

DIVERSITY OF DRY GRASSLANDS IN THE POVAŽSKÝ INOVEC MTS (SLOVAKIA) – A NUMERICAL ANALYSIS

Daniela MICHÁLKOVÁ*

Abstract

The paper reveals a numerical and ecological analysis of 128 published relevés of xerothermic vegetation of the Považský Inovec Mts. Four associations have been recognised: *Festuco valesiacae-Stipetum capillatae* Sillinger 1930, *Festuco pallentis-Caricetum humilis* Sillinger 1930 corr. Gutermann et Mucina 1993, *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966 nom. invers. propos. and *Minuartio setaceae-Seslerietum coeruleae* Klika 1931 nom. mut. propos. Through the numerical methods, the study reconsiders the conception of the dry grassland associations, which are traditionally used in phytocoenological literature. It also defines the indication taxa group of the associations and characterises their environmental conditions. Major environmental gradients influencing the vegetation were interpreted using average Ellenberg indication values. Finally, the classification within the higher vegetation units, the nomenclature of the associations and the environmental threats are discussed.

Key words: classification, cluster analysis, dry grasslands, *Festucetalia valesiacae*, ordination, Považský Inovec Mts, Slovakia, syntaxonomy.

Izveček

V článku je prikazana numerična in ekološka analiza 128 objavljenih popisov kserotermne vegetacije hribovja Považský Inovec. Ugotovljene so štiri asociacije: *Festuco valesiacae-Stipetum capillatae* Sillinger 1930, *Festuco pallentis-Caricetum humilis* Sillinger 1930 corr. Gutermann et Mucina 1993, *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966 nom. invers. propos. in *Minuartio setaceae-Seslerietum coeruleae* Klika 1931 nom. mut. propos. Z numeričnimi metodami je avtorica ponovno preverila sinsistem asociacij suhih travnikov, ki so omejnene v fitocenološki literaturi. Opredelila je skupine značilnih vrst asociacij in značilnosti rastiščnih razmer. S povprečnimi Ellenbergovimi indikacijskimi vrednostmi so prikazani glavni ekološki gradienti, ki vplivajo na floristično sestavo vegetacije suhih travnišč. Članek obravnava uvrstitev asociacij v višje sintaksonomske enote, nomenklaturu asociacij in njihovo ogroženost.

Ključne besede: klasifikacija, klastrska analiza, suha travnišča, *Festucetalia valesiacae*, ordination, Považský Inovec, Slovaška, sintaksonomija.

1. INTRODUCTION

The Považský Inovec Mts are located in the western part of Slovakia along the river Váh in the prae-Carpathian limestone zone (Fig. 1). The central part of the mountains, the Tematínske kopce Hills, is built up by dolomites. In this area, the numerous dry grasslands are located. However, the potential vegetation of this area are the forests, mostly the oak-hornbeam forests (*Carici pilosae-Carpinetum*) and locally the thermophilous oak forests (*Quercion*

pubescentis-petraeae, Michalko et al. 1987). The major part of the forest cover had been destroyed during the Turkish war approximately in the 16th and 17th century. These areas later became grasslands.

The dry grassland vegetation is geographically influenced from two directions. From the south, the study area is in near contact with the eu-Pannonian lowland region, which influences the vegetation by numerous Pontic-Pannonian and sub-Mediterranean thermophilous species. From the north, the Carpathian mountain species descend

* Slovak Academy of Sciences, Institute of Botany, Dúbravská cesta 14, SK-845 23 Bratislava, Slovakia. E-mail: daniela.michalkova@savba.sk



Figure 1: Location of the Považský Inovec Mts within Slovakia.

Slika 1: Lokacija hribovja Považský Inovec na Slovaškem.

and build up some dealpine and praealpine elements (Deván et al. 2006).

This vegetation is interesting from the floristical, historical as well as the successional point of view. It was studied in detail only in two older works (Sillinger 1930, Maglocký 1979). Although some works have recently been done (Micháľková, Škodová & Mertanová 2006; Janišová 2005, 2006a, b, 2007a, b), no numerical analysis has been performed so far. The presented paper brings a numerical classification of all published relevés. The use of numerical methods endeavours to support or eventually correct the current phytosociological scheme of the dry grasslands of the study area. The aim is also to define the indication taxa group of the associations and some characteristics of their environmental conditions.

2. MATERIAL AND METHODS

The numerical analyses were performed using the published relevés of xerothermic vegetation of the Považský Inovec Mts, created by applying the standard Central-European method (Braun-Blanquet 1964, Westhoff & van der Maarel 1973). The analysed data set comprised 128 relevés from the works Maglocký (1979), Sillinger (1930), Klika (1931) and Micháľková, Škodová & Mertanová (2006). The taxa determined only on the level of genus were excluded from the analyses. The layer E_0 was excluded as a whole, because mosses and lichens were not determined in all relevés analysed. Some taxonomically problematic species, which were not

distinguished by all authors of the relevés, were classified within higher or more broadly defined taxa: *Anthyllis vulneraria* agg. (subsp. *polyphylla*), *Artemisia campestris* (subsp. *lednicensis*), *Colymbada scabiosa* agg. (*C. badensis*), *Dactylis glomerata* agg. (*D. polygama*), *Acosta rhenana* agg. (*Acosta biebersteinii*), *Helianthemum grandiflorum* s. l. (subsp. *grandiflorum*, subsp. *obscurum*, *H. nummularium*), *Pulsatilla slavica* (*P. subslavica*), *Primula veris* (subsp. *canescens*), *Thalictrum minus* (subsp. *pseudominus*).

Initial data analysis to remove outlier relevés (relevés, of which the species composition did not correspond to the rest of the analysed data set) was carried out using the CANOCO 4.5 package (ter Braak & Šmilauer 2002). It was necessary to exclude 4 relevés (Maglocký 1979: Table 23, relevés 1–3; Table 25, relevé 20). There were 124 relevés used in the subsequent classification. We compared the results of more types of cluster analyses carried out by using different algorithms. The paper presents the results of the cluster analysis processed by the program PC-ORD 4 (McCune & Melford 1999) where Ward's method and the relative Euclidean distance as a resemblance measure were applied. These results proved to be floristically and ecologically well interpretable and were supported by our field experience as well.

Diagnostically important taxa for the individual clusters were determined by calculating the constancy and fidelity measure of each species to each cluster, using the *phi* coefficient of association (Sokal & Rohlf 1995, Chytrý et al. 2002) in the program Juice (Tichý 2002). The results of the classification were summarised in a synoptic

table (Table 1), in which both percentage species frequencies (constancies) and fidelities (ϕ coefficient multiplied by 100, $p < 0.001$) were shown, and diagnostic species were ranked by decreasing fidelity (Chytrý et al. 2002). Fisher's exact test excluded the accidental species with high fidelity measures (Tichý & Holt 2006). The threshold values of the indication taxa group were selected subjectively: fidelity of **diagnostic species** was higher than 40 %; **constant species** were those with a relative constancy value higher than 60 %; **dominant species** were defined as all species that had cover values higher

than 30 %. The number values indicate fidelity for the diagnostic species and constancy for the constant species in the chapter "Nomenclature and species characteristics of the associations". There is also a number given to each dominant species, which stands for the percentage of relevés meeting the threshold criteria. The indication taxa group of each cluster was compared to the diagnostic species from Holub et al. (1967), Chytrý et al. (2007) and Mucina & Kolbek (1993), which enabled interpretation of the associations in terms of higher phytosociological units (orders and alliances, Tab. 1).

