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Formalized classification of rocky Pannonian grasslands and dealpine *Sesleria*-dominated grasslands in Slovakia using a hierarchical expert system

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With 3 figures and 4 tables

Abstract. The main aim of this paper was to perform the syntaxonomical revision of rocky Pannonian grasslands (Bromo pannonici-Festucion pallentis) and dealpine *Sesleria*-dominated grasslands (Diantho lumnitzeri-Seslerion) in Slovakia and to provide a reasonable tool for their identification at both, associations and alliance levels. Hierarchical expert system was formulated to achieve this aim. The syntaxonomical revision was performed based on recent and historical data available in the Slovak Phytosociological Database. The stratified data set of 16 640 relevés belonging to all syntaxa stored in this database was used to generate sociological species groups by the COCKTAIL method. In total, 18 sociological species groups were used to formulate formal definitions of alliances and associations. The assignment of a relevé to an association was allowed on condition that this relevé fulfilled the definition criteria of the given alliance. The formulation of definitions at two hierarchical levels enabled classification of typically developed vegetation to strictly defined associations as well as assignment of less developed vegetation lacking sufficient diagnostic species to broadly defined alliances. The hierarchical expert system was more effective than a simple expert system in sense of higher percentage of matched relevés. Its benefits and drawbacks were discussed in more details. Six associations of the Bromo pannonici-Festucion pallentis and three associations of the Diantho lumnitzeri-Seslerion alliances were recognized after the syntaxonomical revision. Each association was characterized by its diagnostic, constant and dominant species, physiognomical, synchorological and synecological attributes. Along with climatic-topographical (temperature and moisture) and soil-geological factors (soil reaction, soil depth, available nutrients) our analyses confirmed a strong effect of geographical location on differentiation of the studied vegetation.

Keywords: Bromo pannonici-Festucion pallentis, diagnostic species, Diantho lumnitzeri-Seslerion, formal definitions, hierarchical expert system, synchorology, synecology.

Introduction

The rocky Pannonian grasslands and dealpine blue moor grass communities were formerly classified mainly within the broadly defined alliance Seslerio-Festucion pallentis Klika 1931. As the included vegetation types differ significantly not only in their species composition but also in their habitat conditions and chorology, the two alliances were treated individually in later vegetation reviews (Mucina & Kolbek 1993, Chytrý et al. 2007). In this particular case of syntaxon splitting, the original alliance name could not be used for one of the new alliances (Weber et al. 2000, Art. 35) although Art. 24 of the International Code of Phytosociological Nomenclature implicitly suggests so. For this reason, new names were adopted for individual alliances: Bromo pannonici-Festucion pallentis Zólyomi 1966 and Diantho lumnitzeri-Seslerion (Soó 1971) Chytrý et Mucina in Mucina et al. 1993.

Until now, the syntaxonomical position of numerous associations belonging to the studied vegetation remained rather vague. In the commonly used syntaxonomical overview of Slovak vegetation (Mucina & Maglocký 1985) the studied communities were classified within two classes (Festuco-Brometea and Sedo-Scleranthetea) and three alliances (Seslerio-Festucion pallentis, Festucion valesiacae and Helianthemo cani-Festucion pallentis, see Tables 1 and 2 for details). This classification differed significantly from the classifications used in the neighbouring countries (Borhidi 2003, Moravec et al. 1995, Mucina & Kolbek 1993, Solomakha 1996). A syntaxonomical revision of this traditional classification was thus necessary. It was performed within a broader study of grassland vegetation in Slovakia using modern formalized classification methods and an overview of the distinguished syntaxa was published by Janišová et al. (2007). In this survey, we bring the detailed information on the studied syntaxa including the synecological analysis and synoptic table.

The application of expert systems based on formal definitions of associations (Chytrý et. al. 2007, Janišová et al. 2007) gives an opportunity to identify precisely phytosociological relevés which are well developed and contain sufficient number of diagnostic species. Such relevés matched by the definitions are assigned directly to individual associations. To classify the relevés non-matching the association definitions, the similarity indices are used comparing the floristic composition of a given relevé with groups of

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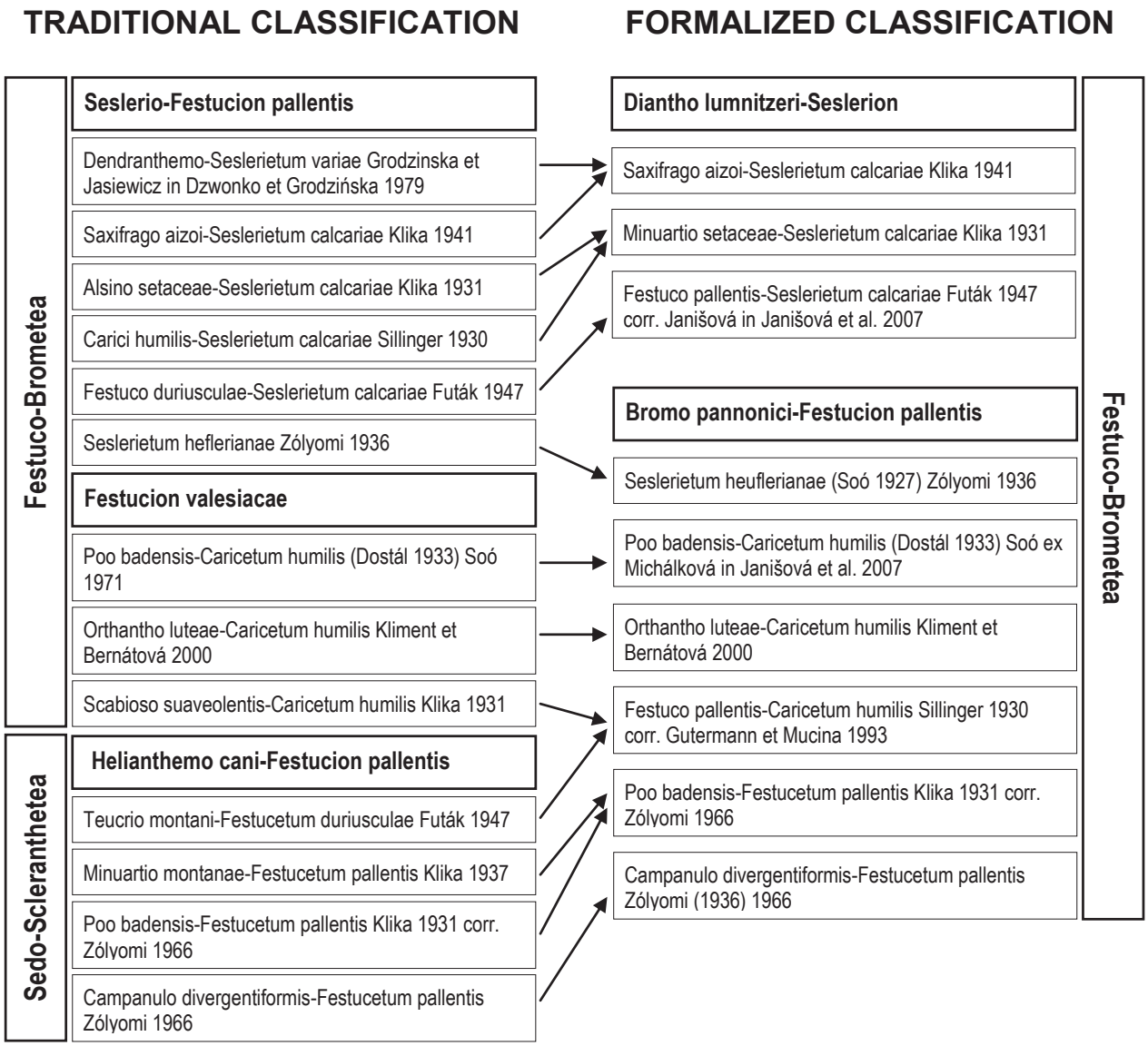
Table 1. Scheme of the main changes and shifts at both the association and alliance levels made during the syntaxonomical revision. The so-called traditional classification scheme is based on Mucina & Maglocký (1985).



relevés unequivocally assigned to associations (Tichý 2005). In this step, the decision is made among several proposed associations having the highest similarity indices. It is common, that relevés of transitional or atypically developed communities show the highest similarity indices to an associations belonging to different alliances or even to different classes. Such relevés can hardly be classified to association but, what is worse, also their classification to alliances remains rather vague.

Nevertheless, the classification at the level of alliances is commonly practiced by specialists beyond the phytosociological research dealing mostly with registering and managing of natural resources (habitat mapping and identification, nature conservation, landscape planning, etc.). For these reasons, we tried to develop a hierarchical expert system suitable for identification of syntaxa at both association and alliance levels. Supported by two types of definitions – broader ones for alliances and narrower ones for associations, all based on the same sociological species groups, we proposed a hierarchical expert system for assignment to alliances of broader spectrum of relevés including those not typically developed or those having a transitional features to other dry grassland communities. In this paper we applied the proposed hierarchical expert system for classification of the two studied alliances, Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion. The assignment of a relevé to an associa-

Table 2. Sociological species groups used for definition of associations and alliances.

Species group	Species
Aster alpinus	*Aster alpinus, Erysimum witmannii, Pulsatilla slavica, Saxifraga paniculata*
Bromus monocladus	*Anthericum ramosum*, *Bromus monocladus*, *Buphthalmum salicifolium*
Carex humilis	*Carex humilis*, *Globularia punctata*, *Teucrium montanum*
Cyanus triumfettii	*Asplenium ruta-muraria*, *Cyanus triumfettii*, *Polygonatum odoratum*, *Vincetoxicum hirundinaria*
Daphne arbuscula	*Daphne arbuscula*, *Pulsatilla subslavica*, *Thymus pulcherrimus*
Draba lasiocarpa	*Dianthus praecox*, *Draba lasiocarpa*, *Hornungia petraea*
Festuca pallens	*Festuca pallens*, *Jovibarba globifera*, *Sedum album*, *Seseli osseum*
Festuca tatrae	*Festuca tatrae*, *Minuartia langii*, *Primula auricula*, *Trisetum alpestre*
Festuca valesiaca	*Bothriochloa ischaemum*, *Eryngium campestre*, *Festuca valesiaca*, *Koeleria macrantha*, *Thymus pannonicus*
Galium verum	*Galium verum* agg., *Pimpinella saxifraga* agg., *Plantago media*, *Trifolium montanum*
Melica ciliata	*Allium flavum*, *Lactuca perennis*, *Melica ciliata*, *Stachys recta*, *Verbascum lychnitis*
Poa badensis	*Campanula sibirica*, *Poa badensis*, *Potentilla arenaria* agg.
Rhodax canus	*Dorycnium pentaphyllum* agg., *Hippocrepis comosa*, *Rhodax canus*, *Potentilla heptaphylla*
Scabiosa lucida	*Carduus glaucinus*, *Phyteuma orbiculare*, *Scabiosa lucida*, *Thesium alpinum*
Scorzonera austriaca	*Alyssum montanum*, *Fumana procumbens*, *Linum tenuifolium*, *Scorzonera austriaca*, *Thymus praecox*
Sempervivum montanum	*Allium senescens*, *Asplenium septentrionale*, *Hylotelephium maximum* agg., *Sempervivum montanum* agg.
Sesleria albicans	*Genista pilosa*, *Leontodon incanus*, *Sesleria albicans*
Sesleria heufleriana	*Aconitum anthora*, *Linaria pallidifolia*, *Sesleria heufleriana*, *Spiraea media*

tion was allowed only on condition that this relevé fulfilled the definition of a given alliance. Thus the definitions of associations published in Janišová et al. (2007) needed to be reconsidered with regards to the newly formulated definitions of alliances.

The main aims of this paper can be summarized as follows:

1. to create formal definitions of the studied alliances (Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion) and to reconsider the definitions of their associations published in Janišová et al. (2007);
2. to estimate diagnostic, differential, constant and dominant species, synecological and synchorological attributes of the newly defined alliances and associations;
3. to identify the main environmental gradients responsible for variability of the studied vegetation;
4. to investigate the main advantages and drawbacks of the proposed hierarchical expert system for identification of the studied syntaxa at both association and alliance levels.

Material and methods

The scope of individual associations and alliances used in our paper was taken from a national survey of Slovak grassland vegetation (Janišová et al. 2007) based on a critical revision of traditional classification of the grassland vegetation formerly used in Slovakia (Mucina & Maglocký 1985, Table 1). For this revision, a large geographically stratified data set was used containing 16 640 phytosociological relevés belonging to all vegetation types stored in the Slovak Phytosociological Database (http://ibot.sav.sk/cdf/index.html, Hegedüšová 2007; for the stratification details see Janišová 2007 et al.). The same data set was used to formulate the hierarchical expert system presented in this paper. It was generated in order to determine the membership of relevés to both alliances and associations based on alliance and association definitions, respectively. Both types of definitions are based on the same sociological species groups (Bruelheide 1995, Table 2) created by the COCKTAIL method (Bruelheide 2000) with the degree of species co-occurrence calculated by the *phi* coefficient of association (Chytrý et al. 2002). In the definitions, the presence of sociological species groups is combined with species dominance criteria while all formulated criteria are connected by logical operators (Bruelheide 1997). Program JUICE (Tichý 2002) was used for the formulation of definitions and calculation of diagnostic, constant and dominant species. The meaning of a formal definition can be explained using an example of the association *Poo badensis-Festucetum pallentis*:

(Group Draba lasiocarpa OR Group Scorzonera austriaca) AND *Festuca pallens* cover > 5% NOT (Group Cyanus triumfettii OR *Carex humilis* cover > 5%)

The relevé will be assigned to this association if it contains either the group Draba lasiocarpa or the group Scorzonera austriaca along with the cover of species *Festuca pallens* exceeds 5%. At the same time, the group Cyanus triumfetii should not be present, and the cover of species *Carex humilis* should not be higher than 5%. The sociological group is considered

to be represented in the relevé if the relevé contains at least half of all species of the group.

The relevés were considered to be matched by the formulated definitions only if they apparently belonged to grassland vegetation, i.e. if the cover of woody species in the tree or shrub layers did not exceed 20%. If a relevé was assigned to more than one association, it was classified using the Frequency-Positive Fidelity Index (Tichý 2005). In this process, the species composition of individual relevé was compared to groups of relevés unequivocally assigned to the particular associations. The assignment of a relevé to an association was allowed on condition that this relevé fulfilled the definition of a given alliance. Altogether, 430 relevés in the large stratified data set fulfilled the criteria of either of the two alliance definitions. Those relevés which fulfilled simultaneously the criteria of some of the association definitions were used for calculation of diagnostic, differential, constant and dominant species of individual associations (their numbers are shown in the parentheses before their formal definitions). In our conception, we distinguished the diagnostic and differential species while both groups were based on fidelity calculation (the occurrence concentration of species in relevés of the particular association) using the *phi* coefficient. The diagnostic species are species with high fidelity to the given syntaxon calculated in the stratified data set of all vegetation types. On the other hand, differential species show a high fidelity merely within the syntaxonomical units belonging to the nearest higher syntaxon. Fidelity was determined with the *phi* coefficient (threshold value of *phi* was set to 0.20), after standardizing the size of relevé groups to 1% of the total size of data set. Fisher's exact test ($p < 0.001$) was used to eliminate the fidelity value of species with a non-significant pattern of occurrence (Chytrý et al. 2002, Chytrý et al. 2007). Calculation of diagnostic, constant and dominant species of alliances was based on relevés assigned to individual associations of a given alliance. In the characteristics of individual syntaxa, diagnostic species with *phi* > 0.2 (those with *phi* > 0.4 printed in bold), constant species with frequency > 40% (those > 80% printed in bold) and species dominant (cover value over 25%) in more than 5% of relevés (those dominant in more than 50% of relevés printed in bold) are shown. The diagnostic, constant and dominant species are listed alphabetically. The differential species are listed for both associations and alliances while species concurrently diagnostic for a given syntaxon are indicated by abbreviation (dif.). In the synoptic table, differential species are marked by the abbreviation of the syntaxon name.

The ecological relationships among associations were evaluated by the PCA. For interpretation of main environmental gradients, average non-weighted indicator values for light, temperature, continentality, soil reaction, moisture and nutrients (Borhidi 1993) were calculated for relevés. Differences among the associations in Borhidi indicator values, altitude and Shannon-Wiener diversity index were tested by Kruskal-Wallis ANOVA with a post-hoc comparisons of mean ranks of all pairs of groups (StatSoft Inc. 2006).

All relevés analyzed were recorded according to the principles of the Zürich-Montpellier school (Braun-Blanquet 1964). Plant taxa nomenclature was unified according to Marhold (1998). The delimitation of broader defined taxonomical groups (species aggregates, s. lat. concepts) and nomenclature of syntaxa are based on Janišová et al. (2007).

Results

According to the traditional classification (Mucina & Maglocký 1985), most relevés in our data set were originally classified within the broadly defined alliances *Seslerio-Festucion pallentis* and *Festucion valesiacae*. Numerous relevés were assigned only at the level of class to the *Festuco-Brometea*. Altogether 17 associations of the studied vegetation types were recognized in Slovakia. Four of them were considered to be synonyms of other associations (Weber et al. 2000). Out of 13 remaining associations nine were recognized as acceptable according to our syntaxonomical revision (Table 1) and they were defined by the formal definitions. According to both, their floristic composition and habitat conditions, six of them were assigned to the alliance Bromo pannonici-Festucion pallentis and three to the Diantho lumnitzeri-Seslerion. The association Seslerietum heuflerianae has an intermediate position which is obvious also from the PCA ordination graph (Fig. 1).

