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Research Paper

Numerical analysis of the order *Scorzoneretalia villosae*

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Abstract: The *Scorzoneretalia villosae* (= *Scorzonero-Chrysopogonetalia*) order was originally defined to describe the sub-Mediterranean grasslands of western Croatia, but its distribution range has since been extended to Albania, Bosnia and Herzegovina, Bulgaria, Italy, Kosovo, Montenegro, Slovenia and Serbia. Major syntaxonomic revisions of the order have been performed at the regional or national scale and show inconsistencies both for the syntaxonomic schemes and relative diagnostic taxa. This situation presents some difficulties in comparing or transferring findings between regions or when using syntaxonomic information for practical purposes. To tackle these inconsistencies, nearly nine hundred relevés already assigned to the *Scorzoneretalia villosae* were classified with the goal of establishing syntaxonomic relationships among associations. Diagnostic taxa of the main clusters of relevés were identified via Indicator Species Analysis (ISA). Results of statistical analyses were then interpreted from a syntaxonomic standpoint. Associations were ordinated (non-metric multidimensional scaling) on the basis of taxa frequencies in order to visualise their floristic and chorological relationships. Based on the results, associations were grouped within four alliances: *Scorzonerion villosae*, *Chrysopogono-Saturejion subspicatae*, *Saturejion subspicatae* and *Centaureion dichroanthae* were assigned to two new suborders, the meso-xerophytic *Scorzonerenalia villosae* and the xerophytic *Koelerienalia splendentis*, classified within the *Scorzoneretalia villosae* of the *Festuco-Brometea*. The order covers the western part of the Balkan Peninsula and, in the northern part of its range, the southeastern portion of the pre-Alpine sectors. Floristic similarities between the *Scorzonerenalia villosae* and other eastern meso-xerophytic syntaxa of the class have been highlighted. I review the nomenclature for the order, describing or validating two suborders and four associations for the first time, and lectotypifying three syntaxa .

Keywords: Balkan Peninsula; dry grassland; *Festuco-Brometea*; phytosociological nomenclature; *Scorzonero-Chrysopogonetalia*; syntaxonomy.

Nomenclature: Taxonomic nomenclature follows the Euro+Med Plantbase (http://ww2.bgbm.org/EuroPlusMed/, accessed 1 June 2014) and subordinately Conti et al. (2005) and the Flora Croatica Database (FDC; http://hirc.botanic.hr/fcd/Search.aspx). Syntaxonomical nomenclature refers to Terzi (2011) if not indicated otherwise.

Abbreviations: ICPN = International Code of Phytosociological Nomenclature (Weber et al. 2000); IndSp = Indicator Species; IndVal = Indicator Value index (Dufrêne & Legendre 1997); ISA = Indicator Species Analysis; NMDS = Nonmetric Multi-Dimensional Scaling (Kruskal 1964; Mather 1976).

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Introduction

The sub-Mediterranean dry grasslands of the Adriatic western Balkan Peninsula were united by Horvatić and Horvat (Horvatić 1958, 1963; Horvat 1962) within the *Scorzonero-Chrysopogonetalia* and assigned to the *Brachypodio-Chrysopogonetea*. According to these authors, the order would substitute the continental inland vegetation of the *Festuco-Brometea* towards the Adriatic coastal strip and give way to the eu-Mediterranean vegetation of the *Cymbopogono-Brachypodietalia* at lower altitude, near the sea. The concept of a high-rank syntaxon with the intermediate role between the eu-Mediterranean and continental vegetation was subsequently extended to the whole of Southern Europe by Barbero & Loisel (1972) who included the *Scorzonero-Chrysopo-*

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gonetalia into the European class *Brachypodio-Brometea* nom. illeg. (Art. 29c of the International Code of Phytosociological Nomenclature, ICPN, Weber et al. 2000).

In the following years, the biogeographic context of the *Scorzonero-Chrysopogonetalia* was interpreted differently and the order was classified within the *Festuco-Brometea* and the *Thero-Brachypodietea* or it was divided into two new orders, *Scorzoneretalia villosae* and *Koelerietalia splendentis*, which were classified in the aforementioned classes (e.g., Horvatić 1973; Blečić & Lakušić 1976; Royer 1991). In the following text, reference is made to the *Scorzoneretalia villosae* instead of the *Scorzonero-Chrysopogonetalia* for reasons explained below.

The distribution range of syntaxa of the *Scorzoneretalia villosae* was at first limited to the western side of Croatia (Horvat 1931; Horvatić 1934, 1949), and it was subsequently extended to other countries: Italy (Ferlan & Giacomini 1957), Slovenia (Tomazić 1941), Bosnia and Herzegovina (Kovačević 1959), Serbia (Nikolić & Diklić 1966), Montenegro (Černjavski et al. 1949), Macedonia (Jovanović et al. 1986), Albania (Dring et al. 2004) and Bulgaria (Tzonev 2009).

Many syntaxonomic revisions of the order have been performed at national or regional scales, the most influential being those of Horvatić (1958, 1963, 1975), Horvat (1962), Wendelberger (1965), Barbero & Loisel (1972), Horvat et al. (1974), Blečić & Lakušić (1976), Jovanović et al. (1986), Poldini (1989), Royer (1991), Feoli Chiapella & Poldini (1993), Poldini & Kaligarič (1997), Redžić (1999), Dring et al. (2004), Antonić et al. (2005) and Trinajstić (2008). Nonetheless, there has not as yet been no revision that takes into consideration all the associations across the entire distribution range of the order. Papers dealing with the *Scorzoneretalia villosae* very often refer to different syntaxonomic arrangements (see Terzi 2011) and indicate different character and differential species of high-rank syntaxa. Moreover, in many cases, new syntaxonomic schemes were proposed without any indication of the data set from which they were obtained nor the statistical methods utilised. This causes difficulties in comparing or transferring results from one region to another or when using syntaxonomic information for practical purposes, such as in the context of biodiversity conservation.

In addition, inconsistencies also occur in syntaxa names, and many contradictory or incorrect names are, in fact, used in scientific and technical literature. To solve this problem, I reviewed the nomenclature for the order in a previous publication (Terzi 2011). In this study, I have additionally found other papers rarely quoted in scientific literature (e.g., Černjavski et al. 1949; Kovačević 1959; Tomić-Stanković 1970), where some pivotal names were validly published for the first time. For example, the order name *Scorzoneretalia villosae* was validly published for the first time by Kovačević (1959).

The syntaxonomic and nomenclatural inconsistencies highlighted above are mainly due to the lack of an overall and supranational revision of phytosociological literature with modern statistical methods. The aim of this study was twofold: (1) to establish the syntaxonomic relationships among associations along the entire distribution range of the *Scorzoneretalia villosae*, and (2) to identify diagnostic species of high rank syntaxa using statistical methods.

Data and Methods

Data set

The data set consisted of 936 relevés already assigned to the *Scorzoneretalia villosae* and recorded in Italy (398 relevés), Slovenia (115), Croatia (338), Bosnia and Herzegovina (42), Serbia (18), Montenegro (22) and Bulgaria (3) (Fig. 1 and Supplement S1). Incomplete relevés such as those from Albania quoted in Buzo (1991) were not taken into consideration.

Some taxa were combined under the same tag if their differentiation in tables was uncertain or not possible; however, they were treated separately when discussing their diagnostic roles if some of them were traditionally dealt with as diagnostic species. I considered *Koeleria splendens* C. Presl also for the western Balkans even though some authors questioned its presence in that area (Brullo et al. 2009; see also Quintanar & Castroviejo 2013). Records of *Koeleria lobata* in the northeast of Italy (Feoli Chiapella & Poldini 1993) were assigned to *K. splendens*. In fact, according to Brullo et al. (2009), *K. lobata* should be excluded from the flora of Italy. Taxa quoted only at the genus level were omitted from the data set as well as bryophytes and lichens. Abundance-dominance values of the Braun-Blanquet scale were converted into the ordinal scale as proposed by van der Maarel (1979).

Plot size

Information regarding plot sizes was missing in 78 relevés. For the relevés reported by Poldini (1989) and Feoli-Chiapella & Poldini (1993), I considered an average plot size of 85 m^2, because each relevé was recorded on an area ranging 70–100 m^2 (Poldini, personal communication). For the entire data set, plot size varied from 4 to 2000 m^2. However in 90% of cases, it ranged between 10 and 150 m^2 with a median of 85 m^2 and a mean of 90 m^2. These values are clearly higher than those proposed for herbaceous vegetation by Chytrý & Otýpková (2003).

Even if the plot size could affect classification and ordination results (Dengler et al. 2009), the knowledge of

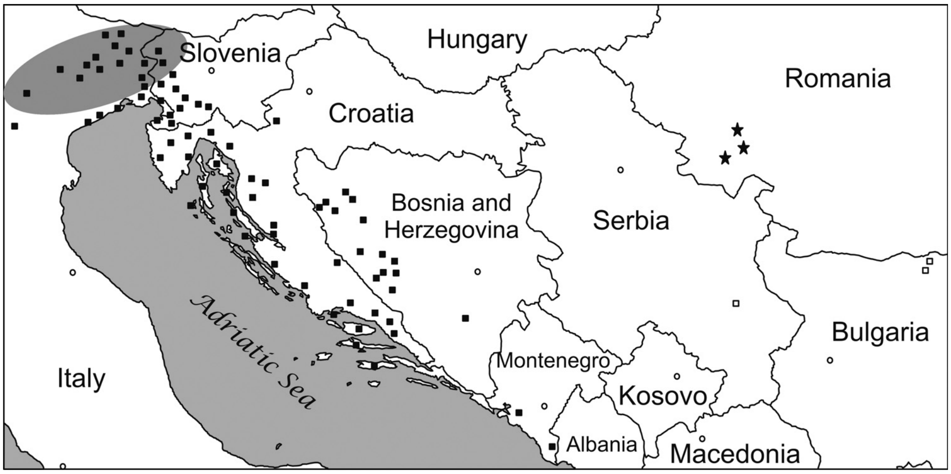

Fig. 1. Localities of relevés (square symbols). The shaded area corresponds to the distribution area of the *Centaureion dichroanthae* and *Hypochoeridenion maculatae*. The *Scorzonerenion villosae*, *Chrysopogono-Saturejion subspicatae* and *Saturejion subspicatae* lie in the remaining part of the distribution range of the *Scorzoneretalia villosae* (full squares), with the *Chrysopogono-Saturejion subspicatae* mostly at lower altitude. Empty squares indicate localities of relevés that should be excluded from the *Scorzoneretalia villosae*. Star symbols refer to the *Danthonio-Brachypodion* described by Boşcaiu (1972). Circles indicate the capital cities in the area.

such effects is insufficient (Otýpková & Chytrý 2006). Relevés with an unusually large plot size (> 200 m^2) and the small-sized ones (< 10 m^2) were deleted from the data set. However, the type-relevés of associations described in literature were always kept even if their plot size exceeded the aforementioned thresholds.

Resampling and outliers

In order to reduce redundancy of information, relevés representing similar ecological conditions, as reflected by their floristic composition, were excluded from the matrix. Once the Sørensen distance was calculated between each pair of relevés on the basis of presence/absence of species data, starting from the lowest distance value up to the arbitrary threshold of 0.3 (see also Westhoff & van der Maarel 1980), one relevé for each pair was randomly deleted (De Cáceres et al. 2008); if the selection involved a nomenclatural type, it was always included.

Because outlier relevés can influence multivariate analysis (McCune & Grace 2002), they were identified using the outlier analysis in PC-ORD 6.11 (McCune & Mefford 2011). Once the Sørensen distance matrix on presence/absence data was calculated, relevés that were more than two standard deviation units away from the mean were removed. Type relevés of the following associations turned out to be outliers and they were removed together with the remaining relevés of the associations: *Lino-Gypsophiletum glomerati*, *Potentillo-Achilleetum clypeolatae*, *Poo-Saturejetum subspicatae*, *Physospermo-Saturejetum montanae*, *Saturejo-Festucetum dalmaticae* and *Artemisio-Salvietum officinalis*. After resampling and outlier analysis, the data matrix consisted of 649 relevés.

