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Ramondo-Ostryetum carpinifoliae – a new association from the hop-hornbeam forests of the Sharri Mountains, Kosovo

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Key words: phytosociology, *Ramonda*, synsystematics, Sharri Mountains, Kosovo, *Ramondo-Ostryetum*.

Ključne besede: fitocenologija, *Ramonda*, sinsistematika, Šar planina, Kosovo, *Ramondo-Ostryetum*.

Abstract

In Europe, the genus *Ramonda* is represented with three species: *Ramonda nathaliae*, *Ramonda serbica* and *Ramonda myconi*. The first two are endemic Balkan species that are distributed also in Kosovo. These species grow in limestone as well as serpentine substrates, forming chasmophytic vegetation. The species *Ramonda nathaliae* is found in Macedonia, Greece, Serbia and in two localities in Kosovo, in the Sharri Mountains (Luboten and Gotovushë). *R. nathaliae* forms the following plant associations in the serpentines of Macedonia: *Asplenio-Ramondetum nathaliae* and *Scorzonero-Ramondetum nathaliae*, and the *Achilleo-Ramondetum nathaliae* in limestone substrates. *Ostrya carpinifolia* is charateristic species in *Querco pubescentis-Ostryetum carpinifoliae*, *Ostryo-Fagetum*, *Querco-Ostryetum carpinifoliae* and *Corylo colurnae-Ostryetum carpinifoliae*. This paper presents plant communities of *Ramonda nathaliae* and *Ostrya carpinifolia* in a limestone habitat, where the proposed new plant association named *Ramondo-Ostryetum carpinifoliae* ass. nova. is described. This plant community belongs to the class *Quercetea pubescentis*, order *Quercetalia pubescenti-petraeae* and alliance *Fraxino orni-Ostryion*. It was found and described on the limestone substrate on Mt. Luboteni (at 960–982 m a.s.l.).

Izvleček

Rod *Ramonda* ima v Evropi tri predstavnike: *Ramonda nathaliae*, *Ramonda serbica* in *Ramonda myconi*. Prvi dve vrsti sta balkanska endemita, ki sta razširjeni tudi na Kosovu. Vrsti uspevata na apnencu kot tudi na serpentinitu in gradita hazmoftsko vegetacijo. Vrsta *Ramonda nathaliae* je razširjena v severnem in srednjem delu Makedonije, severni Grčiji, jugovzhodni Srbiji in na dveh lokalitetah na Kosovu na Šari (Luboten in Gotovushë). *R. nathaliae* je značilna vrsta v Makedoniji v asociacijah na serpentinitu: *Asplenio-Ramondetum nathaliae* in *Scorzonero-Ramondetum nathaliae*, ter na karbonatu *Achilleo-Ramondetum nathaliae*. *Ostrya carpinifolia* je značilna vrsta v asociaciji *Querco pubescentis-Ostryetum carpinifoliae*, v asociaciji *Ostryo-Fagetum* in asociacijah *Querco-Ostryetum carpinifoliae* ter *Corylo colurnae-Ostryetum carpinifoliae*. V članku predstavljamo rastlinske združbe vrst *Ramonda nathaliae* in *Ostrya carpinifolia* na karbonatu in novoopisano asociacijo *Ramondo-Ostryetum carpinifoliae* ass. nova. Združbo uvrščamo v razred *Quercetea pubescentis*, red *Quercetalia pubescenti-petraeae* in zvezo *Fraxino orni-Ostryion*. Opisana je bila na kabrbonatnem substratu na gori Ljuboten (med 960–982 m n.m.v) na Kosovu v bližini meje z Republiko Makedonijo.

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Introduction

Poikilohydric plants have the unique ability of surviving in complete dehydration and are capable of fully recovering within a short period of time. This physiological phenomenon is very rare among vascular plants – only 300 plant species in the world (Porembski, 2011) and only five eudicots in Europe, all of which belong to the Gesneriaceae family, are known to have this special ability. These tertiary relict species are: *Ramonda serbica* Panč., *R. nathaliae* Panč. et Petrov., *R. myconi* (L.) Rchb., *Haberlea rhodopenis* Friv. and *Jancaea heldreichii* (Boiss.) Boiss, all of them remnants from the age when the European climate was warmer and more humid than today. During the Ice Age, these species found shelter in deep canyons and cliffs, places where they can still be found today.

Since their discovery in the 19th century (Pančić 1874, Petrović 1885), the Balkan *Ramonda* species were continuously studied from different biological and ecological aspects and have awakened the curiosity of researchers. The studied features include taxonomy, phytogeography, ecology, embryology and ecophysiology (Košanin 1921, 1939, Stefanoff & Georgiev 1937, Micevski 1956, Quezel 1968, Meyer 1970, Janković & Stevanovic 1981, Stevanović & Stevanović 1985, Stevanović et al. 1986a, 1986b, 1987, 1991, 2014, Stevanović, 1986, 1989, Stevanović et al. 1992, Gashi et al. 2011, 2012a, 2012b, 2013a, 2013b). The *Ramonda* species and their various facets are continually being studied due to the curiosity that they attract.

In our study we were interested in the species of the genus *Ramonda* and their corresponding plant communities, in particular plant communities of *R. nathaliae* Panč. et Petrov. Out of three European species of the genus, two are Balkan endemics: *Ramonda serbica* Panč. and *R. nathaliae* Panč. et Petrov. These two species are characterized by their disjunctive distributional patterns – each having its own ecological characteristics. *R. nathaliae* is confined to the Republic of Macedonia, N. Greece, the slopes of the Sharri Mts. in Kosovo (Figure 1) and a few small localities in SE Serbia (Micevski 1956, Košanin 1921). The largest distributional range of *R. serbica* is in Albania, and it has also been reported for NW Greece, W Republic of Macedonia, SW and NE Montenegro, S and W Kosovo, SE and NE Serbia and NE Bulgaria (Rakić et al. 2014, Millaku et al. 2013, Stevanović et al. 1986). Even though they prefer limestone rocks, *R. nathaliae* has also been found on serpentine and granite substrates. As it prefers more open habitats and higher altitudes it is considered to be more tolerant than *R. serbica*. (Stevanović et al. 1991).

From the phytosociological point of view, *R. nathaliae* is represented in numerous plant communities in the Balkan