Synopsis of the studied vegetation after our syntaxonomical revision is as follows (the main changes and shifts at both the association and alliance levels are depicted in Table 1):

Class Festuco-Brometea **Br.-Bl. et Tüxen ex Soó 1947**

Order Stipo pulcherrimae-Festucetalia pallentis **Pop 1968**

Alliance Bromo pannonici-Festucion pallentis **Zólyomi 1966**

1. Ass. Poo badensis-Festucetum pallentis Klika 1931 corr. Zólyomi 1966 nom. invers. propos.
2. Ass. Festuco pallentis-Caricetum humilis Sillinger 1930 corr. Gutermann et Mucina 1993
3. Ass. Orthantho luteae-Caricetum humilis Kliment et Bernátová 2000
4. Ass. Campanulo divergentiformis-Festucetum pallentis Zólyomi (1936) 1966
5. Ass. Poo badensis-Caricetum humilis (Dostál 1933) Soó ex Michálková in Janišová et al. 2007
6. Ass. Seslerietum heuflerianae Zólyomi 1936

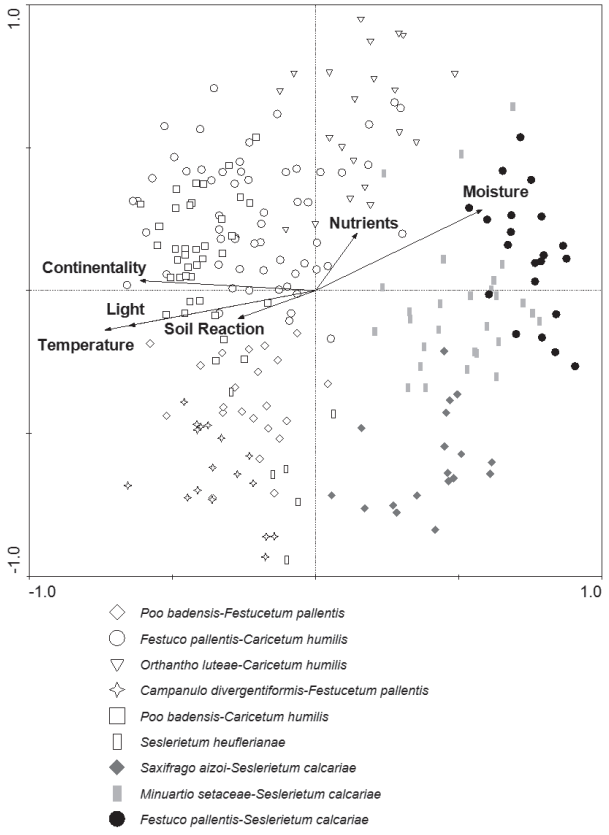


Fig. 1. Principal Component Analysis of relevés matched by association definitions. Borhidi indicator values were used as passive environmental variables. The first and the second axes are shown ($Eig_1 = 0.122$ and $Eig_2 = 0.084$) explaining 12.2% and 7.7% of the total species variability, respectively.

Alliance Diantho lumnitzeri-Seslerion **(Soó 1971) Chytrý et Mucina in Mucina et al. 1993**

1. Ass. Saxifrago aizoi-Seslerietum calcariae Klika 1941 nom. invers. propos.
2. Ass. Minuartio setaceae-Seslerietum calcariae Klika 1931 nom. invers. propos. et nom. mut. propos.
3. Ass. Festuco pallentis-Seslerietum calcariae Futák 1947 corr. Janišová in Janišová et al. 2007 nom. invers. propos.

The sociological species groups used to define associations and alliances are shown in Table 2. A combined synoptic table of frequency and fidelity was constructed for the associations (Table 3). Distribution maps of associations and alliances (Fig. 2) show the relevés matched by the definitions. Relationship of the defined associations to environmental factors and altitude, together with the Shannon-Wiener diversity indices are shown in Fig. 3 and Table 4.

Description of syntaxa

Festuco-Brometea Br.-Bl. et Tüxen ex Soó 1947

Orig. (Soó 1947): Festuco-Brometea Br.-Bl. et Tx. **Syn.:** Festuco-Brometea Br.-Bl. et Tüxen 1944 (Art 2b), Festuco-Brometea Br.-Bl. et Tüxen 1944 ex Klika et Hadač (Art 2b).

The class involves primary and secondary thermo- and (sub-)xerophilous grasslands in the temperate and continental regions of Europe, growing mainly on calcareous and nutrient-poor soils. Within the class, the studied alliances belong to the most drought-tolerant communities of extremely warm and dry habitats.

Stipo pulcherrimae-Festucetalia pallentis Pop 1968

Rocky grasslands of central and south-eastern Europe

Syn.: Festucetalia valesiacae Br.-Bl. et Tüxen ex Br.-Bl. 1949 p. p. **Incl.:** Seslerio-Festucenalia pallentis Pop 1968 em. Royer 1987.

The order includes rocky grasslands over all bedrock types (carbonates, silicates, serpentines) developed on topographically, edaphically and microclimatically specific habitats in the area of central and south-eastern Europe (Pop 1968, Mucina & Kolbek 1993). Most of these grasslands represent primary communities of extreme habitats almost untouched by human influence. This vegetation shows close relationships to pioneer communities of the Sedo-Scleranthetea class distributed in rocky habitats with extremely shallow soils (Valachovič & Maglocký 1995). In Slovakia, two alliances can be distinguished within this order, both including communities restricted to calcareous habitats.

Bromo pannonici-Festucion pallentis Zólyomi 1966

Rocky Pannonian grasslands

Orig. (Zólyomi 1966): Bromo-Festucion pallentis (Bromus pannonicus Kumm. et Sendtn.). **Syn.:** Seslerio-Festucion glaucae Klika 1931 p. p. (Art. 35, 43), Seslerio-Festucion pallentis Klika 1931 corr. Zólyomi 1966 p. p. (Art. 35).

Diagnostic species: *Allium flavum* (dif.), ***Alyssum montanum*** *(dif.), Anthericum ramosum, Asperula cynanchica, Bothriochloa ischaemum* (dif.), ***Campanula sibirica*** (dif.), ***Carex humilis,*** *Draba lasiocarpa,* ***Festuca pallens*** (dif.), ***Fumana procumbens*** (dif.), *Globularia punctata, Helianthemum nummularium agg., Hornungia petraea, Inula ensifolia, Jovibarba globifera, Lactuca perennis* (dif.), *Leontodon incanus,* ***Linum tenuifolium*** (dif.), *Melica ciliata* (dif.), *Onosma visianii, Pilosella bauhinii,*

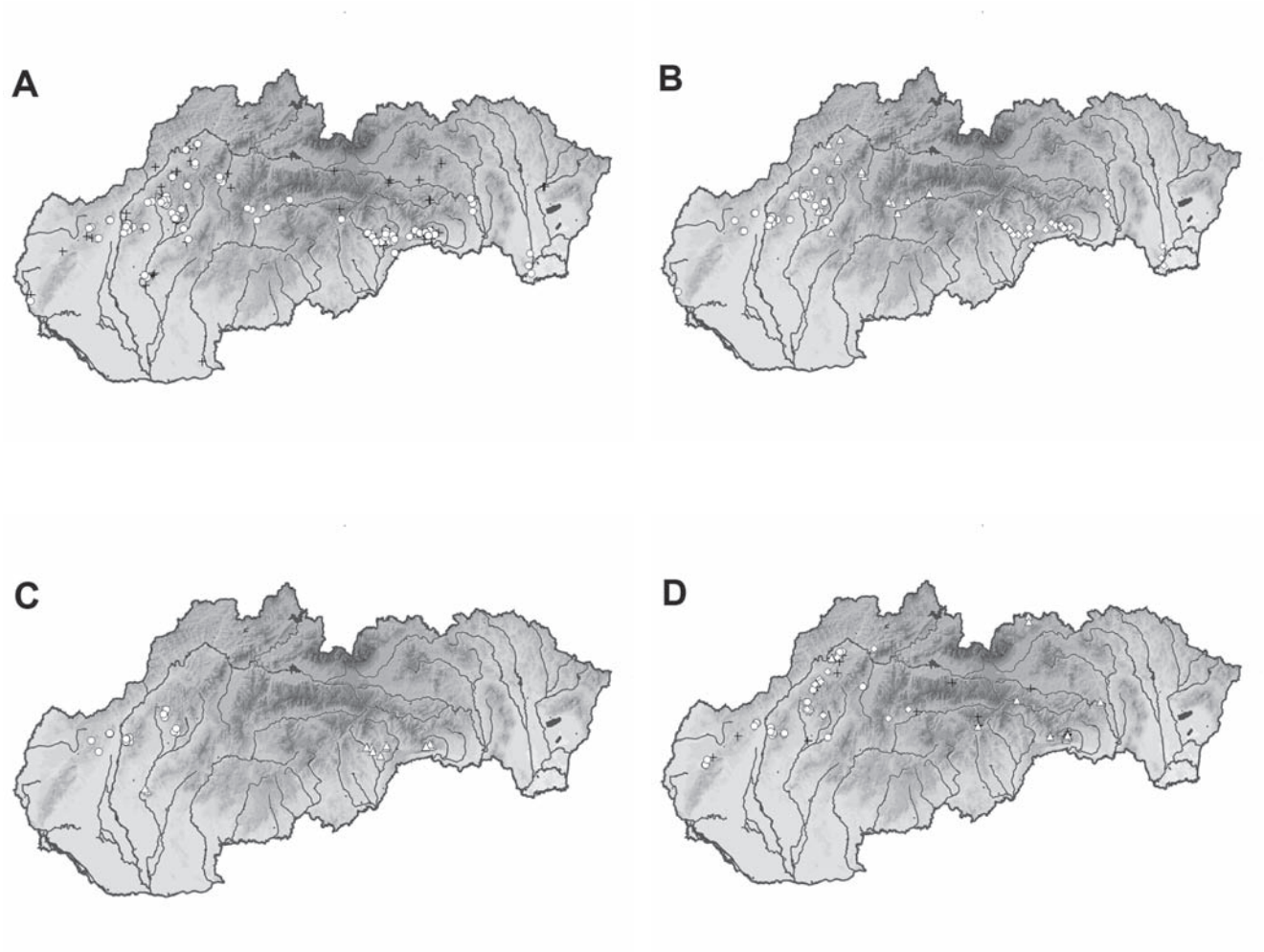


Fig. 2. Distribution of relevés of the studied communities in Slovakia. A) Relevés matched by the definition of Bromo pannonici-Festucion pallentis alliance (crosses) and relevés matched together by associations definitions (circles). B) Festuco pallentis-Caricetum humilis (circles), Orthantho luteae-Caricetum humilis (triangles) and Poo badensis-Caricetum humilis (diamonds). C) Poo badensis-Festucetum pallentis (circles), Campanulo divergentiformis-Festucetum pallentis (triangles) and Seslerietum heuflerianae (diamonds). D) Relevés matched by the definition of Diantho lumnitzeri-Seslerion alliance (crosses) and relevés matched also by associations definitions: Saxifrago aizoi-Seslerietum calcariae (triangles), Minuartio setaceae-Seslerietum calcariae (circles) and Festuco pallentis-Seslerietum calcariae (diamonds).

Poa badensis (dif.), *Potentilla arenaria agg.* (dif.), *Rhodax canus, Sanguisorba minor,* ***Scorzonera austriaca,*** *Seseli osseum, Silene otites agg.* (dif.), *Stachys recta, Stipa pulcherrima* (dif.), *Teucrium chamaedrys,* ***Teucrium montanum, Thymus praecox,*** *Tithymalus cyparissias, Verbascum lychnitis* (dif.).

Other differential species: *Acinos arvensis, Acosta rhenana, Arenaria serpyllifolia* agg., *Echium vulgare, Eryngium campestre, Hypericum perforatum, Koeleria macrantha, Medicago falcata, Stipa capillata, Thlaspi perfoliatum, Thymus pannonicus.*

Constant species: *Alyssum montanum, Anthericum ramosum, Asperula cynanchica, Campanula sibirica,* ***Carex humilis,*** *Festuca pallens, Globularia punctata, Helianthemum nummularium* agg., *Jovibarba globifera, Leontodon incanus, Linum tenuifolium, Melica ciliata, Pilosella bauhinii, Potentilla arenaria* agg., *Sanguisorba minor, Seseli osseum, Teucrium chamaedrys, Teucrium montanum, Thymus praecox, Tithymalus cyparissias.*
Dominant species: *Carex humilis, Festuca pallens, Potentilla arenaria* agg.

Formal definition (304 relevés): *Festuca pallens* cover > 5% OR *Sesleria heufleriana* cover > 5% OR [*Carex humilis* cover > 5% AND (Group Rhodax canus OR Group Melica ciliata OR Group Poa badensis OR Group Scorzonera austriaca)] NOT (*Sesleria albicans* cover > 5% OR Group Aster alpinus OR Group Scabiosa lucida OR Group Festuca tatrae OR *Brachypodium pinnatum* cover > 25% OR *Festuca valesiaca* cover > 50% OR *Festuca pseudovina* cover > 5%).

Table 3. Combined synoptic table of frequencies and fidelities (phi coefficient x 100 in the upper indices) of communities belonging to Bromo pannonici-Festucion pallentis (BF) and Diantho lumnitzeri-Seslerion (DS). Each column represents an association: 1 - Poo badensis-Festucetum pallentis (pf), 2 - Festuco pallentis-Caricetum humilis (fc), 3 - Orthantho luteae-Caricetum humilis (oc), 4 - Campanulo divergentiformis-Festucetum pallentis (cf), 5 - Poo badensis-Caricetum humilis (pc), 6 - Seslerietum heuflerianae (sh), 7 - Saxifrago aizoi-Seslerietum calcariae (ss), 8 - Minuartio setaceae-Seslerietum calcariae (ms) and 9 - Festuco pallentis-Seslerietum calcariae (fs). In our conception, diagnostic species are species with high fidelity to the given syntaxon calculated in the stratified data set of all vegetation types. On the other hand, differential species show a high fidelity merely within the syntaxonomical units belonging to the nearest higher syntaxon.

Average % cover values of most important diagnostic species are shown below the table header. Diagnostic species with phi > 0.2 and other species with percentage constancy over 15% in any of the associations or over 5% in any of the two alliances are shown (223 species altogether). Species differential for an association or an alliance within the nearest higher syntaxon are marked by an abbreviation of the association or the alliance name, respectively.