Cluster analysis

Relevés were classified and, for the main clusters of relevés, IndSp were identified by ISA (Dufrêne & Legendre 1997). Cluster analysis and ISA were based on relevés (instead of synoptic tables) to achieve a higher accuracy of results. All the statistical analyses described below were performed by the software PC-ORD 6.11 (McCune & Mefford 2011).

Two agglomerative clustering methods, which were previously suggested as good choices for dealing with community data, were used: the flexible beta method, $\beta = -0.25$, with Bray and Curtis distance measure with and without standardisation by relevé totals (i.e., Sørensen and Relative Sørensen distance measures); and Ward's method on a chord distance matrix (Ward 1963, Legendre & Gallagher 2001, McCune & Grace 2002). Species values (y) were transformed (y') as follows: $y' = y^x$, with x ranging from 1 (untransformed data) to 0.5 (lowered species value), 0.25 (near presence/absence) and 0 (presence/absence). In total, 12 dendrogram solutions were obtained.

Since this paper focuses on high rank syntaxa, I considered only the first 15 partitioning levels for every dendrogram, and each ISA was performed among relevant clusters of relevés in order to identify the partition level with the highest number of significant ($p < 0.01$) IndSp as a result of a Monte Carlo test with 5000 permutations.

The ISA was performed on presence/absence data of taxa present in at least three relevés (Tichý & Chytrý 2006: 813). Of the 12 dendrograms, the one containing the node with the largest number of IndSp was chosen as the best-clustering solution. The number of IndSp has been suggested as a criterion to compare dendrograms (Aho et al. 2008, Tichý et al. 2010). The largest number of IndSp also identified the most informative node, where the selected dendrogram was pruned (McCune & Grace 2002). To increase interpretability of results – starting from the first level with all the relevés in only one cluster and descending the dichotomic hierarchy of the dendrogram – each significant IndSp was assigned to the cluster of relevés where its IndVal first reached the maximum value (Dufrêne & Legendre 1997). In this way, each significant IndSp was associated with only one cluster of relevés.

The main clusters of relevés were interpreted in syntaxonomic terms. For each of them, I selected a set of diagnostic taxa. These were chosen among the significant IndSp associated with that cluster or with its further subdivisions on the basis of information reported in scientific literature (Supplement S2) and personal judgement. That is, among taxa already judged as character or differential taxa, I selected the ones whose diagnostic roles were coherent with results of the ISA. Although each IndSp can be considered a diagnostic species, the subjective selection was needed because the small size of the data set did not allow overall evaluation of the sociological roles of all plant taxa (Terzi et al. 2010). The terms ingressive and transgressive species were used according to the definitions given by Poldini & Sburlino (2005).

Ordination

For each association, the diagnosis containing the nomenclatural-type relevé or subordinately the original diagnosis were selected (Supplement S1). Association diagnoses with fewer than four relevés were ignored and, when available, another diagnosis for those associations was used. Given the importance of the *Scorzonero-Danthonietum calycinae* for the nomenclature of the order and its wide distribution range, more diagnoses were considered (see below). Some associations from western Romania, previously assigned to the *Danthonio-Brachypodion* and classified within the same Balkan order (*Brachypodio-Chrysopogonetalia* nom. inval.) together with alliances of the *Scorzoneretalia villosae* (Boşcaiu 1972), were also added for comparative purposes.

In the association x taxa matrix, taxa variables were represented by percentage frequencies in the phytosociological tables. For the associations described only by synoptic tables, constancy classes were substituted with the central values of corresponding frequency ranges. Before ordination, outlier analysis in PC-ORD (McCune & Mefford 2011) was used to identify and remove outlier associations (*Artemisio-Salvietum officinalis*, *Poo-Saturejetum subspicatae*, *Genisto-Caricetum mucronatae* [from Horvat et al. 1974] and *Leontodonto-Seslerietum calcariae*). Nonmetric multidimensional scaling ordination (NMDS; Kruskal 1964; Mather 1976) was performed with the chord distance in the PC-ORD slow and thorough autopilot mode (McCune & Mefford 2011).

Life-form and chorological spectra

For each association, life-form and chorological spectra were calculated, weighted by species frequencies. Life forms and chorotypes were selected from works of Poldini (1991) and, to a lesser extent, Pignatti (1982), Horvatić et al. (1968), Assyov et al. (2006) and Lakušić & Redžić (1991). The following chorotypes were used: Alpine; Arctic-Alpine; Atlantic; Atlantic-Mediterranean; Circumboreal; Eurasian; European; Southeastern European, including Balkan species; Eurosiberian species; Illyrian species, composed of south- and north-Illyrian species *sensu* Poldini (1991) and endemics of the eastern and north Adriatic Region; Steno-Mediterranean; Eury-Mediterranean; Southern European orophyte, including Montane-Mediterranean *sensu* Pignatti (1982); Paleotemperate; Pontic species, including Mediterranean-Pontic species *sensu* Pignatti (1982); and widespread plants. Joint plots with an r^2 cut-off of 0.30 were used to show the strengths of the relationships between life-forms and chorotypes and ordination scores.

Phytosociological nomenclature

Decisions about nomenclature were taken following the 3rd edition of the ICPN (Weber et al. 2000), in addition to the suggestions of Willner et al. (2011). Complete syntaxon names are listed with specific epithets and names of authors in Appendix 1.

Results and discussion

Ward's clustering

The clustering solution obtained using Ward's method on square-root-transformed data contained the node with the largest number of IndSp followed by those obtained with fourth-root transformed data and the flexible-beta method with relative Sørensen distance on presence/absence data (491, 489 and 486 IndSp, respectively). Once the three dendrograms were pruned, they showed roughly similar groups of associations. Main differences existed in the positions of relevés of the *Ononido-Brometum condensati*, *Teucrio-Chrysopogonetum grylli*, *Leontodonto-Seslerietum calcariae* and in some other asso-

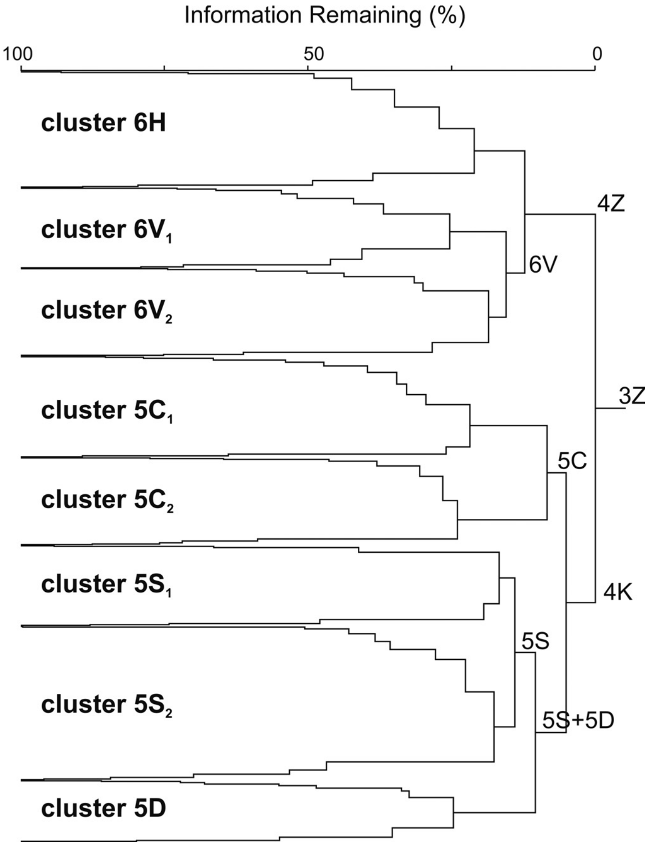

Fig. 2. Ward's clustering (chord distance) of relevés based on square-root-transformed species data. Cluster 4Z = suborder *Scorzonerenalia villosae* and alliance *Scorzonerion villosae*; cluster 4K = suborder *Koelerienalia splendentis*; cluster 5C = *Chrysopogono-Saturejion subspicatae*; cluster 5S = *Saturejion subspicatae*; cluster 5D = *Centaureion dichroanthae*; 6H = *Hypochoeridenion maculatae*; 6V = *Scorzonerenion villosae*.

ciations described by Trinajstić & Šugar (1972), Trinajstić (1977, 1999, 2005) and Lakušić & Redžić (1991). These differences have been considered in the interpretation of results. The dendrogram obtained with Ward's method on square-root data was selected as the best solution and will be addressed in the following sections.

The dendrogram (Fig. 2) was cut at the seventh partition level resulting in eight clusters of relevés. Each association was assigned to a cluster on the basis of the nomenclatural-type positions. Associations not yet typified were assigned to clusters containing the vast majority of their relevés.

Cluster 6H: *Avenulo-Brometum erecti*, *Chamaecytiso-Chrysopogonetum grylli*, *Gladiolo-Molinietum arundinaceae*, *Onobrychido arenariae-Brometum erecti*, *Schoeno-Chrysopogonetum grylli*, *Gentianello-Brometum erecti* and the relevés assigned to the *Avenulo-Brometum* by Lasen (1995) that, according to Pignatti & Pignatti (2014), would be ascribed to the *Thlaspio-Trifolietum pratensis*. This cluster can be considered representative of the *Hypochoeridenion maculatae*.

Cluster $6V_1$: *Scorzonero-Danthonietum calycinae* (relevés from Poldini 1989; Poldini & Kaligarič 1997).

Cluster $6V_2$: *Scorzonero-Danthonietum calycinae* (other relevés assigned to this association), *Globulario-Chrysopogonetum grylli*, *Festuco-Armerietum canescentis*, *Scorzonero-Hypochoeridetum maculatae* nom. nud. (only one relevé), *Carici-Scabiosetum leucophyllae*, *Globulario-Scabiosetum leucophyllae*, *Stipo-Genistetum dalmaticae*, *Ononido-Brometum condensati*, *Teucrio-Chrysopogonetum grylli*, *Artemisio-Rutetum graveolentis*, *Thymo-Teucrietum chamaedryos*, *Achilleo-Dorycnietum herbacei*. Cluster $6V_1$ and part of cluster $6V_2$ are representative of *Scorzonerenion villosae*; some associations of this group must be classified within other alliances or orders.

Cluster $5C_1$: *Asphodelo-Chrysopogonetum grylli*, *Bromo-Chrysopogonetum grylli*, *Koelerio-Festucetum illyricae*, *Bromo-Festucetum lapidosae*, *Stipo-Salvietum officinalis*, *Narcisso-Asphodeletum microcarpi*, *Festucetum illyrico-valesiacae*, *Koelerio-Brachypodietum retusi* and *Salvio-Seslerietum juncifoliae*.

Cluster $5C_2$: *Dichanthio-Cleistogenetum serotinae*, *Salvio-Euphorbietum fragiferae*, *Seseli-Artemisietum albae*, *Centaureo-Chrysopogonetum grylli* and *Lactuco-Bothriochloetum ischaemum*. Cluster 5C represents the *Chrysopogono-Saturejion subspicatae*.

Cluster $5S_1$: *Centaureo-Caricetum humilis* (relevés from Trinajstić 1987; Trinajstić & Pavletić 1990; Trinajstić et al. 1993; and few others from Poldini 1989), *Astragalo-Seslerietum robustae*, *Seslerio-Juniperetum sibiricae*, *Bromo-Seslerietum interruptae*, *Stipo-Caricetum humilis*, *Minuartio-Genistetum pulchellae*, *Genisto-Globularietum bellidifoliae*, *Genisto-Seslerietum tenuifoliae*, *Genisto-Seslerietum kalnikensis*, and *Seslerio-Caricetum humilis*.

Cluster $5S_2$: *Centaureo-Caricetum humilis* (other relevés assigned to this association), *Saturejo-Caricetum humilis*. The cluster 5S is representative of the *Saturejion subspicatae*.