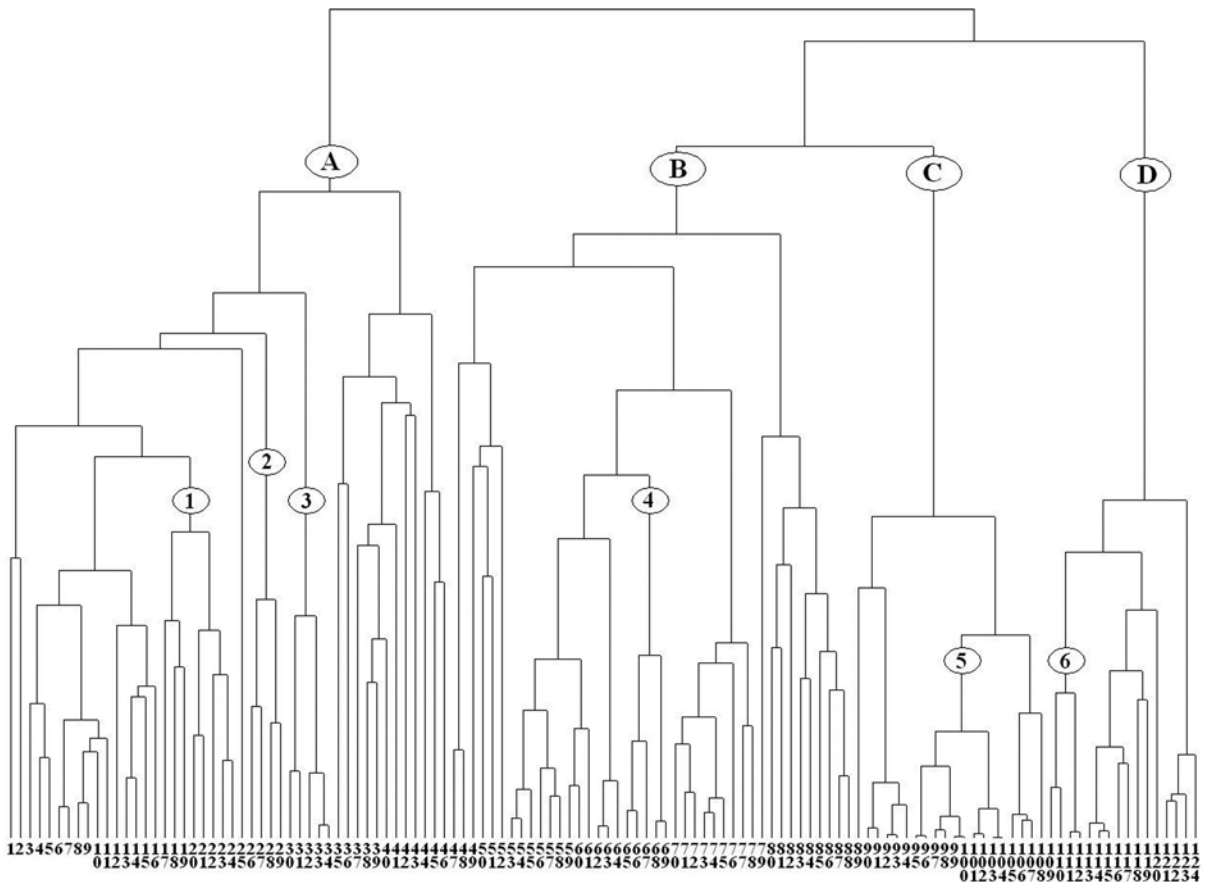


Figure 2: Dendrogram of the cluster analysis (Ward's method, relative Euclidean distance).

Slika 2: Dendrogram klasterne analize (Wardova metoda, relativna Evklidska razdalja).

A – *Festuco valesiaca*-*Stipetum capillatae* (1 – *festucetosum rupicoae*, 2 – *botryochloetosum ischaemii*, 3 – *caricetosum caryophyllae*), B – *Festuco pallentis*-*Caricetum humilis* (4 – *typicum*, *Koeleria macrantha*-variant), C – *Poo badensis*-*Festucetum pallentis* (5 – *jovibarbetosum hitrae*), D – *Minuartio setaceae*-*Seslerietum caeruleae* (6 – *festucetosum pallentis*).

Sources of relevés (Viri popisov): Cluster A: 1-2 – d: rel. 1, 2; 3-24 – a: Table 27, rel. 4, 12, 16, 5, 7, 6, 20, 9, 8, 28, 29, 32, 34, 33, 17, 18, 19, 21, 22, 23, 24, 25; 25 – d: rel. 3; 26-34 – a: Table 27, rel. 26, 27, 30, 31, 10, 11, 13, 14, 15; 35-36 – d: rel. 4, 5; 37 – Chytrý 1995, ined.; 38-40 – a: Table 27, rel. 1, 2, 3; 41-43 – b: p. 36, rel. 2, 1, 3; 44-46 – d: rel. 6-8; Cluster B: 47-48 – d: rel. 9, 10; 49-52 – b: p. 36, rel. 4, 5, 6, 7; 53 – c: p. 363, rel. 14; 54 – a: Table 26, rel. 18; 55 – c: p. 363, rel. 15; 56-78 – a: Table 26, rel. 14, 21, 23, 5, 15, 8, 19, 20, 22, 11, 12, 13, 16, 17, 1, 6, 7, 4, 24, 10, 3, 2, 9; 79-88 – d: rel. 11-20; Cluster C: 89 – c: p. 363, rel. 13; 90-108 – a: Table 22, rel. 2, 6, 7, 9, 11, 1, 15, 8, 10, 14, 16, 13, 17, 18, 19, 3, 4, 5, 12; Cluster D: 109 – c: p. 370, rel. 29; 110-124 – a: Table 25, rel. 3, 2, 6, 10, 13, 15, 12, 21, 24, 25, 22, 16, 18, 17, 23. **Abbreviations (Okrajšave):** a – Maglocký (1979), b – Sillinger (1930), c – Klika (1931), d – Mičálková, Škodová & Mertanová (2006).

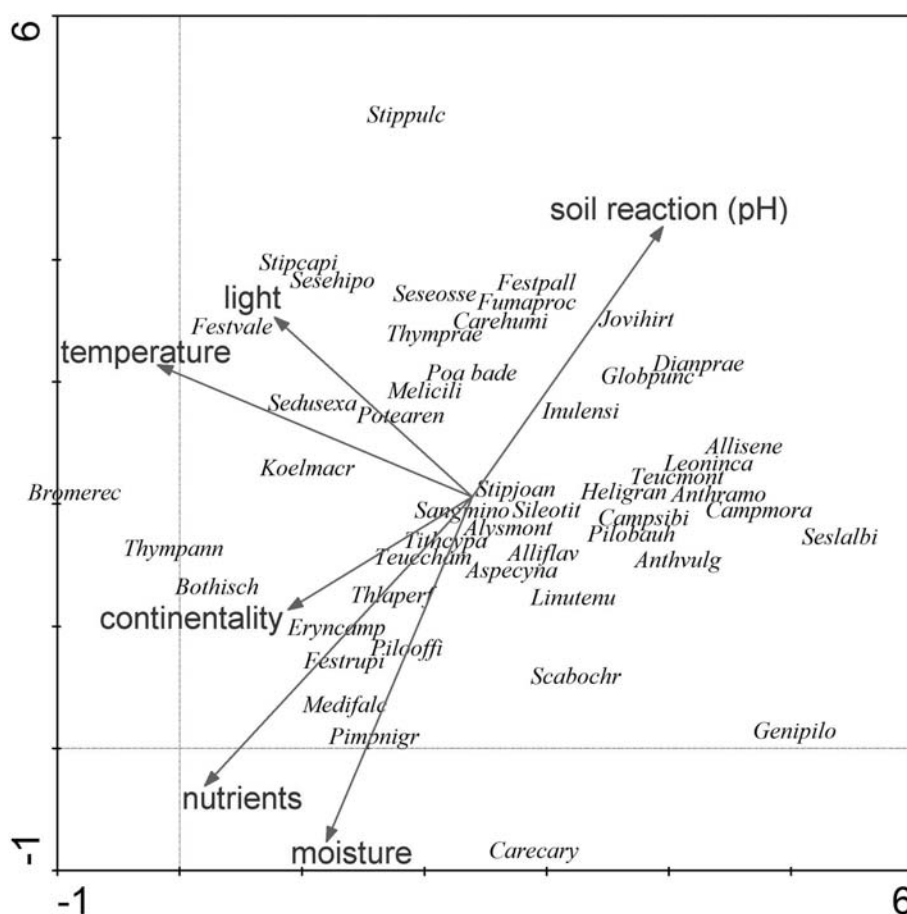


Figure 3: Detrended correspondence analysis (DCA) ordination diagram of the species occurring in the dry grassland vegetation of the Považský Inovec Mts.

Slika 3: Ordinacijski diagram korespondenčne analize z odstranjenim trendom (DCA) floristične sestave suhih travnikov na hribovju Považský Inovec.