Group No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
No. of relevés	**22**	**57**	**20**	**17**	**41**	**6**	**18**	**28**	**20**
Alliance	**BF**	**BF**	**BF**	**BF**	**BF**	**BF**	**DS**	**DS**	**DS**
Average % cover values of edificator species									
Festuca pallens	***26***	*7*	*2*	***21***	*5*	*11*	*8*	*2*	*10*
Carex humilis	*2*	***27***	***26***	*3*	***30***	*8*	*5*	*8*	*11*
Sesleria heufleriana	.	.	.	.	.	***29***	.	.	.
Sesleria albicans	*2*	*3*	*2*	*2*	*1*	.	***29***	***45***	***50***
Poo badensis-Festucetum pallentis									
Arabis auriculata	**23** $^{35.1}$	7 $^{12.3}$	. $^{---}$	6 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Pilosella bauhinii	**68** $^{26.1}$	51 $^{19.1}$	40 $^{14.6}$	24 $^{---}$	32 $^{11.1}$	. $^{---}$	6 $^{---}$	39 $^{14.3}$	25 $^{---}$
Cerastium brachypetalum	**18** $^{21.7}$	4 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Saxifraga tridactylites	**18** $^{25.9}$	7 $^{10.6}$	. $^{---}$	12 $^{17.4}$	2 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Erophila verna agg.	**23** $^{21.3}$	2 $^{---}$	5 $^{---}$	12 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Festuco pallentis-Caricetum humilis									
Stipa joannis	5 $^{---}$	**35** $^{36.0}$	. $^{---}$	. $^{---}$	12 $^{13.3}$	. $^{---}$	. $^{---}$	7 $^{---}$	. $^{---}$
Helichrysum arenarium	. $^{---}$	**9** $^{22.6}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Dorycnium pentaphyllum agg.	9 $^{---}$	**35** $^{21.4}$	25 $^{15.1}$	. $^{---}$	20 $^{11.5}$	. $^{---}$	. $^{---}$	4 $^{---}$	30 $^{18.2}$
Inula hirta (fc)	. $^{---}$	**16** $^{21.0}$	. $^{---}$	. $^{---}$	2 $^{---}$	. $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$
Orthantho luteae-Caricetum humilis									
Orchis militaris	. $^{---}$	2 $^{---}$	**15** $^{29.8}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$
Thesium linophyllon (oc)	. $^{---}$	7 $^{---}$	**45** $^{28.2}$	6 $^{---}$	12 $^{---}$	33 $^{---}$	17 $^{---}$	25 $^{15.5}$	. $^{---}$
Ophrys insectifera	. $^{---}$	4 $^{---}$	**15** $^{28.0}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$
Colymbada scabiosa (oc)	. $^{---}$	18 $^{6.7}$	**60** $^{27.0}$	6 $^{---}$	7 $^{---}$	. $^{---}$	17 $^{---}$	11 $^{---}$	5 $^{---}$
Prunella grandiflora (oc)	. $^{---}$	. $^{---}$	**25** $^{26.9}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	5 $^{---}$
Polygala major (oc)	. $^{---}$	. $^{---}$	**30** $^{26.1}$	. $^{---}$	2 $^{---}$	. $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$
Festuca rupicola (oc)	. $^{---}$	5 $^{---}$	**80** $^{25.2}$	. $^{---}$	10 $^{---}$	. $^{---}$	. $^{---}$	11 $^{---}$	25 $^{---}$
Brachypodium pinnatum (oc)	9 $^{---}$	2 $^{---}$	**65** $^{23.5}$	18 $^{---}$	7 $^{---}$	17 $^{---}$	. $^{---}$	11 $^{---}$	10 $^{---}$
Orthantha lutea	. $^{---}$	. $^{---}$	**15** $^{22.7}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Scorzonera hispanica	. $^{---}$	2 $^{---}$	**10** $^{22.6}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Plantago media (oc, fs)	. $^{---}$	5 $^{---}$	**85** $^{20.4}$	. $^{---}$	. $^{---}$	33 $^{---}$	. $^{---}$	18 $^{---}$	70 $^{16.2}$
Trommsdorfia maculata (oc)	. $^{---}$	. $^{---}$	**25** $^{20.4}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	5 $^{---}$
Campanulo divergentiformis-Festucetum pallentis									
Lecidea lurida (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{39.2}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Orthotrichum anomalum (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**24** $^{36.4}$	2 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Grimmia tergestina (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{36.1}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Aurinia saxatilis (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{32.1}$	. $^{---}$	. $^{---}$	6 $^{---}$	. $^{---}$	. $^{---}$
Toninia sedifolia	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{29.9}$	. $^{---}$	. $^{---}$	6 $^{---}$	. $^{---}$	. $^{---}$
Pseudoleskea catenulata (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{29.5}$	. $^{---}$	. $^{---}$	6 $^{---}$	. $^{---}$	. $^{---}$
Squamarina cartilaginea	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{29.2}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Orthotrichum cupulatum	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{28.6}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Leucodon sciuroides	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{27.8}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Medicago prostrata	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{27.7}$	7 $^{12.4}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Encalypta vulgaris (cf)	. $^{---}$	. $^{---}$	. $^{---}$	**18** $^{27.2}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Weissia controversa	. $^{---}$	2 $^{---}$	5 $^{---}$	**12** $^{26.7}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Tortula intermedia	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{25.5}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Cerastium semidecandrum	. $^{---}$	5 $^{8.0}$	. $^{---}$	**18** $^{25.4}$	10 $^{14.7}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Cladonia convoluta	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{23.8}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Echium vulgare (BF)	14 $^{---}$	12 $^{5.8}$	10 $^{---}$	**41** $^{22.5}$	37 $^{19.9}$	. $^{---}$	11 $^{---}$	. $^{---}$	. $^{---}$
Porella platyphylla	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{22.5}$	. $^{---}$	17 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Stipa capillata (BF)	18 $^{16.9}$	21 $^{19.5}$	. $^{---}$	**24** $^{21.8}$	17 $^{15.9}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Linaria genistifolia	5 $^{---}$	18 $^{12.7}$	. $^{---}$	**29** $^{21.6}$	15 $^{10.5}$	. $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$
Sempervivum marmoreum	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{21.1}$	7 $^{13.7}$	17 $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Valerianella dentata	. $^{---}$	. $^{---}$	. $^{---}$	**12** $^{21.1}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$	. $^{---}$
Tithymalus cyparissias	64 $^{13.8}$	75 $^{17.1}$	80 $^{18.3}$	**88** $^{20.6}$	68 $^{15.1}$	67 $^{---}$	78 $^{17.7}$	64 $^{14.0}$	50 $^{10.0}$
Acinos arvensis (BF)	18 $^{---}$	18 $^{7.9}$	5 $^{---}$	**41** $^{20.6}$	39 $^{19.4}$	17 $^{---}$	6 $^{---}$	7 $^{---}$	. $^{---}$

Group No.	1	2	3	4	5	6	7	8	9
No. of relevés	22	57	20	17	41	6	18	28	20
Alliance	BF	BF	BF	BF	BF	BF	DS	DS	DS
Poo badensis-Caricetum humilis									
Artemisia campestris (pc)	9 ---	5 ---	. ---	24 19.8	**37** 30.3	17 ---	11 ---	4 ---	. ---
Astragalus vesicarius	. ---	. ---	. ---	. ---	**10** 29.3	. ---	. ---	. ---	. ---
Galium glaucum (pc)	. ---	5 ---	. ---	29 17.4	**41** 24.7	17 ---	17 ---	21 12.4	5 ---
Thymus pannonicus (BF, pc)	. ---	2 ---	. ---	24 ---	**49** 24.5	17 ---	. ---	4 ---	. ---
Bothriochloa ischaemum (BF)	23 13.8	26 16.1	20 12.0	18 ---	**39** 24.1	. ---	. ---	4 ---	. ---
Acosta rhenana (BF, pc)	9 ---	19 10.0	. ---	18 ---	**44** 24.1	17 ---	. ---	7 ---	. ---
Linaria pallidiflora	. ---	. ---	. ---	6 ---	**15** 23.2	17 ---	. ---	. ---	. ---
Eryngium campestre (BF, pc)	5 ---	9 ---	. ---	18 ---	**44** 22.6	. ---	. ---	. ---	. ---
Sedum acre	18 12.1	7 ---	5 ---	24 15.9	**32** 21.6	. ---	6 ---	4 ---	5 ---
Eremogone micradenia	. ---	. ---	. ---	. ---	**5** 20.7	. ---	. ---	. ---	. ---
Onosma tornensis	. ---	. ---	. ---	. ---	**7** 20.0	. ---	. ---	. ---	. ---
Seslerietum heuflerianae									
Sesleria heufleriana (sh)	. ---	. ---	. ---	. ---	. ---	**100** 97.1	. ---	. ---	. ---
Aconitum anthora (sh)	. ---	. ---	. ---	12 ---	2 ---	**83** 77.5	6 ---	. ---	. ---
Melica picta (sh)	. ---	. ---	. ---	. ---	. ---	**50** 66.7	. ---	. ---	. ---
Spiraea media (sh)	. ---	. ---	. ---	6 ---	2 ---	**67** 65.6	6 ---	. ---	. ---
*Valeriana * angustifolia* (sh)	. ---	. ---	. ---	. ---	2 ---	**50** 59.8	. ---	. ---	. ---
Rosa tomentosa	. ---	. ---	. ---	. ---	. ---	**33** 56.0	. ---	. ---	. ---
Dracocephalum austriacum	. ---	. ---	. ---	6 ---	. ---	**33** 55.1	. ---	. ---	. ---
Waldsteinia geoides (sh)	. ---	. ---	. ---	. ---	. ---	**50** 51.7	. ---	. ---	. ---
Veronica austriaca	. ---	4 ---	. ---	18 17.0	20 18.8	**50** 44.9	. ---	4 ---	. ---
Tithymalus epithymoides (sh)	. ---	2 ---	. ---	. ---	2 ---	**50** 42.3	6 ---	4 ---	. ---
Verbascum phoeniceum	. ---	. ---	. ---	. ---	2 ---	**33** 41.9	. ---	. ---	. ---
Ferula sadleriana	. ---	. ---	. ---	. ---	. ---	**17** 40.7	. ---	. ---	. ---
Encalypta rhaptocarpa	. ---	. ---	. ---	. ---	. ---	**17** 39.9	. ---	. ---	. ---
Thalictrum foetidum	. ---	. ---	. ---	. ---	. ---	**17** 39.7	. ---	. ---	. ---
Potentilla recta	. ---	. ---	. ---	. ---	. ---	**33** 34.7	6 ---	. ---	. ---
Vicia tenuifolia	. ---	. ---	. ---	. ---	. ---	**33** 34.0	. ---	. ---	5 ---
Ajuga genevensis (sh)	. ---	. ---	5 ---	. ---	7 ---	**50** 33.8	6 ---	4 ---	. ---
Carduus collinus	. ---	2 ---	. ---	. ---	. ---	**33** 33.4	. ---	. ---	. ---
Geranium sanguineum	. ---	4 ---	. ---	24 14.8	27 17.0	**50** 31.8	11 ---	4 ---	15 ---
Fragaria moschata (sh)	. ---	. ---	. ---	6 ---	7 ---	**50** 28.4	. ---	. ---	. ---
Trifolium alpestre	. ---	. ---	. ---	18 ---	5 ---	**50** 25.8	6 ---	. ---	5 ---
Other differential species of Bromo pannonici-Festucion pallentis									
Melica ciliata (BF)	**36** 21.1	**42** 24.4	5 ---	**76** 43.8	**61** 35.2	**50** 29.0	6 ---	4 ---	. ---
Campanula sibirica (BF, pc)	**36** 23.9	**37** 24.2	. ---	**76** 48.7	**78** 49.6	**50** 32.7	6 ---	7 ---	. ---
Potentilla arenaria agg. (BF, pc, ms)	**68** 28.0	**54** 22.1	20 ---	**82** 34.0	**100** 41.3	17 ---	11 ---	43 17.1	. ---
Poa badensis (BF, pc)	23 18.7	23 18.8	. ---	**41** 33.2	**54** 42.4	17 ---	. ---	. ---	. ---
Koeleria macrantha (BF)	32 14.0	23 9.5	**50** 22.8	24 ---	**46** 21.0	. ---	6 ---	. ---	. ---
Linum tenuifolium (BF, fc)	**64** 45.9	**81** 56.7	**35** 26.2	6 ---	20 14.6	. ---	. ---	21 16.0	20 14.9
Stipa pulcherrima (BF)	14 14.3	**25** 25.3	5 ---	**24** 24.3	**32** 32.0	. ---	6 ---	. ---	. ---
Alyssum montanum (BF, fc)	**50** 35.7	**65** 45.5	10 ---	**29** 21.4	**29** 21.2	. ---	6 ---	18 12.8	15 ---
Festuca pallens (BF, pf, ss)	**100** 43.6	**81** 35.2	10 ---	**100** 43.6	**59** 25.4	**83** 36.4	**89** 38.8	32 13.2	10 ---
Lactuca perennis (BF, cf)	. ---	. ---	. ---	**53** 44.9	**37** 32.1	**50** 42.7	. ---	. ---	. ---
Allium flavum (BF, cf)	27 15.6	23 12.9	. ---	**94** 53.1	**51** 29.7	33 ---	22 12.5	11 ---	. ---
Arenaria serpyllifolia agg. (BF)	32 17.7	30 16.5	5 ---	24 12.8	15 7.4	17 ---	6 ---	4 ---	. ---
Fumana procumbens (BF, pf, fc)	**73** 65.6	**63** 58.4	. ---	. ---	. ---	. ---	. ---	18 18.8	5 ---
Medicago falcata (BF)	. ---	7 ---	30 11.0	6 ---	44 17.0	17 ---	. ---	4 ---	. ---
Verbascum lychnitis (BF, pc)	. ---	. ---	. ---	**35** 32.1	**39** 35.2	17 ---	. ---	. ---	. ---
Hypericum perforatum (BF)	5 ---	18 ---	10 ---	18 ---	39 10.0	. ---	. ---	4 ---	5 ---
Thlaspi perfoliatum (BF)	23 17.9	25 19.3	15 ---	6 ---	7 ---	. ---	. ---	4 ---	. ---
Silene otites agg. (BF, fc)	**41** 33.9	**42** 34.8	. ---	**24** 20.0	5 ---	. ---	6 ---	7 ---	5 ---
Saxifrago aizoi-Seslerietum calcariae									
Saxifraga paniculata (DS, ss)	. ---	. ---	. ---	6 ---	2 ---	17 ---	**61** 41.1	. ---	. ---
Dendranthema zawadskii	. ---	. ---	. ---	. ---	. ---	. ---	**11** 27.1	. ---	. ---
Aster alpinus	. ---	. ---	. ---	6 ---	. ---	. ---	**22** 26.8	. ---	. ---
Rosa pimpinellifolia	. ---	. ---	. ---	. ---	. ---	17 ---	**17** 23.4	. ---	. ---
Hieracium bupleuroides	. ---	2 ---	. ---	. ---	2 ---	. ---	**22** 21.2	. ---	10 ---
Pulsatilla subslavica	. ---	4 ---	. ---	. ---	2 ---	. ---	**17** 21.0	. ---	15 19.0
Minuartio setaceae-Seslerietum calcariae									
Allium senescens (ms)	5 ---	23 15.5	5 ---	6 ---	10 ---	. ---	6 ---	**46** 31.5	10 ---
Bupleurum falcatum	5 ---	19 9.8	10 ---	18 ---	20 9.9	33 ---	33 17.9	**46** 25.1	15 ---
Viola collina	. ---	2 ---	10 ---	. ---	. ---	. ---	. ---	**21** 25.1	. ---
Festuco pallentis-Seslerietum calcariae									
Acinos alpinus (DS)	5 ---	16 10.1	25 16.5	. ---	. ---	. ---	17 ---	29 18.9	**65** 42.2
Galium pumilum agg. (DS, fs)	14 ---	4 ---	25 10.7	. ---	. ---	. ---	. ---	7 ---	**75** 34.7
Allium ochroleucum	. ---	4 ---	. ---	. ---	5 ---	. ---	. ---	4 ---	**30** 28.8
Polygala amara agg. (DS)	. ---	4 ---	5 ---	. ---	. ---	. ---	6 ---	25 13.8	**50** 28.3
Phyteuma orbiculare (DS)	. ---	5 ---	15 ---	. ---	. ---	. ---	17 ---	18 ---	**55** 25.3
Carex ornithopoda	. ---	. ---	5 ---	. ---	. ---	. ---	. ---	. ---	**20** 23.3
Potentilla inclinata	. ---	2 ---	. ---	. ---	. ---	. ---	. ---	. ---	**10** 23.0
Thalictrum minus	. ---	4 ---	. ---	6 ---	17 14.7	33 ---	6 ---	21 18.5	**25** 21.5

