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Chasmophytic communities of endemic and relict species *Ramonda nathaliae* Pančić & Petrović on ophiolithic substrate in Republic of Macedonia

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ABSTRACT: Chasmophytic communities of endemic and relict species *Ramonda nathaliae* on ophiolithic (serpentine) substrate are very rare phenomenon in the whole range of the species considering that it grows mainly on limestone. The paper presents the two communities of *R. nathaliae* on serpentine habitats: *Asplenio-Ramondaetum nathaliae* previously described near the village Raduša and new community *Scorzonero-Ramondaetum nathaliae* from the gorge of the river Pčinja. Floristic composition, chorological and life form spectra of these two communities are compared. The syntaxonomical position of these communities in relation to the alliance of chasmophytic vegetation on limestone *Ramondion nathaliae* and alliance of serpentine rocky grasslands of alliance *Centaureo - Bromion fibrosi* is discussed. Due to significant floristic differences between communities of *R. nathaliae* on serpentine and those growing on limestone, a new sub-alliance *Ramondion nathaliae serpentinicum* is proposed.

Key words: *Ramonda nathaliae*, serpentine bedrock, chasmophytic communities, Balkans

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INTRODUCTION

Endemic and resurrection Balkan species of the genus *Ramonda* - *R. serbica* Pančić and *R. nathaliae* Pančić and Petrović from their discovery to the present time excite the interest of botanists. They studied their distribution and mutual chorological differentiation, idio- and synecology, while in the last few decades of the last and early part of this century, interest has been directed more towards the biochemical and molecular mechanisms of survival during environmental stress and reviviscence from anabiosis, kariology and cytometry as well as phylogeography of these interesting endemic and relict plants.

The species *R. nathaliae* is distributed in the central part of the Balkan Peninsula with two disjunct parts of its range. A significantly smaller range is located in E. Serbia (Mt Suva planina, Jelašnička and Sićevačka gorges), while the larger portion includes gorges, canyons and surrounding mountains in Macedonia and N. Greece. The largest number of localities and the most abundant populations are located in Macedonia, in the basin of the Vardar river and its right tributaries (Fig. 1).

Chorologically, *R. nathaliae* and *R. serbica* are very well differentiated where their ranges are spatially close (W. Macedonia), except in E. Serbia, where both species grow in syntopy and/or sympatry (Stevanović *et al.* 1986a, 1986b). Namely, the major part of the range of *R. nathaliae* is restricted to the Aegean river system in R. Macedonia (Vardar and its tributaries), while the range of *R. serbica* covers gorges, canyons and ravines of the Adriatic river system in Montenegro, S.W. Serbia (Kosovo and Metohija province) and Albania (Košanin 1921; Stevanović *et al.* 1991).

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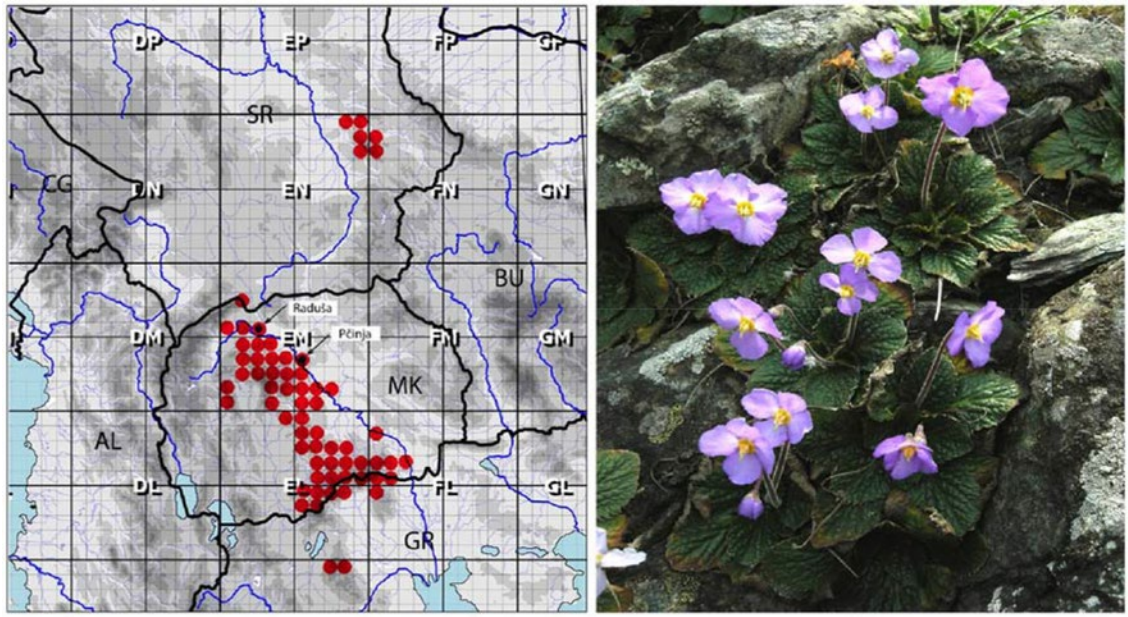

Fig. 1. Distribution of *R. nathaliae* in the Balkans. With arrows are indicated two localities where it grows on ophiolithic bedrocks (left); *R. nathaliae* in ophiolithic habitat of Pčinja gorge (right)

Both *Ramonda* species are typical chasmophytes, and primarily inhabit limestone rock crevices. However, in the central part of the range in Macedonia, *R. nathaliae* can be found rarely on serpentine and some siliceous rocks (Košanin 1921). In addition, it inhabits rocks in a wide altitudinal amplitude from 100 to 2250 m. Both Balkan *Ramonda* species always grow on north facing rocks.

Communities of *R. nathaliae* growing on serpentine rocks and rocky slopes in N. Macedonia have been reported. According to Košanin (1921), Soška (1938) and Micevski (1956), so far only two localities of *R. nathaliae* are known in these habitats, not only in Macedonia, but in its whole range: 1 Kisela voda near the village of Raduša, on the left bank of the Vardar river Gorge and 2. Pčinja river gorge before it flows into the Vardar river. Both sites were floristically and phytosociologically explored in detail.

The aim of this study was to determine differences in the floristic and coenotic composition of the communities growing on serpentine, because of its silicate substrate of specific mineral composition (absence of lime, rich in magnesium and heavy metals (iron, nickel etc.)), while pHs are very similar to those of limestone rocks that are otherwise the optimal habitat of the species.

MATERIAL AND METHODS

Phytocoenological analysis was performed using standard methods of Braun-Blanquet (1965). Determination of belonging of each taxa to its corresponding floristic elements, chorological subgroups and groups was made on the basis of areal maps for widely distributed species, given by Meusel *et al.* (1965, 1978), Meusel & Jäger (1992) and Hulten (1958, 1961, 1962). For endemic species, the working cartographic database of the endemic Balkan flora was used (Stevanović, Tan, Petrova).

Life forms of plants were determined according to principles proposed by Raunkier (1937), supplemented by Ellenberg & Mueller-Dombois (1967).

Floristic similarities among the analyzed communities were determined using the clustering method based on Sorensen distances and unweighted pair-group average hierarchical sorting strategy (UPGMA). All statistical analyses were performed with the Statistica software package (version 5.1; StatSoft, 1997). Detrended correspondence analysis (DCA) was performed using the FLORA software (Karadžić *et al.* 1998).

The annexes are given in on line version at http://botanicaserbica.bio.bg.ac.rs/.

RESULTS AND DISCUSSION

In addition to the previously-described community of *R. nathaliae* on a serpentine bedrock - *Asplenio-Ramondaetum nathaliae* in the vicinity of the village Raduša (Stevanović & Stevanović 1985) , a new community of this endemic and relict species *Scorzonero-Ramondaetum nathaliae* was found and described on the same geological substratum in the gorge of the river Pčinja in N. Macedonia.

Ass. *Scorzonero-Ramondaetum nathaliae* V. Stevanović & V. Matevski [1] ass. nova hoc loco. Holotypus: Tabela I Relevé No 4 (Anex 1): MK: Skopje-Katlanovo, Gorge of the river Pčinja, 7.8 km S. from Katlanovo and 37 km S.W. from Skopje, serpentine; N 41o 49' 18.95"; E 21o 41' 05.15"; altitude: 263 m, 08-05-2011, Vladimir Stevanović & Vlado Matevski.

General characteristics of the habitat. The community was growing at N.-N.W., rarely N.E. slopes of the serpentine hill on the left bank of the gorge of the river Pčinja before flowing into the river Vardar (Taorska gorge). The community had developed in an altitudinal range between 263 and 320 m. The slope was covered with sparse shrubs and small individual trees (Fig. 2a). The general cover of the community ranged from 30-45%, at a slope of 5-70^0. Populations of *R. nathaliae* were very dense, growing on the serpentine rocks and stable screes (Fig. 2b&c).

