Tuexenia 36: 293–320. Göttingen 2016.
doi: 10.14471/2016.36.016, available online at www.tuexenia.de

Syntaxonomy and nomenclatural adjustments of steppe-like vegetation on shallow ultramafic soils in the Balkans included in the order *Halacsyetalia sendtneri*

Syntaxonomisch-nomenklatorische Änderungen bei den Steppenrasen der Ordnung *Halacsyetalia sendtneri* auf flachgründig-ultramafischen Böden des Balkans

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Abstract

Dry open rocky grassland vegetation on shallow ultramafic soils in the Central Balkans represents typical secondary grasslands, which have developed mainly in the zone of thermophilous mixed deciduous broadleaved and pine forests. Although all relevant national and regional syntaxonomic reviews classify these rocky grasslands within the distinct order *Halacsyetalia sendtneri*, the syntaxonomic position of the order in different systems of classification has varied in the past. Considering this as well as the fact that there have been no synoptic works on this specific vegetation type, we gathered all available data on the order *Halacsyetalia sendtnerii* from the serpentinites of the Western and Central Balkan Peninsula for its critical evaluation. The results obtained in our analyses allowed us to propose a new syntaxonomic concept, which is partly in accordance with previously published syntaxonomic schemes. Two alliances can be distinguished: *Centaureo kosaninii-Bromion fibrosi* and *Potentillion visianii*, for which the diagnoses, diagnostic and constant taxa are given. Furthermore, we discussed the syntaxonomic position of the order *Halacsyetalia sendtneri* with respect to the classes *Festuco-Brometea* and *Koelerio-Corynephoretea*, as within the analysed associations, many taxa diagnostic for the class *Koelerio-Corynephoretea* were registered. The thermophytic pioneer grasslands and therophyte sward communities included in the alliance *Thymion jankae* nomen. inval., characterised by the absence of typical species of the order *Halascyetalia sendtneri* and presence of taxa diagnostic for the class *Koelerio-Corynephoretea*, are temporarily left within the order *Halacsyetalia sendtneri*. Finally, we provided nomenclatural adjustments for the analysed associations when necessary, although a conclusive judgement regarding all the associations currently included within the analysed order can only be made after more detailed field surveys including data on cryptogams as well as joint analyses including all floristically and ecologically similar syntaxa (e.g. *Astragalo-Potentilletalia*, *Festucetalia valesiacae*).

Manuscript received 03 April 2015, accepted 10 May 2016
Co-ordinating Editor: Monika Janišová

Keywords: Central Balkan Peninsula, *Halacsyetalia sendtneri*, serpentine vegetation, syntaxonomy

Erweiterte deutsche Zusammenfassung am Ende des Artikels

1. Introduction

For numerous reasons vegetation on serpentinites in the Balkans has been considered as a very attractive research object (KOŠANIN 1939, PAVLOVIĆ 1951, KRAUSE & LUDWIG 1956, 1957, RITTER-STUDNIČKA 1963, 1968, 1970; TATIĆ & VELJOVIĆ 1990). The largest serpentinite areas in Europe are located on the Balkan Peninsula – Greece, Albania, Bosnia and Herzegovina, Serbia, and to a lesser extent in Montenegro, Bulgaria and Macedonia (STEVANOVIĆ et al. 2003). It should be noted that the traditional term serpentinites is generally accepted and used in botanical literature (BROOKS 1987), and we used it in our paper for all types of serpentinised ultramafites of the Balkans.

The specific chemical composition, which is characterised by critically low levels of essential plant nutrients and a set of highly toxic trace elements, texture and the dark colour of serpentinite bedrock contribute to the extremely dry conditions and the pronounced thermophytic character of these habitats. As a result, plants growing here show characteristic adaptations, such as nanism, purpurescence, glaucescence, stenophyllism etc., often referred to as "serpentine syndrome" (RITTER-STUDNIČKA 1963, 1968; JENNY 1980). Also, the particular complex of the overall ecological conditions, most of which are directly or indirectly conditioned by the properties of the bedrock itself, has resulted in a unique flora and vegetation with a great number of relic and endemic species (TATIĆ & VELJOVIĆ 1990, STEVANOVIĆ et al. 2003, BRKOVIĆ et al. 2015).

The first floristic and vegetation studies in the serpentine areas of this part of the Balkans were published in the 19th and the beginning of the 20th century by PANČIĆ (1859), BECK (1901), ADAMOVIĆ (1909) and KOŠANIN (1939). Among the first studies of serpentine grasslands in the Serbian mountains were those carried out by PAVLOVIĆ (1951, 1953, 1955). These were followed by the contributions of KRAUSE & LUDWIG (1956, 1957) dealing with serpentine communities in the area of Gostović in Bosnia and Herzegovina. Furthermore, after exploring the specificity of grassland flora and vegetation in Kosovo and Metohia, BLEČIĆ et al. (1969) described a new alliance *Centaureo-Bromion fibrosi* Blečić et al. 1969, in which they included three newly described associations from serpentinites on Mt. Šara (Kosovo). One year later, as a result of studying serpentinite rocky grasslands in Central and Eastern Bosnia and Herzegovina, RITTER-STUDNIČKA (1970) introduced a new order for steppic rocky grasslands on serpentine soils of Bosnia & Herzegovina, Serbia and Albania – *Halacsyetalia sendtneri* Ritter-Studnička 1970 –, with two newly described alliances – *Polygonion albanicae* Ritter-Studnička 1970 and *Potentillion visianii* Ritter-Studnička 1970. She classified the order within the class *Festuco-Brometea* Br.-Bl. et Tx. ex Klika et Hadač 1944 due to the presence of characteristic taxa of dry grasslands of the order *Festucetalia valesiacae* Br.-Bl. & Tx. ex Br.-Bl. 1950 within these communities, which were also rich in so-called endemic serpentinophytes. Many associations described from serpentine areas in Serbia and Kosovo were afterwards classified within the alliance *Centaureo-Bromion fibrosi* (for reviews see TATIĆ & VELJOVIĆ 1990 and AĆIĆ et al. 2014). Later on BERGMEIER et al. (2009) described four new associations of open serpentinite rocky grasslands in Greece and introduced the new alliance *Alyssion heldreichii* Bergmeier et al. 2009, which they included in the order *Astragalo-Potentilletalia* Micevski 1970. Finally, in the most recent study of TZONEV et al. (2013) regarding Bulgarian serpentine grasslands, relationships of the Balkan

serpentinite syntaxa were seen in a new light. By comparing the Bulgarian syntaxa with those from neighbouring Balkan countries with respect to their floristic composition and diagnostic species, the authors concluded that Bulgarian and Greek syntaxa are part of the order *Astragalo-Potentilletalia*, while syntaxa from Bosnia and Herzegovina, Serbia and Kosovo are part of the order *Halacsyetalia sendtneri.*

In the present paper we followed the original syntaxonomic concept of RITTER-STUDNIČKA (1970), accepted by RODWELL et al. (2002), ZUPANČIČ et al. (1986) and KOJIĆ et al. (2004), which was recently supported by the hierarchical classification of a large data set of phytosociological relevés of dry grasslands in the Central Balkans published in AĆIĆ et al. (2015), considering vegetation of the order *Halacsyetalia sendtneri* as steppe-like vegetation on shallow ultramafic soils in the Balkans classified within the class *Festuco-Brometea*. At the same time, we accepted the geographical concept of ZUPANČIČ et al. (1986) and TZONEV et al. (2013), who considered the order *Halacsyetalia sendtneri* to be restricted to the Western and Central Balkans, from Bosnia and Herzegovina to Serbia and Kosovo.

Various phytocoenological data have been published for the investigated area; however, there have not been any synoptic works on this distinct vegetation type. Considering this, synsystematic relationships within the order *Halacsyetalia sendtneri* were not clearly defined, and critical re-evaluation is needed. Therefore, the main aims of our study were (1) to evaluate described alliances traditionally included in the order *Halacsyetalia sendtneri*, (2) to propose a revised syntaxonomic concept for the serpentine steppe-like vegetation on the Central Balkan Peninsula, (3) to provide a diagnosis with a list of diagnostic, dominant and constant species for the analysed order and alliances and finally (4) to provide nomenclatural adjustments for invalidly published syntaxa.

2. Study area

The studied area is located in the central part of the Balkan Peninsula (south-eastern Europe). It overlaps with the distribution of serpentinite outcrops in Central Bosnia and Herzegovina, Western and Central Serbia and Kosovo (Fig. 1). According to HORVAT et al. (1974), the studied area belongs biogeographically to the eastern part of the Illyrian (Dinaric Alps) and the northern part of the Scardo-Pindian (Scardian Mts.) subregions of the Middle European floristic region.

The climatic conditions in the Illyrian part of the studied area are influenced by the humid Atlantic climate, which reaches it via the western parts of the Balkans (Dinaric Alps). In this region there is a specific sub-type of the moderately continental humid climate (type VI 2b sensu WALTER & LEITH 1964, 2.1 sensu STEVANOVIĆ & STEVANOVIĆ 1995), characterised by 720 to 900 mm of precipitation during the year and absence of dry and semi-dry periods (occasionally, there are months with semi-dry days). The moderately continental humid climate is also significantly influenced by the mountains; therefore, it may be described as transitional variety in between moderately-continental and mountain climate of the Middle-European type (type VI 2b/X 1 sensu WALTER & LEITH 1964, 2.1/4.1 sensu STEVANOVIĆ & STEVANOVIĆ 1995). The climatic conditions in the Scardo-Pindian part of the studied area are influenced by the arid Mediterranean climate, which reaches it via canyons and gorges of Montenegro and Albania from southwest (influence from the Adriatic Sea) or via valleys and plains of Macedonia (influence from the Aegean Sea). In this region there are specific transitional sub-types between Mediterranean and moderately continental

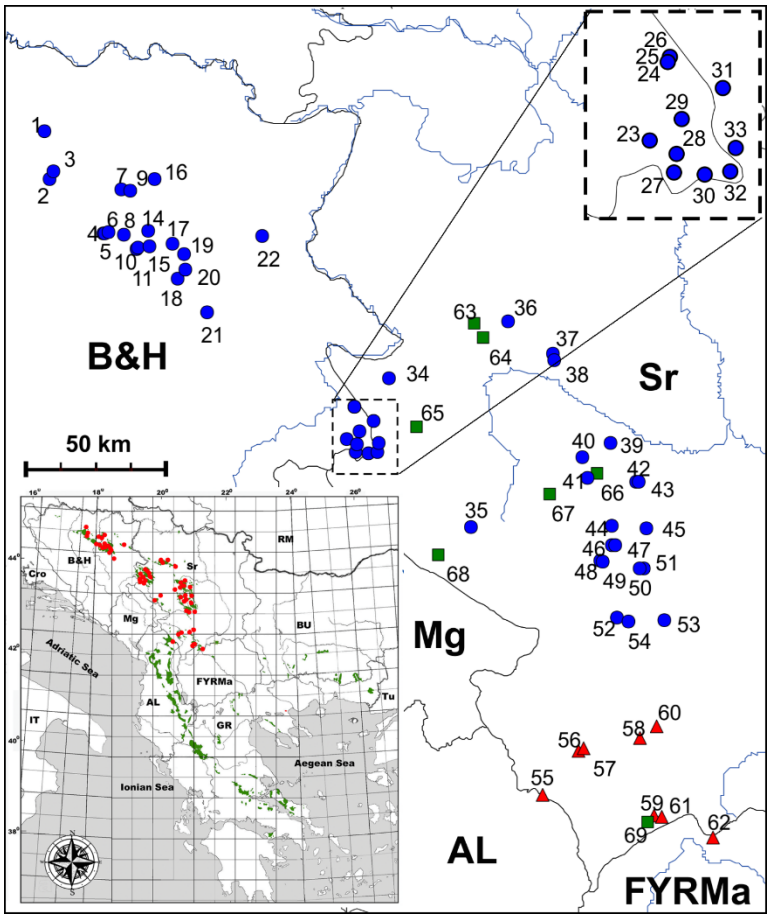

Fig. 1. Map of the localities of analysed syntaxa. Numbers on the map correspond to data given in the Supplement E1. Blue dots – syntaxa belonging to the *Potentillion visianii*; red triangles – syntaxa belonging to the *Centaureo kosaninii-Bromion fibrosi*; green squares – syntaxa belonging to the "*Thymion jankae*" prov. The distribution of the serpentinites in the Balkan Peninsula (green outcrops) and the studied syntaxa (red dots) are provided in the map insert (lower left). B&H – Bosnia and Herzegovina, Sr – Serbia, Mg – Montenegro, AL – Albania, FYRMa – Macedonia, GR – Greece, BU – Bulgaria, RM – Romania, Cro – Croatia, IT – Italy, Tu – Turkey.

Abb. 1. Karte der Untersuchungsgebiete. Die Nummern der Gebiete entsprechen denen in Anhang E1. Blaue Punkte – Gesellschaften des *Potentillion visianii*, rote Dreiecke – Gesellschaften des *Centaureo kosaninii-Bromion fibrosi*, Grüne Quadrate – Gesellschaften des "*Thymion jankae*" prov. In der kleinen Karte sind die Vorkommen der Serpentinite auf dem Balkan als grüne Fläche und die Lage der Untersuchungsgebiete als rote Punkte dargestellt. B&H – Bosnien und Herzegovina, Sr – Serbien, Mg – Montenegro, AL – Albanien, FYRMa – Mazedonien, GR – Griechenland, BU – Bulgarien, RM – Rumänien, Cro – Kroatien, IT – Italien, Tu – Türkei.

humid climate (types IV 5 and IV 6 sensu WALTER & LEITH 1964; 1.2./2.1. and 1.3./2.2 sensu STEVANOVIĆ & STEVANOVIĆ 1995), characterised by 500 to 700 mm of precipitation during the year and the presence of a dry period lasting up to two months and a semi-dry period that can last up to four months.

3. Methods

3.1 Data collecting

For the purposes of this study, phytocoenological literature on different serpentine areas in the Western and Central Balkans (Bosnia and Herzegovina, Serbia and Kosovo) was studied. More detailed information regarding all analysed syntaxa is given in Table 1. The analysed syntaxa are distributed throughout the area of serpentinite outcrops in Bosnia and Herzegovina, Serbia and Kosovo (Fig. 1, Supplement E1).

The nomenclature and taxonomy of plant taxa is in agreement with the Flora Europaea Database (TUTIN et al. 2001), except for the species *Bothriochloa ischaemum* (L.) Keng., *Bromus fibrosus* Hack., *Cytisus procumbens* Bojer ex Baker var. *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 and *Viola kopaonikensis* Pančić and for the critical taxa with unresolved relationships, which were included in species complexes (aggregates) – Table 2. Taxa determined at the level of genus were omitted from the analyses, as well as mosses, which were recorded only in synoptic tables of RITTER-STUDNIČKA (1970) and KRAUSE & LUDWIG (1957). The names of infraspecific taxa in tables are presented with the genus name and the infraspecific epithet with an asterisk in between (the specific epithet is omitted; e.g. *Stachys recta* subsp. *baldaccii* = *Stachys * baldaccii*).