Species list (Seznam vrst): *Allium flavum*, *A. senescens* ssp. *montanum*, *Alyssum montanum*, *Anthericum ramosum*, *Anthyllis vulneraria*, *Asperula cynanchica*, *Bothriochloa ischaemum*, *Bromus erectus*, *Campanula moravica*, *C. sibirica*, *Carex caryophylllea*, *C. humilis*, *Dianthus praecox* ssp. *lumnitzerii*, *Eryngium campestre*, *Festuca pallens*, *F. rupicola*, *F. valesiaca*, *Fumana procumbens*, *Genista pilosa*, *Globularia punctata*, *Helianthemum grandiflorum*, *Inula ensifolia*, *Jovibarba hirta* ssp. *glabrescens*, *Koeleria macrantha*, *Leontodon incanus*, *Linum tenuifolium*, *Medicago falcata*, *Melica ciliata*, *Pilosella bauhinii*, *P. officinarum*, *Pimpinella nigra*, *Poa badensis*, *Potentilla arenaria*, *Sanguisorba minor*, *Scabiosa ochroleuca*, *Sedum sexangulare*, *Seseli hippomarathrum*, *S. osseum*, *Sesleria albicans*, *Silene otites*, *Stipa capillata*, *S. joannis*, *S. pulcherrima*, *Teucrium chamaedrys*, *T. montanum*, *Thlaspi perfoliatum*, *Thymus pannonicus*, *T. praecox*, *Tithymalus cyparissias*.

The ordination techniques, using the detrended correspondent analysis (DCA) from the CANOCO 4.5 package, defined the major gradients in the spatial arrangement of species of the analysed data set. For ecological interpretation of the ordination axes, average Ellenberg indication values (Ellenberg et al. 2001) for relevés were plotted onto a DCA ordination diagram as supplementary environmental data (Fig. 3 and 4).

The nomenclature of vascular plants follows Marhold & Hindák (1998). The nomenclature of

higher syntaxa is in accordance with Chytrý et al. (2007) and Mucina & Kolbek (1993). Phytosociological nomenclature of associations is reconsidered according to Weber, Moravec & Theurillat (2000). For the individual associations, these abbreviations were used in Fig. 4 and 5: **Fv-Sc** – *Festuco valesiacae-Stipetum capillatae*, **Fp-Ch** – *Festuco pallentis-Caricetum humilis*, **Pb-Fp** – *Poa badensis-Festucetum pallentis* and **Ms-Sc** – *Minuartio setaceae-Seslerietum caeruleae*.

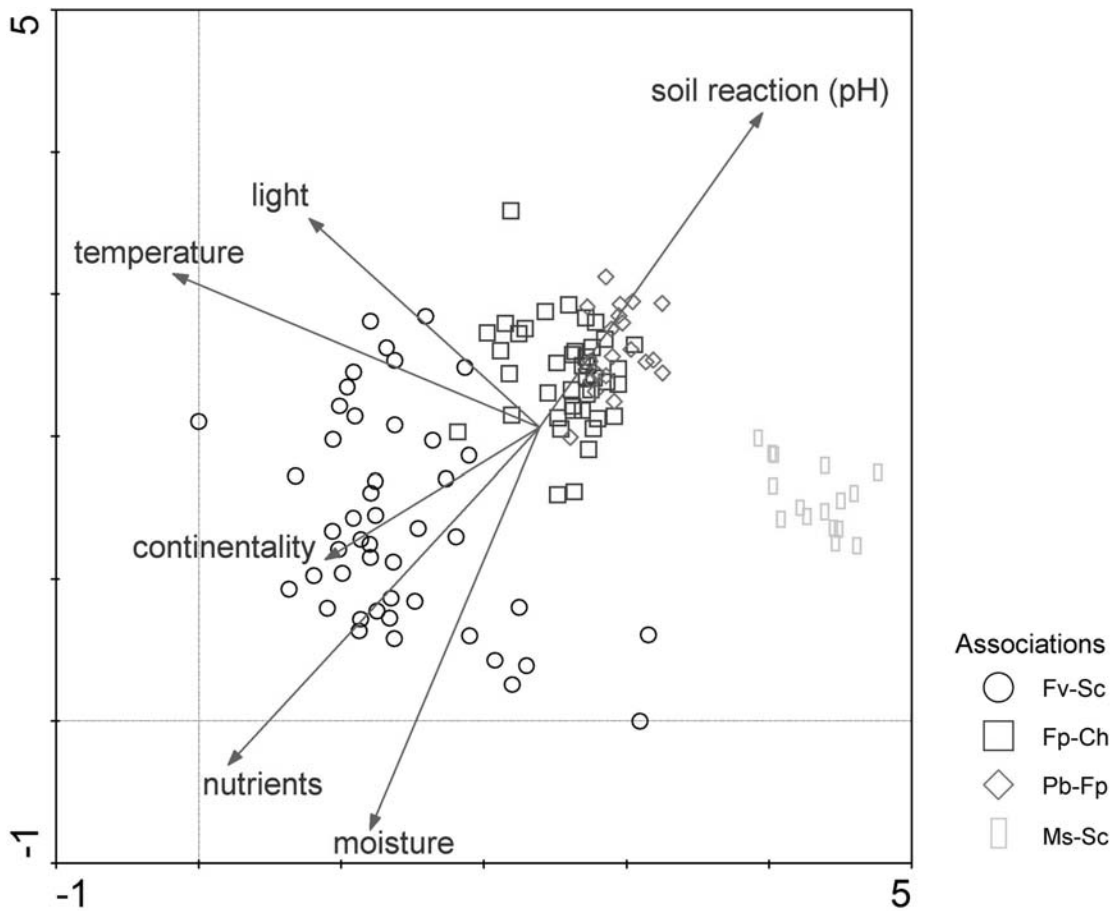


Figure 4: Detrended correspondence analysis (DCA) ordination diagram of the relevés, based on average Ellenberg indicator values.

Slika 4: DCA ordinacijski diagram popisov na osnovi povprečnih Ellenbergovih indikacijskih vrednosti.

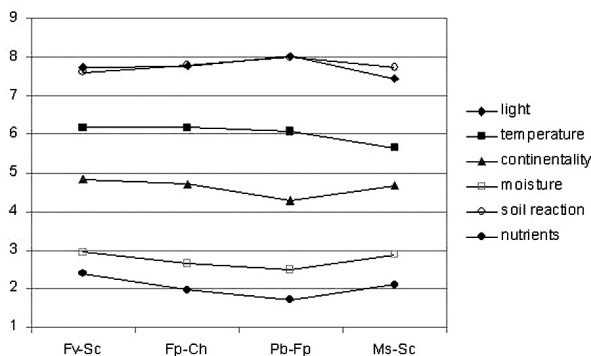


Figure 5: Average Ellenberg indication values of the ecological factors of vascular plants occurring in individual clusters (associations) produced as outputs of the cluster analysis.

Legend (Ellenberg et al. 2001): Light: 7 – plants in well lit places, sometimes occurring in partial shade, 8 – light-loving plants. Temperature: 5 – indicator of fairly warm condition, 7 – warmth indicator. Continentality: 4 – sub-oceanic,

5 – intermediate. Moisture: 1 – indicator of extreme dryness, 3 – dry sites indicator. Soil reaction: 7 – indicator of weakly acid to weakly basic conditions, never found on very acid soils, 9 – basic reaction and lime indicator. Nutrients: 1 – indicator of sites extremely poor in available nitrogen, 3 – indicator of sites more or less poor in available nitrogen.

Slika 5: Povprečne Ellenbergove indikacijske vrednosti posameznih klastrov (asociacij), ki so rezultat klastrske analize.

Legenda (Ellenberg et al. 2001): Svetloba: 7 – rastline svetlobe, včasih uspevajo v delni senci, 8 – rastline svetlobe. Temperatura: 5 – nakazovalke zmerno toplih razmer, 7 – indikatorji relativno toplih razmer. Kontinentalnost: 4 – sub-oceanske razmere, 5 – vmesne razmere. Vlažnost: 1 – indikatorji skrajno sušnih razmer, 3 – indikatorji sušnih razmer. Kemična reakcija tal: 7 – indikatorji slabo kislih oziroma slabo bazičnih tal, tovrstnih rastlin nikoli ne najdemo na zelo kislih tleh, 9 – nakazovalke bazične reakcije ali zelo karbonatnih tal. Hrabnila: 1 – nakazovalke rastišč, najrevnejših z razpoložljivim dušikom, 3 – nakazovalke rastišč, revnih z razpoložljivim dušikom.

3. RESULTS

3.1 Cluster analysis

Interpreting the results of the cluster analysis, four associations have been distinguished in the dendrogram at the third highest level of dissimilarity (Fig. 2). They are: *Festuco valesiacae-Stipetum capillatae*

Sillinger 1930 (Fig. 6), *Festuco pallentis-Caricetum humilis* Sillinger 1930 corr. Gutermann et Mucina 1993 (Fig. 7), *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966 nom. invers. propos. and *Minuartio setaceae-Seslerietum calcariae* Klika 1931 nom. mut. propos. All of these vegetation units, using different synonyms, have been traditionally diagnosed in the phytocoenological literature (cf. Maglocký 1979).