Group No.	1	2	3	4	5	6	7	8	9
No. of relevés	22	57	20	17	41	6	18	28	20
Alliance	BF	BF	BF	BF	BF	BF	DS	DS	DS
Other differential species of Diantho lumnitzeri-Selerion									
Sesleria albicans (DS)	9 ---	16 4.8	15 ---	6 ---	7 ---	. ---	**100 40.7**	**100 40.7**	**100 40.7**
Genista pilosa (DS, oc)	9 ---	33 15.6	**70 33.7**	12 ---	7 ---	. ---	22 ---	**75 36.1**	**90 43.2**
Biscutella laevigata (DS)	18 13.9	18 13.4	. ---	. ---	. ---	. ---	**44 33.7**	**36 27.4**	**30 23.1**
Campanula rotundifolia agg. (DS)	36 18.3	26 12.9	10 ---	18 ---	5 ---	. ---	33 16.7	**43 21.8**	**60 30.7**
Leucanthemum vulgare agg. (DS, oc)	5 ---	. ---	20 ---	. ---	. ---	. ---	22 ---	14 ---	30 ---
Linum catharticum (DS, oc)	. ---	5 ---	45 12.6	. ---	2 ---	. ---	11 ---	25 ---	50 14.3
Leontodon hispidus (DS, fs)	. ---	. ---	10 ---	. ---	2 ---	17 ---	. ---	4 ---	55 10.0
Briza media (DS, oc, fs)	5 ---	. ---	35 ---	. ---	. ---	. ---	. ---	14 ---	55 ---
Pulsatilla slavica (DS)	. ---	. ---	. ---	6 ---	5 ---	. ---	11 ---	14 12.0	20 16.9
Tephroseris integrifolia (DS)	. ---	. ---	. ---	. ---	. ---	. ---	. ---	14 19.9	10 ---
Diagnostic species common for two or more associatins									
Sedum album	**45 30.7**	**30 20.3**	. ---	24 15.9	2 ---	. ---	22 15.0	18 11.9	10 ---
Hornungia petraea	**14 27.2**	**12 25.0**	. ---	. ---	. ---	. ---	. ---	4 ---	. ---
Leontodon incanus (pf, fc)	**82 43.3**	**72 38.3**	**50 26.7**	. ---	. ---	. ---	28 14.4	**68 36.1**	**90 47.4**
Helianthemum nummularium agg.	**64 20.5**	**68 22.2**	**70 22.8**	53 16.7	59 18.7	50 ---	33 ---	**68 22.0**	60 19.2
Thymus praecox (pf, fc, fs)	**100 50.7**	**95 48.1**	**55 28.3**	24 11.5	32 15.9	. ---	. ---	**43 21.9**	**75 38.5**
Globularia punctata (fc, oc)	**50 30.2**	**68 40.9**	**80 47.4**	6 ---	5 ---	. ---	6 ---	**61 36.5**	**60 36.1**
Sanguisorba minor (fc)	**68 20.0**	**95 28.8**	**80 23.9**	24 ---	27 6.1	. ---	11 ---	57 16.3	**80 23.9**
Teucrium montanum (ms)	**73 32.4**	**88 39.1**	30 12.6	**59 26.1**	**73 32.6**	. ---	28 11.5	**96 43.0**	**70 31.2**
Jovibarba globifera (ss)	**55 24.1**	44 19.2	15 ---	**82 36.7**	**66 29.3**	17 ---	**78 34.7**	25 10.2	5 ---
Draba lasiocarpa (pf)	**45 53.3**	12 17.0	. ---	**24 30.8**	. ---	. ---	6 ---	4 ---	. ---
Rhodax canus (fs)	**32 27.8**	**37 31.9**	10 ---	18 15.6	**29 25.7**	. ---	6 ---	7 ---	**45 38.3**
Dianthus praecox	**27 24.1**	18 15.6	5 ---	6 ---	. ---	. ---	**50 42.3**	**29 25.2**	. ---
Scorzonera austriaca (fc)	**36 39.1**	**53 53.4**	. ---	. ---	7 8.4	. ---	17 19.2	**18 20.5**	15 17.3
Inula ensifolia	9 ---	**42 21.3**	35 17.6	6 ---	39 19.7	. ---	**56 28.3**	43 21.7	30 14.9
Jurinea mollis	9 ---	**19 23.4**	. ---	12 ---	7 9.1	. ---	. ---	**18 21.7**	5 ---
Carex humilis (fc, pc, ms)	45 17.5	**100 40.0**	**100 40.0**	24 ---	**100 40.0**	17 ---	22 ---	**100 40.0**	**80 31.9**
Anthericum ramosum	27 9.5	**63 24.6**	**75 29.5**	35 12.9	**56 21.7**	17 ---	**72 28.3**	**86 33.8**	**50 19.1**
Asperula cynanchica	59 19.6	**68 23.0**	**65 21.7**	59 19.5	**73 24.7**	. ---	50 16.2	43 13.5	**70 23.6**
Seseli osseum	36 13.7	**65 25.9**	15 ---	**82 33.1**	**71 28.3**	50 ---	**78 31.2**	**57 22.6**	25 ---
Teucrium chamaedrys (pc)	32 ---	54 14.8	**80 23.1**	**76 21.9**	**95 27.9**	**83 24.2**	22 ---	50 13.3	70 19.9
Hippocrepis comosa (oc, fs)	14 ---	19 10.3	**90 49.8**	12 ---	10 ---	. ---	. ---	7 ---	**75 41.9**
Potentilla heptaphylla (oc, fs)	14 ---	40 13.9	**95 35.3**	. ---	. ---	. ---	6 ---	36 12.1	**80 29.5**
Anthyllis vulneraria (fs)	23 ---	51 15.4	**65 20.4**	6 ---	37 10.3	. ---	22 ---	25 ---	**70 22.1**
Bromus monocladus (oc)	. ---	2 ---	**45 33.3**	. ---	. ---	. ---	. ---	18 13.3	**35 26.2**
Iris pumila	. ---	4 ---	. ---	**24 33.9**	**15 22.4**	. ---	. ---	. ---	. ---
Stachys recta (cf)	. ---	16 7.6	5 ---	**88 46.5**	**51 27.3**	**50 26.7**	17 ---	11 ---	5 ---
Asplenium ruta-muraria	5 ---	5 ---	. ---	**47 28.4**	**34 20.5**	33 ---	**67 39.8**	4 ---	10 ---
Campanula xylocarpa (cf)	. ---	. ---	. ---	**29 37.0**	2 ---	**33 41.1**	11 15.3	. ---	. ---
Erysimum odoratum	5 ---	7 ---	5 ---	**47 27.9**	22 12.6	**67 39.1**	22 12.8	18 10.1	5 ---
Chamaecytisus hirsutus	. ---	2 ---	. ---	**24 21.0**	12 10.8	**50 42.6**	. ---	4 ---	5 ---
Cyanus triumfettii (sh, ss)	. ---	4 ---	5 ---	**29 22.2**	5 ---	**67 48.1**	**56 40.7**	. ---	5 ---
Vincetoxicum hirundinaria (ss)	. ---	35 11.5	20 ---	24 ---	34 11.2	**83 30.2**	**94 34.4**	25 7.5	45 15.4
Pulsatilla grandis	5 ---	12 10.2	5 ---	12 ---	12 10.1	**33 27.9**	**28 23.4**	21 18.1	. ---
Polygonatum odoratum (ss)	. ---	5 ---	10 ---	24 11.9	17 8.2	**50 26.5**	**50 26.5**	. ---	10 ---
Other differential species for associations									
Pilosella officinarum (fc, fs)	23 ---	42 12.4	30 ---	6 ---	5 ---	. ---	6 ---	4 ---	40 11.7
Salvia pratensis (oc)	9 ---	9 ---	60 17.9	18 ---	44 12.3	33 ---	11 ---	4 ---	15 ---
Carex caryophyllea (oc)	9 ---	7 ---	50 19.7	. ---	10 ---	. ---	. ---	7 ---	. ---
Carlina acaulis (oc)	14 ---	7 ---	40 9.8	. ---	. ---	. ---	. ---	14 ---	45 11.4
Dianthus carthusianorum agg. (oc)	. ---	2 ---	55 16.9	6 ---	17 ---	. ---	22 ---	7 ---	15 ---
Salvia verticillata (oc)	. ---	4 ---	35 18.0	6 ---	2 ---	. ---	6 ---	. ---	. ---
Pimpinella saxifraga agg. (oc, fs)	9 ---	18 ---	70 14.5	12 ---	12 ---	33 ---	11 ---	18 ---	80 17.2
Lotus corniculatus (oc, fs)	5 ---	4 ---	65 9.6	6 ---	10 ---	. ---	. ---	14 ---	55 ---
Trifolium montanum (oc)	. ---	. ---	35 ---	6 ---	. ---	. ---	. ---	4 ---	10 ---
Seseli annuum (oc)	. ---	. ---	20 19.9	. ---	2 ---	. ---	. ---	4 ---	. ---
Knautia kitaibelii (oc)	. ---	. ---	40 19.2	. ---	. ---	. ---	. ---	7 ---	15 ---
Achillea millefolium agg. (pc)	5 ---	4 ---	30 ---	12 ---	34 ---	17 ---	. ---	4 ---	15 ---
Festuca valesiaca (pc)	. ---	14 5.5	5 ---	12 ---	41 19.6	17 ---	11 ---	. ---	. ---
Pseudolysimachion spicatum (pc)	. ---	9 ---	10 ---	. ---	29 19.7	33 ---	. ---	11 ---	5 ---
Glechoma hederacea (sh)	. ---	. ---	. ---	. ---	. ---	50 ---	. ---	. ---	. ---
Other species with higher frequencies									
Arabis hirsuta agg.	14 ---	21 9.2	25 11.3	12 ---	17 7.2	17 ---	6 ---	7 ---	15 ---
Scabiosa ochroleuca	23 ---	39 16.8	25 10.3	29 12.4	44 19.4	17 ---	. ---	32 13.8	35 15.1
Viola hirta	5 ---	5 ---	40 12.6	12 ---	17 ---	33 ---	28 ---	. ---	25 ---
Sedum sexangulare	23 11.2	25 12.2	25 12.5	18 ---	17 8.0	. ---	. ---	11 ---	. ---
Taraxacum sect. *Erythrosperma*	5 ---	2 ---	10 ---	12 ---	17 19.2	. ---	6 ---	. ---	. ---
Taraxacum sect. *Ruderalia*	5 ---	2 ---	5 ---	6 ---	17 ---	. ---	. ---	. ---	5 ---
Cardaminopsis arenosa agg.	5 ---	4 ---	10 ---	6 ---	2 ---	. ---	17 ---	. ---	10 ---
Carlina vulgaris	14 ---	11 ---	30 15.1	. ---	10 ---	. ---	6 ---	14 ---	5 ---
Minuartia langii	9 ---	4 ---	5 ---	. ---	. ---	. ---	11 ---	4 ---	5 ---
Onosma visianii	9 16.7	11 19.1	. ---	6 ---	7 13.7	. ---	. ---	. ---	. ---
Minuartia rubra	9 ---	11 15.5	. ---	12 ---	5 ---	. ---	. ---	. ---	. ---
Asperula tinctoria	5 ---	11 7.3	5 ---	. ---	. ---	. ---	6 ---	21 15.7	20 14.6
Tortella tortuosa	. ---	12 ---	10 ---	24 ---	7 ---	17 ---	28 13.9	11 ---	. ---
Ditrichium flexicaule	. ---	7 ---	10 ---	12 ---	2 ---	17 ---	17 ---	4 ---	. ---

Group No.	1	2	3	4	5	6	7	8	9
No. of relevés	22	57	20	17	41	6	18	28	20
Alliance	BF	BF	BF	BF	BF	BF	DS	DS	DS
Poa pratensis agg.	.	2	5	6	12	33	.	4	5
Medicago lupulina	.	2	15	6	12	.	11	.	5
Tortella inclinata	.	12 19.7	5	6	.	.	.	.	.
Plantago lanceolata	.	7	25	.	17	33	.	4	25
Primula veris	.	4	15	.	7	33	6	.	25
Ranunculus bulbosus	.	4	20	.	7	17	.	.	5
Thuidium abietinum	.	4	20 14.0	.	2	17	6	4	.
Bromus erectus	.	4	20	.	2	.	.	4	5
Peucedanum cervaria	.	2	5	.	.	17	.	7	10
Hypnum cupressiforme	.	11	15	.	.	.	6	4	5
Antennaria dioica	.	2	5	.	.	.	.	4	25 15.9
Gymnadenia conopsea	.	2	5	.	.	.	.	.	15
Cotoneaster tomentosus	.	2	.	.	.	17	6	11 11.8	10
Thesium alpinum	.	5	.	.	.	.	17	.	20 14.7
Epipactis atrorubens	.	2	.	.	.	.	11	.	15 13.0
Hieracium bifidum	.	2	.	.	.	.	.	.	10
Galium mollugo agg.	.	.	15	29	20	67	11	4	.
Securigera varia	.	.	15	6	22	17	22	.	.
Achillea nobilis	.	.	5	24 15.9	15 9.5	.	.	.	.
Phleum phleoides	.	.	20 13.9	6	10	17	6	.	.
Lembotropis nigricans	.	.	10	6	5	.	6	4	15
Fragaria viridis	.	.	15	.	17	.	.	4	.
Carex montana	.	.	10	.	.	17	.	.	10
Carex alba	.	.	5	.	.	.	6	4	20 13.8
Platanthera bifolia	.	.	5	.	.	.	6	7	10
Pinus sylvestris	.	.	5	.	.	.	.	11	5
Alchemilla spec. div.	.	.	10	.	.	.	.	.	15
Carex flacca	.	.	10	.	.	.	.	.	10
Origanum vulgare	.	.	.	29 14.2	22 10.2	33	22	4	.
Asplenium trichomanes	.	.	.	12	7	33	11	.	.
Agropyron intermedium	.	.	.	24 19.6	2	17	.	.	.
Hylotelephium maximum agg.	.	.	.	18	5	17	.	.	.
Homalothecium philippeanum	.	.	.	18 16.8	.	17	17 15.8	.	.
Cotoneaster integerrimus	.	.	.	6	.	.	.	11 14.3	5
Digitalis grandiflora	.	.	.	.	7	33	6	.	.
Cladonia pyxidata	.	.	.	.	2	17	17 15.0	4	.
Scabiosa lucida	.	.	.	.	.	17	22 11.9	4	5
Laserpitium latifolium	.	.	.	.	.	17	11	4	10
Viola tricolor	.	.	.	.	.	33	.	.	.
Fallopia convolvulus	.	.	.	.	.	33	.	.	.
Betonica officinalis	.	.	.	.	.	33	.	.	10
Euphrasia salisburgensis	.	.	.	.	.	.	11	7	5
Cyanus mollis	.	.	.	.	.	.	17 19.1	7	.
Trifolium pratense	.	.	.	.	.	.	.	4	10
Bellidiastrum michelii	.	.	.	.	.	.	.	.	20 14.3
Potentilla erecta	.	.	.	.	.	.	.	.	15
Ranunculus nemorosus	.	.	.	.	.	.	.	.	10
Euphrasia rostkoviana agg.	.	.	.	.	.	.	.	.	10

Table 4. Borhidi indicator numbers, altitude and Shanon-Wiener index of associations: medians. Associations with the same letter in a given column do not differ significantly (multiple comparisons within individual alliances, $P < 0.05$).

Association	Light	Temperature	Continentality	Moisture	Soil reaction	Nutrients	Shannon-Wiener index	Altitude (m)
Bromo pannonici-Festucion pallentis								
1	8.21^{c}	6.48^{a}	4.63^{ab}	2.13^{d}	7.95^{a}	1.84^{d}	2.86^{b}	330^{b}
2	8.00^{b}	6.37^{a}	4.77^{ab}	2.35^{cd}	7.82^{a}	2.07^{cd}	3.00^{ab}	414^{bc}
3	7.54^{a}	5.67^{b}	4.58^{b}	3.28^{a}	7.35^{c}	2.48^{ab}	3.18^{a}	480^{acd}
4	8.00^{bc}	6.44^{a}	4.78^{cb}	2.45^{cd}	7.59^{bc}	2.24^{ac}	3.15^{a}	483^{ab}
5	7.96^{b}	6.44^{a}	4.92^{c}	2.49^{bc}	7.63^{b}	2.37^{ab}	2.85^{ab}	385^{bd}
6	7.47^{a}	6.10^{b}	4.92^{ac}	3.07^{ab}	7.41^{bc}	2.65^{b}	2.93^{ab}	618^{a}
Diantho lumnitzerii-Seslerion								
7	7.62^{a}	5.75^{a}	4.49^{a}	2.74^{a}	7.50^{ab}	2.21^{ab}	2.53^{a}	525^{a}
8	7.67^{a}	6.00^{b}	4.54^{a}	2.66^{a}	7.77^{a}	2.18^{a}	2.36^{a}	490^{a}
9	7.44^{b}	5.69^{a}	4.19^{b}	3.15^{b}	7.46^{b}	2.36^{b}	2.56^{a}	540^{a}

This alliance represents open dry grasslands on limestone and dolomite bedrock in the Pannonian region and lower peri-Carpathian mountain ranges or Inner-Carpathian basins (intermontane basins of northern and central Slovakia) with warm and dry climate (see Fig. 2a for their distribution). They inhabit mild or steep sun-exposed slopes with shallow soils and karst rocky fields. The regular periods of summer drought act as limiting factor in formation of open communities dominated by competitively week but stress-tolerant species. In Slovakia, the floristic composition and the overall structure of these communities are affected mainly by the geographical location, microclimatic features and bedrock type. Numerous rare and endemic species grow in these communities (e.g. *Campanula xylocarpa*, *Dianthus praecox* subsp. *lumnitzeri*, *Draba lasiocarpa* subsp. *klasterskyi*, *Onosma tornensis*). Caespitose grasses (*Festuca pallens*, *Sesleria heufleriana*) or graminoids (*Carex humilis*) dominate in these communities and determine substantially their syntaxonomical position.

The extremely dry and warm habitats dominated by *Festuca pallens* are classified to two associations vicarious in their geographical distribution (Fig. 2c): Poo badensis-Festucetum pallentis (south-western Carpathian margins) and Campanulo divergentiformis-Festucetum pallentis (southern Carpathian margin in the Slovak-Hungarian karst region). In both associations special drought-adapted species groups are abundant such as succulents (*Jovibarba globifera*, *Sedum* spec. div.), chamaephyts (*Fumana procumbens*, *Draba lasiocarpa*, *Teucrium montanum*, *Thymus praecox*, *T. pannonicus*) and ephemeral terophyts (*Erophila verna* agg., *Cerastium brachypetallum*, *C. semidecandrum*, *Holosteum umbellatum*, *Hornungia petraea*, *Saxifraga tridactylites*).

Among *Carex humilis*-dominated communities three associations can be recognized (Fig. 2b): Festuco pallentis-Caricetum humilis (western Slovakia), Poo badensis-Caricetum humilis (southern Slovakia) and Orthantho luteae-Caricetum humilis (north-western and central Slovakia). Typical is a marked vegetation structure (fairy rings or „Hexenringe“) formed by the dominat *Carex humilis* and occurence of numerous chamaephyts of genera *Thymus*, *Teucrium*, *Helianthemum* and *Rhodax*.

The association Seslerietum heuflerianae occurs in Slovakia at the border of its geographical distribution (Fig. 2c). Its floristical composition is similar to other dry grasslands in the eastern Pannonian region. Due to its position on both temperature and moisture gradients (Fig. 1) we consider it to be a transitional community to the dealpine blue moor grass communties of the Diantho lumnitzeri-Seslerion alliance.

Outside Slovakia, the vegetation of the Bromo pannonici-Festucion pallentis alliance occurs in Hungary (Transdanubian Range and Northern Range; Zólyomi 1966, Dúbravková et al. 2010) and in the Carpathian periphery in Moravia (Chytrý et al. 2007), Lower Austria (Mucina & Kolbek 1993) and Romania (Coldea 1991). Similar vegetation in the foothills of Alps and Hercynian mountains is classified within the alliance Xero-Bromion (Br.-Bl. et Moor 1938) Moravec in Holub et al. 1967 with more oceanic character.

Poo badensis-Festucetum pallentis Klika 1931 corr. Zólyomi 1966 nom. invers. propos.

West-Pannonian rocky steppes on calcareous bedrock

Orig. (Klika 1931): Festuca glauca-Poa badensis-Assoziation (Festuca glauca = F. pallens). **Syn.:** Festucetum glaucae Podpěra 1928 (Art. 2b, 36, 43), Festucetum glaucae Sillinger 1930 (Art. 36, 43), Festucetum glaucae pannonicum moravicum (Sillinger 1930) Zólyomi 1936 (Art. 34a, 43), Minuartio montanae-Festucetum glaucae Klika 1937 (Art. 43), Festuca duriuscula-Poa badensis-Assoziation Klika (1931) 1939 (Art. 29, 43). **Non:** Seslerieto-Festucetum duriusculae Dostál 1933.