All relevés used in this article are stored in the database of Grassland Vegetation of Serbia (GIVD number: EU-RS-002, AĆIĆ et al. 2012).

3.2 Data analyses

Prior to the numerical analyses of analytical data and their transformation in synoptic columns, we evaluated the quality of the available information regarding geographical positions and plot sizes of relevés. It turned out that in our dataset we had very different plot sizes, which were unevenly distributed in the study area (Table 3). There were 88 relevés (32%) without any information on the plot size: all relevés from Bosnia and Herzegovina (100%) and 57% from Kosovo. On the other hand, there were 76 relevés (28%) with plot sizes larger than 50 m^2: 25% of the relevés from Kosovo and 36% of those from Serbia. If we take into consideration (i) the fact that the outcomes of numerical analyses are very sensitive to different plot sizes (for discussion on this topic see DENGLER 2003, CHYTRÝ & OTÝPKOVÁ 2003, MICHL et al. 2010 etc.) and (ii) the recommendation that the maximal plot size for numerical analyses of most types of herbaceous vegetation should not exceed 10 m² (DENGLER 2003), 16 m² (CHYTRÝ & OTÝPKOVÁ 2003) or 50 m² (MICHL et al. 2010), we can conclude that a large part of our data (65% of the total data set: 100% for Bosnia and Herzegovina, 73% for Kosovo and 58% for Serbia) do not meet the afore-mentioned criteria.

Considering the fact that we had two different types of data – 26 associations published in the form of analytical tables (277 relevés) and 7 associations in the form of synoptic columns, data analyses were conducted in four steps: In the first step, we performed several cluster analyses of analytical data with different combinations of distance measures and group linkage methods in order to determine whether all relevés originally published as belonging to particular syntaxa form compact, "floristically well-characterised groups". Secondly, we prepared 26 synoptic columns for the associations that were published with associated analytical tables. In the third step, synoptic columns for the associations published with accompanying analytical tables (26 synoptic columns) were joined together with the synoptic tables of seven associations published by RITTER-STUDNIČKA (1970) and KRAUSSE & LUDWIG (1957). Finally, the classification of the synoptic table (33 synoptic columns and 499 taxa) was carried out based on combined "classical phytosociological methods" (table sorting using simple numerical tools, e.g. calculated frequencies, as proposed by TICHÝ et al. 2012).

Table 1. Analysed associations (valid names) per localities with number of analysed relevés and sources of published data (Legend: st – synoptic table). Original names of the associations are provided in the syntaxonomic overview of Aćić et al. (2014) and in section 4.2.2.3 Nomenclatural adjustments at association level.

Tabelle 1. Untersuchte Assoziationen mit Lokalitäten, der Anzahl an verwendeten Aufnahmen sowie Quellenangaben. st – Stetigkeitstabelle. Die Originalnamen der Assoziationen werden in der syntaxonomischen Übersicht von Aćić et al. (2014) und im Kapitel 4.2.2.3 angegeben.

No.	Association	Locality	No. relevés	Source of relevés
Bosnia and Herzegovina				
1	*Alysso muralae-Silenetum vulgaris* H. Ritter-Studnička 1970	Gostović, Krivaja, Papratnica, Žepce	st	Ritter-Studnička 1970
2	*Dorycnio germanicae-Scabietosum cineraeae* H. Ritter-Studnička 1970	Duboštica, Krivaja, Maglaj, Ozren, Žepce	st	Ritter-Studnička 1970
3	*Erysimo linariifoliae-Jovibarbetum heuffelii* H. Ritter-Studnička 1970	Rudo, Varda, Višegrad	st	Ritter-Studnička 1970
4	*Euphorbio montenegrinae-Brometum erecti* Krause & Ludwig 1956	Gostović	5	Krause & Ludwig 1956
5	*Fumano bonapartei-Euphorbietum glabriflorae* H. Ritter-Studnička 1970	Hranska Kosa, Rudo, Vardište, Višegrad	st	Ritter-Studnička 1970
6	*Halacsyio sendtneri-Caricetum humilis* Krause & Ludwig 1956	Gostović	6	Krause & Ludwig 1956
7	*Halacsyo sendtnerii-Seselietum rigidae* H. Ritter-Studnička 1970	Gostović, Kalesija, Krivaja, Ljeskovica, Maglaj, Olovo, Pribinić, Prnjavor, Velež, Velika Jaovorova, Žepce	st	Ritter-Studnička 1970
8	*Scrophulario tristis-Linarietum rubioides* H. Ritter-Studnička 1970	Rudo, Uvac, Varda, Višegrad	st	Ritter-Studnička 1970
9	*Violo beckianae-Seslerietum serbicae* Krause & Ludwig 1957	Gostović	st	Krause & Ludwig 1957
Serbia				
10	*Alysso markgrafii-Artemisietum albae* Aćić et al. 2014	Mt Goč	7	Blaženčić & Vučković 1983
11	*Artemisio albae-Achnatheretum calamagrostis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014	Mt Goč, Mt Kopaonik (Rajićeva Gora, Vlajkovci)	4	GIVD: EU-RS-002
12	*Artemisio albae-Silenetum armeriae* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopanik (Vlajkovci)	8	GIVD: EU-RS-002
13	*Brometum fibrosi* Pavlović 1962	Mt Stolovi, Mt Rogozna	2	Pavlović 1962
14	*Bromo fibrosi-Artemisietum albae* A. Marković ex Aćić et al. 2014	Mt Suvobor, Brđani Gorge	10	Marković 2007
15	*Bromo fibrosi-Chrysopogonetum grylli* Tatić 1969	Mt Studena	13	Tatić 1969
16	*Festuco ovinae-Euphorbietum glabriflorae* S. Jovanović et R. Jovanović-Dunjić in S. Jovanović et al. ex Aćić et al. 2014	Mt Tara, Mt Zlatibor	11	Jovanović et al. 1992
17	*Festuco pancicianae-Caricetum humilis* Jovanović-Dunjić et S. Jovanović ex Aćić et al 2014	Mt Kopaonik (Rajićeva Gora)	5	GIVD: EU-RS-002

No.	Association	Locality	No. relevés	Source of relevés
18	*Halacsyo sendtneri-Potentilletum mollis* Pavlović 1955	Crni Rzav-Uvac, Mt Rogozna	2	Pavlović 1962
19	*Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953	Mt. Maljen	1	Cincović & Kojić 1955
20	*Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953	Mt. Maljen (Divčibare)	10	Cincović & Kojić 1956
21	*Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953	Mt. Maljen (Tometino polje)	4	Kojić & Ivanović 1953
22	*Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953	Mt. Radočelo (Rudnjanska visoravan)	2	Kojić et al. 1992
23	*Poo molinerii-Plantaginetum holostei* Pavlović 1951	Mt. Ozren	9	Pavlović 1955
24	*Poo molinerii-Plantaginetum holostei* Pavlović 1951	Mt. Studena	12	Tatić 1969
25	*Poo molinerii-Plantaginetum holostei* Pavlović 1951	Mt. Zlatibor	16	Pavlović 1951
26	*Potentillo tomasinianae-Festucetum pancicianae* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopaonik (Krmeljica)	9	GIVD: EU-RS-002
27	*Potentillo tommasinianae-Stipetum pennatae* A. Marković ex Aćić et al. 2014	Mt Goč, Brđani Gorge	10	Marković 2007
28	*Seslerio serbicae-Caricetum humilis* D. Lakušić et Kabaš in Aćić et al. 2014	Mt Kopaonik (Kukavica)	8	GIVD: EU-RS-002
29	*Stipetum novakii* Kabaš et D. Lakušić in Kabaš et al. 2013	Brđani Gorge	11	Kabaš et al. 2013
Kosovo				
30	*Centaureo kosaninii-Euphorbietum glabriflorae* S. Jovanović et V. Stevanović in Aćić et al. 2014	Mt Šar-Planina (Brezovica)	6	GIVD: EU-RS-002
31	*Cynancho vincetoxici-Saponarietum intermediae* Blečić et al. 1969	Mt Šar-Planina (Brezovica)	13	Blečić et al. 1969
32	*Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014	Mt Drenica (Nekoc)	10	Krasniqui & Milaku 2007
33	*Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014	Mt Goleš, Mt Koznica	11	Rexhepi 1978
34	*Carici kitaibelianae-Euphorbietum glabriflorae* (Ranđelović et al.) D. Lakušić et Kuzmanović in Kuzmanović et al*ass. nov. hoc loco*	Mt Kopaonik (Barelj)	5	Ranđelović et al. 1979 and this paper
35	*Onosmo echioidis-Scabiosetum fumarioidis* Rexhepi ex Aćić et al. 2014	Koznička Boka	10	Rexhepi 1978, 1985
36	*Polygalo dörfleri-Genistetum hassertianae* Blečić et al. 1969	Koznička Boka	10	Blečić et al. 1969
37	*Polygalo dörfleri-Genistetum hassertianae* Blečić et al. 1969	Đakovica	10	Rexhepi 1978
38	*Potentillo tommasinianae-Fumanetum bonapartei* Rexhepi ex Aćić et al. 2014	Mt. Kopaonik (Lis Čuka, Belaška), Mt. Rogozna (Banjska)	10	Rexhepi 1979
39	*Sedo serpentini-Bornmuellerietum dieckii* Blečić et al. 1969	Mt Šar Planina (Ostrovica)	11	Blečić et al. 1969
40	*Sedo serpentini-Dianthetum serbici* Pavlović 1967	Mt Rogozna	7	Pavlović 1967
41	*Stipo mayerii-Convolvuletum compacti* Millaku et al. 2011	Gurane	10	Millaku et al. 2011

Table 2. Species complexes (aggregates) of the critical taxa used in this paper.

Tabelle 2. Kritische Artengruppen (Art-Aggregate), die in dieser Studie verwendet werden.

Agreggate taxon	Included taxa
Anthyllis vulneraria agg.	*Anthyllis vulneraria*, *A. vulneraria* subsp. *carpatica*, *A. vulneraria* subsp. *polyphylla*
Astragalus onobrychis agg.	*Astragalus onobrychis*, *A. onobrychis* var. *chlorocarpus*, *A. onobrychis* var. *multijugus*, *A. onobrychis* f. *kraljevensis*
Festuca ovina agg.	*Festuca ovina*, *F. duriuscula*
Leontodon crispus agg.	*Leontodon crispus*, *L. crispus* subsp. *asper*, *L. crispus* subsp. *asperrimus*
Minuartia verna agg.	*Minuartia verna*, *M. verna* subsp. *montana*, *M. montana* f. *glandulosa*, *M. collina*
Poa badensis agg.	*Poa badensis*, *P. badensis* var. *glaucescens*, *P. concinna*, *P. molinieri*, *P. perconcinna*
Sanguisorba minor agg.	*Sanguisorba minor*, *S. minor* subsp. *minor*, *S. minor* subsp. *muricata*
Scabiosa columbaria agg.	*Scabios columbaria*, *S. dubia*, *S. portae*
Silene vulgaris agg.	*Silene anthelopum*, *S. cucubalus* subsp. *bosniaca*, *S. vulgaris*, *S. willdenowii* var. *serpentina*
Stachys recta agg.	*Stachys recta* s.l. excluding: *S. recta* subsp. **baldaccii*, *S. recta* subsp. **rhodopaea*

*Subspecies *S. recta* subsp. *baldaccii* and *S. recta* subsp. *rhodopaea* represent morphologically and geographically distinct entities, which can easily be distinguished from other infraspecific taxa within *S. recta* s.l. They were therefore treated as separate taxa in our study.

Table 3. Plot sizes and their distribution in the analysed syntaxa in the study area. No – number of relevés.

Tabelle 3. Flächengrößen der analysierten Aufnahme und ihre Verteilung innerhalb des Untersuchungsgebiets.

Area [m²]	Total		Bosnia and Herzegovina		Kosovo		Serbia	
	No	%	No	%	No	%	No	%
No data	88	32	18	100	65	57	5	4
1–15	4	1	0	0	2	2	2	1
16–25	80	29	0	0	23	20	57	41
26–50	25	9	0	0	0	0	25	18
51–100	76	28	0	0	25	22	51	36
Σ	273	100	18	100	115	100	140	100

In the cluster analyses of analytical tables (273 relevés × 455 taxa × 24 associations), the original cover-abundance values for individual taxa were transformed into an ordinal scale as proposed by VAN DER MAAREL (1979). Cluster analyses (Bray-Curtis & Paired group average, Euclidean & Ward's method, Relative Euclidean & Flexible beta, β = -0.25) were done in the programme packages PAST (HAMMER et al. 2001) and Juice (TICHÝ 2002). 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. In the cases when relevés that were *a-priori* classified as one association formed more than one compact cluster, each cluster was treated as a separate association for which its own synoptic column was formed. In contrast, in the cases when relevés that were *a-priori* classified into two or more syntaxa

formed one compact cluster, this cluster was treated as a unique syntaxon for which its own synoptic column was formed. In this way we prepared 24 synoptic columns for the associations that were published with associated analytical tables. Two additional synoptic columns were formed for the two associations described by PAVLOVIĆ (1955, 1962), each on the basis of two relevés from different localities (ass. 1.1.22 – *Brometum fibrosi* and ass. 1.1.23 – *Halacsyo sendtneri-Potentilletum mollis*). It should be emphasised, however, that a conclusive judgement regarding these associations can only be made after more comprehensive analyses of dry grasslands on the Balkans – a study being in course (Vassilev et al., in prep.), as well as the critical revision of the currently used association concept. Since the aim of our study was not to evaluate syntaxa at association level, we used in our analyses practically all known associations traditionally classified within the order *Halacsyetalia sendtneri*, which were treated in the same form in more recent studies of AĆIĆ et al. (2015) and VASSILEV et al. (2016).

Considering the above-mentioned shortcomings of our dataset, numerical approaches of phytosociological classification based on the direct translation of the results of statistical analyses into a syntaxonomic scheme could not be applied. Consequently, the classification of the synoptic table (on the basis of which we proposed a new syntaxonomic concept) was carried out based on combined "classical phytosociological methods" (table sorting using simple numerical tools, e.g. calculated frequencies, as proposed by TICHÝ et al. 2012) including the determination of a relative diagnostic/fidelity value, which was used as additional parameter while sorting the columns of the synoptic table.

Taxa in the synoptic table were represented by constancy (expressed in percentage) and relative fidelity (written as a superscript of the constancy value: ** if *phi* was ≥ 0.5 and * if it was ≥ 0.25). *Phi* values are given only for synoptic columns of analytical tables.