Cluster 5D: *Bupleuro-Brometum condensati*, *Centaureo-Globularietum cordifoliae*, *Leontodonto-Seslerietum calcariae*, *Bromo-Stipetum eriocaulis*, *Saturejo-Brometum condensati* and the relevés assigned to *Genisto-Caricetum mucronatae* by Poldini (1989). The cluster represents the *Centaureion dichroanthae*.

Indicator Species Analysis

The results of the ISA (Supplement S2) showed that IndSp of the first clustering level (all the relevés belonging to the same cluster, 3Z in Fig. 2) included taxa of the *Festuco-Brometea* and others already considered diagnostic for the *Scorzoneretalia villosae*, such as *Salvia pratensis* subsp. *bertolonii* (together with *S. pratensis* subsp. *pratensis* in the data set), *Plantago holosteum*, *Festuca illyrica* (with *F. stricta* subsp. *sulcata* in the dataset), *Stachys officinalis*, *Scabiosa triandra*, *Veronica barrelieri*, *Medicago prostrata*, *Noccaea praecox*, and, transgressive from the class, *Eryngium amethystinum*, *Dorycnium pentaphyllum* subsp. *germanicum*, *Inula hirta*, *Linum tenuifolium*, and *Chrysopogon gryllus*.

With the first dendrogram partition, the cluster 4Z resulted as floristically well defined due to the many IndSp and the high IndVal. Some of the IndSp have been considered character species of meso-xerophytic syntaxa of the *Scorzoneretalia villosae* (*Hypochaeris maculata, Dorycnium pentaphyllum* subsp. *herbaceum*, *Danthonia alpina*), or are transgressive-differential from the *Festuco-Brometea* (e.g., *Ononis spinosa*, *Filipendula vulgaris*, *Plantago media*, *Euphorbia verrucosa*) or ingressive-differential from other classes (e.g., *Buphthalmum salicifolium*, *Agrostis capillaris*, *Trifolium rubens*). There are also many species that are widespread in mesophilous alliances of the *Festuco-Brometea* and ingressive from the *Molinio-Arrhenatheretea*. IndSp of further subdivisions of cluster 4Z are numerous, indicative of meso-xerophytic communities and some of relatively acidic soil conditions (e.g., *Genista germanica*, *Danthonia decumbens*, *Festuca filiformis*), but few can be listed as character taxa (e.g., *Scorzonera villosa* subsp. *villosa*, *Centaurea jacea* subsp. *weldeniana*, *Knautia illyrica*). For this reason, only one alliance (*Scorzonerion villosae*), divided into two sub-alliances (*Hypochoeridenion maculatatae* and *Scorzonerenion villosae*), was considered. It is interesting to note that some IndSp of clusters 4Z and 6H were included among the character species of the *Brachypodietalia pinnati* (Supplement S2 columns 15 and 16). Very few IndSp, without high IndVal and transgressive from the class, were associated with cluster $6V_2$. In effect, this cluster includes some associations that must be excluded from the alliance. The *Artemisio-Rutetum graveolentis*, *Thymo-Teucrietum chamaedryos* and *Achilleo-Dorycnietum herbacei* were originally classified within the *Saturejion montanae* (presumably instead of the *Saturejenion montanae*) and the *Saturejion subspicatae* even if they contained few species of the *Scorzoneretalia villosae*. The *Carici-Scabiosetum leucophyllae* was originally classified within the *Saturejion subspicatae* but then moved to the *Xerobromion erecti* (Redžić et al. 1984, 2013; Redžić 1999). There are important floristic differences with other central European associations of the *Xerobromion erecti* and Redžić (1999) proposed a Balkan suballiance *Fumano-Scabiosenion leucophyllae*. In fact, the relationships between the *Scorzoneretalia villosae* and Balkan associations classified within the *Xerobromion*, and the *Brometalia erecti / Artemisio-Brometalia erecti* (Mucina et al. 2009) in general, remain to be clarified; the *Carici-Scabiosetum leucophyllae* and *Globulario-Scabiosetum leucophyllae* share important species with the *Scorzoneretalia villosae*, where they are provisionally arranged. Two other associations of this group, the *Stipo-Genistetum dalmaticae* and the *Teucrio-Chrysopogonetum grylli*, have been provisionally moved to the *Saturejion subspicate* and the *Centaureion dichroanthae,* respectively, due to the presence of a few but important diagnostic species of these alliances, such as *Centaurea rupestris*, *Satureja subspicata*, and *Cytisus purpureus* (see Redžić et al. 1984; Sburlino et al. 2008).

On the other side of the dendrogram, IndSp of cluster 4K grouped taxa already regarded as diagnostic to more xerothermic syntaxa of the *Scorzoneretalia villosae* (i.e., *Koelerietalia splendentis* in the syntaxonomic scheme of Horvatić 1973). IndSp of cluster 5C (*Chrysopogono-Saturejion subspicatae*) or of its further subdivisions were composed of many Mediterranean and Illyrian taxa. Some can be considered diagnostic of the alliance. Others are ingressive from the Mediterranean *Thero-Brachypodietea*, while others are common to southern xerothermic syntaxa of the *Festuco-Brometea* (e.g., *Artemisia alba, Melica ciliata*, *Petrorhagia saxifraga*, *Bothriochloa ischaemum*, *Asperula aristata*). Cluster $5C_2$ includes associations of the northern part of the alliance range (Karst area surrounding Trieste and Gorizia and the Island of Krk), which is an area without proper summer drought and with cooler winters than in Dalmatia (Hršak 2003; Poldini 2009). Nonetheless, due to edaphic and mesoclimatic conditions (Ferlan & Giacomini 1957; Poldini 1989, 2009), associations of this cluster show high percentage of Mediterranean chorotypes (Supplement S3) and can be assigned to the *Chrysopogono-Saturejion subspicatae* owing to the presence of important diagnostic taxa of this alliance (Table 1).

The IndSp of cluster 5C+5D were shared by the *Saturejion subspicatae* and the *Centaureion dichroanthae* (e.g. *Genista sericea*, *Inula ensifolia*, *Scorzonera austriaca*, *Plantago argentea*). The *Centaureion dichroanthae* (cluster 5D) was differentiated by ingressive taxa from the *Elyno-Seslerietea* and de-Alpine taxa, such as *Globularia cordifolia*, *Hieracium porrifolium*, *Polygala nicaeensis* subsp. *carniolica* and *Carduus defloratus*. Despite some floristic similarities with the *Saturejion subspicatae*, it was considered an autonomous alliance, vicariant in the pre-Alpine region (shaded area in Figure 1), for both the numerous IndSp and Alpine taxa. A very recent study by Pignatti & Pignatti (2014) extended the distribution area of the *Centaureion dichroanthae* up to the Dolomites, thereby integrating new associations with relevés not included in my data set. Nevertheless, based on my results but different from their findings, the *Bromo-Stipetum eriocaulis* and the *Avenulo-Brometum erecti* sensu Lasen 1995 non Feoli Chiapella et Poldini 1993 were classified as originally proposed by Lasen (1995). The *Centaureion dichroanthae* (cluster 5D) also included the relevés assigned to the *Genisto-Caricetum mucronatae* by Poldini (1989). The presence of many species of the *Centaureion* *dichroanthae* within this association had already been noted (Poldini 1989). Unfortunately, the original diagnosis of the *Genisto-Caricetum* consisted only of a synoptic table (Horvat et al 1974), and there were no other relevés from its original area (Gorski Kotar, Croatia). In effect, *Euphorbia triflora* subsp. *triflora* turned out to be among IndSp of the *Centaureion dichroanthae*, even though it is at the edge of its range in the Trnovski Gozd (Slovenia). Regardless, on the basis of the diagnosis given by Poldini (1989), the *Genisto-Caricetum mucronatae* can be classified within the *Centaureion dichroanthae*.

The IndSp belonging to the clusters derived from further divisions of cluster 5S were assigned to the *Saturejion subspicatae* (Table 1). Numerous IndSp (but with low IndVal), many of which are thermophilous taxa, were associated with cluster $5S_1$, which represents a transition towards the more thermo-xeric *Chrysopogono-Saturejion subspicatae*.

NMDS

The three-axis solution of the NMDS ordination attained a minimum stress of 11.7, indicating a fairly usable and good ordination (McCune & Grace 2002). The proportion of variance represented by the three axes were 36.9%, 25.4% and 15.5%, respectively, thus explaining 77.8% of total variation. For simplification purposes, I presented only the first two dimensions (Fig. 3). The relationships between ordination scores and chorological spectra (Fig. 3, Supplement S3) showed a gradient along axis 1 from the chorotypes Steno-Mediterranean (r^2= 0.40) and Illyrian (r^2= 0.60) to Eurosiberian (r^2= 0.77), Eurasian (r^2=0.76) and European (r^2= 0.59); along axis 2, a second gradient from Paleotemperate (r^2= 0.36) and Eury-Mediterranean (r^2= 0.51) to Orophyte (r^2= 0.66) was present. Moreover, there were positive correlations of therophytes (r^2= 0.45) with axis 2 and hemicryptophytes (r^2= 0.62) with axis 1 and a negative correlation of chamaephytes (r^2= 0.56) with axis 1.

Three main groups of associations, roughly corresponding to clusters 4Z, 5C and 5S+5D, occupied different parts of the diagram (Fig. 3). Associations of the clus-

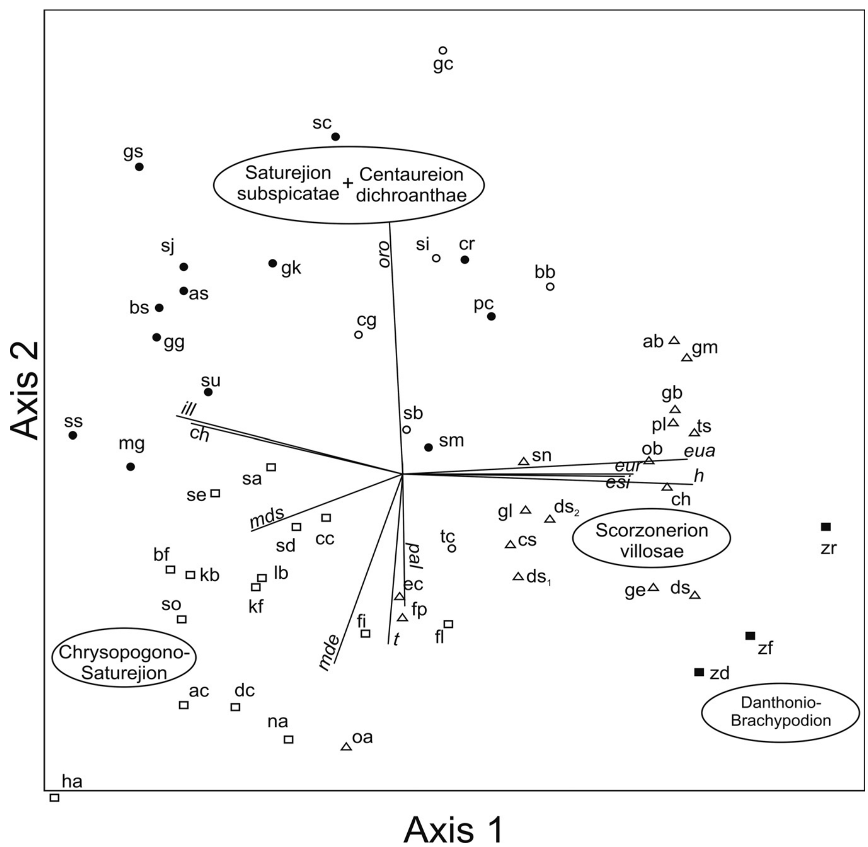

Fig. 3. Nonmetric multidimensional scaling ordination diagram (axes 1 and 2). Empty squares indicate *Chrysopogono-Saturejion subspicatae*, full circles *Saturejion subspicatae*; empty circles *Centaureion dichroanthae*; triangles *Scorzonerion villosae*; full squares *Danthonio-Brachypodion*. Abbreviations: eua = Eurasian; eur = European; esi = Eurosiberian species; ill = Illyrian species; mds = Steno-Mediterranean; mde = Eury-Mediterranean; oro = Southern European orophyte; pal = Paleotemperate; h = hemicryptophyte; t = therophyte; ch = chamaephyte. Syntaxa abbreviations in Appendix 1.

ter 4Z were on the right side of the ordination space, together with associations of the *Danthonio-Brachypodion*. This group, composed of meso-xerophytic associations, showed the lowest percentage of Illyrian and Mediterranean species and high percentages of Eurasian, European and Eurosiberian species (Fig. 3; Supplement S3). As expected, orophilous species were well-represented within the associations of the *Saturejion subspicatae* and the *Centaureion dichroanthae*, which are partly overlapping in the upper part of the diagram. The *Centaureion dichroanthae* is differentiated by higher percentages of Alpine species (Supplement S3). Associations of cluster $5S_1$ are located in the upper-left side of the diagram with some of its associations close to the *Chrysopogono-Saturejion subspicatae*, as noted above. These associations showed the highest percentage of Illyrian species; Mediterranean chorotypes were more prevalent within the *Chrysopogono-Saturejion subspicatae*.

