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Stipetum novakii ass. *nova* – a new association of serpentine rocky grassland vegetation (*Halacsyetalia sendtneri*) in Serbia

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Abstract – Phytosociological characteristics of grassland communities above serpentines (order *Halacsyetalia sendtneri* H. Ritter-Studnička 1970) in Serbia, are analyzed according to Braun-Blanquet methodology. In order to detect the basic floristic differentiation of analyzed communities ordinary correspondence analysis was applied. Cluster analysis was also performed to see the structure and separation of the communities based on the floristic composition. In order to determine diagnostic species, fidelity indices with presence/absence data and the size of all groups standardized to equal size were calculated. The new association *Stipetum novakii* is described in open rocky serpentine grasslands in Brdjani Gorge.

Key words: *Stipetum*, serpentine, ordination, fidelity, Serbia

Introduction

Serpentine (ophiolithic, ultramafic) rocks represent a group of siliceous rocks which are characterized by calcium deficiency, high concentrations of aluminium, iron, magnesium, nickel, cobalt and chromium, and a few plant nutrients. In contrast to other acid siliceous rocks, the pH values of the serpentine substrate vary from basic to ultrabasic (pH 5.5–8). Serpentine flora and vegetation differ from those occurring on other types of siliceous substrates or limestone. Open serpentine habitats are characterized by pronounced thermophilous character and xeric conditions. The xerothermic character of serpentine plants is also enhanced by the specific chemical composition of the serpentine substrate (STEVANOVIĆ et al. 2003). All of this results in a great number of specific adaptations (nanism, purpur-

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escence, glaucescence, stenophyllism, plagiotropism etc.) as well as the occurrence of numerous relic and endemic species.

The largest serpentine areas in Europe are in the Balkan peninsula (Epirus, Thessaly and Sterea Ellas in Greece, N, NC and SE Albania, C and E Bosnia, W, SW and C Serbia, E and C Rhodopes mountains in Bulgaria and gorge of River Pčinja and SE slopes of Mt Šar Planina in the NE part of Republic of Macedonia). In the territory of Serbia, the most frequent serpentine zones are in its C, W, NW and SW parts (JAKOVLJEVIĆ et al 2011). General overviews of the rich and interesting endemic serpentine flora in the Balkans are given by TATIĆ and VELJOVIĆ (1990) and STEVANOVIĆ et al. (2003).

In Serbia 19 associations were described in serpentine rocky grasslands (JOVANOVIĆ et al. 1986, LAKUŠIĆ and SABOVLJEVIĆ 2005) within the alliance *Centaureo-Bromion fibrosi* Blečić et al. 1960 (order *Halacsyetalia sendtneri* H. Ritter-Studnička 1970. Since the ultrabasic serpentine substrate appears between 500 to 1900 m a.s.l., their syntaxonomic diversity might be considerable, and this kind of vegetation requires a more objective revision of all syntaxa within the alliance *Centaureo-Bromion fibrosi* and order *Halacsyetalia sendtneri*.

The aim of this paper is to present the phytosociological analyses of the community dominated by *Stipa novakii* Martinovsky and compare it with the other communities of this type in Serbia, as well as to give an insight into the ecological characteristics in order to clarify its syntaxonomic position.

Materials and methods

Study area

The community dominated by *Stipa novakii* has been studied on serpentine rocky soils and small screes in different phases of genesis in Brđani Gorge in Serbia. Brđani Gorge is located high between Mt Vujan and Ilijak hill. It is 5 km long, 5 km away from the town of Gornji Milanovac, extending in a north to south direction, passing through the Ibarska highway. The gorge was cut by the Western Morava 3rd rank tributary, the Despotovica. The sides of the gorge are slanted at an angle of 10–70°, at an altitude around 300 m. Geologically, the gorge is mostly composed of the serpentine habsburgite–serpentinite. Rock erosion led to the formation of a pedological layer. These are rather shallow soils of low fertility and rock particles are abundantly and inherently present. The soil is eroded and has a mildly alkaline to neutral reaction (VIĆENTIJEVIĆ-MARKOVIĆ 2004). The xerophilous oak forests of the alliance *Quercion frainetto* represent the potential of vegetation in this place (HORVAT et al. 1974). However, since the major parts of the forests are completely degraded, the dominant vegetation type in this place is steppe–like grassland vegetation. Climate type in this area is temperate-continental, but in its slighter subhumid variant (Fig. 1.). The annual mean temperature is 10.8 °C and the annual precipitation is 796 mm. January is the coldest month with a temperature of –3.8 °C, while August is the warmest with atemperature of 26.5 °C. The wettest month is May with a precipitation of 89 mm and February is the driest, with 50 mm (HIJMANS et al. 2005). The vegetation period lasts eight months. It is important to say that the greatest amount of precipitation comes precisely during the vegetation season (from April to June), winter is the driest season, and winds are not frequent.

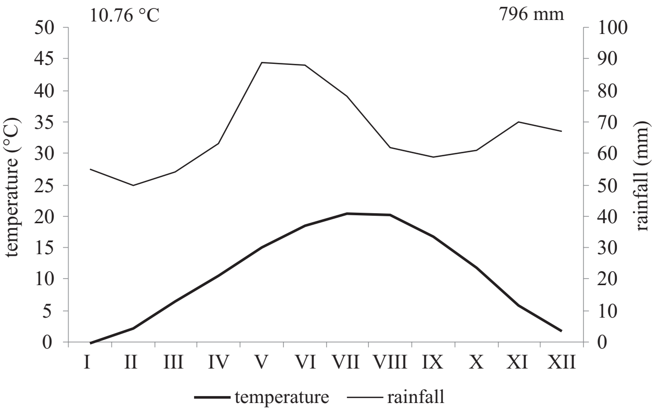

Fig. 1. The climate diagram for Brđjani Gorge in Serbia (from WALTER and LEITH 1964).