The approach of "relative fidelity" has been used to search for the optimum occurrence of a species among a group of floristically similar communities (WILLNER 2006, WILLNER et al. 2009). In this case, we calculated the diagnostic value (*phi*) not taking into account the distribution of species in all types of vegetation in a geographically defined region, but their distribution within a syntaxon of higher hierarchical level (order *Halacsyetalia sendtneri* as abstract vegetation unit) that includes lower-level syntaxa for which diagnostic species are to be determined.

Criteria for diagnostic and constant species in the diagnosis of syntaxa were as follows:

- Species with *phi* values higher than ≥ 0.25 have been taken into account in the selection of diagnostic species. We considered species as highly diagnostic when *phi* was ≥ 0.50 and as diagnostic when *phi* was ≥ 0.25 (CHYTRÝ 2007).
- The threshold frequency values for constant species were 30% for the order and 40% for the alliances.
- The diagnostic species of classes were determined by use of the EuroVegChecklist Expert System, using the ESL1 species list (MUCINA et al. in press) in the programme JUICE (TICHÝ et al. 2012), except for the species that are not classified yet in the ESL1 (e.g. *Genista hassertiana*, *Polygala doerfleri*).

The diagnostic species of the order *Halacsyetalia sendtneri* proposed by RITTER-STUDNIČKA (1970) as well as possible diagnostic characters of highly frequent and dominant serpentinophytes from our dataset were tested by the analysis of their distribution in the main types of grasslands in Serbia (*Molinio-Arrhenatheretea*, *Festucetalia valesiacae*, *Festucetalia vaginatae*, *Astragalo-Potentilletalia*, *Halacsyetalia sendtneri*) stored in the database of Grassland Vegetation of Serbia (GIVD number: EU-RS-002, AĆIĆ et al. 2012). For that purpose we analysed the distribution of 33 obligate or facultative serpentinophytes within 3,346 relevés formally classified in 5 groups, which correspond to the main types of grasslands in Serbia recognised and characterised in the study of AĆIĆ et al. (2015).

4. Results and Discussion

4.1 Cluster analysis of analytical tables

Various algorithms and (dis)similarity measures yielded a very similar clustering topology (resulting clusters not shown). Apart from the associations *Halacsyo sendtneri-Caricetum humilis*, *Euphorbio montenegrinae-Brometum erecti* and *Hyperico barbati-Euphorbietum glabriflorae*, all other analysed associations appeared as "floristically homogenous and well-characterised groups" forming compact clusters regardless of the method applied in the cluster analysis.

The two associations described by KRAUSE & LUDWIG (1956) – *Halacsyo sendtneri-Caricetum humilis* and *Euphorbio montenegrinae-Brometum erecti* – were joined together in one compact cluster in all numerical analyses. Therefore, we treated them as one association (Ass. 1.1.1) in our study. Furthermore, relevés belonging to the association *Hyperico barbati-Euphorbietum glabriflorae* formed two distinct clusters, allowing us to treat relevés recorded on Mt. Kopaonik as belonging to a different association, named here provisionally as *Carici kitaibelianae–Euphorbietum glabriflorae* (Ass. 1.1.21).

4.2 Syntaxonomy and nomenclatural adjustments

4.2.1 Syntaxonomy and delimitation of the order *Halacsyetalia sendtneri*

Land use and related anthropogenic influences on the Balkan Peninsula have been very intensive in the past. As a result, naturally occurring forest vegetation types have been degraded, leading to an expansion of secondary grasslands. Dry open rocky grassland vegetation on thin sceletogenous shallow ultramafic soils in the central Balkans (steppic vegetation on ultramafic soils in the Balkans) included in the order *Halacsyetalia sendtneri* represents typical secondary grasslands, which have developed mainly in the zone of thermophilous mixed deciduous broadleaved forests [*Quercion frainetto* Horvat 1954, *Quercion petraeacerris* (Lakušić et Jovanović 1980) Čarni et al. 2009] and pine forests (*Erico-Pinetalia* Horvat 1959) and sporadically on south-exposed slopes in the zone of montane to subalpine beech forests (*Fagetalia sylvaticae* Pawlowski et al. 1928, HORVAT et al. 1974). The presence of woody (*Cotinus coggygria*, *Fraxinus ornus*, *Pinus nigra*, *Prunus mahaleb*, *Quercus cerris*, *Quercus pubescens*) and shrub species (*Genista ovata*, *Genista tinctoria*, *Juniperus oxycedrus*, *Lembotropis nigricans*, *Rosa pendulina*, *Rosa pimpinellifolia*) within the analysed syntaxa indicates that in some of them the progressive succession could continue in the direction of re-establishment of the afore-mentioned forests.

Although all relevant national (LAKUŠIĆ et al. 1978, ZUPANČIČ 1986, KOJIĆ et al. 1998, 2004, LAKUŠIĆ & SABOVLJEVIĆ 2005, AĆIĆ et al. 2014, 2015) and regional (RODWELL et al. 2002, MUCINA et al. in press) syntaxonomic reviews treat secondary open rocky grasslands developed on shallow sceletogenous ultramafic soils in the central Balkans as uniqe independent order *Halacsyetalia sendtneri* as proposed by RITTER-STUDNIČKA (1970), the syntaxonomic position of this order in different systems of classification has varied in the past. Namely, even though in the original description RITTER-STUDNIČKA (1970) classified the order *Halacsyetalia sendtneri* within the class *Festuco-Brometea*, LAKUŠIĆ et al. (1978) listed it within *Thero-Brachypodietea* Br.-Bl. 1947, ZUPANČIČ (1986) and KOJIĆ et al. (1998) considered it to be part of *Festucetea vaginatae* Soó 1968, while LAKUŠIĆ & RANĐELOVIĆ (1996), RODWELL et al. (2002), KOJIĆ et al. (2004), and AĆIĆ et al. (2014, 2015) classified it

back in *Festuco-Brometea*. Finally, a recent proposal by MUCINA et al. (in press) changed the position of this syntaxon classifying it within the class *Koelerio-Corynephoretea* Klika in Klika et Novák 1941. However, in the classification of the vegetation of South-Eastern Europe proposed by HORVAT et al. (1974), this type of vegetation was discussed in the context of azonal pine forests (*Erico-Pinetea* Horvat 1959).

Regardless of the fact that within the analysed associations many taxa diagnostic for the class *Koelerio-Corynephoretea* are registered (e.g. *Arenaria leptoclados*, *A. serpyllifolia*, *Festuca ovina*, *Logfia arvensis*, *Petrorhagia prolifera*, *P. saxifraga*, *Plantago holosteum*, *Potentilla inclinata*, *Rumex acetosella*, *Scleranthus anuus*, *S. perennis* subsp. *perennis*, *Sedum acre*, *S. rupestre*, *S. sexangulare*, *Sideritis montana*, *Trifolium arvense*, *T. campestre* etc.), which was the main argument of some authors to exclude the order *Halacsyetalia sendtneri* from the class *Festuco-Brometea*, the EuroVegChecklist Expert System assigned 98% of analysed relevés to the class *Festuco-Brometea* and only 1% to the class *Koelerio-Corynephoretea*. This formal classification is consistent with the fact that within the analysed associations, taxa diagnostic for the class *Festuco-Brometea* (e.g. *Allium flavum*, *Artemisia alba*, *Asperula cynanchica*, *A. purpurea*, *Astragalus onobrychis*, *Carex caryophyllea*, *C. humilis*, *Centaurea biebersteinii*, *Chrysopogon gryllus*, *Danthonia alpina*, *Dorycnium pentaphyllum* subsp. *germanicum*, *Festuca panciciana*, *F. valesiaca*, *Hippocrepis comosa*, etc.) have the highest frequency and abundance (Supplement S1).

The uniqueness of the order *Halacsyetalia sendtneri* is unambiguously confirmed in a recently published study on classification, ecology and biodiversity of Central Balkan dry grasslands, which analysed a large data set of phytosociological relevés (1,897 relevés with 1,323 species) of grasslands included in the classes *Festuco-Brometea* and *Festucetea vaginatae* (AĆIĆ et al. 2015). This study has shown that the main core of diagnostic species of the order are obligate serpentinophytes endemic to the Balkan. Many of them are stenoendemic plants or Tertiary relicts with a wider distribution on serpentinite areas of the Central Balkan Peninsula (BLEČIĆ et al. 1969, RITTER-STUDNIČKA 1970, STEVANOVIĆ et al. 2003, TOMOVIĆ et al. 2014, AĆIĆ et al. 2015).

In our dataset 499 taxa were registered within the analysed associations. Forty nine of them represent obligate or facultative serpentinophytes, of which forty are endemics of the Balkan Peninsula: *Alyssum montanum* subsp. *serbicum*, *Alyssum markgrafii*, *Alyssum bertolonii* subsp. *scutarinum*, *Aster albanicus*, *Bornmuellera dieckii*, *Centaurea kosaninii*, *Convolvulus boissieri* subsp. *compactus*, *Dianthus sylvestris* f. *papillosus*, *Dianthus pinifolius* subsp. *serbicus*, *Dianthus giganteus* subsp. *croaticus*, *Eryngium serbicum*, *Euphorbia glabriflora*, *Euphorbia montenegrina*, *Euphorbia serpentini*, *Fumana bonapartei*, *Genista hassertiana*, *Halacsya sendtneri*, *Haplophyllum boissierianum*, *Linaria rubioides*, *Linum tauricum* subsp. *serbicum*, *Polygala doerfleri*, *Polygonum albanicum*, *Potentilla mollis*, *Potentilla visianii*, *Sanguisorba albanica*, *Saponaria sicula* subsp. *intermedia*, *Scabiosa fumarioides*, *Scrophularia canina* subsp. *tristis*, *Sedum serpentini*, *Sesleria serbica*, *Silene bupleuroides* subsp. *staticifolia*, *Stachys recta* subsp. *baldaccii*, *Stachys scardica*, *Stipa mayeri*, *Stipa novakii*, *Tragopogon pterodes*, *Tulipa serbica*, *Verbascum glabratum* subsp. *bosnense*, *Viola beckiana* and *Viola kopaonikensis* (STEVANOVIĆ et al. 2003, TOMOVIĆ et al. 2014).

Given that many of these taxa were proposed by RITTER-STUDNIČKA (1970) as diagnostic for the order *Halacsyetalia sendtneri* and that many highly frequent and dominant serpentinophytes from our dataset have diagnostic character, we analysed their distribution in other types of grasslands stored in the database of Grassland Vegetation of Serbia (GIVD number: EU-RS-002, AĆIĆ et al. 2012). In fact we analysed the distribution of 33 obligate or faculta-

tive serpentinophytes whitin 3,346 relevés formally classified in 5 groups, which correspond to the main types of grasslands in Serbia (*Molinio-Arrhenteretea*, *Festucetalia valesiacae*, *Festucetalia vaginatae*, *Astragalo-Potentilletalia* and *Halacsyetalia sendtneri*). The results of this analysis have shown that all analysed serpentinophytes, both endemic and non-endemic, are almost completely restricted to dry open rocky grasslands on shallow sceletogenous ultramafic soils and that they may be considered as diagnostic for the order *Halacsyetalia sendtneri* and associated alliances (Table 4).

Although large serpentinite areas are also present in the southern and southeastern part of the Balkan Peninsula (large areas in Greece and smaller portions in Bulgaria and Macedonia, see Figure 1 and STEVANOVIĆ et al. 2003), where similar dry grasslands on metalliferous soils are found, recent studies have shown that associations from Greece and Bulgaria should be assigned to the order *Astragalo-Potentilletalia* (BABALONAS et al. 1997, TZONEV et al. 2013).

4.2.2 Nomenclatural adjustments

4.2.2.1 Nomenclatural adjustments at order level

***Halacsyetalia sendtneri* Ritter-Studnička 1970 (*Festuco-Brometea*)**

Name-giving species: *Halacsya sendtneri* (Boiss.) Dörfler
Typus: *Potentillion visianii* Ritter-Studnička 1970 (*lectotypus hoc loco*)
Diagnostic taxa: *Alyssum markgrafii*, *A. montanum* subsp. *serbicum*, *Asplenium cuneifolium*, *Bromus fibrosus*, *B. pannonicus*, *Dianthus sylvestris* f. *papillosus*, *Echium rubrum*, *Euphorbia glabriflora*, *Fumana bonapartei*, *Halacsya sendtneri*, *Linum tauricum* subsp. *serbicum*, *Notholaena marantae*, *Potentilla australis*, *P. visianii*, *Scabiosa fumarioides*, *Sedum serpentini*, *Silene bupleuroides* subsp. *staticifolia*, *S. paradoxa*, *Stachys recta* subsp. *baldaccii*, *S. scardica*.
Constant taxa: *Acinos alpinus*, *Aethionema saxatile*, *Allium flavum*, *Alyssum montatnum* subsp. *serbicum*, *A. markgrafii*, *A. murale*, *Artemisia alba*, *Asperula cynanchica*, *A. purpurea*, *Asplenium cuneifolium*, *Astragalus onobrychis*, *Bromus fibrosus*, *Carex caryophyllea*, *C. humilis*, *Centaurea biebersteinii*, *Chrysopogon gryllus*, *Dorycnium pentaphyllum* subsp. *germanicum*, *Echium rubrum*, *Euphorbia cyparissias*, *E. glabriflora*, *Festuca valesiaca*, *Fraxinus ornus*, *Galium lucidum*, *Halacsya sendtneri*, *Hieracium bauhinii*, *Hypericum barbatum*, *Iris reichenbachii*, *Juniperus oxycedrus*, *Leontodon crispus*, *Lotus corniculatus*, *Medicago prostrata*, *Melica ciliata*, *Minuartia verna*, *Notholaena marantae*, *Petrorhagia saxifraga*, *Plantago holosteum*, *Poa badensis*, *Potentilla australis*, *P. pedata*, *Rumex acetosella*, *Sanguisorba minor*, *Scabiosa columbaria*, *Scleranthus perennis* subsp. *dichotomus*, *Sedum hispanicum*, *Sedum serpentini*, *Silene bupleuroides* subsp. *staticifolia*, *Silene paradoxa*, *Stachys recta*, *Stachys recta* subsp. *baldaccii*, *Stachys scardica*, *Stipa novakii*, *Teucrium montanum*, *Thymus jankae*, *T. longicaulis*.
Distribution: Central part of the Balkan Peninsula, in the territories of Bosnia and Herzegovina, Serbia and Kosovo, Montenegro and Albania (probably also in N Macedonia). From a synchorological viewpoint, the *Halacsyetalia sendtneri* vegetation belongs to the two main Balkan biogeographical provinces: Illyrian (Dinaric Alps) and the northern part of Scardo-Pindian (Scardian Mts.) (sensu HORVAT et al. 1974).
Diagnosis: Rocky steppic grasslands over shallow soils on ultramafic bedrocks in the Central Balkans.

Table 4. Distribution of 33 obligate or facultative serpentinophytes within the main types of grasslands in Serbia. Legend: Hal – diagnostic for the order *Halascyetalia sendtneri*, Pvis – diagnostic for the alliance *Potentillion visianii*, CBfib – diagnostic for the alliance *Centaureo kosaninii-Bromion fibrosi*, Tjan – diagnostic for the alliance "*Thymion jankae*".

