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VASCULAR PLANTS ON BEECH DEAD WOOD IN TWO SLOVENIAN FOREST RESERVES

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Abstract

The vascular plant flora on dead beech trees in two Slovenian virgin forest reserves, Rajhenavski Rog and Krokar, has been investigated. Plant species were determined on 110 dead trees in Rajhenavski Rog, and on 102 in Krokar. The selected trees represent different decay phases and size categories. Crowns, logs and snags were investigated separately. Species composition and frequency, distribution of life-forms were studied. A total of 110 vascular plant species were found on dead wood and in its contact zone, 71 species in Rajhenavski Rog and 85 in Krokar. *Cardamine trifolia* L. and *Oxalis acetosella* L. are the most common species, occurring on 85 % of all dead trees. On more than half of the selected trees we found *Galium odoratum* (L.) Scop. (76 %), *Fagus sylvatica* L. (67 %), *Omphalodes verna* Moench (63 %) and *Cardamine enneaphyllos* (L.) Crantz (55 %) too. Most of species favoured the bottom of snags and well-decayed logs. More than 50% of dead wood inhabiting vascular plants are hemicryptophytes, geophytes are frequent too. In these two near-natural forests in southern Slovenia dead wood is one of the crucial elements of biodiversity. It plays an important role in forest regeneration and enhances the richness of vascular plants.

Key words: dead wood, coarse woody debris, *Fagus sylvatica* L., undergrowth, biodiversity, virgin forest remnant, Kočevska, Slovenia.

VASKULARNE RASTLINE NA ODMRLEM BUKOVEM DREVJU V DVEH GOZDNIH REZERVATIH V SLOVENIJI

Izvleček:

V dveh slovenskih pragozdnih ostankih (Rajhenavski Rog in Krokar) smo raziskovali prisotnost vaskularnih rastlin na odmrlem bukovem drevju (veliki lesni ostanki). Rastline smo popisali na 110 odmrlih drevesih v Rajhenavskem Rogu in na 102 drevesih v Krokarju. Izbrano drevje je bilo v različnih fazah razgradnje in različnih debelin. Ločeno smo obravnavali rastline na panjih, ležečih deblih in krošnjah odmrlih dreves. Analizirali smo vrstno sestavo vaskularnih rastlin, frekvenco pojavljanja, pestrost in delež posameznih življenjskih oblik. Na odmrlem drevju in njegovem neposrednem kontaktnem območju smo skupaj popisali 110 rastlinskih vrst. V rezervatu Rajhenavski Rog smo našli 71 vrst, v Krokarju pa 85 vrst. Najpogostejši vrsti (Cardamine trifolia L. in Oxalis acetosella L.) smo našli na 85 % vseh izbranih dreves. Na več kot polovici dreves smo popisali tudi vrste Galium odoratum (L.) Scop. (76 %), Fagus sylvatica L. (67 %), Omphalodes verna Moench (63 %) in Cardamine enneaphyllos (L.) Crantz (55 %). Večina popisanih vrst se pojavlja med koreničnikom dreves (ob razpadajočem panju) in na bolj razgrajenih ležečih deblih. Več kot polovico popisanih vrst predstavljajo hemikriptofiti; pogosti so tudi geofiti. V proučevanih pragozdnih rezervatih je odmrlo drevje eden ključnih elementov biodiverzitete. Pomembno vlogo ima pri obnovi in pomlajevanju gozda ter za povečanje vrstne pestrosti.

Ključne besede: odmrlo drevje, veliki lesni ostanki, Fagus sylvatica L., pritalna vegetacija, biotska pestrost, vrstna raznolikost, pragozd, Kočevska, Slovenija.

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VSEBINA

1 INTRODUCTION
UVOD

Dead wood (or coarse woody debris; CWD) is regarded as an important structural and ecological component of forest ecosystems. It is an important nutrient storage, influences geomorphologic processes, and is essential to a lot of organisms (e.g. fungi, bryophytes, lichens, invertebrates, amphibians, cavity nesting birds and small mammals such as bats) (HARMON *et al.* 1986, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, CSÓKA 2000). Dead wood offers very favourable conditions for many vascular plants too. Herbaceous plants growing on dead wood usually occur on the forest floor and are seldom if ever obligatory epixylics.

Soil disturbances connected to tree uprooting (pits, mounds etc.) create important colonisation possibilities for herbaceous plants. Logs have a significant effect on the regeneration of tree species and ferns. In boreal forests nurse logs facilitate seedling establishment of *Pseudotsuga menziesii* (Mirbel) Franco and *Tsuga heterophylla* (Raf.) Sarg. in North America and of *Picea abies* (L.) Karst. in Europe (HARMON *et al.* 1986, HOFGAARD 1993, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, ESSEEN *et al.* 1997, ULANOVA 2000). The survival rate of seedlings is higher on logs than on the forest floor.