Field sampling

Sampling was done according to the methodology and protocols traditionally used in phytosociology. Relevés were made according to BRAUN-BLANQUET (1964). Plot size was usually 25 square meters, with the exception of three stands which were made on smaller relevé area (6, 20 and 14 m^2) because of the terrain features. The stands were recorded on serpentine soil on altitudes between 320 and 360 m on south, east and south-east exposed slopes with an inclination of 10 to 40 °. Cover of rocks within the stand area varied from 10–70%. The sampling period was spring, 2011. Nomenclature of plant taxa, with a few exceptions, follows the FLORA EUROPAEA DATABASE. All taxa with authors' names quoted in the paper are given in table 1.

Data analysis

In order to detect specificity and resolve the syntaxonomy of the community dominated by *Stipa novakii*, we processed 185 relevés belonging to 18 associations traditionally included in the alliance *Centaureo-Bromion fibrosi* (*Halacsyetalia sendtneri*), distributed throughout the territory of Serbia (Table 1, Fig 2). The communities *Eryngio-Brometum fibrosi* Z. Pavlović, 1962 ex V. Randjelović 2004 and *Halascya sendtneri-Potentilla mollis* Z. Pavlović 1962, are described just on the basis of two relevés and hence not included in numerical analyses.

After transformation of Braun-Blanquet abundance-cover scale according to WESTHOFF and VAN DER MAAREL (1973), the relevés were subjected to correspondence analysis (CA) in order to detect the basic structure of the floristic composition. Relevés that showed a significant deviation from the main core of the relevés typical of the analyzed vegetation were excluded from further numerical analysis. Finally, the main core of relevés was classified using the UPGMA (unweighted pair-group average linkage) cluster method based on Chord distance as a heterogeneity measure. These analyses were performed using FLORA software (KARADŽIĆ et al. 1998).

Due to the fact that traditionally recognized characteristic and differential species, in most cases, have mainly regional validity, the same species can occur in different species

Tab. 1. Communities traditionally included in alliance *Centaureo-Bromion fibrosi* of order *Halacsyetalia sendtneri*, that are used to compare**.**

No.	Associations	UTM (10×10 km)	Localities	Reference
1.	*Festuco duriusculae-Euphorbietum glabriflorae* S. Jov. et R. Jov.	CP75	Tara, Zlatibor, 980–1060 m a.s.l.	JOVANOVIĆ et al. (1992)
2.	*Festuco sulcatae- Potentilletum zlatiborensis* Z. Pavlović 1951	CT94	Zlatibor, 890–1020 m a.s.l.	PAVLOVIĆ (1951)
3.	*Poo molinieri- Plantaginetum holostei* Z. Pavlović 1951	DP72	Studena Mt., 910–1250 m a.s.l.	PAVLOVIĆ (1951)
4.	*Artemisio-Teucrietum montani* Blaženčić, Vučković, R. 1983	DP91	Goč, Mitrovo Polje, 710 –810 m a.s.l.	BLAŽENČIĆ and VUČKOVIĆ (1986)
5.	*Carici humilis-Festucetum pancicianae* R. Jovanović et S. Jovanović 1987	DM79	Kopaonik, 1650–1900 m a.s.l.	JOVANOVIĆ-DUNJIĆ and JOVANOVIĆ (1987)
6.	*Potentillo tommasinianae-Festucetum pancicianae* D. Lakušić 1989	DM79	Kopaonik, Krmeljica, 1050–1070 m a.s.l.	LAKUŠIĆ and RANĐELOVIĆ (1996)
7.	*Artemisio-Silenetum armeriae* D. Lakušić 1989	DM99	Kopaonik, Vlajkovci, 700–750 m a.s.l.	LAKUŠIĆ and RANĐELOVIĆ (1996)
8.	*Sedo-Dianthetum serbici* Z. Pavlović 1967	DN77	Rogozna, 500–850 m a.s.l.	PAVLOVIĆ (1967)
9.	*Potentillo-Fumanetum bonaparti* Rexhepi 1979	DN85	Ibar Valley – Kosovo, 600–900 m a.s.l.	REXHEPI (1979)
10.	*Hyperico-Euphorbietum glabriflorae* Rexhepi 1978	EN05	Kopaonik, Barelj, 1500m a.s.l.	REXHEPI (pers. comm.)
11.	*Onosmato-Scabiosetum fumarioides* Rexhepi 1978	DN60	Koznička Boka, 800–960 m a.s.l.	REXHEPI (1985)
12.	*Polygalo-Genistetum hassertianae* Blečić et al. 1969	DN60	Koznička Boka, 620–810 m a.s.l.	BLEČIĆ et al. (1969)
13.	*Hyperico-Euphorbietum glabriflorae* Rexhepi 1978	DN80	Drenica, Nekoc, 730–895 m a.s.l.	KRASNIQI and MILLAKU (2007).
14.	*Sedo-Bornmüellerietum dieckii* Blečić et al. 1969	DN97	Šarplanina, Ostrovica, 1280–1380 m a.s.l.	BLEČIĆ et al. (1969)
15.	*Bornmüellero dieckii-Seslerietum latifoliae* S. Jov. et V. Stev.	DN97	Šarplanina, Ostrovica, 1700 m a.s.l.	JOVANOVIĆ et al. (1992)
16.	*Cynancho-Saponarietum intermediae* Blečić, Tatić et Krasnići 1969	EM07	Šara Mt., Brezovica, 820–1270 m a.s.l.	BLEČIĆ et al. (1969)
17.	*Stipeto-Convolvuletum compacti* Millaku et al. 2011	EM16	Kosovo, Gurane, 650–735 m a.s.l.	MILLAKU et al. (2011)
18.	*Festuco-Plantaginetum serpentini* Randjelović et Ružić 1982	EM57	Preševo, Miratovac, 600–960 m a.s.l.	RANĐELOVIĆ and RUŽIĆ (1983)