Figure 6: *Festuco valesiacae-Stipetum capillatae* in the Nature Reserve Beckovské skalice (township of Beckov).
Photo: D. Micháľková, 19. 7. 2005.

Slika 6: Asociacija *Festuco valesiacae-Stipetum capillatae* v naravnem rezervatu Beckovské skalice (občina Beckov).
Foto: D. Micháľková, 19. 7. 2005.



Figure 7: Spring aspect of *Festuco pallentis*-*Caricetum humilis*. Photo: M. Janišová, 24. 5. 2005.

Slika 7: Spomladanski aspekt asociacije *Festuco pallentis*-*Caricetum humilis*. Foto: M. Janišová, 24. 5. 2005.

3.1.1 Nomenclature and species characteristics of the associations (cf. Table 1)

Cluster A – *Festuco valesiaca*-*Stipetum capillatae* Sillinger 1930

Orig. (Sillinger 1930: 35): *Festuceto (valesiaca)*-*Stipetum capillatae*

Phantom name: *Festuco valesiaca*-*Stipetum capillatae* Sillinger 1931 (in Mucina & Maglocký 1985: 189), *Stipa capillatae*-*Festucetum valesiaca* Sillinger 1931 (in Maglocký 1979: 92)

Nomenclatural type: Sillinger 1930: 36, rel. 3, holotypus

Remark: We considered the possibility of suggesting the inversion of the order of species names in *Festuco valesiaca*-*Stipetum capillatae* Sillinger 1930. *Festuca valesiaca* seems to dominate over *Stipa capillata* in the growths of this association and therefore it should stay in the second position of the association's name (Art. 10b). However, *Stipa capillata* grows at the higher herb level compared to *Festuca valesiaca* and it dominates in a few stands in Southern Moravia (Chytrý in litt.). For these reasons we decided to keep the name in its original form described by Sillinger (1930).

Diagnostic taxa: *Festuca valesiaca* 77.8, *Medicago falcata*

74.4, *Eryngium campestre* 69.1, *Securigera varia* 61.5, *Pimpinella nigra* 60.8, *Acosta rhenana* agg. 57.7, *Thymus pannonicus* 54.4, *Festuca rupicola* 52.9, *Carex caryophylla* 49.8, *Koeleria macrantha* 48.5, *Astragalus onobrychis* 47.8, *Medicago lupulina* 47.8, *Plantago lanceolata* 46.7, *Poa angustifolia* 46.4, *Salvia pratensis* 45.7, *Fragaria viridis* 44.6, *Teucrium chamaedrys* 44.2, *Adonis vernalis* 41.5, *Agrimonia eupatoria* 41.5, *Galium verum* 41.5, *Achillea collina* 41.4, *Ranunculus bulbosus* 40.4

Constant taxa: *Sanguisorba minor* 83, *Potentilla arenaria* agg. 74, *Tithymalus cyparissias* 72, *Asperula cynanchica* 61, *Pilosella officinarum* 61

Dominant taxa: *Festuca valesiaca* 22, *Bothriochloa ischaemum* 11, *Carex caryophylla* 9

Cluster B – *Festuco pallentis*-*Caricetum humilis* Sillinger 1930 corr. Gutermann et Mucina 1993

Orig. (Sillinger 1930: 28): Asociace *Festuca glauca*-*Carex humilis* (*Glauceto-Caricetum humilis*)

Syntax. syn.: *Scabioso suaveolentis*-*Caricetum humilis* Klika 1931

Nomenclatural type: Michálková, Škodová & Mertanová (2006): Table 1, rel. 12, lectotypus hoc loco.

Diagnostic taxa: *Alyssum montanum* 55.0, *Stipa joannis*

51.5, *Poa badensis* 47.2, *Colymbada scabiosa* agg. 41.0, *Carex humilis* 40.5

Constant taxa: *Helianthemum grandiflorum* s. lat. 93, *Thymus praecox* 93, *Sanguisorba minor* 93, *Globularia punctata* 86, *Tithymalus cyparissias* 86, *Potentilla arenaria* agg. 83, *Teucrium montanum* 83, *Festuca pallens* 76, *Leontodon incanus* 69, *Anthyllis vulneraria* agg. 64, *Linum tenuifolium* 64, *Asperula cynanchica* 62

Dominant taxa: *Carex humilis* 55, *Stipa joannis* 12

Cluster C – *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966 nom. invers. propos.

Orig. (Klika 1931: 360): *Festuca glauca-Poa badensis*-Assoziation

Nomenclatural type: Klika 1931: 363, rel. 16, lectotypus (assigned in Toman 1975)

Diagnostic taxa: *Fumana procumbens* 54.8, *Festuca pallens* 50.5, *Draba lasiocarpa* 44.6

Constant taxa: *Teucrium montanum* 100, *Thymus praecox* 100, *Helianthemum grandiflorum* s.lat. 85, *Leontodon incanus* 85, *Globularia punctata* 65, *Potentilla arenaria* agg. 65

Dominant taxa: *Festuca pallens* 30, *Poa badensis* 5

Cluster D – *Minuartio setaceae-Seslerietum caeruleae* Klika 1931 nom. mut. propos.

Orig. (Klika 1931: 367): *Sesleria calcaria-Alsine setacea*-Assoziation (*Alsine setacea* = *Minuartia setacea*, *Sesleria calcaria* = *S. caerulea*, Art. 45)

Syn.: *Seslerio-Caricetum humilis* Sillinger 1930 (Art. 31), *Carici humilis-Seslerietum calcariae* Sillinger 1930 nom. invers. (Art. 31)

Non: *Carici humilis-Seslerietum calcariae* Zlatník 1928
Nomenclatural type: Klika 1931: 369, rel. 21, lectotypus (assigned in Toman 1975)

Diagnostic taxa: *Sesleria albicans* 96.9, *Genista pilosa* 74.2, *Thalictrum minus* 70.1, *Thesium linophyllum* 67.0, *Phyteuma orbiculare* 60.7, *Allium senescens* ssp. *montanum* 56.6, *Thlaspi montanum* 55.7, *Bupleurum falcatum* 51.2, *Polygala amara* ssp. *brachyptera* 51.0, *Campanula moravica* 50.0, *Bromus monocladus* 44.7, *Carex humilis* 40.5

Constant taxa: *Teucrium montanum* 100, *Helianthemum grandiflorum* s.lat. 88, *Anthericum ramosum* 81, *Leontodon incanus* 75, *Sanguisorba minor* 69, *Globularia punctata* 62

Dominant taxa: *Sesleria albicans* 100, *Genista pilosa* 25

3.2 Ordination and analysis of Ellenberg indication values

The detrended gradient analysis (DCA) has been used to define the major gradients in the species composition of the dry grassland vegetation (Fig. 3 and 4, Table 2). Figure 4 shows the species scatter

plot of DCA based on individual relevés. Ellenberg indication values, plotted onto the ordination diagram, show that the major variation in species composition of the dry grasslands corresponds to the combination of several gradients. The first axis of the ordination diagram interprets 7.6 % of the variability of the data set (lengths of gradient 4.763, eigenvalue 0.642) and it may be more or less associated with the temperature gradient. The second axis (lengths of gradient 3.587, eigenvalue 0.398) is associated with the soil reaction gradient, which negatively correlates to the moisture (which could be later combined with the soil nutrient availability gradient).

Individual clusters strikingly differ in their relationships to major environmental factors (Fig. 3 and 4). Connected to the temperature gradient, vegetation of cluster A (*Festuco valesiacae-Stipetum capillatae*) occupies very warm sites, while cluster D (*Minuartio setaceae-Seslerietum caeruleae*) is confined to the coolest sites. The gradients of soil nutrients and moisture are mutually correlated, with cluster A (*Festuco valesiacae-Stipetum capillatae*) associated with high values and clusters B (*Festuco pallentis-Caricetum humilis*) and C (*Poo badensis-Festucetum pallentis*) with low values.

There is a relatively variable association of *Festuco valesiacae-Stipetum capillatae* dissociated in the left lower part of the diagram. In comparison to the rest of the data set, this unit includes the vegetation of warm and moist stands, which are the richest in soil nutrients and the most continental (Fig. 5). This closed vegetation occurs in the stands with deeper soil, which indicates also its species composition (Table 1). These dry grasslands were used as pastures in the past. They occur in the near vicinity of the rural settlements on the slight slopes at lower altitudes.