Diagnostic species: *Alyssum montanum, Arabis auriculata, Campanula sibirica, Cerastium brachypetalum, Dianthus praecox,* ***Draba lasiocarpa*** (dif.)*, Erophila verna agg.,* ***Festuca pallens*** (dif.)*,* ***Fumana procumbens*** (dif.)*, Globularia punctata, Helianthemum nummularium agg., Hornungia petraea, Jovibarba globifera,* ***Leontodon incanus*** (dif.)*,* ***Linum tenuifolium****, Melica ciliata, Pilosella bauhinii, Potentilla arenaria* agg.*, Rhodax canus, Sanguisorba minor, Saxifraga tridactylites, Scorzonera austriaca, Sedum album, Silene otites* agg.*, Teucrium montanum,* ***Thymus praecox*** (dif.)**.**

Constant species: *Alyssum montanum, Asperula cynanchica, Carex humilis, Draba lasiocarpa,* ***Festuca pallens****, Fumana procumbens, Globularia punctata, Helianthemum nummularium* agg.*, Jovibarba globifera,* ***Leontodon incanus****, Linum tenuifolium, Pilosella bauhinii, Potentilla arenaria* agg.*, Sanguisorba minor, Sedum album, Silene otites* agg.*, Teucrium montanum,* ***Thymus praecox****, Tithymalus cyparissias.*

Dominant species: *Festuca pallens.*

Formal definition (22 relevés): (Group Draba lasiocarpa OR Group Scorzonera austriaca) AND *Festuca pallens* cover > 5% NOT (Group Cyanus triumfettii OR *Carex humilis* cover > 5%).

This association represents the most xerophilous community of the alliance (Fig. 3) including early successional stages as well as primary rocky grasslands in climatically and edaphically specific habitats. The stands are low and open, soils shallow and poorly developed, often with the highest percentage cover of dolomite gravel or rocky outcrops. Stands are usually dominated by tussocks of *Festuca pallens*. Succulents (*Jovibarba hirta*, *Sedum acre*, *S. album*, *S. sexangu-*

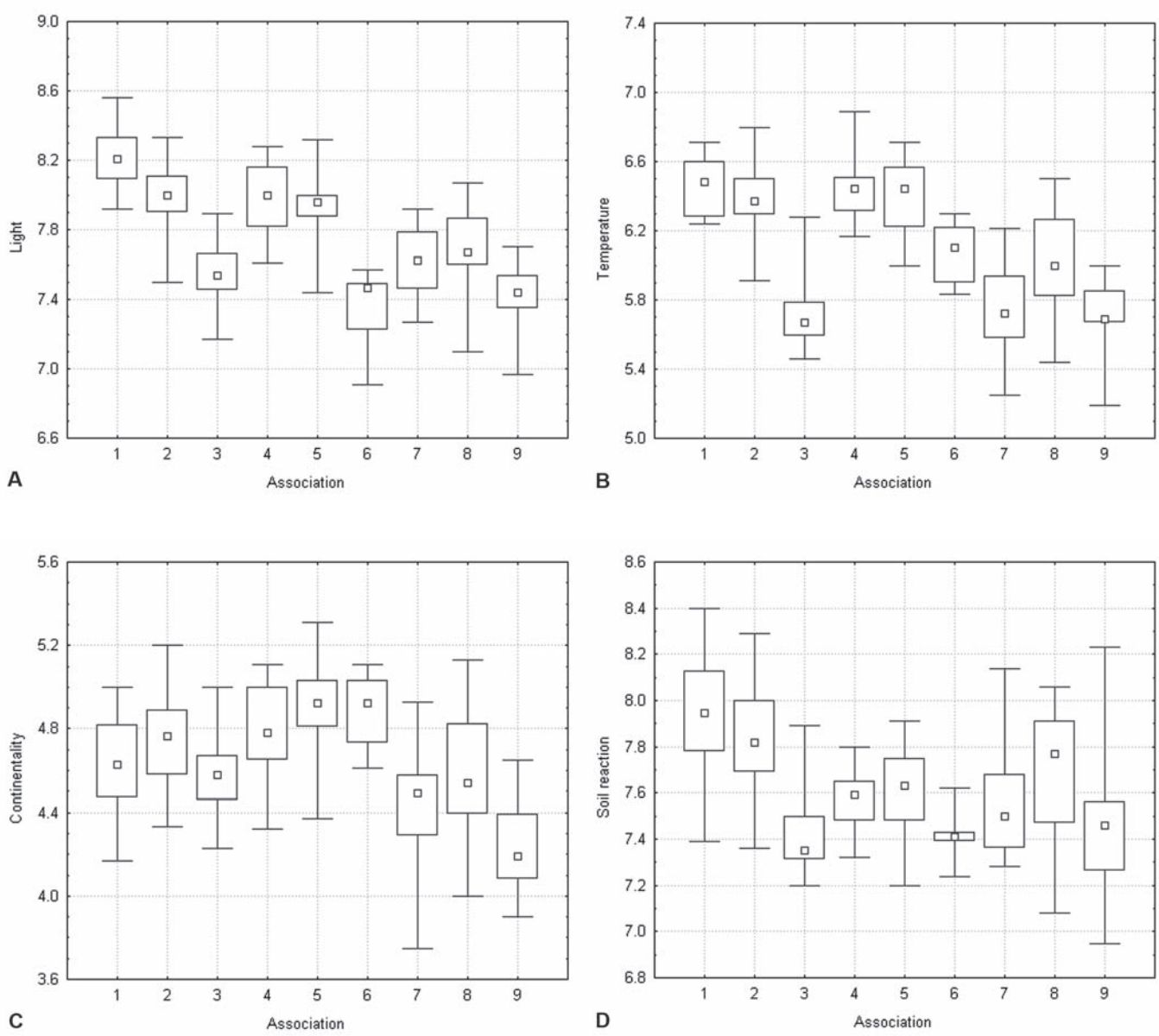
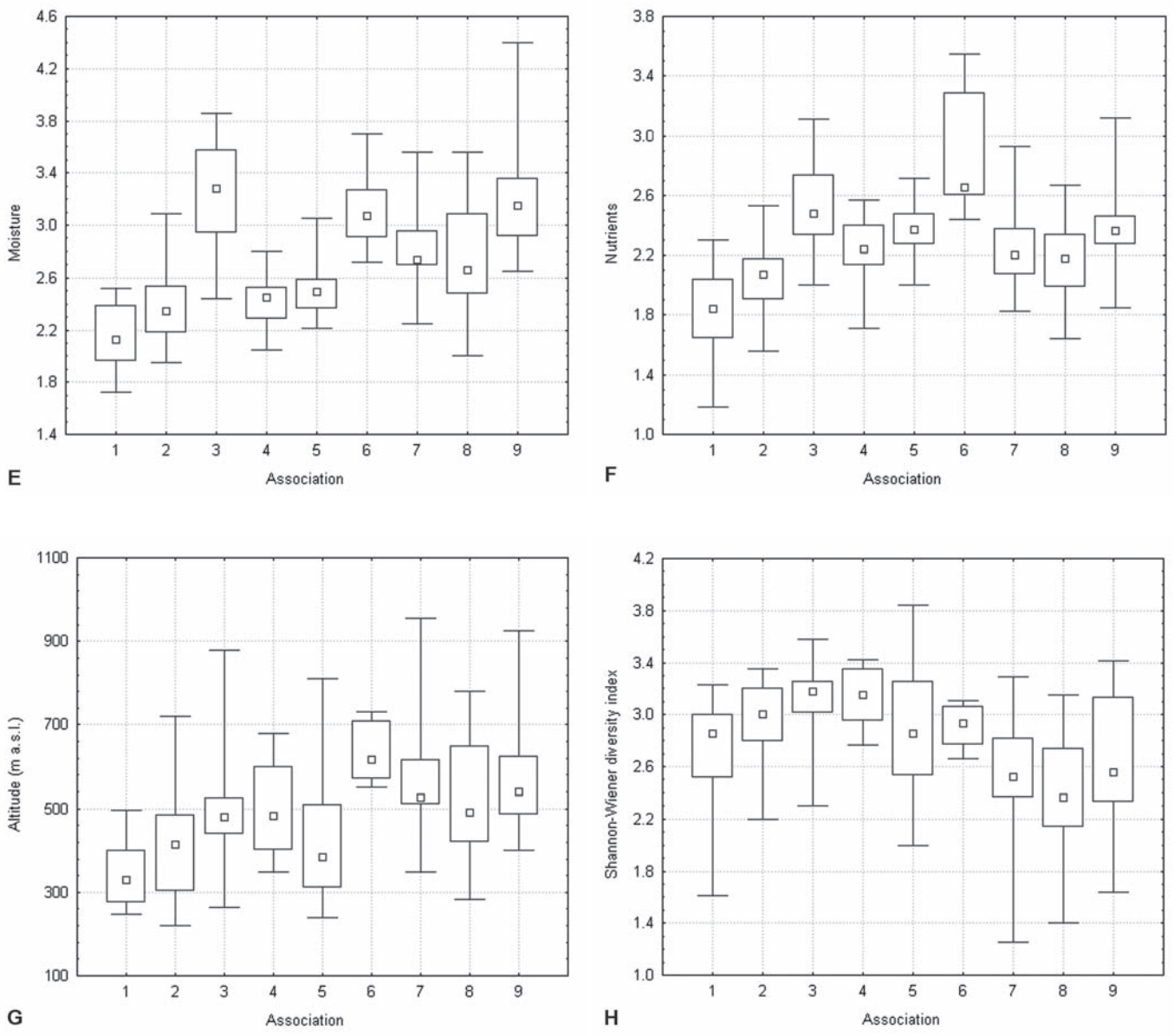


Fig. 3. Relationships of the defined associations to environmental factors expressed by Borhidi indicator values (Borhidi 1993), to altitude and Shannon-Wiener diversity index. Median values, quartiles and ranges are shown. 1 - Poo badensis-Festucetum pallentis, 2 - Festuco pallentis-Caricetum humilis, 3 - Orthantho luteae-Caricetum humilis, 4 - Campanulo divergentiformis-Festucetum pallentis, 5 - Poo badensis-Caricetum humilis, 6 - Seslerietum heuflerianae, 7 - Saxifrago aizoi-Seslerietum calcariae, 8 - Minuartio setaceae-Seslerietum calcariae, 9 - Festuco pallentis-Seslerietum calcariae.

lare) and chamaephytes (*Alyssum montanum*, *Fumana procumbens*, *Helianthemum nummularium* agg., *Teucrium montanum* and *Thymus praecox*) are constantly present. Among forbs, *Leontodon incanus*, *Potentilla arenaria* agg. and *Sanguisorba minor* are very frequent, still non of them reaches higher cover or dominance. These communities have a marked seasonal dynamics with a numerous terophytes (*Cerastium brachypetalum*, *C. pumilum*, *Erophila verna* agg., *Hornungia petraea*, *Saxifraga tridactylites* and *Holosteum umbellatum*) developing in early spring and a very diverse cryptogamic flora reaching the highest percentage cover during wet periods.

In Slovakia, the association occurs in the western part of the country where it inhabits steeper, often eroded slopes over limestones and dolomites at altitudes between 250 and 500 m (Fig. 2c). It was documented from the Malé Karpaty Mts (Domin 1932, Klika 1937), Považský Inovec Mts (Sillinger 1930, Maglocký 1979) and from the southern-most part of



the Strážovské vrchy Mts (Futák 1960). In the past, this vegetation has spread due to intensive grazing. Recently, it is endangered by forest succession (locally speeded up by artificial plantation of *Pinus* spec. div. and *Fraxinus ornus*), atmospheric nitrogen deposition and subsequent invasion of competitive grasses (Michálková 2007). Outside Slovakia, this vegetation occurs in the Pavlovské vrchy Mts in southern Moravia (Klika 1931, Chytrý et al. 2007) and in the north-eastern Austria (Hainburger Berge Mts, Weinviertel; Eijsink et al. 1978, Mucina & Kolbek 1993).

Festuco pallentis-Caricetum humilis Sillinger 1930 corr. Gutermann et Mucina 1993

West-Pannonian *Carex humilis*-grasslands

Orig. (Sillinger 1930): Festuco glaucae-Caricetum humilis (Festuca glauca = F. pallens). **Syn.:** Caricetum humilis Podpěra 1928 (Art. 36), Scabioso suaveolentis-Caricetum humilis Klika 1931, Caricetum humilis praecarpaticum (Klika 1931) Soó 1945 (Art. 29c, 34a), Festuca duriuscula-Teucrium montanum Futák 1947. **Incl.:** Festuca duriuscula-Teucrium montanum Futák 1947 subas. with *Potentilla heptaphylla*, Festuca duriuscula-Teucrium montanum Futák 1947 subas. with *Potentilla arenaria*. **Non:** Caricetum humilis carpaticum Sillinger 1933 (Art. 34a),

Chrysopogono-Caricetum humilis Zólyomi 1950 (Art. 2b).

Diagnostic species: ***Alyssum montanum*** (dif.)**,** *Anthericum ramosum, Asperula cynanchica, Campanula sibirica, Carex humilis* (dif.), *Dorycnium pentaphyllum* agg., *Festuca pallens,* ***Fumana procumbens*** (dif.)**,** ***Globularia punctata*** (dif.)**,** *Helianthemum nummularium* agg., *Helichrysum arenarium, Hornungia petraea, Inula ensifolia, Inula hirta* (dif.), *Jurinea mollis, Leontodon incanus* (dif.), ***Linum tenuifolium*** (dif.), *Melica ciliata, Potentilla arenaria* agg., *Rhodax canus, Sanguisorba minor* (dif.), ***Scorzonera austriaca*** (dif.)**,** *Sedum album, Seseli osseum, Silene otites* agg. (dif.), *Stipa joannis* (dif.), *Stipa pulcherrima, Teucrium montanum* (dif.), ***Thymus praecox*** (dif.).

Other differential species: *Pilosella officinarum*.

Constant species: *Alyssum montanum, Anthericum ramosum, Anthyllis vulneraria, Asperula cynanchica,* ***Carex humilis, Festuca pallens****, Fumana procumbens, Globularia punctata, Helianthemum nummularium* agg., *Inula ensifolia, Jovibarba globifera, Leontodon incanus,* ***Linum tenuifolium****, Melica ciliata, Pilosella bauhinii, Pilosella officinarum, Potentilla arenaria* agg., ***Sanguisorba minor****, Scorzonera austriaca, Seseli osseum, Silene otites* agg., *Teucrium chamaedrys, Teucrium montanum, Thymus praecox, Tithymalus cyparissias.*

Dominant species: *Carex humilis, Stipa joannis.*

Formal definition (57 relevés): Group Scorzonera austriaca AND *Carex humilis* cover > 5% NOT (*Sesleria albicans* cover > 5% OR Group Aster alpinus).

These open and low-growing dry grasslands are dominated by *Carex humilis* which forms typical ring-tussocks and determines the overall structure of this community. High abundance is usually achieved by *Festuca pallens* and other thermophilous species adapted to extremely dry summers such as dwarf shrubs (chamaephytes) *Alyssum montanum*, *Helianthemum nummularium* agg., *Fumana procumbens*, *Potentilla arenaria* agg., *Teucrium montanum*, *Thymus praecox* and *Rhodax canus* as well as spring ephemeral terophytes (e.g. *Erophila verna* agg., *Holosteum umbellatum*, *Hornungia petraea*, *Saxifraga tridactylites*). The last mentioned species group is especially species-rich occupying gaps in the open vegetation where its abundance fluctuates strongly not only during the vegetation season but also among the years. In a similar manner, bryophytes (*Thuidium abietinum*, *Tortella inclinata* and *T. tortuosa*, etc.) reach the highest cover during wet springs and autumns. In several localities, the rare species *Pleurochaete squarrosa* occurs as well.

The stands occur on shallow soils (rendzinas) over carbonate bedrock (dolomites and limestones) in ridge plateaus or gentle south- or south-west-facing slopes at altitudes from 220 to 500 (650) m. This vegetation frequently grows in mosaic with the Poo badensis-Festucetum pallentis association by wich it is replaced in extremely steep and dry habitats. Previously grazed stands are recently endangered mainly by succession of competitive woody and grass species. As they are habitats of numerous rare and vulnerable species, these communities require an effective conservation.

In Slovakia, the distribution is restricted to the lower mountains on the south-western Carpathian periphery (Fig. 2b) having its centre in the Považský Inovec Mts (Sillinger 1930, Maglocký 1979, Michálková 2007) and Malé Karpaty Mts (Klika 1937). Isolated localities are in the Strážovské vrchy Mts and Hornonitrianska kotlina Basin (Futák 1947, 1960). Outside Slovakia this vegetation occurs in north-eastern Austria (Hainburger Berge and Weinviertel, Mucina & Kolbek 1993, Waitzbauer 1990).

We distinguish two variants which were already recognized by Futák (1947). Variant with *Potentilla arenaria* agg., *Stipa joannis*, *Silene otites*, *Campanula sibirica*, *Helianthemum nummularium* agg., *Onosma visianii* and *Trinia glauca* is distributed in the Považský Inovec Mts, Malé Karpaty Mts (including locality Devínska Kobyla connecting the Slovak and Austrian distribution area), and the southern-most part of Strážovské vrchy Mts. Variant with *Potentilla heptaphylla*, *Rhodax canus*, *Dorycnium pentaphyllum* agg., *Helichrysum arenarium* and *Daphne cneorum* occurs in the Strážovské vrchy Mts at altitudes up to 650 m. Species *Potentilla heptaphylla* and *Rhodax canus* replace species *Potentilla arenaria* agg. and *Helianthemum nummularium* agg. from the former variant as vicariants.