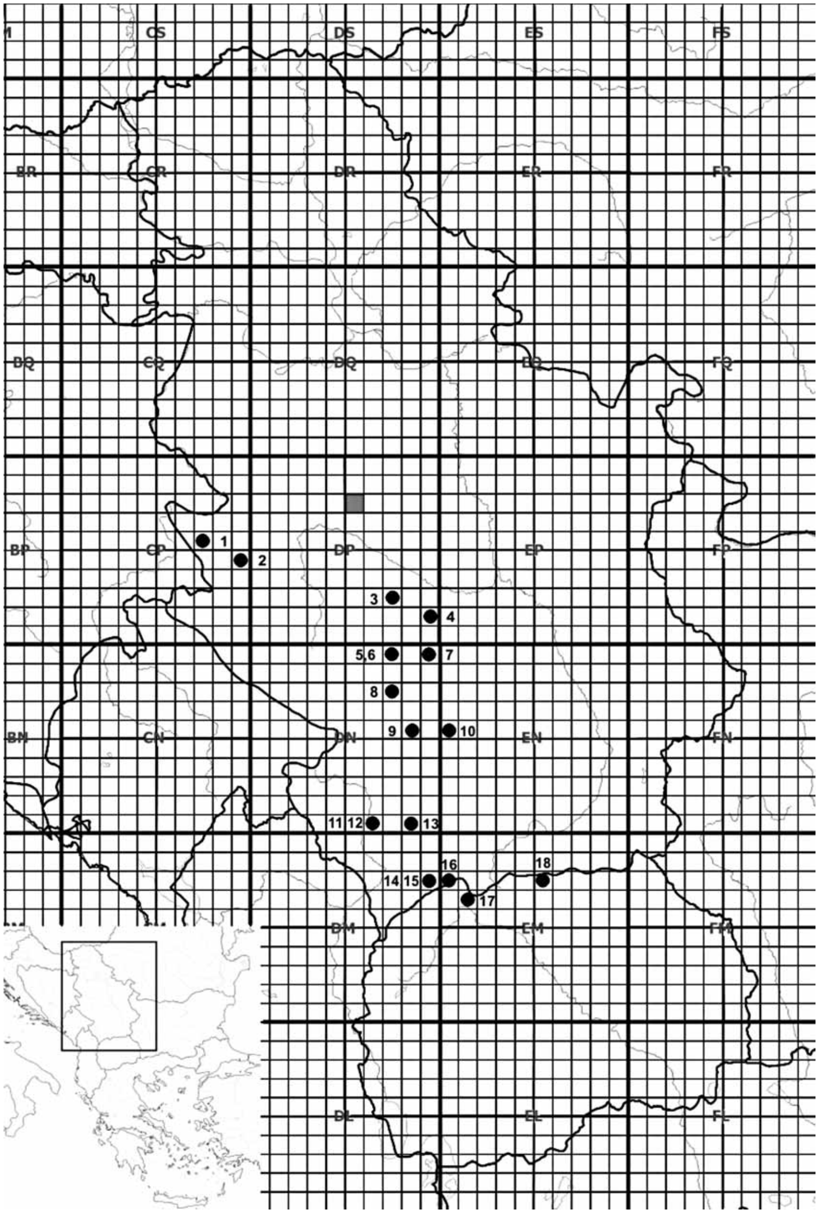

Fig. 2. The map of the localities of analyzed communities. The distribution is mapped using an underlying 10 x 10 UTM coordinate grid 100 x 100 km (UTM Grid zone 34, the black dots with the corresponding ordinal numbers represents the localities of the communities listed in table 1. The black square represents the locality of the *Stipa novakii* community.

combinations in different regions (e.g. in other mountain ranges as a consequence of a different florogenesis). This is the case with all the mentioned lists of Balkan syntaxa in which characteristic and differential species are characterized with a high degree of subjectivity, rather intuitive than objective. Therefore, in this article, we used the concept of diagnostic and dominant species proposed by CHYTRÝ et al. (2002) and CHYTRÝ and TICHÝ (2003). Using the statistical measures of fidelity, we quantified concentrations of species occurrences in groups of classified sites in order to determine diagnostic species (CHYTRÝ et al. 2002). The size of the site groups in the data set is virtually equalized, while the relative frequencies of species occurrence within and outside of these groups are kept constant (TICHÝ and CHYTRÝ 2006). Then, fidelity is calculated using the Φ-values of the association. With the use of this approach, species fidelity to a community types does not depend on the number of available field records. Since these values of fidelity measures are not the functions of statistical significance of fidelity, we performed the Monte Carlo test of significance of observed maximum indicator value for species with 4999 permutations. For the calculation of Φ-values, PcOrd 6.0 software (MCCUNE and MEFFORD 2011) was used. In order to determine dominant species we calculated the coverage index (Ic) according to LAUSI et al. (1982). In the purpose of defining the geoelements we used the groupings made by MEUSEL et al. (1965, 1978), MEUSEL and JÄGER (1992), modified for the Serbian territory by STEVANOVIĆ (1992).

Results

Ordination

Correspondence analysis has shown that the relevés of ass. *Festuco sulcatae-Potentilletum zlatiborensis* are completely separated from the rest of the relevés along the negative part of the first principal axes (Fig.3), which correlates with the highest extent of variability (about 85%). At the same time, this analysis completely separated the relevés with the domination of *Stipa novakii* from the rest of the communities along the positive part of the second axis. It can also be seen that the Kosovan site groups *Festuco-Plantaginetum serpentini*, *Hyperico-Euphorbietum glabriflorae* and *Stipeto-Convolvuletum compacti* are well separated along the negative part of the second axis. The rest of the relevés representing the *Centaureo-Bromion fibrosi* communities are concentrated in the centre of correspondence space.

Classification

The results of the cluster analysis, performed on the data set from which relevés of ass. *Festuco sulcatae-Potentilletum zlatiborensis* were excluded has shown that three main »stand groups« (clusters) could be differentiated. The cluster that separates at the highest heterogeneity level consists of two relevés from the ass. *Poo molinieri-Plantaginetum holostei*. These two stands are separated from the community they belong to, probably because they were recorded in open rocky grasslands, covering up to 25% and at higher altitudes of 1250 m a.s.l. From 91 species in total in these stands, only 10 and 12 species of the association are present. At the next level two main clusters can be seen, one of them representing the community dominated by *Stipa novakii*, and the other one representing the rest of the *Centaureo-Bromion fibrosi* communities. Within this last cluster, at different heterogeneity levels, 18 small subclusters can be distinguished. Each of them represents a more or less discrete community (Fig 4).