The floristic composition[2]. The community was described on the basis of six stands (Annex 1). It consisted of 54 species of vascular flora. The characteristic species of the community were *Ramonda nathaliae*, *Scorzonera austriaca*, *Cheilathes marantae* and *Cerastium banaticum* subsp. *kosaninii*. In addition, the following facultative serpentinophytes from the alliance *Centauro-Bromion fibriosi* were recorded: *Dianthus pinifolius* subsp. *pinifolius*, *Alyssum serpentini*, *Convolvulus boissieri* subsp. *compactus*, *Chamaecytisus austriacus* subsp. *heuffelii*, and *Minuartia hirsuta* subsp. *falcata*. The majority of species is indifferent to the substratum, inhabiting often thermophilous limestone rocky grasslands and, rarely rocks. These species are: *Dianthus gracilis* subsp. *armerioides, Sedum ochroleucum, Galium oreophilum, Asplenium ceterach, Aethionema saxatile, Leontodon crispus, Asplenium trichomanes, Valeriana dioscoridis, Festuca callieri, Stipa pulcherrima, Potentilla astracanica, Medicago pseudorupestris, Poa bulbosa, Scabiosa triniiifolia, Thymus thracicus* var. *stribrny, Iris suaveolens, Koeleria splendens, Hypericum rumeliacum* etc. A large number of species of this community are constituents of thermophilous rocky grasslands of the class *Festuco-Brometea*.

Chorological spectrum of the community[3]. The chorological spectrum of the community formed a few basic groups: Mediterranean-sub-Mediterranean (MED-SUBMED) with 26 taxa or 48.1% and Mediterranean-sub-Mediterranean-Pontic (MED-SUBMED-PONT) with 14 taxa (25.9%) of the total spectrum. Both groups participated with 74% of the total chorological spectrum of the community. These are species that inhabit warm Mediterranean rocky habitats and their hinterland (MED-SUBMED), with their ranges additionally comprising the Pontic steppe region (MED-SUBMED-PONT). Numerous taxa from the Mediterranean-sub-Mediterranean group are endemic to the Macedonian-Thracian or the Adriatic-Ionian-Aegean sub-mediterranean province. The percentage of endemic species in this group was 55%. The following was a South European mountain group (SEM) with seven taxa or 13%. The percentage of endemic species in this group was 70%, mainly contributed by Dinaric-Balkan and Balkan orophytes. Other chorologic groups, such as the Eurasian with four taxa (7.4%), Central European (two taxa -3.7%) and holarctic with one taxon (1.9%), contributed to significantly lesser extents in the total chorological spectrum of the community. Detailed analysis of the participation of each chorological group and subgroup is shown in Annex 3.

Life form spectrum[4]. This community was of a hemicryptophytic-chamaephytic character. The two main life forms hemicryptophytes and chamaephytes contributed 70 % to the total life form spectrum of the community (H - 23 taxa - 42.6 %; Ch -15 taxa - 27.8 %). Participation of therophytes (6 taxa -11,1 %) was considerably lower. Phanerophytes (P) were presented by seven species (9.8%), i.e. trees (P scap) contributed with two deciduous species (3.7%) and shrubs (P caesp) with five species (9.3%), including three deciduous and two evergreen species. Physiognomically, shrublands with small trees of the serpentine slopes resembled scattered pseudomachia. The largest surface of the slope was covered with xerophyllous grassland. The most frequent were scapose hemicryptophytes (H. scap) with nine (16.7%) and rosette-semirosette hemicryptophytes (H. ros-semiros) with eight (14.8%), while caespitose forms (H caesp) were present with six taxa (11.1%). Among the life form of chamaephytes, suffrutecent and ceaspitose herbaceus forms with six (11.1%) and five taxa(9.3%), respectively, were the most abundant subgroup of this life form.

Ass. *Asplenio-Ramondaetum nathaliae*[5]

This community was described earlier in the vicinity of Raduša village on the left bank of the river Vardar (Stevanović & Stevanović 1985).

The community was developing on predominantly north to north-northwest exposed serpentine slopes, at an altitude range from 470 to 650 m, while the slope was from 20-90^0. The whole slope was covered with very

1. see annexes in on line version at http://botanicaserbica.bio.bg.ac.rs
2. Annexes 1 & 2, available in online version
3. Annex 3, available in on line version
4. Annex 4, available in on line version
5. Annex 2, available in on line version

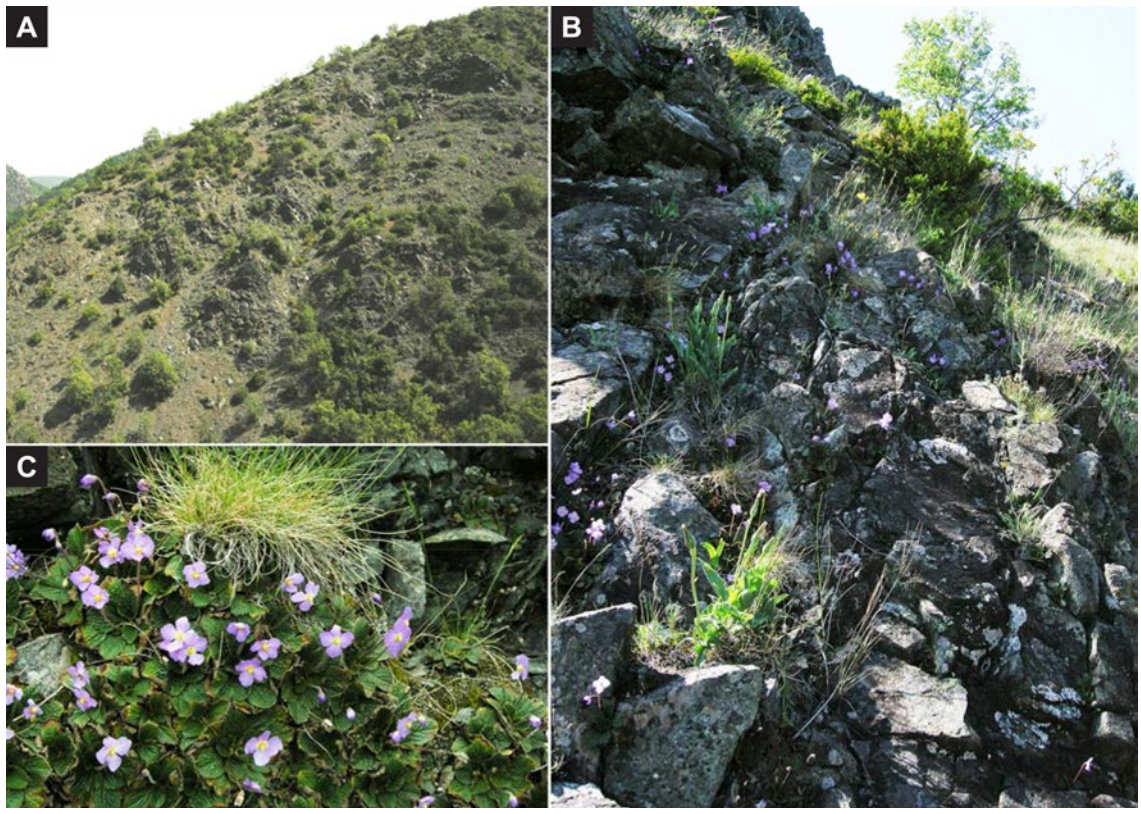

Fig. 2. a) Serpentine rocky slopes - habitat of the community *Scorzonero-Ramondaetum nathaliae* in gorge of the river Pčinja; b) Physiognomy of the community; c) *Ramonda nathaliae* densely covers rock crevices of serpentine rocks

scattered shrubs. The shrub cover increased towards the top of the slope. The total covering of the community ranged from 10-45%. Populations of *R. nathaliae* here were very dense and inhabited nearly every crevice of serpentine rocks and to a lesser extent stable screes.

The community is described on the basis of 15 relevés, composed of 73 species, while the characteristic species of communities were *Ramonda nathaliae*, *Asplenium cuneifolium*, *Cheilanthes marantae*, *Sesleria latifolia* var. *serpentinica*, *Dianthus gracilis* subsp. *armerioides* and *Campanula versicolor* var. *thessala*. The participation of species of serpentine rocks and rocky grasslands of the alliance *Centaureo-Bromion fibrosi*, such as *Alyssum serpentini*, *Euphorbia glabriflora*, *Alyssum montanum* subsp. *serbicum*, *Stachys baldaccii*, *Potentilla visianii*, *Eryngium serbicum* et al. was significant. In addition, species of limestone and serpentine steppe-like rocky slopes from the class *Festuco-Brometea*, order *Halacsyetalia sendtneri* and alliance *Centaureo-Bromion fibrosi* as well as alliances *Festucion rupicolae* and *Satureion montanae* were also frequent (Annex 2).

The floristic composition, chorological and life form spectra of the community *Asplenio-Ramondaetum nathaliae* are presented in Annexes 2, 3 and 4.

A brief comparison of the two communities. Populations of *R. nathaliae* in both communities were developed in very similar conditions at the north exposed, larger or smaller blocks of serpentine rocks and stable screes. There were some differences in the floristic richness between the two communities as the community near the village Raduša was richer by 19 species compared with the one from Pčinja gorge. There were 27 common species, while the degree of floristic similarity was moderate 35.23% (ISs).