Based on the data, the floristic autonomy of the *Festucion illyricae* seems questionable, because this alliance lacks character species, while its associations (*Festuco-Linetum flavi* and *Festucetum illyrico-valesiacae*) share taxa with both the *Scorzonerion villosae* (*Centaurea jacea* subsp. *weldeniana*, *Plantago media*, *Dorycnium pentaphyllum* subsp. *herbaceum*, *Knautia illyrica*, *Prunella laciniata*) and the *Chrysopogono-Saturejion subspicatae* (*Koeleria splendens*, *Ornithogalum orthophyllum* subsp. *kochii*, *Bupleurum veronense*, *Potentilla tommasiniana*). These associations, together with the *Festuco-Poetum bulbosae*, *Ononido-Brometum condensati* and *Euphorbio-Chrysopogonetum grylli*, are also intermediate between these two alliances from a chorological standpoint. The ratio of the sum of Eurasian, European and Eurosiberian species and the sum of Mediterranean species is generally equal to or less than 1 in the *Chrysopogono-Saturejion subspicatae* and near to or more than 2 in the *Scorzonerion villosae*. However, a precise comparative analysis is difficult when dealing only with synoptic tables, which often lack some of the rarer taxa (see synoptic tables in Horvatić 1963 and Horvat et al. 1974). For this reason, the classification of these associations has to be considered as provisional, and new data are required.

Syntaxonomy, ecology and distribution

The numerical analysis of the *Scorzoneretalia villosae* differentiated two main groups of associations, corresponding to meso-xerophytic meadows (*Scorzonerion villosae*) on the one hand and sub-Mediterranean thermo-xerophytic grasslands (*Chrysopogono-Saturejion subspicatae*) and pre-Alpine/ Dinaric Mediterranean-montane pastures on the other (*Centaureion dichroanthae* and *Saturejion subspicatae*).

Pastures and stony grasslands on shallow calcareous soils are classified within the *Chrysopogono-Saturejion subspicatae*, *Saturejion subspicatae* and *Centaureion dichroanthae*. The *Chrysopogono-Saturejion subspicatae* occurs along the eastern and northern Adriatic coast; at higher altitude, the alliance gives way to the *Saturejion subspicatae* (Dinarides) and the *Centaureion dichroanthae* (southeastern part of pre-Alps: shaded area in Fig. 1).

The *Scorzonerion villosae* was originally conceived to include the Illyrian-Dinaric dry grasslands on deep and partly decalcified terra rossa soil and on variably acidic soils (Horvatić 1949, 1958, 1963). Feoli-Chiapella & Poldini (1993) unified the *Scorzonerion villosae* with the *Hypochoeridion maculatae* and extended the alliance distribution area up to the pre-Alpine region in north-eastern Italy and Slovenia (shaded area in Fig. 1). This resultant alliance was floristically well differentiated, with few character species and many differential ones shared with other meso-xerophytic alliances of the *Festuco-Brometea* that are often shared with mesotrophic meadows belonging to the *Molinio-Arrhenatheretea*. Similar findings have been reported by Pipenbaher et al. (2011), specifically for the Slovenian karst area. Associations of the *Scorzonerion villosae* showed a prevalence of hemicryptophytes and high percentages of European, Eurasian and Eurosiberian taxa.

On the other hand, Mediterranean and Illyrian taxa are more concentrated in the other alliances. The *Chrysopogono-Saturejion subspicatae* has a higher percentage of Mediterranean taxa with many ingressive taxa from the *Thero-Brachypodietea* s.l., while orophilous (and Mediterranean-montane) and Alpine taxa penetrate into the *Saturejion subspicatae* and *Centaureion dichroanthae*.

These differences were translated into syntaxonomic terms with two suborders of the *Scorzoneretalia villosae*, *Scorzonerenalia villosae* (including *Scorzonerion villosae*) and *Koelerienalia splendentis* (including the other three alliances).

It is interesting to note that already Horvat and Horvatić (in Horvatić 1958: 69) proposed separating the associations of the *Scorzonerion villosae* from those of the *Chrysopogono-Saturejion subspicatae* (part of which was later moved to *Saturejion subspicatae*) at the order level. Some years later, Horvatić (1973, 1975) proposed a new syntaxonomic scheme with the *Saturejion subspicatae* and *Scorzonerion villosae* being assigned to the *Scorzoneretalia villosae* and the *Chrysopogono-Saturejion subspicatae* being assigned to the *Koelerietalia splendentis*.

The latter has been reduced here to the rank of suborder and the alliances *Centaureion dichroanthae* and *Saturejion subspicatae* have been assigned to it. With increasing altitude (or distance from the sea), the Mediterranean influence decreases and mesophilous species of the *Scorzonerion villosae* may occurr in communities of the *Koelerienalia splendentis*. However, the overall floristic and chorological patterns support the arrangement of alliances in the two suborders as described above.

Both suborders are placed within the the *Scorzoneretalia villosae* and the *Festuco-Brometea*. This scheme refers to a classical interpretation of the class, with geographically defined orders and with the *Scorzoneretalia villosae* lying between the western suboceanic *Brometalia erecti* and the eastern sub-continental *Festucetalia valesiacae* (Royer 1991; see also Dengler et al. 2012). Braun-Blanquet (1974) refuted the floristic autonomy of *Scorzoneretalia villosae* and considered only one alliance, *Chrysopogono-Saturejion subspicatae*, within the *Brometalia erecti*. For many other authors, the floristic autonomy of *Scorzoneretalia villosae* is due to a set of sub-Mediterranean and Illyrian species (Horvat 1962; Horvat et al. 1974; Barbero & Loisel 1972; Royer 1991). Most Illyrian taxa are concentrated within the xerophytic *Koelerienalia splendentis*, which is, consequently, better differentiated than the *Scorzonerenalia villosae*. The latter has fewer Illyrian and sub-Mediterranean taxa but shares many taxa with neighbouring alliances, especially with Balkan associations of the *Bromion erecti*.

The transition between the *Bromion erecti* and the *Scorzonerion villosae* is abrupt in some areas but gradual in others; it has been related to decreasing inland temperature (Horvat et al. 1974; Gaži-Baskova & Šegulja 1978; Redžić 1999). Pipenbaher et al. (2013) directly compared plant traits and floristic compositions of the Slovenian records of the associations *Scorzonero-Danthonietum calycinae* and *Onobrychido-Brometum erecti* T. Müller 1966, concluding that two orders are justified for these vegetation types. However, while in Slovenia the boundary between the *Scorzonerion villosae* and the *Bromion erecti* is clearly related to the bioclimatic transition from Mediterranean to more continental types, in the western Balkan Peninsula the floristic relationships between the two alliances are more complex (Kovačević 1959; Ritter-Studnička 1972; Ilijanić et al. 1972; Trinajstić et al. 1981; Lakušić et al. 1982; Royer 1991). Over time, Mediterranean plants must have migrated inland (i.e. *Lathyrus latifolius*, *Eryngium amethystinum*, *Scabiosa triandra*), across the Dinaric Alps penetrating into Balkan communities of the *Brometalia erecti* (Horvat et al. 1974; Royer 1991). Ilijanić et al. (1972) highlighted the similarities between the *Globulario-Chrysopogonetum grylli*, recorded in a karst area west of Karlovac (Croatia) and originally classified within the *Brometalia erecti*, and the *Scorzonero-Danthonietum calycinae*, with taxa such as *Danthonia alpina*, *Chrysopogon gryllus*, *Filipendula vulgaris*, *Trifolium montanum*, *Plantago media*, *Dorycnium pentaphyllum* subsp. *herbaceum*, *Scabiosa triandra*, *Globularia bisnagarica*, *Brachypodium pinnatum* and *Prunella laciniata*, among others. Many of these taxa can be considered diagnostic of the *Scorzoneretalia villosae* or its subordinated syntaxa.

The nomenclatural reconsideration of the order leads to the conclusion that the type relevé of the *Scorzonero-Danthonietum calycinae*, and consequently of the *Scorzonerion villosae*, was recorded in the area of Bosanski Petrovac, in Bosnia (Kovačević 1959), and brings the *Scorzonerenalia villosae* nearer to other meso-xerophytic alliances of the Balkans. For example, plant communities from the same area which had been assigned to the *Bromo-Plantaginetum mediae* (Kovačević 1959), are very similar to the *Scorzonero-Danthonietum calycinae*.

Boşcaiu (1972) reduced the *Brachypodio-Chrysopogonetea* to the order level (contravening ICPN Art. 27, Note 1; Weber et al. 2000) and proposed to extend its distribution range as far as western Romania, including the *Danthonio-Brachypodion*. The new order would constitute a Balkan vicariant of the western *Brometalia erecti* (Boşcaiu 1972). Some authors (Sanda et al. 2008) followed this approach. It is now clear that the similarities pointed out by Boşcaiu (1972) regarded only the suborder *Scorzonerenalia villosae* even though, among the diagnostic species of the *Danthonio-Brachypodion* and *Brachypodio-Chrysopogonetalia* (Boşcaiu 1972), only *Danthonia alpina* and *Chrysopogon gryllus* had a significant IndVal in my analysis (Fig. 3, Supplement S2). The *Danthonio-Brachypodion* recently has been considered part of the *Cirsio-Brachypodion pinnati*, within the *Brachypodietalia pinnati* (Dengler et al. 2012), following a proposal to group all meso-xerophytic syntaxa of the *Festuco-Brometea* within only one order. The name of the meso-xerophytic order would be *Brometalia erecti*, a name proposed to be rejected as *nomen ambiguum* and substituted with *Brachypodietalia pinnati* as the next younger valid name (Dengler et al. 2003). Results of ISA (Supplement S2: columns 15 and 16) showed that some diagnostic species of *Scorzonerenalia villosae* coincide with those identified for the *Brachypodietalia pinnati*. Floristic and chorological similarities of the *Scorzonerenalia villosae* with Balkan associations of the *Bromion erecti* and further eastwards with the *Danthonio-Brachypodion* might suggest to group all these communities within only one order. Consequently, the *Scorzonerenalia villosae* (and thus the order name), or at least its more mesophilous associations, could be moved to the *Brachypodietalia pinnati* while the remaining xerophytic alliances would be assigned to the Illyrian xerophytic order *Koelerietalia splendentis*.

However, the most appropriate model for the *Festuco-Brometea* should be determined by means of a large-scale comparative study. No such revision has yet been carried out, with the exception of the thorough works performed by Royer (1991) and, for the Balkan Peninsula, by Horvat et al. (1974). Both these studies support the classical concept of the class with geographically defined orders. Therefore, the traditional approach is followed here, considering two suborders within the *Scorzoneretalia villosae*.