Unfortunately, all of the European forest stands are influenced by people and only a few near-natural stands exist (PETERKEN 1996, ROSE 1992). In managed stands the amount of dead wood is much less than in near-natural, old-growth forests. It amounts to cca. 5-10 % in boreal forests (ANDERSSON / HYTTEBORN 1991, LESICA *et al.* 1991, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, JONSSON 2000), and to cca. 10-20 % in broad-leaved forests (GREEN / PETERKEN 1997, KIRBY *et al.* 1997, BONČINA 2000a, b, ÓDOR / STANDOVÁR 2001). Unmanaged and managed forests also differ considerably in the quality of dead wood (SÖDERSTRÖM 1988, ANDERSSON / HYTTEBORN 1991, RAMBO / MUIR 1998, KRUYS *et al.* 1999, JONSSON 2000, ÓDOR / STANDOVÁR 2001). In old-growth forests the proportion of large logs and snags is high, the distribution of decay stages is more even and logs of different sizes and decay phases are continuously present in time. In managed stands, however, the proportion of fine woody debris (small branches and logs) and stumps is

high, well-decayed logs are under-represented and the presence of dead wood depends mainly on forestry activities (CHRISTENSEN / EMBORG 1996, KRUYS *et al.* 1999, CSÓKA 2000). As a consequence of the restricted availability of dead wood in managed forests, especially when logs of greater size are missing, the diversity of wood inhabiting organisms is much lower compared with near-natural stands. This is shown for bryophytes and vasculars (AUDE / LAWESSON 1998, LESICA *et al.* 1991, GUSTAFSSON / HALLINGBÄCK 1988, ANDERSSON / HYTTEBORN 1991, SÖDERSTRÖM 1988, ÓDOR / STANDOVÁR 2001, RAMBO / MUIR 1998). Studies on fungi (SILLER 1986, SIPPOLA / RENVALL 1999), invertebrates (SIITONEN 2001) and cavity nesting birds (SANDSTRÖM 1992) lead to the same conclusion.

Two near-natural forest reserves are Rajhenavski Rog and Krokar located near Kočevje in Slovenia. Both reserves contain old beech and fir dominated stands with a multi-layered canopy, a mosaic of different development phases and a high amount of dead wood. Some studies from these reserves include vascular plants, fungi, bryophytes and lichens (PUNCER / ZUPANČIČ 1970, PUNCER / WOJTERSKI / ZUPANČIČ 1974, MARINČEK / PUNCER / ZUPANČIČ 1980, PUNCER 1980, HOČEVAR *et al.* 1985, 1995, ZUPANČIČ / PUNCER 1995). However the vascular plants on dead wood were not studied in detail yet. This study describes the dead wood inhabiting flora of these stands, characterising the frequencies of the species and their status.

2 SITE DESCRIPTION
OPIS RAZISKOVALNIH OBJEKTOV

The two sites investigated are located in the northern part of Dinaric mountains, near Kočevje in southern Slovenia. The elevation is between 850 and 900 m a.s.l., and the bedrock is dolomite intermixed with limestone. The climate of these regions is montane Dinaric with an annual precipitation of about 1500 mm. Both reserves had been virgin forests until 1894, when they were taken out of exploitation with the first forest management plan. Minor fellings were recorded on the edges of Rajhenavski Rog in 1948, while Krokar was closed to the public until 1990. Stand structure, regeneration, and spatial distribution of forest developmental phases have been studied in these reserves in detail, mainly in Rajhenavski Rog (BONČINA 1999). Phytosociological relations of

ground flora of both reserves have also been studied (PUNCER / ZUPANČIČ 1970, PUNCER / WOJTERSKI / ZUPANČIČ 1974, PUNCER 1980, HOČEVAR *et al.* 1985, 1995, ZUPANČIČ / PUNCER 1995). The amount of dead trees is high, 284 m^3/ha in Rajhenavski Rog and 153 m^3/ha in Krokar, all of the decay phases and size categories are represented in dead wood (HARTMAN 1999).

3 METHODS
METODE

Altogether 212 dead beech trees were selected: 110 in the southern part of Forest Reserve Rajhenavski Rog, and 102 in the southern part of Forest Reserve Krokar. The selected trees represent all of the decay phases (ÓDOR / STANDOVÁR 2001) and size categories. In autumn of 2001 and springtime of 2002, all of the vascular species were registered on the selected trees including snags, logs, crowns, tree bases (soil contact zone at the bottom of snags) and uprooted parts. For survey of vascular plants on CWD we used following abundance (cover) categories: 1 - very rare (cover very few); 2 - rare (cover few); 3 - frequent (large patch); 4 – frequent, dominant (large cover, dominant). The nomenclature followed TRPIN / VREŠ (1995) and MARTINČIČ *et al.* (1999). Species richness and frequency of species occurrence were calculated. Based on the list of plant species and their frequency, the distribution of Raunkiaer's life-forms categories (1934, cited by MARTINČIČ *et al.* 1999) were analysed.