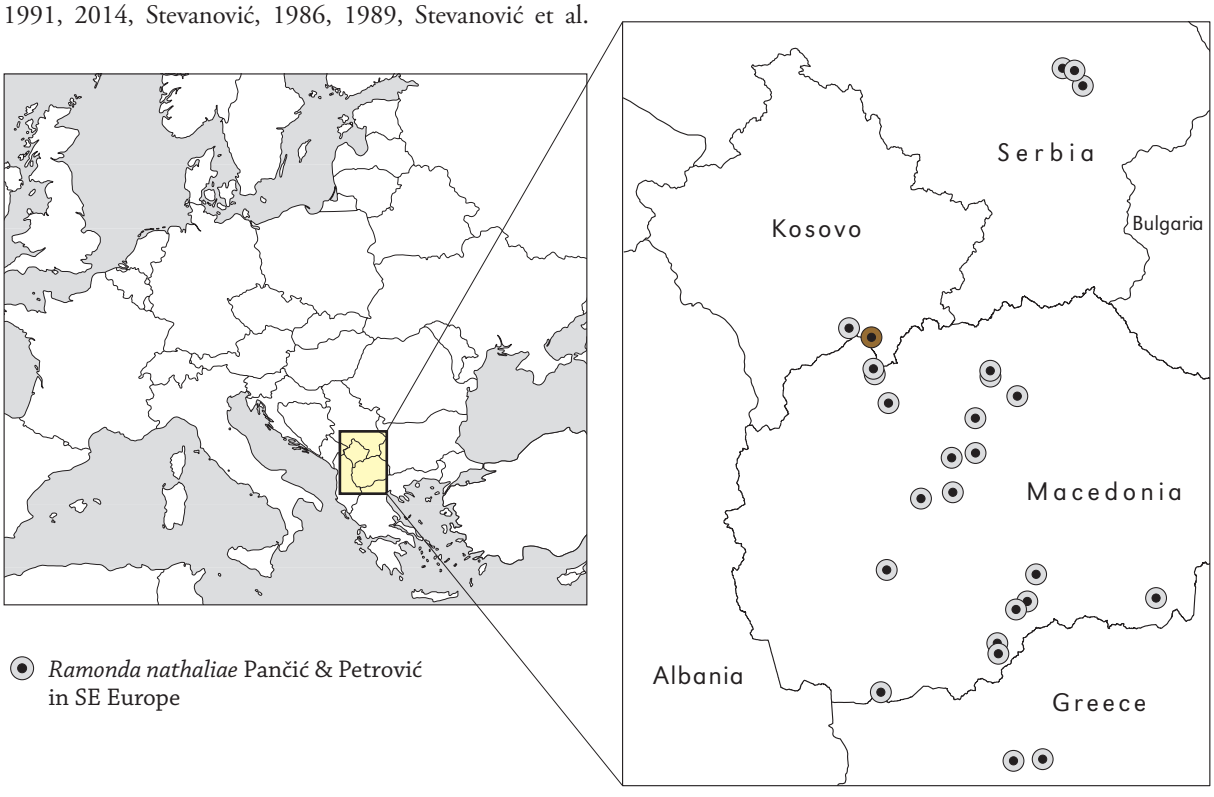


Figure 1: Distribution of *Ramonda nathaliae* Pančić & Petrović in SE Europe, brown dot shows the studied locality.
Slika 1: Razširjenost vrste *Ramonda nathaliae* Pančić & Petrović v jugovzhodni Evropi, rjava točka prikazuje preučevano lokacijo.

Peninsula. In Macedonia it forms three plant associations: *Asplenio-Ramondetum nathaliae* and *Scorzonero-Ramondetum nathaliae* on serpentine bedrock and *Achilleo-Ramondetum nathaliae* on limestone bedrock (Stevanović et al. 2014). They belong to the alliance *Ramondion nathaliae* Horvat ex Simon 1958, to which all chasmophytic vegetation of calcareous rock crevices in the alpine belt of the southern and central regions of the Balkans supposedly belongs (Horvat 1936). The reliability of such grouping is questionable (Stevanović et al. 2014) as there is vast ecological and floristic diversity within the chasmophytic groups that belong to this alliance, This issue therefore remains to be adequately addressed in future studies.

As the European hop-hornbeam (*Ostrya carpinifolia* Scop.) was recorded with great presence in the same studied environments we have to conclude that from the phytosociological point of view *Ostrya carpinifolia* Scop. belongs to two distinctive classes, and therefore forms three known plant associations in the Balkans. From the class *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959, order *Quercetalia pubescenti-petraeae* Klika 1933, alliance *Fraxino orni-Ostryion* Tomažič 1940 it forms the following two associations: *Querco pubescentis-Ostryetum carpinifoliae* Horvat 1938 and *Corylo colurnae-Ostryetum carpinifoliae* Blečić 1958. From the class *Carpino-Fagetea sylvaticae* Jakucs ex Passarge 1968, order *Fagetalia sylvaticae* Pawłowski 1928, alliance *Aremonio-Fagion* (Horvat 1950) Borhidi in Török et al. 1989, it forms the association *Ostryo-Fagetum* M. Wraber ex Trinajstić 1972.

The aim of our study is to provide phytosociological data on the new forest plant community that grows within the forest made primarily out of *Ostrya carpinifolia* and *Ramonda nathaliae*, and to determine the floristic and ecological features of known plant communities with *R. nathaliae* as well as those dominated by *O. carpinifolia*, absence of *R. nathaliae*, and finally to offer a discussion regarding the syntaxonomical position of this fragile and rare plant community.

Material and methods

Standard principles and methods of Zürich-Montpellier school (Braun-Blanquet 1964, Mueller-Dombois & Ellenberg 1974) were applied. Plot sizes of 10×10 m were used, resulting in 10 relevès. On each plot, a complete list of vascular plants was recorded, alongside with cover-abundance values on a five-degree scale (Braun-Blanquet 1932). The diagnostic table (Table 1) offers all 10 relevès that represent the new plant association as described in this paper. The plant taxa nomenclature follows the Euro+Med Plant Base (Euro+Med 2006+). All relevès were made on limestone substrate, at altitudes ranging from 965 up to 979 m. a.s.l., at predominantly northern and north-western slopes of the Luboteni massif, the Sharri Mts. To facilitate the statistical analysis process we converted the standard Braun-Blanquet scale into ordinal numbers (Westhoff & Maarel 1979) and used the TurboVeg (Hennekens & Schaminée 2001) software to digitize and store the obtained data. In order to arrange and further analyse the relevès we used JUICE software (Tichý 2002). As integrated within JUICE, TWINSPAN analysis method (Hill 1979) was used to compare different associations and build a dendrogram. In order to assess the similarity between relevès from six other similar plant communities, we relied on NMDS plot analysis in R (R Core Team 2018) in comparing plant communities. All this fully integrated into JUICE software. The classification of taxa into life forms was performed according to Raunkiaer (1934), while the chorological types follow the chorological division of Europe as proposed by Oberdorfer (1990) and Pignatti (1982). The chorological spectrum of the new association and six similar plant associations were analysed and a detailed chorological and life form spectrum of the new plant association was made. Moreover, the studied community was compared to seven forest plant communities dominated by *O. carpinifolia* in the context of floristic composition and potential similarities concerning the community ecology, dominant life forms and chorological groups.

Results and discussion

After analysing the sampled phytosociological data and comparing the findings with other known relevant plant associations that had similar floristic and ecologic constitution, it was observed that association *Ramondo-Ostryetum carpinifoliae* represents an interesting forest plant community in the Sharri Mts. Its distinctive vegetation composition and corresponding habitat features have not been described until now. Below we describe its syntaxonomical hierarchical position:

Ramondo-Ostryetum carpinifoliae ass. nova.

Table 1, Relevé 8 *holotypus hoc loco.* Character taxa: *Ostrya carpinifolia, Ramonda nathaliae, Euonymus latifolius, Saxifraga sempervivum, Cotoneaster tomentosus, Hieracium waldsteinii*. Differential taxa: *Arabis procurrens, Cytisus hirsutus, Bupleurum flavicans* and *Arenaria serpyllifolia*. Dominant taxa: *Ostrya carpinifolia* and *Ramonda nathaliae*. Constant taxa: *Ostrya carpinifolia, Ramonda nathaliae, Cotoneaster tomentosus, Asperula purpurea*.