The distribution range of the *Scorzoneretalia villosae* (Fig. 1) covers the western part of the Balkan Peninsula, omitting the associations described by Tzonev (2009) in

Bulgaria and the *Artemisio-Salvietum* officinalis in Serbia. The latter contains many taxa indicative of a different ecological context (*Linaria concolor*, *Koeleria simonkaii*, *Euphorbia taurinensis*, *Achillea clypeolata*, *Erysimum crepidifolium*, *Achillea crithmifolia*, *Dianthus pelviformis*, *Thymus praecox* subsp. *jankae*), and diagnostic taxa of the *Scorzoneretalia villosae* were lacking almost entirely.

North- and westward, the order *Scorzoneretalia villosae* follows the south-eastern pre-Alpine sectors (Feoli Chiapelli & Poldini 1993; Lasen 1995; Pignatti & Pignatti 2014) where it came in connection with the *Festucetalia valesiacae*. Its syntaxonomic relationships with the *Diplachnion*, especially with associations descibed by Meyer (1976) along the southern pre-Alpine lakes, remain to be solved. Regarding the Italian Peninsula, some authors extended the order range to xerophytic and meso-xerophytic basophilous grasslands of the Apennines (Bonin 1978; Biondi & Galdenzi 2012). However, preliminary results of a comparative study among xerophytic grasslands of the amphi-Adriatic area (Terzi & Di Pietro 2013) highlighted important floristic differences between the Balkan and peninsular Italian sides of the Adriatic Sea, notably Illyrian/south-eastern European taxa on the Balkan side (e.g., *Chrysopogon gryllus*, *Festuca illyrica*, *Festuca valesiaca*, *Genista* spp., *Scorzonera villosa* subsp. *villosa*, *Stipa eriocaulis*) and other taxa, mostly Italian endemics, on the other side (e.g., *Festuca circummediterranea, Phleum ambiguum, Cerastium suffruticosum, Crepis lacera, Scorzonera villosa* subsp. *columnae, Thymus spinulosus*). As some of these taxa are often dominant, a differentiation at the order level was proposed (Terzi & Di Pietro 2013). This idea has been strengthened by the recent description of some new endemic orders for peninsular Italian grasslands (Ubaldi 2011; Biondi et al. 2014).

Syntaxonomic scheme and phytosociological nomenclature

Based on these results, the syntaxonomic scheme below is proposed together with a set of diagnostic taxa. The classification of associations described by few relevés or by synoptic tables is only provisional, and more in-depth studies are required to determine their correct syntaxonomic positions. Moreover, associations quoted in Pignatti & Pignatti (2014) but not included in the analysis, were added to the scheme for completeness but marked by an asterisk. Numbers within square brackets refer to the nomenclatural notes in Appendix 2.

1F. Class: *Festuco-Brometea* Br.-Bl. & Tx. ex Klika & Hadač 1944

3Z. Order: *Scorzoneretalia villosae* Kovačević 1959 [1]

Nomenclatural synonym: *Scorzonero villosae-Chrysopogonetalia* grylli Horvatić & Horvat in Horvatić 1963; *Scorzoneretalia villosae* Horvatić 1973. Holotypus: *Scorzonerion villosae* Horvatić ex Kovačević 1959. Diagnostic taxa: *Anthyllis vulneraria* subsp. *polyphylla*; *Centaurea jacea* subsp. *gaudinii*; *Chrysopogon gryllus*; *Cyanus triumfettii*; *Dorycnium pentaphyllum* subsp. *germanicum*; *Eryngium amethystinum*; *Euphorbia nicaeensis*; *Festuca illyrica*; *Festuca valesiaca*; *Leucanthemum platylepis*; *Medicago prostrata*; *Noccaea praecox*; *Plantago argentea*; *Plantago holosteum*; *Potentilla heptaphylla* subsp. *australis*; *Salvia pratensis* subsp. *bertolonii*; *Scabiosa triandra*; *Seseli montanum* subsp. *tommasinii*; *Stachys officinalis* subsp. *serotina*; *Veronica barrelieri*.

4K. Suborder: *Koelerienalia splendentis* (Horvatić 1973) stat. nov. hoc loco (Horvatić 1973: 7)

Holotypus: *Chrysopogono grylli-Koelerion splendentis* Horvatić 1973 (that is a syntaxonomic synonym of *Chrysopogono grylli-Saturejion subspicatae* Horvat & Horvatić ex Černjavski, Grebenščikov & Pavlović 1949). Diagnostic taxa: *Dianthus sylvestris* subsp. *tergestinus*; *Euphrasia illyrica*; *Genista holopetala*; *Genista sericea*; *Genista sylvestris* subsp. *sylvestris*; *Globularia cordifolia*; *Hyacinthella dalmatica*; *Inula ensifolia*; *Koeleria splendens*; *Linum narbonense*; *Ornithogalum orthophyllum* subsp. *kochii*; *Potentilla heptaphylla* subsp. *australis*; *Potentilla tommasiniana*; *Satureja montana* subsp. *variegata*; *Scorzonera austriaca*; *Seseli kochii*; *Stachys recta* subsp. *subcrenata*; *Stipa eriocaulis*; *Teucrium montanum*; *Trinia glauca*.

5C. Alliance: *Chrysopogono grylli-Saturejion subspicatae* Horvat & Horvatić ex Černjavski, Grebenščikov & Pavlović 1949 [5]

Syntaxonomic Synonym: *Chrysopogono grylli-Koelerion splendentis* Horvatić 1973. Lectotypus: *Bromo erecti-Chrysopogonetum grylli* Horvatić 1934. Diagnostic taxa: *Achillea nobilis*; *Astragalus muelleri*; *Bupleurum veronense*; *Carduus nutans* subsp. *micropterus*; *Centaurea cristata*; *Centaurea spinosociliata*; *Centaurea tommasinii*; *Dianthus ciliatus*; *Euphorbia fragifera*; *Festuca lapidosa*; *Genista sylvestris* subsp. *dalmatica*; *Onobrychis arenaria* subsp. *tommasinii*; *Onosma echioides* subsp. *dalmatica*; *Salvia officinalis*; *Satureja montana* subsp. *variegata*.

Associations: ac – Bromo erecti-Chrysopogonetum grylli Horvatić 1934 [6]; bf – Bromo erecti-Festucetum lapidosae Trinajstić 1992; cc – Centaureo cristatae-Chrysopogonetum grylli Ferlan & Giacomini 1957 [7]; dc – Dichanthio ischaemum-Cleistogenetum serotinae Horvatić ex Trinajstić in Poldini 1975 nom. mut. propos.; fi – Festucetum illyrico-valesiacae Horvat in Horvat et al. 1974 corr. Trinajstić 2000; fl – Festuco-Linetum flavi Ritter-Studnička 1972; ha – Helichryso italici-Armerietum dalmaticae Horvatić 1963; kb – Koelerio macranthae-Brachypodietum retusi ass. nov. hoc loco [9]; kf –

Table 1. Abridged synoptic table of the *Scorzoneretalia villosae*, from the level of suballiance to the level of class. Diagnostic taxa are selected from IndSp associated to the clusters in Figure 2, corresponding to the following syntaxa: 5C = *Chrysopogono-Saturejion subspicatae*; 5S = *Saturejion subspicatae*; 5D = *Centaureion dichroanthae*; 6H = *Hypochoeridenion maculatae*; 6V = *Scorzonerenion villosae*. The percentage frequencies of taxa are given in columns. For each taxon, the IndVal and the associated cluster are indicated in the last two columns. The list of IndSp is reported in the Supplement S2.

	5C	5S	5D	6H	6V	IndVal	Cluster
Number of relevés	159	198	51	98	142		
Alliance: *Chrysopogono grylli-Saturejion subspicatae*							
Satureja montana subsp. *variegata*	**42**	15	21	1	4	75	$5C_2$
Bupleurum veronense	**40**	4	.	.	4	35	5C
Salvia officinalis	**31**	8	.	.	.	27	$5C_1$
Onosma echioides subsp. *dalmatica*	**18**	4	.	.	7	13	5C
Euphorbia fragifera	**15**	4	.	.	1	19	$5C_2$
Centaurea cristata	**15**	6	.	.	.	16	$5C_2$
Carduus nutans subsp. *micropterus*	**14**	5	.	.	2	23	$5C_1$
Genista sylvestris subsp. *dalmatica*	**11**	5	.	.	4	13	$5C_1$
Centaurea spinosociliata	**9**	3	.	.	.	14	$5C_1$
Centaurea tommasinii	**9**	1	.	.	3	13	$5C_1$
Astragalus muelleri	**7**	2	.	.	.	10	$5C_1$
Festuca lapidosa	**4**	.	.	.	.	8	$5C_1$
Achillea nobilis	**4**	1	.	.	2	6	$5C_1$
Onobrychis arenaria subsp. *tommasinii*	**3**	.	.	.	.	7	$5C_2$
Alliance: *Saturejion subspicatae*							
Centaurea rupestris	9	**51**	8	.	8	32	5S
Sesleria tenuifolia subsp. *tenuifolia*	3	**42**	.	.	1	38	$5S_1$
Satureja subspicata	.	**42**	2	.	1	39	5S
Anthyllis montana subsp. *jacquinii*	.	**29**	4	.	1	25	5S
Jurinea mollis	3	**20**	.	.	.	16	5S
Muscari botryoides	5	**19**	.	2	4	11	5S
Edraianthus tenuifolius	5	**16**	.	.	2	29	$5S_1$
Gentiana verna subsp. *tergestina*	.	**14**	4	.	4	11	$5S_2$
Pulsatilla montana	.	**13**	.	1	2	13	$5S_2$
Globularia meridionalis	.	**11**	.	.	.	26	$5S_1$
Crepis chondrilloides	1	**11**	.	.	.	9	5S
Bunium alpinum subsp. *montanum*	2	**10**	.	.	1	23	$5S_1$
Narcissus poeticus subsp. *radiiflorus*	.	**9**	.	5	1	7	5S
Astragalus croaticus	.	**7**	.	.	.	19	$5S_1$
Iris pallida subsp. *illyrica*	3	**6**	.	.	.	4	$5S_1$
Klasea radiata subsp. *cetinjensis*	.	**4**	.	.	.	10	$5S_1$
Alliance: *Centaureion dichroanthae*							
Sesleria caerulea	.	.	**87**	16	.	80	5D
Cytisus purpureus	.	3	**54**	16	3	45	5D
Stachys recta subsp. *labiosa*	1	.	**52**	7	1	48	5D
Hieracium porrifolium	.	.	**44**	.	.	44	5D
Carex mucronata	.	1	**38**	1	.	37	5D
Lomelosia graminifolia subsp. *graminifolia*	.	1	**35**	3	.	33	5D
Polygala nicaeensis subsp. *carniolica*	.	.	**31**	2	.	30	5D
Leontodon incanus	.	2	**31**	1	.	29	5D

Table 1. cont.