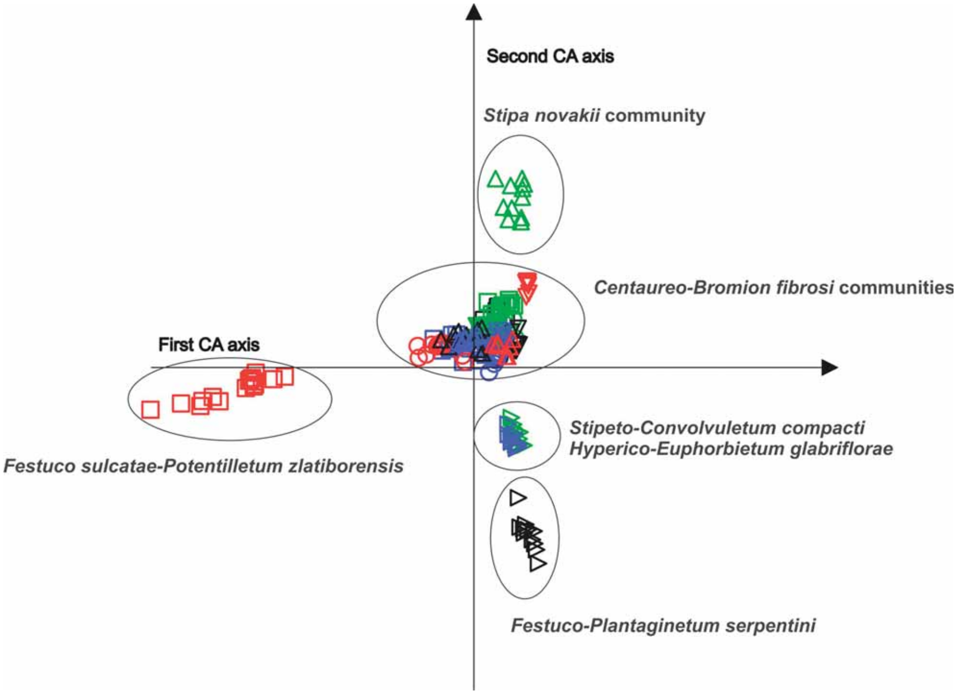

Fig. 3. Correspondence analysis (CA) of 19 analyzed communities of serpentine rocky ground vegetation traditionally included in alliance *Centaureo-Bromion fibrosi* of order *Halacsyetalia sendtneri* in Serbia.

Dominant and diagnostic species

Five taxa out of 476 were exclusively present in the *Stipa novakii* community from Brđani Gorge, whereas 445 taxa were exclusive for the rest of the analyzed communities (*Centaureo-Bromion fibrosi*) and absent from the relevés from Brđani Gorge. Only 26 taxa were present in both groups.

The most frequent and the most abundant species with large coverage indices in *Stipa novakii* community are: *Stipa novakii Chamaecytisus hirsutus* (L.) Link, *Erysimum linariifolium* Tausch, *Silene bupleuroides* L., *Artemisia lobelii* All., *Galium purpureum* L., *Chrysopogon gryllus* (L.) Trin., *Polygala supina* Schreber and *Cheilanthes marantae* (L.) Domin (Tab. 2).

Species with the highest Φ-values, and a high degree of fidelity to this community are: *Stipa novakii*, *Chamaecytisus hirsutus*, *Erysimum linariifolium*, *Polygala supina*, *Chrysopogon gryllus* which again indicates that these species could be diagnostic for this community. A set of species characterized by relatively high Ic-values, but very low Φ-values was the following: *Leontodon crispus* subsp. *asper* (Waldst. et Kit.) Rohlena, *Halacsya sendtneri* (Boiss.) Dörfler and *Teucrium montanum* L. (Tab. 2). High Ic-values and low Φ-values indicate that they are common (with relatively large frequency, abundance and cover) in the investigated community, but without a diagnostic value for the *Stipa novakii* community. Their fidelity values are much greater in respect to some other communities of *Centaureo-Bromion fibrosi,* where they can even be a diagnostic species.

Tab. 2. Diagnostic table of new association *Stipetum novakii* ass. nova. from Brđanska Gorge in Serbia. (**holotypus hoc loco*)

Area type[2]	UTM grid	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	34T, DP57	Frequency (%)	Constancy class	Cover index according to Lausi (Ic)	Fidelity index (F)	p (Monte Carlo test)
	Altitude (m)	320	321.9	321.9	327.1	331.9	331.9	355.1	335.9	338.9	342.9	360.9					
	Exposition	SE	SE	SE	SE	SE	E	SE	S	S	S	SE					
	Slope (°)	35-40	40	30	10-15	30	30	15-20	30	30	35	30					
	Cover of rocks (%)	45	10	15	70	30	65	30	50	45	40	50					
	Relevé area (m²)	25	6	20	14	25	25	25	25	25	25	25					
	Number of species per relevé	20	8	12	18	11	11	12	13	12	13	17					
	Relevé No.[1]	1	2	3	4*	5	6	7	8	9	10	11					
PONT-SUBM	*Stipa novakii* Martinovský	3	1	1	3	1	3	1	3	2	2	2	100	V (1-3)	55.56	0.97	0.0002
SUBM	*Chamaecytisus hirsutus* (L.) Link	1	+	1	1	1	2	1	1	2		1	91	V (+-2)	33.33	0.91	0.0002
SEP	*Erysimum linariifolium* Tausch	1		1		1	+	+	1	1	1	1	82	V (+-1)	25.25	0.83	0.0002
PONT-SUBM	*Silene bupleuroides* L.	1			1	1	+	+	1	1	1	1	82	V (+-1)	25.25	0.52	0.0014
EAZ	*Cheilanthes marantae* (L.) Domin	1	1	1		1			1	1	1		64	IV (1)	21.21	0.55	0.0006
SUBM	*Artemisia lobelii* All.	+		1	1	1		1		2	2	1	73	IV (+-1)	27.27	0.5	0.0020
PONT-SUBM	*Chrysopogon gryllus* (L.) Trin.				+	1	1	1	1	1	1	1	73	IV (+-1)	23.23	0.71	0.0002
EAP	*Galium purpureum* L.	1	1	1		1	1	+		1	1		73	IV (+-1)	23.23	0.65	0.0002
PONT-SUBM	*Polygala supina* Schreber	1	+	1	+		1			1	1	1	73	IV (+-1)	22.22	0.72	0.0002
MED-SUBM	*Fraxinus ornus* L.	r		+	1		+					+	45	III (r-1)	14.14	0.52	0.0002
MED-PONT	*Leontodon crispus* Vill. *subsp. asper* (Waldst. et Kit.) Rohlena					r	+	r	1		1	+	55	III (r-1)	12.12	0.18	0.3249
MED-SUBM	*Scrophularia canina* L. *subsp. tristis* (K. Malý) Nikolić		1	1		1			1	1	1		55	III (1)	18.18	0.58	0.0002
PONT-SUBM	*Bromus pannonicus* Kummer et Sendtner	2	1	1	1			+					45	III (+-2)	16.16	0.41	0.0030
EAZ	*Thymus glabrescens* Willd. *subsp.* glabrescens	1		1	+			1	1			1	55	III (+-1)	17.17	0.58	0.0002