Tabelle 4. Verbreitung von 33 obligaten oder fakultativen Sepentinophyten innerhalb der Haupt-Graslandtypen Serbiens. Hal – diagnostische Arten der Ordnung *Halascyetalia sendtneri*, Pvis – diagnostische Arten des Verbands *Potentillion visianii*, CBfib – diagnostische Arten des Verbands *Centaureo kosaninii-Bromion fibrosi*, Tjan – diagnostische Arten des Verband "*Thymion jankae*".

	Group No.	1		2		3		4		5	
	Syntaxon	*Molinio-Arrhenteretea*		*Festucetalia valesiacae*		*Festucetalia vaginatae*		*Astragalo-Potentilletalia*		*Halacsyetalia sendtneri*	
	No. of releves	1351		1066		619		162		148	
	Taxon	%	*phi*	%	*phi*	%	*phi*	%	*phi*	%	*phi*
Hal	*Alyssum markgrafii*	.	–	2	–	2	–	.	–	**58**	**28**
Hal	*Euphorbia glabriflora*	.	–	.	–	1	–	.	–	**55**	**38**
Hal	*Stachys recta* incl. *S.*baldaccii*	.	–	5	–	22	1.5	7	–	**49**	**15**
Hal	*Stachys scardica*	.	–	6	–	.	–	.	–	**46**	**23**
Hal	*Bromus fibrosus*	.	–	1	–	2	–	1	–	**45**	**25**
Hal	*Silene bupleuroides* incl. *S.*staticifolia*	.	–	1	–	3	–	.	–	**28**	**18**
Hal	*Echium rubrum*	.	–	1	–	.	–	.	–	**27**	**18**
Hal	*Sedum album* (incl. *S. serpentini*)	.	–	1	–	3	–	.	–	**27**	**25**
Hal	*Potentilla australis*	.	–	2	–	.	–	.	–	**26**	**16**
Hal	*Halacsya sendtneri*	.	–	.	–	.	–	.	–	**18**	**19**
Hal	*Dianthus sylvestris* incl. *D.*papillosus*	.	–	.	–	1	–	.	–	**16**	**17**
Hal	*Silene paradoxa*	.	–	.	–	.	–	.	–	**16**	**16**
Hal	*Fumana bonapartei*	.	–	.	–	.	–	.	–	15	15
Hal	*Linum*serbicum*	.	–	1	–	.	–	.	–	15	12
Hal	*Notholaena marantae*	.	–	.	–	.	–	.	–	12	14
Hal	*Scabiosa fumarioides*	.	–	1	–	.	–	.	–	**10**	**21**
Hal	*Dianthus*serbicus*	.	–	.	–	.	–	.	–	**9**	**18**
Hal	*Alyssum*serbicum*	.	–	.	–	.	–	.	–	6	9.7
Hal	*Asplenium cuneifolium*	.	–	.	–	.	–	.	–	5	8.2
Pvis	*Tragopogon pterodes*	.	–	.	–	.	–	.	–	7	10
Pvis	*Stipa novakii*	.	–	.	–	.	–	.	–	3	7.8
Pvis	*Alyssum*scutarinum*	.	–	.	–	.	–	.	–	2	5.7
Pvis	*Eryngium serbicum*	.	–	.	–	.	–	.	–	1	6.7
Pvis	*Haplophyllum boissieranum*	.	–	.	–	.	–	.	–	1	4.2
CBfib	*Centaurea kosaninii*	.	–	.	–	.	–	.	–	**16**	**21**
CBfib	*Polygala doerfleri*	.	–	.	–	.	–	.	–	9	11
CBfib	*Saponaria*intermedia*	.	–	.	–	.	–	.	–	9	12
CBfib	*Convolvulus*compactus*	.	–	.	–	.	–	.	–	**7**	**21**
CBfib	*Stipa mayeri*	.	–	.	–	.	–	.	–	7	13
CBfib	*Genista hassertiana*	.	–	.	–	.	–	.	–	5	12
CBfib	*Aster albanicus*	.	–	.	–	.	–	.	–	1	4.6
CBfib	*Sanguisorba albanica*	.	–	.	–	.	–	.	–	1	4.2
Tjan	*Bornmuellera dieckii*	.	–	.	–	.	–	.	–	**13**	**19**

Syntaxonomy and nomenclature: Although many taxa diagnostic for the class *Koelerio-Corynephoretea* are present in the analysed associations, the results of our study confirmed the opinion of the authors who classified the analysed order in the class *Festuco-Brometea* (RITTER-STUDNIČKA 1970, LAKUŠIĆ & RANĐELOVIĆ 1996, RODWELL et al. 2002, KOJIĆ et al. 2004, AĆIĆ et al. 2014, 2015).

The order *Halacsyetalia sendtneri* was originally described along with two alliances. Later the alliance *Centaureo-Bromion fibrosi* Blečić et al. 1969 (ZUPANČIČ 1986, KOJIĆ et al. 1998) was also included in this order, the same concept being applied in an overview of European vegetation proposed by RODWELL et al. (2002).

In the original description, RITTER-STUDNIČKA (1970) proposed 18 taxa as diagnostic for the order. According to the results of our analyses, eight taxa can maintain the status of "diagnostic for the order" (*Alyssum markgrafii*, *Asplenium cuneifolium*, *Bromus pannonicus*, *Dianthus sylvestris* f. *papillosus*, *Halacsya sendtneri*, *Notholaena marantae*, *Silene bupleuroides* subsp. *staticifolia*, *Stachys recta* subsp. *baldaccii*), two can be considered as "diagnostic for the alliance" *Potentillion visiani* (*Dianthus giganteus* subps. *croaticus*, *Scrophularia canina* subsp. *tristis*), while others can be considered as "diagnostic for the class" *Festuco-Brometea* in the area of the Central Balkan peninsula (*Alyssum murale*, *Asperula cynanchica*, *Medicago prostrata*, *Minuartia verna*, *Silene armeria*) or *Koelerio-Corynephoretea* (*Rumex acetosella*, *Scleranthus perennis* subsp. *perennis*, *Sedum ochroleucum*). At the same time, the results of our analyses showed that twelve new taxa can be considered as diagnostic for the order (Supplement S1). Some of them were previously proposed as diagnostic for the alliances, while some were proved as diagnostic for the first time in this work (e.g. *Alyssum montanum* subsp. *serbicum*, *Linum tauricum* subsp. *serbicum*, *Potentilla australis*, *Scabiosa fumarioides*, *Sedum serpentini*, etc.).

4.2.2.2 Nomenclatural adjustments at alliance level

***Potentillion visianii* Ritter-Studnička 1970 (*Halacsyetalia sendtneri*, *Festuco-Brometea*) incl. *Polygonion albanicae* Ritter-Studnička 1970**

Name-giving species: *Potentilla visianii* Pančić
Nomenclature type: *Fumano bonapartei-Euphorbietum glabriflorae* Ritter-Studnička 1970 (*lectotypus hoc loco*)
Diagnostic taxa: *Alyssum bertolonii* subsp. *scutarinum*, *Cardamine plumieri*, *Dianthus giganteus* subsp. *croaticus*, *Eryngium serbicum*, *Euphorbia montenegrina*, *Haplophyllum boissierianum*, *Linaria rubioides*, *Polygonum albanicum*, *Potentilla mollis*, *Scrophularia canina* subsp. *tristis*, *Sesleria serbica*, *Stipa novakii*, *Tragopogon pterodes*, *Tulipa serbica*, *Verbascum glabratum* subsp. *bosnense*, *Viola beckiana*, *Viola kopaonikensis*.
Constant taxa: *Alyssum markgrafii*, *A. murale*, *Artemisia alba*, *Asperula cynanchica*, *A. purpurea*, *Asplenium cuneifolium*, *Astragalus onobrychis*, *Bromus fibrosus*, *Carex humilis*, *Centaurea biebersteinii*, *Dorycnium pentaphyllum* subsp. *germanicum*, *Euphorbia glabriflora*, *Festuca valesiaca*, *Fraxinus ornus*, *Halacsya sendtneri*, *Leontodon crispus*, *Lotus corniculatus*, *Medicago prostrata*, *Melica ciliata*, *Minuartia verna*, *Notholaena marantae*, *Petrorhagia saxifraga*, *Poa badensis*, *Rumex acetosella*, *Sanguisorba minor*, *Silene bupleuroides* subsp. *staticifolia*, *Silene paradoxa*, *Stachys recta* subsp. *baldaccii*, *Stipa novakii*, *Teucrium montanum*, *Thymus jankae*.

Distribution: Central part of the Balkan peninsula, in the territories of C & E Bosnia and Herzegovina, C & W Serbia. From a synchorological viewpoint, the *Potentillion visianii* vegetation is restricted to the Illyrian biogeographical province (Dinaric Alps) (sensu HORVAT et al. 1974).

Diagnosis: Rocky steppic grasslands over ultramafic bedrocks in Bosnia and Herzegovina and C & W Serbia.

Syntaxonomy and nomenclature: The alliance *Potentillion visianii* was described by RITTER-STUDNIČKA (1970). Following the original diagnosis, RODWELL et al. (2002) defined this alliance as "rocky steppic grasslands over ultramafic bedrocks in Eastern Bosnia". In the same paper, RITTER-STUDNIČKA (1970) described another alliance under the name *Polygonion albanicae* Ritter-Studnička 1970, which was also treated in the overview of RODWELL et al. (2002), defined as "rocky steppic grasslands over ultramafic bedrocks in Central Bosnia".

Although the above-mentioned alliances were validly published as being accompanied by several associations supported with synoptic tables (ICPN Art. 7), the analyses of our complete dataset did not confirm their specificity. Thus out of six taxa singled out by RITTER-STUDNIČKA (1970) as diagnostic for the alliance *Polygonion albanicae*, three can be considered as diagnostic for the class *Festuco-Brometea* (*Centaurea biebersteinii* subsp. *biebersteinii*, *Lotus corniculatus*, *Dorycnium pentaphyllum* subsp. *germanicum*). *Sesleria latifolia* is a common species of rocky grassland occurring on limestone bedrock (*Festuco-Brometea*, JOVANOVIĆ-DUNJIĆ 1955, 1956, PEDASHENKO et al. 2013, VASSILEV et al. 2014) and subalpine grasslands (*Elyno-Seslerietea*, JOVANOVIĆ et al. 1992, RANĐELOVIĆ et al. 1979, RANĐELOVIĆ & REXHEPI 1984). Therefore, only *Euphorbia montenegrina* and *Polygonum albanicum* exhibit higher affinity to serpentine rocky grasslands of Central Bosnia and Herzegovina. It should be noted that part of the populations of *Euphorbia montenegrina* are inhabiting subalpine grasslands on silicates (*Juncetea trifidi*) and carbonates (*Elyno-Seslerietea*) in Montenegro and Bosnia and Herzegovina (ŠILIĆ 1984) and that the obligate serpentine species *Polygonum albanicum* was also recorded on the serpentine outcrops of northern Albania and Greece (AKEROYD 1987, STEVANOVIĆ et al. 2003). Similarly, out of twelve taxa defined by RITTER-STUDNIČKA (1970) as diagnostic for the alliance *Potentillion visianii*, only *Linaria rubioides*, *Potentilla mollis* and *Verbascum glabratum* subsp. *bosnense* can be considered as characteristic for the serpentine grasslands of Eastern Bosnia and Herzegovina, provided that the significant part of their areas are also on serpentinites of Western Serbia. Moreover, with the exception of *Erysimum linariifolium* and *Silene vulgaris*, which occur also in non-serpentine habitats, other taxa determined as diagnostic for the alliance *Potentillion visianii* by RITTER-STUDNIČKA (1970) occur exclusively on serpentinites of Kosovo and Southern Serbia as well and should therefore be considered as diagnostic for the order.

Furthermore, infraspecific taxa defined as diagnostic for the alliances *Polygonion albanicae* and *Potentillion visianii* by RITTER-STUDNIČKA (1970) – *Sesleria latifolia* (Adam.) Degen var. *serpentinica* Deyl, *Dorycnium germanicum* (Gremli) Rouy var. *serpentinicola* Rt., *Lotus corniculatus* L. f. *serpentina* Novák, *Armeria canescens* Host var. *serpentina* Novák and *Silene cucubalus* Wibel var. *zlatiborensis* Novák – are, according to the most recent taxonomic treatments (e.g. EURO+MED 2006), neglected or considered conspecific with broadly defined species (*Sesleria latifolia*, *Dorycnium pentaphyllum*, *Lotus corniculatus*, *Armeria canescens* and *Silene vulgaris* agg.). Considering the fact that syntaxa belonging to the two mentioned alliances share a significant number of taxa and that almost all the

identified diagnostic taxa are also present on the territory of Serbia, we included in the *Potentillion visianii* all syntaxa occuring either on the serpentine outcrops in Central and Eastern Bosnia and Herzegovina or on the serpentinites in C & W Serbia and N Kosovo. For the moment, we also included the assocations published by PAVLOVIĆ (1955, 1962) – *Halacsyo sendtneri-Potentilletum mollis* and *Brometum fibrosi* – in this alliance, on the basis of their floristic composition.