There are relevés of *Minuartio setaceae-Seslerietum caeruleae* separated in the right part of the ordination space (Fig. 4). This is the most cool-liking association, in which some mountain plant species are present. *Sesleria albicans*, *Phyteuma orbiculare* and *Acinos alpinus* are the examples of the dealpine species, while *Leontodon incanus*, *Thlaspi montanum* and *Biscutella laevigata* are the prealpine taxa. In comparison to the other associations, *Minuartio setaceae-Seslerietum caeruleae* grows in the humid stands and it does not have high light requirements (Fig. 5). It occurs at the highest altitudes in the NE to NW expositions. *Bromus monocladus* (*B. pannonicus* ssp. *monocladus*), a remarkable endemic of the Western Carpathians, prefers less extreme, mesophilous stands.

Table 2: The outputs of the detrended correspondence analysis (DCA) of the phytocoenological relevés of the dry grassland vegetation of the Považský Inovec Mts.

Axes	1	2	3	4	Total inertia
Eigenvalues:	0.642	0.398	0.329	0.192	8.461
Lengths of gradient:	4.763	3.587	3.533	2.228	
Cumulative percentage variance of spec. data:	7.6	12.3	16.2	18.5	
Sum of all eigenvalues					8.461

There are two associations (*Festuco pallentis-Caricetum humilis* and *Poo badensis-Festucetum pallentis*) located in the central part of the diagram (Fig. 4). Their inter-separation is rather poorly presented in this projection of the ordination space. Both associations positively correlate to the increasing of the basic character of the substrate and negatively to the

amount of soil nutrients and moisture. The more extreme open vegetation of *Poo badensis-Festucetum pallentis* naturally occurs on the dolomite and limestone screes with the minimal amount of soil available, which contains nutrients and holds water.

3.3 Exposition and inclination of the slopes

The exposition of slopes is an important environmental factor, which influences the distribution of dry grassland associations in the study area (MAGLOCKÝ 1978, JANIŠOVÁ 2005). While the *Minuartio setaceae-Seslerietum caeruleae* evidently prefers the northern expositions, all the other associations tend to occur mostly on the south facing slopes (Fig. 8). The *Festuco valesiacae-Stipetum capillatae* occurs on

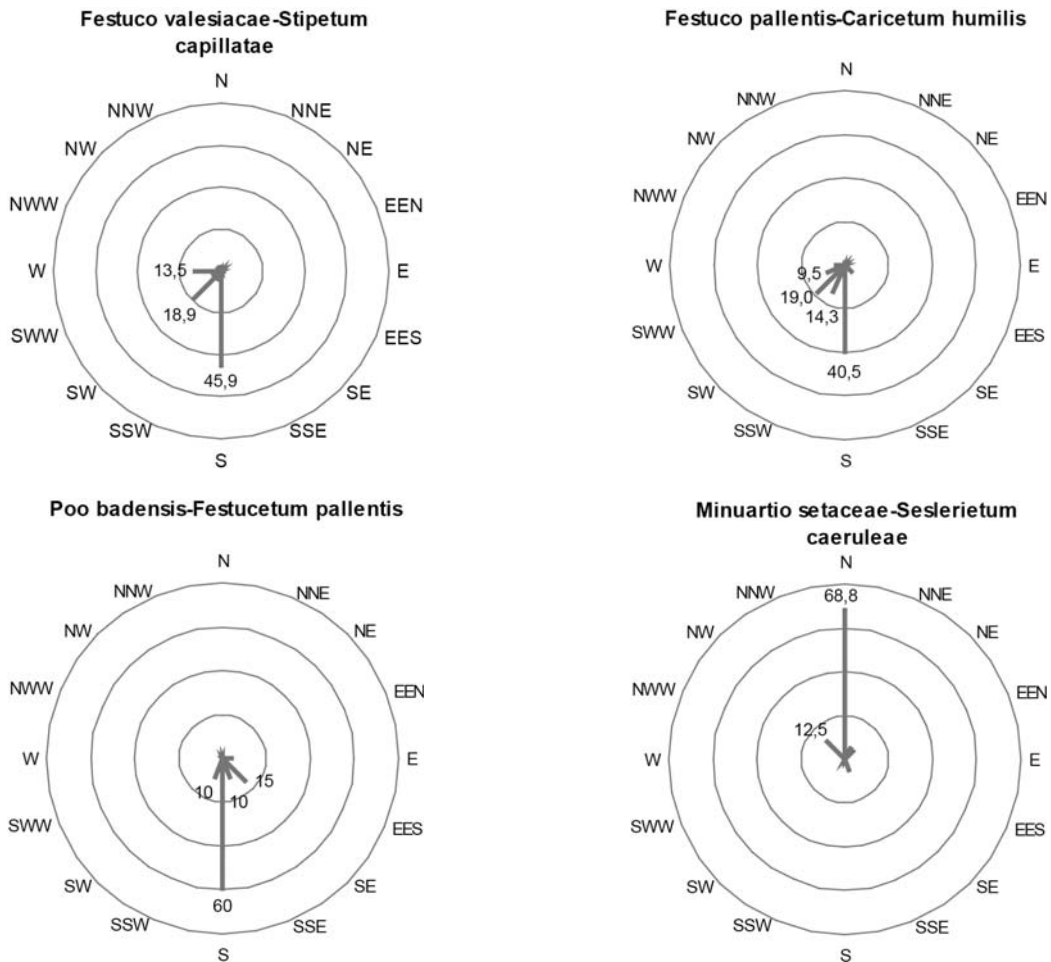


Figure 8: Circle diagrams indicating the slope exposition priorities of the associations. Grey circle scale measures show 20, 40, 60 and 80 %. The number values are marked starting from 9 %.

Slika 8: Krožni diagrami prikazuju nebesno lego in naklon rastišč posameznih asociacij. Sivi krogi prikazuju naklon: 20, 40, 60 in 80 %. Vrednosti so označene od naklona 9 % navzgor.

the slight slopes (Tab. 1, average inclination 11°) in the warm expositions (S, SW, W). The driest association *Poo badensis-Festucetum pallentis* prefers south to east facing slopes, which are relatively steep (average inclination 26°). *Festuco pallentis-Caricetum humilis* grows usually in south to west expositions, mostly at the ridges of the hills (Fig. 9).

4. SYNTAXONOMY

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

Festucetalia valesiacae Br.-Bl. et Tx. ex Br.-Bl. 1949

Festucion valesiacae Klika 1931

***Festuco valesiacae-Stipetum capillatae* Sillinger 1930**

Bromo pannonici-Festucion pallentis Zólyomi 1936 corr. 1966

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

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

Diantho lumnitzeri-Seslerion albicantis (Soó 1971)

Chytrý et Mucina in Mucina et Kolbek 1993

***Minuartio setaceae-Seslerietum caeruleae* Klika 1931 nom. mut. propos.**

The classification of the associations within the class *Festuco-Brometea* is rather problematic. The traditional conception of the class division into orders and alliances (cf. Mucina & Maglocký 1985) is not identical to the more recent works (cf. Mucina & Kolbek 1993, Michálková & Šibík 2006, Chytrý et al. 2007).

Only the classification of the *Festuco valesiacae-Stipetum capillatae* appears to be definite, because both in the traditional and modern literature sources, the association is classified within the subcontinental alliance *Festucion valesiacae* (cf. Maglocký 1979, Mucina & Maglocký 1985, Moravec et al. 1995, Chytrý et al. 2007).

The author of the description of *Festuco pallentis-Caricetum humilis* did not classify this association within any higher syntaxon. At the time of its publication in Sillinger (1930), no alliances of the class *Festuco-Brometea* had yet been described. On the other hand, the association *Scabioso suaveolentis-Caricetum humilis* (syntax. syn. of the *Festuco pallentis-Caricetum humilis*) was included by the author of its description in *Festucion valesiacae* (Klika 1931). Later some authors followed this conception (Maglocký 1979, Mucina & Maglocký 1985). These dry grasslands are classified in the works of Mucina &

Kolbek (1993: 475) and Chytrý et al. (2007) within *Bromo pannonici-Festucion pallentis*. This alliance includes the circum-Pannonian thermophilous grassland biotopes on dolomite bedrocks.