JEP	*Teucrium montanum* L.						1	+	1	1	1	1	55	III (+-1)	17.17	0.07	0.7660
SE	*Galium album* Miller	1			+	1	1		1				36	III (+-1)	10.10	0.53	0.0002
HOL	*Asplenium ruta-muraria* L.	1	r		+								27	II (r-1)	6.06	0.34	0.0068
PONT-SUBM	*Medicago prostrata* Jacq.	r			1							+	27	II (r-1)	6.06	0.07	0.7037
MED-SUBM	*Halacsya sendtneri* (Boiss.) Dörfler				3			1				2	27	II (1-3)	15.15	0.17	0.3749
MED-SUBM	*Aethionema saxatile* (L.) R. Br. *subsp.* saxatile	1			+				+			+	36	II (+-1)	9.09	0.36	0.0088
PONT-SUBM	*Stachys recta* L.	1								+		+	27	II (+-1)	7.07	0.25	0.0288
PONT-SUBM	*Centaurea stoebe* L. subsp. *rhenana* (Boreau) Schinz et Thell.	r							+				18	I (r-+)	3.03	0.24	0.0686
SJEP	*Asplenium cuneifolium* Viv.	1			+								18	I (+-1)	5.05	0.20	0.1464
PONT-SUBM	*Prunus mahaleb* L.				+							+	18	I (+)	4.04	0.32	0.0050
PONT-SUBM	*Cotinus coggygria* Scop.										+	+	18	I (+)	4.04	0.30	0.0142
SE	*Ajuga genevensis* L.	+											9	I (+)	2.02	0.22	0.0602
PONT-SUBM	*Carduus candicans* Waldst. et Kit. subsp. *candicans*	+											9	I (+)	2.02	0.22	0.0602
MED-SUBM	*Quercus cerris* L.				+								9	I (+)	2.02	0.22	0.0678
MED-SUBM	*Quercus pubescens* Willd. subsp. *pubescens*				+								9	I (+)	2.02	0.22	0.0678
MED-SUBM	*Scabiosa fumarioides* Vis. et Pančić										+		9	I (+)	2.02	0.04	10.000
MED-SUBM	*Silene paradoxa* L.			+									9	I (+)	2.02	0.00	10.000

[1] Relevés 1-11: Serbia, Brđanska klisura, 43.993 N, 20.420 E

[2] PONT-SUBM- Pontic-Submediterranean, SUBM- Submediterranean, SEP- Central European Mountain, EAZ- Euroasian, EAP- Euroasian Mountain, MED-SUBM- Mediterranean-Submediterranean, JEP- South European Mountain, SE- Central European, HOL- Holarctic, SJEP- Central-Southern European Mountain