The dominant chorological group in both communities was Mediterranean-sub-Mediterranean (MED-SUBMED) i.e. 32 taxa or 43.8% of this group contributed to the chorological spectrum of the community in the vicinity of the village Raduša, and 26 taxa (48.1 %) in the community from Pčinja gorge. In addition, Mediterranean-submediterranean-Pontic (MED-SUBMED-PONT) elements were also numerous in both communities, represented with 18 taxa (24.6 %) in the ass. *Asplenio-Ramondaetum nathaliae* and with 14 taxa (25.9%) in the ass. *Scorzonero-Ramondaetum nathaliae*. Both chorological groups (MED-SUBMED and MED-SUBMED –PONT) participated with more than 68.4 % in the ass. *Asplenio-Ramondaetum nathaliae* and with 74 % in the ass. *Scorzonero-Ramondaetum nathaliae* in

Table 1. Floristic similarity according to Sorensen between communities of serpentine grasslands (*Centaureo-Bromion fibrosi*), chasmophytic vegetation on serpentine (*Ramondion nathaliae sepentinicum*) and limestone (*Ramondion nathaliae*).

Alliance and /or sub-alliance	***Centaureo-Brometum fibrosi***	***Centaureo-Brometum fibrosi***	***Centaureo-Brometum fibrosi***	***Centaureo-Brometum fibrosi***	***Ramondion nathaliae serpentinicum***	***Ramondion nathaliae serpentinicum***	***Ramondion nathaliae***
Community	***Hyperico-Euphorbietum glabriflorae***	***Stipo -Convolvuletum cohlearis***	***Cynancho-Saponarietum intermediae***	***Polygalo-Genistetum hassertianae***	***Scorzonero-Ramondaetum nathaliae***	***Asplenio-Ramondaetum nathaliae***	***Achilleo-Ramondaetum nathaliae prov.***
Hyperico-Euphorbietum glabriflorae	**100.00**	**58.76**	**26.67**	**20.16**	**16.54**	**17.81**	**11.76**
Stipo -Convolvuletum cohlearis	**58.76**	**100.00**	**32.12**	**21.92**	**20.00**	**20.86**	**9.63**
Cynancho-Saponarietum intermediae	**26.67**	**32.12**	**100.00**	**42.70**	**8.60**	**22.64**	**1.54**
Polygalo-Genistetum hassertianae	**20.16**	**21.92**	**42.70**	**100.00**	**0.00**	**15.65**	**2.88**
Scorzonero-Ramondaetum nathaliae	**16.54**	**20.00**	**8.60**	**0.00**	**100.00**	**35.29**	**33.57**
Asplenio-Ramondaetum nathaliae	**17.81**	**20.86**	**22.64**	**15.65**	**35.29**	**100.00**	**15.38**
Achilleo-Ramondaetum nathaliae prov.	**11.76**	**9.63**	**1.54**	**2.88**	**33.57**	**15.38**	**100.00**

the total chorological spectrum of these communities. A slightly higher percentage of MED-SUBMED and MED-SUBMED-PONT elements in the ass. *Scorzonero-Ramondaetum nathaliae* could be explained by the dominant influence of Aegean flora which penetrated into the continental part of Macedonia along Vardar river valley. The main differences between the two communities were obvious regarding the presence of South European mountain (SEM) elements. Thus, the number of SEM element in the ass. *Asplenio-Ramondaetum nathaliae* was significantly higher (18 taxa – 24.6%) than in the community in the Pčinja river gorge (seven taxa -13 %). The proximity of the high-mountain chain of Mts Šaplanina is the probable reason for the presence of a significantly higher number of SEM elements in the community near the village Raduša.

The two communities of *Ramonda nathaliae* on the serpentinites of N. Macedonia, in the localities Raduša and Pčinja had very similar hemicryptophytic-chamaephytic spectra of life forms (Annex 4). This indicates very similar habitat conditions in which the populations of this sensitive endemic and relict species occur.

Comparison with the communities of serpentine rocky grassland from the alliance *Centaureo-Bromion fibrosi* and calcareous chasmophytic communities of the alliance *Ramondion nathaliae* in Macedonia and neighboring territories. In both communities

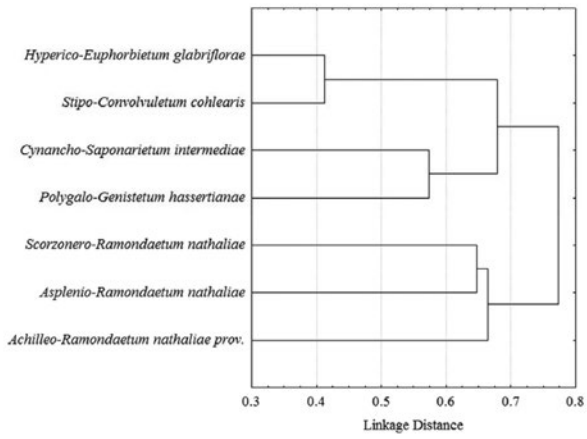

Fig. 3. Cluster analysis of 7 compared communities based on their floristic composition

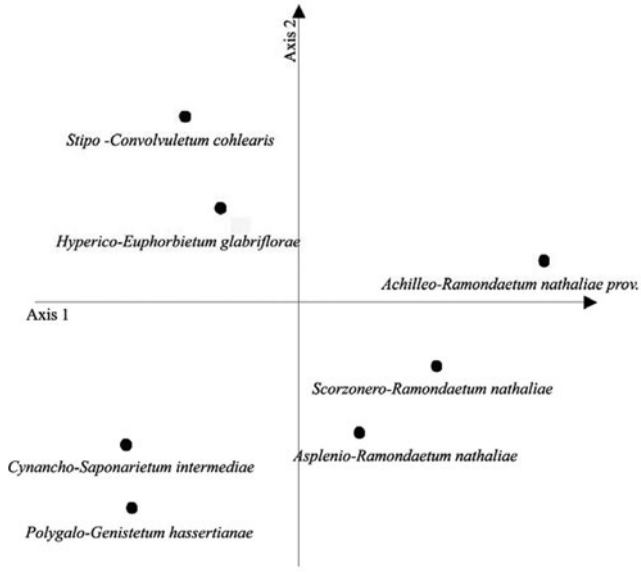

Fig. 4. Detrended correspondence analysis (DCA) for the 7 communities according to their floristic composition

there are numerous species of rocky grasslands, primarily various xerophilous grasses and herbs of the class *Festuco-Brometea*, order *Halacsyetalia sendtneri* and alliance *Centaureo-Bromion fibrosi*. Therefore, communities of *R. nathaliae* on serpentine bedrock were compared with geographically-neighboring communities of thermophilous serpentine grasslands of hilly regions in Kosovo and Metohija province, belonging to the alliance *Centaureo-Bromion fibrosi*: *Hyperico-Euphorbietum glabriflorae* (Krasniqi & Millaku 2007), *Stipo-Convolvuletum cochlearis* (Millaku *et al.* 2011), *Cynacho-Saponarietum intermediae* (Blečić *et al.* 1969) and *Polygalo-Genistetum hassertianae* (Blečić & Krasniqi 1971). Communities of mountainous regions *Sedo-Bornmullerietum dieckii* (Blečić *et al.* 1969) and *Bornmullero-Seslerietum latifoliae* (Jovanović *et al.* 1992), which belong to the same alliance, were not compared considering that they grow in different habitats at higher altitudes. A small number of common facultative and obligate serpentinophytes were found between the community of *R. nathaliae* and those of alliance *Centaureo-Bromion fibrosi*. Floristic similarity of two *Ramonda nathaliae* serpentine communities with serpentine rocky grasslands from Kosovo and Metochia province was very low (see Table 1). Several species, such as *Convolvulus parnassicus*, *Hypericum rumeliacum, Scorzonera austriaca, Dianthus pinifolius, Potentilla astracanica, Sipa pulcherrima, etc.* connected the communities of *R. nathaliae* on serpentine bedrock with serpentine grasslands from the alliance *Centaureo-Bromino fibrosi*.

In addition, comparative analysis included a typical limestone chasmophytic community of *R. nathaliae* from Macedonia (Raec, Treska, Vrapče, Veles), based on 25 field relevés, provisionally named *Achilleo-Ramondaetum nathaliae*. The chasmophytic communities of *R. nathaliae* on limestone, which were also the subject of our research, are probably included in a few floristically similar communities, where almost without exception, the species *Achillea ageratifolia* occurs with high abundance.

Almost all chasmophytic communities within a wide altitude range of E. Serbia, Macedonia and N. Greece were included in the alliance *Ramondion nathaliae* (Horvat 1936). However, the alliance *Ramondion nathaliae* partially incorporates the exceptional floristic and ecological diversity of chasmophytic vegetation of this part of the Balkan Peninsula. It is known that *R. nathaliae* forms communities exclusively on north facing rocks, while chasmophytic vegetation on other expositions is characterized not only by the absence of *R. nathaliae*, but has a different floristic composition dominated by numerous ecologically more plastic species. Therefore, the question is to what extent it is correct to include the majority of chasmophytic communities in the Central Balkans into the alliance *Ramondion nathaliae*. This will be the subject of our future research of chasmophytic vegetation in the Central Balkans.