4 RESULTS AND DISCUSSION
REZULTATI IN RAZPRAVA

A total of 110 species was recorded during the field sampling, 71 in Rajhenavski Rog and 85 in Krokar. Total number of occurrences is 1.359 in Rajhenavski Rog, and 1.387 in Krokar. In Rajhenavski Rog the mean species richness per tree is 9,97±4,82 (standard deviation) ranging from 2 to 29; in Krokar 11,13±5,25 and ranging from 0 to 26, respectively.

The most common species are *Cardamine trifolia* L. and *Oxalis acetosella* L. (Table 1). In both two sites together they occur on 85 % of all 212 selected dead trees. *Cardamine trifolia* occurs on 92.7 % of the selected trees in Rajhenavski Rog and on 77.5 % in Krokar. *Oxalis acetosella* is present on 91.8 % of the selected trees in Rajhenavski Rog and on 78.4 % in Krokar. On more than half of all selected trees we found *Galium odoratum* (L.) Scop., *Fagus sylvatica* L., *Omphalodes verna* Moench, *Cardamine enneaphyllos* (L.) Crantz. Species present on more than one third of the selected trees are *Galium odoratum*, *Fagus sylvatica*, *Omphalodes verna*, *Abies alba* Mill., *Brachypodium sylvaticum* (Huds.) P. Beauv., *Cardamine enneaphyllos*, *Senecio fuchsii* C. C. Gmelin in Rajhenavski Rog, and *Galium odoratum*, *Cardamine enneaphyllos*, *Anemone nemorosa* L., *Omphalodes verna*, *Fagus sylvatica*, *Mercurialis perennis* L., *Galeobdolon luteum* agg., *Isopyrum thalictroides* L., *Acer pseudoplatanus* L. in Krokar.

The regeneration of the two dominant tree species (*Fagus sylvatica* and *Abies alba*) is quite different in two sites (Appendix 1). While beech seedlings are very common in both sites fir is restricted to Rajhenavski Rog, although mature fir-trees are common in both sites. Probably grazing pressure is much higher in Krokar and animals prefer fir saplings above beech. Fir establishment is also dependent on high air humidity. Humidity is much higher in Rajhenavski Rog than in Krokar because of its sheltered position, the presence of karst holes ("vrtače") and the dense beech regeneration in the lower part of the forest.

Brachypodium sylvaticum, *Sanicula europaea* L., *Fragaria vesca* L., *Polystichum aculeatum* (L.) Roth are more frequent on dead trees in Rajhenavski Rog than in Krokar. These are differential species of Rajhenavski Rog vs. Krokar. In Krokar geophytes as *Anemone nemorosa*, *Isopyrum thalictroides*, *Cardamine enneaphyllos*, *Leucojum vernum* L., *Cardamine bulbifera* (L.) Crantz and *Allium ursinum* (L.) are much more frequent than in Rajhenavski Rog. Other differential species of Krokar vs. Rajhenavski Rog are *Mercurialis perennis*, *Acer pseudoplatanus* and *Veronica montana* L.

Plants occur mostly on logs: 52,7 % of total number of 2.746. Very few species are found on the crowns of dead trees (only 4,2 % of total number of occurrences).

The majority of plant records was made at the bottom of snags (leg of the snag) and on well-decayed logs. Plants colonising dead trees in early decay phases are very rare.

Oxalis acetosella, *Cardamine trifolia*, and seedlings of *Fagus sylvatica* and *Abies alba* are the most common. They mostly establish themselves in the fissures of bark.

In Rajhenavski Rog among the most common species *Fagus sylvatica* and *Cardamine trifolia* have the highest average estimation of abundance (cover estimation). In Krokar *Oxalis acetosella*, *Galium odoratum* and *Anemone nemorosa* have the highest average estimation.

In both sites the dominant Raunkiaer's life form is hemicryptophyte (Table 1). Judged by the species as well as by the number of occurrences, hemicryptophytes represent around 50% or even more of all records. Second in importance are the geophytes. Both lists show a higher frequency for Krokar. Especially in occurrence list of Rajhenavski Rog the mega-phanerophytes form a relatively large group. Apart from juveniles of the dominant tree-species *Fagus sylvatica* and *Abies alba* also *Acer pseudoplatanus* is quite frequent, thus stressing dead wood as an important substratum for tree regeneration. *Picea abies* and *Prunus avium* L. are recorded in Rajhenavski Rog. In Krokar *Acer obtusatum* W. & K. ex Willd. is recorded too.