The following associations are currently included in this alliance:

Ass. 1.1.1 – *Halacsyo sendtneri-Caricetum humilis* Krause & Ludwig 1956 *nomen inversum propositum* (incl. *Euphorbio montenegrinae-Brometum erecti* Krause & Ludwig 1956)

Ass. 1.1.2 – *Violo beckianae-Seslerietum serbicae* Krause & Ludwig 1957 *nomen inversum propositum*

Ass. 1.1.3 – *Halacsyo sendtnerii-Seselietum rigidae* Ritter-Studnička 1970 *nomen inversum propositum*

Ass. 1.1.4 – *Dorycnio germanicae-Scabietosum cinereae* Ritter-Studnička 1970 *nomen mutatum propositum*

Ass. 1.1.5 – *Alysso muralis-Silenetum vulgaris* (Ritter-Studnička 1970) Kuzmanović *et al. nom. nov. hoc loco*

Ass. 1.1.6 – *Erysimo linariifoliae-Jovibarbetum heuffelii* Ritter-Studnička 1970 *nomen mutatum propositum*

Ass. 1.1.7 – *Fumano bonapartei-Euphorbietum glabriflorae* Ritter-Studnička 1970 *nomen inversum propositum*

Ass. 1.1.8 – *Scrophulario tristis-Linarietum rubioides* Ritter-Studnička 1970 *nomen mutatum propositum*

Ass. 1.1.9 – *Stipetum novakii* Kabaš et D. Lakušić in Kabaš et al. 2013

Ass. 1.1.10 – *Potentillo tommasinianae-Stipetum novakii* A. Marković ex Aćić et al. 2014 *nomen mutatum propositum*

Ass. 1.1.11 – *Bromo fibrosi-Chrysopogonetum grylli* Tatić 1969

Ass. 1.1.12 – *Bromo fibrosi-Artemisietum albae* A. Marković ex Aćić et al. 2014

Ass. 1.1.13 – *Alysso markgrafii-Artemisietum albae* Aćić et al. 2014

Ass. 1.1.14 – *Artemisio albae-Achnatheretum calamagrostis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014

Ass. 1.1.15 – *Festuco ovinae-Euphorbietum glabriflorae* S. Jovanović et R. Jovanović-Dunjić in S. Jovanović et al. ex Aćić et al. 2014

Ass. 1.1.16 – *Potentillo tommasinianae-Festucetum pancicianae* D. Lakušić et Kabaš in Aćić et al. 2014

Ass. 1.1.17 – *Festuco pancicianae-Caricetum humilis* Jovanović-Dunjić et S. Jovanović ex Aćić et al. 2014

Ass. 1.1.18 – *Seslerio serbicae-Caricetum humilis* D. Lakušić et Kabaš in Aćić et al. 2014

Ass. 1.1.19 – *Potentillo tommasinianae-Fumanetum bonapartei* Rexhepi ex Aćić et al. 2014

Ass. 1.1.20 – *Sedo serpentini-Dianthetum serbici* Pavlović 1967

Ass. 1.1.21 – *Carici kitaibelianae-Euphorbietum glabriflorae nom. prov.*

Ass. 1.1.22 – *Brometum fibrosi* Pavlović 1962

Ass. 1.1.23 – *Halacsyo sendtneri-Potentilletum mollis* Pavlović 1955

***Centaureo kosaninii-Bromion fibrosi* Blečić et al. 1969 (*Halacsyetalia sendtneri*, *Festuco-Brometea*)**

Orig. *Centaureo-Bromion fibrosi* Blečić et al. 1969
Name-giving species: *Centaurea kosaninii* Hayek, *Bromus fibrosus* Hack.
Nomenclature type: *Polygalo doerfleri-Genistetum hassertianae* Blečić et al. 1969 (*lectotypus hoc loco*)
Diagnostic taxa: *Aster albanicus*, *Centaurea kosaninii*, *Convolvulus boissieri* subsp. *compactus*, *Genista hassertiana*, *Polygala doerfleri*, *Sanguisorba albanica*, *Saponaria sicula* subsp. *intermedia*, *Stipa mayeri*.
Constant taxa: *Achillea coarctata*, *Acinos alpinus*, *Agropyron cristatum*, *Allium flavum*, *Alyssum markgrafii*, *A. montanum* subsp. *serbicum*, *Anthyllis vulneraria*, *Artemisia alba*, *Astragalus onobrychis*, *Bromus fibrosus*, *Carex caryophyllea*, *C. praecox*, *Centaurea kosaninii*, *C. stereophylla*, *Convolvulus cantabrica*, *Dorycnium penthaphyllum* subsp.*germanicum*, *Erysimum diffusum*, *Euphorbia cyparissias*, *E. glabriflora*, *Festuca panciciana*, *Filipendula vulgaris*, *Galium lucidum*, *Halacsya sendtneri*, *Hieracium bauhinii*, *H. cymosum*, *Hippocrepis comosa*, *Hypericum barbatum*, *H. perforatum*, *Iris reichenbachii*, *Juniperus oxycedrus*, *Koeleria macrantha*, *Leontodon crispus*, *Linum perenne*, *Lotus corniculatus*, *Melica ciliata*, *Minuartia verna*, *Orobanche gracilis*, *Petrorhagia saxifraga*, *Plantago argentea*, *P. holosteum*, *P. lanceolata*, *Poa badensis*, *Polygala doerfleri*, *Potentilla argentea*, *P. pedata*, *Rumex acetosella*, *Sanguisorba minor*, *Scabiosa columbaria*, *Scorzonera laciniata*, *Sedum ochroleucum*, *S. serpentini*, *Silene bupleuroides* subsp. *staticifolia*, *S. paradoxa*, *S. vulgaris*, *Stachys recta* subsp. *baldaccii*, *S. scardica*, *Stipa pulcherrima*, *Teucrium montanum*, *Thesium arvense*, *Thymus longicaulis*, *Vincetoxicum fuscatum*.
Distribution: Central part of the Balkan peninsula, in the territories of S Serbia, Kosovo and N Albania. From a synchorological viewpoint, the *Centaureo kosaninii-Bromion fibrosi* vegetation is typical for the northern part of the Scardo-Pindian biogeographical province (Scardian Mts.) (sensu HORVAT et al. 1974).
Diagnosis: Rocky steppic grasslands over ultramafic bedrocks in S Serbia, Kosovo and N Albania.
Syntaxonomy and nomenclature: The alliance *Centaureo kosaninii-Bromion fibrosi* was described by BLEČIĆ et al. (1969). Following the original diagnosis, RODWELL et al. (2002) defined this alliance as "rocky steppic grasslands over ultramafic bedrocks in Serbia and Albania". The analyses of our complete dataset verified *Centaureo kosaninii-Bromion fibrosi* as well-defined alliance. However, it turned out that the broadly defined concept of the *Centaureo kosaninii-Bromion fibrosi* proposed by ZUPANČIČ (1986) and RODWELL et al. (2002), which included all rocky steppic grasslands over ultramafic bedrock in Serbia and Albania, is not adequate. The results of our analyses suggest that this alliance should be restricted to the rocky grasslands occurring on the territories of South Serbia (personal field observation in surrounding of Preševo), Kosovo and North Albania (personal field observation in surrounding of Shkoder). This distinction is not merely geographic, but also based on different climatic conditions, with the prevailing influence of the Mediterranean climate from the south. Additionally, the main part of the area of this alliance is situated in the northern part of the Scardo-Pindic phytogeographic province (sensu HORVAT el. 1974).

In the original description, BLEČIĆ et al. (1969) proposed 10 taxa as diagnostic for the alliance. According to the results of our analyses, only *Centaurea kosaninii* can maintain the status "diagnostic for the alliance", while *Bromus fibrosus* can be considered as diagnostic for the order *Halacsyetalia sendtneri*. All other taxa originally defined as "diagnostic for the

alliance" are in fact typical *Festuco-Brometea* (*Astragalus onobrychis*, *Galium lucidum*, *Potentilla pedata*, *Scabiosa columbaria*, *Teucrium montanum*, *Thymus longicaulis*) or *Koelerieo-Corynephoretea* species (*Plantago holosteum*, *Poa badensis*). Moreover, we identified seven new taxa that can be considered as diagnostic for the alliance. This alliance was characterised by many endemic taxa, suggesting that historical biogeographic events have had a significant influence on the differentiation of the flora within this region. Thus, local endemic taxa were found within this group (obligate serpentine endemics sensu STEVANOVIĆ et al. 2003), such as *Aster albanicus*, *Centaurea kosaninii*, *Genista hassertiana*, *Polygala doerfleri*, *Sanguisorba albanica*, *Saponaria sicula* subsp. *intermedia* and *Stipa mayeri*.

The following associations are currently included in it:

Ass. 1.2.1 – *Cynancho fuscati-Saponarietum intermediae* Blečić et al. 1969 *nomen mutatum propositum*
Ass. 1.2.2 – *Centaureo kosaninii-Euphorbietum glabriflorae* S. Jovanović et V. Stevanović in Aćić et al. 2014
Ass. 1.2.3 – *Polygalo doerfleri-Genistetum hassertianae* Blečić et al. 1969
Ass. 1.2.4 – *Hyperico barbati-Euphorbietum glabriflorae* Rexhepi ex Aćić et al. 2014
Ass. 1.2.5 – *Onosmo echioidis-Scabiosetum fumarioidis* Rexhepi ex Aćić et al. 2014
Ass. 1.2.6 – *Stipo mayeri-Convolvuletum compacti* Milaku et al. 2011

"*Thymion jankae*"

The peculiarity of the associations of the type "*Poo-Plantaginetum holostei*" was noticed by KOJIĆ et al. (1992). They proposed a new alliance *Thymion jankae* citing the following characteristic taxa: *Rumex acetosella*, *Carex verna*, *Cerastium glutinosum*, *Potentilla inclinata* and *Thymus jankae*. However, this name was not validly published since the nomenclatural type for the association that was determined as typical for this alliance was not indicated as required by Art. 5. These associations dominated by *Plantago holosteum* (incl. *P. carinata*, *P. subulata*) and small grasses from the *Poa badensis* group (*Poa badensis*, *P. concinna*, *P. molinieri*, *P. perconcinna*) were classified in the order *Halacsyetalia sendtneri* by AĆIĆ et al. (2014).

The thermophilous pioneer grasslands and therophyte sward communities of ultramafic fine-grained and shallow soils and rocky outcrops in the Central Balkans, named here as associations of the type "*Poo-Plantaginetum holostei*" and segregated by KOJIĆ et al. (1992) in the alliance *Thymion jankae* are physiognomically and floristically easily identifiable. All the associations included in this group are floristically rather poor. Given the absence of typical species of the order *Halascyetalia sendtneri* and the presence of taxa diagnostic for the class *Koelerio-Corynephoretea* (*Plantago holosteum*, *Scleranthus perennis* subsp. *perennis*, *S. perennis* subsp. *dichotomus*, *S. annuus*, *Rumex acetosella*), these assocations could even be classified within the latter class and not *Festuco-Brometea*. Given that, as mentioned before, our data suffer from serious methodological problems with respect to plot sizes and gaps in data on cryptogams, a more accurate judgement regarding the syntaxonomic position of these syntaxa can only be made after additional detailed field surveys.

As pointed out in the paper of PEDASHENKO et al. (2013), little attention has been paid to studying this type of vegetation in the Balkans. The main problem is that there are no records of bryophytes and lichens in published associations for the territories of Serbia and Kosovo, which was already discussed in a wider context of phytocenoses of SE European grasslands by PEDASHENKO et al. (2013) and APOSTOLOVA et al. (2014). Additional issues that have

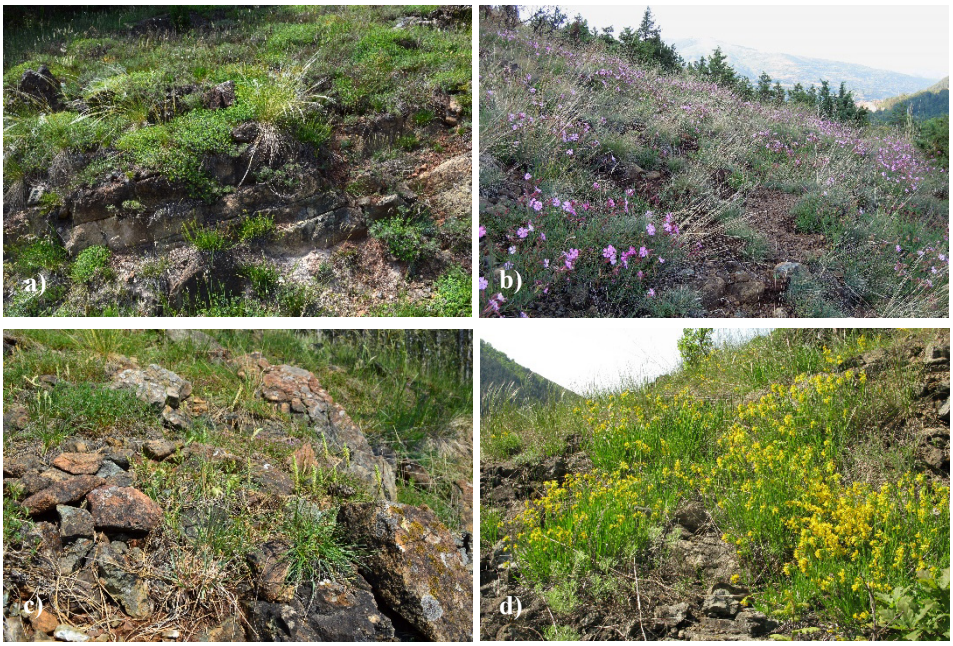

Fig. 2. Steppe-like vegetation on shallow ultramafic soils in the Balkans included in the order *Halacsyetalia sendtneri*. **a)** Stand of a *Festuco ovinae-Euphorbietum glabriflorae* (*Potentillion visianii*) in the Mt Zlatibor Mountain, Serbia. Visible are *Artemisia alba*, *Euphorbia glabriflora*, *Halacsya sendtneri* and *Stipa* gr. *pulcherrima* (Photo: N. Kuzmanović, 12.06.2015). **b)** Stand of a *Cynancho vincetoxici-Saponarietum intermediae* (*Centaureo kosaninii-Bromion fibrosi*) in the Mt Šarplanina Mountain, Brezovica, Gradište, Kosovo. Visible are *Festuca* gr. *valesiaca* and *Saponaria sicula* subsp. *intermedia* (Photo: M. Lazarević, 11.08.2014). **c)** Stand of a *Poo alpinae-Plantaginetum holostei* ("*Thymion jankae*") in the Mt Tara Mountain, Kremna, Serbia. Visible are *Plantago holosteum*, *Poa badensis* gr. and *Thymus jankae* (Photo: N. Kuzmanović, 10.06.2015). **d)** Stand of a *Stipetum novakii* (*Potentillion visianii*) in the Brđani-Schlucht, Serbia. Visible are *Halacsya sendtneri*, *Stipa novakii* und *Artemisia alba* sowie Gebüsche aus *Quercus cerris* und *Fraxinus ornus*. (Foto: D. Lakušić, 10.05.2011).

Abb. 2. Steppenrasen der Ordnung *Halacsyetalia sendtneri* auf flachgründig-ultramafischen Böden auf dem Balkan. **a)** Bestand eines *Festuco ovinae-Euphorbietum glabriflorae* (*Potentillion visianii*) am Mt Zlatibor, Serbien mit *Artemisia alba*, *Euphorbia glabriflora*, *Halacsya sendtneri* und *Stipa* gr. *pulcherrima* (Foto: N. Kuzmanović, 12.06.2015). **b)** Bestand eines *Cynancho vincetoxici-Saponarietum intermediae* (*Centaureo kosaninii-Bromion fibrosi*) am Mt Šarplanina, Brezovica, Gradište, Kosovo, mit *Festuca* gr. *valesiaca*, *Saponaria sicula* subsp. *intermedia* (Foto: M. Lazarević, 11. 08.2014). **c)** Bestand eines *Poo alpinae-Plantaginetum holostei* ("*Thymion jankae*") am Mt Tara, Kremna, Serbien, mit *Plantago holosteum*, *Poa badensis* gr. und *Thymus jankae* (Foto: N. Kuzmanović, 10.06.2015). **d)** Bestand eines *Stipetum novakii* (*Potentillion visianii*) in der Brđani-Schlucht in Serbien mit blühende *Halacsya sendtneri* (nach den österreichischen bzw. deutschen Botanikern Eugen von Halácsy und Otto Sendtner), *Stipa novakii* und *Artemisia alba* sowie Gebüsche aus *Quercus cerris* und *Fraxinus ornus*. (Foto: D. Lakušić, 10.05.2011).

already been pointed out by SOPOTLIEVA & APOSOTOLOVA (2014) were noticed in our study as well: Some associations exhibited transitional character, having almost equal shares of diagnostic taxa of both mentioned classes. The reason for this might be that this transitional association is in a more advanced successional stage. Or it has not been degraded by overgrazing to the same extent as the other associations belonging to this group.