Both communities of *R. nathaliae* on serpentinite rocks floristically deviated from the characteristic species of the alliance *Ramondion nathaliae* which includes chasmophytic communities growing on limestone. The characteristic species of *Ramondion nathaliae* according to Horvat (1935) are *Ramonda nathaliae, Micromeria cristata, Saxifraga grisebachii, Hieracium pannosum, Campanula versicolor, Alyssum corymbosum* and *Cerastium banaticum* (Horvat *et al.* 1974). Of these species, *Campanula versicolor* and *Cerastium banaticum*

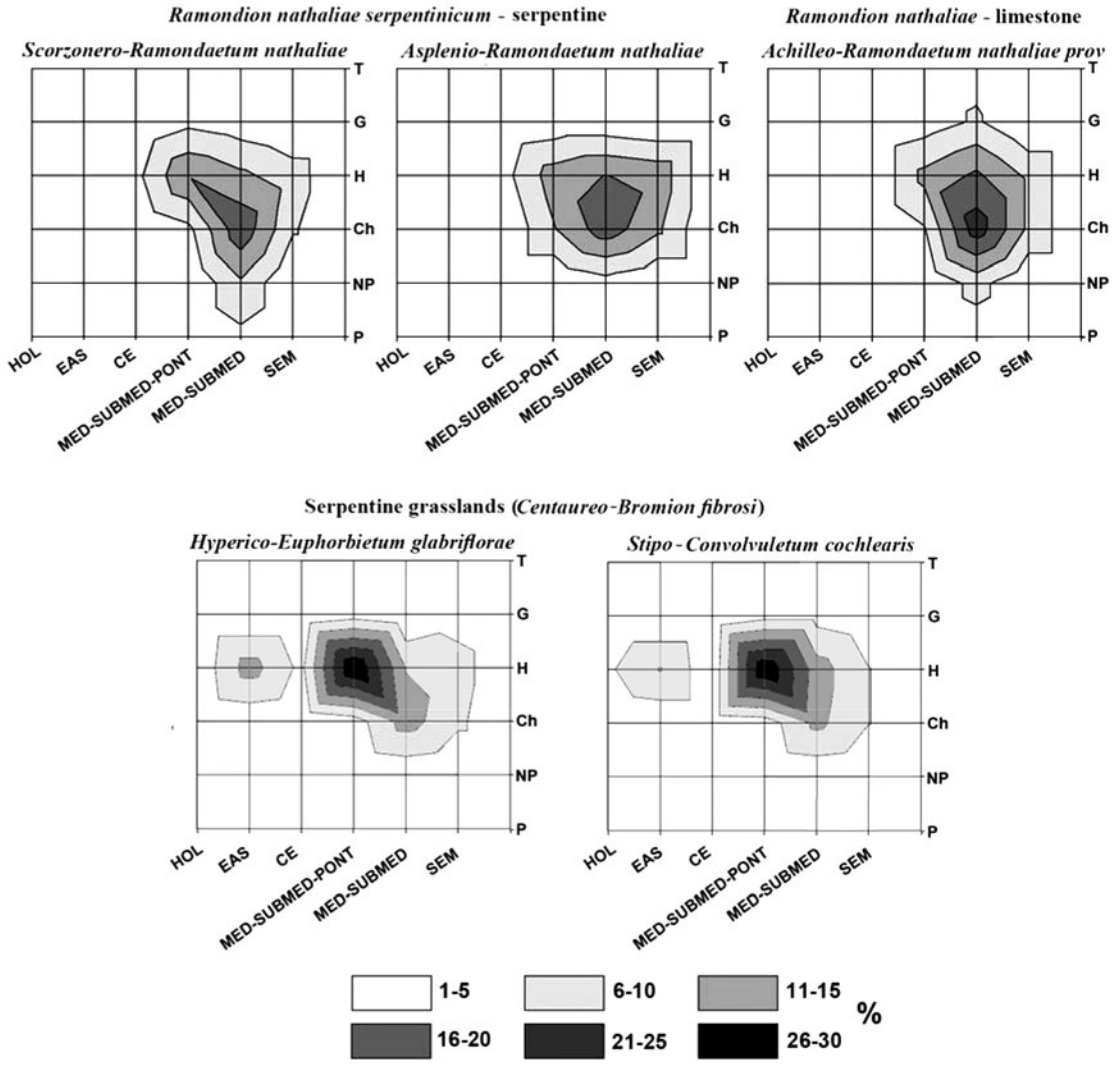

Fig.5. Crossed chorological and life form spectra of the serpentine rocky grassland communities of alliance *Centaureo-Bromion fibrosi*, communities of *R. nathaliae* on serpentine (*Ramondion nathaliae serpentinicum*) and limestone (*Ramondion nathaliae*)

were recorded in both serpentine communities of *R. nathaliae*, while the other three are known to grow exclusively in limestone rock vegetation. *Cheilanthes maranthae, Asplenium cuneifolium, Sesleria latifolia* var. *serpentinica*, *Scorzonera austriaca* and *Dianthus gracilis* subsp. *armerioides*, as characteristic species of serpentine communities, are differentiated from those growing on limestone rocks. The floristic similarity between the ass. *Achilleo-Ramondaetum nathaliae* and ass. *Asplenio-Ramondaetum nathaliae* was only 15.38%, while it was much higher (33.57%) compared with the community *Scorzonero Ramondaetum nathaliae* (Table 1). However, the specificity of communities of *R. nathaliae* on serpentine and their mutual floristic similarity on the one hand, as well as floristic differences in comparison with limestone communities of this species, on the other, suggest that serpentine communities should be classified as a new sub-alliance *Ramondion nathaliae serpentinicum*. Characteristic and, at the same time, differentiating species of this sub-alliance in relation to the alliance *Ramondion nathaliae* were *Cheilanthes maranthae, Asplenium cuneifolium, Sesleria latifolia* var. *serpentinica*, *Convolvulus parnassicus* and *Scorzonera austriaca*. This was confirmed by cluster analysis based on the floristic similarities of *R. nathaliae* communities (Fig. 3).

In addition, cluster analysis clearly indicated two distinct groups of communities. One consists of serpentine rocky grassland communities of the alliance *Centaureo-Bromion fibrosi* and the second one includes communities of *Ramonda nathaliae* on serpentine and limestone (Fig. 3). Moreover, detrended correspondence analysis (DCA)

resulted in the same two entities, completely separated along the first axis (Fig. 4). Communities belonging to the alliance *Centaureo-Bromion fibrosi* formed a group in the negative part of the first axis, while those with *Ramonda nathaliae* were clustered in its positive part.

Also, differences between the communities of *R. nathaliae* on serpentine and those of the alliance *Centaureo-Bromion fibrosi* were obvious in cross-spectra chorological groups and life forms (Fig. 5). Communities of the alliance *Centaureo-Bromion fibrosi* were characterized by the highest proportion of Mediterranean-sub-Mediterranean-Pontic groups within the life forms hemicryptophytes, while in communities of the alliance *Ramondion nathaliae seprentinicum* these were Mediterranean-sub-Mediterranean elements within the life forms chamaephytes. Crossed spectra of chorological groups and life forms of communities of the sub-alliance *Ramondion nathaliae serpentinicum* were similar to the limestone community *Achilleo-Ramondaetum nathaliae* prov. from the alliance *Ramondion nathaliae*. In addition, communities of the alliance *Centaureo-Bromion fibrosi* were characterized by a larger percentage of species widespread within the Eurasian and Holarctic distribution types among hemicryptophytes. Among other things, this suggests larger zoo-anthropogenic impacts on serpentine stony grassland, than in the communities *R. nathaliae*.

CONCLUSION

Communities of *Ramonda nathaliae* on serpentine bedrock are rare in the whole range of the species. They are interesting not only because of their rarity and occurrence on a specific bedrock, but also by the fact that the terrain configuration of the serpentine habitats is significantly different from that typically related to limestone gorges and canyons.

Some differences in floristic richness and chorological composition between the two serpentine communities of *R. nathaliae* were found between the previously-described *Asplenio-Ramondaetum nathaliae* in the vicinity of the village Raduša and newly-described *Scorzonero-Ramondaetum natahaliae* Stevanović & Matevski in the Pčinja river gorge in N Macedonia. In general, the chorological spectrum in both communities was similar and primarily comprised species from Mediterranean-sub-Mediterranean, Mediterranean-sub-Mediterranean-Pontic and Southern European mountain chorological groups, which in both communities participated with 87.5% and 75.5% of the total chorologic spectra of communities, respectively. A significant percentage of endemics in both communities were recorded. Dominant life forms in both communities were hemicryptophyte and chamaephyte.