Table 1: Association *Ramondo-Ostryetum carpinifoliae* ass. nova.
Tabela 1: Asociacija *Ramondo-Ostryetum carpinifoliae* ass. nova.

	No. of relevé	1	2	3	4	5	6	7	8	9	10		
	Locality	Luboten	Luboten	Luboten	Luboten	Luboten	Luboten	Luboten	Luboten	Luboten	Luboten		
	Altitude (m)	978	979	966	974	978	965	977	978	975	969		
	Exposition	N	N	N	N	W	NW	N	N	N	N		
	Slope	45	40	55	75	65	70	82	75	70	42		
	Geological substratum	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone		
	Size of relevé (m²)	10	10	10	10	10	10	10	10	10	10	Constancy	Floristic el.
	Date	5/11/2016	5/20/2016	5/20/2017	5/9/2017	6/1/2017			5/28/2017				
	Coordinates	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248	42.164426 21.192248		
	Character species of Ass. *Ramondo-Ostryetum carpinifoliae* ass. nova.												
P	*Ostrya carpinifolia*	4	4	1	2	3	3	3	4	4	5	V	Medit.mont.
P shrub	*Ostrya carpinifolia*	+	.	2	2	2	1	.	1	.	.	IV	Medit.mont.
H	*Ramonda nathaliae*	2	4	3	3	3	4	4	4	4	1	V	Balkan.
P	*Euonymus latifolius*	+	+	.	.	1	1	.	1	1	+	V	Mediter.mont.
H	*Saxifraga sempervivum*	+	1	.	+	2	.	1	+	+	.	V	Balkan.
H	*Arabis procurrens*	+	+	.	+	.	+	.	+	+	.	IV	Balkan.
P	*Cotoneaster tomentosus*	+	1	1	+	+	1	+	1	2	+	V	S. Europe
Ch	*Asperula purpurea*	1	.	1	.	1	1	+	1	1	+	V	SE Europe
Ch	*Cytisus hirsutus*	1	.	+	.	1	1	1	+	.	.	IV	Eurosib.
H	*Hieracium pannosum*	+	.	.	.	+	.	.	.	.	.	I	Balkan.
T	*Bupleurum flavicans*	1	.	.	.	+	.	+	.	.	+	III	Balkan.
H	*Centaurea stoebe*	+	.	.	+	.	.	.	.	.	+	II	Centro-Europ.
H	*Euphorbia cyparissias*	.	+	.	.	.	.	.	.	+	.	I	Centro-Europ.
P	*Fagus sylvatica*	.	.	.	.	.	.	1	.	.	+	I	Centro-Europ.
P shrub	*Juniperus communis*	.	.	.	.	.	.	.	.	1	.	I	Circumbor.
H	*Asplenium ruta-muraria*	.	.	.	.	.	.	+	.	+	.	I	Circumbor.
H	*Asplenium trichomanes*	+	.	1	.	.	.	.	.	.	.	.	Cosmopol.
T	*Arenaria serpyllifolia*	+	1	.	2	2	.	.	.	.	.	III	Euro-Asiat.
H	*Musci* (*Neckera crispa*)	.	2	1	.	+	.	1	.	2	.	III	Euro-Asiat.
H	*Primula veris*	.	.	.	.	.	.	+	.	.	.	I	Euro-Asiat.
H	*Viola sylvestris*	.	.	.	.	.	.	.	+	.	.	I	Euro-Asiat.
H	*Ceterach officinarum*	.	+	.	.	.	+	.	.	.	.	I	Euro-Asiat.
H	*Sedum acre*			1	1	1						II	Euro-Cauc.
P	*Acer campestre*	1		+						+		II	Euro-Cauc.
H	*Hieracium pilosella*	+									+	I	Euro-Cauc.
Ch	*Helianthemum canum*		1								+	I	Euro-Cauc.
H	*Primula vulgaris*								+			I	Euro-Cauc.
Ch	*Teucrium chamaedrys*	1		1	1			+				III	Euro-Med.

	No. of relevé	1	2	3	4	5	6	7	8	9	10		
T	*Calamintha acinos*	+		+			+					II	Euro-Med.
Ch	*Minuartia setacea*					1						I	Europ.
H	*Hieracium cymosum*		+									I	Europ.
H	*Fragaria viridis*	.	+	.	1	.	+	.	1	+	.	III	Eurosib.
H	*Sedum telephium*	.	+	.	2	2	.	.	.	.	.	II	Eurosib.
H	*Hieracium murorum*	.	.	.	.	+	.	+	.	.	.	I	Eurosib.
H	*Fragaria vesca*	.	.	+	.	.	.	.	.	.	.	I	Eurosib.
H	*Leucanthemum vulgare*	.	.	.	+	.	.	.	.	.	.	I	Eurosib.
H	*Hieracium waldsteinii*	1	.	.	+	.	+	1	.	+	.	III	Illyric
H	*Arabis alpina* subsp. *caucasica*	1	1	.	+	.	+	.	.	+	.	III	Medit.
H	*Aurinia corymbosa*	.	.	+	.	.	.	.	+	.	.	I	Medit.
H	*Koeleria splendens*	.	.	.	1	.	.	.	+	.	.	I	Medit.mont.
P shrub	*Rosa canina*	.	.	+	1	.	.	.	+	+	.	III	Paleotemp.
P shrub	*Crataegus monogyna*	+	.	.	.	.	.	.	+	+	.	II	Paleotemp.
T	*Bromus japonicus*	+	.	.	.	.	.	.	.	.	.	I	Paleotemp.
P	*Fraxinus ornus*	.	.	.	.	.	1	1	1	1	.	III	S. Europe
H	*Achnatherum calamagrostis*	+	+	+	.	.	.	1	.	.	+	III	S. Europe
T	*Arabis turrita*	1	.	+	.	.	.	+	1	.	.	III	S. Europe
H	*Scabiosa ochroleuca*	1	+	.	.	+	.	+	.	.	.	III	S. Europe
H	*Trifolium montanum*	1	.	.	.	+	.	.	.	.	.	I	S. Europe
H	*Leontodon crispus*	+	.	.	.	.	.	.	.	+	.	I	S. Europe
H	*Stipa pulcherrima*	+	.	.	1	.	.	.	.	.	.	I	S. Europe
H	*Linaria concolor*	.	+	.	.	.	.	.	.	.	.	I	S. Europe
H	*Silene saxifraga*	.	.	.	.	.	.	.	.	.	+	I	S. Europe
P shrub	*Quercus pubescens*	.	.	1	.	.	.	.	.	.	.	I	SE Europe
H	*Helleborus odorus*	.	1	+	+	.	.	.	.	.	.	II	SE Europe
T	*Sedum caespitosum*	.	.	.	+	1	+	.	.	.	.	II	Steno-Med.
Ch	*Teucrium polium*	1	.	.	+	.	.	.	.	.	.	I	Steno-Med.
G	*Cyclamen hederifolium*	.	.	1	.	.	.	.	.	+	.	I	Steno-Medit.

The syntaxonomic position:

Class: *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959

Order: *Quercetalia pubescenti-petraeae* Klika 1933

Alliance: *Fraxino orni-Ostryion* Tomažič 1940

Association: *Ramondo-Ostryetum carpinifoliae* ass. nova.

