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Phytosociological characteristics of seven poorly known associations of serpentine rocky grassland vegetation of the order *Halacsyetalia sendtneri* in Serbia

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ABSTRACT: Although it is well known that dry open rocky grassland vegetation on shallow serpentine (ultramafic) soils represents one of the most interesting, highly endemic, and often studied vegetation types, the authors of several detailed studies of Balkan serpentine flora and vegetation suggested that the vegetation cover of Balkan ultramafics needs further exploration due to its heterogeneity. In this article, phytosociological characteristics of seven poorly known associations of grassland communities from the order *Halacsyetalia sendtneri* are analysed. In order to provide additional descriptions of these communities (with diagnosis and lists of diagnostic, dominant, and constant species), check their phytosociological validity, and confirm their syntaxonomical position, the stands of these communities were compared with 18 associations distributed throughout the area of serpentine outcrops in Bosnia and Herzegovina and Serbia. The results of cluster analysis confirmed that the analysed heretofore poorly known associations in the vegetation of open rocky serpentine grasslands are floristically well-defined.

Keywords: Balkan Peninsula, numerical analyses, phytosociology, syntaxonomy, serpentine, ultramafic grasslands

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INTRODUCTION

Despite the fact that different types of ultramafic (including serpentine) rocks represent only a negligible fraction (less than 1%) of the Earth's surface (Brooks 1987), they have been of great interest to researchers since the middle of the 19th Century. This type of rocks and their effects on flora and vegetation have held special interest for European botanists, particularly in the Balkans, since the largest continuous ultramafic areas in Europe are present there (Brooks 1987). Interest in the topic began to be shown in a number of classical papers dealing with the ultramafic (i.e., serpentine) flora of the Balkan Peninsula: Grisebach (1843), Pančić (1859), Beck (1901), Malý (1908, 1910), Adamović (1909), Janchen (1920), Jávorka (1921), Hayek (1923), Markgraf (1926, 1931), Nyárády (1927), Novak (1928), Rechinger (1957), etc. Later papers include more comprehensive studies focusing on floristics and florogenesis, ecophysiological aspects of the ultramafic flora and vegetation, and geological and edaphic properties of the ultramafic substrate itself: Pichi-Sermolli (1948), Kruckeberg (1951, 1954, 1967, 1985), Walker (1954), Whittaker (1954), Tadros (1957), Proctor & Woodell (1975), Karataglis *et al.* (1982), Reed (1986), Brooks (1987), Vergnano-Gambi (1992), Chiarucci *et al.* (1995), Stevanović *et al.* (2003), Kazakou *et al.* (2008), Brković *et al.* (2015).

Interest in the serpentine flora and vegetation has continued to grow, and numerous papers have served as a solid basis for further studies of vegetation found on ultramafic substrates. During the second half of the 20th

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Century, research was carried out almost simultaneously in the Balkan countries, mainly in Serbia and Bosnia and Herzegovina.

The first vegetation studies on ultramafics of the Central Balkan Peninsula dealt with rocky dry grassland vegetation in the mountains of Serbia (Pavlović 1951, 1953, 1955a, b; Kojić & Ivanović 1953; Cincović & Kojić 1955, 1956). Synthetic papers on serpentine plant associations of Bosnia and Herzegovina were published not long after (Krause & Ludwig 1956, 1957; Krause *et al*. 1963). Subsequently, Blečić *et al*. (1969) published an important study on the specifics of the grassland flora and vegetation of Kosovo and Metohija, and three new associations were published and included within the alliance *Centaureo-Bromion fibrosi* Blečić et al. 1969. One year later, as a result of research on serpentine rocky grasslands of Bosnia and Herzegovina, Ritter-Studnička (1970) described a new order encompassing steppe-like rocky grassland vegetation on serpentine substrates of Bosnia and Herzegovina, Serbia, and Albania – *Halacsyetalia sendtneri* Ritter-Studnička 1970. The range of this order coincides with the area of its nominal species, the serpentine endemic *Halacsya sendtneri*. Within this order, two new alliances were described in the same paper, namely *Polygonion albanicae* Ritter-Studnička 1970 in Central and *Potentillion visianii* Ritter-Studnička 1970 in Eastern Bosnia and Herzegovina. This vegetation order, although rich in serpentine endemic and relic species, is classified in *Festuco-Brometea* Br.-Bl. et Tx. ex Klika et Hadač 1944 due to the presence of elements characteristic of dry grassland vegetation of the order *Festucetalia valesiacae* Br.-Bl. & Tx. ex Br.-Bl. 1950 (Ritter-Studnička 1970).

In the years to follow, many papers describing new associations from different ultramafic localities in Serbia and Kosovo were published: Jovanović *et al*. (1992), Kojić *et al*. (1992), Marković (2007), Millaku *et al*. (2011), Kabaš *et al*. (2013). All these new associations were listed in some review articles and books within the order *Halacsyetalia sendtneri* (Horvat *et al*. 1974; Lakušić *et al*. 1978; Zupančič 1986; Tatić & Veljović 1992; Kojić *et al*. 1998; Aćić *et al*. 2014). Nevertheless, the results of a recent study of Kuzmanović *et al*. (2016) on the complete vegetation of the order *Halacsyetalia sendtneri* in the Central Balkans suggested a somewhat different syntaxonomical scheme within it and provided new solutions for the alliances. To be specific, the existence of two geographically and floristically well-defined alliances was pointed out: (1) *Centaureo kosaninii-Bromion fibrosi* on the territory of Kosovo and Northern Albania; and (2) *Potentillion visianii* in Eastern Bosnia and Herzegovina and Western and Central Serbia.

Moreover, the authors of several detailed studies of the Balkan serpentine flora and vegetation suggested that the vegetation cover of Balkan ultramafics needs further exploration due to its heterogeneity (Tatić & Veljović 1992; Jakovljević *et al*. 2011; Aćić *et al*. 2014). Accordingly, the aims of this paper were to provide phytosociological tables, accurate diagnosis, and floristic and ecological data of seven poorly known serpentine dry grassland associations in Serbia, including Kosovo. Six of them are associations whose invalid names were regularly quoted in several national reviews of the plant communities in Serbia (Kojić *et al*. 1998; Kojić *et al*. 2004; Lakušić & Sabovljević 2005) and were validated in a recent nomenclatural revision of dry grassland syntaxa of the Central Balkans (Aćić *et al*. 2014). Also, we here give a formal description of one new association, provisionally named by Kuzmanović *et al*. the *Carici kitaibelianae–Euphorbietum glabriflorae* association (Kuzmanović *et al*. 2016).

MATERIAL AND METHODS

Study area. The study area is located in the central part of the Balkan Peninsula (southeastern Europe). It overlaps with the distribution of serpentine outcrops in Western and Central Serbia and Kosovo. According to Horvat *et al*. (1974), the study area biogeographically belongs to the Eastern Illyrian (Dinaric Alpic) and the Northern Scardian Mountain subregions of the Central European floristic region.

Each location of the studied syntaxa was characterised by its basic bioclimatic parameters (Table 1), which were extracted from the WorldClim set of global climate layers, and the climatic types were defined according to Stevanović & Stevanović (1995). The extraction of bioclimatic parameters was done with DIVA-GIS 7.5 software (Hijmans *et al*. 2012). For details about the distribution of serpentinite outcrops, climatic conditions, and vegetational characteristics of the study area, see Kuzmanović *et al*. (2016).

Data collecting. For the purposes of this study, a data set of 298 relevés of 25 associations distributed throughout the area of serpentinite outcrops in Bosnia and Herzegovina and Serbia including Kosovo was studied. More detailed information regarding all analysed syntaxa is given in Table 2. All relevés used in this article are stored in the Grassland Vegetation of Serbia Database (GIVD number: EU-RS-002, Aćić *et al*. 2012).

Relevés were made according to the methodology of Braun-Blanquet (1964). The plot size was usually the one standard for grasslands (Chytrý & Otýpková 2003), but generally relevés varied from 9–100 m^2.

The nomenclature and taxonomy of plant taxa are in agreement with the Flora Europaea Database (Tutin *et al*. 2001; http://rbgweb2.rbge.org.uk/FE/fe.html), except for *Bothriochloa ischaemum* (L.) Keng., *Bromus fibrosus* Hack., *Cytisus procumbens* Bojer ex Baker var.

Table 1. Basic bioclimatic variables for locations of studied syntaxa, extracted from the WorldClim set of global climate layers (BIO1 = annual mean temperature, BIO6 = minimum temperature of coldest month, BIO9 = mean temperature of driest quarter, BIO12 = annual precipitation, BIO18 = precipitation of warmest quarter, BIO19 = precipitation of coldest quarter).

	Associations	Localities	BIO1	BIO6	BIO9	BIO12	BIO18	BIO19
1	*Artemisio albae-Achnatheretum calamagrostis*	Mt Kopaonik (Rajićeva Gora, 1100 m a.s.l, Vlajkovci, 750 m a.s.l.)	7,8	-5,8	-0,1	834	227	184
2	*Artemisio albae-Silenetum armeriae*	Mt Kopanik (Vlajkovci), 700-750 m a.s.l., Mt Tara, 980 m a.s.l.	7,8	-5,8	-0,1	834	227	184
3	*Carici kitaibelianae-Euphorbietum glabriflorae*	Mt Kopaonik (Barelj), 1500m a.s.l.	5,6	-7,3	11,1	885	221	212
4	*Festuco pancicianae-Caricetum humilis*	Mt Kopaonik (Rajićeva Gora), 1200 m a.s.l.	6,8	-6,5	-0,9	873	228	200
5	*Potentillo tommasinianae-Festucetum pancicianae*	Mt Kopaonik (Krmeljica), 1050-1070 m a.s.l.	8,1	-5,6	0,2	874	228	198
6	*Seslerio serbicae-Caricetum humilis*	Mt Kopaonik (Kukavica), 1500-1650 m a.s.l.	6,9	-6,4	-0,9	900	240	203
7	*Centaureo kosaninii-Euphorbietum glabriflorae*	Mt Šar Planina (Brezovica), 1100 m a.s.l.	8,4	-5,3	16,8	811	162	215

Table 2. Analysed syntaxa of serpentine rocky grasslands used in the analysis. Detailed data with relevé coordinates and map of distribution are published in Kuzmanović *et al*. 2016.

No.	**Association**	**Locality**	**Table source**	**No. of relevés**
	Bosnia and Hercegovina			
1	*Euphorbio montenegrinae-Brometum erecti* Krause & Ludwig 1956	Gostović	Krause et Ludwig 1956	5
2	*Halacsyio sendtneri-Caricetum humilis* Krause & Ludwig 1956	Gostović	Krause et Ludwig 1956	6
	Serbia (central)			
3	*Alysso markgrafii-Artemisietum albae* Aćić et al. 2014	Mt Goč	Blaženčić et Vučković 1983	7
4	*Artemisio albae-Achnatheretum calamagrostis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014	Mt Goč, Mt Kopaonik (Rajićeva Gora, Vlajkovci)	this paper	5
5	*Artemisio albae-Silenetum armeriae* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopanik (Vlajkovci)	this paper	16
6	*Bromo fibrosi-Artemisietum albae* A. Marković ex Aćić et al. 2014	Mt Suvobor, Brđani Gorge	Marković 2007	10
7	*Bromo fibrosi-Chrysopogonetum grylli* Tatić 1969	Mt Studena	Tatić 1969	13
8	*Festuco ovinae-Euphorbietum glabriflorae* S. Jovanović et R. Jovanović-Dunjić in S. Jovanović et al. ex Aćić et al. 2014	Mt Tara, Mt Zlatibor	Jovanović et al. 1987	11