Communities of *R.nathaliae* on serpentines were floristically, ecologicaly and physiognomically different from those chasmophytic communities growing on limestone. A relatively small number of species characteristic of the alliance *Ramondion nathaliae* were recorded in communities on serpentine. The most frequent were facultative grassland serpentinophytes or those that were indifferent to the geological substrate. Indeed, the floristic composition of serpentine communities of *R. nathaliae* indicated a syntaxonomical position between the alliances *Ramondion nathaliae* and *Centaureo-Bromion* fibrosi. However, the presence of characteristic species of the alliance *Ramondion nathaliae* (*R. nathaliae*, *Campanula versicolor* and *Cerastium banaticum*) makes them similar to serpentine communities to the alliance *Ramondion nathaliae*. Clear differences between serpentine and limestone communities of *R. nathaliae*, were reflected primarily in the presence of serpentinophytes, indicating that serpentine communities *R. nathaliae* should be united in a new sub-alliance *Ramondion nathaliae serpentincum* Stevanović &Matevski. Thus, the floristic and significant ecological differences between communities of *R. nathaliae* on serpentine and limestone, in syntaxonomical sence, would be prominent.

Further investigations of chasmophytic vegetation on limestone cliffs and canyons in Macedonia will provide answers related to the diversity of this type of vegetation and the validity of the inclusion of the majority of chasmophytic communities into the alliance *Ramondion nathaliae*.

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Botanica SERBICA

REZIME

Hazmofitske zajednice endemične i reliktne vrste *Ramonda nathaliae* Pančić & Petrović na ofiolitima Makedonije

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Prisustvo hazmofitske zajednice endemo-reliktne vrste *Ramonda nathaliae* na ofiolitskoj (serpentinitskoj) podlozi predstavlja veoma redak fenomen u čitavom aealu vrste, s obzirom da je ona predominantno vezana za krečnjak. U ovom radu su predstavljene dve zajednice *R. nathaliae* sa serpentinskih staništa: zajednica *Asplenio-Ramondaetum nathaliae*, ranije opisana u okolini sela Raduša, kao i *Scorzonero-Ramondaetum nathaliae*, nova zajednica iz klisure reke Pčinje. Urađeno je poređenje njihovog floorističkog sastava, horološkog, kao i spektra životnih formi. Analiziran je sintaksonomski položaj ovih zajednica u odnosu na hazmofitsku vegetaciju na krečnjacima obuhvaćenu svezom *Ramondion nathaliae*, kao i u odnosu na serpentinsku travnu vegetaciju sveze *Centaureo - Bromion fibrosi*. Imajući u vidu značajne florističke razlike između zajednica *R. nathaliae* sa serpentinita i krečnjaka, predložena je nova podsveza: *Ramondion nathaliae serpentinicum*.

Ključne reči: *Ramonda nathaliae*, serpentinska podloga, hazmofitske zajednice, Balkan

Annex 1. Phytocoenological table of ass. nova *Scorzonero-Ramondaetum nathaliae* Stevanović & Matevski

Association	*Scorzonero-Ramondaetum nathaliae*						
Locality	Pčinja	Pčinja	Pčinja	Pčinja	Pčinja	Pčinja	
No of relevé	1	2	3	4	5	6	
Size of relevé (m^2)	25	25	16	20	20	30	
Slope (^{0})	55	70	45	3'-50	35-45	60	
Covering (%)	40	30	40	45	45	30	
Altitude (m)	263	270	286	289	294	310	
Exposition	N	NNW	NW	NNE	NNW	N	
Geological substratum	serpentine	serpentine	serpentine	serpentine	serpentine	serpentine	
Date	08-05-2011	08-05-2011	08-05-2011	08-05-2011	08-05-2011	08-05-2011	
Characteristic species of association							Constancy class
Ramonda nathaliae	3.5	3.5	2.3	2.3	2.4	3.5	V
Scorzonera austriaca	2.2	1.2	1.2	1.2	1.2	+.2	V
Cheilanthes marantae	+.1	+.1	+.1	+.1	+.1	+.2	V
Cerastium banaticum subsp. *kosaninii*	+.1	+.1	1.2	1.2	+.1	1.2	V
The species growing mainly on serpentine rocky slopes (facultative serpentinophytes)							
Dianthus pinifolius subsp. *pinifolius*	-	+.1	1.2	+.1	1.2	+.1	V
Alyssum serpentinum	-	+.1	+.2	+.1	-	+.1	IV
Convolvulus boissieri subsp. *compactus*	+.2	-		1.2	-	1.2	III
Seseli peucedanoides	-	-	1.2	+.2	1.2	+.1	IV
Cytisus austriacus subsp. *heuffelii*	-	-	-	1.1	+.1	+.1	III
Minuartia hirsuta subsp. *falcata*	-	-	-	-	-	+.2	I
Species of rocks and rocky grasslands indifferent to geological substrata							
Dianthus gracilis subsp. *armerioides*	+.1	+.1	+.2	1.2	+.1	1.2	V
Sedum ochroleucum	2.3	1.2	+.2	1.2	2.3	+.2	V
Galium oreophilum	1.2	1.2	+.1	+.1	-	+.1	V
Asplenium ceterach	+.2	+.1	+.1	+.2	+.2	+.1	V
Aethionema saxatile	+.2	+.1	+.2	+.2	+.1	+.1	V
Leontodon crispus	+.1	+.1	+.1	+.1	+1	+.1	V
Asplenium trichomanes	+.2	+.1	-	+.1	+.1	+.1	V
Valeriana dioscoridis	+.2	+.1	-	+.1	-	-	III
Species of dry hilly and montane grasslands indifferent to geological substrate							

Festuca stricta subsp. *sulcata*	1.3	2.3	2.3	1.2	1.2	1.3	V
Stipa pulcherrima	+.2	+.2	1.2	2.3	2.2	1.2	V
Potentilla astracanica	1.2	1.2	+.2	+.2	1.2	+.2	V
Medicago prostrata subsp. *pseudorupestris*	+.1	+.1	+.2	+.2	+.1	+.1	V
Poa bulbosa	+.1	+.1	+.2	+.1	+.1	+.1	V
Scabiosa triniifolia	1.2	+.2	+.1	1.1	+.1	+.1	V
Thymus thracicus var. *stribrnyi*	+.2	+.2	+.2	+.1	+.1	+.1	V
Iris suaveolens	+.2	-	+.2	+.1	+.2	+.2	V
Koeleria splendens	+.2	+.2	+.1	+.1	+.1	-	V
Hypericum rumeliacum	+.2	+.1	+.1	+.1	-	+.1	V
Centaurea grisebachii	+.1	+.1	+.1	+.1	+.1	+.1	V
Genista januensis subsp. *lydia*	+.1	+.1		+.1	+.1	-	IV
Anthoxanthum odoratum	+.2	-	+.2	1.3	+.1	-	IV
Clinopodium suaveolens	+.2	+.1	+.1	+.1	+.1	+.1	V
Rumex acetosella	-	+.1	+.1	+.1	+.1	+.2	V
Sanquisorba minor	+.1	-	-	-	-	-	I
Teucrium polium	-	-	+.1	-	-	-	I
Species of surrounding shrub-land							
Buxus sempervirens	+.1	1.1	1.2	+.1	1.1	1.1	V
Fraxinus ornus	+.1	+.1	-	-	-	1.1	III
Pistacia terebinthus	+.1	+.1	-	-	-	0.1	III
Syringa vulgaris	+.1	+.1	-	-	+.1	-	III
Juniperus oxycedrus	-	-	-	+.1	+.1	-	II
Hippocrepis emerus subsp. *emeroides*	-	-	-	-	-	1.1	I
Rhamnus rhodopaeus	-	+.1	-	-	-	-	I
Accompanying species							
Cerastium brachypetalum	+.2	+.2	+.2	+.2	+.2	+.2	V
Sedum urvillei	-	+.2	1.3	+.2	+.2	-	IV
Arenaria serpyllifolia	-	+.1	+.1	+.1	-	+.1	IV
Buglossoides arvensis	-	-	-	-	+.1	+.1	II
Leopoldia comosa	+.1	-	-	-	-	+.1	II
Myosotis ramosissima	-	-	-	+.1	+.1	-	II
Veronica austriaca subsp. *dentata*	-	-	-	+.1	+.1	-	II
Euphorbia taurinensis	-	-	-	+.1	-	-	I
Asperula purpurea	+.1	+.1	-	-	-	-	II
Luzula campestris	-	-	-	+.2	-	-	I
Muscari neglectum	-	-	-	+.2	-	-	I
Musci	1.3	1.3	1.3	+.2	+.2	1.3	V

Annex 2. List of the taxa from communities *Asplenio-Ramondaetum nathaliae* and *Scorzonero-Ramondaetum nathaliae* from suballiance *Ramondion nathaliae serpentinicum* and their quantitative presence (abundance and constancy class) in each community as well as their chorological groups and correspondent floristic elements and life forms