The following associations are currently included in it:

Ass. 1.3.1 – *Sedo serpentini-Bornmuellerietum* dieckii Blečić et al. 1969
Ass. 1.3.2 – *Poo molinerii-Plantaginetum holostei* Pavlović 1951
Ass. 1.3.3 – *Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953 nomen mutatum propositum

Finally, it was rather difficult to determine the final position of the association *Artemisio albae-Silenetum armeriae*. It exhibited high specificity in the cluster analysis, being characterised by a significant number of *Festuco-Brometea* species, but only one character species of the order *Halacsyetalia sendtneri* and one of the alliance "*Thymion jankae*". For the moment we left it classified in the class *Festuco-Brometea*, although it could be placed even in another class after more comprehensive studies of similar syntaxa.

4.2.2.3 Nomenclatural adjustments at association level

Most of the syntaxa published by RITTER-STUDNIČKA (1970) and KRAUSE & LUDWIG (1957) in the form of synoptic tables listed below were validly published (Art. 5 & 7, ICPN, WEBER et al. 2000). Only the name *Silenetum willdenowii serpentinae* of RITTER-STUDNIČKA (1970) is illegitimate according to Art. 34a. The provided corrections are related to their orthographically correct form according to Art. 41 and in some cases adaptations of syntaxa names to taxonomic nomenclature (Art. 45). However, no data were available for designating neotypes (Art. 21) for these associations, and they remained without nomenclatural type. For the two associations published by KRAUSE & LUDWIG (1956), lectotypes have been designated. Another lectotype has been designated for the association *Poo alpinae-Plantaginetum holostei* incorrectly synonymised in AĆIĆ et al. (2014). For the two associations 1.1.10 and 1.2.1, the corrections are related to adaptations of syntaxa names to taxonomic nomenclature (Art. 45). Lectotypes were defined for the determination of the correct names for syntaxa not yet typified.

- *Erysimo linariifoliae-Jovibarbetum heuffelii* Ritter-Studnička 1970 nomen mutatum propositum. Orig. (RITTER-STUDNIČKA 1970): *Erysimo-Semperviretum heuffelii* (Art. 41, 45)
- *Fumano bonapartei-Euphorbietum glabriflorae* Ritter-Studnička 1970 nomen inversum propositum. Orig. (RITTER-STUDNIČKA 1970): *Euphorbio-Fumanetum bonapartei* (Art. 10b, 41, 42)
- *Scrophulario tristis-Linarietum rubioides* Ritter-Studnička 1970 nomen mutatum propositum. Orig. (RITTER-STUDNIČKA 1970): *Linarietum concoloris* (Art. 41, 45)
- *Alysso muralis-Silenetum vulgaris* (Ritter-Studnička 1970) Kuzmanović et al. *nom. nov. hoc loco*. Orig. (RITTER-STUDNIČKA 1970): *Silenetum willdenowii serpentinae nomen illeg.* (Art. 34a, 39)
- *Dorycnio germanicae-Scabietosum cineraeae* Ritter-Studnička 1970 nomen mutatum propositum. Orig. (RITTER-STUDNIČKA 1970): *Dorycnio-Scabiosetum leucophyllae* (Art. 41, 45)

- *Halacsyo sendtnerii-Seselietum rigidae* Ritter-Studnička 1970 Orig. (RITTER-STUDNIČKA 1970): *Halacsyo-Seselietum rigidae* (Art. 41)
- *Violo beckianae-Seslerietum serbicae* Krause et Ludwig 1957 nomen inversum propositum. Orig. (KRAUSE & LUDWIG 1957): *Sesleria rigida-Viola beckiana* (Art. 10b, 41, 42, 45)
- *Euphorbio montenegrinae-Brometum erecti* Krause & Ludwig 1956 1956 nomen inversum propositum. Orig. (KRAUSE & LUDWIG 1956): *Bromus erectus-Euphorbia montenegrina* (Art. 10b, 41, 42). Typus: Krause & Ludwig 1956, Tab. 1, rel. 68 [Lectotypus hoc loco]
- *Halacsyo sendtneri-Caricetum humilis* Krause & Ludwig 1956 nomen inversum propositum. Orig. (KRAUSE & LUDWIG 1956): *Carex humilis-Halacsya sendtneri* (Art. 10b, 41, 42). Typus: Krause & Ludwig 1956, Tab. 1, rel. 82 [Lectotypus hoc loco]
- *Poo alpinae-Plantaginetum holostei* Kojić et Ivanović 1953 nomen mutatum propositum. Orig. (KOJIĆ & IVANOVIĆ 1953): *Poeto alpinae-Plantaginetum carinatae* (Art. 45). Typus: Kojić et Ivanović 1953, Tab. 3, rel. 1 [Lectotypus hoc loco] Note: This association was wrongly listed as homonym of *Poo molinerii-Plantaginetum holostei* Pavlović 1951 in AĆIĆ et al. (2014).
- *Cynancho fuscati-Saponarietum intermediae* Blečić et al. 1969 nomen mutatum propositum. Orig. (BLEČIĆ et al. 1969): *Cynancho vincetoxici-Saponarietum intermediae* (Art. 45)
- *Potentillo tommasinianae-Stipetum novakii* A. Marković ex Aćić et al. 2014 nomen mutatum propositum. Orig. (AĆIĆ et al. 2014): *Potentillo tommasinianae-Stipetum pennatae* (Art. 45)

5. Conclusion and outlook

The results of our study, in which we included all available data on the order *Halascyetalia sendtneri*, are partly in accordance with previous syntaxonomic views. The confirmation of the position of the order *Halascyetalia sendtneri* within the class *Festuco-Brometea* as well as the fact that the order is characterised by a significant number of obligate endemic serpentinophytes confined to the Central Balkan Peninsula allowed us to re-evaluate the alliances traditionally classified in it. We distinguished two alliances (*Centaureo kosaninii-Bromion fibrosi* and *Potentillion visianii*), for which the diagnoses, diagnostic and constant taxa are given. The alliance *Centaureo kosaninii-Bromion fibrosi* is restricted to the rocky grasslands occurring on the territories of South Serbia, Kosovo and North Albania. The area of this alliance is situated in the Scardo-Pindic phytogeographic province influenced by arid Mediterranean climate. The alliance *Potentillion visianii*, in which we also included all syntaxa previously considered as being part of the *Polygonion albanicae*, is restricted to rocky grasslands occurring on the serpentine outcrops in Central and Eastern Bosnia and Herzegovina, Central and West Serbia and North Kosovo. In contrast to the alliance *Centaureo kosaninii-Bromion fibrosi*, the area of the alliance *Potentillion visianii* is situated in the Illyrian biogeographical province, influenced by humid Atlantic climate. Finally, the thermophytic pioneer grasslands and therophyte sward communities included in the alliance *Thymion jankae* (nomen. inval.), characterised by the absence of typical species of the order *Halascyetalia sendtneri* and the presence of taxa diagnostic for the class *Koelerio-*

Corynephoretea, are temporarily left within the order *Halacsyetalia sendtnerii* (class *Festuco-Brometea*), although more detailed field surveys, in which data on cryptogams will be included, are needed for the formal validation of this syntaxon.

Nevertheless, a more detailed syntaxonomic revision of the analysed order *Halacsyetalia sendtneri* as well as a conclusive judgement regarding all the associations currently included in it can only be given after additional detailed field surveys on the territories of Bosnia and Herzegovina, Albania, Montenegro and northern Macedonia and more comprehensive analyses, in which all floristically and ecologically similar syntaxa (e.g. *Astragalo-Potentilletalia*, *Brachypodietalia pinnati*, *Festucetalia valesiacae*, *Stipo pulcherrimae-Festucetalia pallentis*) will be included.

Erweiterte Deutsche Zusammenfassung

Einleitung – Extensive Landnutzung spielte auf dem Balkan lange Zeit eine große Rolle und in Folge davon degradierten die natürlichen Wälder und sekundäres Grasland breitete sich stark aus. Auf flachgründigen Serpentinböden mit hohen Magnesium-Gehalten konnten sich dabei in der Zone der thermophilen Laubmisch- und Kiefernwälder sog. Serpentin-Steppenrasen entwickeln, die in der Ordnung *Halacsyetalia sendtneri* zusammengefasst sind. Diese Ordnung mit zahlreichen endemischen Serpentinophyten wurde von Ritter-Studnička nach Untersuchungen der Bestände des zentralen und östlichen Bosniens und Herzegowinas aufgestellt und in die beiden Verbände *Polygonion albanicae* und *Potentillion visianii* untergliedert (RITTER-STUDNIČKA 1970). Aufgrund des zahlreichen Vorkommens von Charakterarten der *Festucetalia valesiacae* wurde die Ordnung in die Klasse *Festuco-Brometea* eingegliedert. Diese Stellung war bislang jedoch umstritten. Einigkeit bestand lediglich darin, dass die Serpentin-Steppenrasen des Balkans eine eigene Ordnung *Halacsyetalia* bildeten. Eine konsistente Gliederung der *Halacsyetalia* fehlte bislang ebenfalls. Daher revidieren wir hier das Syntaxon der *Halacsyetalia* kritisch.

Untersuchungsgebiet – Das Untersuchungsgebiet umfasst die Serpentin-Ausstriche von Bosnien und Herzegowina sowie von West-Serbien und Kosovo; somit liegt das Untersuchungsgebiet auf dem zentralen Balkan (Abb. 1). Aus biogeographischer Sicht gehört das Gebiet zum östlichen Teil der Dinarischen Alpen (Illyrien) und mit dem Šar-Gebirge auch zum nördlichen Teil der skardo-pindischen Region der mitteleuropäischen Florenregion (HORVAT et al. 1974).

Material und Methoden – Zunächst wurde die pflanzensoziologische Literatur aus den Serpentingebieten des westlichen und zentralen Balkans zusammengetragen und die darin vorhandenen Aufnahmen in die Datenbank „Grassland Vegetation of Serbia“ eingegeben (GIVD Nummer: EU-RS-002, AĆIĆ et al. 2012). Die Nomenklatur der Taxa folgt dabei außer für einige wenige Arten der Flora Europaea. Wegen der heterogenen Datengrundlage von 277 Einzelaufnahmen aus 26 Assoziationen sowie 7 Assoziationen, die lediglich durch Stetigkeitstabellen vertreten waren, wurde die Datenanalyse in mehreren Schritten durchgeführt. Im ersten Schritt wurden mehrere Cluster-Analysen mit verschiedenen Kombinationen aus Distanzmaßen und Methoden der Gruppenverknüpfung durchgeführt. Dadurch sollte geklärt werden, ob alle Aufnahmen, die in der Originalliteratur einem bestimmten Syntaxon zugeordnet waren, floristisch klar abgegrenzte Gruppen bildeten. Für die Cluster-Analyse der verwendeten 273 Aufnahmen (455 Taxa, 24 Assoziationen) wurden die ursprünglichen Deckungswerte der einzelnen Arten ordinal-transformiert (VAN DER MAAREL 1979). Die Cluster-Analysen (Bray-Curtis und gepaarte Gruppenmittel, euklidische Distanzen und Ward-Methode, relative euklidische Distanzen und flexibles Beta, β = -0,25) wurden mit den Programmen PAST (HAMMER et al. 2001) und JUICE (TICHÝ 2002) durchgeführt. Im zweiten Schritt wurden dann 26 synoptische Stetigkeitsspalten für diejenigen Assoziationen vorbereitet, die als analytische Tabellen publiziert waren. Schließlich wurden die synoptischen Spalten mit den synoptischen Tabellen von sieben Assoziationen von RITTER-STUDNIČKA (1970) und KRAUSSE & LUDWIG (1957) zusammengeführt. Am Ende wurde die Klassifikation der gesamten Tabelle (499 Taxa und 33 Gruppen) gemäß klassischer

pflanzensoziologischer Tabellensortierung anhand von berechneten Frequenzen (TICHÝ et al. 2012) durchgeführt. Für jedes Taxon wurde die prozentuale Stetigkeit und relative Treue (s. hochgestellte *phi*-Werte über den Stetigkeiten, mit „**“ wenn *phi* ≥ 0,5 war und „*“ wenn *phi* ≥ 0,25 war) berechnet und in einer synoptischen Tabelle festgehalten. *Phi*-Werte wurden nur für diejenigen synoptischen Spalten, die auf analytischen Tabellen beruhten, angegeben. Basierend auf dem Konzept der relativen Treue wurde das Optimum jeder Art in einer Gruppe floristisch-ähnlicher Gesellschaften bestimmt (WILLNER 2006, WILLNER et al. 2009).

Bei der Berechnung der *phi*-Werte wurde das Vorkommen einer Art innerhalb eines höherangigen Syntaxons berücksichtigt. Die Ordnung *Halacsyetalia sendtneri* wurde dabei als abstrakte Einheit genutzt um die *phi*-Werte der diagnostischen Arten innerhalb ihrer Verbände zu bestimmen. Arten mit *phi* ≥ 0,25 wurden als diagnostisch und stet und Arten mit *phi* ≥ 0,50 als hoch-diagnostisch betrachtet (CHYTRÝ 2007). Konstante Arten mussten dagegen einen Frequenzwert von mindestens 30 % (Ordnung) und 40 % (Verband) aufweisen. Die diagnostischen Arten der Klassen wurden anhand des EuroVegChecklist Expert-Systems und mit Hilfe der ESL1-Artenliste (MUCINA et al. in press) mit dem Programm JUICE (TICHÝ et al. 2012) bestimmt. Eine Ausnahme bildeten Arten, die noch nicht in der ESL1-Artenliste klassifiziert waren (z. B. *Genista hassertiana* und *Polygala doerfleri*).

Weiterhin wurde das Auftreten diagnostischer Arten der *Halacsyetalia sendtneri* sowie weiterer potentiell diagnostischer, hoch-frequenter und dominanter Serpentinophyten aus unserem Datensatz in den fünf wichtigsten Grasslandtypen Serbiens (*Molinio-Arrhenatheretea*, *Festucetalia valesiacae*, *Festucetalia vaginatae*, *Astragalo-Potentilletalia*, *Halacsyetalia sendtneri*) untersucht. Diese Analyse basierte auf der Datenbank Grassland Vegetation of Serbia (GIVD number: EU-RS-002, AĆIĆ et al. 2012, 2015). Dabei wurden insgesamt 33 obligate oder fakultative Serpentinophyten bzw. 3.346 Aufnahmen berücksichtigt.