The association *Poo badensis-Festucetum pallentis* is classified in Mucina & Kolbek (1993: 473) and Chytrý et al. (2007) within the alliance *Bromo pannonici-Festucion pallentis*. On the other hand, in older works (Klika 1931, Maglocký 1979, Mucina & Maglocký 1985) it was considered as a part of the broadly defined alliance *Seslerio-Festucion pallentis* Klika 1931 corr. Zólyomi 1966. Considering the nomenclatural remark in Mucina & Kolbek (1993: 460), we regard it as a nomen ambiguum. According to the presence of numerous diagnostic taxa of the alliance *Bromo pannonici-Festucion pallentis* in the vegetation of both associations (cf. Table 1), we agree with this newer concept.

The alliance *Seslerio-Festucion pallentis* has been divided into two alliances in recent literature. One of them is *Bromo pannonici-Festucion pallentis*. The other, *Diantho lumnitzeri-Seslerion albicantis*, includes the closed dealpine xerophilous vegetation on the limestone bedrock, mostly dominated by *Sesleria albicans*. The association *Minuartio setaceae-Seslerietum caeruleae* belongs to this alliance (cf. Mucina & Kolbek 1993, Chytrý et al. 2007).

5. DISCUSSION AND CONCLUSION

The results of the presented numerical analyses support the traditional conceptions (Sillinger 1930, Klika 1931, Maglocký 1979), which were created through the deductive classification methods. It is very important that the clusters representing individual associations include the relevés of the original association description (cf. Fig. 2, sources of relevés). The relevés of the original description of the *Festuco valesiacae-Stipetum capillatae* (cluster A) are in Sillinger (1930: 36, rel. 1, 2 and 3). Cluster B (*Festuco pallentis-Caricetum humilis*) contains the relevés of the original description also from Sillinger (1930: 36, rel. 4, 5, 6 and 7). Cluster C (*Poo badensis-Festucetum pallentis*) includes a relevé from Klika (1931: 363, rel. 13). Cluster D (*Minuartio setaceae-Seslerietum caeruleae*) does not involve any relevés from Sillinger (1930), because there is only a synoptic table in this work. However, cluster D contains only the relevé from the Považský Inovec Mts, which occurs in Klika (1931: 370, rel. 29).

On the other hand, the cluster analyses did not support the validity of the numerous subasso-



Figure 9: Influence of slope exposition on the distribution of the dry grassland associations. In front is the *Festuco pallentis-Caricetum humilis*. The *Poo badensis-Festucetum pallentis* is marked by a white rectangle in the background. Locality Hradlová nivka (township of Lúka). Photo: M. Janišová, 7. 5. 2005.

Slika 9: Vpliv naklona in nebesne lege na razširjenost asociacij suhih travnikov. V ospredju sestoji asociacije *Festuco pallentis-Caricetum humilis*. Sestoj asociacije *Poo badensis-Festucetum pallentis* je označen z belim pravokotnikom v ozadju. Lokacija Hradlová nivka (občina Lúka). Foto: M. Janišová, 7. 5. 2005.

ciations and variants assigned in Maglocký (1979). According to Art. 5 of the International Code of Phytosociological Nomenclature (Weber, Moravec & Theurillat 2000), these subassociations were invalidly described, because there was no nomenclatorial typus designated in the paper. In this study, only some relevés of Maglocký's subassociations aggregated at the lower hierarchical level of the dendrogram (Fig. 2, numbers 1–6). In the *Festuco valesiacae-Stipetum capillatae festucetosum rupicoae*, 8 from 9 relevés published in Maglocký (1979) grouped together. In the *F. v.-S. c. botryochloetosum ischaemii* it was 6 from 9 relevés and in the *F. v.-S. c. caricetosum caryophyllae* 6 from 7 relevés (Fig. 2, numbers 1–3). None of the subassociations described in the dry grasslands, which Maglocký named *Scabioso suaveolentis-Caricetum humilis*, were confirmed by the analysis. Only 5 from 8 relevés of *S. s.-C. h. typicum*, *Koeleria macrantha*-variant aggregated

in the dendrogram (Fig. 2, number 4). All seven relevés of *Poo badensis-Festucetum pallentis jovibarbetosum hirtae* from Maglocký (1979) gathered together. Moreover two other relevés joined this group (Fig. 2, number 5). A small cluster was created by all of the three relevés of *Minuartio setaceae-Seslerietum caeruleae* (syn. *Carici humilis-Seslerietum calcariae*) *festucetosum pallentis* (Fig. 2, number 6). This study does not attempt to solve the problems of variability within the studied associations. For this purpose, it is necessary to analyse a representative data set consisting of the relevés from the whole area of the associations' occurrence.

Nowadays, the dry grasslands in the Považský Inovec Mts have to face many threats. First of all, the abandonment of the pastures (mostly *Festuco valesiacae-Stipetum capillatae*) causes successional changes in the species composition as well as shrub progression. Mostly deer and mouflons (*Ovis ammon* subsp.

musimon) graze the vegetation of *Festuco pallentis-Caricetum humilis*, which can be found at the higher altitudes, away from the settlements. However, the non-native mouflons, introduced into this area in the past, can cause the erosion (particularly in the *Poo badensis-Festucetum pallentis*) and increase the amount of nitrogen in the soil. In the past decades, an intensive planting of non-native *Pinus nigra* and *Fraxinus ornus* was accomplished in large areas. This destroyed or eventually reduced the size of many sites where mostly *Festuco pallentis-Caricetum humilis* and *Minuartio setaceae-Seslerietum caeruleae* had occurred. In some areas, the grasslands of *Festuco valesiacae-Stipetum capillatae* were completely destroyed by ploughing in order to intensify the agricultural production in the communistic times (Maglocký in verb., Deván et al. 2006).

Because of the consistent reduction of the area of the dry grasslands, it is necessary to continue with the management activities. Although this vegetation is secondary and human-influenced, it represents a refuge for many rare thermophilous species and it is a valuable contribution to the diversity of habitats in Slovakia.

ACKNOWLEDGEMENTS

The author is grateful to Milan Chytrý, Monika Janišová, Jiří Kolbek, Jozef Šibík, Milan Valachovič and Mária Zaliberová for their valuable comments on the manuscript and willingness to help with the numerical analyses. I also thank to Jana Sadloňová for helping to create the charts and to Sylvia Mertanová who made the map. Lucia Kwon performed the language correction. For intensive help in solving the nomenclatural problems, I am deeply indebted to Ján Kliment. The research study was funded by projects APVT-51-015804 and VEGA 2/5084/25.

REFERENCES

Braun-Blanquet, J. 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde. Ed. 3. Springer Verlag, Wien, 865 pp.

Chytrý, M., Hoffmann, A. & Novák, J. 2007: Suché trávníky. Třída *Festuco-Brometea*. In: Chytrý M. (ed.): Vegetace České republiky. 1. Travinná a keříčková vegetace. Academia, Praha. In press. <http://www.sci.muni.cz/botany/vegsci/vegetace.php?lang=cz>

Chytrý, M., Tichý, L., Holt, J. & Botta-Dukát, Z. 2002: Determination of diagnostic species with statistical fidelity measures. *J. Veg. Sci.* 13: 79–90.

Deván, P., Devánová, K., Mered'a, P. jun., Smanatová, J. & Rajcová, K. 2006: Charakteristika flóry záujmového územia floristického kurzu v Pruskom. *Bul. Slov. Bot. Spoločn.*, 28, Suppl. 1: 13–21.

Ellenberg, H., Weber, H. E., Düll, R., Wirth, W. & Werner, W. 2001: Zeigerwerte von Pflanzen in Mitteleuropa. Ed. 3. *Scr. Geobot.* 18: 1–262.

Holub, J., Hejný, S., Moravec, J. & Neuhäusl, R. 1967: Übersicht der höheren Vegetationseinheiten der Tschechoslowakei. *Rozpr. Českoslov. Akad. Věd, Praha* 77: 3–75.

Janišová, M. 2005: Vegetation – environment relationships in dry calcareous grasslands. *Ekológia*, 24 (1): 25–64.

Janišová, M. 2006a: Caespitose grasses in dry grassland communities at several organization scales. In: Bültmann, H., Fartmann, T., Hasse, T. (eds): *Trockenrasen auf unterschiedlichen Betrachtungsebenen*. *Arb. Inst. Landschaftsökol. Münster* 15: 43–49.

Janišová, M. 2006b: Tiller demography of *Festuca pallens* Host (Graminae) in two dry grassland communities. *Pol. J. Ecol.* 54 (2): 201–213.

Janišová, M. 2007a: Leaf demography of *Festuca pallens* Host in dry grassland communities. *Biologia, Bratislava* (in press).

Janišová, M. 2007b: Spatial genotypical diversity of *Sesleria albicans* (Poaceae) in a dry grassland community. *Biologia, Bratislava* (submitted).