Taxon	*Asp.-Ram. nat.*	*Scor.-Ramo.nath*	LF-basic	LF-subdivision	Chorological group	Floristic elements	E
Achnatherum calamagrostis (L.) P. Beauv.	V +.1-1.3		H	H caesp	SEM	Pyr-Alp(S)-Apen-Dinar(W-E)-Balk(Scard-Pind(N-S))-Carp	
Aethionema saxatile (L.) W. T. Aiton	II +.1-+.2	V+.1-+.2	T	T scap-semiros	MED-SUBMED	Med-submed(W-E)	
Agropyron cristatum subsp. *pectinatum* (M. Bieb.) Tzvelev	IV +.1-1.3		H	H caesp	PONT-SUBMED	Pont (W-E)-Med-submed(W-E)	
Alkanna scardica Griseb.	I +.1		H	H scap	SEM	Dinar (SE)-Balk(Scard-Pind(N))	E
Allium carinatum subsp. *pulchellum* (G. Don) Bonnier & Layens	III r-+.2		G	G bulb	MED-SUBMED-PONT	Med-submed(C-E)-pont(W)	
Alyssum montanum subsp. *serbicum* Novák	III r-+.2		Ch	Ch herb rept	SUBMED	Illyr (W)-Balk (Maced(N))	
Alyssum serpentinum Micevski	IV r-+.2	IV	Ch	Ch suffrut	SUBMED	Balk (Maced(N))	E
Anthoxanthum odoratum L.		IV	H	H caesp	EAS	EAs(W-E)(arct-merid); Bor-CE-Pont-sib(S)	
Arenaria serpyllifolia L.	I r-+.2	IV+.1	T	T scap	EAS	EAs (W-E) (temp-merid)	
Armeria canescens (Host) Boiss.	II r-+.1		H	H caesp	SEM	Apen(C-S)-Illyr(W-E)-Balk(sc-pind(N-S)	
Artemisia alba Turra	II r-+.1		Ch	Ch frut	SEM	Pyr-CP-Alp(E)-Apen(N-S)-Dinar(W-E)-Balk(sc-pind(N-C)-Moes(W-E)-Carp(W-C)	
Asperula aristata L. subsp. *condensata* (Boiss.) Ehrend. & Krendl	IV r-+.2		Ch	Ch herb caesp	SEM	Dinar (SE)-Balk(Scard-Pind(N-C)-moes(SW))	E
Asperula purpurea (L.) Ehrend.	II r-+.2	II+.1	Ch	Ch herb caesp	SUBMED	Med-submed(W-E)	
Asplenium adiantum-nigrum L. subsp. *serpentini* (Tausch) Heufl.	V +.1-1.2		H	H ros semp	SUBMED-CEu	Submed(W-E)-CEu(C-E)	
Asplenium ceterach L.	I r-+.1	IV+.1	H	H ros semp poik.	MED-SUBMED-OR	Med-submed(W-E)-orient	
Asplenium trichomanes L.	IV r-+.1	V+.1—+.2	H	H ros semp	HOL	Circumholarctic(cosm)	
Astragalus onobrychis L.	II +.1		Ch	Ch herb caesp	PONT-SUBMED	Pont(W-E)-Med-submed(W-E)	
Asyneuma limonifolium (L.) Janch.	IV +.1-+.2		H	H scap	MED-SUBMED	Apen(S)-Adr-Illyr(W-S)-Balk(Maced-Thrac(W)-Moes(W-C))-Anatol	

Taxon	*Asp.-Ram. nat.*	*Scor.-Ramo.nath*	LF-basic	LF-subdivision	Chorological group	Floristic elements	E
Aurinia saxatilis (L.) Desv. subsp. *orientalis* (Ard.) T. R. Dudley	III +.1-+.2		Ch	Ch suffrut	SUBMED-PONT	Submed(C-E); Adr-Illyr(W-E)-Balk(Maced-Thrac-Ion-Aeg-Moes(W-E))-Pont(W-C)	
Buglossoides arvensis (L.) I. M. Johnst.		II+.1	T	T scap	EAS	EAS(W-E) (bor-merid); Evrobor-CEu(W-E)-Pont(W-E)-Sib(S)-Med-submed(W-E)	
Bupleurum apiculatum Friv.	II +.2		T	T scap	MED-SUBMED	Illyr(SE)-Balk(Maced-Thrac-Aeg-Moes(W-E))	E
Buxus sempervirens L.		V+.1—1.2	NP	NP caesp semp	MED-SUBMED	Med-submed(W-E)	
Campanula versicolor Andrews	III r-1.2		Ch	Ch suffrut	MED-SUBMED	Apen(S)-Balk(Maced-Thess-Epir-Moes(SW))	
Carpinus orientalis Mill.	I r		P	P scap	MED-SUBMED	Med-submed(C-E)	
Centaurea grisebachii (Nyman) Heldr.			H	H scap	MED-SUBMED	Balk(Maced-thrac(W)-aeg(W))	E
Centaurea stoebe L. subsp. *australis* (A. Kern.) Greuter	I r		H	H scap	PONT-SUBMED	Pont(W-C)-Submed(C-E)-(Ceu(C-E))	
Cephalaria leucantha (L.) Roemer & Schultes	III r-+.1		H	H scap	MED-SUBMED	Med-submed(W-E)	
Cerastium banaticum (Rochel) Heuff.	II +.1	V +.1-1.2	Ch	Ch herb caesp	SEM	Balk(Scard-Pind(N-C)-Moes(W))	E
Cerastium brachypetalum Pers.		V+.2	T	T scap	MED-SUBMED-PONT-(CEu)	Med-submed(W-E)-Pont(W)-CEu	
Clinopodium suaveolens (Sm.) Kuntze	IIr-+.1	V+.1-+.2	Ch	Ch herb caesp-rept	MED-SUBMED-PONT	Med-submed(C-E)-Pont(W)	
Convolvulus boissieri Steudel subsp. *compactus* (Boiss.) Stace	I 1.1	III +.2-1.2	Ch	Ch suffrut caesp	SEM	Balk(Scard-Pind(N-S)-Moes(SW))	
Cytisus austriacus L. subsp. *heuffelii* (Wierzb.) Asch. & Graebn.			H	Ch frut	PONT-SUBMED	Pont(W-C)-Illyr(N)-Balk(Maced-Thrac)-Moes(W-E)-anatol(N)	
Cytisus hirsutus L.	II r-1.1		Ch	Ch frut	PONT-SUBMED-(CEu))	Pont(W-C)-Med-submed(W-E)-(CEu)	
Dianthus gracilis subsp. *armerioides* (Griseb.) Tutin	IV r-2.2	V +.1-1.2	Ch	Ch suffrut	SUBMED	Balk(Maced-Thrac(W))	E
Dianthus pinifolius Sm. subsp. *pinifolius*			Ch	Ch suffrut	SUBMED	Balk(Maced-Thrac(W)-Moes(W))-Carp(SW)	
Dictamnus albus L.	II +-1.2		H	H scap	PONT-CEu	Pont(W-C)-(C Eu)	
Dorycnium pentaphyllum Scop. subsp. *herbaceum* (Vill.) Bonnier & Layens	I +.1		Ch	Ch suffrut	SUBMED-PONT	Submed(W-E)-pont(W-C)	

Taxon	*Asp.-Ram. nat.*	*Scor.-Ramo.nath*	LF-basic	LF-subdivision	Chorological group	Floristic elements	E
Eryngium serbicum Pančić	I +.1		H	H scap	SUBMED	Balk (Maced(N)-moes(W))	E
Euphorbia glabriflora Vis.	IV +.1-1.1		Ch	Ch frut	SUBMED	Illyr(E)-Balk(Ab(N-S)-Maced(N-C)-Epir(N-C))	E
Euphorbia taurinensis All.		I+.1	T	T scap	MED-SUBMED	Med-submed(W-E)	
Festuca stricta Host. subsp. *sulcata* (Hack.) Pils		V1.2—2.3	H	H caesp	PONT-SUBMED	Pont-Med-submed(C-E)	
Festuca valesiaca Gaudin	II +.1-+.2		H	H caesp	PONT-CAs)	Pont(W-E)-Aralo-Casp-Mong(W)	
Fraxinus ornus L.	X	III+.1—1.1	P	P scap	MED-SUBMED	Med-submed(C-E)	
Fumana bonapartei Maire & Petitmengin	II r-+.1		Ch	Ch suffrut rept	SUBMED	Illyr(C-E)-Balk(Alb-Maced-Epir-thes)	E
Galium oreophilum Krendl		V+.1—1.2	H	H scap	SEM	Balk(Scard-Pind(N-S))	E
Genista januensis Viv. subsp. *lydia* (Boiss.) Kit Tan & Ziel.	II r-+.1	IV+.1	Ch	Ch frut	SUBMED	Balk(Maced-Thrac(W)-Moes(W-E)-Anatol	
Genista depressa M. Bieb. subsp. *friwaldszkyi*(Boiss.) Hayek	III r-+.1		Ch	Ch frut	SEM	Dinar(W)-Balk(Scard-Pind(N)-Moes(W)	E
Hellenocarum strictum (Griseb.) Hand	I r-+.1		H	H scap	SEM	Apen(S)-Balk(Scard-Pindh(N-C))	
Hippocrepis emerus (L.) Lassen subsp. *emeroides* (Boiss. & Spruner) Lassen	I +.1	I1.1	NP	NP caesp dec	MED-SUBMED	Med-submed(E)	
Hypericum rumeliacum Boiss.		V+.1—+.2	H	H scap	SUBMED	Balk(Maced-thrac-moes(W-E)	E
Inula ensifolia L.	III +.1-+.2		H	H scap	PONT-SUBMED	Pont(W-E)-Illyr(W-E)-Balk(Moes(W-E)	
Iris suaveolens Boiss. & Reut.	I +.1	V+.1—+.2	G	G rhiz	SUBMED	Balk(Maced-Moes)-Carp(S)-Anatol	
Jasione heldreichii Boiss. & Orph.	II r-+.1		H	H scap	MED-SUBMED	Balk(Maced-Thrac-Aeg(N)-Moes(W)-Anatol(W)	
Juniperus oxycedrus L.	X	II+.1	NP	NP caesp semp	MED-SUBMED	Med-submed(W-E)	
Koeleria splendens C. Presl	I r-+.1	V+.1—+.2	H	H caesp	MED-SUBMED	Med-submed(W-E)	
Leontodon crispus Vill.	I r-+.1	V+.1	H	H semiros	MED-SUBMED-PONT	Med-submed(W-E)-Pont(W-C)	
Leopoldia comosa (L.) Parl.		II+.1	G	G bulb	MED-SUBMED-PONT-(CEu)	Med-submed(W-E)-Pont(W-C)-(CEu)	
Luzula campestris (L.) DC.		I+.2	H	H caesp	CE	C Eu (W-SE)	