No.	Association	Locality	Table source	No. of relevés
9	*Festuco pancicianae-Caricetum humilis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014	Mt Kopaonik (Rajićeva Gora)	this paper	5
10	*Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953	Mt. Maljen (Divčibare, Tometino polje), Mt. Radočelo (Rudnjanska visoravan)	Cincović et Kojić 1955, 1956, Kojić et Ivanović 1953	25
11	*Poo molinerii-Plantaginetum holostei* Pavlović 1951	Mt. Ozren, Mt. Studena, Mt. Zlatibor	Pavlović 1951, 1955, Tatić 1969	54
12	*Potentillo tomasinianae-Festucetum pancicianae* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopaonik (Krmeljica)	this paper	9
13	*Potentillo tommasinianae-Stipetum pennatae* A. Marković ex Aćić et al. 2014	Mt Goč, Brđani Gorge	Marković 2007	10
14	*Seslerio serbicae-Caricetum humilis* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopaonik (Kukavica)	this paper	8
15	*Stipetum novakii* Kabaš et D. Lakušić in Kabaš et al. 2013	Brđani Gorge	Kabaš et al. 2013	11
	Serbia (Kosovo)			
16	*Centaureo kosaninii-Euphorbietum glabriflorae* S. Jovanović et V. Stevanović in Aćić et al. 2014	Mt Šar-Planina (Brezovica)	this paper	6
17	*Cynancho vincetoxici-Saponarietum intermediae* Blečić et al. 1969	Mt Šar-Planina (Brezovica)	Blečić et al. 1969	13
18	*Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014	Mt Goleš, Mt Koznica	Rexhepi 1978	21
19	*Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014	Mt Kopaonik (Barelj)	Ranđelović et al. 1979	5
20	*Onosmo echioidis-Scabiosetum fumarioidis* Rexhepi ex Aćić et al. 2014	Koznička Boka	Rexhepi 1978	10
21	*Polygalo dörfleri-Genistetum hassertianae* Blečić et al. 1969	Koznička Boka	Blečić et al. 1969	10
22	*Potentillo tommasinianae-Fumanetum bonapartei* Rexhepi ex Aćić et al. 2014	Mt. Kopaonik (Lis Čuka, Belaška), Mt. Rogozna (Banjska)	Rexhepi 1979	10
23	*Sedo serpentini-Bornmuellerietum dieckii* Blečić et al. 1969	Mt Šar Planina (Ostrovica)	Blečić et al. 1969	11
24	*Sedo serpentini-Dianthetum serbici* Pavlović 1967	Mt Rogozna	Pavlović 1967	7
25	*Stipo mayerii-Convolvuletum compacti* Millaku et al. 2011	Gurane	Millaku et al. 2011	10
	TOTAL			298

petrovicii (Adamović) Diklić, *Dianthus sylvestris* Wulfen f. *papillosus* (Vis. & Pančić) Novák, *Echium rubrum* Forssk., *Potentilla arenaria* Borkh. ex G. Gaertn., *Potentilla tommasiniana* F.W. Schultz, *Sedum serpentini* Janch., *Sesleria serbica* (Adamović) Ujhelyi, *Stachys recta* subsp. *baldaccii* (K. Malý) Hayek, *S. recta* subsp. *rhodopaea* (Velen.) Chrtek, *Thymus jankae* Čelak, *Tulipa serbica* Tatić & Krivošej, *Veronica austriaca* subsp. *jacquinii* (Baumg.) Eb. Fisch, *Viola kopaonikensis* Pančić ex Tomović & Niketić, and critical taxa with unresolved relationships, which were included in species complexes (for details, see Table 2 in Kuzmanović *et al.* 2016). Taxa

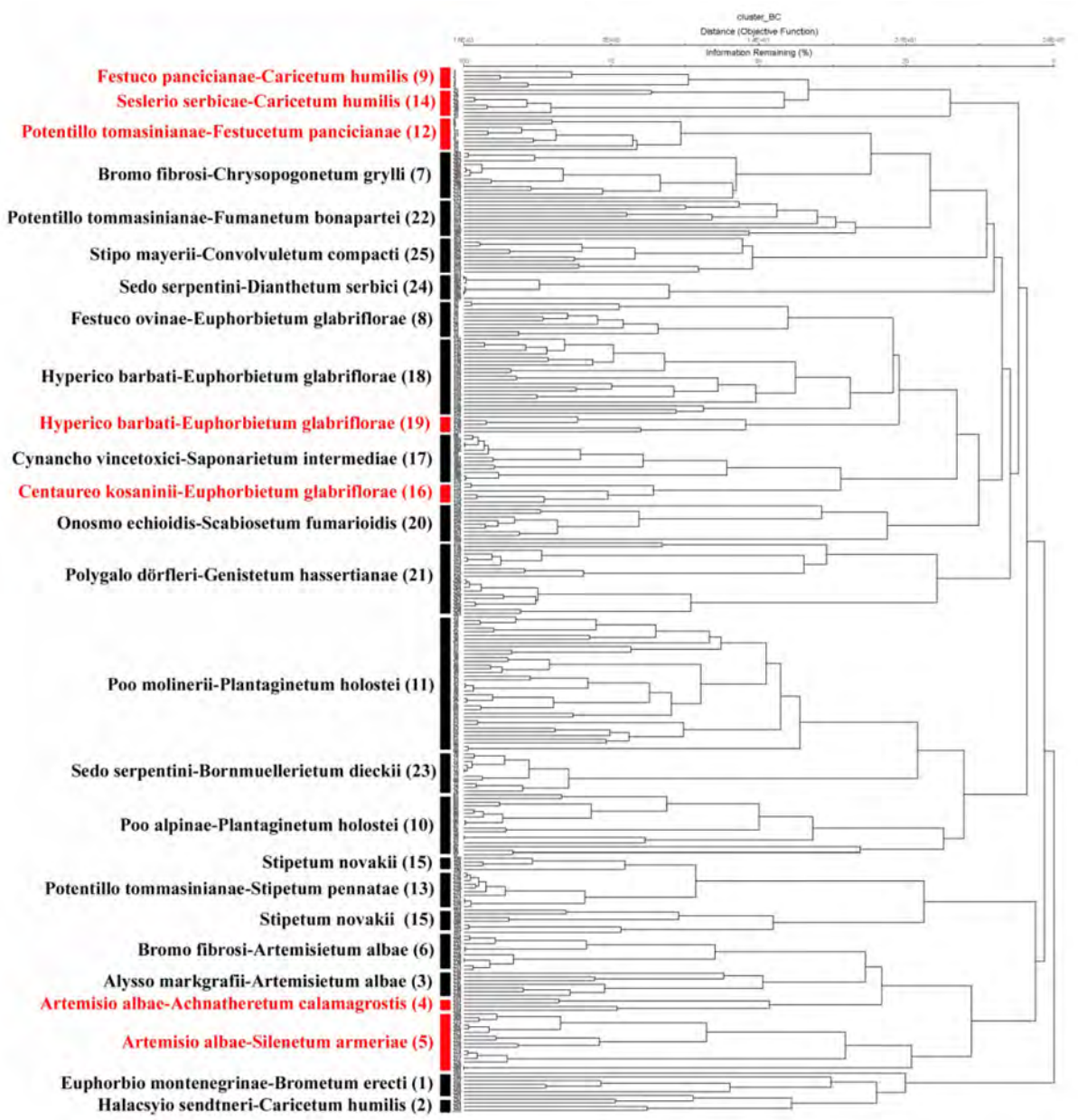

Fig. 1. Cluster Analysis of stands of 25 associations from serpentine rocky grassland vegetation of the order *Halacsyetalia sendtneri* Ritter-Studnička 1970 in Serbia and Bosnia and Herzegovina. The number in brackets corresponds to the ordinal number of the association in Table 2. Communities studied in the present paper are marked in red.

determined at the level of genus were omitted from the numerical analyses.

Data analyses. In order to determine whether all relevés originally published within particular syntaxa form compact "floristically well-characterised groups", we performed several cluster analyses of analytical data with different combinations of distance measures and group linkage methods. The criterion for floristically well-characterised groups of relevés derived from analytical tables was that in different cluster analyses groups of relevés belonging to particular syntaxa formed compact clusters regardless of the method applied in the cluster analysis (for details, see Kuzmanović *et al.* 2016). In cluster analyses of the analytical tables (298 relevés x 465 taxa x 25 associations), the original cover–abundance values for individual taxa were transformed into an ordinal scale as proposed by Van Der Maarel (1979). Cluster analysis was done in the PAST (Hammer *et al.* 2001) and PcOrd 6 (McCune & Mefford 2011) program packages. In the paper, we present the results of cluster analysis based on Bray-Curtis distance measures and the paired group average linkage method.

The concept of diagnostic species proposed by Chytrý *et al.* (2002) and Chytrý & Tichý (2003) was

used and Fisher's exact test ($p<0.05$) was applied in the paper. Employing the statistical measure of fidelity (phi-coefficient) for this purpose, we quantified concentrations of species occurrences in groups of classified sites in order to determine diagnostic species using the JUICE package (Chytrý *et al.* 2002). Species with phi-coefficient values higher than 0.20 are considered to be diagnostic. In order to determine the dominant species, the coverage index (Ic) according to Lausi *et al.* (1982) was calculated. Species with an Ic value higher than 40 on the association level are accepted as being dominant. Species recorded in a minimum of 60% of relevés within the association are considered to be constant.

Characteristic species of class, order, and alliances follow Kuzmanović *et al.* (2016). The nomenclature of high-rank syntaxa of potential forest vegetation for habitats of the studied dry grassland associations follows Mucina *et al.* (2016).

Syntaxonomical scheme of studied associations

Festuco-Brometea Br.-Bl. et Tx. ex Soó 1947
Halacsyetalia sendtneri Ritter-Studnička 1970

Potentillion visianii Ritter-Studnička 1970

1. *Artemisio albae-Achnatheretum calamagrostis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014
2. *Artemisio albae-Silenetum armeriae* D. Lakušić et Kabaš in Aćić et al. 2014
3. *Carici kitaibelianae-Euphorbietum glabriflorae* D. Lakušić et Kuzmanović *ass. nov. hoc loco*
4. *Festuco pancicianae-Caricetum humilis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014
5. *Potentillo tommasinianae-Festucetum pancicianae* D. Lakušić et Kabaš in Aćić et al. 2014
6. *Seslerio serbicae-Caricetum humilis* D. Lakušić et Kabaš in Aćić et al. 2014

Centaureo kosaninii-Bromion fibrosi Blečić *et al.* 1969

7. *Centaureo kosaninii-Euphorbietum glabriflorae* S. Jovanović et V. Stevanović in Aćić et al. 2014

RESULTS

Classification of studied syntaxa. The results of cluster analysis showed that almost all the analysed associations appeared as "floristically homogeneous and well-characterised groups" (Fig. 1). The only exception is *Hyperico barbati-Euphorbietum glabriflorae*, whose stands from different localities (subalpine belt of Mt. Kopaonik in North Kosovo and montane belt of Mt. Goleš in Central Kosovo) formed two distinct clusters, allowing us to accept the opinion of Kuzmanović *et al.* (2016) that relevés from Mt. Kopaonik belong to a new association, viz., *Carici kitaibelianae–Euphorbietum glabriflorae* (Table 5).

The other six poorly known serpentine dry grassland associations recently validated by Aćić *et al.* (2014) were well separated and completely distinct within this heterogeneous group in the cluster analysis. They can therefore be accepted as well-defined associations.

Syntaxonomy and phytocoenological adjustments

1. Artemisio albae-Achnatheretum calamagrostis Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014 (Table 3)

Syn.: *Artemisio-Achnatheretum calamagrostis* Jovanović-Dunjić et S. Jovanović 1987 nom. nud.

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia, Mt. Kopaonik, Rajićeva Gora, 43.34 N, 20.94 E

(authors of relevés R. Jovanović-Dunjić and S. Jovanović, date 27.06.1984)

Diagnostic species: *Achnatherum calamagrostis, Alyssum murale, Artemisia alba, Phleum phleoides*, and *Teucrium montanum.*

Constant species: *Achnatherum calamagrostis, Acinos alpinus, Alyssum murale, Artemisia alba, Asperula purpurea, Bromus erectus, Danthonia alpina, Dorycnium pentaphyllum* subsp. *germanicum, Juniperus oxycedrus, Koeleria splendens, Leontodon crispus, Melica ciliata, Phleum phleoides, Sanguisorba minor, Stachys recta, Teucrium montanum, Thymus jankae*, and *Vincetoxicum hirundinaria.*

Dominant species: *Achnatherum calamagrostis* and *Artemisia alba.*

Extended diagnosis: The *Artemisio albae-Achnatheretum calamagrostis* is secondary rocky grassland developed mostly on southern and southeastern exposed slopes with an inclination of about 40-70° at altitudes between 700 and 1100 m a.s.l. In the five relevés representing this community, 65 species were recorded, with an average of 26 species per relevé and total cover between 35 and 60% of the relevé area. This association is developed in a humid moderately continental climate (subtype 2.1 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. Potential vegetation of zonal Dinaric forests of Turkey oak (*Quercus cerris*) and forests of Hungarian oak (*Quercus frainetto*) and Turkey oak (*Quercus cerris*) is determined by these climatic conditions and the geographic position (Fukarek & Jovanović 1983). According to Horvat *et al.* (1974), the surrounding landscape belongs to the vegetation subzone of Balkan oak forests from the *Quercion frainetto* Horvat 1954. The stands of this open rocky grassland represent a degradation stage of oro-pedo-climatically conditioned azonal pine forests (Fig. 2) on a serpentine substrate (*Pinetum sylvestris-nigrae* Pavlović 1951, *Seslerio serbicae-Pinetum* Ritter-Studnička