Ergebnisse und Diskussion – Trotz zahlreichen Auftretens von diagnostischen Arten der Klasse *Koelerio-Corynephoretea* wurden auf der Basis des *EuroVegChecklist Expert-Systems* lediglich 1 % der Aufnahmen in diese Klasse gestellt; die anderen 98 % Aufnahmen wurden den *Festuco-Brometea* zugeordnet. Dieses Ergebnis wurde von der Tatsache unterstützt, dass in den analysierten Assoziationen, diagnostische Taxa der *Festuco-Brometea* die höchste Frequenz und Abundanz aufwiesen. Insgesamt enthielt unser Datensatz 499 Taxa, darunter 49 obligate oder fakultative Serpentinophyten, von denen wiederum 40 für die Balkan Halbinsel endemisch sind. Die Analyse der Verbreitung von 33 obligaten oder fakultativen Serpentinophyten zeigte, dass sowohl endemische als auch nicht-endemische Sippen fast ausschließlich in den Fels-Steppenrasen auf ultramafischen Böden vorkommen. Sie können daher zwanglos als diagnostische Arten der *Halacsyetalia sendtneri* und deren Verbände betrachtet werden (Tab. 4).

Die Wiedereinordnung der Ordnung *Halascyetalia sendtneri* in die *Festuco-Brometa* sowie die signifikante Zahl von endemischen obligaten Serpentinophyten ermöglichten auch eine Evaluation der Verbände. Zwei Verbände konnten bestätigt und durch diagnostische und stete Arten charakterisiert werden: Das *Centaureo kosaninii-Bromion fibrosi* umfasst Fels-Steppenrasen in Süd-Serbien, im Kosovo und in der vom Mittelmeerklima beeinflussten skardisch-pindischen Florenprovinz Nord-Albaniens. Das *Potentillion visianii* (dem hier auch Syntaxa zugeordnet werden, die früher im *Polygonion albanicae* standen), umfasst dagegen Fels-Steppenrasen auf Serpentin-Ausstrichen des zentralen und östlichen Bosnien und Herzegowinas, des zentralen und westlichen Serbiens und des nördlichen Kosovo. Dieser Verband siedelt in der illyrischen Region, die vom niederschlagsreichen Atlantikklima beeinflusst wird.

Das thermophytische Pionier-Grasland und die therophytischen Rasengesellschaften des Verbandes *Thymion jankae* (nomen. inval.) wurden provisorisch in der Ordnung *Halacsyetalia sendtnerii* belassen. Diese Vegetationstypen sind durch das Fehlen der typischen Arten der *Halacsyetalia sendtneri* gekennzeichnet und weisen stattdessen mehr diagnostische Taxa der *Koelerio-Corynephoretea* auf.

Acknowledgements

We acknowledge the financial support provided by the Serbian Ministry of Education, Science and Technological Development (projects No. 173030 and 31057). We are grateful to Jürgen Dengler (Bayreuth, Germany) for help with the literature search, the editor Monika Janišová and the two anonymous reviewers for their helpful comments and suggestions that significantly improved an earlier version of this manuscript. Finally, thanks go to Aiko Huckauf who kindly checked our English, and Viktoria Wagner (Brno, Czech Republic) and Thomas Becker (Trier, Germany) for German translations.

Supplements

Supplement S1. Synoptic table for associations, alliances, order and classes.

Beilage S1. Übersichtstabelle der Assoziationen, Verbände, Ordnungen und Klassen.

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Supplement E1. Localities of analysed syntaxa.

Anhang E1. Lokalitäten der untersuchtren Syntaxa.

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Supplement S1. Synoptic table for associations, alliances, order and classes. Taxa were represented by constancy and *phi*-values, where the thresholds were 0.50 (superscript **) and 0.25 (superscript *). The names of infraspecific taxa are presented with genus name and infraspecific epithet with asterisk in between (the specific epithet is omitted).

Beilage S1. Übersichtstabelle der Assoziationen, Verbände, Ordnungen und Klassen. Für die Arten sind Stetigkeiten mit phi-Werten angegeben. **, *phi* = ≥ 0,50, *, *phi* = ≥ 0,25. Die Namen von infraspezifischen Taxa sind als Gattungsnamen und von infraspezifischen Arten mit Sternchen zwischen den Epitheten angegeben (das betreffende Epitheton wurde entfernt).