Taxon	*Asp.-Ram. nat.*	*Scor.-Ramo.nath*	LF-basic	LF-subdivision	Chorological group	Floristic elements	E
Medicago prostrata Jacq. subsp. *pseudorupestris* (Hayek) Micevski	III r-+.1	V+.1—+.2	Ch	Ch suffrut rept	SUBMED	Illyr(SW)-Balk(Maced)	E
Melica ciliata L.	III r-+.1		H	H caesp	MED-SUBMED-Ceu	Med-submed(W-E)-(C Eu (S))	
Minuartia hirsuta (M. Bieb.) Hand.-Mazz. subsp. *falcata* (Griseb.) Mattf.	III r-+.1	I+.2	Ch	Ch suffrut caesp	SEM	Dinar(E)-Balk(Scard-Pind(N-C)-Moes(W-E))	E
Muscari neglectum Guss. ex Ten.		I+.2	G	G bulb	MED-SUBMED-PONT	Med-submed(W-E)-CEu(W-E)-Pont(W-C)	
Myosotis ramosissima Rochel		II+.1	T	T scap	MED-SUBMED-PONT-(CEu)	Med-submed(W-C)-Pont (W)-C Eu)	
Cheilanthes marantae (L.) Domin	IV r-+.2	V +.1-+.2	H	H ros semp poik.	SUBMED	Med-submed(C-E)	
Paronychia kapela (Hacq.) A. Kern.	II +.1		Ch	Ch herb rept	SEM	Pyr-Alp(S)-Apen-Dinar(E)-Balk(Scard-Pind-Moes)-Carp(S))	
Petrorhagia saxifraga (L.) Link	I +.1		Ch	Ch herb caesp	SUBMED-PONT	Submed(W-E)-Pont(W)	
Pilosella pavichii (Heuff.) Arv.-Touv.	II +.1		H	H scap-semiros-rept	CE	CEu(SE); Illyr-Balk(Sc-pind(N-S)-Moes(W-C)-Anatol	
Pistacia terebinthus L.	I r	III+.1	P	P scap	MED-SUBMED	Med-submed(W-E)	
Plantago holosteum Scop.	III r-+.1		H	H caesp	SUBMED	Submed(W-E)	
Poa bulbosa L.		V+.1—+.2	H	H caesp	MED-SUBMED-PONT-OR-TUR-(Ceu)	Med-submed(W-E)-Pont(W-E)-Orient-Tur-C Eu(W-E)	
Poa molinerii Balb.	I +.2		H	H caesp	SEM	Pyr-Alp(S)-Dinar(W-E)-Balk(Scard-Pind(N-C)	
Potentilla astracanica Jacq.		V+.2—1.2	H	H semiros	SUBMED-PONT	Submed(E)-Pont(W-E); balk(Maced-Thrac-Moes(W-E))-Anatol	
Potentilla visianii Pančić	I +.1		H	H scap-semiros	SUBMED	Illyr(E)-Balk(Alb-Maced(N))	E
Ramonda nathaliae Pančić & Petrovič	V 1.3—3.5	V 2.3—3.5	H	H ros semp poik.	SEM	Balk(sc-pind(N))-moes(W)	E
Rhamnus rhodopeus Velen.		I+.1	NP	NP caesp	SUBMED	Balk(Maced-Thrac(W-C)	E
Rumex acetosella L.		V+.1—+.2	H	H scap	EAS	Evrosib (subbor-merid)	
Sanguisorba minor Scop.		I+.1	H	H semiros	SUBMED-PONT-CE	Submed(W-E)-Pont(W-C)-C Eu(W-E)	
Scabiosa columbaria L.	I +.1		H	H scap semiros	MED-SUBMED-PONT	Med-submed(C-E)-Pont(W-C)-Orient-Tur	

Taxon	*Asp.-Ram. nat.*	*Scor.-Ramo.nath*	LF-basic	LF-subdivision	Chorological group	Floristic elements	E
Scabiosa triniifolia Friv.		V+.1—+.2	H	H scap	SUBMED	Illyr(E)-Maced-Thrac-Moes(W-E)-Anatol	
Scleranthus perennis L. subsp. *marginatus* (Guss.) Nyman	I +.1		H	H rept	SEM	Apen-Dinar-Balk-Carp(S)	
Scorzonera austriaca Willd.	I r-+.1	V +.2-2.2	H	H scap-ros	SEM	Cp-Jur-Alp-Apen-Dinar(W-E)-Balk(Scard-Pind(N)-Moes(W-E)	
Sedum ochroleucum Chaix	III +.1-+.2	V+.2—2.3	Ch	Ch succ	MED-SUBMED	Med-submed(W-E)	
Sedum urvillei DC.	IV +.1-+.2	IV+.2—1.3	Ch	Ch succ rept	SUBMED-PONT	Submed(C-E)-Pont(W)	
Seseli peucedanoides (M. Bieb.) Koso-Pol.	I +.2+	IV+.1-1.2	H	H scap	SUBMED-PONT	Submed(W-E)-Pont(W-C)	
Sesleria latifolia (Adamović) Degen	IV +.1-1.3		H	H caesp	SEM	Balk(Sc-pind(N)-Moes(W))	E
Silene paradoxa L.	II r-+,1		Ch	Ch suffrut	SUBMED	Submed(W-E)	
Stachys recta L. subsp. *baldaccii* (K. Malý) Hayek	III +.1-+.2		H	H scap	SEM	Dinar(W-E)-Balk(Scard-Pind(N))	E
Stipa pulcherrima K. Koch	III r-+.2	V+.2—2.3	H	H caesp	MED-SUBMED-PONT	Med-submed(W-E)-Pont(W-C)	
Syringa vulgaris L.		III+.1	NP	NP caesp	SUBMED	Balk(Moes (W-E)-Carp(SW)-Anatol(N)	
Teucrium montanum L.	II +.1-+.2		Ch	Ch herb caesp-rept	SEM	Pyr-CP-Jur-Alp-Apen-Dinar-Balk(Sc-Pind(N-S)-Moes(W-C)-Carp	
Teucrium polium L.		I+.1	Ch	Ch herb caesp	MED-SUBMED	Med-submed(W-E)	
Thesium linophyllon L.	I +.1		T	T scap	CE	C Eu (C-E)	
Thymelaea passerina (L.) Coss. & Germ.	I r-+.1		T	T scap	MED-SUBMED-PONT-OR-TUR	Med-submed(W-E)-Pont-Orient-Turan	
Thymus ciliatopubescens (Halácsy) Halácsy	IV +.1-1.3		Ch	Ch herb rept	MED-SUBMED	Balk(Maced-Aeg(N-W))	E
Thymus thracicus Vel. var. *stribrnyi* (Vel.) Stoj. & Stef.		V+.1—+.2	Ch	Ch herb rept	SUBMED	Balk(Maced -Thrac)	E
Valeriana dioscoridis Sibth. & Sm.		III+.1—+.2	H	H scap	MED-SUBMED	Illyr(SW)-Balk(Maced-Thrac(W)-Ion-Aeg(W-E))	
Veronica austriaca L. subsp. *dentata* (F. W. Schmidt) Watzl	II r-+.1	II+.1	H	H scap	CE	C Eu (C-E)	

Legend: *Asp.-Ram. nat.- Asplenio-Ramondaetum nathaliae* ; *Scor.-Ramo.nath - Scorzonero-Ramondaetum nathaliae*; LF - Life form; E - Endemics

Annex 3. Participation of chorological groups and subgroups in communities from suballiance *Ramondion nathaliae serpentinicum*