Table 3. Analytical table of the association ***Artemisio albae-Achnatheretum calamagrostis*** Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1**: Serbia, Mt. Goč (Mitrovo Polje), 43.50 N, 20.88 E; **2-3**: Serbia, Mt. Kopaonik (Vlajkovci), 43.34 N, 20.94 E; **4-5**: Serbia, Mt. Kopaonik (Rajićeva Gora), 43.17 N, 20.89 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)								
		Altitude (m)	700	750	750	1100	1100		
		Exposition	S	SE	SE	SE	S		
		Slope (°)	40-50	70	70	40	70		
		Cover (%)	35-45	50	40	60	35-40	Frequency (%)	Cover index according to Lausi (Ic)
		Plot size (m^2)	100	100	100	100	100		
		No. of species per relevé	25	36	30	16	25		
		No. Relevé	1	2	3	4	5*		
F-B	Dg	Artemisia alba	2,2	3,3	2,2	2,2	1,2	100	55,56
	Dg	Achnatherum calamagrostis	2,2	1,2	1,2	2,2	2,2	100	46,67
F-B	Dg	Alyssum murale	+.1	1.1	1,1	2,1	+.2	100	33,33
F-B		Teucrium montanum	1.1	+.1	+	+.1	+.2	100	24,44
F-B		Thymus jankae	+.1	+	+	+.1	+	100	22,22
F-B		Melica ciliata subsp. ciliata	2,1	+	1,1	+.1	.	80	26,67
F-B		Asperula purpurea	+.1	.	+	1.2	+	80	20,00
F-B		Acinos alpinus subsp. alpinus	.	+.1	+	+	+	80	17,78
		Juniperus oxycedrus subsp. oxycedrus	+	+	+	.	+	80	17,78
F-B		Sanguisorba minor subsp. minor	+	+	.	+.1	+	80	17,78
F-B		Dorycnium pentaphyllum subsp. germanicum	1.1	.	.	1,1	1,2	60	20,00
		Bromus erectus	+.1	1.1	1,1	.	.	60	17,78
K-C		Koeleria splendens	+.1	1,1	+	.	.	60	15,56
F-B		Danthonia alpina	+	.	+	.	+	60	13,33
F-B		Leontodon crispus subsp. crispus	.	+	+	.	+	60	13,33
	Dg	Phleum phleoides	+	+	+	.	.	60	13,33
		Stachys recta agg.	+	+	+.1	.	.	60	13,33
F-B		Vincetoxicum hirundinaria	+	+	+	.	.	60	13,33
F-B		Astragalus onobrychis	1.1	1,1	.	.	.	40	13,33
Hal		Bromus fibrosus	.	.	.	1.1	1,1	40	13,33
Hal		Euphorbia glabriflora	.	1,2	.	.	+.2	40	11,11
		Festuca rupicola subsp. rupicola	.	1,1	+	.	.	40	11,11
		Asplenium adianthum-nigrum	.	+	+	.	.	40	8,89
F-B		Centaurea biebersteinii subsp. biebersteinii	.	+	+	.	.	40	8,89
		Dichanthium ischaemum	.	+	+	.	.	40	8,89
	Dg	Euphrasia rostkoviana subsp. rostkoviana	.	+	+	.	.	40	8,89
		Hieracium praealtum subsp. bauhinii	.	+	+	.	.	40	8,89
		Hieracium sp.	.	.	.	+	+	40	8,89
Hal		Potentilla visianii	.	+	+.2	.	.	40	8,89
		Rosa pendulina	+	.	.	.	+	40	8,89
K-C		Rumex acetosella subsp. acetosella	.	+	.	.	+	40	8,89
		Sedum hispanicum	.	+	+	.	.	40	8,89
	Dg	Silene italica subsp. italica	+	.	.	+.1	.	40	8,89
	Dg	Teucrium chamaedrys	+	+	.	.	.	40	8,89
F-B		Carex humilis	.	.	.	1.1	.	20	6,67

	No. Relevé	1	2	3	4	5*		
F-B	Aethionema saxatile subsp. saxatile	.	.	.	.	+	20	4,44
F-B	Allium flavum	.	+	.	.	.	20	4,44
	Anchusa sp.	+	.	.	.	.	20	4,44
	Arenaria sp.	.	.	+	.	.	20	4,44
	Campanula cervicaria	.	.	+	.	.	20	4,44
	Carduus hamulosus subsp. hamulosus	.	.	.	.	+	20	4,44
	Carthamus lanatus subsp. lanatus	+	.	.	.	.	20	4,44
F-B	Chrysopogon gryllus	+.1	.	.	.	.	20	4,44
	Dianthus sp.	.	.	.	.	+	20	4,44
F-B	Festuca panciciana	.	.	.	.	+.1	20	4,44
	Fraxinus ornus	.	.	+	.	.	20	4,44
	Galium album	+	.	.	.	.	20	4,44
	Galium flavescens	.	.	+.1	.	.	20	4,44
	Galium sp.	.	+	.	.	.	20	4,44
	Genista pilosa	.	.	+	.	.	20	4,44
	Hieracium piloselloides subsp. piloselloides	.	.	.	.	+	20	4,44
	Hippocrepis sp.	+	.	.	.	.	20	4,44
	Koeleria pyramidata	.	.	.	.	+	20	4,44
	Polygala major	.	.	.	+	.	20	4,44
	Psilurus incurvus	.	.	.	.	+	20	4,44
	Pyrus pyraster	.	.	+	.	.	20	4,44
	Scorzonera laciniata	.	+	.	.	.	20	4,44
K-C	Sideritis montana subsp. montana	.	+	.	.	.	20	4,44
	Silene armeria	.	+	.	.	.	20	4,44
	Silene flavescens	.	+	.	.	.	20	4,44
	Stachys sp.	.	+	.	.	.	20	4,44
P_vis	Stipa novakii	.	.	.	+	.	20	4,44
	Thesium bavarum	.	.	.	.	+	20	4,44
	Verbascum nigrum subsp. nigrum	.	+	.	.	.	20	4,44
	Vulpia sp.	.	+	.	.	.	20	4,44

1970, *Erico-Pinetum gocensis* Krause 1957, and *Euphorbio glabriflorae-Pinetum* B. Jovanović 1972, included in *Erico-Fraxinion orni* Horvat 1959). These warm serpentine rocky grounds and steep slopes provide suitable conditions for xerophilous taxa (representatives of Pontic, Pontic—sub-Mediterranean, or Mediterranean—sub-Mediterranean area types) like *Astragalus onobrychis*, *Carex humilis*, *Chrysopogon gryllus*, *Stipa novakii, Teucrium chamaedrys*, etc. The association is particulary characterised by numerous Balkan endemic species such as the xerophilous grasses *Festuca panciciana* and *Stipa novakii*, as well as by the taxa *Euphorbia glabriflora, Potentilla visianii*, *Scrophularia canina* subsp. *tristis*, *Silene flavescens*, and *Thymus jankae*. Apart from the locus classicus at Rajićeva Gora, stands of this association have been registered in the environs of Vlajkovci on Mt. Kopaonik and Mitrovo Polje on Mt. Goč.

2. Artemisio albae-Silenetum armeriae D. Lakušić et Kabaš in Aćić et al. 2014 (Table 4, Fig. 3D)

Syn.: *Artemisio-Silenetum armeriae* D. Lakušić 1989 nom. nud.

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia, Mt. Kopaonik, Vlajkovci, 43.34 N, 20.94 E

(author of relevés: 1-13: Mt. Kopaonik: D. Lakušić, date 04.07.1989, 18.06.2016; 15-16: Mt. Tara: Kabaš, E., date 08.07.2016)

Diagnostic taxa: *Acinos alpinus* subsp. *alpinus, Centaurea rhenana, Galium corrudifolium*, and *Silene armeria.*

Constant taxa: *Acinos alpinus* subsp. *alpinus, Alyssum murale, Artemisia alba, Astragalus onobrychis, Festuca panciciana, Galium corrudifolium, Melica*

Fig. 2. The eastern slopes of Mt. Kopaonik with dominance of secondary open rocky grassland developed on the sites of oro-pedo-climatically conditioned azonal pine forests on an ultrabasic serpentine substrate (*Pinetum sylvestris-nigrae*, *Seslerio serbicae-Pinetum, Erico-Pinetum*, and *Euphorbio glabriflorae-Pinetum*). In the foreground is the summer aspect of the association *Festuco pancicianae-Caricetum humilis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014 (photo: D. Lakušić)

ciliata, *Petrorhagia saxifraga, Sedum acre*, and *Silene armeria*.

Dominant species: *Artemisia alba* and *Silene armeria*.

Extended diagnosis: The *Artemisio albae-Silenetum armeriae* is secondary rocky grassland developed on southwestern exposed slopes with an inclination of between 30 and 70° at altitudes between 640 and 990 m a.s.l. The very poorly developed thin pioneer soil layer results in relatively low plant diversity. In the 16 relevés representing this community, only 48 species were found, with total cover of between 40 and 80% of the relevé area. The average number of species per relevé is 15. This association is developed in a humid moderately continental climate (subtype 2.1 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. The surrounding landscape belongs to the vegetation subzone of Balkan oak forests (*Quercion frainetto*) (Horvat *et al*. 1974). The stands of this open rocky grassland represent some of the final degradation stages of relict *Pinus nigra* forests on ultramafic substrates of the Dinarides (*Erico-Fraxinion orni* Horvat 1959) and thermophilous montane oak forests of the Central Balkans (*Quercion petraeo-cerridis* Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015). In keeping with the relatively low plant diversity, only five Balkan endemic species are present in this community (*Festuca panciciana, Linaria rubioides, Potentilla visianii, Sedum serpentini*, and *Stachys scardica*). However, despite the relatively low diversity, those habitats are important in terms of both survival and successful development of numerous xerophilous Pontic or Mediterranean elements like *Astragalus onobrychis*, *Arenaria serpyllifolia* subsp. *leptoclados*, *Centaurea rhenana* subsp. *rhenana*, *Cytisus procumbens* var. *petrovicii*, *Koeleria pyramidata*, *Petrorhagia saxifraga, Silene otites*, etc.

3. Carici kitaibelianae–Euphorbietum glabriflorae D. Lakušić et Kuzmanović *ass. nov. hoc loco* (Table 5)

= *Hyperico-Euphorbietum glabriflorae* Rexhepi et al. 1978 in Ranđelović et al. (1979)

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Holotypus: rel. 2, Table 8 in Ranđelović *et al*. (1979: 988-989)

Locus classicus: Serbia (Kosovo), Mt. Kopaonik, Barelj; 42.97 N, 21.01 E

(author of relevés unknown)

Diagnostic species: *Armeria rumelica, Carex kitaibeliana, Carlina acaulis, Centaurea napulifera, Euphrasia salisburgensis, Genista depressa, Jovibarba heuffelii*, and *Thesium alpinum*.

Constant taxa: *Asperula cynanchica, Alyssum markgrafii, Anthyllis vulneraria, Armeria rumelica, Bromus fibrosus, Carex kitaibeliana, Centaurea biebersteinii, Dorycnium pentaphyllum* subsp. *germanicum, Euphorbia glabriflora, Euphrasia salisburgensis, Genista depressa, Hypericum barbatum, Jovibarba heuffelii, Plantago holosteum, Poa badensis, Potentilla australis, Scabiosa columbaria, Sedum serpentini, Teucrium montanum*, and *Thymus longicaulis*.

Dominant taxa: *Carex kitaibeliana, Dorycnium pentaphyllum* subsp. *germanicum, Euphorbia glabriflora*, and *Plantago holosteum*.