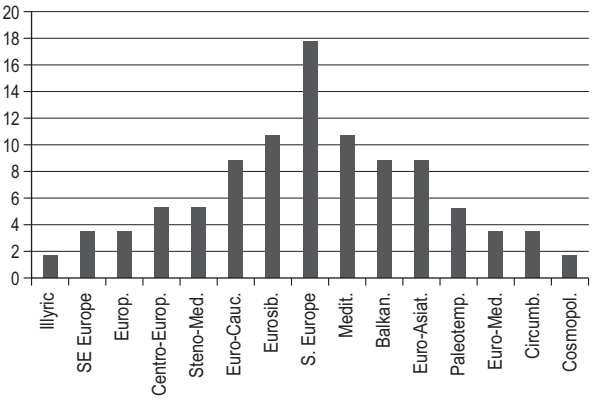
General characteristics of the habitat

The described plant community grows on the northern, north-western and rarely western slopes of the Mt. Luboteni massif (Figure 1), on the right side of the road Ferizaj – Glloboqicë, 52 km S from Prishtina. It develops at the altitudinal range from 965 up to 979 m a.s.l. All our relevés were made on a limestone substrate. The surveyed site was covered with trees and shrubs (Figure 2), while the general cover of the community ranged from 30–45%. The plant association was characterized with a structure that is almost closed, developing on stable screes (Figure 4), where populations of *R. nathaliae* were very dense.

Floristic composition of the association

The floristic composotion of the community is presented in the phytosociological table (Table 1) containing 10 relevés with a total of 56 species present. The species *Asperula purpurea* had a constancy level of V, while the constancy level of *Arabis procurrens* and *Ostrya carpinifolia* as a shrub was IV. The species *Arabis alpina* subsp. *caucasica*, *Achnatherum calamagrostis*, *Fragaria viridis*, *Teucrium chamaedrys*, *Fraxinus ornus*, *Arenaria serpyllifolia*, *Rosa canina*, *Bupleurum flavicans*, *Arabis turrita*, *Scabiosa ochroleuca* and Musci (*Neckera crispa*) had a constancy level of III. It is important to emphasize that the following species were substrate tolerant: *Asplenium trichomanes*, *Asplenium ruta-muraria*, *Leontodon crispus*, *Stipa pulcherrima*, *Koeleria splendens*, *Sedum acre* and *Clinopodium acinos*.

Figure 2: Typical appearance of the association *Ramondo-Ostryetum carpinifoliae* in Luboten on stable screes (Photo: F. Millaku, 2017).
Slika 2: Tipičen videz sestojev asociacije *Ramondo-Ostryetum carpinifoliae* na Ljubotenu na stabilnem melišču (foto: F. Millaku, 2017).



Chorological spectrum

The geographical position of this community can be illustrated through the spectrum of species distribution in terms of present geographical elements (Figure 3). The distribution of floristic elements of the community is: South-European 17.8%, Mediterranean 10.7%, European-Siberian 10.7%, Balkan 8.9%, European-Asiatic 8.9%, European-Caucasian 8.9%, Central-European 5.3%, Steno Mediterranean 5.3%, Paleotemperate 5.3%, South-Eastern European 3.5%, European 3.5%, European-Mediterranean 3.5%, Circumboreal 3.5%, Illyric 1.7% and Cosmopolite 1.7%. This chorological spectrum was compared with those from the six associations,

Figure 3: Geographical elements in the florsitic composition of the association *Ramondo-Ostryetum carpinifoliae*. Illyric 1.7%, SE Europe (South-Eastern Europe) 3.5%, Europ. (European) 3.5%, Centro-Europ. (Central-European) 5.3%, Steno-Med. (Steno Mediterranean) 5.3%, Euro-Cauc. (European-Caucasian) 8.9%, Eurosib. (European-Siberian) 10.7%, S. Europe (South-European) 17.8%, Medit. (Mediterranean) 10.7%, Balkan 8.9%, Euro-Asiat. (European-Asiatic) 8.9%, Paleotemp. (Paleotemperate) 5.3%, Euro-Med. (European-Mediterranean) 3.5%, Circumb. (Circumboreal) 3.5%, Cosmopol. (Cosmopolite) 1.7%.
Slika 3: Geoelementi v floristični sestavi asociacije *Ramondo-Ostryetum carpinifoliae*. Ilyric (ilirski) 1,7%, SE Europe (jugovzhodno evropski) 3,5%, Europ. (evropski) 3,5%, Centro-Europ (srednjeevropski) 5,3%, Steno-Med. (stenomediteranski) 5,3%, Euro-Cauc. (evropsko-kavkazijski) 8,9%, Eurosib. (evropsko-sibirski) 10,7%, S. Europe (južnoevropski) 17,8%, Medit. (mediteranski) 10,7%, Balkan (balkanski) 8,9%, Euro-Asiat. (evropsko-azijski) 8,9%, Paleotemp. (paleotemperatni) 5,3%, Euro-Med. (evropsko-mediteranski) 3,5%, Circumb. (cirkumborealni) 3,5%, Cosmopol. (kozmopolitski) 1,7%.

Figure 4: *Ramonda nathaliae* Pančić & Petrović as seen on studied site, growing on limestone rocks and stable screes (Photo: F. Millaku, 2017).
Slika 4: *Ramonda nathaliae* Pančić & Petrović na preučevanem rastišču na stabilnem karbonatnem melišču (foto: F. Millaku, 2017).

and it was observed (Figure 8) that the Mediterranean mountain floristic element is clearly more pronounced, with many differences in other floral elements of the chorological spectrum.

In the Balkan chorological group, *Ramonda nathaliae* and *Saxifraga sempervivum* (with constancy class V) as well as *Hieracium waldsteinii* (with constancy class III) were the characteristic species of the association, while accompanying species from the same geoelement were: *Arabis procurrens* (IV), *Bupleurum flavicans* (III) and *Hieracium pannosum* (I).

In the Mediterranean chorological group (Medit. mont.) there were five species, two of them (*Ostrya carpinifolia* and *Euonymus latifolius* – both with constancy class V) were also the character species of the association *Ramondo-Ostryetum carpinifolia*.

The species *Ramonda nathaliae*, *Saxifraga sempervivum* and *Hieracium waldsteinii* from Balkan floristic elements and *Ostrya carpinifolia* and *Euonymus latifolius* from the Mediterranean mountain geoelement − as a character species of the association, contribute in giving this plant community a Balkan to Mediterranean montane character.