Community	***Asp.-Ram.nath.***	***Sco.-Ram.nath.***
	No taxa (%)	**No taxa (%)**
1. HOLARTIC	**1 (1.4)**	**1 (1.8)**
2. EURASIAN	**1 (1.4)**	**4 (7.4)**
2.1. *Eurasian (W-E) (temp-merid)*	*1 (1.4)*	*1 (1.8)*
2.3. *Eurasian (W-C) (bor-submerid)*		*2 (3.7)*
2.4. *Eurasian (W-E) (arct-merid)*		*1 (1.8)*
3. MEDITERRANEAN-SUBMEDITERRANEAN-PONTIC GROUP	**18 (24.6)**	**14 (25.9)**
3.1. *Mediterranean-Submediterranean-Pontic* — (Oriental-Turanian)- (Central European)	***6 (8.2)***	***8 (14.8)***
3.1.1. *Mediterranean –Submediterranean(W-E)-Pontic (W-C)*	*3 (4.1)*	*3 (5.5)*
3.1.2. *Mediterranean –Submediterranean (C-E)-Pontic (W)*	*2 (2.7)*	*1 (1.8)*
3.1.3.*Mediterranean –Submediterranean (W-E)-Pontic (W-C) - Oriental- Turanian*	*1(2.7)*	*1 (1.8)*
3.1.4. *Mediterranean –Submediterranean (C-E)-Pontic (W) –(C. European)*		*3 (5.5)*
3.2. *Submediterranean-Pontic* +*(Central European)*	***5 (6.8)***	***4 (7.4)***
3.2.1**.** *Submediterranean (W-E)-Pontic (W)*	*1 (1.4)*	*1 (1.8)*
3.2.2. *Submediterranean (W-E)-Pontic (W-C)*	*2 (2.7)*	*1 (1.8)*
3.2.3. *Submediterranean (C-E)-Pontic (W-C)*	*1 (1.4)*	
3.2.4. *Submediterranean (C-E)-Pontic (W)*	*1 (1.4)*	*1 (1.8)*
3.2.5. *Submediterranean (E)-Pontic (W-E)*		*1 (1.8)*
3.3. Pontic-*Submediterranean — (Central European)*	***7 (9.6)***	***2 (3.7)***
3.3.1 *Pontic (W-E)-Submediterranean* (W-E)-C Asian	*3 (4.1)*	
3.3.2. *Pontic (W-E)-Submediterranean* (W-C)		
3.3.2. *Pontic (C-E)-Submediterranean (W-E)*	*1 (1.4)*	
3.3.3. *Pontic (W-E)-Submediterranean* (W-E)		
3.3.4. *Pontic (W-C)-Submediterranean (C-E)*	*1 (1.4)*	*2 (3.7)*
3.3.4. *Pontic (W-C)-(Central European)2 (1.4)*		
4. MEDITERRANEAN-SUBMEDITERRANEAN GROUP	**32 (43.8)**	**26 (48.1)**
4.1. Mediterranean-Submediterranean	***16 (21.9)***	***13 (24.1)***
4.1.1. *Mediterranean-Submediterranean (W-E)*	*6 (8.2)*	*8 (14.8)*
4.1.2. *Mediterranean-Submediterranean (W-E)-(Oriental)*	*1 (1.4)*	*1 (1.8)*
4.1.2. *Mediterranean-Submediterranean(C-E)*	*5 (6.8)*	*2 (3.7)*
4.1.3. *Mediterranean-Submediterranean (E)*	*3 (4.1)*	*2 (3.7)*
4.1.4. Mediterranean-Submediterranean-(Central European(S))	*1 (1.4)*	
4.2. Submediterranean	***16 (21.9)***	***13 (24.1)***
4.2.1. *Submediterranean (W-E)*	*3 (4.1)*	*1 (1.8)*
4.2.2. *Submediterranean (W-E)-(Central European (C-E))*	*1 (1.4)*	

Community	***Asp.-Ram.nath.***	***Sco.-Ram.nath.***
	No taxa (%)	**No taxa (%)**
4.2.3. *Submediterranean (C-E)*	*6 (8.2)*	*3 (5.5)*
4.2.5. *Submediterranean (E)*	*6 (8.2)*	*9 (16.6)*
5. CENTRAL EUROPEAN GROUP	**3 (4.1)**	**2 (3.7)**
5.1. *Central European (W-C)*		*1 (1.8)*
5.2. *Central European (W-SE)*		*1 (1.8)*
5.3. *Central European (C-E)*	*2 (2.7)*	
5.4. *Central European (SE)*	*1 (1.4)*	
6. SOUTH EUROPEAN MOUNTAIN GROUP	**18 (24.6)**	***7(9.6)***
6.1. *South European mountain (W-E)*	***6 (8.2)***	***1 (1.8)***
6.1.1. *Pyreneean-Alpine-Apennine-Dinaric-Balkan-Carpathian*		*4 (5.5)*
6.1.3. *Pyreneean-Alpine-Dinaric-Balkan*	*1 (1.4)*	
6.1.4. *Alpine-Apennine-Dinaric-Balkan (Scardo-Pindhic-Moesian)*	*1 (1.4)*	*1 (1.8)*
6.2. *South European mountain (C-E)*	***8 (11)***	***2 (3.7)***
6.2.1. *Dinaric-Balkan mountain (Scardo-Pindhic-Moesian)*	*3 (4.1)*	*1 (1.8)*
6.2.2. *Dinaric-Balkan mountain (Scardo-Pindhic)*	*2 (2.7)*	*1 (1.8)*
6.2.3 .*Apennine-Balkan (Scardo-Pindhic)*	*1 (1.4)*	
6.3.4 .*Apennine-Dinaric-Balkan (Scardo-Pindhic)*	*1 (1.4)*	
6.3.5. *Apennine-Dinaric-Balkan (Scardo-Pindhic-Moesian)-Carpathian*	*1 (1.4)*	
6.3. *South European mountain (E)*	***4 (5.5)***	***4 (7.4)***
6.3.1. *Balkan mountain (Scardo-Pindhic-Moesian)*	*4 (5.5)*	*3 (4.1)*
6.3.2. *Balkan mountain (Scardo-Pindhic)*		*1 (1.4)*
Total	**73 (100)**	**54 (100)**

Annex 4. Participation of life forms in communities from suballiance *Ramondion nathaliae serpentinicum*

Community	*Asp.-Ram.nath.*	*Sco.-Ram.nath.*
	No taxa (%)	*No taxa (%)*
1. PHANEROPHYTES (P)	**5 (6.8)**	**7 (12.9)**
1.1. Trees (Phanerophyte scapose)	***3 (4.1)***	***2 (3.7)***
1.1.1. Decidious (P scap dec)	*3 (4.1)*	*2 (3.7)*
1.2. Shrubs (Phanerophyte caespitose)	***2 (2.8)***	***5 (9.3)***
1.2.1. Decidious (P caesp dec)	*1 (1.4)*	*3 (5.6)*
1.2.2. Evergreen (P scap semp)	*1 (1.4)*	*2 (3.7)*
2.CHAMAEPHYTES (C)	**28 (38.3)**	**14 (25.9)**
2.1. Frutescent (Fruticose chamaephyte)	**5 (6.8)**	**2 (3.7)**
2.2. Suffrutescent (Suffruticose chamaephyte)	**11 (15.1)**	**6 (11.1)**
2.2.1. Scapose (Ch suffrut scap)	*7 (9.6)*	*3 (5.6)*
2.2.2. Ceaspitose (Ch suffrut caesp)	*2 (2.8)*	*2 (3.7)*
2.2.2. Reptant (Ch suffrut rept)	*2 (2.7)*	*1 (1.8)*
2.3. Herbaceous (Herbaceous chamaephyte)	**10 (13.7)**	**5 (9.3)**
2.3.1. Ceaspitose (Ch herb caesp)	*7 (9.6)*	*4 (7.4)*
2.3.2. Reptant (Ch herb rept)	*3 (4.1)*	*1 (1.8)*
2.4. Succulent (Succulent chamaephyte -Ch succ)	**2 (2.7)**	**2 (3.7)**
3.HEMICRYPTOPHYTES (H)	**33 (45.2)**	**23 (42.6)**
3.1. Scapose (Scapose hemicryptophyte -H scap)	**14 (19.1)**	**9 (16.7)**
3.2. Caespitose (Caespitose hemicryptophyte -H caesp)	**10 (13.7)**	**6 (11.1)**
3.3. Reptant (Reptant hemicryptophyte - H rept)	**1 (1.4)**	
3.4. Rosette-semirosette (Rosette and/or semirosette hemicryptophyte- H ros/semiros)	**8 (10.9)**	**8 (14.8)**
3.4.1. *Evrergreen*	*2 (2.7)*	*1 (1.8)*
3.4.2. *Evergreen poikilohydrous*	*3 (4.1)*	*3 (5.6)*
3.4.3. *Deciduous*	*3 (4.1)*	*4 (7.4)*
4. GEOPHYTES (G)	**2 (2.8)**	**3 (5.6)**
4.1. Bulbous (Bulbous geophyte -G. bulb)	**1 (1.4)**	**2 (3.7)**
4.2. Rhizome (Rhizome- geophyte - G. rhiz)	**1 (1.4)**	**1 (1.8)**
5. THEROPHYTES (T)	**5 (6.8)**	**6 (11.1)**
5.1. Scapose (Scapose therophyte – T scap)	**4 (5.5)**	5 (9.3)
5.3. Rosette-semirosette (Rosette and/or semirosette therophyte – T ros/semiros)	**1 (1.4**)	1 (1.8)
Total	**73 (100)**	**54 (100)**