Diagnosis: The *Carici kitaibelianae-Euphorbietum glabriflorae* is developed on serpentine bedrock over which skeletal rendzina soil types occur, most often on southeastern (rarely on eastern or northeastern) slopes at altitudes between 1400 and 1500 m a.s.l. The total number of recorded taxa in five relevés was 50, with 26 being the average number of taxa per relevé area. Within the association, there was a prevalence of thermophilous *Festuco-Brometea* species such as *Asperula cynanchica*, *Centaurea biebersteinii* subsp. *biebersteinii*, *Dorycnium*

Table 4. Analytical table of the association ***Artemisio albae-Silenetum armeriae*** D. Lakušić et Kabaš in Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi*, **F-B** = *Festuco-Brometea*, **Hal** = *Halacsyetalia sendtneri*, **K-C**= *Koelerio-Corynephoretea*, **P_vis** = *Potentillion visianii*). Relevés: **1-14**: Serbia, Mt. Kopaonik (Vlajkovci), 43.34 N, 20.94 E; **15-16**: Serbia, Mt. Tara (Zaovine), 43.89 N, 19.42 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)	Altitude (m)	640	640	640	640	640	640	640	640	660	660	670	670	670	640	983	983	Frequency (%)	Cover index according to Lausi (Ic)
		Exposition	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SE	SE		
		Slope (°)	40	40	40	40	40	40	40	40	20-30	40	10-30	10	30-60	10-30	70	70		
		Cover (%)	50	80	80	50	40	80	40	40	65	80	60	70	60	60	80	80		
		Plot size (m^2)	25	25	25	25	25	25	25	25	25	20	16	25	16	16	25	25		
		No. of species per relevé	16	17	13	12	12	14	12	11	22	12	17	15	12	19	10	10		
		No. Relevé	1	2*	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
	Dg	Silene armeria	3,4	4,5	4,4	3,4	2,3	5,5	2,3	3,4	2,3	2,4	2,4	2,2	2,3	2,3	2,2	2,3	100	66,67
F-B		Artemisia alba	1,2	1,2	1,2	1,2	.	1,2	1,2	2,3	3,3	3,4	3,4	3,3	2,3	2,3	.	.	81	42,36
F-B		Melica ciliata subsp. ciliata	1,2	.	1,2	.	1,2	1,2	1,2	.	2,2	1,3	2,2	1,2	1,1	1,2	3,3	3,3	81	35,42
F-B		Festuca panciciana	.	1,1	1,2	1,1	1,1	1,2	1,2	1,2	2,3	2,2	1,2	1,2	1,3	1,3	.	.	81	29,86
F-B		Alyssum murale	1,2	2,2	1,2	2,2	2,3	1,3	1,3	1,1	.	.	.	1,2	.	1,2	.	.	63	25,00
	Dg	Galium corrudifolium	1,2	1,2	.	.	1,2	1,1	.	.	1,2	1,2	1,3	1,1	1,2	1,2	.	.	63	20,83
K-C		Petrorhagia saxifraga	1,1	+	.	1,1	1,1	1,1	1,1	1,1	1,1	1,1	.	.	.	1,1	.	.	63	20,35
F-B		Astragalus onobrychis	1,2	+	1,1	.	.	1,2	1,1	.	1,3	1,2	1,2	1,2	.	1,2	.	.	63	20,14
K-C		Sedum acre	+	1,1	1,1	1,1	1,1	1,1	1,2	.	.	.	1,2	.	1,1	1,2	.	.	63	20,14
F-B	Dg	Acinos alpinus subsp. alpinus	1,2	1,2	1,2	1,2	1,1	.	1,2	1,2	1,2	.	.	.	.	1,2	.	.	63	18,75
		Stachys recta agg.	+	1,1	.	1,1	1,1	.	.	.	1,1	1,1	+	1,1	1,1	.	.	.	56	17,36
F-B		Allium flavum	2,2	1,1	1,1	1,1	1,1	1,1	1,1	1,1	.	.	.	.	.	.	.	.	50	18,06
Hal		Euphorbia glabriflora	.	.	.	.	.	.	.	.	3,4	3,4	2,3	3,3	1,2	.	1,2	1,2	44	24,31
Hal		Sedum serpentini	.	1,1	1,1	1,1	1,1	1,1	1,1	1,2	.	.	.	.	.	.	.	.	44	14,58
	Dg	Centaurea rhenana subsp. rhenana	1,1	1,1	.	1,1	.	.	1,1	1,1	.	.	.	.	.	1,1	.	.	38	12,50
K-C		Rumex acetosella subsp. acetosella	+	.	1,1	.	.	.	.	1,1	.	.	+	1,1	.	1,1	.	.	38	11,11
Hal		Bromus fibrosus	.	.	.	.	.	.	.	.	2,3	.	1,2	1,3	1,2	1,1	.	.	31	11,81
K-C		Trifolium arvense	1,1	1,1	1,1	.	.	.	.	.	.	.	.	.	.	1,1	.	.	25	8,33
K-C		Arenaria serpyllifolia subsp. leptoclados	.	.	.	.	.	.	.	.	+	.	1,1	1,1	.	+	.	.	25	6,94
		Asplenium ruta-muraria subsp. ruta-muraria	1,2	.	.	1,1	.	.	.	.	.	.	.	.	+	.	.	.	25	5,56

	Verbascum sp.	.	.	.	.	.	.	.	.	+	.	+	.	+	+	.	.	25	5,56
Hal	Potentilla visianii	.	.	.	.	.	.	.	.	2,2	2,2	1,1	.	.	.	.	.	19	9,03
	Alyssum repens	.	.	1,2	.	.	.	.	.	.	1,2	1,3	.	.	.	.	.	19	6,25
	Cytisus procumbens var. petrovicii	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1,1	1,1	19	5,56
	Leontodon hispidus subsp. hispidus	.	1,1	.	.	.	.	.	.	1,1	.	.	.	.	+	.	.	19	5,56
	Lactuca saligna	+	.	.	.	.	+	.	1,1	.	.	.	.	.	.	.	.	19	4,86
F-B	Dorycnium pentaphyllum subsp. germanicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2,2	1,2	13	5,56
	Koeleria pyramidata	.	.	.	.	.	.	.	.	1,1	.	.	1,2	.	.	.	.	13	4,17
Hal	Stachys scardica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,1	1,1	13	4,17
	Thymus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,2	1,1	13	4,17
Hal	Silene paradoxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,1	+	13	3,47
F-B	Teucrium montanum	.	.	.	.	.	.	.	.	1,2	.	.	+	.	.	.	.	13	3,47
F-B	Vincetoxicum fuscatum	.	.	.	.	.	.	.	.	1,1	.	.	.	.	+	.	.	13	3,47
F-B	Aethionema saxatile	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	13	2,78
	Achnatherum calamagrostis	.	.	.	.	.	.	.	.	1,2	.	.	.	.	.	.	.	6	2,08
P_vis	Linaria rubioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,1	.	6	2,08
	Phleum sp.	.	.	.	.	.	.	.	.	.	1,2	.	.	.	.	.	.	6	2,08
	Pinus nigra subsp. nigra	.	.	.	.	.	1,2	.	.	.	.	.	.	.	.	.	.	6	2,08
	Campanula patula subsp. patula	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	1,39
	Dianthus sp.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	6	1,39
	Euphrasia stricta	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	6	1,39
	Hieracium pilosella	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	6	1,39
	Orobanche minor	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	6	1,39
F-B	Sanguisorba minor subsp. minor	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	6	1,39
	Silene otites	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	6	1,39
	Taraxacum sp.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	6	1,39
	Viola arvensis	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	6	1,39
	Viola odorata	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	1,39

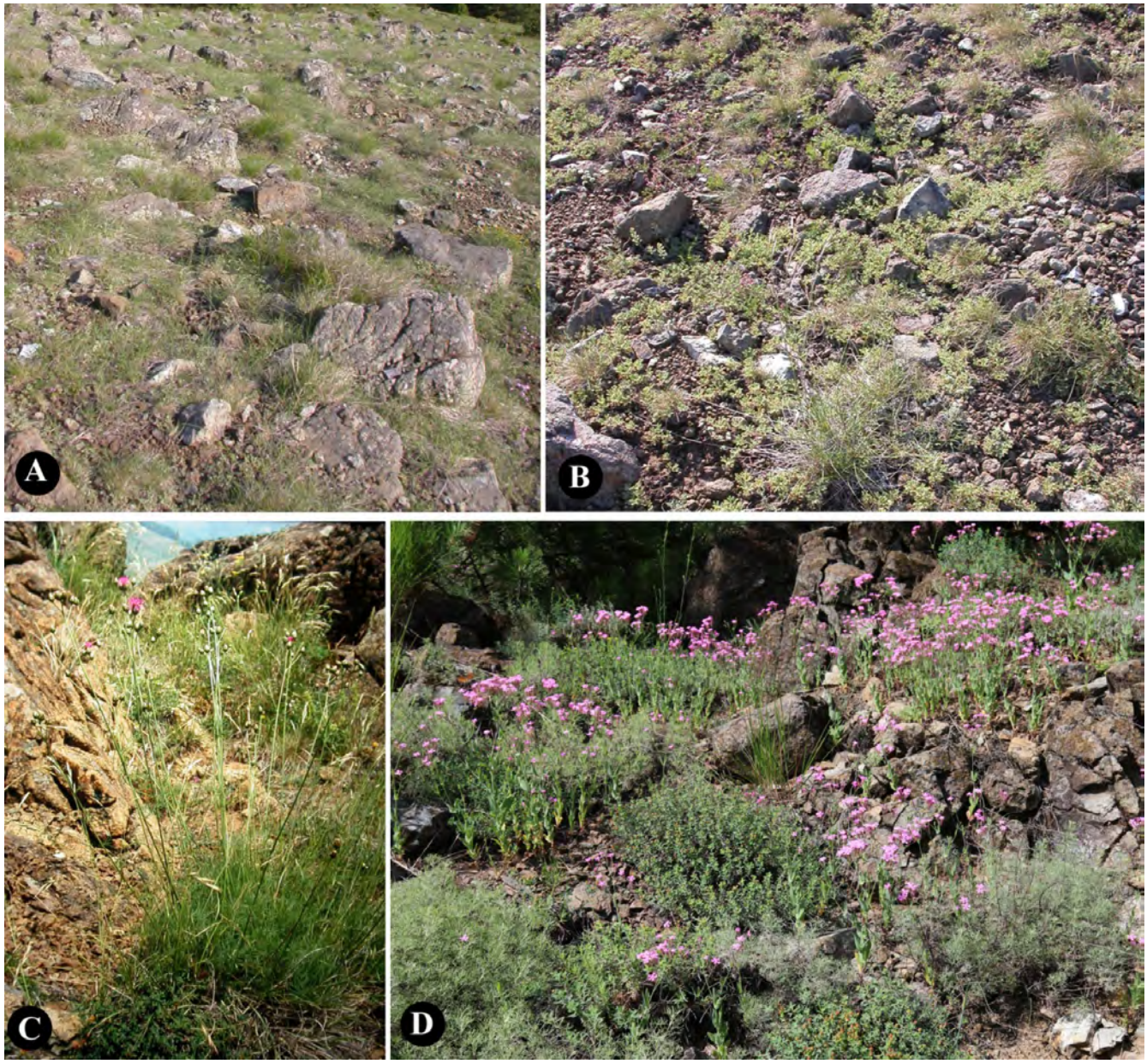

Fig. 3. Summer aspect of the associations (A) *Festuco pancicianae-Caricetum humilis*, (B) *Potentillo tommasinianae-Festucetum pancicianae*, (C) *Centaureo kosaninii-Euphorbietum glabriflorae*, and (D) *Artemisio albae-Silenetum armeriae* (photos A, B & D: D. Lakušić, photo C: S. Jovanović).

pentaphyllum subsp. *germanicum, Teucrium montatnum*, etc., as well as diagnostic species of the order *Halascyetalia sendtneri* (Table 4). Secondary stands of this association are developed within subalpine beech forests (*Fagion sylvaticae* Luquet 1926). However, no woody species were recorded, and only *Juniperus oxycedrus* was present in the shrub layer in several stands, indicating that progressive succession could continue in the direction of re-establishment of beech forests. The stands of associations of this type probably represent some of the final stages of degradation of these climatogenic forests. It should also be noted that within the stands, characteristic elements of the class *Elyno-Seslerietea* occurred as well (e.g., *Carex kitaibeliana* and *Euphrasia salisburgensis*). As the stands of this association are developed in the subalpine belt, it might be the case that after comparisons with similar syntaxa (developing in the subalpine and alpine belts) this association will have more in common with alpine grasslands of the aforementioned class. The stands of this association are developed in a continental mountain climate (subtype 4.2 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. The association is particulary characterised by numerous

Balkan endemic taxa such as *Alyssum markgrafii, Armeria rumelica, Cerastium decalvans* subsp. *leontopodium, Euphorbia glabriflora, Linum tauricum* subsp. *serbicum, Sedum serpentini, Stachys scardica*, and *Stipa novakii*. In addition to the aforementioned thermophilous taxa from the *Festuco-Brometea* class, due to the xeric habitat conditions usually found on skeletal soils, there are also some xerophilous Pontic or Mediterranean elements like *Carex caryophyllea, Trifolium alpestre*, etc.

Note: The relevés on the basis of which we have described the new association *Carici kitaibelianae–Euphorbietum glabriflorae* were published in Ranđelović *et al.* (1979: Table 8). These relevés were originally classified as part of the association *Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014, whose description is based on relevés from Mt. Goleš and Mt. Koznica in Central Kosovo (Rexhepi 1978).