Table 1: Distribution of different life-forms categories in percentages in Rajhenavski Rog and Krokar based on presence and number of occurrences (crowns, logs, snags). Life-forms categories: mP - mega-phanerophyte, nP - nano-phanerophyte, Ch - chamaephyte, H - hemicryptophyte, G - geophyte, T – therophyte.

Preglednica 1: Deleži življenjskih oblik v rezervatih Rajhenavski Rog in Krokar; izračunani so na osnovi seznama rastlinskih vrst in na osnovi pojavljanja po delih dreves (ležeče krošnje, ležeča debla, panji); življenjske oblike rastlin: mP – megafanerofit, nP – nanofanerofit, Ch – hamefit, H – hemikriptofit, G – geofit, T – terofit

	Presence (in %) / *Delež v seznamu rastlin (v %)*						Proportion in occurrences (in %) / *Delež v pojavljanju (v %)*					
	mP	nP	Ch	H	G	T	mP	nP	Ch	H	G	T
Rajhenavski Rog	7,0	14,1	7,0	52,1	18,3	1,4	15,4	3,2	4,9	56,4	20,1	0,1
Krokar	4,7	5,9	4,7	57,6	24,7	2,4	7,9	0,9	4,5	49,4	36,6	0,6

Mega-phanerophytes on dead wood are in different stages of the juvenile phase. As already mentioned by HOČEVAR *et al.* (1985, 1995) only a few nano-phanerophytes are to be found.

The importance of dead wood as a favourable substrate to regeneration is not restricted to trees. It also may enhance the diversity of the forest ecosystem by enabling the establishment of a variety of vascular species.

The plant-species composition on CWD is more or less similar to that of the surroundings (PUNCER / ZUPANČIČ 1970, PUNCER / WOJTERSKI / ZUPANČIČ 1974, PUNCER 1980, HOČEVAR *et al.* 1985, 1995, ZUPANČIČ / PUNCER 1995). But due to very specific site-conditions of dead wood significant differences in abundance of plant species between CWD and surrounding forest could be found. Nurse logs are important in the regeneration of fir in Rajhenavski Rog.

Especially in Krokar, species richness is high. In contrast to bryophytes (ÓDOR / VAN DORT 2002) the species richness is higher in Krokar than in Rajhenavski Rog. Though both sites are located in a well-forested landscape, on limestone and dolomite, the dead wood of Krokar seems to be influenced by a greater variation in factors as micro-climate, soil and air humidity, effect of wind etc. These very heterogeneous site conditions are favourable to plants with very different demands. Consequently we found characteristic plants of humid-wet soil as well as species that favour more sunny and warm conditions. On CWD of Krokar, characteristic species of very different syntaxa were found: *Vaccinio-Piceetea* (e.g. *Vaccinium myrtillus* L.), *Tilio-Acerion* (e.g. *Leucojum vernum*) on one hand, and *Erico-Pinetea* s. lat. (e.g. *Laserpitium krapfii* Crantz), *Adenostyletalia* (e.g. *Thalictrum aquilegiifolium* L.) on other hand. In Rajhenavski Rog the site conditions are more uniform (with less extremes), and mesophilic species predominate.

The investigated part of Rajhenavski Rog belongs to the dinaric fir-beech forest (*Omphalodo-Fagetum* (Treg. 1957) Mar. et al. 1993), which could be divided to many different subassociations.

The selected part of Krokar has already been described by HOČEVAR *et al.* (1985) as a beech forest with Pre-Dinaric floristic elements. Based on this and the fact that the only

floristic element discriminating between mountain beech forest and Dinaric fir-beech forest is *Abies alba* (MARINČEK / PUNCER / ZUPANČIČ 1983), we have described the selected site as a transition zone between Pre-Dinaric mountain beech forest and Dinaric fir-beech forest despite presence of the floristic elements of very different syntaxa.

5 CONCLUSIONS
ZAKLJUČKI

In two near-natural forests in southern Slovenia dead wood is one of the crucial elements of biodiversity. It plays a significant role in forest regeneration. Many species frequently establish themselves and regenerate often on logs and (the base of) snags of dead trees. In these two virgin forest remnants dead wood offers very favourable conditions for many vascular plants and enhances their richness.