	5C	5S	5D	6H	6V	IndVal	Cluster
Number of relevés	159	198	51	98	142		
Euphorbia triflora subsp. *kerneri*	.	.	**25**	5	.	23	5D
Cytisus pseudoprocumbens	.	7	**23**	7	4	15	5D
Carduus defloratus	.	.	**21**	3	.	20	5D
Gypsophila repens	.	.	**19**	3	.	18	5D
Centaurea dichroantha	.	.	**19**	6	.	17	5D
Moltkia suffruticosa	.	.	**19**	.	.	19	5D
Calamagrostis varia	.	1	**19**	3	.	17	5D
Allium ericetorum	1	3	**17**	4	.	12	5D
Gentiana clusii	.	2	**15**	6	.	12	5D
Potentilla pusilla	1	.	**12**	1	2	8	5D
Erysimum sylvestre	.	4	**10**	.	.	7	5D
Euphrasia cuspidata	.	.	**8**	.	.	8	5D
Suborder: *Koelerienalia splendentis*							
Teucrium montanum	**38**	**63**	**71**	20	8	43	4K
Koeleria splendens	**60**	**50**	**15**	4	17	40	4K
Globularia cordifolia	5	36	79	11	3	48	5D
Stipa eriocaulis	**24**	**30**	**48**	2	4	27	4K
Scorzonera austriaca	**6**	**32**	**37**	5	4	25	5D+5S
Seseli kochii	**13**	**12**	**42**	3	1	21	5D
Potentilla heptaphylla subsp. *australis*	**16**	**21**	**25**	5	6	15	4K
Genista sericea	7	36	19	5	.	26	5D+5S
Inula ensifolia	**2**	**21**	**33**	.	1	21	5D+5S
Dianthus sylvestris subsp. *tergestinus*	**26**	**24**	**.**	1	5	19	4K
Genista sylvestris subsp. *sylvestris*	**13**	**32**	**4**	.	2	20	4K
Trinia glauca	**1**	**17**	**19**	4	4	14	5D+5S
Potentilla tommasiniana	9	24	2	.	1	14	4K
Stachys recta subsp. *subcrenata*	**15**	**19**	**.**	.	1	14	4K
Linum narbonense	**.**	**11**	**13**	2	1	11	5D+5S
Ornithogalum orthophyllum subsp. *kochii*	**7**	**5**	**.**	.	2	8	$5C_1$
Euphrasia illyrica	**2**	**5**	**2**	.	.	3	4K
Hyacinthella dalmatica	3	.	.	.	.	5	$5C_1$
Suballiance: *Hypochoeridenion maculatae*							
Centaurea scabiosa subsp. *fritschii*	2	1	15	**47**	4	31	6H
Cirsium pannonicum	.	5	2	**41**	13	28	6H
Knautia ressmannii	.	.	15	**40**	.	29	6H
Rhinanthus alectorolophus subsp. *freynii*	1	1	2	**35**	10	24	6H
Prunella grandiflora	.	9	10	**31**	4	18	6H
Carex montana	.	4	8	**27**	4	17	6H
Achillea roseoalba	.	.	.	**18**	.	18	6H
Linum viscosum	.	1	6	**14**	1	10	6H
Alliance: *Scorzonerion villosae* and							
Suballiance: *Scorzonerenion villosa*e							
Filipendula vulgaris	1	29	2	**57**	**43**	38	4Z
Plantago media	5	18	4	**45**	**50**	39	4Z

Table 1. cont.

	5C	5S	5D	6H	6V	IndVal	Cluster
Number of relevés	159	198	51	98	142		
Ononis spinosa	4	4	2	**27**	**42**	32	4Z
Euphorbia verrucosa	.	14	4	**44**	**21**	25	4Z
Trifolium rubens	1	5	2	**30**	**28**	26	4Z
Hypochaeris maculata	1	8	6	**35**	**19**	21	4Z
Scorzonera villosa subsp. *villosa*	11	30	.	**7**	**46**	30	$6V_2$
Knautia illyrica	1	30	8	**8**	**45**	39	$6V_2$
Centaurea jacea subsp. *weldeniana*	4	14	.	**1**	**45**	44	$6V_2$
Danthonia alpina	.	6	.	**12**	**30**	20	4Z
Dorycnium pentaphyllum subsp. *herbaceum*	8	8	6	**12**	**27**	16	4Z
Ferulago campestris	3	6	2	**13**	**20**	25	$6V_2$
Prunella laciniata	4	2	.	**4**	**29**	19	6V
Lathyrus latifolius	.	2	.	**1**	**29**	33	$6V_2$
Tragopogon tommasinii	.	3	.	**.**	**7**	11	$6V_2$
Order: *Scorzoneretalia villosae*							
Salvia pratensis	32	35	15	54	55	40	3Z
Eryngium amethystinum	69	46	25	11	32	42	3Z
Chrysopogon gryllus	48	10	21	37	62	36	3Z
Festuca illyrica + *F. stricta* subsp. *sulcata*	32	41	17	56	31	37	3Z
Plantago holosteum	38	48	21	15	30	34	3Z
Anthyllis vulneraria subsp. *polyphylla*	2	23	56	34	13	30	5D
Stachys officinalis	4	35	10	45	27	25	3Z
Scabiosa triandra	18	19	8	34	32	23	3Z
Centaurea jacea subsp. *gaudinii*	1	9	44	37	2	27	5D
Dorycnium pentaphyllum subsp. *germanicum*	19	47	2	3	20	24	3Z
Festuca valesiaca	43	17	2	4	15	51	$5C_1$
Veronica barrelieri	8	16	12	9	11	12	3Z
Medicago prostata	23	14	2	1	14	13	3Z
Noccaea praecox	9	7	17	11	4	8	3Z
Plantago argentea	.	31	19	18	6	21	5D+5S
Cyanus triumfettii	.	23	23	16	8	16	5D+5S
Leucanthemum platylepis	1	29	.	5	27	23	$5S_2$
Euphorbia nicaeensis	4	26	.	.	10	21	$5S_2$
Seseli montanum subsp. *tommasinii*	6	6	.	.	1	7	$5C_1$
Class: *Festuco-Brometea*							
Bromopsis erecta s.l. + *B. condensata*	79	86	81	87	82	83	3Z
Lotus corniculatus	26	52	46	85	66	53	3Z
Sanguisorba minor	52	43	40	39	48	45	3Z
Carex humilis	17	84	75	24	13	58	5D+5S
Helianthemum nummularium subsp. *obscurum*	21	33	58	43	39	35	3Z
Brachypodium pinnatum + *B. rupestre*	11	17	23	87	51	54	4Z
Thymus longicaulis s.l.	58	34	42	11	37	38	3Z
Galium lucidum	33	47	63	8	30	35	3Z
Teucrium chamaedrys	26	33	60	24	32	32	3Z
Galium verum	4	7	31	78	39	47	4Z

Table 1. cont.

	5C	5S	5D	6H	6V	IndVal	Cluster
Number of relevés	159	198	51	98	142		
Briza media	1	14	6	81	44	52	4Z
Euphorbia cyparissias	28	28	33	30	23	27	3Z
Asperula cynanchica	24	19	33	44	15	24	3Z
Hippocrepis comosa	25	29	25	31	23	27	3Z
Globularia bisnagarica	9	25	38	24	17	20	3Z
Anthericum ramosum	7	34	35	29	9	21	3Z
Carex flacca	1	6	12	53	30	35	4Z
Leontodon crispus	23	27	23	8	16	21	3Z
Carex caryophyllea	8	11	13	37	22	21	4Z
Linum tenuifolium	20	14	38	2	12	15	3Z
Asperula purpurea	19	14	29	5	9	25	$5C_2$
Sedum sexangulare	48	8	6	5	8	37	5C
Pilosella officinarum	20	8	8	19	18	18	$5C_1$
Carlina acaulis	2	14	21	26	6	12	3Z
Petrorhagia saxifraga	42	8	6	2	10	31	5C
Campanula glomerata	1	6	8	45	4	31	6H
Pimpinella saxifraga + P. alpina	2	3	12	39	6	24	6H
Allium lusitanicum	9	18	23	2	1	14	4K
Bothriochloa ischaemum	35	3	6	3	6	52	$5C_2$
Asperula aristata	18	18	8	1	6	16	$5C_1$
Medicago falcata	1	6	8	10	15	10	4Z
Centaurea jacea	3	1	4	22	4	13	6H
Koeleria pyramidata	.	5	21	72	27	42	6H
Trifolium montanum	.	18	4	61	32	37	4Z
Fumana procumbens + F. ericoides	30	15	44	.	6	21	4K
Linum catharticum	.	8	21	43	14	21	6H
Koeleria macrantha	12	9	21	.	10	10	3Z
Artemisia alba	19	7	23	.	2	30	$5C_2$
Thymus pulegioides	1	5	.	31	13	19	6H
Dianthus sylvestris	.	5	37	1	1	32	5D
Melica ciliata	23	12	4	.	2	16	5C
Medicago lupulina	4	1	.	19	15	15	4Z
Trifolium campestre	11	5	.	5	14	12	$5C_1$
Ranunculus bulbosus	1	2	.	16	11	12	4Z
Echinops ritro	4	12	4	.	4	11	$5S_1$
Anthyllis vulneraria	26	34	.	.	13	21	4K
Polygala nicaeensis	9	35	.	.	24	19	5S
Teucrium capitatum subsp. *capitatum*	36	6	.	.	6	55	$5C_1$
Polygala comosa	.	.	13	21	6	11	6H
Galium corrudifolium	19	18	.	.	2	26	$5C_1$
Satureja montana	13	20	.	.	3	18	$5S_1$
Carex hallerana	19	8	.	.	4	17	$5C_1$
Kengia serotina	18	.	8	.	1	35	$5C_2$
Paronychia kapela	7	12	.	.	1	25	$5S_1$

Table 1. cont.

	5C	5S	5D	6H	6V	IndVal	Cluster
Number of relevés	159	198	51	98	142		
Alyssum montanum	14	3	2	.	.	13	$5C_2$
Poa bulbosa	8	2	.	.	4	12	$5C_1$
Armeria canescens	1	6	.	.	2	13	$5S_1$
Thymus praecox	.	.	17	3	.	16	5D
Argyrolobium zanonii	9	.	.	.	1	12	$5C_2$
Thymus striatus	.	5	.	.	1	14	$5S_1$
Lactuca viminea	6	.	.	.	.	12	$5C_2$
Onobrychis alba subsp. *laconica*	.	4	.	.	.	12	$5S_1$

Koelerio splendentis-Festucetum illyricae Horvatić 1963 corr. Trinajstić 1992; na – Narcisso tazettae-Asphodeletum microcarpi Šegulja 1969; se – Salvio officinalis-Euphorbietum fragiferae Lausi & Poldini 1962; ss – Salvio officinalis-Seslerietum juncifoliae Trinajstić 1977 (transition to Saturejion subspicatae); sd – Saturejo montanae-Dichanthietum ischaemum Horvat in Horvat et al. 1974 nom. corr.; so – Stipo bromoidis-Salvietum officinalis Horvatić 1963.

5S. Alliance: *Saturejion subspicatae* Tomić-Stanković 1970 [3]

Lectotypus: *Centaureo rupestris-Caricetum humilis* Horvat 1931. Diagnostic taxa: *Anthyllis montana* subsp. *jacquinii*; *Astragalus croaticus*; *Bunium alpinum* subsp. *montanum*; *Centaurea rupestris*; *Crepis chondrilloides*; *Edraianthus tenuifolius*; *Gentiana verna* subsp. *tergestina*; *Globularia meridionalis*; *Iris pallida* subsp. *illyrica*; *Jurinea mollis*; *Klasea radiata* subsp. *cetinjensis*; *Muscari botryoides*; *Narcissus poeticus* subsp. *radiiflorus*; *Pulsatilla montana*; *Satureja subspicata*; *Sesleria tenuifolia* subsp. *tenuifolia.*

Associations: as – *Astragalo croatici-Seslerietum robustae* Trinajstić ex Terzi 2011; bs – *Bromo erecti-Seslerietum interruptae* Trinajstić ex Terzi 2011; cr – *Centaureo rupestris-Caricetum humilis* Horvat 1931 [4]; gk – *Genisto sericeae-Seslerietum kalnikensis* Dakskobler & Peljhan ex Terzi ass. nov. hoc loco [8]; gs – *Genisto sericeae-Seslerietum tenuifoliae* Poldini 1980; gg – *Genisto-Globularietum bellidifoliae* Tomić-Stanković 1970; mg – *Minuartio capillaceae-Genistetum pulchellae* Šegulja & Bedalov ex Terzi 2011; pc – *Pediculari acaulis-Caricetum humilis* Horvat in Horvat et al. 1974; sm – *Saturejo subspicatae-Caricetum humilis* Trinajstić 1999; su – *Saturejo subspicatae-Edraianthetum tenuifolii* Horvat in Horvat et al. 1974; sj – *Seslerio robustae-Juniperetum sibiricae* Domac 1962; sc – *Seslerio tenuifoliae-Caricetum humilis* Horvat 1930; st – *Stipo eriocaulis-Caricetum humilis* Trinajstić ex Terzi 2011; sg – *Stipo pennatae-Genistetum dalmaticae* Redžić et al. ex Terzi 2011

5D. Alliance: *Centaureion dichroanthae* Pignatti 1952

Holotypus: *Centaureo dichroanthae-Globularietum cordifoliae* Pignatti 1952. Diagnostic taxa: *Allium ericetorum*; *Calamagrostis varia*; *Carduus defloratus*; *Carex mucronata*; *Centaurea dichroantha*; *Cytisus pseudoprocumbens*; *Cytisus purpureus*; *Erysimum sylvestre*; *Euphorbia triflora* subsp. *kerneri*; *Euphrasia cuspidata*; *Gentiana clusii*; *Gypsophila repens*; *Hieracium porrifolium*; *Leontodon incanus*; *Lomelosia graminifolia* subsp. *graminifolia; Moltkia suffruticosa*; *Polygala nicaeensis* subsp. *carniolica*; *Potentilla pusilla*; *Sesleria caerulea*; *Stachys recta* subsp. *labiosa*.