The specificity of Ass. *Carici kitaibelianae-Euphorbietum glabriflorae,* revealed in our numerical analyses (Fig. 1) and previously indicated in a synoptic table for syntaxa of steppe-like vegetation on shallow ultramafic soils in the Balkans included in the order *Halacsyetalia sendtneri* (Kuzmanović *et al.* 2016: Supplement S1), is unquestionably the result of significant differences of climatic conditions between subalpine stands on Mt. Barelj and montane stands on Mt. Goleš. To be specific, while the stands of *Carici kitaibelianae-Euphorbietum glabriflorae* are developed in a continental mountain climate (subtype 4.2 *sensu* Stevanović & Stevanović 1995), the stands of *Hyperico barbati-Euphorbietum glabriflorae* occur in a climate transitional between humid sub-Mediterranean and moderately continental (subtype 1.2./2.1 *sensu* Stevanović & Stevanović 1995).

Table 5. Analytical table of the association ***Carici kitaibelianae-Euphorbietum glabriflorae*** D. Lakušić et Kuzmanović in S. Jovanović et al. 2017 *ass. nov. hoc.* Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1-5**: Serbia (Kosovo), Mt. Kopaonik (Barelj), 42.97 N, 21.01 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)								Frequency (%)	Cover index according to Lausi (Ic)
		Altitude (m)	1460	1480	1500	1500	1500			
		Exposition	SE	SE	E	SE	NE			
		Slope (°)								
		Cover (%)								
		Plot size (m^2)								
		No. of species per relevé	22	27	27	28	24			
		No. Relevé	1	2	3	4	5			
	Dg.	Carex kitaibeliana	2,2	3,2	3,2	3,2	1,2		100	64,44
Hal		Euphorbia glabriflora	2.2	2.2	2.2	3.3	3.2		100	64,44
F-B		Dorycnium pentaphyllum subsp. germanicum	1.2	1.2	1.2	2.2	3.2		100	46,67
K-C		Plantago holosteum	1.1	1.1	1.2	3.2	2.1		100	46,67
Hal		Sedum serpentini	1.2	1.2	1.2	2.2	1.2		100	37,78
Hal		Alyssum markgrafii	1.2	+	1.2	+.2	2.2		100	33,33
K-C		Poa badensis agg.	1.2	1.2	1.2	1.2	1.2		100	33,33
		Potentilla australis	1.1	+	1.1	1.1	+		100	28,89
F-B		Asperula cynanchica	+	1.2	1.2	+	+		100	26,67
F-B		Thymus longicaulis	1.2	+.2	1.2	+.2	+.2		100	26,67
	Dg.	Jovibarba heuffelii	1.2	1.2	.	2.2	2.2		80	35,56
F-B		Centaurea biebersteinii subsp. biebersteinii	+	.	+	+	+		80	17,78
F-B		Teucrium montanum	+.2	+.2	+.2	.	+		80	17,78
F-B		Scabiosa columbaria agg.	1.1	.	1.1	.	1.1		60	20,00
Hal		Bromus fibrosus	1.2	+.2	+.2	.	.		60	15,56
		Anthyllis vulneraria agg.	.	+	+	+	.		60	13,33
F-B		Hypericum barbatum	+	.	+	+	.		60	13,33
	Dg.	Armeria rumelica	+	.	+	.	+		60	13,33
	Dg.	Euphrasia salisburgensis	.	+	.	+	+		60	13,33
	Dg.	Genista depressa	+	+	.	.	+		60	13,33

		No. Relevé	1	2	3	4	5		
F-B		Carex caryophyllea	1.2	.	.	1.2	.	40	13,33
F-B		Hieracium pavichii	1.1	.	.	1.1	.	40	13,33
	Dg.	Carlina acaulis	.	+	.	+	.	40	8,89
	Dg.	Centaurea napulifera	.	.	+	.	+	40	8,89
F-B		Acinos alpinus	.	+	.	+	.	40	8,89
		Cerastium decalvans subsp. leontopodium	.	+.2	.	+	.	40	8,89
		Dianthus sylvestris agg.	.	+	.	+	.	40	8,89
		Hypericum richeri subsp. grisebachii	.	+	+	.	.	40	8,89
Hal		Linum tauricum subsp. serbicum	.	.	+	.	+	40	8,89
F-B		Minuartia verna agg.	.	.	+	+	.	40	8,89
		Scorzonera purpurea subsp. rosea	.	.	.	+	+	40	8,89
Hal		Silene paradoxa	.	+	.	+	.	40	8,89
Hal		Stachys scardica	.	.	+	+	.	40	8,89
P_vis		Stipa novakii	.	+.2	.	+.2	.	40	8,89
	Dg.	Thesium alpinum	.	+	+	.	.	40	8,89
		Agrostis capillaris	+	.	.	.	.	20	4,44
		Alyssum repens	.	.	+	.	.	20	4,44
		Anthoxanthum odoratum	.	.	.	+	.	20	4,44
		Danthonia alpina	.	.	+.2	.	.	20	4,44
		Helianthemum nummularium	.	.	.	+	.	20	4,44
		Juniperus oxycedrus	.	.	.	.	+	20	4,44
		Linum hologynum	.	.	.	.	+	20	4,44
F-B		Lotus corniculatus	.	.	.	.	+	20	4,44
		Melica transsilvanica	.	+	.	.	.	20	4,44
		Plantago lanceolata	.	+	.	.	.	20	4,44
K-C		Potentilla pedata	+	.	.	.	.	20	4,44
		Rosa pimpinellifolia	.	.	+	.	.	20	4,44
K-C		Rumex acetosella	.	.	.	.	+	20	4,44
F-B		Sanguisorba minor agg.	.	+	.	.	.	20	4,44
		Trifolium alpestre	.	.	+	.	.	20	4,44

4. Festuco pancicianae-Caricetum humilis Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014 (Table 6, Fig. 3A)

Syn.: *Carici humilis-Festucetum pancicianae* Jovanović-Dunjić et S. Jovanović 1987 nom. nud.

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia, Mt. Kopaonik, Rajićeva Gora, 43.17 N, 20.89 E

(authors of relevé R. Jovanović-Dunjić and S. Jovanović, date 27.06.1984)

Diagnostic species: *Bromus pannonicus, Carex humilis, Carex montana, Hieracium piloselloides*, and *Orobanche teucrii.*

Constant taxa: *Acinos alpinus, Alyssum murale, Artemisia alba, Asperula purpurea, Bromus fibrosus, Bromus pannonicus, Carex humilis, Carex montana, Centaurea biebersteinii, Dorycnium pentaphyllum* subsp. *germanicum, Festuca panciciana, Juniperus oxycedrus, Koeleria pyramidata, Leontodon crispus, Minuartia verna, Orobanche teucrii, Potentilla heptaphylla, Rumex acetosella, Sanguisorba minor, Scabiosa columbaria, Teucrium montanum, Thymus jankae*, and *Veronica austriaca.*

Dominant taxa: *Carex humilis* and *Dorycnium pentaphyllum* subsp. *germanicum.*

Extended diagnosis: The *Festuco pancicianae-Caricetum humilis* is secondary rocky grassland developed mostly on southern exposed serpentine slopes with inclination ranging from 30° to even 60° at altitudes of about 1200 m a.s.l. The total number of species recorded in five relevés representing this community is 52, with an average of 28 species per relevé. The stands of this association can be said to be richly

developed, since the species cover 60-90% of the relevé area. They occur in a humid moderately continental climate (subtype 2.1 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. Potential vegetation of zonal mountain beech forests (*Fagus moesica*) is determined by these climatic conditions and the geographic location (Fukarek & Jovanović 1983). According to Horvat *et al*. (1974), the surrounding landscape belongs to the vegetation subzone of Moesic beech forests from the alliance *Fagion moesiacae* Blečić & R. Lakušić 1976. The stands of this open rocky grassland represent a degradation stage of relict *Pinus nigra* forests on ultramafic substrates of the Dinarides (*Erico-Fraxinion orni* Horvat 1959; Mucina *et al*. 2016). Those warm serpentine rocky grounds and steep slopes, in addition to the presence of heavily eroded dry soils, made possible the occurrence of numerous xerophilous Pontic or Mediterranean elements like *Bromus pannonicus* subsp. *pannonicus*, *Brachypodium pinnatum, Carex humilis*, *Carduus hamulosus*, *Koeleria pyramidata*, *Stipa pulcherrima, Veronica austriaca*, etc. The association is particulary characterised by many Balkan endemic species such as the constant xerophilous grass *Festuca panciciana*, as well as by the species *Euphorbia glabriflora, Potentilla visianii*, *Silene flavescens*, *Thymus jankae*, and *Viola kopaonikensis*.

5. Potentilo tommasinianae-Festucetum pancicianae D. Lakušić et Kabaš in Aćić et al. 2014 (Table 7, Fig. 3B)

Syn.: *Potentilo tommasinianae-Festucetum pancicianae* D. Lakušić 1989 nom. nud.

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia, Mt. Kopaonik, Krmeljica, 43.26 N, 20.74 E

(author of relevés D. Lakušić, date 04.07.1989)

Diagnostic taxa: *Centaurea calvescens, Euphorbia esula* subsp. *tommasiniana, Fallopia convolvulus, Festuca panciciana, Paronychia kapela*, and *Potentilla tommasiniana*.

Constant species: *Alyssum montanum, Artemisia alba, Astragalus onobrychis, Bromus fibrosus, Carex humilis, Festuca panciciana, Leontodon crispus, Medicago prostrata, Paronychia kapela, Plantago holosteum, Potentilla tommasiniana, Teucrium montanum*, and *Thymus jankae*.

Dominant species: *Carex humilis, Festuca panciciana*, and *Potentilla tommasiniana*.

Extended diagnosis: The *Potentillo tommasinianae-Festucetum pancicianae* is secondary rocky grassland developed mostly on southern and southeastern exposed slopes with an inclination of 0-35° at altitudes of about 1000-1100 m a.s.l. Rarely some stands of this community can be developed on northern and northwestern exposed slopes. The soil layer is very poorly developed and thin. This is the particular reason for the relatively low plant diversity within these habitats. In nine relevés representing this community, only 42 species were found. The average number of species per relevé was 20, with covering ranging between 40 and 80% of the relevé area. The stands of this association are developed in a humid moderately continental climate (subtype 2.1 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. Potential vegetation of zonal Dinaric forests of Turkey oak (*Quercus cerris*) is determined by these climatic conditions and the geographic location (Fukarek & Jovanović 1983). According to Horvat *et al*. (1974), the surrounding landscape belongs to the vegetation subzone of Balkan oak forests from the alliance *Quercion frainetto.* The stands of this open rocky grassland represent a degradation stage of relict *Pinus nigra* forests on ultramafic substrates of the Dinarides (*Erico-Fraxinion orni* Horvat 1959) and thermophilous montane oak forests of the Central Balkans (*Quercion petraeo-cerridis* Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015). Due to the specific habitat conditions (warm serpentine rocky grounds, poorly developed soils), xerophilous Pontic or Mediterranean elements like *Arenaria serpyllifolia* subsp. *leptoclados*, *Asperula cynanchica, Astragalus onobrychis*, *Carex humilis*, *Herniaria incana*, *Medicago prostrata*, *Petrorhagia saxifraga*, *Potentilla tommasiniana*, *Stipa novakii*, *Teucrium chamaedrys*, etc., are present. The association is particulary characterised by numerous Balkan endemic species such as the grasses *Festuca panciciana* and *Stipa novakii*, as well as by the taxa *Centaurea calvescens, Euphorbia glabriflora*, *Sedum serpentini*, and *Thymus jankae*.

6. Seslerio serbicae-Caricetum humilis D. Lakušić et Kabaš in Aćić et al. 2014 (Table 8)

(*Potentillion visianii*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia, Mt. Kopaonik, Kukavica, 43.33 N, 20.74 E

(author of relevés D. Lakušić, date 04.07.1989)

Diagnostic taxa: *Carex humilis, Dorycnium pentaphyllum* subsp. *germanicum, Edraianthus graminifolius, Sesleria serbica*, and *Silene parnassica* subsp. *serbica*.

Constant taxa: *Asperula cynanchica, Bromus fibrosus, Carex humilis, Dorycnium pentaphyllum* subsp. *germanicum, Minuartia verna, Plantago holosteum, Sedum serpentini*, and *Sesleria serbica*.

Dominant taxa: *Carex humilis, Dorycnium pentaphyllum* subsp. *germanicum*, and *Sesleria serbica*.