Orthantho luteae-Caricetum humilis Kliment et Bernátová 2000

Submontane *Carex humilis* grasslands

Orig. (Kliment & Bernátová 2000): Orthantho luteae-Caricetum humilis ass. nova. **Syn.:** Caricetum humilis Klika 1929 (Art. 31). **Non:** Caricetum humilis Domin 1928, Klika 1928.

Diagnostic species: *Anthericum ramosum, Anthyllis vulneraria, Asperula cynanchica, Brachypodium pinnatum* (dif.), *Bromus monocladus* (dif.), *Carex humilis, Colymbada scabiosa* (dif.), *Festuca rupicola* (dif.), *Genista pilosa* (dif.), *Globularia punctata* (dif.), *Helianthemum nummularium* agg., *Hippocrepis comosa* (dif.)**,** *Koeleria macrantha, Leontodon incanus, Linum tenuifolium, Ophrys insectifera, Orchis militaris, Orthantha lutea, Plantago media* (dif.), *Polygala major* (dif.), *Potentilla heptaphylla* (dif.), *Prunella grandiflora* (dif.), *Sanguisorba minor, Scorzonera hispanica, Teucrium chamaedrys, Thesium linophyllon* (dif.), *Thymus praecox, Trommsdorfia maculata* (dif.).

Other differential species: *Briza media, Carex caryophyllea, Carlina acaulis, Dianthus carthusianorum* agg., *Knautia kitaibelii, Leucanthemum vulgare* agg., *Linum catharticum, Lotus corniculatus, Pimpinella saxifraga* agg., *Salvia pratensis, Salvia verticillata, Seseli annuum, Trifolium montanum.*

Constant species: *Anthericum ramosum, Anthyllis vulneraria, Asperula cynanchica, Brachypodium pinnatum, Bromus monocladus, Carex caryophyllea, Carex humilis, Colymbada scabiosa, Dianthus carthusianorum* agg., *Festuca rupicola, Genista pilosa, Globularia punctata, Helianthemum nummularium* agg., *Hippocrepis comosa, Koeleria macrantha, Leontodon incanus, Linum catharticum, Lotus corniculatus, Pimpinella saxifraga* agg., *Plantago media, Potentilla heptaphylla*, *Salvia pratensis, Sanguisorba minor, Teucrium chamaedrys, Thesium linophyllon, Thymus praecox, Tithymalus cyparissias.*

Dominant species: *Thuidium abietinum, Bromus erectus, Bromus monocladus, Carex humilis, Inula ensifolia*.

Formal definition (20 relevés): Group Rhodax canus AND *Carex humilis* cover > 5% AND (Group Bromus monocladus OR Group Galium verum) NOT (Group Scabiosa lucida OR Group Aster alpinus OR *Brachypodium pinnatum* cover > 25% OR *Sesleria albicans* cover > 5%).

The association represents the most mesic grassland type within Bromo pannonici-Festucion pallentis (Fig. 3). Along with the dominant *Carex humilis* subxerophilous grass species (such as *Bromus monocladus* and *Festuca rupicola*) reach the highest cover and numerous mesophilous forbs are also present (*Pimpinella saxifraga* agg., *Plantago media*, *Salvia pratensis*, etc.) together with a large group of calcareous Carpathian species (*Genista pilosa*, *Hippocrepis comosa*, *Potentilla heptaphylla*, *Teucrium chamaedrys*, *Thymus praecox*). Some typical thermophilous species are still present (e.g. *Bothriochloa ischaemum*, *Koeleria macrantha* and *Linum tenuifolium*) but with low cover values. The stands are almost closed (herb layer covers usually 70–90% and moss layer up to 70%) and very species-rich (30–55 species per relevé). Numerous species with high conservational value are present (e.g. *Avenula praeusta*, *Ophrys insectifera*, *Orchis militaris*, *Orthantha lutea*, *Pulsatilla subslavica*, *Scabiosa canescens*). Within Festuco-Brometea this association represents a transition to sub-xerophilous vegetation dominated by *Bromus erectus* and *Brachypodium pinnatum* (alliances Bromion erecti and Cirsio-Brachypodion pinnati). At the same time it connects the Pannonian thermophilous *Carex humilis*-dominated communitites (associations Festuco pallentis-Caricetum humilis and Poo badensis-Caricetum humilis differentiated by *Fumana procumbens*, *Alyssum montanum*, *Scorzonera austriaca* and *Stipa joannis*) with the montane *Carex humilis*-dominated stands of central-Carpathian mountains which are classified within the Elyno-Seslerietea class and Astero alpini-Seslerion calcariae alliance (Kliment et al. 2007) based on presence of numerous montane species such as *Aster alpinus*, *Euphrasia salisburgensis*, *Gentiana clusii*, *Globularia cordifolia* and *Rhodax rupifragus*.

The stands of this community occur on dolomites, limestones, travertines or fluvial limestone gravels at altitudes from (260) 400–650 (880) m. They are relic and infrequent, thus they require an urgent effective conservation as recently most localities are endangered by abandonment, succession, spread of expansive grasses or anthropogene disturbances (building activities and motocross). The association is known only from Slovakia (Fig. 2b) where it occurs in the Inner-Carpathian basins of its north-western and central part (Turčianska kotlina Basin, Kliment & Bernátová 2000; Hornonitrianska kotlina Basin, Žilinská kotlina Basin, Zvolenská kotlina Basin, Horehronské podolie Valley; Baláž ined., Janišová ined.) and in some central Carpathian mountain ranges (Strážovské vrchy Mts, Starohorské vrchy Mts, Tríbeč Mts and Nitrianska pahorkatina Mts; numerous unpublished relevés). Similar vegetation on melaphyr bedrock in Spišská kotlina Basin (locality Sivá brada, Prímovce; Šmarda 1961, Kliment & Bernátová 2000) misses most mesophilous species and thus does not fulfil the definition criteria.

Campanulo divergentiformis-Festucetum pallentis Zólyomi (1936) 1966

Festuca pallens-dominated rocky grasslands of the north-eastern periphery of the Pannonian Basin

Orig. (Zólyomi 1966): Campanulo divergentiformis-Festucetum pallentis Zólyomi 36, nom. nov. 66. **Syn.:** Festucetum glaucae Zólyomi 1933 (Art. 43), Seslerio-Festucetum duriusculae pannonicae Dostál 1933 (Art. 34a, 43), Festucetum glaucae subcarpaticum Zólyomi 1936 (Art. 34, 43), Campanulo xylocarpae-Festucetum pallentis Petrík nom. ined. (Art. 1).

Diagnostic species: *Acinos arvensis, Allium flavum* (dif.), *Alyssum montanum, Asplenium ruta-muraria, Aurinia saxatilis* (dif.), *Campanula sibirica*, *Campanula xylocarpa* (dif.), *Cerastium semidecandrum, Cladonia convoluta, Cyanus triumfettii, Draba lasiocarpa, Echium vulgare, Encalypta vulgaris* (dif.), *Erysimum odoratum*, *Festuca pallens*, *Grimmia tergestina* (dif.), *Chamaecytisus hirsutus, Iris pumila, Jovibarba globifera, Lactuca perennis* (dif.), *Lecidea lurida* (dif.), *Leucodon sciuroides, Linaria genistifolia, Medicago prostrata, Melica ciliata, Orthotrichum anomalum* (dif.), *Orthotrichum cupulatum, Poa badensis, Porella platyphylla, Potentilla arenaria* agg., *Pseudoleskea catenulata* (dif.), *Sempervivum marmoreum, Seseli osseum, Squamarina cartilaginea, Stachys recta* (dif.), *Stipa capillata, Stipa pulcherrima, Teucrium chamaedrys, Teucrium montanum, Tithymalus cyparissias, Toninia sedifolia, Tortula intermedia, Valerianella dentata, Verbascum lychnitis, Weissia controversa*.

Constant species: *Acinos arvensis, Allium flavum, Asperula cynanchica, Asplenium ruta-muraria, Campanula sibirica, Echium vulgare, Erysimum odoratum, Festuca pallens, Helianthemum nummularium* agg., *Jovibarba globifera, Lactuca perennis, Melica ciliata, Poa badensis, Potentilla arenaria* agg., *Seseli osseum, Stachys recta, Teucrium chamaedrys, Teucrium montanum, Tithymalus cyparissias.*

Dominant species: *Festuca pallens, Potentilla arenaria* agg.

Formal definition (17 relevés): Group Festuca pallens AND Group Melica ciliata AND *Festuca pallens* cover > 5% NOT (Group Festuca valesiaca OR Group Scorzonera austriaca OR *Carex humilis* cover > 5% OR *Sesleria albicans* cover > 5%).

This association involves open rocky dry grasslands of rocky karst habitats (karst rocky fields, cliffs and terraces) dominated by *Festuca pallens*. Along with stress-tolerant xerophilous species (*Jovibarba hirta*, *Sedum* sp. div.), numerous subxerophilous (*Allium flavum*, *Lactuca perennis*, *Stachys recta*, *Verbascum lychnitis*) and mesophilous species (*Brachypodium pinnatum*, *Salvia pratensis*, *Tithymalus cyparissias*) are constantly present in the stands. Cryptogamous species play also an important role, numerous of them showing high fidelity to this association, e.g. *Grimmia tergestina*, *Lecidea lurida*, *Orthotrichum anomalum*, *Pseudoleskea catenulata* and *Toninia sedifolia*. The presence of several rare endemic vascular plants such as *Campanula xylocarpa*, *Dianthus praecox* subsp. *pseudopraecox* and *Draba lasiocarpa* subsp. *klasterskyi* (Kliment 1999) reveals a high conservational value of this vegetation.

These grasslands inhabit steep rocky mostly south-facing slopes over limestones at altitudes 340–670 m. According to Zólyomi (1936) and Háberová et al. (1985) they represent a primary (relic) grasslands of extreme habitats almost untouched by human influence. In Slovakia, the association occurs at the northern border of its distribution area, which includes Hungary (Zólyomi 1936) and Romania (Sanda et al. 1999). Typically developed stands are restricted to the karst habitats of the Slovenský kras Mts and adjacent regions (Fig. 2c; Háberová et al. 1985, Miadok 1987, Dúbravková-Michálková et al. 2008). The formal definition matched also several rocky grasslands in the Tríbeč Mts (Vozárová 1986) representing the transition to the *Poo badensis-Festucetum pallentis* association.

Poo badensis-Caricetum humilis (Dostál 1933) Soó ex Michálková in Janišová et al. 2007

Carex humilis-dominated rocky grasslands of the north-eastern periphery of the Pannonian Basin

Orig. (Dostál 1933): Caricetum humilis pannonicum (Art. 34a). **Syn.**: Potentilletum tommasinianae Krajina 1936 (Art. 31, 43), Poo badensis-Caricetum humilis (Dostál 1933) Soó 1971 (Art. 2b, Recom. 46D). **Incl.**: Sesleario-Festucetum duriusculae poetosum badensis Dostál 1933.

Diagnostic species: *Acosta rhenana* (dif.), *Allium flavum, Alyssum montanum, Anthericum ramosum, Artemisia campestris* (dif.), *Asperula cynanchica, Asplenium ruta-muraria, Astragalus vesicarius, Bothriochloa ischaemum, Campanula sibirica* (dif.), *Carex humilis* (dif.), *Eremogone micradenia, Eryngium campestre* (dif.), *Festuca pallens, Galium glaucum* (dif.), *Iris pumila, Jovibarba globifera, Koeleria macrantha, Lactuca perennis, Linaria pallidiflora, Melica ciliata, Onosma tornensis, Poa badensis* (dif.), *Potentilla arenaria* **agg.** (dif.), *Rhodax canus, Sedum acre, Seseli osseum, Stachys recta, Stipa pulcherrima, Teucrium chamaedrys* (dif.), *Teucrium montanum, Thymus pannonicus* (dif.), *Verbascum lychnitis* (dif.).

Other differential species: *Achillea millefolium* agg., *Festuca valesiaca, Hypericum perforatum, Medicago falcata, Pseudolysimachion spicatum.*

Constant species: A*costa rhenana, Allium flavum, Anthericum ramosum, Asperula cynanchica, Campanula sibirica, Carex humilis, Eryngium campestre, Festuca pallens, Festuca valesiaca, Galium glaucum, Helianthemum nummularium* agg., *Jovibarba globifera, Koeleria macrantha, Medicago falcata, Melica ciliata, Poa badensis, Potentilla arenaria* agg., *Salvia pratensis, Scabiosa ochroleuca, Seseli osseum, Stachys recta, Teucrium chamaedrys, Teucrium montanum, Thymus pannonicus, Tithymalus cyparissias.*

Dominant species: *Carex humilis, Potentilla arenaria* agg., *Festuca valesiaca.*

Formal definition (41 relevés): Group Poa badensis AND *Carex humilis* cover > 5% AND (Group Melica ciliata OR Group Festuca valesiaca) NOT (Group Scorzonera austriaca OR Group Sempervivum montanum OR *Festuca pseudovina* cover > 5%).

This community is represented by open to semi-open dry grasslands dominated by *Carex humilis*, which could be replaced by *Potentilla arenaria* agg. or *Stipa pulcherrima*. Chamaephytes (*Alyssum montanum*, *Fumana procumbens*, *Helianthemum nummularium* agg., *Rhodax canus*, *Teucrium chamaedrys*, *T. montanum*, *Thymus pannonicus*) are important structural components. Due to the very heterogeneous habitat conditions of the karst rocky fields its floristic composition varies from place to place. On deeper soils (sub-)xerophilous caespitose grasses (*Festuca valesiaca*, *F. rupicola*, *Stipa capilata*) are more frequent and this vegetation builds a mosaic with the Alysso heterophylli-Festucetum valesiacae association. On steeper rocky slopes, the transition to the Campanulo divergentiformis-Festucetum pallentis association is obvious, and numerous thermophilous species occur in both associations (e.g. *Campanula sibirica*, *Festuca pallens*, *Lactuca perennis*, *Melica ciliata*, *Poa badensis*, *Seseli osseum*).

This community inhabits gentle slopes and terraces at altitudes from 350 to 550 m in the karst regions of the southern and south-eastern Slovakia (Slovenský kras Mts, Drienčanský kras Mts; Háberová et al. 1985, Miadok 1987, Dúbravková-Michálková et al. 2008), in Čierna hora Mts (Jurko 1951), Zemplínske vrchy Mts and on hills of Východoslovenská rovina Lowland (Fig. 2b). In Hungary, it occurs in

the Aggteleki-karszt Mts and Bükk Mts (Zólyomi 1936, Dúbravková et al. in prep).

This vegetation has developed in the zone of former oak forests with *Quercus pubescens* and *Q. cerris* after long period of grazing (Klika 1939), only the steepest habitats are considered to be primary grasslands. If abandoned, most localities overgrow by spiny woody species (*Cerasus mahaleb*, *Berberis vulgaris*). Endangered and rare species are very frequent in this vegetation, e.g. endemic *Onosma tornensis*. We consider this community to be vicarious to the Festuco pallentis-Caricetum humilis association from western Slovakia.

Seslerietum heuflerianae Zólyomi 1936

Pannonian *Sesleria heufleriana* grasslands

Orig. (Zólyomi 1936): Sesleria Heufleriana Ass. **Syn.:** Seslerio-Festucetum duriusculae campanuletosum carpaticae Dostál 1933 p. p., Seslerietum Heuflerianae bükkense Zólyomi 1933, Seslerietum heuflerianae-hungaricae Zólyomi (1936) 1966. **Non:** Seslerietum Heuflerianae Soó 1927, Seslerietum Heuflerianae transsilvanicum (Soó 1927) Zólyomi 1936.

Diagnostic species: ***Aconitum anthora*** (dif.), *Ajuga genevensis* (dif.), *Campanula sibirica,* ***Campanula xylocarpa,*** *Carduus collinus,* ***Cyanus triumfettii*** (dif.), ***Dracocephalum austriacum,*** *Encalypta rhaptocarpa, Erysimum odoratum,* ***Ferula sadleriana,*** *Festuca pallens, Fragaria moschata* (dif.), *Geranium sanguineum,* ***Chamaecytisus hirsutus, Lactuca perennis,*** *Melica ciliata,* ***Melica picta*** (dif.), *Polygonatum odoratum, Potentilla recta, Pulsatilla grandis,* ***Rosa tomentosa, Sesleria heufleriana*** (dif.), ***Spiraea media*** (dif.), *Stachys recta, Teucrium chamaedrys, Thalictrum foetidum,* ***Tithymalus epithymoides*** (dif.), *Trifolium alpestre,* ***Valeriana stolonifera subsp. angustifolia*** (dif.), ***Verbascum phoeniceum, Veronica austriaca,*** *Vicia tenuifolia, Vincetoxicum hirundinaria,* ***Waldsteinia geoides*** (dif.).