6 POVZETEK

Odmrlo drevje oziroma veliki lesni ostanki (ang. coarse woody debris; CWD) predstavljajo pomembno strukturno in ekološko komponento gozdnih ekosistemov: so pomemben vir hranil, močno vplivajo na pedogenetske procese in imajo pomembno vlogo v življenju mnogih organizmov (npr. glive, mahovi, lišaji, nevretenčarji, dvoživke, ptiči – duplarji, mali sesalci) (HARMON et al. 1986, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, CSÓKA 2000). Odmrlo drevje nudi ugodne pogoje tudi za življenje mnogih vaskularnih rastlin; vendar med njimi ni takih, ki bi bile obligatno vezane na lesne ostanke. Odmrlo drevje ima tudi pomembno negovalno vlogo pri pomlajevanju gozda v borealnih ekosistemih (HARMON et al. 1986, HOFGAARD 1993, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, ESSEEN et al. 1997, ULANOVA 2000).

Evropski gozdovi so večinoma pod vplivom človeka, zato je le malo naravnih gozdov (pragozdnih ostankov), v katerih v preteklosti ni bilo intenzivnega gospodarjenja (PETERKEN 1996, ROSE 1992). V gospodarskih gozdovih je delež mase odmrlih dreves precej manjši kot v naravnih oziroma sonaravnih gozdovih (GREEN / PETERKEN 1997,

KIRBY et al. 1997, ANDERSSON / HYTTEBORN 1991, LESICA et al. 1991, SAMUELSSON / GUSTAFSSON / INGELÖG 1994, BONČINA 2000a,b, JONSSON 2000, ÓDOR / STANDOVÁR 2001).

Med redkimi pragozdnimi ostanki v Evropi sta tudi rezervata Rajhenavski Rog in Krokar na jugu Slovenije, v bližini Kočevja. Zanju so značilni sestoji z dominatno bukvijo in jelko, z razgibano večplastno vertikalno zgradbo; z mozaikom različnih razvojnih faz; z velikim deležem odmrlega drevja. V preteklosti so bile v obeh rezervatih že opravljene nekatere raziskave višjih rastlin, gliv, mahov in lišajev (PUNCER / ZUPANČIČ 1970, PUNCER / WOJTERSKI / ZUPANČIČ 1974, MARINČEK / PUNCER / ZUPANČIČ 1980, PUNCER 1980, HOČEVAR et al. 1985, 1995, ZUPANČIČ / PUNCER 1995), vendar vaskularne rastline na odmrlem drevju do sedaj še niso bile posebej proučevane.

V ta namen smo na južnem robu Rajhenavskega Roga izbrali 110 odmrlih drevesih, na južnem robu Krokarja pa 102 drevesi. Izbrano drevje je bilo v različnih fazah razgradnje in različnih debelin. Jeseni 2001 in spomladi 2002 smo popisali rastline na panjih, ležečih deblih in krošnjah izbranih odmrlih dreves. Upoštevali smo tudi rastline, ki se pojavljajo med koreničnikom (deloma na mineralnih tleh tik ob panjih dreves), in rastline na koreninah izruvanih dreves. Njihovo obilje (številčnost in zastiranje) smo ocenili v štiristopenjski skali.

Nomenklaturo rastlin smo povzeli po delih Register flore Slovenije (TRPIN / VREŠ 1995) in Mala flora Slovenije (MARTINČIČ et al. 1999). Analizirali smo vrstno sestavo vaskularnih rastlin, frekvenco pojavljanja, pestrost in delež Raunkiaer-jevih življenjskih oblik (1934, povzeto po MARTINČIČ et al. 1999).

Po tej metodologiji smo na 212 odmrlih drevesih popisali 110 vaskularnih rastlin. V Rajhenavskem Rogu smo našli 71 vrst, v Krokarju pa 85 vrst. Ločeno smo na vseh delih (ležeče krošnje, ležeča debla, panji) izbranih dreves v Rajhenavskem Rogu ugotovili 1.359 pojavljanj rastlinskih vrst, v Krokarju pa 1.387 pojavljanj. V povprečju smo na drevo (združeni vsi obstoječi deli) v Rajhenavskem Rogu popisali 9,97 vrst (na posameznem drevesu je raslo med 2 in 29 vrst); v Krokarju je bilo v povprečju 11,13 vrst na drevo (razpon med 0 in 26 vrst).

Najpogostejši vrsti sta bili Cardamine trifolia in Oxalis acetosella, ki smo ju našli na 85 % vseh 212 dreves. Na več kot polovici vseh dreves smo popisali tudi vrste Galium odoratum (76 %), Fagus sylvatica (67 %), Omphalodes verna (63 %) in Cardamine enneaphyllos (55 %).

Vrste, ki so na objektu Rajhenavski Rog poleg Cardamine trifolia in Oxalis acetosella prisotne na več kot tretjini izbranih dreves, so: Galium odoratum, Fagus sylvatica, Omphalodes verna, Abies alba, Brachypodium sylvaticum, Cardamine enneaphyllos, Senecio fuchsii. Na Krokarju pa so to naslednje vrste: Galium odoratum, Cardamine enneaphyllos, Anemone nemorosa, Omphalodes verna, Fagus sylvatica, Mercurialis perennis, Galeobdolon luteum agg., Isopyrum thalictroides, Acer pseudoplatanus.