Extended diagnosis: The *Seslerio serbicae-Caricetum humilis* is secondary rocky grassland developed mostly on exposed southern or southwestern (rarely on northern or northeastern) serpentine slopes with an inclination of 30-70° at altitudes between 1500 and

Table 6. Analytical table of the association ***Festuco pancicianae-Caricetum humilis*** Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1-5**: Serbia, Mt. Kopaonik (Rajićeva Gora), 43.17 N, 20.89 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)	Altitude (m)	1150	1160	1175	1185	1200	Frequency (%)	Cover index according to Lausi (Ic)
		Exposition	SE	S	SE	S	S		
		Slope (°)	45-60	45-60	30	30	30		
		Cover (%)	60	60	90	60	60		
		Plot size (m^2)	100	100	100	100	100		
		No. of species per relevé	29	29	31	25	24		
		No. Relevé	1	2*	3	4	5		
F-B	Dg	Carex humilis	2,2	3,2	3,3	2,2	2,2	100	80,56
F-B		Dorycnium pentaphyllum subsp. germanicum	2,2	2,2	1,2	2,2	2,2	100	63,89
F-B		Festuca panciciana	1,2	2,1	1,2	+.1	1,1	100	44,44
F-B		Asperula purpurea	+	1,1	1,1	+	1,1	100	36,11
F-B		Teucrium montanum	1,1	1,1	+	+	1,1	100	36,11
F-B		Alyssum murale	+	+	+	+.1	1.1	100	30,56
Hal		Bromus fibrosus	+	+	+	+	1.1	100	30,56
F-B		Sanguisorba minor subsp. minor	+	1.1	+.1	+.1	+	100	30,56
K-C		Rumex acetosella subsp. acetosella	+	+	+	+	+	100	27,78
F-B		Artemisia alba	+	+.1	.	2,1	1,2	80	33,33
Hal	Dg	Bromus pannonicus subsp. pannonicus	+	+	1.1	1.1	.	80	27,78
F-B		Thymus jankae	+	1,1	+	+	.	80	25,00
F-B		Acinos alpinussubsp. alpinus	+	+	.	+	+	80	22,22
		Juniperus oxycedrus subsp. oxycedrus	+	+	+	+	.	80	22,22
	Dg	Orobanche teucrii	.	+	+	+	+	80	22,22
F-B		Scabiosa columbaria agg.	+	+	+	.	+	80	22,22
		Potentilla heptaphylla	+.1	+	1.1	.	.	60	19,44
	Dg	Carex montana	+.1	+	+	.	.	60	16,67
F-B		Centaurea biebersteinii subsp. biebersteinii	.	+	+	.	+	60	16,67
		Koeleria pyramidata	+	+.1	+	.	.	60	16,67
F-B		Leontodon crispus subsp. crispus	+	.	.	+	+	60	16,67
F-B		Minuartia verna agg.	+	+	+	.	.	60	16,67
		Veronica austriaca subsp. austriaca	+	+	+	.	.	60	16,67
Hal		Euphorbia glabriflora	.	.	.	2,3	1,2	40	22,22
K-C		Plantago holosteum	+	.	1,1	.	.	40	13,89
		Stipa pulcherrima	.	.	.	1,1	+	40	13,89
		Agrostis capillaris	.	+	.	.	+	40	11,11
	Dg	Hieracium piloselloides subsp. piloselloides	.	.	+	+	.	40	11,11
F-B		Hypericum barbatum	+	.	+	.	.	40	11,11
		Hypericum richeri subsp. grisebachii	.	+	+	.	.	40	11,11
F-B		Lotus corniculatus	+	.	+	.	.	40	11,11
Hal		Potentilla visianii	+	+	.	.	.	40	11,11
F-B		Vincetoxicum hirundinaria	.	.	.	+	+	40	11,11
		Viola kopaonikensis	+	+	.	.	.	40	11,11
F-B		Danthonia alpina	.	.	1.1	.	.	20	8,33
F-B		Aethionema saxatile subsp. saxatile	.	.	.	+	.	20	5,56

	No. Relevé	1	2	3	4	5		
	Asplenium adianthum-nigrum	.	.	+	.	.	20	5,56
	Brachypodium pinnatum subsp. pinnatum	.	.	.	.	+	20	5,56
	Carduus hamulosus subsp. hamulosus	.	.	+	.	.	20	5,56
	Euphrasia pectinata	.	+	.	.	.	20	5,56
	Galium album	.	.	.	+	.	20	5,56
	Helianthemum nummularium	.	.	+.1	.	.	20	5,56
	Iris graminea	+	.	.	.	.	20	5,56
	Leontodon hispidus subsp. hispidus	.	+	.	.	.	20	5,56
	Linum catharticum	.	.	+	.	.	20	5,56
	Orobanche alba	+	.	.	.	.	20	5,56
	Phleum pratense subsp. pratense	.	.	.	+	.	20	5,56
K-C	Poa perconcinna	.	.	+	.	.	20	5,56
K-C	Scleranthus perennis subsp. perennis	.	+	.	.	.	20	5,56
	Silene flavescens	.	.	.	+	.	20	5,56
	Silene roemeri	.	.	.	.	+	20	5,56
	Thesium bavarum	+	.	.	.	.	20	5,56

1650 m a.s.l. The total number of species in the stands is 51, with an average of 17 species per relevé. The stands are relatively well developed, covering 30-80% of the relevé area. The stands of this community are developed in a continental mountain climate (subtype 4.2 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. Potential vegetation of zonal mountain beech forest (*Fagus moesica*) and common silver fir (*Abies alba*), as well as mountain forest of spruce (*Picea abies*), is determined by these climatic conditions and the geographic location (Fukarek & Jovanović 1983). According to Horvat *et al.* (1974), the surrounding landscape belongs to the vegetation subzone of Moesic beech forests from the alliance *Fagion moesiacae* and the subzone of mountain and subalpine spruce forests of the alliance *Vaccionio-Piceion*. The stands of this open rocky grassland represent a degradation stage of oro-pedo-climatically conditioned mixed forests of spruce and silver fir on ultrabasic serpentine substrates (*Erico-Abieti-Piceetum* Mišić & Popović 1960, included in *Piceion excelsae* Pawłowski et al. 1928). The association is particulary characterised by numerous Balkan endemic species such as *Cerastium decalvans* subsp. *leontopodium, Cytisus procumbens* var. *petrovicii*, *Edraianthus graminifolius*, *Festuca panciciana*, *Pedicularis heterodonta*, *Sedum serpentini*, *Sesleria serbica*, *Silene parnassica* subsp. *serbica*, *Thymus jankae*, and *Viola kopaonikensis*. Some xerophilous Pontic or Mediterranean elements in this serpentine association on shallow rocky soil are: *Asperula cynanchica*, *Carex caryophyllea*, *Carex humilis*, *Cytisus procumbens* var. *petrovicii*, *Trinia glauca*, and *Veronica spicata*.

Note: The invalid name *Carici humilis-Festucetum pancicianae* R. Jovanović-Dunjić et S. Jovanović 1987 subass. *cytisetosum petrovicii* D. Lakušić 1989 nom. nud. (Lakušić & Sabovljević 2005) corresponds with this association.

7. Centaureo kosaninii-Euphorbietum glabriflorae S. Jovanović et V. Stevanović in Aćić et al. 2014 (Table 9, Fig. 3C)

Syn.: *Centaureo kosaninii-Euphorbietum glabriflorae* S. Jovanović et V. Stevanović 1990 nom. inval.

(*Centaureo kosaninii-Bromion fibrosi*, *Halacsyetalia sendtneri*, *Festuco-Brometea*)

Locus classicus: Serbia (Kosovo), Šar Planina Mountains, Brezovica, Gradište, 42.22 N, 21.01 E

(authors of relevés S. Jovanović and V. Stevanović, date 30.06.1990)

Diagnostic taxa: *Alyssum repens, Asplenium ceterach, Centaurea alba* subsp. *ipecensis, Centaurea kosaninii, Cytisus procumbens* var. *petrovicii, Danthonia alpina, Festuca rupicola, Galium album*, and *Viola kopaonikensis.*

Constant taxa: *Acinos alpinus, Allium flavum, Alyssum markgrafii, Alyssum repens, Asplenium ceterach, Asplenium cuneifolium, Astragalus onobrychis, Centaurea kosaninii, Cytisus procumbens* var. *petrovicii, Danthonia alpina, Euphorbia glabriflora, Festuca rupicola, Galium album, Juniperus oxycedrus, Leontodon crispus, Melica ciliata, Minuartia verna, Petrorhagia saxifraga, Plantago holosteum, Poa perconcinna, Sanguisorba minor, Saponaria sicula* subsp. *intermedia, Sedum serpentini, Silene bupleuroides* subsp. *staticifolia, Stachys recta*, and *Stipa pulcherrima.*

Dominant species: *Centaurea kosaninii, Euphorbia glabriflora*, and *Melica ciliata*.

Extended diagnosis: The *Centaureo kosanini-Euphorbietum glabriflorae* represents a secondary rocky grassland developed mostly on southern exposed serpentine slopes with an inclination of 5-45° at altitudes of about 1100 m a.s.l. The total number of species in the stands is 49, with an average of 31 species per relevé. The stands of this community are relatively well developed, covering 40-60% of the relevé area. They are developed in a climate transitional between humid sub-Mediterranean and moderately continental (subtype 1.2/2.1 *sensu* Stevanović & Stevanović 1995), whose main bioclimatic parameters are shown in Table 1. Potential forests of Hungarian oak (*Quercus frainetto*) and Turkey oak (*Quercus cerris*) are determined by these climatic conditions and the geographic location (Fukarek & Jovanović 1983). According to Horvat *et al*. (1974), the surrounding landscape belongs to the vegetation subzone of Balkan oak forests from the alliance *Quercion frainetto.* The stands of this open rocky grassland represent a degradation stage of thermophilous oak forests on an ultrabasic serpentine substrate (*Quercetum frainetto-cerris* Rudski 1949, included in *Quercion confertae* Horvat 1958). The thermophilous character and xeric conditions in those open serpentine habitats made possible the presence of numerous taxa of Pontic or Pontic-Mediterranean area types like *Allium flavum, Astragalus onobrychis*, *Festuca rupicola*, *Petrorhagia saxifraga*, *Potentilla tommasiniana*, *Sanguisorba minor*, *Stipa pulcherrima*, etc. The association is also characterised by many Balkan endemic taxa such as *Alyssum markgrafii*, *Campanula lingulata, Centaurea alba* subsp. *ipecensis*, *Centaurea kosaninii*, *Cytisus procumbens* var. *petrovicii*, *Euphorbia glabriflora*, *Saponaria sicula* subsp. *intermedia*, *Sedum serpentini*, *Thymus jankae*, *Vincetoxicum huteri*, and *Viola elegantula*.

DISCUSSION

The results of our analysis confirmed that the associations *Artemisio albae-Achnatheretum calamagrostis, Artemisio albae-Silenetum armeriae, Festuco pancicianae-Caricetum humilis, Potentillo tommasinianae-Festucetum pancicianae, Seslerio serbicae-Caricetum humilis*, and *Centaureo kosaninii-Euphorbietum glabriflorae,* whose invalid names are regularly quoted in several national reviews of the plant communities in Serbia (Kojić *et al*. 1998; Kojić *et al*. 2004; Lakušić & Sabovljević 2005) and which were validated in the recent nomenclatural revision of dry grassland syntaxa of the Central Balkans (Aćić *et al*. 2014), are characterised by a number of distinctive features and hence can be accepted as well-defined associations. Furthemore, the performed cluster analysis revealed two distinct clusters of *Hyperico barbati-Euphorbietum glabriflorae* stands, allowing us to accept the proposal of Kuzmanović *et al*. (2016) and treat relevés from Mt. Kopaonik as belonging to a new association, viz., *Carici kitaibelianae–Euphorbietum glabriflorae*.

Six of the analysed associations are distributed from the submontane to subalpine vegetational belts of Mt. Kopaonik (*Artemisio albae-Achnatheretum calamagrostis, Artemisio albae-Silenetum armeriae, Festuco pancicianae-Caricetum humilis, Potentillo tommasinianae-Festucetum pancicianae, Carici kitaibelianae-Euphorbietum glabriflorae,* and *Seslerio serbicae-Caricetum humilis*), while one is registered in the montane belt of the Šar Planina Mountains (*Centaureo kosaninii-Euphorbietum glabriflorae*).

All of the analysed associations are the result of previous management practices and represent secondary vegetation developed on the sites of different kinds of oro-pedo-climatically conditioned broadleaved deciduous or evergreen coniferous forests. The associations *Artemisio albae-Achnatheretum calamagrostis, Artemisio albae-Silenetum armeriae, Festuco pancicianae-Caricetum humilis*, and *Potentillo tommasinianae-Festucetum pancicianae* represent a degradation stage of relict *Pinus nigra* forests on ultramafic substrates of the Dinarides (*Erico-Fraxinion orni* Horvat 1959) or thermophilous montane oak forests of the Central Balkans (*Quercion petraeo-cerridis* Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015). On the other hand, the associations *Carici kitaibelianae-Euphorbietum glabriflorae* and *Seslerio serbicae-Caricetum humilis* are a degradation stage of refugial post-glacial basiphilous beech and mixed fir-beech forests of the temperate part of Europe (*Fagion sylvaticae* Luquet 1926) or European boreo-montane spruce forests and subalpine open pine woods on nutrient-poor podzolic soils (*Piceion excelsae* Pawłowski et al. 1928), while the association *Centaureo kosaninii-Euphorbietum glabriflora* represents a degradation stage of thermophilous deciduous oak forests on slightly acidic deep soils of the Central Balkans (*Quercion confertae* Horvat 1958).