Other differential species: *Glechoma hederacea.*

Constant species: ***Aconitum anthora,*** *Ajuga genevensis, Campanula sibirica, Cyanus triumfettii, Erysimum odoratum,* ***Festuca pallens,*** *Fragaria moschata, Galium mollugo agg., Geranium sanguineum, Glechoma hederacea agg., Helianthemum nummularium agg., Chamaecytisus hirsutus, Lactuca perennis, Melica ciliata, Melica picta, Polygonatum odoratum, Seseli osseum,* ***Sesleria heufleriana,*** *Spiraea media, Stachys recta,* ***Teucrium chamaedrys,*** *Tithymalus cyparissias, Tithymalus epithymoides, Trifolium alpestre, Valeriana stolonifera subsp. angustifolia, Veronica austriaca,* ***Vincetoxicum hirundinaria,*** *Waldsteinia geoides.*
Dominant species: *Festuca pallens, Geranium sanguineum,* ***Sesleria heufleriana,*** *Teucrium chamaedrys.*

Formal definition (6 relevés): Group Sesleria heufleriana AND *Sesleria heufleriana* cover > 5% NOT *Spiraea media* cover > 5%.

It is a multi-layer merely closed community dominated by *Sesleria heufleriana* with a significant proportion of thermophilous shrubs (*Rhamnus cathartica*, *Rosa tomentosa*, *Spiraea media*) and fringe species (*Geranium sanguineum*, *Origanum vulgare*, *Trifolium alpestre*). Species *Aconitum anthora*, *Cyanus triumfetii*, *Festuca pallens*, *Lactuca perennis*, *Melica ciliata*, *Seseli osseum*, *Teucrium chamaedrys* and *Vincetoxicum hirundinaria* are constantly present. The other species composition reminds the vegetation of the Poo badensis-Caricetum humilis association frequently occuring in close vicinity. Several rare and vulnerable species occur in the Seslerietum heuflerianae association, e.g. *Aconitum anthora*, *Cotinus coggygria*, *Dracocephalum austriacum*, *Rosa pimpinellifolia* and *Waldsteinia geoides.*

In Slovakia, this vegetation occurs at the northern margin of its distribution area. In the Slovenský kras Mts it inhabits western edges of the Plešivecká planina Plateau (Háberová et al. 1985) and the eastern edge of the Koniarska planina Plateau (Šuvada, ined.) at altitudes between 520 and 730 m (Fig. 2c). According to Klika (1939) and Zólyomi (1936) it represents secondary vegetation in zone of former beech forest. Slovak stands are similar to the Hungarian ones from the Bükk Mts (Vojtkó 1997). Slightly different stands occuring in Romania (surrounding of Cluj-Napoca, Soó 1927) were assessed as subassociation Seslerietum heuflerianae transsilvanicum by Zólyomi (1936). However, Soó (1959) distinguished them strictly from the association described by Zólyomi (1936) ordering them even within another alliance, Seslerion rigidae.

Due to the floristic composition, overall physiognomy and habitat conditions, we classify this association within the Bromo pannonici-Festucion pallentis alliance although it shows several transitional features resembling vegetation of Diantho lumnitzeri-Seslerion (Fig. 1).

Diantho lumnitzeri-Seslerion (Soó 1971) Chytrý et Mucina in Mucina et al. 1993

Dealpine *Sesleria*-grasslands

Orig. (Mucina et al. 1993): Diantho lumnitzeri-Seslerion albicantis (Soó 1971) Chytrý et Mucina comb. nova (Sesleria albicans = S. caerulea, S. heufleriana, S. hungarica, S. sadlerana). **Syn.:** Seslerio-Festucion glaucae Klika 1931 p. p. (Art. 35, 43), Seslerio-Festucion pallentis (Klika 1931) corr. Zólyomi 1966 p. p. (Art. 35), Diantho-Seslerienion Soó 1971.

Nomenclature note: As in the original paper by Soó (1971) numerous *Sesleria* species were mentioned, the epiteton „albicantis" used by Mucina & Kolbek (1993) was illegitimate. Therefore, we use the name Diantho lumnitzeri-Seslerion.

Diagnostic species: *Acinos alpinus* (dif.), *Allium senescens, Anthericum ramosum, Asperula cynanchica, Biscutella laevigata*

(dif.), *Bromus monocladus, Bupleurum falcatum, Campanula rotundifolia agg.* (dif.), *Carex humilis, Dianthus praecox, Festuca pallens,* ***Genista pilosa*** (dif.)**,** *Globularia punctata, Helianthemum nummularium* agg., *Hippocrepis comosa, Inula ensifolia, Jovibarba globifera,* ***Leontodon incanus****, Polygala amara* agg. (dif.), *Rhodax canus, Scorzonera austriaca, Seseli osseum,* ***Sesleria albicans*** (dif.)**,** ***Teucrium montanum****, Thalictrum minus, Thymus praecox, Vincetoxicum hirundinaria.*

Other differential species: *Briza media, Galium pumilum* agg.**,** *Leontodon hispidus, Leucanthemum vulgare* agg.*, Linum catharticum, Phyteuma orbiculare, Pulsatilla slavica, Saxifraga paniculata, Tephroseris integrifolia.*

Constant species: *Anthericum ramosum, Asperula cynanchica, Campanula rotundifolia* agg.*, Carex humilis, Festuca pallens, Genista pilosa, Globularia punctata, Helianthemum nummularium* agg.*, Inula ensifolia, Leontodon incanus, Potentilla heptaphylla, Sanguisorba minor, Seseli osseum,* ***Sesleria albicans****, Teucrium chamaedrys, Teucrium montanum, Thymus praecox, Tithymalus cyparissias, Vincetoxicum hirundinaria.*

Dominant species: *Carex humilis, Sesleria albicans.*

Formal definition (126 relevés): *Sesleria albicans* cover > 5% AND (Group Festuca pallens OR Group Carex humilis OR Group Galium verum) NOT (Group Daphne arbuscula OR Group Festuca tatrae).

The alliance involves communities dominated by *Sesleria albicans* at lower altitudes (colline to submontane belt). They occupy usually cooler and moister (often north-facing or inverse) locations in the warm peri-Carpathian calcareous mountains (see Fig. 2d for their distribution in Slovakia). Typical is presence of numerous dealpine species which are usually distributed in the subalpine and alpine belt but occasionally occur in relic localities of lower altitudinal belts (Skalický 1990). Among them *Acinos alpinus*, *Biscutella laevigata*, *Carduus glaucinus*, *Leontodon incanus*, *Phyteuma orbiculare*, *Polygala amara* subsp. *brachyptera*, *Saxifraga paniculata* and *Thesium alpinum* are the most frequent. Thermophilous Festuco-Brometea species (*Anthericum ramosum*, *Asperula cynanchica*, *Globularia punctata*, *Helianthemum nummularium* agg., *Hippocrepis comosa*, *Potentilla arenaria* agg., *Sanguisorba minor*, *Teucrium montanum* and *Thymus praecox*) differentiate these communities from *Sesleria*-dominated communities of higher altitudes belonging to the alliance Astero alpini-Seslerion calcariae and suballiance Pulsatillo slavicae-Caricenion humilis Uhlířová in Kliment et al. 2005 (Kliment et al. 2007). Bryophytes are usually present with high cover, in closed stands *Ditrichum flexicaule* and *Hypnum cupressiforme* are most common while in open rocky habitats *Homalothecium phillipeanum* and *Tortella tortuosa* prevail.

These communities are bound to calcareous bedrock (limestones and dolomites) and rendzina soils which are rather deep with high humus content. They inhabit upper ridge slopes or steep rock cliffs some of which were presumably never covered by closed forests. Wood cutting and grazing contributed to spread of this vegetation in the past. Recently, many of its relic localities are endangered by succession or afforestation and need a strict conservation.

The communities of the Diantho lumnitzeri-Seslerion are distributed mainly at the periphery of central European mountains, the Alps and the Carpathians (Mucina & Kolbek 1993). Similar vegetation in Switzerland, France and Germany is classified within the Xero-Bromion (Br.-Bl. et Moor 1938) Moravec in Holub et al. 1967 alliance.

Saxifrago aizoi-Seslerietum calcariae Klika 1941 nom. invers. propos.

Dealpine *Sesleria*-grasslands of calcareous rocky slopes and cliffs

Orig. (Klika 1941): Asociace Sesleria calcaria-Saxifraga aizoon (Sesleria calcaria = S. albicans, Saxifraga aizoon = S. paniculata). **Syn.:** Dendranthemo-Seslerietum variae Dzwonko & Grodzińska 1979 (Art. 3, 5).

Diagnostic species: *Anthericum ramosum, Asplenium ruta-muraria* (dif.), *Aster alpinus, Biscutella laevigata,* ***Cyanus triumfettii*** (dif.), *Dendranthema zawadskii,* ***Dianthus praecox****, Festuca pallens* (dif.), *Hieracium bupleuroides, Inula ensifolia, Jovibarba globifera* (dif.), *Polygonatum odoratum (dif.), Pulsatilla grandis, Pulsatilla subslavica, Rosa pimpinellifolia,* ***Saxifraga paniculata*** (dif.)**,** *Seseli osseum,* ***Sesleria albicans****, Vincetoxicum hirundinaria* (dif.).

Constant species: *Anthericum ramosum, Asperula cynanchica, Asplenium ruta-muraria, Biscutella laevigata, Cyanus triumfettii, Dianthus praecox,* ***Festuca pallens****, Inula ensifolia, Jovibarba globifera, Polygonatum odoratum, Saxifraga paniculata, Seseli osseum,* ***Sesleria albicans****, Tithymalus cyparissias,* ***Vincetoxicum hirundinaria****.*

Dominant species*: Festuca pallens, Inula ensifolia, Rhytidium rugosum, Rosa pimpinellifolia, Saxifraga paniculata,* ***Sesleria albicans****.*

Formal definition (18 relevés): Group Cyanus triumfettii AND Group Festuca pallens AND *Sesleria albicans* cover > 5% NOT (Group Carex humilis OR Group Daphne arbuscula OR Group Festuca tatrae).

The association comprises open or semi-closed grasslands dominated by *Sesleria albicans* and frequent occurrence of chasmophytes (*Asplenium ruta-muraria*, *A. trichomanes*, *Festuca pallens*, *Jovibarba hirta*). Due to the cool microclimatic conditions montane species (*Aster alpinus*, *Dendranthema zawadski*, *Draba aizoon*, *Hieracium bupleuroides*, *Minuartia langii*, *Primula auricula*, *Saxifraga paniculata*) enter these communities and differentiate them from other dealpine *Sesleria*-grasslands. In the well devel-

oped moss-layer *Ditrichum flexicaule*, *Homalothecium philippeanum*, *Rhytidium rugosum* and *Tortella tortuosa* are the most frequent.

The association develops on cliffs and rocky slopes with cool and humid microclimatic conditions situated usually in narrower river valleys of warm peri-Carpathian regions built by carbonates (Fig. 2d; Zádielska dolina and Hájska dolina in the Slovenský kras Mts, Manínska and Kostolecká tiesňava in the Strážovské vrchy Mts). In warm regions this vegetation is restricted to north-facing slopes while at higher altitudes it occurs in warmer microhabitats, too (e.g. Haligovské skaly in the Pieniny Mts). The bedrock is always calcareous, soils are developed in patches (accumulated mainly close to the *Sesleria*-tussocks) and vary significantly in depth.

This vegetation shows close relationship to montane *Sesleria*-grasslands of the Elyno-Seslerietea class and the Astero alpini-Seslerion calcariae alliance. It is vicariant to Minuartio langii-Festucetum pallentis (Sillinger 1933) Mucina ex Kliment et al. 2005 distributed at higher altitudes in central Carpathian mountain ranges with co-dominant *Sesleria albicans* and *Festuca pallens.* Several relevés with transitional features recorded in the Muránska planina Mts and Slovenský raj Mts at especially warm microhabitats also matched the definition. On the other hand, some relic stands retained in fragments with impoverished floristic composition (hosting usually just a single montane species) did not fulfil the criteria of association definition. Nevertheless, most of these relevés were matched by definition of alliance and thus they were included into Fig. 2d where they are depicted by crosses. Outside Slovakia, the community occurs in similar habitats in the Czech Republic (Chytrý et al. 2007).

Minuartio setaceae-Seslerietum calcariae Klika 1931 nom. invers. propos. et nom. mut. propos.

Dry peri-Carpathian *Sesleria albicans*-grasslands

Orig. (Klika 1931): Sesleria calcaria-Alsine setacea-Assoziation (Sesleria calcaria = S. albicans, Alsine setacea = Minuartia setacea). **Syn.:** Seslerieto-Caricetum humilis Sillinger 1930 (Art. 32d). **Non:** Carici humilis-Seslerietum caerulae Zlatník 1928.

Diagnostic species: *Allium senescens* (dif.), *Anthericum ramosum, Biscutella laevigata, Bupleurum falcatum, Campanula rotundifolia agg., Carex humilis* (dif.), *Dianthus praecox, Genista pilosa, Globularia punctata, Helianthemum nummularium agg., Inula ensifolia, Jurinea mollis, Leontodon incanus, Scorzonera austriaca, Seseli osseum,* ***Sesleria albicans, Teucrium montanum*** (dif.), *Thymus praecox, Viola collina.*

Other differential species: *Potentilla arenaria* agg.
Constant species: *Allium senescens,* ***Anthericum ramosum,*** *Asperula cynanchica, Bupleurum falcatum, Campanula rotundifolia* agg., ***Carex humilis,*** *Genista pilosa, Globularia punctata, Helianthemum nummularium* agg., *Inula ensifolia, Leontodon incanus, Potentilla arenaria* agg., *Sanguisorba minor, Seseli osseum,* ***Sesleria albicans,*** *Teucrium chamaedrys,* ***Teucrium montanum,*** *Thymus praecox, Tithymalus cyparissias.*

Dominant species: *Carex humilis,* ***Sesleria albicans.***

Formal definition (28 relevés): Group Carex humilis AND *Sesleria albicans* cover > 5% NOT (Group Cyanus triumfettii OR Group Daphne arbuscula OR Group Festuca tatrae OR Group Rhodax canus OR Group Scabiosa lucida).

These closed, uniform and moderately species-rich grasslands are dominated by *Sesleria albicans*. Among all *Sesleria*-dominated communities, they contain most thermophilous species penetrating from the neighbouring associations Festuco pallentis-Caricetum humilis and Poo badensis-Festucetum pallentis, e.g. *Alyssum montanum*, *Dianthus praecox* subsp. *lumnitzeri*, *Jurinea mollis* and *Viola collina*. Species *Anthericum ramosum*, *Carex humilis*, *Genista pilosa* and *Teucrium montanum* reach the highest constancy and percentage cover. Dealpine species diagnostic for the *Diantho lumnitzeri-Seslerion* (e.g. *Biscutella laevigata*, *Leontodon incanus*, *Phyteuma orbiculare* and *Thlaspi montanum*) are also frequent. *Hypnum cupressiforme* and *Thuidium abietinum* dominate the moss layer.

In Slovakia, this vegetation occurs in warm regions in its western part (Fig. 2d), where it is confined to cooler and moister north-facing slopes at altitudes from 280 to 675 (750) m. Rendzina soils are moderately deep, slightly alcaline and rich in humus (Klika 1931). Best developed stands were recorded in the Považský Inovec Mts (Sillinger 1930, Maglocký 1979, Michálková 2007) and Malé Karpaty Mts (Domin 1931, Maglocký 1979), while this vegetation occurs also in the Strážovské vrchy Mts (Futák 1960, Michálková 2006) and Hornonitrianska kotlina Basin (Futák 1960). Outside Slovakia, the community is known from southern Moravia (Pavlovské vrchy Mts; Klika 1931, Chytrý et al. 2007) and Lower Austria (Mucina & Kolbek 1993).

Festuco pallentis-Seslerietum calcariae Futák 1947 corr. Janišová in Janišová et al. 2007 nom. invers. propos.

Submontane *Sesleria albicans*-grasslands

Orig. (Futák 1947): Asociácia Sesleria calcaria-Festuca duriuscula (Sesleria calcaria = S. albicans, Festuca duriuscula auct. non L. = F. pallens Host) (Art. 10b, Art. 43).

Diagnostic species: ***Acinos alpinus,*** *Allium ochroleucum, Anthyllis vulneraria* (dif.), *Asperula cynanchica, Biscutella laevigata, Bromus monocladus, Campanula rotundifolia* agg., *Carex humilis, Carex ornithopoda, Galium pumilum* agg. (dif.), ***Genista pilosa,*** *Globularia punctata,* ***Hippocrepis comosa*** (dif.),

***Leontodon incanus*, *Phyteuma orbiculare*, *Polygala amara* agg., *Potentilla heptaphylla* (dif.), *Potentilla inclinata*, *Rhodax canus (dif.)*, *Sanguisorba minor*, ***Sesleria albicans*, *Teucrium montanum*, *Thalictrum minus*, *Thymus praecox* (dif.).**

Other differential species: *Briza media, Leontodon hispidus, Lotus corniculatus, Pilosella officinarum, Pimpinella saxifraga* agg., *Plantago media.*

Constant species: *Acinos alpinus, Anthericum ramosum, Anthyllis vulneraria, Asperula cynanchica, Briza media, Campanula rotundifolia* agg., *Carex humilis, Carlina acaulis, Galium pumilum* agg., ***Genista pilosa*, *Globularia punctata, Helianthemum nummularium* agg., *Hippocrepis comosa, Leontodon hispidus,* ***Leontodon incanus*, *Linum catharticum, Lotus corniculatus, Phyteuma orbiculare, Pimpinella saxifraga* agg., *Plantago media, Polygala amara* agg., *Potentilla heptaphylla, Rhodax canus, Sanguisorba minor,* ***Sesleria albicans*, *Teucrium chamaedrys, Teucrium montanum, Thymus praecox, Tithymalus cyparissias, Vincetoxicum hirundinaria.**

Dominant species: *Bromus monocladus, Carex humilis, Genista pilosa, Hypnum cupressiforme, Pulsatilla subslavica,* ***Sesleria albicans.***

Formal definition (20 relevés): Group Sesleria albicans AND (Group Galium verum OR Group Rhodax canus) AND *Sesleria albicans* cover > 25%.