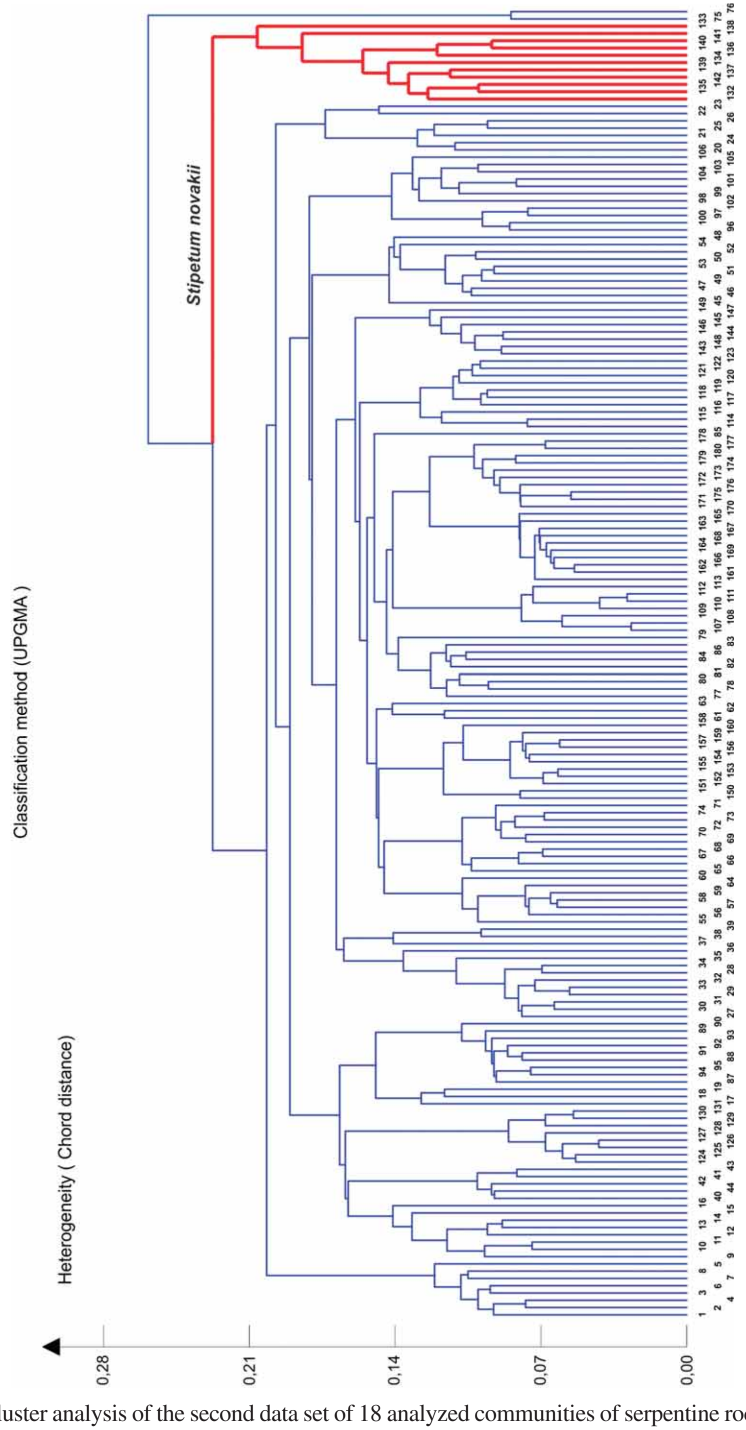

Fig. 4. Cluster analysis of the second data set of 18 analyzed communities of serpentine rocky ground vegetation traditionally included in the alliance *Centaureo-Bromion fibrosi* of the order *Halacsyetalia sendtneri* in Serbia.

Phytogeographic analysis

Floristic composition of *Stipa novakii* community showed the dominance of species of Mediterranean-sub-Mediterranean and Pontic-sub-Mediterranean geoelements (11 taxa i.e. 35% in each chorological type). Taxa with centres of distribution primarily in the central European or mountain regions are present in much lower numbers (Tab. 2). Since the community is developed in serpentine open rocky grasslands, such a floristic composition was expected. These habitats are known to have extremely thermophilous character, conditioned by the serpentine geological substratum, and the deriving shallow and poor soils, developing on more or less steep slopes with southern expositions.

All the results presented suggest that the community dominated by *Stipa novakii* developed on open serpentine rocky soils in Brđani Gorge is well differentiated from other associations within the alliance *Centaureo-Bromion fibrosi*, and we propose a new association under the name *Stipetum novakii* ass. nova hoc loco.

Syntaxonomical treatement

Ass. *Stipetum novakii* ass. nova hoc loco (Holotypus Tab. 2, rel. 4, Fig. 5)

Dominant species: *Stipa novakii* (1–3) (Ic = 56), *Chamaecytisus hirsutus* (+–2) (Ic = 33), *Erysimum linariifolium* (+–1) (Ic = 25), *Silene bupleuroides* (+–1) (Ic = 25), *Artemisia lobeli* (+–1) (Ic = 27), *Galium purpureum* (+–1) (Ic = 23), *Chrysopogon gryllus* (+–1) (Ic = 23), *Polygala supina* (+–1) (Ic = 22), *Cheilanthes marantae* (1) (Ic = 21).

Diagnosis: *Stipetum novakii* is secondary rocky grassland developed on mostly SE and S (rarely E) exposed cliffs, with an inclination between 10° and 40°. The dominant and characteristic species *Stipa novakii* with its dense tufts, forms poorly to richly developed stands up to 60 cm high, covering 10–70 % (average 40.9 %) of the relevé area (Tab. 2). The very poorly developed, thin pioneer soil layer with a large concentration of heavy metals

Fig. 5. Grassland of the association *Stipetum novakii* in Brđani Gorge serpentines (Photo: S. Vukojičić)

results in there being relatively low plant diversity. In eleven relevés representing this community only 31 species were found. The average number of species per relevé was 13. Diagnostic species of the association are: *Stipa novakii*, *Chamaecytisus hirsutus*, *Erysimum linariifolium*, *Polygala supina*, *Chrysopogon gryllus*, *Galium purpureum.* However, such a situation enables the development of a certain number of endemic serpentine species such as *Stipa novakii*, *Halacsya sendtneri* (Boiss.) Dörfler*, Scrophularia canina* L. subsp. *tristis* (K. Malý) Nikolić etc. Since the other characteristic species, as well as the differential ones, appear to be common accompanying species, we have chosen only *Stipa novakii* as a name giving species. The fact that it is endemic for very small serpentine area in western Serbia is also the criteria for *Stipa novakii* to be elected for the nominal species and also points up the endemic status of the community itself. The occurrence of some differential shrub and forest species, such as *Chamaecytisus hirsutus, Prunus mahaleb* L., *Cotinus coggygria* Scop., *Quercus cerris* L., *Quercus pubescens* Willd., distinctly characterizes this grassland community. The community basically represents a relatively short-term transitional syngenetic stage in the succession of vegetation, performing its role in binding and fixing the mobile substrate of mature screes on serpentine slope bedrock. The progressive succession will probably result in secondary grasslands of the *Chrysopogonetum grylli* type, after which shrubs and short trees will prevail in the physiognomy of the vegetation cover.

Nomenclatural remark

Holotypus: Tab. 2, relevé 4 – holotypus hoc loco
Syntaxonomical scheme
Festuco-Brometea Br.-Bl. et R. Tx. 1943
  Halacsyetalia sendtneri H. Ritter-Studnička 1970
    All. non defined
Stipetum novakii Kabaš et D. Lakušić ass. nova hoc loco

Discussion

In the analyzed serpentine rocky grasslands vegetation, only 5 out of 476 taxa were exclusively presented in stands dominated by *Stipa novakii*. All of the investigated communities had 26 taxa in common, with a certain number of Balkan serpentine endemics among them, such as: *Scrophularia canina* subsp. *tristis*, *Silene bupleuroides*, *Scabiosa fumarioides* Vis. et Pancic, *Halacsya sendtneri* and others, suggesting that they really do belong to the same higher syntaxa. Of the taxa, 454 were not recorded in the community from Brđani Gorge, and were present only in the rest of the *Centaureo-Bromion fibrosi* communities. The most frequent and the most abundant species present in the stands from Brđani Gorge is *Stipa novakii*. This is an endemic species for West Serbian serpentines. Its range descends southwards Kosovo, where it is gradually replaced with another endemic species, *Stipa mayeri* Martinovský. The endemic status of its dominant species implies the endemic status of the community *Stipetum novakii* itself.