Klika, J. 1931: Studien über die xerotherme Vegetation Mitteleuropas I. Die Pollauer Berge im südlichen Mähren. *Beih. Bot. Cbl.* 47 B: 343–398.

Maglocký, Š. 1978: Porovnanie ekoklimatických podmienok v rastlinných spoločenstvách na Bôrovišti (Považský Inovec). *Biológia, Bratislava* 33: 333 – 341.

Maglocký, Š. 1979: Xerothermná vegetácia v Považskom Inovci. *Biol. Pr.*, Bratislava 25 (3): 1–129.

Marhold, K. & Hindák, F. (eds) 1998: *Zoznam nižších a vyšších rastlín Slovenska*. Veda, Bratislava, 688 pp.

McCune, B. & Mefford, M. J. 1999: PC-ORD. Multivariate analysis of ecological data, Version 4.0. MjM Software Design, Gleneden Beach, 237 pp.

Michalko, J., Berta, J., Magic, D., Maglocký, Š. & Špániková, A. 1987: Geobotanical map of CSSR. Slovak socialist republic. *Maps. Veda, Bratislava*.

- Michálková, D. & Šibík, J. 2006: A numerical approach to the syntaxonomy of plant communities of the class *Festuco-Brometea* in Slovakia. *Tuxenia*, Göttingen 26: 145–158.
- Michálková, D., Škodová, I. & Mertanová, S. 2006: Príspevok k fytoocenológii xerotermných rastlinných spoločenstiev v Považskom Inovci. In: Rajcová, K. (ed.): Najvzácnejšie prírodné hodnoty Tematínskych vrchov. Zborník výsledkov inventarizačného výskumu územia európskeho významu Tematínske vrchy. KOZA a Pre prírodu, Trenčín, pp. 25–44.
- Moravec, J., Balátová-Tuláčková, Blažková, D., E., Hadač, E., Hejný, S., Husák, Š., Jeník, J., Kolbek, J., Krahulec, F., Kropáč, Z., Neuhäusel, R., Rybníček, B., Řehořek, V. & Vicherek, J. 1995: Rostlinné spoločenstva České republiky a jejich ohrožení. Severočeskou Přír., příl. 1995, Litoměřice, Ed. 2., 206 pp.
- Mucina, L. & Kolbek, J. 1993: *Festuco-Brometea*. In: Mucina, L., Grabherr, G. & Ellmauer, T. (eds): Die Pflanzengesellschaften Österreichs. Teil I. Gustav Fischer Verlag, Jena, pp. 420–492.
- Mucina, L. & Maglocký, Š. (eds) 1985: A list of vegetation units of Slovakia. *Docum. Phytosociol.* N. S., Camerino, 9: 175–220.
- Sillinger, P. 1930: Vegetace Tematínských kopců na západním Slovensku. Příspěvek k fytogeografii a fytosociologii vápencových obvodů v jihozápadních výběžcích karpatských. *Rozpr. 2. Tř. České Akad.* 40 (13): 1–46.
- Sokal, R. R. & Rohlf, F. J. 1995: *Biometry. The principles and practice of statistics in biological research*. Ed. 3. W. H. Freeman & Co., New York, 887 pp.
- Stanová, V. & Valachovič, M. (eds), 2002: *Katalóg biotopov Slovenska*. DAPHNE – Inštitút aplikovanej ekológie, Bratislava, 225 pp.
- ter Braak, C. J. F. & Šmilauer, P. 2002: *CANOCO reference manual and CanoDraw for Windows user's guide*. Software for canonical community ordination (version 4.5). Biometris, Wageningen & České Budějovice, 500 pp.
- Tichý, L. & Holt, J. 2006: JUICE – program for management, analysis and classification of ecological data. First part of the program manual. http://www.sci.muni.cz/botany/juice/JC_man1.pdf
- Tichý, L. 2002: JUICE, software for vegetation classification. *J. Veg. Sci.*, Uppsala 13: 451–453.
- Toman, M. 1975: Materiál k fytoocenológii spoločenstev třídy *Festuco-Brometea* na Pavlovských kopcích (Jižní Morava). *Zborn. Ped. Fak. Prešov. Univ. P. J. Šafárika, Košice*, 1: 127–134.
- Weber, H. E., Moravec, J. & Theurillat, J.-P. 2000: *International Code of Phytosociological Nomenclature*. Ed. 3. *J. Veget. Sci.*, Uppsala 11: 739–768.
- Westhoff, V., van der Maarel, E. 1973: The Braun-Blanquet approach. In: Whittaker, R. H. (ed.): *Ordination and Classification of Communities*. Dr. W. Junk Publishers, The Hague, pp. 617–727.

Recieved 21. 11. 2006

Revision recieved 29. 1. 2007

Accepted 19. 3. 2007

Table 1: A synoptic table of four associations produced by cluster analysis. The values in first columns are percentage frequencies. The fidelities (ϕ coefficient multiplied by 100) are given in smaller characters in the second columns.

Tabela 1: Sinoptična tabela štirih asociacij narejena na osnovi rezultatov klastrske analize. Vrednosti v prvem stolpcu so frekvence v odstotkih. Vrednosti v drugi koloni (manjše številke) so navezanost (ϕ koeficient pomnožen s 100).

Association (cluster)	A	B	C	D
Number of relevés	46	42	20	16
Average number of species	34	32	20	26
Average inclination	11°	22°	26°	28°

Festuco valesiacae-Stipetum capillatae

<i>Festuca valesiaca</i>	87	77,8	21	---	.	---	.	---
<i>Medicago falcata</i>	76	74,4	7	---	.	---	6	---
<i>Eryngium campestre</i>	63	69,1	7	---	.	---	.	---
<i>Securigera varia</i>	48	61,5	2	---	.	---	.	---
<i>Pimpinella nigra</i>	63	60,8	19	---	.	---	.	---
<i>Acosta rhenana</i> agg.	50	57,7	2	---	.	---	6	---
<i>Thymus pannonicus</i>	39	54,4	2	---	.	---	.	---
<i>Festuca rupicola</i>	50	52,9	2	---	.	---	12	---
<i>Carex caryophyllea</i>	39	49,8	7	---	.	---	.	---
<i>Koeleria macrantha</i>	72	48,5	43	---	15	---	.	---
<i>Astragalus onobrychis</i>	28	47,8	.	---	.	---	.	---
<i>Medicago lupulina</i>	28	47,8	.	---	.	---	.	---
<i>Plantago lanceolata</i>	35	46,7	.	---	.	---	6	---
<i>Poa angustifolia</i>	37	46,4	2	---	.	---	6	---
<i>Salvia pratensis</i>	26	45,7	.	---	.	---	.	---
<i>Fragaria viridis</i>	33	44,6	.	---	.	---	6	---
<i>Teucrium chamaedrys</i>	80	44,2	52	---	.	---	38	---
<i>Galium verum</i>	22	41,5	.	---	.	---	.	---
<i>Adonis vernalis</i>	22	41,5	.	---	.	---	.	---
<i>Agrimonia eupatoria</i>	22	41,5	.	---	.	---	.	---
<i>Achillea collina</i>	35	41,4	7	---	5	---	.	---
<i>Ranunculus bulbosus</i>	24	40,4	2	---	.	---	.	---

Festuco pallentis-Caricetum humilis

<i>Alyssum montanum</i> B-F	37	---	81	55	5	---	19	---
<i>Stipa joannis</i>	4	---	38	51,5	.	---	.	---
<i>Poa badensis</i> B-F	7	---	40	47,2	5	---	.	---
<i>Colymbada scabiosa</i> agg.	11	---	33	41	.	---	.	---

Poo badensis-Festucetum pallentis

<i>Festuca pallens</i> B-F	13	---	76	22,7	100	50,5	38	---
<i>Fumana procumbens</i> B-F	7	---	57	21,8	85	54,8	6	---
<i>Draba lasiocarpa</i>	.	---	21	---	50	44,6	6	---

Minuartio setaceae-Seslerietum caeruleae

<i>Sesleria albicans</i> D-S	.	---	5	---	.	---	100	96,9
<i>Genista pilosa</i>	17	---	29	---	5	---	100	74,2
<i>Thalictrum minus</i>	.	---	.	---	.	---	56	70,1
<i>Thesium linophyllum</i>	2	---	7	---	.	---	62	67
<i>Phyteuma orbiculare</i> D-S	.	---	.	---	.	---	44	60,7
<i>Allium *montanum</i> D-S	4	---	31	---	10	---	75	56,6
<i>Thlaspi montanum</i> D-S	.	---	.	---	.	---	38	55,7
<i>Bupleurum falcatum</i>	7	---	29	---	.	---	62	51,2