The syntaxonomical position and floristic specificity of the here presented associations within the framework of complete vegetation of the order *Halacsyetalia sendtneri* in the Central Balkans are discussed in more detail in Kuzmanović *et al*. (2016). According to that study, the *Centaureo kosaninii-Euphorbietum glabriflorae* association from the Šar Planina Mountains belongs to the alliance *Centaureo kosaninii-Bromion fibrosi*, while all the others belong to the alliance *Potentillion visianii*. Floristic differences between communities belonging to these two alliances can be attributed to differences in recent climatic conditions and different geological history. The areas of these alliances in fact correspond with two phytochoria of subregion rank: the Illyrian subregion vs. the Scardo-Pindian subregion (Horvat *et*

Table 7. Analytical table of the association ***Potentillo tommasinianae-Festucetum pancicianae*** D. Lakušić et Kabaš in Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1-9**: Serbia, Mt. Kopaonik (Krmeljica), 43.26 N, 20.74 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)	Altitude (m)	1060	1050	1070	1070	1050	1050	1050	1070	1070	Frequency (%)	Cover index according to Lausi (Ic)
		Exposition	NE	S	SE		S	SE	SW	N	N		
		Slope (°)	35	25	5	0	30	30	35	35	35		
		Cover (%)	60	60	50	40	40	40	40	80	40		
		Plot size (m^2)	50	25	25	25	100	25	25	15	15		
		No. of species per relevé	19	25	17	16	28	21	23	13	15		
		No. Relevé	1	2	3*	4	5	6	7	8	9		
F-B	Dg	Potentilla tommasiniana	3,3	2,3	2,3	2,3	2,3	2,2	1,3	3,3	2,2	100	58,02
F-B		Carex humilis	1,2	2,2	1,2	1,3	1,3	2,3	1,3	3,4	2,3	100	45,68
	Dg	Festuca panciciana	2,2	2,2	2,2	1,2	2,2	2,2	1,2	1,2	1,2	100	45,68
Hal		Bromus fibrosus	1,2	1,1	1,1	1,2	1,2	2,2	1,2	1,2	1,1	100	35,80
F-B		Astragalus onobrychis	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	100	33,33
F-B		Leontodon crispus subsp. crispus	1,1	1,1	1,1	1,1	1,1	1,2	1,1	1,1	1,1	100	33,33
K-C		Plantago holosteum	1,2	1,2	1,2	1,2	1,2	1,2	1,1	1,1	1,2	100	33,33
F-B		Teucrium montanum	1,2	1,2	1,2	1,2	1,1	1,2	1,2	1,2	1,1	100	33,33
F-B		Thymus jankae	1,2	1,2	1,2	1,1	1,3	1,2	1,1	1,1	1,2	100	33,33
	Dg	Paronychia kapela subsp. kapela	1,2	1,2	1,2	1,2	1,2	1,2	1,2	.	1,2	89	29,63
		Alyssum montanum subsp. montanum	1,1	1,1	1,1	.	1,1	.	1,1	1,1	1,1	78	25,93
F-B		Medicago prostrata	2,2	1,2	.	1,2	1,2	1,2	1,2	.	.	67	24,69
F-B		Artemisia alba	.	1,2	.	1,3	1,2	1,3	1,2	1,2	.	67	22,22
F-B		Asperula cynanchica	1,1	1,1	1,1	.	1,1	1,1	.	.	.	56	18,52
F-B		Scabiosa columbaria agg.	1,1	.	.	.	1,1	.	1,1	1,1	1,1	56	18,52
K-C		Scleranthus perennis subsp. dichotomus	1,2	1,2	.	.	.	1,1	1,2	.	1,1	56	18,52
		Galium corrudifolium	1,1	.	.	.	1,1	1,1	1,1	.	.	44	14,81
K-C		Rumex acetosella subsp. acetosella	.	1,1	1,1	.	1,1	1,1	.	.	.	44	14,81
F-B		Sanguisorba minor subsp. minor	.	.	.	.	1,2	1,1	1,1	.	1,1	44	14,81
Hal		Euphorbia glabriflora	+	.	1,3	.	1,2	.	1,3	.	.	44	13,58
		Pinus nigra subsp. nigra	1,1	.	1,1	.	.	.	.	+	1,2	44	13,58
F-B		Aethionema saxatile subsp. saxatile	.	1,1	.	.	1,2	.	1,1	.	.	33	11,11
	Dg	Centaurea calvescens	.	1,1	.	.	1,1	1,1	.	.	.	33	11,11
		Stachys recta agg.	.	1,1	1,1	.	1,1	.	.	.	.	33	11,11
K-C		Arenaria leptoclados	.	1,1	1,1	.	.	.	.	.	.	22	7,41
		Carduus carduelis	.	.	.	.	1,1	1,1	.	.	.	22	7,41
F-B		Dorycnium pentaphyllum subsp. germanicum	.	.	.	.	1,1	.	1,2	.	.	22	7,41
F-B		Melica ciliata subsp. ciliata	.	1,1	.	.	1,1	.	.	.	.	22	7,41
		Scorzonera cana	.	1,1	.	.	1,1	.	.	.	.	22	7,41
		Juniperus oxycedrus subsp. oxycedrus	.	1,1	.	+	.	.	.	.	.	22	6,17
F-B		Acinos alpinus subsp. alpinus	.	1,2	.	.	.	.	.	.	.	11	3,70
F-B		Asperula purpurea	.	.	.	1,1	.	.	.	.	.	11	3,70
		Chamaecytisus sp.	.	.	.	1,3	.	.	.	.	.	11	3,70
F-B	Dg	Fallopia convolvulus	.	.	.	.	3	.	.	.	.	11	3,70
		Herniaria incana	.	.	.	.	1,2	.	.	.	.	11	3,70
F-B		Hieracium praealtum subsp. bauhinii	.	.	.	.	.	.	1,1	.	.	11	3,70

		No. Relevé	1	2	3*	4	5	6	7	8	9		
K-C		Petrorhagia saxifraga	.	1,1	.	.	.	.	.	.	.	11	3,70
Hal		Sedum serpentini	.	.	.	1,1	.	.	.	.	.	11	3,70
P_vis		Stipa novakii	.	.	.	.	.	.	1,2	.	.	11	3,70
		Taraxacum erythrospermum	.	.	.	.	.	1,1	.	.	.	11	3,70
	Dg	Euphorbia esula subsp. tommasiniana	.	.	.	.	.	+	.	.	.	11	2,47
		Teucrium chamaedrys	+	.	.	.	.	.	.	.	.	11	2,47

Table 8. Analytical table of the association ***Seslerio serbicae-Caricetum humilis*** D. Lakušić et Kabaš in Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1-6**: Serbia, Mt. Kopaonik (Kukavica), 43.33 N, 20.74 E, **7-8:** Serbia, Mt. Kopaonik (Kozje Stene), 43.33 N, 20.74 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)	Altitude (m)	1650	1650	1650	1650	1650	1650	1500	1500	Frequency (%)	Cover index according to Lausi (Ic)
		Exposition	SW	SW	S	S	S	SE	NE	N		
		Slope (°)	45	30	30	50	30	50	70	70		
		Cover (%)	30	50	70	70	80	80	80	60		
		Plot size (m²)	80	80	48	40	50	105	56	16		
		No. of species per relevé	18	16	16	17	14	20	23	12		
		No. Relevé	1	2	3	4*	5	6	7	8		
F-B	Dg	Carex humilis	2,4	2,4	4,5	4,5	5,5	4,5	4,5	2,5	100	77,78
P_vis	Dg	Sesleria serbica	3.5	1.4	1.3	1.3	1.3	1.3	1.2	4.4	100	45,83
F-B	Dg	Dorycnium pentaphyllum subsp. germanicum	3.5	2.4	3.3	1.4	3.4	2.3	2.3	.	88	54,17
Hal		Sedum serpentini	1.1	1.2	1.2	1.2	.	+	+	1,2	88	26,39
F-B		Minuartia verna agg.	1,2	1,3	1,1	+	+	+	.	+	88	23,61
K-C		Plantago holosteum	1.2	1.1	1.1	1.2	1.2	1.3	.	.	75	25,00
F-B		Asperula cynanchica	1,2	1,2	1,2	1,2	+	.	1,2	.	75	23,61
Hal		Bromus fibrosus	.	1,2	1,1	+	1,3	1,2	.	.	63	19,44
		Cytisus procumbens var. petrovicii	1,4	.	.	1,4	1,2	1,3	.	.	50	16,67
		Potentilla heptaphylla	.	.	.	1.2	1.2	1.2	1.2	.	50	16,67
F-B		Thymus jankae	.	.	.	1.3	1.2	1.2	+	.	50	15,28
		Anthyllis vulneraria subsp. carpatica	+	1.2	.	.	1.2	.	.	+	50	13,89
K-C		Koeleria splendens	+	+	+	.	+	.	.	.	50	11,11
F-B		Scabiosa columbaria agg.	+	+	.	+	.	.	+	.	50	11,11
F-B		Trinia glauca subsp. glauca	+	.	.	+	.	+	.	+	50	11,11
K-C		Poa badensis	1.2	1.2	1.2	.	.	.	.	.	38	12,50
K-C		Rumex acetosella subsp. acetosella	1.2	1.2	1.2	.	.	.	.	.	38	12,50
	Dg	Silene parnassica subsp. serbica	.	1,4	1,3	.	.	.	1,4	.	38	12,50
F-B		Festuca panciciana	.	.	+	+	1.2	.	.	.	38	9,72
P_vis		Cardamine plumieri	.	+	+	.	.	.	.	+	38	8,33
F-B		Armeria rumelica	.	.	1,3	.	.	.	.	1,2	25	8,33
F-B		Carex caryophyllea	.	.	.	.	1,1	1,2	.	.	25	8,33
	Dg	Edraianthus graminifolius	.	.	.	.	.	.	1,2	1,3	25	8,33
		Campanula rotundifolia agg.	.	.	.	.	.	.	1,3	+	25	6,94
		Carex digitata	.	.	+	.	.	+	.	.	25	5,56
		Pedicularis heterodonta	.	.	.	.	.	.	+	+	25	5,56

	No. Relevé	1	2	3	4*	5	6	7	8		
K-C	Sedum acre	+	.	.	.	.	+	.	.	25	5,56
F-B	Danthonia alpina	.	.	.	.	.	2.4	.	.	13	6,94
F-B	Leontodon crispus subsp. crispus	.	+	.	.	.	+	.	.	13	5,56
	Alyssum repens	.	.	.	.	.	.	1,1	.	13	4,17
	Asplenium adianthum-nigrum	.	.	.	.	.	1,2	.	.	13	4,17
	Asplenium trichomanes-ramosum	.	.	.	.	.	.	.	1,2	13	4,17
	Cerastium decalvans subsp. leontopodium	.	.	.	.	.	.	1,2	.	13	4,17
	Dianthus petraeus subsp. petraeus	.	.	.	.	.	.	1.3	.	13	4,17
	Dianthus sylvestris agg.	.	.	.	.	.	.	1.3	.	13	4,17
	Gentiana utriculosa	.	.	.	1.1	.	.	.	.	13	4,17
	Leucanthemum vulgare	.	.	.	1,3	.	.	.	.	13	4,17
	Rumex scutatus subsp. scutatus	.	.	.	.	.	.	1.2	.	13	4,17
K-C	Scleranthus perennis subsp. marginatus	1,2	.	.	.	.	.	.	.	13	4,17
	Seseli rigidum subsp. rigidum	.	.	.	.	.	.	1,2	.	13	4,17
F-B	Teucrium montanum	.	.	.	.	.	.	1,3	.	13	4,17
P_vis	Viola kopaonikensis	1,1	.	.	.	.	.	.	.	13	4,17
	Asplenium ruta-muraria subsp. ruta-muraria	.	.	.	+	.	.	.	.	13	2,78
F-B	Galium lucidum	.	.	.	.	.	.	+	.	13	2,78
	Galium mollugo	.	.	.	.	.	+	.	.	13	2,78
	Genista ovata	.	.	.	.	.	.	+	.	13	2,78
F-B	Hypericum barbatum	.	.	.	.	.	.	+	.	13	2,78
	Juniperus communis subsp. alpina	.	.	.	.	.	+	.	.	13	2,78
F-B	Lotus corniculatus	.	.	.	.	.	+	.	.	13	2,78
	Pinus nigra subsp. nigra	+	.	.	.	.	.	.	.	13	2,78
	Veronica spicata	.	.	.	.	.	.	+	.	13	2,78

al. 1974). Climatic conditions in the Illyrian part of the study area are influenced by the humid Atlantic climate, which reaches it from the western parts of the Balkans, while the climatic conditions in the Scardo-Pindian part of the study area are influenced by the arid Mediterranean climate, which reaches it from the southern parts of the Balkans (Horvat *et al*. 1974; Kuzmanović *et al*. 2016). Additionally, two subalpine associations from Mt. Kopaonik (*Carici kitaibelianae-Euphorbietum glabriflorae* and *Seslerio serbicae-Caricetum humilis*) are under strong influence of continental mountain climate and therefore bear a certain resemblance to alpine and subalpine calcicolous swards of the nemoral mountain ranges of Europe (*Elyno-Seslerietea* Br.-Bl. 1948).