Life form spectrum

The studied plant community has a predominantly hemicryptophytic to phanerophytic character. The two main life forms (Figure 5) together constitute 77% of the whole life form spectrum of the association (H – 33 taxa – 59%; P – 10 taxa – 18%). The participation of chamaephytes (6 taxa – 11%) and therophytes (6 taxa – 11%) is similar, while geophytes have one species only (1.7%). It is worth noting that phanerophytes include 10 species, where *O. carpinifolia* is represented as a tree (P scap) as well as a shrub (P caesp), depending on the plant age. In total there are two trees (3.6%) and eight shrubs (14%). In this context, from the character species of the community, species *O. carpinifolia*, *C. tomentosus* and *E. latifolius* are all dominant species with constancy V while hemicryptophytes with constancy V comprise *R. nathaliae*, *S. sempervivum* and *A. purpurea*. One species has constancy IV and four constancy III. Chamaephytes have one species respectively for constancies V, IV and III, and the remaining three species with constancy I. Therophytes are represented with three species with constancy III, two species with constancy II and one species with

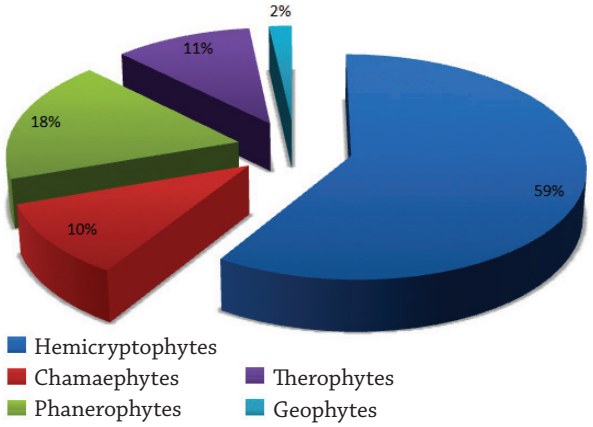


Figure 5: Life form spectrum of the association: *Ramondo-Ostryetum carpinifoliae.*
Slika 5: Spekter življenskih oblik asociacije *Ramondo-Ostryetum carpinifoliae.*

constancy I. in terms of the overall physiogonomy of the plant community, species *O. carpinifolia* as a tree as well as in the shrub formation covers all screes where *R. nathaliae* occurs.

Comparisons with other similar plant communities with Balkan Ramonda species

R. nathaliae populations can develop on calcareous as well as serpentine substrates, with preference for north-exposed rocks, crevices and stable screes (Stevanović et al. 2014, Stevanović & Matevski 2011, Stevanović & Stevanović 1985). From conducted phytosociological studies in a sympatric area where *R. nathaliae* and *R. serbica* occurred together (Radovanski k., Serbia), it was reported that these two species can even establish a unique community: *Ceterachi-Ramondetum serbicae ramondetosum nathaliae* (Stevanović et al. 1987).

The population of the ass. *Ramondo-Ostryetum carpinifoliae* growing on limestone screes in the mountain massif of Luboten was covered with trees and shrubs of *Ostrya carpinifolia*. The differences observed between two serpentine plant communities (ass. *Scorzonero-Ramondaetum nathaliae* and ass. *Asplenio-Ramondaetum nathaliae*) and *Ramondo-Ostryetum carpinifoliae* are multiple. There are clear differences in floristic richness between the three plant associations.

The ass. *Scorzonero-Ramondaetum nathaliae* V. Stevanović & V. Matevski (Stevanović & Matevski 2011) has 54 species, of which only 7 are shared with *Ramondo-Ostryetum carpinifoliae*. It was recorded on a serpentine substrate, at a far lower altitude (>700 m difference), with different character species and dissimilar community ecology. These differences can be easily seen on the TWINSPAN dendrogram analysis (Figure 6) as well as in NMDS ordination (Figure 7), whereby we can conclud that it is probably more related to *Asplenio-Ramondaetum nathaliae*.

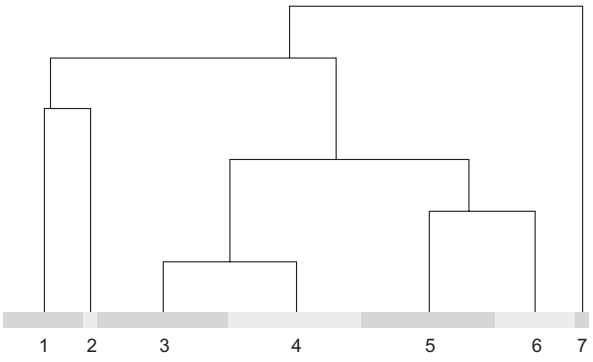


Figure 6: Dendrogram of cluster analysis between six most similar plant associations with *Ramonda* and the *Ramondo-Ostryetum carpinifoliae.*
Slika 6: Dendrogram klastrske analize šestih najbolj podobnih rastlinskih združb z vrstami rodu *Ramonda* in asociacije *Ramondo-Ostryetum carpinifoliae.*
1. *Scorzonero-Ramondietum nathaliae*, 2. *Asplenio-Ramondietum nathaliae*, 3. *Ramondo-Ostryetum carpinifoliae*, 4. *Ceterachi-Ramondietum serbicae*, 5. *Valeriano tripterae-Ramondietum serbicae*, 6. *Musco-Ramondietum nathaliae*, 7. *Geranio-Ramondietum serbicae.*

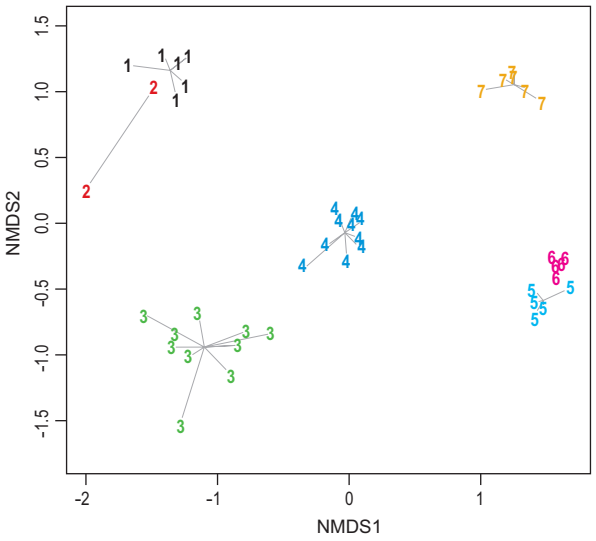


Figure 7: NMDS ordination plot analysis between the six compared most similar plant associations with *Ramonda* species and *Ramondo-Ostryetum carpinifoliae.*
Slika 7: Ordinacijska analiza (NMDS) šestih najbolj podobnih rastlinskih združb z vrstami rodu *Ramonda* in asociacije *Ramondo-Ostryetum carpinifoliae.*
1. *Scorzonero-Ramondietum nathaliae*, 2. *Asplenio-Ramondietum nathaliae*, 3. *Ramondo-Ostryetum carpinifoliae*, 4. *Ceterachi-Ramondietum serbicae*, 5. *Valeriano tripterae-Ramondietum serbicae*, 6. *Musco-Ramondietum nathaliae*, 7. *Geranio-Ramondietum serbicae.*

The *Asplenio-Ramondaetum nathaliae* V. Stevanović & B. Stevanović 1985 (Stevanović & Stevanović 1985) has 73 species, 9 of which are shared with *Ramondo-Ostryetum carpinifoliae*. In terms of species richness association is 23% richer than *Ramondo-Ostryetum carpinifoliae*. It also grows on serpentine substrate, at a lower altitude (>670 m difference), with different characteristic species and dissimilar community ecology. The existing differences between two of these *R. nathaliae* plant communities can be easily observed on TWINSPAN dendrogram (Figure 6) as well as on NMDS ordination (Figure 7). Due to the fact that this plant community is described based on only two relevès, the conducted non-metric multidimensional scaling shows one of its relevès (Figure 7) to be within the range of the *Scorzonero-Ramondaetum nathaliae* community.