Correspondence analysis has shown, firstly, that ass. *Festuco sulcatae-Potentilletum zlatiborensis* is completely separated from all other analyzed communities, representing well-supported syntaxa. In addition to its obvious detachment from other communities, we have noticed that the community was listed within *Halacsyetalia sendtneri* and *Centau-*

reo-Bromion fibrosi by mistake. Due to ecological, physiognomic and structural characteristics such as closed plant cover with ground cover of 90–100%, a typical grassland look, the fact that it is developed on plateaus (slope = 0–5°, extremely 15°) with the thicker soil layer with more humus, a higher floristic richness (86 registered species), in the original paper in which it was published, it was considered to be an intermediate syngenetic stage connecting the open serpentine vegetation of *Poo molinieri-Plantaginetum holostei* and the dry mountainous grasslands of *Koelerietum montanae* type (PAVLOVIĆ 1951). The authors consider that this association does not belong to the order *Halacsyetalia sendtneri* and should be listed within *Festucetalia valesiacae* Br.-Bl. et R. Tx. 1943 and *Chrysopogoni--Danthonion alpinae* Kojić 1957, but this exceeds the aim of this paper.

Furthermore, both numerical analyses have also shown that *Stipetum novakii* ass. nova significantly differs from the rest of the communities representing *Centaureo-Bromion fibrosi*. The fact that species *Bromus erectus* Hudson subsp. *fibrosus* (Hackel) Stojan. et Stefanov. is absent from the community from Brđani Gorge, as are most of the diagnostic species of alliance *Centaureo-Bromion fibrosi*, such as *Centaurea kosaninii* Hayek, *Sedum serpentini* Janchen, *Alyssum montanum* L. subsp. *serbicum* Novák, *Thymus lykae* Degen et Jáv., *Stachys recta* L. subsp. *baldaccii* (K. Malý) Hayek, *Stachys scardica* (Griseb.) Hayek, *Euphorbia glabriflora* Vis., *Poa badensis* Haenke ex Willd., *Alyssum markgrafii* O. E. Schulz, *Plantago holosteum* Scop. etc., indicates the high specificity and distinctiveness of this community and may lead us to think that its place is not at all within *Centaureo--Bromion fibrosi*. Regarding this, there is a high probability that *Stipetum novakii* ass.nova should belong to a new alliance, yet to be defined by further research. On the other hand, high Φ-values in the species *Scrophularia canina* subsp. *tristis, Cheilanthes marantae, Silene bupleuroides, Artemisia lobelii, Bromus pannonicus* Kummer et Sendtner*, Halacsya sendtneri,* and negative Φ-values within the species *Festuca duriuscula* L., *Potentilla arenaria* Borkh. var. *tommasiniana* (F. W. Schultz) Hegi, *Koeleria splendens* C. Presl, *Danthonia provincialis* DC., *Festuca valesiaca* Schleicher ex Gaudin subsp. *sulcata* (Hackel) Hegi, *Festuca valesiaca* subsp. *pseudovina* (Hackel ex Wiesb.) Hegi, indicate that the *Stipetum novakii* community should not be listed within xerophilous rocky grasslands of the order *Festucetalia valesiacae*, and its syntaxonomical position is, without any doubt, within the endemic order of the Central Balkans, *Halacsyetalia sendtneri*.

Since our numerical analysis showed that the heterogeneity level that separates *Stipetum novakii* ass. nova from the rest of the analyzed communities provides a sufficient basis for conferring on it the status of the association and also indicates that a new alliance should be introduced, further analyses are needed in order to get a more consistent syntaxonomic classification within the order *Halacsyetalia sendtneri*.

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References

BLAŽENČIĆ, Ž., VUČKOVIĆ, R., 1986: Meadow and pasture vegetation on southern slopes of the Goč Mountain in the Vicinity of Mitrovo Polje (In Serbian). Proceedings Symposium Man and Plant. Matica Srpska, Novi Sad, 441–448.

BLEČIĆ, V., TATIĆ, B., KRASNIĆI, F., 1969: Three endemic communities on serpentine soil in Serbia (In Serbian). Acta Botanica Croatica 28, 43–48.

BRAUN-BLANQUET, J., 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde, 3. Springer, Wien – New York.

CHYTRÝ, M., TICHÝ, L., 2003: Diagnostic, constant and dominant species of vegetational classes and alliances of the Czech Republic: A statistical revision. Folia Facultatis Scientarum Naturalium Universitatis Masarykianae Brunensis. Biologia 108, 1–231.

CHYTRÝ, M., TICHÝ, L., HOLT, J., BOTTA-DUKÁT, Z., 2002: Determination of diagnostic species with statistical fidelity measures. Journal of Vegetation Science 13, 79–90.

FLORA EUROPAEA DATABASE: Royal Botanic Garden Edinburgh. Retreived November 23, 2012 from http://rbg-web2.rbge.org.uk/FE/fe.html

HIJMANS, J., CAMERON, E., PARRA, L., JONES, G., JARVIS, A., 2005: Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25, 1965–1978.

HORVAT, I., GLAVAČ, V., ELLENBERG, H., 1974: Vegetation Südosteuropas. Geobotanica Selecta 4. Gustav Fischer Verlag, Stuttgart.

JAKOVLJEVIĆ, K., LAKUŠIĆ, D., VUKOJIČIĆ, S., TOMOVIĆ, G., ŠINŽAR-SEKULIĆ, J., STEVANOVIĆ, V., 2011: Richness and diversity of pontic flora on serpentine of Serbia. Central European Journal of Biology 6, 260–274.