Ugotovili smo očitno razliko v pomlajevanju dveh vodilnih drevesnih vrst – bukve in jelke. Medtem ko je bukev pogosta na odmrlem drevju v obeh rezervatih, se jelka večinoma pojavlja le v Rajhenavskem Rogu. Vzroka za to razliko sta verjetno: (a) večji pritisk divjadi (obžiranje jelke) na Krokarju; (b) manjša zračna vlažnost. Na delu Krokarja, kjer se nahajajo izbrana drevesa, je namreč zaznaven izrazit vpliv toplih zračnih mas, ki se iz Kolpske doline dvigajo prek južnih- in jugozahodnih ostenij Borovške gore. K nižji zračni vlažnosti proučevanega predela Krokarja prispeva tudi odprtost oziroma večja prezračenost. V Rajhenavskem Rogu je večja zračna vlažnost posledica bolj izrazite večplastnosti sestojev, tesnejšega sklepa krošenj (bolj senčno), gostih pomladitvenih jeder bukve in osojnih vrtač.

Razlikovalne vrste, ki so bolj pogoste v Rajhenavskem Rogu kot na Krokarju in dobro nakazujejo razlike med njima, so npr. Brachypodium sylvaticum, Sanicula europaea, Fragaria vesca in Polystichum aculeatum.

Med razlikovalnimi vrstami Krokarja proti Rajhenavskem Rogu so predvsem geofiti, kot so npr. Anemone nemorosa, Isopyrum thalictroides, Cardamine enneaphyllos, Leucojum vernum, Cardamine bulbifera in Allium ursinum, poleg njih pa še Mercurialis perennis, Acer pseudoplatanus in Veronica montana.

Glede na frekvenco pojavljanja na vseh delih odmrlega drevja smo vaskularne vrste najpogosteje našli na ležečih deblih (52,7 % od 2.746 pojavljanj). Zelo redke so vrste, ki naseljujejo krošnje odmrlih dreves.

Večino pojavljanj so prispevale rastline, ki poraščajo tla v območju koreničnikov dreves (ob vznožju razpadajočih panjev), in rastline, ki rastejo na bolj razgrajenih ležečih deblih. Vrste, ki poraščajo malo razgrajene lesne ostanke, so redke. Med njimi smo najpogosteje našli vrsti Oxalis acetosella in Cardamine trifolia ter bukove in jelove klice. Te naseljujejo večje razpoke na lubju.

Med prevladujočimi vrstami sta v Rajhenavskem Rogu imeli najvišjo oceno obilja (zastiranja) bukev in trilistna penuša (Cardamine trifolia); na Krokarju pa Oxalis acetosella, Galium odoratum in Anemone nemorosa.

Med življenjskimi oblikami prevladujejo hemikriptofiti, ki predstavljajo približno 50 % v seznamu rastlin in v celotnem številu pojavljanja po posameznih delih dreves. Poleg njih imajo večji delež tudi geofiti. Med megafanerofiti smo poleg dominantnih vrst (bukve in jelke) pogosteje zabeležili tudi gorski javor (Acer pseudoplatanus). Le izjemoma smo na velikih lesnih ostankih Rajhenavskega Roga našli smreko (Picea abies) in češnjo (Prunus avium), na Krokarju pa topolistni javor (Acer obtusatum).

V nasprotju z mahovi (ÓDOR / VAN DORT 2002) je pestrost vaskularnih rastlin večja na Krokarju kot v Rajhenavskem Rogu. Rastiščne razmere (mikroklima, talna in zračna vlažnost, vpliv vetra itd.) so na Krokarju bolj raznolike. Zaradi tega lahko tu najdemo tako vrste razmeroma vlažnih rastišč kot vrste prisojnih, toplih rastišč. Na odmrlem drevju in v neposrednem območju njihovega vpliva smo popisali vrste različnih sintaksonov, kot so Vaccinio-Piceetea (npr. Vaccinium myrtillus), Tilio-Acerion (npr. Leucojum vernum), Erico-Pinetea s. lat. (npr. Laserpitium krapfii) in Adenostyletalia (npr. Thalictrum aquilegiifolium). V proučevanem delu Rajhenavskega Roga so rastiščne razmere manj raznolike (manj ekstremov), zato tu prevladujejo mezofilne vrste.