Associations: si – *Bromo condensati-Stipetum eriocaulis* Lasen ex Terzi ass. nov. hoc loco [8]; bb – *Bupleuro ranunculoides-Brometum condensati* ass. nov. hoc loco [9]; cg – *Centaureo dichroanthae-Globularietum cordifoliae* Pignatti 1952; gc – *Genisto-Caricetum mucronatae* Horvat in Horvat, et al. 1974 (*sensu* Poldini 1989); *Laserpitido-Festucetum alpestris* Pedrotti 1970*; ls – *Leontodonto brumatii-Seslerietum calcariae* Dakskobler et al. 2012; sb – *Saturejo variegatae-Brometum condensati* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993; tc – *Teucrio capitati-Chrysopogonetum grylli* Sburlino et al. 2008 (transition to *Chrysopogono-Saturejion subspicatae*).

4Z. Suborder: *Scorzonerenalia villosae* subord. nov. hoc loco

Holotypus: *Scorzonerion villosae* Horvatić ex Kovačević 1959 (Kovačević 1959: 18). Same diagnostic taxa of *Scorzonerion villosae*.

5V. Alliance: *Scorzonerion villosae* Horvatić ex Kovačević 1959 [1]

Holotypus: *Scorzonero villosae-Danthonietum calycinae* Kovačević 1959. Diagnostic taxa: *Centaurea jacea* subsp. *weldeniana*; *Cirsium pannonicum*; *Danthonia alpina*; *Dorycnium pentaphyllum* subsp. *herbaceum*; *Euphorbia verrucosa*; *Ferulago campestris*; *Filipendula vulgaris*; *Hypochaeris maculata*; *Knautia illyrica;*

Lathyrus latifolius; *Ononis spinosa*; *Plantago media*; *Prunella laciniata*; *Scorzonera villosa* subsp. *villosa*; *Tragopogon tommasinii*; *Trifolium rubens*.

6V. Suballiance: *Scorzonerenion villosae* Poldini & Feoli Chiapella 1993

Holotypus: *Scorzonero villosae-Danthonietum calycinae* Kovačević 1959. Same diagnostic taxa of *Scorzonerion villosae*.

Associations: ec – *Euphorbio nicaeensis-Chrysopogonetum grylli* Horvatić 1963; fp – *Festuco illyricae-Poetum bulbosae* Horvat in Horvat et al. 1974 corr. Terzi 2011; fa – *Festuco-Armerietum canescentis* Trinajstić & Sugar 1972; ge – *Globulario elongatae-Chrysopogonetum grylli* Ilijanić et al. ex Terzi 2011; oa – *Ononido antiquorum-Brometum condensati* Horvatić (1934) 1963; ds – *Scorzonero villosae-Danthonietum calycinae* Kovačević 1959 [1, 2]. Uncertain position: cs – *Carici vernae-Scabiosetum leucophyllae* Redžić et al. ex Terzi 2011; gl – *Globulario cordifoliae-Scabiosetum leucophyllae* Redžić et al. ex Terzi 2011

6H. Suballiance: *Hypochoeridenion maculatae* Poldini & Feoli Chiapella ex Terzi 2011

Holotypus: *Onobrychido arenariae-Brometum erecti* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993. Diagnostic taxa: *Achillea roseoalba*; *Carex montana*; *Cirsium pannonicum*; *Centaurea scabiosa* subsp. *fritschii*; *Knautia ressmannii*; *Linum viscosum*; *Prunella grandiflora*; *Rhinanthus alectorolophus* subsp. *freynii*.

Associations: ab – *Avenulo praeustae-Brometum erecti* Poldini & Feoli Chiapella ex Terzi 2011; ch – *Chamaecytiso hirsuti-Chrysopogonetum grylli* Pignatti ex Feoli Chiapella & Poldini 1993; gb – *Gentianello pilosae-Brometum erecti* Dakskobler & Završnik 2009; gm – *Gladiolo palustris-Molinietum arundinaceae* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993; ob – *Onobrychido arenariae-Brometum erecti* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993; sn – *Schoeno nigricantis-Chrysopogonetum grylli* Pignatti ex Feoli Chiapella & Poldini 1993 (transition to *Centaureion dichroanthae*); ts – *Thlaspio-Trifolietum pratensis* Zanotto 1960*.

Conclusion

The numerical analysis of relevés and associations previously assigned to the *Scorzoneretalia villosae* highlights two main groups of associations classified within the new meso-xerophytic *Scorzonerenalia villosae* and the xerophytic *Koelerienalia splendentis*. The latter is well differentiated by the presence of numerous sub-Mediterranean and Illyrian species, while the *Scorzonerenalia villosae*, except from few Illyrian and south-eastern European diagnostic taxa, shares many taxa with mesophytic syntaxa of the *Festuco-Bometea*. The results of this study clarify the syntaxonomy and nomenclature of the *Scorzoneretalia villosae* but also demonstrate the need for a syntaxonomic revision of the *Festuco-Brometea*, especially of its more mesophilous associations. Apart from the classical model of the class, with geographically defined orders, other proposals suggest a single order for the meso-xerophytic plant communities of the class (Dengler et al. 2003) or a specific Balkanic order for the more mesophilous communities (Boşcaiu 1972). These issues were beyond the scope of this paper but it emerged that the more mesophilous associations of the *Scorzonerenalia villosae* (together with the order and suborder names) would have to be involved in such a revision.

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Appendix 1: List of syntaxon names quoted in the text.

Abbreviations of syntaxon names used in Figures and Tables in square brackets. Syntaxon abbreviations consist of a number, indicating the rank (1 class, 3 order, 4 suborder, 5 alliance, 6 suballiance), followed by a capital letter; abbreviations of associations consist of 2 lower-case letters. The abbreviation "0B" indicates the surclass *Festuco-Brachypodio-Brometales* described by Barbero and Loisel (1972).

Classes: *Brachypodio-Brometea* Barbero et Loisel 1972 nom. illeg. (Art. 29c) [1L]; *Brachypodio-Chrysopogonetea* Horvatić 1963 [1B]; *Calluno-Ulicetea* Br.-Bl. & Tx. ex Klika & Hadač 1944 [1U]; *Elyno-Seslerietea* Br.-Bl. 1948 [1S]; *Erico carneae-Pinetea sylvestris* Horvat 1959 [1E]; *Festuco-Brometea* Br.-Bl. & Tx. ex Klika & Hadač 1944 [1F; 1Fx and 1Fm indicate xerophytic and mesophytic syntaxa of the class, respectively]; *Molinio-Arrhenatheretea* Tx. 1937 [1M]; *Thero-Brachypodietea* Br.-Bl. 1947 [1T; sensu lato]; *Trifolio-Geranietea sanguinei* T. Müller 1962 [1G].

Orders: *Artemisio albae-Brometalia erecti* Ubaldi ex Dengler ('Denggler') & Mucina in Mucina et al. 2009; *Brachypodietalia pinnati* Korneck 1974 [3C]; *Brachypodio-Chrysopogonetalia* (Horvatić 1958) Boşcaiu 1972 nom. inval. (Art. 3m; note 1 of Art. 27); *Brometalia erecti* Koch 1926 [3F]; *Cymbopogono hirti-Brachypodietalia ramosi* Horvatić 1963; *Festucetalia valesiacae* Br.-Bl. & Tx. ex Br.-Bl. 1950 [3V]; *Koelerietalia splendentis* Horvatić 1973 [3K]; *Scorzoneretalia villosae* Kovačević 1959 [3Z]; *Scorzoneretalia villosae* Horvatić 1973 nom. illeg. (synonym of *Scorzoneretalia villosae* Kovačević 1959); *Scorzonero villosae-Chrysopogonetalia grylli* Horvatić & Horvat in Horvatić 1963 (synonym of *Scorzoneretalia villosae*) [3S].

Suborders: *Koelerienalia splendentis* (Horvatić 1973) Terzi 2015 [4K]; *Mesobromenalia erecti* Royer 1991 nom. inval. (Art. 3h) [4M]; *Scorzonerenalia villosae* Terzi 2015;

Alliances: *Bromion erecti* Koch 1926 [5B]; *Centaureion dichroanthae* Pignatti 1952 [5D]; *Chrysopogono grylli-Danthonion calycinae* Kojić 1959 [5T]; *Chrysopogono grylli-Koelerion splendentis* Horvatić 1973 (included within *Chrysopogono grylli-Saturejion subspicatae*) [5K]; *Chrysopogono grylli-Saturejion subspicatae* Horvat & Horvatić ex Černjavski et al. 1949 (syn. *Chrysopogono grylli-Koelerion splendentis* Horvatić 1973) [5C]; *Cirsio-Brachypodion pinnati* Hadač & Klika in Klika & Hadač 1944; *Danthonio-Brachypodion* Boşcaiu 1972; *Diplachnion* Br.-Bl. 1961; *Festucion illyricae* Trinajstić 2000 [5F]; *Hypochoeridion maculatae* Horvatić ex Terzi 2011 [5H]; *Mesobromion erecti* Oberd. 1949 (synonym of *Bromion erecti*) [5M]; *Saturejion montanae* Horvat in Horvat et al. 1974 [5J]; *Saturejion subspicatae* Tomić-Stanković 1970 [5S]; *Scorzonerion villosae* Horvatić ex Kovačević 1959; *Xerobromion erecti* Zoller 1954.

Suballiances: *Centaureenion dichroanthae* (Pignatti 1952) Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993 [6D]; *Festucenion illyricae* Horvat in Horvat et al. 1974 corr. Trinajstić 2000 [6F]; *Fumano-Scabiosenion* leucophyllae Redžić 1991; *Hypochoeridenion maculatae* Poldini & Feoli Chiapella ex Terzi 2011 [6H]; *Saturejenion montanae* Horvat ex Wendelberger 1965 [6M]; *Scorzonerenion villosae* Feoli Chiapella & Poldini 1993 [6V].

