp. *agardhiana*, *Peltula euploca*, *Placocarpus schaereri*, *Psorotichia diffracta*, *Solenopsora candicans*, *Staurothele immersa*, and *Verrucaria marmorea*. Representatives of the family Lichinaceae mentioned by NIMIS & LOI (op. cit.) are not that frequent in Črni Kal, due mainly to the absence of periodically humid vertical rocks. The steep cliffs of Črni Kal dry relatively quickly after rain, and members of the Peccanio-Thyreetum pulvinatae, typical for such conditions, can be found only rarely on the bottom of the cliffs (loc. 1,6,7) or were inaccessible without climbing equipment. The absence of humid or shaded habitats is also shown by the lack of otherwise common species like *Acrocordia conoidea*, *Gyalecta jenensis*, *Porina linearis* or *Protoblastenia calva*.

Central European-mediterranean species (42%) like *Acarospora cervina*, *Anema decipiens*, *Caloplaca chalybaea*, *C. coronata*, *Lecanora pruinosa* or *Verrucaria compacta* are most frequent in Črni Kal. Widely distributed species (Arctic-Mediterranean, Boreal-Mediterranean) like *Aspicilia contorta*, *Catillaria lenticularuis*, *Lecanora crenulata*, *Physcia caesia* or *Verrucaria nigrescens* comprise nearly one third of all taxa. This nitrophytic species are often favoured by manured conditions on top of boulders visited by birds.

Terricolous lichens include species like *Fulgensia fulgens*, *Mycobilimbia lurida*, *Placidium rufescens*, *Psora decipiens*, *Squamarina cartilaginea*, *Toninia candida*, *T. tristis* ssp. *asiae-centralis* and *T. tumidula* growing on minimal accumulations of soil in rock crevices and on bare soil corresponding to the community *Fulgensietum fulgentis* and species as *Cladonia convoluta* and *C. rangiformis* in more developed stages referring to the *Cladonietum covolutae*. Terricolous lichens are about 12 % of all species. *Agonimia opuntiella* and *Leptogium lichenoides* are members of the poorly developed muscicolous lichen flora.

In total 65 of 127 lichens reported from Val Rosandra were also found in Črni Kal, while 45 additional species were recorded here. Some noteworthy species like *Agonimia opuntiella*, *Caloplaca biatorinoides*, *Rinodina zwackhiana*, *Sarcopyrenia beckhausiana*, *Verrucaria latericola* or the lichenicolous fungus *Weddellomyces pachyosporicola* are even rare through whole Europe.

The composition of the lichen flora of Črni Kal reflects the position of the whole karst as a transitional area between Mediterranean and Central European flora and climate, and the occurence of many rare species underlines also the specific status of single localities to a country's natural heritage.

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