These *Sesleria*-dominated grasslands represent a transitional community between the colline Minuartio setaceae-Seslerietum calcariae association and montane grasslands of the Pulsatillo slavicae-Caricenion humilis sub-alliance. They lack both strict thermophilous and true montane species (*Aster alpinus*, *Campanula cochlearifolia*, *Festuca tatrae*, *Minuartia langii*, *Primula auricula*, *Tofieldia calyculata*), while mesophilous species prevail (e.g. *Briza media*, *Lotus corniculatus*, *Pimpinella saxifraga* agg., *Plantago media*, *Potentilla heptaphylla*, *Sanguisorba minor*). Prealpine species (e.g. *Acinos alpinus*, *Biscutella laevigata*, *Leontodon incanus*, *Phyteuma orbiculare*, *Polygala amara* subsp. *brachyptera*) are also common. Along with the dominant *Sesleria albicans*, *Carex humilis* or *Bromus monocladus* reach the highest percentage cover in the herb layer and *Hypnum cupressiforme* in the moss layer.

The community is restricted to the north-western and central Slovakia where it usually inhabits north-facing slopes on dolomites or limestones at altitudes up to 920 m. The rendzina soils are moderately deep, rich in calcium and humus (Futák 1947). Best developed stands occur in the Strážovské vrchy Mts or in carbonate foothills of the Nízke Tatry Mts and Malá Fatra Mts (Fig. 2d). In some localities this vegetation forms transitions to Bromion erecti and Cirsio-Brachypodion pinnati communities or it contacts relic pine forests. Such stands are especially vulnerable to both forest succession and grass invasions, which recently represent most severe threatening factors.

Main environmental factors responsible for variability of the studied vegetation

The vegetation of Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion in relation to environmental factors expressed by Borhidi indicator numbers (Borhidi 1993) is shown in Fig. 1. The first ordination axis showed the strongest correlation with temperature (r = −0.74) and light (r = −0.65). The second ordination axis was correlated mainly with moisture (r = 0.28). The relevés belonging to the two alliances are well separated in the ordination graph and their location reflects also the occurrence of dominant species: open *Festuca pallens*-dominated communities are distributed in the warmest and driest habitats (lower left corner), *Sesleria albicans*-dominated stands occupy the wettest and coolest habitats (right side of the graph) and *Carex humilis*-dominated communities are common in intermediate conditions (mostly upper left corner). Relationships of the defined associations to individual environmental factors are shown in Fig. 3 and the results of multiple comparison tests are in Table 4.

Hierarchical expert system

Out of the whole stratified dataset 304 and 126 relevés were assigned by COCKTAIL definitions to the alliances Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion, respectively. Among 304 relevés assigned to Bromo pannonici-Festucion pallentis, 163 relevés were matched also by one of the association definitions (i.e. 54%). Among 126 relevés assigned to Diantho lumnitzeri-Seslerion there were 66 relevés matched by association definitions (i.e. 52%).

Discussion

Syntaxonomical status of the studied communities

Rocky grasslands of colline and submontane regions of central Europe have been studied intensivly since the formation of phytosociological methodology at the beginning of the 20th century. They attracted the attention of botanists due to high species diversity, interesting small-scale patterns and clear ecological relations to the habitat conditions. As a result, numerous associations were described in the central-European countries reflecting mostly various local patterns (Knollová et al. 2006). The classification of these communities was performed mostly within strict regional borders lacking the necessary comparison at a larger scale.

In spite of the recent attempts to revise their classification at the national level (Mucina & Kolbek 1993, Borhidi 2003, Chytrý et al. 2007, Janišová et al. 2007), certain aspects remained rather vague

especially those regarding the syntaxonomical position of these communities within the higher syntaxa. Although the recent national surveys are compatible in sense of classification of the rocky grassland of colline and submontane belt within the class Festuco-Brometea, the membership of associations to alliances and orders is still very inconsistent. According to the Euro-Siberian synthesis of the Festuco-Brometea class made by Royer (1991), the communities studied in our contribution are classified within two alliances of the order Festucetalia valesiacae Br.-Bl. et Tüxen 1943, the Bromo-Festucion pallentis Zólyomi 1966 (association Minuartio setaceae-Seslerietum calcariae) and the Seslerio-Festucion pallentis Klika 1931 (all other associations known at that time of this publication). In more recent surveys (Mucina & Kolbek 1993, Borhidi 2003), the two studied alliances are classified within the order Stipo pulcherrimae-Festucetalia pallentis Pop 1968. Two separate alliances are accepted in Chytrý et al. 2007, although the authors do not consider the membership to orders.

We are aware of numerous, mostly nomenclature questions, which can not be adequately answered based on our analyses of merely national data set. Some of these questions have been solved in the recently published large-scale synthesis by Dúbravková et al. (2010) which included grasslands of the Bromo pannonici-Festucion pallentis and the Festucion valesiacae alliances. However, synthesis of grasslands dominated by various *Sesleria* species (*Sesleria albicans*, *S. sadleriana*, *S. heufleriana*) is still missing. Such analysis should include at least the northern part of Pannonian Basin (Hungary, Austria, Slovak and Czech Republic) together with the adjacent peri-Carpathian mountains. For practical reasons, in our contribution we accepted the concept of a common order of Stipo pulcherrimae-Festucetalia pallentis for both studied alliances. The membership of associations to individual alliances was determined predominantly by the floristic and ecological criteria. Although the associations classified within the two alliances share a high proportion of common species (Table 3), they are clearly differentiated by their ecology (sun exposed south-facing slopes with shallow soils of Bromo pannonici-Festucion pallentis vs. cooler and moister north-facing habitats with deeper soils of Diantho lumnitzeri-Seslerion) and physiognomy (open and semi-open stands of Bromo pannonici-Festucion pallentis vs. nearly closed and closed stands of Diantho lumnitzeri-Seslerion). Moreover, the membership to alliances can easily be determined by dominance of most important diagnostic grass and sedge species (*Festuca pallens*, *Carex humilis* and *Sesleria heufleriana* dominate in Bromo pannonici-Festucion pallentis while *Sesleria albicans* dominates in Diantho lumnitzeri-Seslerion).

Syntaxonomical revision

Our syntaxonomical revision brought significant simplification of the traditional classification system; the number of associations decreased from 13 to 9. Simplification is a common trait in most recent detailed national surveys (Chytrý et al. 2007, Janišová et al. 2007), while the reduction in number of distinguished syntaxa is particularly high for dry grassland vegetation. For the Festuco-Brometea class, number of associations was reduced to 35% of the original number in the Czech national survey (Chytrý et al. 2007) and to 72% in the Slovak national survey (Janišová et al. 2007). This was due to the high variability of dry grassland communities resulting in description of numerous local associations purely differentiated at larger than the local scales.

Separation of the studied vegetation from the related syntaxonomical units

The concept of separation of Bromo pannonici-Festucion pallentis and Festucion valesiacae was supported recently by a large-scale numerical classification of Carpatho-Pannonian grasslands (Dúbravková et al. 2010). According to this study, the Festucion valesiacae alliance includes narrow-leaved continental steppe grasslands of tussocky fescues (*Festuca valesiaca*, *F. pseudodalmatica*, *F. pseudovina* and *F. rupicola*), *Carex humilis* and various species of *Stipa* growing on neutral to alkaline, usually base-rich soil which are deeper than soils supporting vegetation of the Bromo pannonici-Festucion pallentis. A large group of diagnostic species differentiate the Festucion valesiacae (Dúbravková et al. 2010) from the two alliances studied in this paper: *Achillea collina*, *A. pannonica*, *Adonis vernalis*, *Astragalus austriacus*, *A. onobrychis*, *Bromus inermis*, *Chamaecytisus austriacus*, *Crinitina linosyris*, *Dorycnium pentaphyllum*, *Elytrigia intermedia* s.l., *Falcaria vulgaris*, *Festuca pseudodalmatica*, *F. valesiaca*, *Galium glaucum*, *Inula oculus-christi*, *Onobrychis arenaria*, *Poa pannonica*, *Salvia nemorosa*, *Scabiosa ochroleuca*, *Seseli pallasii*, *Stipa capillata*, *S. tirsa*, *Taraxacum serotinum*, *Thymus glabrescens*.

Some of the studied associations (Orthantho luteae-Caricetum humilis and Festuco pallentis-Seslerietum calcariae) show a close relationship to semi-dry grasslands or meadow steppes of the alliances Bromion erecti and Cirsio-Brachypodion pinnati (Škodová 2007a, b). Their classification within Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion can be attributed to the absence of the diagnostic species of the semi-dry alliances (e.g. *Carex montana*, *Cirsium pannonicum*, *Lathyrus latifolius*) and to the clear dominance of *Carex humilis* and *Bromus monocladus* (in the Orthantho luteae-Caricetum humilis) or *Sesleria albicans* (in the Festuco pallentis-Seslerietum calcariae).

The separation of the dealpine (colline) *Sesleria albicans*-dominated grasslands from the montane blue moor grass communities of the Astero alpini-Seslerion calcariae alliance (class Elyno-Seslerietea, cf. Kliment et al. 2007) is based mostly on presence of a large group of thermophilous Festuco-Brometea species in the formerly mentioned communities.

The separation of *Festuca pallens*-dominated grasslands from the pioneer vegetation of the Sedo-Scleranthetea class (Valachovič & Maglocký 1995) is based on presence of numerous diagnostic species of the Bromo pannonici-Festucion pallentis alliance as well as on high floristic diversity of the studied stands due to their advanced successive development.

Main environmental factors responsible for variability of the studied vegetation

Dry grasslands of the studied alliances are generally confined to very dry and warm habitats with a shallow soil layer. Some of their stands have developed and survived as relic communities at microclimatically and edaphically suitable sites. The main difference in environmental conditions between the two alliances is the degree of habitat xericity. This fact indicated by previous studies (e.g. Janišová 2005) was confirmed also by our analysis (Fig. 1, 3). Within the alliances, the vegetation variability is probably determined by the same environmental factors: habitat xericity and soil depth. Both these factors are related to the water availability during the extreme drought periods. Their limiting effect upon the vegetation is well reflected in the low percentage cover of herb layer.

Geographical location as an important factor

Our analysis confirmed a strong effect of geographical location on differentiation of the studied vegetation. A strong geographical pattern could be recognized especially in the *Carex humilis*- and *Festuca pallens*-dominated communities. In each of them, geographically vicarious communities could be distinguished for the western Carpathians margin and for the northern Pannonian region. Climatic differences (continentality), differences in regional species pools, geological bedrock and historical factors are probably some of the main factors contributing to this differentiation.

A strong effect of geographical location was confirmed also by Dúbravková et al. (2010) at overnational level including a natural biogeographical region of the Western Carpathians and adjacent lowland and hilly landscapes of the northern Pannonian Basin. Groups of traditionally distinguished local associations significantly differed in their diagnostic and dominant species, physiognomy, structure and ecology, although it was difficult to separate them at a large scale and in this over-national study they were frequently merged within single clusters (Poo badensis-Festucetum pallentis & Festuco pallentis-Caricetum humilis, Campanulo divergentiformis-Festucetum pallentis & Poo badensis-Caricetum humilis, Orthantho luteae-Caricetum humilis & Festuco pallentis-Seslerietum calcariae). Due to their clear differentiation at the national level and for the purpose of local biodiversity monitoring we consider their separation to be reasonable.

Hierarchical expert system (HES)

About one half of relevés matched by the alliance definitions was formally classified to some of the associations (54 and 52%), the remaining relevés were formally classified merely to alliances. Formulation of alliance definitions thus allowed precise classification (at the level of alliances) of substantial number of relevés which otherwise would remain dismatched. According to the existing expert system for the Slovak grassland vegetation (Janišová et al. 2007) these relevés would be classified based on the similarity indices to following syntaxa: Relevés ordered merely to Bromo pannonici-Festucion pallentis by the HES had the highest similarity indices to associations of Bromo pannonici-Festucion pallentis (66%), Diantho lumnitzeri-Seslerion (32%) and Festucion valesiacae (2%). Relevés ordered merely to *Diantho lumnitzeri-Seslerion* by the HES had the highest similarity indices to associations of Diantho lumnitzeri-Seslerion (89%), Bromo pannonici-Festucion pallentis (10%) and Arrhenatherion elatioris (1%). Even though most of these relevés would be assigned to the same alliance by the HES as by the similarity indices, the HES helped to take decision in 34% of Bromo pannonici-Festucion pallentis relevés and 11% of Diantho lumnitzeri-Seslerion relevés. The main advantage of HES is obviously in determination of relevé membership between the Bromo pannonici-Festucion pallentis and Diantho lumnitzeri-Seslerion alliances, as these two alliances involve the most relative communities sharing numerous common species. While the similarity indices consider merely floristic similarity of a given relevé to a group of relevés matched by definitions of individual associations, classification by alliance definitions allows us to set some additional criteria such as species dominance and presence of sociological species groups. In the studied communities which are defined in particular by dominance of edificator species, this criterium is crucial for a correct classification of relevés.

In addition to the recently used expert systems based on association definitions, the HES classifies phytosociological relevés also at the higher syntaxonomical level, namely to alliances. Regarding the un-

clear membership of numerous dry grassland associations to higher syntaxa (mentioned above), the HES should not be applied without restrictions and it is necessary to consider its specifities before its application: a) Similarly to application of any expert system, the HES should be used to classify vegetation recorded exclusively in the area for which it was formulated, i.e. the area of Slovakia. As several of the studied associations are restricted in their distribution to Slovakia or have here the centre of their distribution, the definitions of the two studied alliances reflect mainly their floristic variability within the area of Slovakia and thus they should not be used outside this area. b) The proposed alliance definitions were developed to distinguish rocky Pannonian grasslands from dealpine *Sesleria*-dominated grasslands in Slovakia. This concept of two groups of communities, the circumpannonic and the dealpine ones, was first proposed by Mucina & Kolbek (1993). Later, it was widely accepted by the Austrian, Czech and Slovak botanists (Stanová & Valachovič 2002, Chytrý et al. 2007, Janišová et al. 2007) and it is reflected also in differentiation of Natura 2000 habitat types and subtypes. We adopted the concept of two alliances also in our HES as it reflects well the ecological, physiognomical and florogenetical characteristics of the studied associations and can be easily used in practical nature conservation.

The usage of alliance definitions might be especially useful for identification of relic grasslands maintained in fragmented habitats as well as grasslands exposed to an increased anthropic pressure. Such stands are usually not fully developed and frequently miss sufficient number of diagnostic species important for a successful classification to associations. Nevertheless, their overall structure and e.g. occurrence of single population of some relic species may indicate their identity rather clearly. Most of such relevés do not fulfil the criteria of association definitions but are matched by broader alliance definitions. In traditional syntaxonomy, the classification of vegetation types lacking species with narrow ecological amplitude (the so-called atypical or fragmentary stands) is possible by addopting one of the following approaches (Dengler et al. 2008): a) The deductive classification affiliates such communities as so-called basal or derivative communities to higher syntaxa. b) According to the concept of central syntaxon, there can be one negativelly differentiated syntaxon within the next superior syntaxon of the hierarchy. The advantage of the HES in classification of the vegetation types poor in diagnostic species is in its formalization; it can be applied and repeated even without any detailed phytosociological background.

In the process of identification of the studied vegetation we recommend to use the following procedure. If a relevé is not matched by an associacion definition, the alliance is determined according to the alliance definition and the association is identified by similarity indices considering only associations belonging to the given alliance. If a relevé is not matched neither by association nor by alliance definition, the alliance is determined according to similarity indices. In this case, two types of similarity indices can be calculated: for associations and for alliances. Comparing floristic composition of a single relevé to a group of relevés assigned to a given alliance by an alliance definition can be advantageous. As the comparison is made with a larger group of relevés including wide variety of stands we suppose that the results obtained are rather robust and the chance of mistake is reduced.

One of the major drawbacks of the proposed hierarchical expert system consists in the variant scope of individual alliances. We are not sure if it is possible to formulate a reasonable definition for each alliance included in the traditional classification system. Formulation of an alliance definition could be rather difficult for alliances involving very heterogeneous vegetation such as communities of wet meadows dominated by numerous species combinations. The formal definition of such heterogeneous syntaxa would thus be very long and complicated.

Another drawback is that the practical application of expert system working at more than one level could be more time consuming and not as straitforward as application of the basic (one-level) expert system.

Seslerietum budensis

Our phytosociological database does not contain relevés of dry grasslands dominated by *Sesleria sadleriana* typical of the Seslerietum budensis Soó ex Zólyomi 1936 association (syn. Seslerietum sadlerianae). This association was recorded in Hungary by Zólyomi (1936) and in the Hainburger Berge Mts close to the Slovak border (Mucina & Kolbek 1993). Its overall species composition is similar to the Saxifrago paniculatae-Seslerietum calcariae. As the recent caryological study of genus *Sesleria* (Lysák et al. 1997) has not confirmed the Deyl's records of *Sesleria sadleriana* from the Malé Karpaty Mts and Slovenský kras Mts (Deyl 1946), where the Seslerietum budensis could occur, we did not include this community to our survey.

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