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8 APPENDIX
PRILOGA

Appendix 1: The list of species includes the number of occurrences of species in Rajhenavski Rog and Krokar. The number of investigated trees was 110 in Rajhenavski Rog and 102 in Krokar. (Life-forms categories: mP - mega-phanerophyte, nP - nano-phanerophyte, Ch - chamaephyte, H - hemicryptophyte, G - geophyte, T – therophyte.)

Priloga 1: Seznam rastlin s številom pojavljanj na odmrlem drevju (velikih lesnih ostankih) v rezervatih Rajhenavski Rog in Krokar; število izbranih dreves: 110 (Rajhenavski Rog) oziroma 102 (Krokar); (življenjske oblike rastlin: mP – megafanerofit, nP – nanofanerofit, Ch – hamefit, H – hemikriptofit, G – geofit, T – terofit)

No. / *Št.*	Species / *Vrsta*	Rajhenavski Rog		Krokar		Life-form / *Življenjska oblika*
		N	%	N	%	
1	*Abies alba* Mill.	61	55,5	1	1,0	mP
2	*Acer obtusatum* W. & K. ex Willd.			1	1,0	mP
3	*Acer pseudoplatanus* L.	17	15,5	36	35,3	mP
4	*Aconitum lycoctonum* L. subsp. *vulparia*			1	1,0	H
5	*Actaea spicata* L.			1	1,0	G
6	*Adoxa moschatellina* L.			3	2,9	H
7	*Ajuga reptans* L.	2	1,8			H
8	*Allium ursinum* L.			15	14,7	G
9	*Allium victorialis* L.			3	2,9	G
10	*Anemone nemorosa* L.	19	17,3	71	69,6	G
11	*Aposeris foetida* (L.) Less.			6	5,9	H
12	*Aremonia agrimonoides* (L.) DC.	14	12,7	1	1,0	H
13	*Arum maculatum* L.			1	1,0	G
14	*Asarum europaeum* L.	1	0,9			H
15	*Athyrium filix-femina* (L.) Roth	13	11,8	11	10,8	H
16	*Brachypodium sylvaticum* (Huds.) P.Beauv.	45	40,9	3	2,9	H
17	*Calamagrostis arundinacea* (L.) Roth	3	2,7	3	2,9	H
18	*Calamintha grandiflora* (L.) Moench	13	11,8	7	6,9	H
19	*Cardamine bulbifera* (L.) Crantz	8	7,3	28	27,5	G
20	*Cardamine enneaphyllos* (L.) Crantz	43	39,1	74	72,5	G
21	*Cardamine trifolia* L.	102	92,7	79	77,5	G
22	*Cardaminopsis arenosa* (L.) Hayek			2	2,0	H
23	*Carex digitata* L.	2	1,8	1	1,0	H
24	*Carex pilosa* Scop.			5	4,9	H
25	*Carex sylvatica* Huds.	11	10,0	3	2,9	H
26	*Chrysosplenium alternifolium* L.	5	4,5			H
27	*Circaea alpina* L.	1	0,9			G
28	*Convallaria majalis* L.			3	2,9	G
29	*Cyclamen purpurascens* Mill.	3	2,7	3	2,9	G

Appendix 1: (continuation)
Priloga 1: (nadaljevanje)