Associations: *Achilleo nobilis-Dorycnietum herbacei* Redžić & Lakušić in Redžić 1999; *Artemisio albae-Rutetum graveolentis* Redžić & Lakušić in Lakušić & Redžić 1991 [ar]; *Artemisio albae-Salvietum officinalis* Grebenščikov 1950 [ao]; *Asphodelo microcarpi-Chrysopogonetum grylli* Horvatić 1963 (cf. *Bromo erecti-Chrysopogonetum grylli* Horvatić 1934) [ac]; *Astragalo croatici-Seslerietum robustae* Trinajstić ex Terzi 2011 [as]; *Avenulo praeustae-Brometum erecti* Poldini & Feoli Chiapella ex Terzi 2011 [ab]; *Avenulo-Brometum erecti* sensu Lasen 1995 non Feoli Chiapella & Poldini 1993 (= *Thlaspidi-Trifolietum pratensis* Zanotto 1960 according to Pignatti & Pignatti 2014) [ts]; *Bromo condensati-Stipetum eriocaulis* Lasen ex Terzi 2015 [si]; *Bromo erecti-Chrysopogonetum grylli* Horvatić 1934 (incl. *Asphodelo microcarpi-Chrysopogonetum grylli* Horvatić 1963) [bc]; *Bromo erecti-Festucetum lapidosae* Trinajstić 1992 [bf]; *Bromo erecti-Plantaginetum mediae* Horvat 1949; *Bromo erecti-Seslerietum interruptae* Trinajstić ex Terzi 2011 [bs]; *Bupleuro ranunculoidis-Brometum condensati* Terzi 2015 (= *Bupleuro-Brometum condensati* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993 nom. inval.) [bb]; *Carici vernae-Scabiosetum leucophyllae* Redžić et al. ex Terzi 2012 [cs]; *Centaureo cristatae-Chrysopogonetum grylli* Ferlan & Giacomini 1957 [cc]; *Centaureo dichroanthae-Globularietum cordifoliae* Pignatti 1952 [cg]; *Centaureo rupestris-Caricetum humilis* Horvat 1931 [cr]; *Chamaecytiso hirsuti-Chrysopogonetum grylli* Pignatti ex Feoli Chiapella & Poldini 1993 [ch]; *Danthonio-Chrysopogonetum grylli* Boşcaiu 1972 [zd]; *Danthonio-Scorzoneretum villosae* Horvat & Horvatić in Horvatić 1963 (synonym of *Scorzonero villosae-Danthonietum calycinae* Kovačević 1959); *Dichanthio ischaemum-Cleistogenetum serotinae* Horvatić ex Trinajstić in Poldini 1975 nom. mut. propos. [dc]; *Euphorbio nicaeensis-Chrysopogonetum grylli* Horvatić 1963 [ec]; *Festucetum illyrico-valesiacae* Horvat in Horvat et al. 1974 corr. Trinajstić 2000 [fi]; *Festuco illyricae-Poetum bulbosae* Horvat in Horvat et al. 1974 corr. Terzi 2011 [fp]; *Festuco rubrae-Danthonietum calycinae* Csűrös et al. 1968 [zr]; *Festuco valesiacae-Danthonietum calycinae* Boşcaiu 1972 [zf]; *Festuco-Armerietum canescentis* Trinajstić & Sugar 1972 [fa]; *Festuco-Linetum flavi* Ritter-Studnička 1972 [fl]; *Genisto sericeae-Seslerietum kalnikensis* Dakskobler & Peljhan ex Terzi 2015 [gk]; *Genisto sericeae-Seslerietum tenuifoliae* Poldini 1980 [gs]; *Genisto-Caricetum mucronatae* Horvat in Horvat et al. 1974 [gc]; *Genisto-Globularietum bellidifoliae* Tomić-Stanković 1970 [gg]; *Gentianello pilosae-Brometum erecti* Dakskobler & Završnik 2009 [gb]; *Gladiolo palustris-Molinietum arundinaceae* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993 [gm]; *Globulario cordifoliae-Scabiosetum leucophyllae* Redžić et al. ex Terzi 2011 [gl]; *Globulario elongatae-Chrysopogonetum grylli* Ilijanić et al. ex Terzi 2011 [ge]; *Helichryso italici-Armerietum dalmaticae* Horvatić 1963 [ha]; *Koelerio macranthae-Brachypodietum retusi* Terzi 2015 (= *Koelerio macranthae-Brachypodietum retusi* Trinajstić 2005 nom. inval., Art. 10b) [kb]; *Koelerio splendentis-Festucetum illyricae* Horvatić 1963 corr. Trinajstić 1992 [kf]; *Lactuco vimineae-Bothriochloetum ischaemum* Poldini 1975 corr. Terzi 2011 [lb]; *Laserpitido-Festucetum alpestris* Pedrotti 1970; *Leontodonto brumatii-Seslerietum calcariae* Dakskobler et al. 2012 [ls]; *Lino linearifolii-Gypsophiletum glomerati* Tzonev 2009 nom. inval. (Art. 1); *Minuartio capillaceae-Genistetum pulchellae* Šegulja & Bedalov ex Terzi 2011 [mg]; *Narcisso tazettae-Asphodeletum microcarpi* Šegulja 1969 [na]; *Onobrychido arenariae-Brometum erecti* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993 [ob]; *Onobrychido-Brometum erecti* T. Müller 1966; *Ononido antiquorum-Brometum condensati* (Horvatić 1934) Horvatić 1963 [oa]; *Pediculari acaulis-Caricetum humilis* Horvat in Horvat et al. 1974 [pc]; *Peucedano oreoselini-Lathyretum filiformis* Ritter-Studnička 1972 [pl]; *Physospermo-Saturejuetum montanae* Redžić & Lakušić in Lakušić & Redžić 1991; *Poo bulbosae-Saturejetum subspicatae* Černjavski et al. 1949 [pb]; *Potentillo pilosae-Achilleetum clypeolatae* Tzonev 2009 nom. inval. (Art. 1); *Salvio officinalis-Euphorbietum fragiferae* Lausi & Poldini 1962 [se]; *Salvio officinalis-Seslerietum juncifoliae* Trinajstić 1977 [ss]; *Saturejo montanae-Dichanthietum ischaemum* Horvat in Horvat et al. 1974 corr. Terzi 2011 [sd]; *Saturejo subspicatae-Caricetum humilis* Trinajstić 1999 [sm]; *Saturejo subspicatae-Edraianthetum tenuifolii* Horvat in Horvat et al. 1974 [su]; *Saturejo subspicatae-Festucetum dalmaticae* Redžić & Lakušić in Lakušić & Redžić 1991 [sf]; *Saturejo variegatae-Brometum condensati* Poldini & Feoli *Chiapella in Feoli Chiapella & Poldini* 1993 [sb]; *Schoeno nigricantis-Chrysopogonetum grylli* Pignatti ex Feoli Chiapella & Poldini 1993 [sn]; *Scorzonero villosae-Danthonietum calycinae* Kovačević 1959 [ds]; *Scorzonero villosae-Hypochoeridetum maculatae*

Horvatić 1949 nom. nud. [sh]; *Seseli gouanii-Artemisietum albae Poldini* 1980 [sa]; *Seslerio robustae-Juniperetum sibiricae* Domac 1962 [sj]; *Seslerio tenuifoliae-Caricetum humilis* Horvat 1930 [sc]; *Stipo bromoidis-Salvietum officinalis* Horvatić 1963 [so]; *Stipo eriocaulis-Caricetum humilis* Trinajstić ex Terzi 2011 [st]; *Stipo pennatae-Genistetum dalmaticae* Redžić et al. ex Terzi 2011 [sg]; *Teucrio capitati-Chrysopogonetum grylli* Sburlino et al. 2008 [tc]; *Thlaspio-Trifolietum pratensis* Zanotto 1960; *Thymo serpylli-Teucrietum chamaedryos* Redžić & Lakušić in Redžić 1999.

Appendix 2: Nomenclatural notes, including descriptions of new syntaxa and typifications.

[1] The names *Scorzoneretalia villosae* and *Scorzonero-Danthonietum calycinae* were validly published for the first time by Kovačević (1959) with five relevés from Bosanski Petrovac (Bosnia). Kovačević (1959) also validated the *Scorzonerion villosae* (Horvatić 1949). Order and alliance, with only one subordinated syntaxon in their original diagnoses, were automatically typified.

[2] The *Scorzonero-Danthonietum calycinae* is typified as follows: lectotypus is relevé 2 of table 7 in Kovačević (1959: 30). The *Scorzonero-Danthonietum calycinae* ranges from Bosnia and Herzegovina to Croatia, Slovenia and Italy. Poldini (1989) and Poldini & Kaligaric (1997) extensively dealt with this association in Italy and Slovenia and Horvatić (1963) in Croatia. However, the diagnoses given by these authors are quite different from those given for Bosnia (Kovačević 1959, Bajić 1960), lacking many important taxa, such as *Ferulago campestris*, *Knautia illyrica*, *Centaurea jacea* subsp. *weldeniana*, and *Dianthus ferrugineus* subsp. *liburnicus*, while including others with higher frequencies, such as *Veronica austriaca* subsp. *jacquinii*, *Scabiosa ochroleuca*, *Phleum phleoides*, *Genista sagittalis* (acidophilous), as well as *Rhinanthus alectorolophus, Scorzoneroides autumnalis, Cynosurus cristatus* and *Lotus tenuis* shared with the *Molinio-Arrenatheretea*. This floristic dissimilarity mirrors different ecological conditions and maybe two different associations could be differentiated.

[3] The *Saturejion subspicatae* was validated by Tomić-Stanković (1970) with the valid publication of the *Genisto-Globularietum bellidifoliae*, containing *Satureja subspicata* (see Terzi 2011).

[4] The *Centaureo-Caricetum humilis* (nomenclatural type of *Saturejion subspicatae*) was invalidly typified in Terzi (2011) due to the erroneous reference; the lectotypus of the *Centaureo-Caricetum humilis* is relevé A in Horvat (1931: 81).

[5] The name of the *Chrysopogono-Saturejion subspicatae* was validated by Černjavski et al. (1949) with the valid publication of the *Poo-Saturejetum subspicatae*, containing *Satureja subspicata* (the other alliance name-giving taxon, *Chrysopogon gryllus*, being within the original diagnosis of *Bromo-Chrysopogonetum grylli*). The *Chrysopogono-Saturejion subspicatae* was thus validly published before the *Chrysopogono-Koelerion splendentis* and it can be no longer considered a superfluous name (see Terzi 2011). The *Bromo-Chrysopogonetum grylli* Horvatić 1934 (table 28 in Horvatić 1934) is designated as the lectotypus of the *Chrysopogono-Saturejion subspicatae* Horvat & Horvatić ex Černjavski et al. 1949. With this choice, I intend to mantain the distinction, largely used until now (e.g., Jovanović et al. 1986; Trinajstić 2008; Poldini 2009), between the *Saturejion subspicatae* and the *Chrysopogono-Saturejion subspicatae* (Recommendation 19A of ICPN).

[6] The type-relevé of the *Bromo-Chrysopogonetum grylli* is very similar to the one of the *Asphodelo-Chrysopogonetum grylli* even though the former has a lower number of species. The two associations can be thus unified under the earliest name.

[7] Following Poldini (1989), the *Lactuco-Bothriochloetum ischaemum* and *Seseli-Artemisietum albae* are reduced to the rank of subassociations of the *Centaureo-Chrysopogonetum grylli* (subass. *sedetosum sexangulari* Poldini (1975) 1989 and subass. *genistetosum sericeae* Poldini (1980) 1989, respectively).

[8] The following associations are validated: *Bromo condensati-Stipetum eriocaulis* Lasen ex Terzi 2015 (invalidly described due to Art. 3b), holotypus is rel. 7, table 1, in Lasen (1995: 193); *Genisto sericeae-Seslerietum kalnikensis* Dakskobler & Peljhan ex Terzi 2015, holotypus is rel. 2, table 4, in Dakskobler & Peljhan (2007: 164).

[9] Two other invalidly described associations (Art. 3g and 10b) can not be validated and must be renamed (Art. 6). The first is *Bupleuro ranunculoidis-Brometum condensati* Terzi 2015, holotypus is rel. 9 in Feoli Chiapella & Poldini (1993: 30); according to Feoli Chiapella & Poldini (1993), differential species of the association are *Calamagrostis varia* and *Bupleurum ranunculoides* (indicated as *Bupleurum ranunculoides* s.l. in Feoli Chiapella & Poldini [1993: 7 and 30]). The other is *Koelerio macranthae-Brachypodietum retusi* Terzi 2015 (holotypus is rel. 5, table 1, in Trinajstić [2005: 351]), whose differential species are those indicated by Trinajstić (2005): *Koeleria macrantha* and *Brachypodium retusum*.

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