JOVANOVIĆ, B., LAKUŠIĆ, R., RIZOVSKI, R., TRINAJSTIĆ, I., ZUPANČIĆ, M. (eds.), 1986: *Prodromus phytocenosum Yugoslaviae ad mappam vegetationis* 1: 200 000. Scientific Council of the Vegetation Maps of Yugoslavia, Bribir – Ilok.

JOVANOVIĆ-DUNJIĆ, R., JOVANOVIĆ, S., 1987: The succesion of vegetation on serpentine rocky grounds on eastern spurs of the Kopaonik Mountain. Archives of Biological Science 39, 93–102.

JOVANOVIĆ, S., STEVANOVIĆ, V., JOVANOVIĆ-DUNJIĆ, R., 1992: Contribution to the knowledge on the serpentine vegetation of Serbia. Glasnik Prirodnjačkog Muzeja u Beogradu, Ser. B 47, 43–51.

KARADŽIĆ, B., ŠAŠO-JOVANOVIĆ, V., JOVANOVIĆ, Z., POPOVIĆ, R., 1998: FLORA – a database and software for floristic and vegetation analyzes. In: TSEKOS, I., MOUSTAKAS, M. (eds.), Progress in botanical research, 69–72. Kluwer Academic Publishers, Dodrecht.

KRASNIQI, E., MILAKU, F., 2007: The association *Hyperico-Euphorbietum glabriflorae* Rexhepi 1978 in the serpentine terrains of Drenica Mountain. Hacquetia 6, 183–193.

LAKUŠIĆ, D., RANĐELOVIĆ, V., 1986: Review of plant communities of Mt. Kopaonik (SW Serbia, Yugoslavia). Ecology 31, 1–16.

LAKUŠIĆ, D., SABOVLJEVIĆ, M., 2005: Phytocoenological classification of vegetation. In: LAKUŠIĆ, D. (ed.), Habitats in Serbia, results of the project »Harmonization of national nomenclature in the classification of habitats with the international standards« (In Serbian). Institute of Botany and Botanical Garden »Jevremovac«, Faculty of Biology, University of Belgrade, Ministry of Science and Environmental protection of the Republic of Serbia. Retrieved July 8, 2012 from http://habitat.bio.bg.ac.rs/nacionalne_klasifikacije_stanista.htm

LAUSI, D., GERDOL, R., PICCOLI, F., 1982: Syntaxonomy of the *Ostrya carpinifolia* woods in the Southern Alps (N Italy) based on numerical methods. Studia Geobotanica 2, 41–58.

MCCUNE, B., MEFFORD, M. J., 2011: PC-ORD for windows: multivariate analysis of ecological data, 6. MjM Software, Gleneden Beach.

MEUSEL, H., JÄGER, E., WEINERT, E., 1965: Vergleichende Chorologie der zentraleuropäischen Flora 1, Karten, Gustav Fischer, Jena.

MEUSEL, H., JÄGER, E., WEINERT, E., 1978: Vergleichende Chorologie der zentraleuropäischen Flora 2, Karten, Gustav Fischer, Jena.

MEUSEL, H., JÄGER, E., 1992: Vergleichende Chorologie der zentraleuropäischen Flora 3, Karten, Gustav Fischer, Jena-Stuttgart-New York.

MILLAKU, F., KRASNIQI, E., REXHEPI, R., 2011: The association *Stipeto-Convolvuletum compacti* ass. nova in Kosovo. Hacquetia 10, 137–147.

PAVLOVIĆ, Z., 1951: Vegetation of the mountain Zlatibor. Proceedings of the Institute of Ecology and Biogeography 11, 115–182.

PAVLOVIĆ, Z., 1967: Sur une association végétale endémique des terrains serpentineux dans la vallée de la riviére Ibar (Serbie). Glasnik Botaničkog zavoda i Bašte Univerziteta u Beogradu, Nova serija 2,189–195.

RANĐELOVIĆ, N., RUŽIĆ, M., 1983: Pastural vegetation on serpentine in south-eastern Serbia (association *Festuco-Plantaginetum serpentini* Ranđ. et Ružić 1982)((In Serbian). Bulletin du Museum d'Histoire Naturelle de Belgrade, Ser. B 38, 55–61.

REXHEPI, F., 1979: Endemic plant community *Potentillo-Fumanetum bonapartei* Rexhepi 1979, ass. nov. Acta Biologiae et Medicinae Experimentalis 4, 41–46.

REXHEPI, F., 1985: Endemic association Onosmo-Scabiosetum fumarioides Rexhepi 1978 on serpentines of Kosovo. Bulletin of the Ecological Society of Bosnia and Herzegovina 4 (B), 133–138.

STEVANOVIĆ, V., 1992: Floristic division of the territory of Serbia with an overview of higher chorions and appropriate floral elements. In: SARIĆ, M. R. (ed.), Flora of Serbia 1, 47–56. SANU, Beograd.

STEVANOVIĆ, V., TAN, K., IATROU, G., 2003: Distribution of the endemic Balkan flora on serpentine I. – obligate serpentine endemics. Plant Systematic and Evolution 242, 149–170.

TATIĆ, B., VELJOVIĆ, V., 1990: Distribution of serpentinized massifs on the Balkan peninsula and their ecology. In: ROBERTS, B. A., PROCTOR, J. (eds.), The ecology of areas with serpentinized rocks, 199–215. Kluwer Academic Publishers, Dordrecht.

TICHÝ, L., CHYTRÝ, M., 2006: Statistical determination of diagnostic species for site groups of unequal size. Journal of Vegetation Science 17, 809–818.

VIĆENTIJEVIĆ-MARKOVIĆ, G., 2004: The serpentinophytae of the Brdjani gorge. Acta Agriculturae Serbica 9, 65–72.

WALTER, H., LEITH, H., 1964: Klimadiagramm-Weltatlas 2. Gustav Fischer Verlag, Jena.

WESTHOFF, V., VAN DER MAAREL, E., 1973: The Braun-Blanquet approach. In: WHITTAKER, R. H. (ed.), Ordination and classification of communities, Handbook of Vegetation Science 5, 619–726. W. Junk, Hague.