Association (cluster)		A	B	C	D		
<i>Polygala *brachyptera</i> D-S	4	---	.	---	.	---	38 51
<i>Campanula moravica</i>	7	---	24	---	60	---	88 50
<i>Bromus monocladus</i>	.	---	.	---	.	---	25 44,7
Festucion valesiaca							
<i>Carex humilis</i>	28	---	100	40,5	40	---	100 40,5
<i>Silene otites</i>	15	---	55	34,2	30	---	12 ---
<i>Asperula cynanchica</i>	61	---	62	---	55	---	38 ---
<i>Erysimum odoratum</i>	11	---	17	---	5	---	19 ---
<i>Pilosella bauhini</i>	33	---	38	---	60	---	44 ---
<i>Allium flavum</i>	24	---	40	---	45	---	19 ---
<i>Scabiosa ochroleuca</i>	52	---	40	---	20	---	44 ---
<i>Jurinea mollis</i>	4	---	26	---	25	---	12 ---
<i>Onosma visianii</i>	2	---	36	34,9	20	---	. ---
<i>Stachys recta</i>	15	---	26	---	10	---	. ---
<i>Veronica prostrata</i>	22	---	7	---	5	---	. ---
<i>Pseudolysimachion spicatum</i>	4	---	21	---	.	---	25 ---
<i>Artemisia campestris</i>	17	---	10	---	.	---	6 ---
<i>Seseli hippomarathrum</i>	15	---	12	---	.	---	6 ---
<i>Vincetoxicum hirundinaria</i>	.	---	31	33,3	5	---	12 ---
<i>Bothriochloa ischaemum</i>	39	37,1	24	---	.	---	. ---
<i>Dianthus carthusianorum</i>	28	39,5	7	---	.	---	. ---
<i>Stipa capillata</i>	33	---	36	---	.	---	. ---
<i>Arenaria leptoclados</i>	7	---	10	---	.	---	. ---
<i>Elytrigia intermedia</i>	17	36,9	.	---	.	---	. ---
<i>Medicago minima</i>	17	36,9	.	---	.	---	. ---
Bromo pannonici-Festucion pallentis							
<i>Thymus praecox</i>	37	---	93	30,4	100	39,3	44 ---
<i>Teucrium montanum</i>	28	---	83	---	100	30,8	100 ---
<i>Melica ciliata</i>	20	---	57	33,5	45	---	. ---
<i>Potentilla arenaria</i>	74	---	83	---	65	---	38 ---
<i>Campanula sibirica</i>	11	---	52	23,8	50	---	19 ---
<i>Scorzonera austriaca</i>	4	---	48	38,8	5	---	25 ---
<i>Sedum album</i>	2	---	24	---	45	---	25 ---
<i>Jovibarba *glabrescens</i>	7	---	38	---	45	---	19 ---
<i>Scabiosa canescens</i>	2	---	24	---	5	---	19 ---
Diantho lumnitzeri-Seslerion albicantis							
<i>Leontodon incanus</i>	17	---	69	---	85	---	75 ---
<i>Biscutella laevigata</i>	4	---	19	---	40	---	50 ---
Seslerio-Festucion pallenis							
<i>Anthericum ramosum</i>	7	---	60	---	45	---	81 38,3
<i>Linum tenuifolium</i>	33	---	64	31,3	30	---	25 ---
<i>Seseli osseum</i>	22	---	48	---	30	---	31 ---
<i>Dianthus *lumnitzerii</i>	7	---	38	---	45	---	38 ---
<i>Minuartia rubra</i>	13	---	17	---	20	---	. ---
<i>Dorycnium herbaceum</i> agg.	17	---	12	---	.	---	6 ---
<i>Cyanus triumfetti</i>	2	---	5	---	.	---	6 ---
<i>Galium glaucum</i>	9	---	7	---	.	---	19 ---
<i>Saxifraga tridactylites</i>	2	---	2	---	15	---	. ---
<i>Hornungia petraea</i>	.	---	19	---	10	---	. ---
<i>Festucetalia valesiaca</i>							
<i>Inula ensifolia</i>	9	---	33	---	10	---	25 ---

Association (cluster)	A		B		C		D	
<i>Linaria genistifolia</i>	15	---	24	---	.	---	6	---
<i>Viola collina</i>	.	---	5	---	10	---	31	---
<i>Veronica austriaca</i>	.	---	7	---	.	---	19	---
<i>Lactuca viminea</i>	17	36,9	.	---	.	---	.	---
Festuco-Brometea								
<i>Helianthemum grandiflorum</i>	48	---	93	20,4	85	---	88	---
<i>Sanguisorba minor</i>	83	---	93	---	50	---	69	---
<i>Tithymalus cyparissias</i>	72	---	86	---	60	---	50	---
<i>Carlina vulgaris</i>	17	---	10	---	5	---	6	---
<i>Acinos arvensis</i>	30	35,1	10	---	5	---	.	---
<i>Arenaria serpyllifolia</i>	13	---	26	---	25	---	.	---
<i>Allium sphaerocephalon</i>	2	---	7	---	5	---	.	---
<i>Arabis hirsuta</i>	20	---	31	---	.	---	12	---
<i>Pimpinella saxifraga</i>	11	---	10	---	.	---	19	---
<i>Plantago media</i>	28	---	10	---	.	---	44	---
<i>Potentilla heptaphylla</i>	17	---	12	---	.	---	44	---
<i>Trinia glauca</i>	17	---	7	---	5	---	.	---
<i>Seseli annuum</i>	20	35,7	2	---	.	---	.	---
<i>Leontodon hispidus</i>	20	30,8	.	---	.	---	6	---
<i>Trifolium campestre</i>	17	---	.	---	.	---	6	---
<i>Crinitina linosyri</i>	11	---	10	---	.	---	.	---
<i>Avenula pubescens</i>	9	---	10	---	.	---	.	---
<i>Phleum phleoides</i>	20	39,3	.	---	.	---	.	---
Other taxa								
<i>Pilosella officinarum</i>	61	34,9	38	---	25	---	6	---
<i>Globularia punctata</i>	15	---	86	33,4	65	---	62	---
<i>Anthyllis vulneraria</i>	37	---	64	29	20	---	38	---
<i>Sedum acre</i>	11	---	12	---	20	---	6	---
<i>Asperula tinctoria</i>	2	---	10	---	5	---	25	---
<i>Sedum sexangulare</i>	46	---	33	---	25	---	.	---
<i>Thlaspi perfoliatum</i>	37	---	29	---	20	---	.	---
<i>Arabis auriculata</i>	24	---	5	---	15	---	.	---
<i>Cerastium brachypetalum</i>	7	---	7	---	25	---	.	---
<i>Cerastium pumilum</i>	7	---	7	---	5	---	.	---
<i>Pulsatilla grandis</i>	.	---	7	---	10	---	12	---
<i>Acinos alpinus</i>	.	---	2	---	15	---	19	---
<i>Galium austriacum</i>	.	---	5	---	20	---	19	---
<i>Hypericum perforatum</i>	37	---	24	---	.	---	6	---
<i>Euphrasia stricta</i> agg.	13	---	5	---	.	---	19	---
<i>Hippocrepis comosa</i>	9	---	5	---	.	---	12	---
<i>Pulsatilla slavica</i>	2	---	7	---	.	---	6	---
<i>Inula hirta</i>	2	---	5	---	.	---	6	---
<i>Silene vulgaris</i>	2	---	2	---	.	---	6	---
<i>Linum catharticum</i>	30	31,9	.	---	.	---	19	---
<i>Sideritis montana</i>	17	36,9	.	---	.	---	.	---
<i>Chondrilla juncea</i>	15	34,4	.	---	.	---	.	---

Abbreviations:

A – *Festuco valesiacae-Stipetum capillatae* Sillinger 1930, B – *Festuco pallentis-Caricetum humilis* Sillinger 1930 corr. Gutermann et Mucina 1993, C – *Poo badensis-Festucetum pallentis* Klika 1931 corr. Zólyomi 1966 nom. invers. propos., D – *Minuartio setaceae-Seslerietum caeruleae* Klika, B-F – *Bromo pannonicum-Festucion pallentis* Zólyomi 1936 corr. 1966, D-S – *Diantho lumnitzeri-Seslerion albicantis* (Soó 1971) Chytrý et Mucina in Mucina et Kolbek 1993.