The *Ceterachi-Ramondetum serbicae* R. Jov.-Dunj. 1952 *ramondetosum nathaliae* V. Stevanović et al. 1987. (Stevanović et al. 1987) has only 36 species registered from 10 relevès, and 11 of them are shared with *Ramondo-Ostryetum carpinifoliae*. Nevertheless, except for *R. nathaliae*, all other shared species are accompanying ones from our described association. In this association the distinctive characteristic is the presence of two Ramonda species (*R. nathaliae* & *R. serbica*) – which is not the case in our community. We see different character species and different ecological characteristics with no relevant conjunction in between. The TWINSPAN dendrogram analysis (Figure 6) and NMDS ordination (Figure 7) convincingly indicate their distinctiveness.

As suggested by its name, the *Valeriano tripterae-Ramondietum serbicae* Janković & Stevanović (Janković & Stevanović 1981) is a plant community characterized by *Valeriana tripteris* and *Ramonda serbica*, both of them absent in the ass. *Ramondo-Ostryetum carpinifoliae*. With only three species in common, differences are obvious in terms of the chorological spectrum (Figure 8) where the boreal floristic element is dominant in *Valeriano tripterae-Ramondetum serbicae*. These two plant communities are clearly distinguishable also via the conducted TWINSPAN dendrogram (Figure 6) as well as in NMDS ordination (Figure 7).

The *Musco Polypodio-Ramondetum serbicae* Petković et al. 1988 is characterized by emphasized montane South-Eastern European floristic elements (Figure 8), which differs significantly from the representation of floristic elements in the ass. *Ramondo-Ostryetum carpinifoliae*. All character species of this association are absent in our studied plant community. Additionally, differences are obvious in floristic richness and disimilarities, 60% fewer species than *Ramondo-Ostryetum carpinifoliae*, with only one shared species (*Asplenium trichomanes*). In addition to dendrogram showing clear differentiation (Figure 6), NMDS ordination (Figure 7) shows *Musco Polypodio-Ramondetum serbicae* to be closer with *Valeriano tripterae-Ramondetum serbicae*.

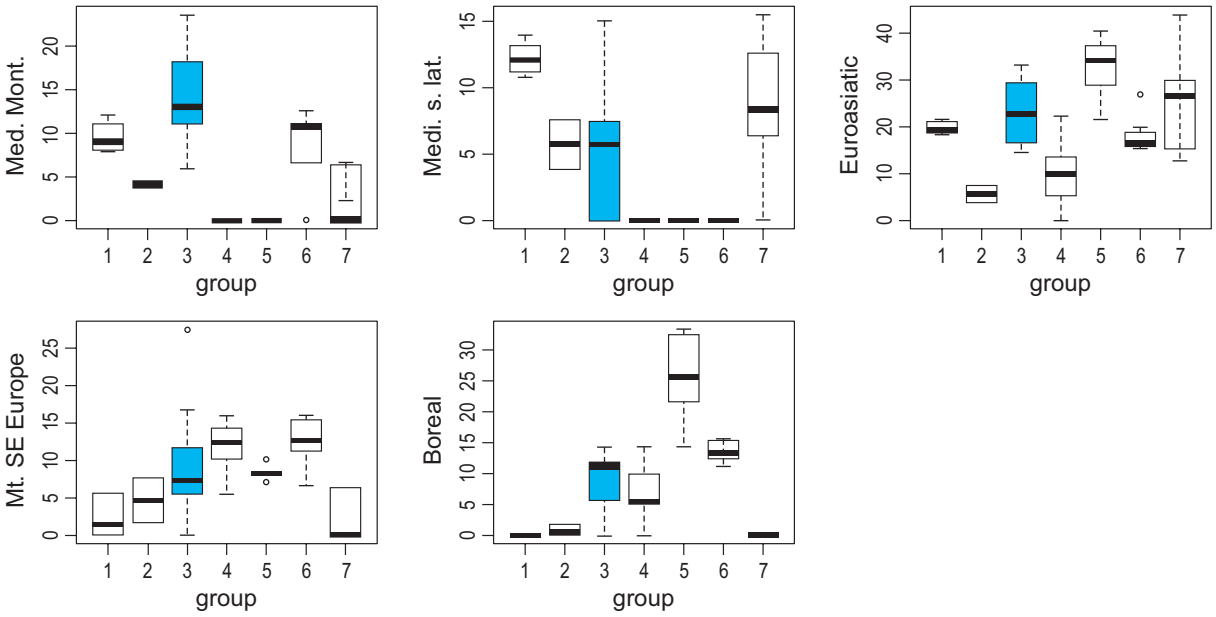


Figure 8: Chorological spectrum of the new association (*in blue*) in comparison to six most similar plant communities with *Ramonda* species.
Slika 8: Primerjava horološkega spektra novopisane asociacije (modro) in šestih najbolj podobnih rastlinskih združb z vrstami rodu *Ramonda*.
1. *Scorzonero-Ramondietum nathaliae*, 2. *Asplenio-Ramondietum nathaliae*, 3. *Ramondo-Ostryetum carpinifoliae*, 4. *Ceterachi-Ramondietum serbicae*, 5. *Valeriano tripterae-Ramondietum serbicae*, 6. *Musco-Ramondietum nathaliae*, 7. *Geranio-Ramondietum serbicae*.

The *Geranio dalmatici- Ramondietum serbicae* Stevanović & Bulić 1992 is a predominantely hemocryptophytic (56%) plant community and to some extent the presence of Euroasiatic floristic elements might be similar to the ass. *Ramondo-Ostryetum carpinifoliae* (Figure 8), which is the only similarity between them. It is very poor in species (31 species from 6 relevès) and has only three acompanying species in common with the ass. *Ramondo-Ostryetum carpinifoliae*. All character species are absent from one another. The NMDS ordination plot (Figure 7) shows a clear distance matrix between the two associations and the dendrogram of the cluster analysis (Figure 6) also shows the two clusters having high negative correlation value.

The prominent and constant presence of the tertiary relict and Balkan endemic species *R. nathaliae* makes this plant community unique among forest plant communities. Additionally, in comparison with similar forest plant communities (Table 2), due to the dominance of *Ostrya carpinifolia* and the constant presence of other diagnostic species like *Primula veris, Primula vulgaris, Cotoneaster tomentosus* and *Fraxinus ornus* as well as certain ecological factors, we concluded that this plant community syntaxonomically belongs to the class *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959. This plant community will not adhere into the anticipated alliance *Ramondion nathaliae* for the mentioned reasons. The practicability and accuracy of including the majority of chasmophytic plant communities from the Central Balkans into the alliance *Ramondion nathaliae* had been discussed before (Stevanović et al. 2014). Surely, further research is needed and the future results will bring new answers to the questions concerning the chasmophytic vegetation in the Balkans.

In all instances, the cluster dendrogram analysis (Figure 6) and the non-metric multidimensional scaling (NMDS) (Figure 7) clearly demonstrated the differentiation of the compared chasmophytic plant communities, in this context of the new ass. *Ramondo-Ostryetum carpinifoliae* in comparison with 6 other plant communities.