The warm serpentine rocky grounds and steep slopes of the study area provide suitable conditions for xerophilous taxa belonging to Pontic, Pontic–sub-Mediterranean, or Mediterranean–sub-Mediterranean types (e.g., *Asperula cynanchica*, *Astragalus onobrychis*, *Bromus pannonicus* subsp. *pannonicus*, *Carex caryophyllea*, *C. humilis*, *Cytisus procumbens* var. *petrovicii*, *Koeleria pyramidata*, *Potentilla tommasiniana, Stipa novakii*, *S. pulcherrima*, *Trinia glauca, Veronica austriaca*, *V. spicata*, etc.). The thermophilous character and xeric conditions in those open serpentine habitats are additionally enhanced by the easy warming of skeletal and heavily eroded soils (Brullo *et al*. 2010). Such a high number of Pontic and Pontic-Mediterranean taxa in regions distant from typical Eurasian steppes could indicate a refugial character of the serpentine areas in Serbia where these associations developed (Jakovljević *et al*. 2011). Furthermore, these associations are also characterised by numerous Balkan endemic species. Among 185 taxa in the seven associations, 23 (12.43 %) are endemics (*Alyssum markgrafii, Armeria rumelica, Campanula lingulata*, *Centaurea calvescens*, *Centaurea kosaninii*, *Cerastium decalvans* subsp. *leontopodium, Cytisus procumbens* var. *petrovicii*, *Euphorbia glabriflora, Festuca panciciana*, *Linaria rubioides, Linum tauricum* subsp. *serbicum, Pedicularis heterodonta*, *Potentilla visianii*, *Saponaria sicula* subsp. *intermedia*, *Scrophularia canina* subsp. *tristis*, *Sedum serpentini, Sesleria serbica, Silene parnassica* subsp. *serbica*, *Stachys scardica*, *Stipa novakii*, *Thymus jankae*, *Viola elegantula*, and *Viola kopaonikensis*). This result is in accordance with the opinion that the mountain areas of Central Serbia and

Table 9. Analytical table of the association ***Centaureo kosaninii-Euphorbietum glabriflorae*** S. Jovanović et V. Stevanović in Aćić et al. 2014. Species are sorted in descending order of frequency and cover index. (Legend: * = holotypus, **C_Brom** = *Centaureo kosaninii-Bromion fibrosi,* **F-B** = *Festuco-Brometea,* **Hal** = *Halacsyetalia sendtneri,* **K-C**= *Koelerio-Corynephoretea,* **P_vis** = *Potentillion visianii*). Relevés: **1-6**: Serbia (Kosovo), Šar Planina Mountains (Brezovica, Gradište), 42.22 N, 21.01 E.

Characteristic species according to Kuzmanović et al. (2016)	Diagnostic species (phi > 0.20)	Altitude (m)	1100	1100	1100	1080	1080	1080	Frequency (%)	Cover index according to Lausi (Ic)
		Exposition	SW	SW	S	S	S	S		
		Slope (°)	10-30	5-15	10-30	5-35	20-30	45		
		Cover (%)	50-60	40-50	40	40-50	45	50		
		Plot size (m^2)	25	9	25	48	12	80		
		No. of species per relevé	31	28	29	48	48	35		
		No. Relevé	1*	2	3	4	5	6		
Hal		Euphorbia glabriflora	3.4	3,3	1,2	2,3	2,3	2,3	100	59,26
C_Brom	Dg	Centaurea kosaninii	2,4	1,3	3,3	2,3	2,4	2,4	100	55,56
F-B		Melica ciliata subsp. ciliata	1.1	1.2	2,2	1.2	2,2	1.2	100	40,74
	Dg	Alyssum repens	1.2	1.1	1.2	1.1	1.2	1.1	100	33,33
	Dg	Cytisus procumbens var. petrovicii	1.2	1,3	1.2	1.2	1.2	1.2	100	33,33
F-B		Stachys recta agg.	1.1	1.1	1.1	1.2	1.1	1.1	100	33,33
	Dg	Festuca rupicola subsp. rupicola	1.2	1.2	1.2	1.2	+.2	1.2	100	31,48
F-B		Leontodon crispus subsp. crispus	1.1	1.1	+	1.1	1.1	1.1	100	31,48
K-C		Petrorhagia saxifraga	1.1	1.1	+.1	1.1	1.1	1.1	100	31,48
Hal		Sedum serpentini	1.2	1.2	1.2	1.2	+.2	1.2	100	31,48
K-C		Plantago holosteum	1.2	1.2	+	1.1	1.1	+.1	100	29,63
K-C		Poa perconcinna	1.2	+.2	+	+.2	+.2	+.2	100	24,07
Hal		Alyssum markgrafii	+	+	+.2	+	+	+	100	22,22
		Juniperus oxycedrus subsp. oxycedrus	1.2	+	+.2	1.2	.	2,2	83	27,78
F-B		Minuartia verna agg.	1.1	1.2	1.2	1,1	.	+.1	83	25,93
F-B		Acinos alpinus subsp. alpinus	+.1	+	.	1.2	1.2	1.2	83	24,07
Hal		Asplenium cuneifolium	+.2	.	+.2	1,3	1.2	1.2	83	24,07
F-B		Astragalus onobrychis	1.1	1.2	+.2	.	+.2	+.2	83	22,22
	Dg	Galium album subsp. album	+.1	1.2	+	+.2	.	+	83	20,37
Hal		Silene bupleuroides subsp. staticifolia	+.1	.	+	+	1.1	+.1	83	20,37
F-B	Dg	Danthonia alpina	1,2	.	.	2,2	1,2	2,2	67	29,63
		Stipa pulcherrima	1,2	2,2	1,2	1.2	.	.	67	25,93
F-B		Sanguisorba minor subsp. minor	.	.	1,1	1,1	1,1	1,1	67	22,22
C_Brom		Saponaria sicula subsp. intermedia	+.1	1.2	1.2	.	.	1,3	67	20,37
	Dg	Asplenium ceterach	+.1	.	+	1.2	.	1.2	67	18,52
		Agrostis sp.	+.2	+.2	.	1.1	+.2	.	67	16,67
F-B		Allium flavum	.	.	+.1	+	+.1	1.1	67	16,67
Hal		Bromus fibrosus	1.1	.	.	1.2	1.1	.	50	16,67
Hal		Notholaena marantae	.	.	1,3	1,3	.	1,3	50	16,67
F-B		Potentilla tommasiniana	.	.	1,1	1,1	.	1,1	50	16,67
	Dg	Centaurea alba subsp. ipecensis	+	1.1	.	1.1	.	.	50	14,81
K-C		Sedum ochroleucum	+	1.2	.	.	.	+	50	12,96
F-B		Thymus jankae	.	+.2	+.2	.	.	1,2	50	12,96
F-B		Vincetoxicum huteri	+	+	.	.	.	1,1	50	12,96
F-B		Aethionema saxatile subsp. saxatile	.	+	.	.	+	+.1	50	11,11
F-B		Hieracium praealtum subsp. bauhinii	+	+.1	.	.	+.1	.	50	11,11

		No. Relevé	1*	2	3	4	5	6		
F-B		Hypericum barbatum	.	.	1,1	1,1	.	.	33	11,11
F-B		Scabiosa columbaria agg.	.	.	.	.	1,1	1,1	33	11,11
		Silene vulgaris	.	1,1	.	.	.	1,1	33	11,11
		Stachys officinalis	+	.	.	.	1,2	.	33	9,26
F-B		Teucrium montanum	.	.	.	.	+.1	1.2	33	9,26
P_vis	Dg	Viola kopaonikensis	.	.	.	+.1	.	1,1	33	9,26
		Asplenium trichomanes subsp. trichomanes	.	.	.	1.2	.	.	17	5,56
F-B		Campanula lingulata	.	.	.	.	1.1	.	17	5,56
		Achillea millefolium	.	.	.	.	+.1	.	17	3,70
F-B		Dorycnium pentaphyllum subsp. germanicum	.	.	.	.	+.2	.	17	3,70
		Quercus cerris	.	.	+	.	.	.	17	3,70
		Thalictrum minus subsp. minus	.	.	.	+	.	.	17	3,70
		Verbascum sp.	.	.	.	+	.	.	17	3,70

Kosovo are centres of florogenesis and refugia of the flora, particularly the orophitic flora, of Central and Southern Europe, and that serpentinite areas represent important centres of endemic flora richness (Stevanović *et al*. 2003; Tomović *et al*. 2014).

CONCLUSION

The associations *Artemisio albae-Achnatheretum calamagrostis, Artemisio albae-Silenetum armeriae, Festuco pancicianae-Caricetum humilis, Potentillo tommasinianae-Festucetum pancicianae, Seslerio serbicae-Caricetum humilis*, and *Centaureo kosaninii-Euphorbietum glabriflorae,* whose invalid names are regularly quoted in several national reviews of the plant communities in Serbia and which were validated in the recent nomenclatural revision of dry grassland syntaxa of the Central Balkans, are floristically well-defined and merit the rank of associations.

The stands from Barelj on Mt. Kopaonik, originally classified as part of the *Hyperico barbati-Euphorbietum glabriflorae* association, are floristically well-defined and also merit the rank of specific associations. They are therefore here described as a new association, viz., *Carici kitaibelianae–Euphorbietum glabriflorae*.

The *Centaureo kosaninii-Euphorbietum glabriflorae* from the Šar Planina Mountains belongs to the *Centaureo kosaninii-Bromion fibrosi*, while all the other associations originally classified in this alliance should be considered as belonging to the *Potentillion visiani* (*Halacsyetalia sendtneri*).

All of the studied associations are the result of previous management practices and represent secondary vegetation developed on the sites of different kinds of oro-pedo-climatically conditioned broadleaved deciduous or evergreen coniferous forests.

The studied associations are all generally characterised by xerophilous taxa belonging to the category of Pontic, Pontic–sub-Mediterranean, or Mediterranean–sub-Mediterranean elements, as well as by the presence of numerous Balkan endemics.

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Botanica SERBICA

REZIME

Fitocenološke karakteristike sedam nedovoljno poznatih asocijacija vegetacije kamenjara na serpentinitima Srbije iz reda *Halacsyetalia sendtneri*

Slobodan Jovanović, Eva Kabaš, Nevena Kuzmanović, Ksenija Jakovljević, Snežana Vukojičić i Dmitar Lakušić

Iako je dobro poznato da suva, otvorena, travna vegetacija kamenjara na plitkim serpentinskim (ultramafitskim) zemljištima predstavlja jedan od najinteresantnijih, visoko endemičnih i kontinuirano istraživanih vegetacijskih tipova, autori nekoliko detaljnih studija Balkanske serpentinske flore i vegetacije sugerišu da vegetacijski pokrivač Balkanskih serpentinita zahteva dalja istraživanja zbog svoje heterogenosti. U ovom radu su analizirane fitocenološke karakteristike sedam nedovoljno poznatih travnih zajednica iz reda *Halacsyetalia sendtneri*. U cilju pružanja što preciznijeg formalnog opisa ovih zajednica (dijagnoza sa listom dijagnostičkih, dominantnih i konstantnih vrsta), kao i provere njihove fitocenološke validnosti i sintaksonomskog položaja, izvršena je uporedna numerička analiza sastojina ovih zajednica sa 18 asocijacija prisutnih na serpentinitima Bosne i Hercegovine i Srbije, uključujući i Kosovo. Rezultati klaster analize potvrđuju fitocenološku validnost sedam floristički dobro definisanih, ali do sada malo poznatih asocijacija u vegetaciji otvorenih travnih kamenjara na Kopaoniku i Šar planini u Srbiji.

Ključne reči: Balkansko poluostrvo, numeričke analize, fitocenologija, sintaksonomija, serpentiniti, ultramafitske travne formacije