Mucina et al. (in press) Euroveg Checklist		1	1.1	1.2	2.1	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	1.1.10	1.1.11	1.1.12	1.1.13	1.1.14	1.1.15	1.1.16	1.1.17	1.1.18	1.1.19	1.1.20	1.1.21	1.1.22	1.1.23	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6	1.3.1	1.3.2	1.3.3	1.?.1
	Or. 1 - Halacsyetalia sendtneri																																					
FES	Euphorbia glabriflora	63.6	65.2	83.3	33.3						30	70	50		20	54		57	25	100	11	40		50	100	100	100	100	77	100	50	100*		90		22		
	Bromus fibrosus	54.5	47.8	100.0	33.3											77	100		25	90	100	100	63	90	29	60	100		23	50	55	100*	50	70	91			
	Alyssum markgrafii	54.5	43.5	100.0	66.7					10					70	77	70	100		60				100	71	100		50	38	100	85	86	100	90		27	65	
SES	Silene *staticifolia	51.5	52.2	66.7	33.3			50			10	30		73	70	23	70		25	50		20		20	100*				100*	83	25		40		82			
ASP	Notholaena marantae	48.5	60.9	33.3	0.0			70	30	30	50	50	30	73*	30	31	40	29		10				20				50	100**	50								
ERI	Asplenium cuneifolium	48.5	60.9	33.3	0.0	18	50	50	50		30			27			10	43	50	10		20	13	10				50	46*	83*								
	Stachys *baldaccii	48.5	52.2	66.7	0.0	82*		50	70	70	30	50	30							70				70	100*		50	50	85*		25	76*	60					
FES	Halacsya sendtneri	42.4	47.8	50.0	0.0	45		90				30		18	20		40			40				50	57		50	100			45	33	30					
	Silene paradoxa	42.4	43.5	50.0	33.3	18			30				10	9				29						20	71*	40	50	100	23		25			30		3		
COR	Sedum serpentini	36.3	26.1	66.7	33.3																11		88*	90*	100*	100*		50		100*		48	50	30	45			38
ERI	Stachys scardica	33.3	21.7	83.3	33.3							30								60				40		40	100		38		65	86*	30	70		57		
FES	Potentilla australis	30.3	30.4	33.3	33.3	82*	50	30	30			10				15										100*						71*		30		35		
	Alyssum *serbicum	30.3	21.7	66.7	33.3							30				46					78*				100*			50	77*		20	71*	60			11		
FES	Echium rubrum	30.3	26.1	33.3	66.7							30				23		29		40				20			50					43		20		76**	6	
COR	Dianthus *papilosus	27.3	34.8	16.7	0.0			50			30	30											13	50*	100**	40		50				14						
	Bromus pannonicus	27.3	34.8	0.0	33.3			50	50	10	10	30		64*								80*					100									24*		
FES	Potentilla visianii	21.2	26.1	16.7	0.0						10	50							50			40		10			50					76**						
	Fumana bonapartei	21.2	26.1	16.7	0.0						10	70								10				80**	100**			100						50*				
FES	Linum *serbicum	9.1	4.3	33.3	0.0																					40						71**		40				
	Scabiosa fumarioides	9.1	4.3	33.3	0.0									9																			100**	50*				
	Dianthus *serbicus	9.1	4.3	33.3	0.0																				100**								20	30				
	All. 1.1 - Potentillion visianii																																					
	Stipa novakii	30.3	43.5	0.0	0.0									100*	100*		40		25	50	11	40		50		40		100										
ASP	Cardamine plumieri	15.2	21.7	0.0	0.0	64**	70			30			50										38*															
	Scrophularia *tristis	15.2	21.7	0.0	0.0					50			70	55**											43*			50										
	Linaria rubioides	15.2	21.7	0.0	0.0						10	30	70							10*								50										
	Euphorbia montenegrina	12.1	17.4	0.0	0.0	91**	70	10	30																													
SES	Dianthus *croaticus	9.1	13.0	0.0	0.0	36**		10	50																													
	Haplophyllum boissierianum	9.1	13.0	0.0	0.0							10				8									14*													
	Viola beckiana	6.1	8.7	0.0	0.0	27**	90																															
FES	Sesleria serbica	6.1	8.7	0.0	0.0		90																100**															
	Polygonum albanicum	6.1	8.7	0.0	0.0			10	50																													
	Viola kopaonikensis	6.1	8.7	0.0	0.0																	40**	13															
	Tragopogon pterodes	6.1	8.7	0.0	0.0																				71**			50										
	Potentilla mollis	6.1	8.7	0.0	0.0						50																	50										
THL	Alyssum *scutarinum	6.1	8.7	0.0	0.0																				29**		50											
FES	Eryngium serbicum	6.1	8.7	0.0	0.0											23*											100											
	Verbascum bosnense	3.0	4.3	0.0	0.0																							50										
	Tulipa serbica	3.0	4.3	0.0	0.0																						50											
	All. 1.2 - Centaureo kosaninii-Bromion fibrosi																																					
FES	Centaurea kosaninii	18.2	0.0	100.0	0.0																								69*	100*	70*	29	20	40				
	Polygala doerfleri	12.1	0.0	66.7	0.0																										50**	10	20	30				
	Saponaria *intermedia	6.1	0.0	33.3	0.0																								100**	67*								
	Genista hassertiana	3.0	0.0	16.7	0.0																										85**							
	Convolvulus * compactus	3.0	0.0	16.7	0.0																													100**				
	Stipa mayeri	3.0	0.0	16.7	0.0																													100**				
	Aster albanicus	3.0	0.0	16.7	0.0																										10*							
	Sanguisorba albanica	3.0	0.0	16.7	0.0																										10*							
	All. 1.3 - "Thymion jankae"																																					
	Viola macedonica	9.1	0.0	0.0	66.7																														27*		18*	13
	Euphorbia serpentini	3.0	0.0	0.0	33.3																															14*		
	Bornmuellera dieckii	3.0	0.0	0.0	33.3																														100**			
	Cl. 1 - Festuco-Brometea																																					
FES	Teucrium montanum	90.9	91.3	100.0	100.0	36		50	90	30	10	70	50	55	100	46	40	100	100	100	100	100	13	50	57	80	100		38	33	60	48	30	40	82	59	12	
ONO	Leontodon crispus	63.6	65.2	83.3	33.3			30			30	30		45	40	69		14	50	80	100	60	25	90	86		50			10	20	81	50	60		41		
FES	Astragalus onobrychis	60.6	43.5	100.0	100.0						30	70	10			92*		86	50		100			90	10			50	77	83	40	67	20	80	36	5	6	63
FES	Sanguisorba minor	60.6	47.8	100.0	100.0										30	31	40	43	75	100	44	100		50		20	50		8	67	70	100*	80	60	45	81	59	
FES	Artemisia alba	60.6	69.6	50.0	0.0						30	30	30	73	40	15	100*	100	100	80	67	80		60	71		100	100				52	20	40				38
FES	Minuartia verna	57.6	56.5	66.7	66.7	18		50	70		10	50	30					57		20		60	88	50	10	40				83		76	90	80		97*	88	
FES	Melica ciliata	57.6	56.5	66.7	33.3			30		30	70	70	30		70	54	40	57	100		22			40	43				85*	10	60			30		11		100*
FES	Lotus corniculatus	48.5	43.5	50.0	100.0	36		30	50							8	20	43		30		40	13			20					45		30	60	82*	19	41	
GAL	Galium lucidum	48.5	39.1	83.3	66.7	100*		10	30		30	50	50					100					13	40					10*		40	86*	50	60	100*	46		
FES	Dorycnium *germanicum	45.5	43.5	83.3	0.0			30	90										50	90*	22	100	88	30	57	10				17	20	95*	80	50				
FES	Scabiosa columbaria	45.5	34.8	66.7	100.0							50								30	56	80	50	20		60	100		54	33	45	43			73	62*	18	
FES	Alyssum murale	42.4	47.8	16.7	33.3	36	30	50	70	70	50	50	50						100*			100*						50				62*				24		88*
FES	Thymus jankae	42.4	47.8	16.7	66.7	73		50	70							92*			100	100*	100	80	50				50	50		50						100**	65	
FES	Asperula purpurea	39.4	52.2	0.0	33.3	36		70	30	50	70	50	30	55*					75	100**	11	100*														5		
FES	Allium flavum	39.4	34.8	50.0	33.3						30	50			20	8		43	25	30					57				69*	67	55*					5		100*
FES	Stachys recta	39.4	34.8	33.3	66.7									18	70	77*	70	71	75		33						50			10*				60		14	6	88*
FES	Centaurea biebersteinii	39.4	43.5	16.7	66.7	55		50	50					9		31			50			60			70*	80*	50							70*		19	6	
FES	Medicago prostrata	39.4	52.2	0.0	33.3			30	30	10	30	70		27		85*				50	67			70	10*			50								65*		
FES	Hypericum barbatum	36.3	21.7	83.3	66.7	18			30													40	13			60				33	20	81*	70	50		32	24	
FES	Asperula cynanchica	36.3	43.5	16.7	33.3	9		10	50		30	30				15					56		75*	20		10*					60*					8		
SES	Acinos alpinus	36.3	26.1	50.0	66.7													29	75		11	80		60		40			85*	83	25				64	22		88*
	Potentilla pedata	36.3	21.7	66.7	100.0											8				20				10		20	50		54		40	33	60		9	19	6	
FES	Festuca valesiaca	36.3	43.5	0.0	66.7			30	10		30	50			70*	92*	70*	43						30			100									22	35	
FES	Carex humilis	33.3	43.5	0.0	33.3	55		10			30					8			25	90*	100*	100*	100*	10												32		
THL	Aethionema saxatile	33.3	39.1	16.7	33.3									27	70*	23	40	71*		30	33	20		10										30		5		
FES	Euphorbia cyparissias	30.3	17.4	66.7	66.7										30	23	50			10											15	52*	30	50		11	24	
FES	Thymus longicaulis	30.3	17.4	83.3	33.3						10	50													10*	10*			15		75*	48	80*	90*	73			
FES	Carex caryophyllea	30.3	21.7	50.0	66.7	9												86*					25	10		40					15	29		40		65*	35	
FES	Chrysopogon gryllus	30.3	34.8	16.7	33.3									73*	80*	100*	70	57	25					50			50							60			18	
FES	Hieracium bauhinii	30.3	26.1	50.0	33.3											54*			50	30	11			20			100			50		52*		30			12	
SES	Iris reichenbachii	30.3	21.7	50.0	66.7	36		10										29		50								50	15			33		30		16	12	
FES	Potentilla tommasiniana	27.3	34.8	16.7	0.0				30			10			100*	92*	70				100*			90*	57									90*				
ART	Silene vulgaris	27.3	21.7	66.7	0.0	9				90					20					30				10					62*	33		52*		30				
FES	Anthyllis vulneraria	27.3	13.0	66.7	66.7															30			50			60					10	33	30	70*		38	59*	
FES	Danthonia alpina	27.3	21.7	33.3	66.7														50	60*		20	13			20				67		24				16	59*	
SES	Festuca panciciana	27.3	17.4	50.0	33.3																100*	100*	38	50					69*			48	70*			11		13
ASP	Campanula lingulata	27.3	30.4	33.3	0.0	9		30	10			30				15								50*			50		8	17								
THL	Vincetoxicum hirundinaria	27.3	34.8	0.0	33.3	9				30					30	62*	70*	29		10							100									11		
FES	Hieracium pavichii	24.2	30.4	0.0	33.3	45*	70	50	30				10													40*	50										24*	
FES	Hippocrepis comosa	24.2	13.0	50.0	66.7															60*				10			50					57*	40	30		22	12	
	Vincetoxicum fuscatum	21.2	13.0	66.7	0.0														75*			40		10					69*	50		43*		30				
FES	Trinia glauca	21.2	13.0	33.3	66.7															30			50		43							52*	40			35	18	
	Cl. 2 - Koelerio-Corynephoretea																																					
COR	Rumex acetosella	66.7	65.2	66.7	66.7	9		10	50		10	50	30		70	69	40		25	30	44	100	38			20			15			38	50	30		32	82*	63
FES	Poa badensis	63.6	56.5	100.0	66.7	9		30	50		30	30						71		60		20	38	60	29	100	50		100*	100	35	33	60	40	100	100*		
COR	Plantago holosteum	54.5	39.1	100.0	100.0											23		43		80	100	40	75	90	71	100			77	100	75	86	50	80	100	100*	100	
COR	Petrorhagia saxifraga	48.5	52.2	50.0	0.0	9		30	50		30	70	30		70*	46	70*				11			10	86*					10*	15		30					88*
TUB	Scleranthus *dichotomus	30.3	30.4	0.0	100.0										40	92*		29		30	56				86		50								91*	70*	47	
COR	Sedum acre	27.3	30.4	16.7	0.0	9						50			30	15	20						25	20										60*				38
COR	Scleranthus *perennis	24.2	26.1	16.7	33.3			30	50			30								10		20		10								10					82**	
COR	Sedum ochroleucum	24.2	21.7	50.0	0.0			30		10	10	30	30																	50*		48**		30				
FES	Dorycnium *herbaceum	24.2	21.7	16.7	66.7	27						50				46		57									50				40				82*	86**		
COR	Trifolium arvense	21.2	13.0	16.7	66.7				30			50				15																		40		14	41*	50*
FES	Koeleria splendens	18.2	17.4	16.7	33.3				30										75	90*			50											30		89**		
COR	Arenaria leptoclados	15.2	17.4	0.0	33.3				30	30		30									22*															8		
COR	Arenaria serpyllifolia	15.2	17.4	0.0	33.3	9										31*				30*							50									5		
COR	Carex praecox	12.1	4.3	50.0	0.0																			10							35*	38*	60*					
COR	Potentilla argentea	9.1	0.0	50.0	0.0																								15	50*				40*				
COR	Sideritis montana	6.1	4.3	16.7	0.0														25															30*				
COR	Petrorhagia prolifera	6.1	4.3	16.7	0.0																			10								19*						
COR	Trifolium campestre	6.1	4.3	0.0	33.3																			10													18*	
COR	Scleranthus annuus	6.1	4.3	0.0	33.3	9																															24*	
COR	Sedum sexangulare	6.1	0.0	0.0	66.7																															3	6	
	Ass. 1.1.1 Halacsyo sendtneri-Caricetum humilis																																					
	Vicia cracca	9.1	13.0	0.0	0.0	91**	50													10																		
	Polygonatum odoratum	3.0	4.3	0.0	0.0	64**																																
	Allium ericetorum	3.0	4.3	0.0	0.0	64**																																
	Clematis recta	3.0	4.3	0.0	0.0	55**																																
	Quercus petraea	3.0	4.3	0.0	0.0	55**																																
	Centaurea triumfetii	6.1	4.3	0.0	33.3	55**																														14		
	Chamaecytisus supinus	3.0	4.3	0.0	0.0	45**																																
	Sesleria latifolia	9.1	13.0	0.0	0.0	45**	30	50																														
	Peucedanum oreoselinum	9.1	13.0	0.0	0.0	45**	70		30																													
	Carduus carduelis	9.1	13.0	0.0	0.0	45**	90														22																	
	Scabiosa cinerea	9.1	13.0	0.0	0.0	45**	70		70																													
	Symphytum tuberosum	6.1	8.7	0.0	0.0	45**	50																															
	Mercurialis ovata	6.1	8.7	0.0	0.0	45**														30*																		
	Chamaecytisus austriacus	3.0	4.3	0.0	0.0	36**																																
	Frangula alnus	6.1	8.7	0.0	0.0	36**											10																					
	Aristolochia pallida	3.0	4.3	0.0	0.0	27**																																
	Thlaspi kovatsii	9.1	13.0	0.0	0.0	27**		10	30																													
	Anemone nemorosa	6.1	8.7	0.0	0.0	27**	30																															
	Lathyrus pratensis	3.0	4.3	0.0	0.0	18*																																
	Melittis melissophyllum	3.0	4.3	0.0	0.0	18*																																
	Muscari botryoides	3.0	4.3	0.0	0.0	18*																																
	Poa pratensis	3.0	4.3	0.0	0.0	18*																																
	Sorbus torminalis	3.0	4.3	0.0	0.0	18*																																
	Clinopodium vulgare	3.0	4.3	0.0	0.0	9*																																
	Crocus vernus	3.0	4.3	0.0	0.0	9*																																
	Cruciata laevipes	3.0	4.3	0.0	0.0	9*																																
	Lilium bosniacum	3.0	4.3	0.0	0.0	9*																																
	Luzula campestris	3.0	4.3	0.0	0.0	9*																																
	Luzula multiflora	3.0	4.3	0.0	0.0	9*																																
	Minuartia recurva	3.0	4.3	0.0	0.0	9*																																
	Primula vulgaris	3.0	4.3	0.0	0.0	9*																																
	Rhamnus saxatilis	3.0	4.3	0.0	0.0	9*																																
	Rubus canescens	3.0	4.3	0.0	0.0	9*																																
	Serratula tinctoria	3.0	4.3	0.0	0.0	9*																																
	Silene nutans	3.0	4.3	0.0	0.0	9*																																
	Tanacetum corymbosum	3.0	4.3	0.0	0.0	9*																																
	Veronica chamaedrys	3.0	4.3	0.0	0.0	9*																																
	Viola reichenbachiana	3.0	4.3	0.0	0.0	9*																																
	Ass. 1.1.2 Violo beckianae-Seslerietum serbicae																																					
	Pulmonaria mollis	3.0	4.3	0.0	0.0		70																															
	Centaurea smolinensis	3.0	4.3	0.0	0.0		50																															
	Cerastium malyi	3.0	4.3	0.0	0.0		50																															
	Gentiana asclepiadea	3.0	4.3	0.0	0.0		50																															
	Luzula sylvatica	3.0	4.3	0.0	0.0		50																															
	Brachypodium sylvaticum	3.0	4.3	0.0	0.0		30																															
	Carex umbrosa	3.0	4.3	0.0	0.0		30																															
	Galium schultesii	3.0	4.3	0.0	0.0		30																															
	Leucanthemum adustum	3.0	4.3	0.0	0.0		30																															
	Spiraea chamaedryfolia	3.0	4.3	0.0	0.0		30																															
	Moehringia muscosa	3.0	4.3	0.0	0.0		10																															
	Valeriana montana	3.0	4.3	0.0	0.0		10																															
	Veratrum lobelianum	3.0	4.3	0.0	0.0		10																															
	Ass. 1.1.4 Dorycnio germanicae-Scabietosum cinereae																																					
	Vicia incana	3.0	4.3	0.0	0.0				30																													
	Viola riviniana	3.0	4.3	0.0	0.0				30																													
	Veronica officinalis	3.0	4.3	0.0	0.0				10																													
	Ass. 1.1.6 Erysimo linariifoliae-Jovibarbetum heuffelii																																					
	Saxifraga blavii	3.0	4.3	0.0	0.0						30																											
	Stipa joannis	3.0	4.3	0.0	0.0						10																											
	Ass. 1.1.7 Fumano bonapartei-Euphorbietum glabriflorae																																					
	Berteroa incana	3.0	4.3	0.0	0.0							30																										
	Lychnis coronaria	3.0	4.3	0.0	0.0							30																										
	Minuartia bosniaca	3.0	4.3	0.0	0.0							30																										
	Verbascum * bosnense	3.0	4.3	0.0	0.0							30																										
	Campanula sibirica	3.0	4.3	0.0	0.0							10																										
	Ass. 1.1.8 Scrophulario tristis-Linarietum rubioides																																					
	Bupleurum karglii	3.0	4.3	0.0	0.0								30																									
	Cirsium candelabrum	3.0	4.3	0.0	0.0								30																									
	Epilobium dodonaei	3.0	4.3	0.0	0.0								30																									
	Ass. 1.1.9 Stipetum novakii																																					
	Chamaecytisus hirsutus	9.1	13.0	0.0	0.0	64*	70							91**																								
	Erysimum linariifolium	6.1	8.7	0.0	0.0						70			82**																								
	Ass. 1.1.10 Potentillo tommasinianae-Stipetum novakii																																					
	Medicago falcata	6.1	8.7	0.0	0.0										100**		70**																					
	Gypsophila muralis	3.0	4.3	0.0	0.0										40**																							
	Sonchus asper	3.0	4.3	0.0	0.0										30**																							
	Festuca heterophylla	3.0	4.3	0.0	0.0										10*																							
	Ass. 1.1.11 Bromo fibrosi-Chrysopogonetum grylli																																					
	Orlaya grandiflora	6.1	8.7	0.0	0.0											46**											50											
	Polygala alpestris	3.0	4.3	0.0	0.0											15*																						
	Sherardia arvensis	3.0	4.3	0.0	0.0											15*																						
	Ass. 1.1.12 Bromo fibrosi-Artemisietum albae																																					
	Neslia paniculata	3.0	4.3	0.0	0.0												40**																					
	Cephalaria transsylvanica	6.1	8.7	0.0	0.0										20		40**																					
	Ass. 1.1.13 Alysso markgrafii-Artemisietum albae																																					
	Thymus pulegioides	9.1	13.0	0.0	0.0				30									100**		20																		
	Koeleria eriostachya	6.1	4.3	0.0	33.3													100**																		14		
	Scorzonera rosea	9.1	8.7	0.0	33.3													71**								40*										5		
	Verbascum nigrum	9.1	13.0	0.0	0.0													71**	25	30*																		
	Ajuga genevensis	6.1	8.7	0.0	0.0									9				57**																				
	Helleborus serbicus	3.0	4.3	0.0	0.0													29**																				
	Stipa capillata	3.0	4.3	0.0	0.0													29**																				
	Ass. 1.1.14 Artemisio albae-Achnatheretum calamagrostis																																					
	Phleum phleoides	9.1	13.0	0.0	0.0			10										29*	75**																			
	Euphrasia rostkoviana	3.0	4.3	0.0	0.0														50**																			
	Silene italica	3.0	4.3	0.0	0.0														50**																			
	Teucrium chamaedrys	9.1	13.0	0.0	0.0							10							50**		11																	
	Carthamus lanatus	3.0	4.3	0.0	0.0														25*																			
	Galium flavescens	3.0	4.3	0.0	0.0														25*																			
	Pyrus pyraster	3.0	4.3	0.0	0.0														25*																			
	Ass. 1.1.15 Festuco ovinae-Euphorbietum glabriflorae																																					
COR	Festuca ovina	9.1	13.0	0.0	0.0	45*	90													100**																		
	Rorippa pyrenaica	3.0	4.3	0.0	0.0															60**																		
	Genista friwaldskyi	6.1	4.3	0.0	33.3															60**																5		
	Chamaespartium sagittale	3.0	4.3	0.0	0.0															40**																		
	Stellaria graminea	3.0	4.3	0.0	0.0															40**																		
	Chamaecytisus ciliatus	3.0	4.3	0.0	0.0															30**																		
	Thlaspi montanum	3.0	4.3	0.0	0.0															30**																		
	Festuca dalmatica	6.1	8.7	0.0	0.0						30									30**																		
	Fritillaria orientalis	3.0	4.3	0.0	0.0															20*																		
	Galium austriacum	3.0	4.3	0.0	0.0															20*																		
	Veronica orchidea	3.0	4.3	0.0	0.0															20*																		
	Coronilla varia	3.0	4.3	0.0	0.0															10*																		
	Erysimum odoratum	3.0	4.3	0.0	0.0															10*																		
	Luzula pilosa	3.0	4.3	0.0	0.0															10*																		
	Rumex acetosa	3.0	4.3	0.0	0.0															10*																		
	Ass. 1.1.16 Potentillo tommasinianae-Festucetum pancicianae																																					
	Paronychia kapela	9.1	4.3	33.3	0.0																89**											33*		70*				
	Euphorbia tommasiniana	3.0	4.3	0.0	0.0																44**																	
	Centaurea calvescens	3.0	4.3	0.0	0.0																33**																	
	Scorzonera cana	3.0	4.3	0.0	0.0																22*																	
	Fallopia convolvulus	3.0	4.3	0.0	0.0																11*																	
	Taraxacum erythrospermum	3.0	4.3	0.0	0.0																11*																	
	Ass. 1.1.17 Festuco pancicianae-Caricetum humilis																																					
	Orobanche teucrii	3.0	4.3	0.0	0.0																	80**																
	Carex montana	9.1	13.0	0.0	0.0											15				10		60**																
	Hieracium piloselloides	6.1	8.7	0.0	0.0															10		40**																
	Carduus hamulosus	3.0	4.3	0.0	0.0																	20*																
	Linum catharticum	3.0	4.3	0.0	0.0																	20*																
	Orobanche alba	3.0	4.3	0.0	0.0																	20*																
	Thesium bavarum	3.0	4.3	0.0	0.0																	20*																
	Ass. 1.1.18 Seslerio serbicae-Caricetum humilis																																					
	Silene serbica	9.1	13.0	0.0	0.0															10			38**					50										
	Edraianthus graminifolius	3.0	4.3	0.0	0.0																		25*															
	Asplenium trichomanes-ramosum	3.0	4.3	0.0	0.0																		13*															
	Galium mollugo	3.0	4.3	0.0	0.0																		13*															
	Juniperus alpina	3.0	4.3	0.0	0.0																		13*															
	Leucanthemum vulgare	3.0	4.3	0.0	0.0																		13*															
	Rumex scutatus	3.0	4.3	0.0	0.0																		13*															
	Scleranthus marginatus	3.0	4.3	0.0	0.0																		13*															

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Fortsetzung auf der Rückseite