Comparisons with typical *Ostrya carpinifolia* dominated forest communities from SE Europe

O. carpinifolia as a native European species is usually found on steep slopes at higher altitudes, commonly in those zonal habitats where *Quercus pubescens* and *Carpinus orientalis* cannot grow normally. Since the ass. *Ramondo-Ostryetum carpinifoliae* in addition to chasmophytic vegetation features had traits of a forest plant community, we compared it against the following seven plant communities with dominant *O. carpinifolia*:

1. *Querco-Ostryetum carpinifoliae* Horvat 1938
2. *Seslerio-Ostryetum carpinifoliae* Ht. et H-ić 1950
3. *Corylo colurnae-Ostryetum* Blečić 1958
4. *Ostrya carpinifolia-Quercetum cerris* Rexhepi & Ružic ex. Matevski 2011
5. *Querco pubescentis-Ostryetum carpinifoliae* Horvat 1938
6. *Seslerio robustae-Ostryetum* Matevski 2011
7. *Aceri-Ostryetum carpinifoliae* B. Petković et al. 1986

1. *Querco-Ostryetum carpinifoliae* Horvat 1938 (Rexhepi 1983) is a typical forest plant community where predominant plants are trees and shrubs: *O, carpinifolia*, *Q. pubescens*, *Fraxinus ornus*, *Cornus mas*. This plant community has 90% more phanerophytes (Figure 9) than *Ramondo-Ostryetum carpinifoliae* and only 15% shared species (Figure 11). In chorological terms, the most dominant groups were: S-Europ.-Sudsib. 20%, Eurasiat. 15%, Europ.-Caucas. 13% (Figure 10) – completely different from those in our studied community. Additional differences were obvious in terms of ecological preferences and overall species richness: + 40% richer than *Ramondo-Ostryetum carpinifoliae*.

Table 2: Comparative overview of the forest *Ostrya carpinifolia* communities with the newly established community *Ramondo-Ostryetum carpinifoliae.*
Tabela 2: Primerjava gozdnih združb z vrsto *Ostrya carpinifolia* z novoopisano asociacijo *Ramondo-Ostryetum carpinifoliae.*

Association	Total no. of taxa	No. of same taxa*	%
Querco-Ostryetum carpinifoliae Horvat 1938	80	12	15
Seslerio-Ostryetum carpinifoliae Ht. et H-ić 1950	65	15	23
Colurno-Ostryetum carpinifoliae Blečić 1957	74	12	16
Ostrya carpinifolia-Quercetum cerris Rexhepi et Ružic ex. Matevski	76	12	15
Querco pubescentis-Ostryetum carpinifoliae Horvat 1938	92	11	12
Seslerio robustae-Ostryetum Matevski 2011	70	9	13
Aceri-Ostryetum carpinifoliae B. Petković et al. 1986	92	12	13

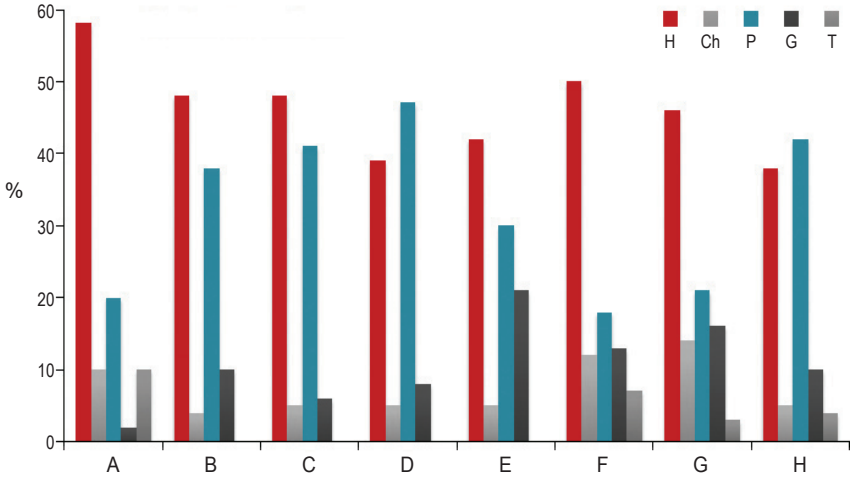


Figure 9: Life form overview of corresponding forest communities.
Slika 9: Pregled življenskih oblik obravnavanim gozdnih združb.
A. *Ramondo-Ostryetum carpinifoliae*,
B. *Querco-Ostryetum carpinifoliae*,
C. *Seslerio-Ostryetum carpinifoliae*,
D. *Colurno-Ostryetum carpinifoliae*,
E. *Ostrya carpinifolia-Quercetum cerris*,
F. *Querco pubescentis-Ostryetum carpinifoliae*,
G. Seslerio robustae-Ostryetum,
H. *Aceri-Ostryetum carpinifoliae*.

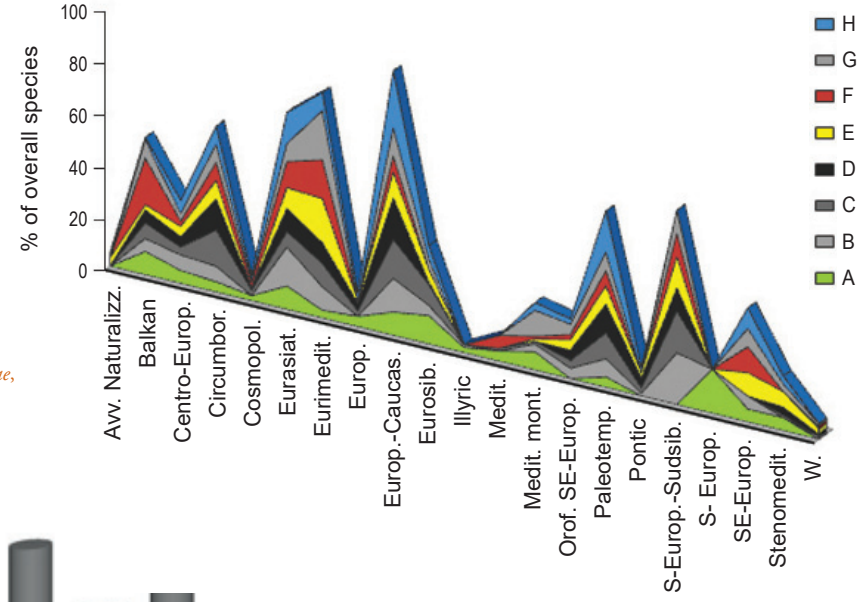


Figure 10: Overview of the chorological spectrum between the *Ramondo-Ostryetum carpinifoliae* and corresponding forest *Ostrya carpinifolia* communities.
Slika 10: Primerjava horoloških spektrov med asociacijo *Ramondo-Ostryetum carpinifoliae* in primerljivimi gozdnimi združbami z vrsto *Ostrya carpinifolia*.
A. *Ramondo-Ostryetum carpinifoliae*,
B. *Querco-Ostryetum carpinifoliae*,
C. *Seslerio-Ostryetum carpinifoliae*,
D. *Colurno-Ostryetum carpinifoliae*,
E. *Ostrya carpinifolia-Quercetum cerris*,
F. *Querco pubescentis-Ostryetum carpinifoliae*,
G. *Seslerio robustae-Ostryetum*,
H. Aceri-Ostryetum carpinifoliae.