No. / *Št.*	Species / *Vrsta*	Rajhenavski Rog		Krokar		Life-form / *Življenjska oblika*
		N	%	N	%	
30	*Cystopteris fragilis* (L.) Bernh.	2	1,8			H
31	*Daphne laureola* L.	8	7,3			nP
32	*Daphne mezereum* L.	9	8,2			nP
33	*Doronicum austriacum* Jacq.	1	0,9	2	2,0	H
34	*Dryopteris carthusiana* agg.	20	18,2	5	4,9	H
35	*Dryopteris filix-mas* agg.	10	9,1	14	13,7	H
36	*Epilobium montanum* L.	5	4,5	2	2,0	H
37	*Euphorbia amygdaloides* L.	11	10,0	10	9,8	Ch
38	*Euphorbia carniolica* Jacq.			8	7,8	H
39	*Fagus sylvatica* L.	86	78,2	55	53,9	mP
40	*Festuca altissima* All.	3	2,7	7	6,9	H
41	*Fragaria vesca* L.	19	17,3			H
42	*Galeobdolon luteum* agg.	27	24,5	41	40,2	Ch
43	*Galium odoratum* (L.) Scop.	87	79,1	75	73,5	H
44	*Gentiana asclepiadea* L.			2	2,0	H
45	*Geranium robertianum* agg.	1	0,9	7	6,9	T
46	*Gymnocarpium dryopteris* (L.) Newm.	2	1,8			G
47	*Hacquetia epipactis* (Scop.) DC.			7	6,9	H
48	*Helleborus niger* L.			5	4,9	H
49	*Helleborus odorus* W. & K. ex Willd.			2	2,0	H
50	*Hepatica nobilis* Schreber			4	3,9	H
51	*Homogyne sylvestris* (Scop.) Cass.			2	2,0	H
52	*Hordelymus europaeus* (L.) C.O.Harz	1	0,9	14	13,7	G
53	*Iris graminea* L.			1	1,0	G
54	*Isopyrum thalictroides* L.	3	2,7	38	37,3	G
55	*Lamium orvala* L.	2	1,8	10	9,8	H
56	*Laserpitium krapfii* Crantz			5	4,9	H
57	*Leucojum vernum* L.			32	31,4	G
58	*Lilium martagon* L.			11	10,8	G
59	*Lonicera alpigena* L.	2	1,8	1	1,0	nP
60	*Luzula sylvatica* (Huds.) Gaudin			1	1,0	H
61	*Lycopodium annotinum* L.	1	0,9			Ch
62	*Maianthemum bifolium* (L.) F.W.Schmidt	5	4,5	1	1,0	G
63	*Melampyrum pratense* L.			1	1,0	T
64	*Melittis melissophyllum* L.			1	1,0	H
65	*Mercurialis perennis* L.	16	14,5	55	53,9	H
66	*Mycelis muralis* (L.) Dum.	22	20,0	21	20,6	H
67	*Myrrhis odorata* (L.) Scop.			1	1,0	H
68	*Neottia nidus-avis* (L.) L.C.Rich.			3	2,9	G
69	*Omphaodes verna* Moench	68	61,8	66	64,7	H
70	*Oxalis acetosella* L.	101	91,8	80	78,4	H
71	*Paris quadrifolia* L.	5	4,5	9	8,8	G
72	*Phegopteris connectilis* (Michx.) Watt	1	0,9			G
73	*Phyllitis scolopendrium* (L.) Newm.	5	4,5			H
74	*Phyteuma ovatum* Honck.			4	3,9	H
75	*Picea abies* (L.) Karsten	1	0,9			mP

Appendix 1: (continuation)
Priloga 1: (nadaljevanje)

No. / *Št.*	Species / *Vrsta*	Rajhenavski Rog		Krokar		Life-form / *Življenjska oblika*
		N	%	N	%	
76	*Platanthera bifolia* (L.) L.C.Rich.	4	3,6			G
77	*Polygonatum multiflorum* (L.) All.			4	3,9	G
78	*Polygonatum verticillatum* (L.) All.			13	12,7	G
79	*Polypodium vulgare* L.	7	6,4	2	2,0	H
80	*Polystichum aculeatum* (L.) Roth	17	15,5			H
81	*Polystichum lonchitis* (L.) Roth	8	7,3			H
82	*Prenanthes purpurea* L.	3	2,7	14	13,7	H
83	*Primula vulgaris* Huds.			2	2,0	H
84	*Prunus avium* L.	1	0,9			mP
85	*Ranunculus lanuginosus* L.			1	1,0	H
86	*Rhamnus fallax* Boiss.	3	2,7			nP
87	*Ribes alpinum* L.	1	0,9			nP
88	*Rubus fruticosus* agg.	8	7,3	2	2,0	nP
89	*Rubus idaeus* L.	7	6,4	6	5,9	nP
90	*Salix caprea* L.	1	0,9			nP
91	*Salvia glutinosa* L.	14	12,7			Ch
92	*Sambucus nigra* L.	2	1,8	1	1,0	nP
93	*Sambucus racemosa* L.	1	0,9	2	2,0	nP
94	*Sanicula europaea* L.	31	28,2	1	1,0	H
95	*Scopolia carniolica* Jacq.	8	7,3			H
96	*Scrophularia nodosa* L.			1	1,0	H
97	*Senecio fuchsii* C.C.Gmelin	37	33,6	32	31,4	H
98	*Solanum dulcamara* L.	1	0,9	3	2,9	Ch
99	*Stellaria montana* Pierrat	7	6,4			H
100	Symphytum tuberosum L.			13	12,7	G
101	*Tanacetum corymbosum* (L.) Schultz-Bip.			1	1,0	H
102	*Taraxacum officinale* F.Weber in Wiggers	2	1,8			H
103	*Thalictrum aquilegiifolium* L.			2	2,0	H
104	*Urtica dioica* L.	2	1,8			H
105	*Vaccinium myrtillus* L.			1	1,0	Ch/nP
106	*Valeriana tripteris* L.			2	2,0	H
107	*Veratrum album* s. lat.	2	1,8	13	12,7	H
108	*Veronica montana* L.	6	5,5	22	21,6	H
109	*Vicia oroboides* Wulf.			11	10,8	H
110	*Viola reichenbachiana* Jordan ex Boreau	37	33,6	21	20,6	H