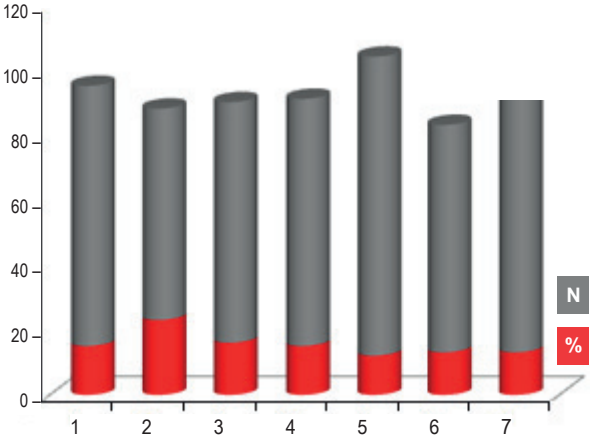


Figure 11: Species similiarity chart-compared to seven forest *Ostrya carpinifolia* communities. N-number of species, % - shared species.
Slika 11: Graf vrstne podobnosti primerjanih gozdnih združb z vrsto *Ostrya carpinifolia*. N-število vrst, % - skupne vrste.
1. *Querco-Ostryetum carpinifoliae*, 2. *Seslerio-Ostryetum carpinifoliae*, 3. *Colurno-Ostryetum carpinifoliae*, 4. *Ostrya carpinifolia-Quercetum cerris*, 5. *Querco pubescentis-Ostryetum carpinifoliae*, 6. *Seslerio robustae-Ostryetum*, 7. *Aceri-Ostryetum carpinifoliae*.

2. *Seslerio-Ostryetum carpinifoliae* Ht. et H-ić 1950 (Rexhepi 1983) – a plant community in Kosovo is described from the Albanian Alps (Mt. Zhleb) of Kosovo at the altitude of 800 m a.s.l. Characteristic taxa for the association are *O. carpinifolia, Sesleria autumnalis* (Scop.) F. W. Schultz, *Cotoneaster tomentosus* (Aiton) Lindl., *Amelancher ovalis* Medik, *Cotinus coggygria* Scop., *Hippocrepis emerus* (L.) Lassen subsp. *emerus* and *Eryngium palmatum* Pančić & Vis. None of these taxa are present in our association with *R. nathaliae*. Furthermore, 15 species (23%) are shared (Figure 11), of which, with the exception of *O. carpinifolia* and *C. tomentonsus*, all other species are accompanying ones in both communities. As can be seen in Figure 9, the most dominant life forms are hemicriptophytes (48%) accompanied by

phanerophytes (42%), whereas in *Ramondo-Ostryetum carpinifoliae* there were three times more hemicryptophytes than phanerophytes, which sufficiently explains the life form spectrum difference between them. Differences are clear also in chorological terms (Figure 10), with Europ.-Caucas.(15%), Circumbor. (14%) and S-Europ.-Sudsib. (14%) being the dominant floristic groups here.

3. *Corylo colurnae-Ostryetum* Blečić 1958 (Rexhepi 1983) represents a very relic plant community with very heterogeneous composition that is additionally (Krasniqi 1972) believed to be of tertiary geologic period. They are ravine forests that develop in the transitional zones between oak and beech (Matevski et al. 2011), dominated by *O. carpinifolia* and *Corylus colurna*, the latter missing entirely in our studied community. Additionally, all of the diagnostic and constant species of the association are absent in the *Ramondo-Ostryetum carpinifoliae*, with only 12 similar species between them. Other major differences are observed in the chorological spectrum (Figure 10), with the Euro-Caucasian floristic element being the dominant one; as well as in the life form spectrum with dominant phanerophytes (47%).
4. *Ostrya carpinifolia-Quercetum cerris* Rexhepi et Ružić ex. Matevski (Matevski et al. 2011) is a *Quercus cerris* dominated forest community developing on a carbonate bedrock. The differences with *Ramondo-Ostryetum carpinifoliae* are numerous also in this association. All of the diagnostic as well as constant species (with the exception of *O. carpinifolia*) are absent in the second. The dominant floristic element is Eurimediterranean (17%) (Figure 10) and in terms of the life form spectrum, geophytes are 20% more represented here than in our studied community (Figure 9), so we concluded that these two plant communities are clearly distinguishable and different.
5. *Querco pubescentis-Ostryetum carpinifoliae* Horvat 1938 (Matevski et al. 2011) is a xerophilous forest community with *O. carpinifolia* and *Q. pubescens*. Only 11 species are shared with the analysed communities with two diagnostic species being the same. Anyway, in *Ramondo-Ostryetum carpinifoliae, Q. pucescens* was present only in one releve (1), and is not as important as it is in this community. Additionally, all other diagnostic and constant species are missing (Matevski et al. 2011). Differences between these two communities are clear also in terms of dominant floristic elements (Figure 10) and life forms (Figure 9).
6. *Seslerio robustae-Ostryetum* Matevski (Matevski et al. 2011) is a plant community of extreme steep slopes over carbonate bedrock. As its name suggests, the community is differentiated by the dominance of *Sesleria robusta* Schott & al. Not only this dominant species, but also all of the diagnostic species are absent in *Ramondo-Ostryetum carpinifoliae*. Only 9 species are shared (Figure 11). In chorological terms (Figure 10) the dominant floristic element is Eurimediterranean, which is represented in the studied community with only 4%.
7. *Aceri-Ostryetum carpinifoliae* Petković (B. Petković et al. 1986, Tomić 1980) – this plant community represents an azonal vegetation type that develops within mountain beech forests. The character species of the associations are: *Cephalanthera rubra* (L.) Rich., *Cephalanthera damasonium* (Mill.) Druce and *Veronica austriaca* subsp. *teucrium* (L.) D. A. Webb. The upper canopy is dominated by *O. carpinifolia* and *F. ornus*. With the exception of *O. carpinifolia*, none of the character and diagnostic species are present in *Ramondo-Ostryetum carpinifoliae.* Out of 92 species, the compared communities share only 12. The dominance of phanerophytes (Figure 9) and the European-Caucasian floristic element dominating the chorological spectrum (Figure 10) of this association underline the differences between these two communities.

Table 2 gives a summarized comparative overview of seven forest-type plant communities with *Ostrya carpinifolia* and the differences that distinguish them from *Ramondo-Ostryetum carpinifoliae*.

Furthermore, it should be noted that calcareous rocky slopes of forest vegetation – including plant communities with *Ramonda nathaliae*, are known to harbour very specific flora that is worthy of protection. Calcareous rocky slopes with chasmophytic vegetation are recorded as habitat type 8210 (PAL.CLASS.: 62.1) according to Directive 92/43/EEC of the EU Commission (Anonymous 2013).

Conclusions

The new association *Ramondo-Ostryetum carpinifoliae* established in the Luboteni massif, the Sharri Mts., belongs to the forest plant communities of the alliance *Fraxino orni-Ostryion* Tomažič 1940. These plant communities are rare and fragile, not only in this part of Kosovo but in the entire species range in the Balkans. They remain very interesting indeed for their rarity and endemism, and even more for the very specific habitats on deep and isolated gorges and canyons that they inhabit.

Additional studies into forest vegetation on limestone cliffs are needed and they will make new answers available with regard to syntaxonomic positioning and management of these interesting vegetation types.

Consistent classification and monitoring of these habitats on a regional as well as European level could enhance the efforts towards their conservation, as they do represent very valuable, yet fragile biodiversity hotspots.

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