



Formalized Classification of Subxerophilous Grassland Vegetation (*Cirsio-Brachypodium pinnati*, *Bromion erecti*) in the Slovak Republic.

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Introduction

The communities of the alliances *Bromion erecti* and *Cirsio-Brachypodium pinnati* Hadač et Klika ex Klika 1951 are synecological transitional between dry and mesophilous grasslands. They belong to the most species-rich plant communities in the west and central Europe being usually dominated by broad-leaved grasses – *Bromus erectus*, *Brachypodium pinnatum*, *Carex montana*, *Bromus monocladus*, and rarely by *Carex humilis*. Within these two alliances, the occurrence of 12 associations was reported from Slovakia. A syntaxonomical revision and formal definitions of these grassland communities were carried out in 2006–2008.

Aims

- Syntaxonomical revision and formal definition of subxerophilous grassland vegetation (*Bromion erecti* and *Cirsio-Brachypodium pinnati*).
- Comparing of the classification of these two alliances with that in other Central European countries.
- Testing whether formal definitions are applicable for the evaluation of the plant community's favourable state.

Results

Within the alliance *Cirsio pannonici-Brachypodium pinnati*, the occurrence of nine communities was reported from Slovakia. Three associations were formally defined: *Scabioso ochroleucae-Brachypodium pinnati* Klika 1933, *Polygalo majoris-Brachypodium pinnati* Wagner 1941, and *Carici albae-Brometum monocladii* Ujházy et al. 2007. Within the alliance *Bromion erecti* the occurrence of three associations was recorded. The formal definition of the two communities – *Brachypodium pinnati-Molinietum arundinaceae* Klika 1939 and *Onobrychido vicifoliae-Brometum erecti* T. Müller 1966 – was carried out.

The list of species groups used in formal definitions:

- group **Calamagrostis varia**: *Calamagrostis varia*, *Laserpitium latifolium*, *Digitalis grandiflora*
- group **Carex humilis**: *Carex humilis*, *Globularia punctata*, *Teucrium montanum*
- group **Cirsium acule**: *Cirsium acule*, *Linum catharticum*, *Ononis spinosa*
- group **Cirsium pannonicum**: *Cirsium pannonicum*, *Carex montana*, *Lathyrus latifolius*, *Trommsdorffia maculata*
- group **Festuca rupicola**: *Festuca rupicola*, *Sanguisorba minor*, *Fragaria viridis*, *Agrimonia eupatoria*
- group **Galium verum**: *Galium verum* agg., *Pimpinella saxifraga* agg., *Plantago media*, *Trifolium montanum*
- group **Heracleum sphondylium**: *Heracleum sphondylium*, *Crepis biennis*, *Anthriscus sylvestris*, *Chaerophyllum groupampratense*, *Geranium pratense*
- group **Onobrychis vicifolia**: *Bromus erectus*, *Onobrychis vicifolia* agg., *Salvia pratensis*
- group **Polygala major**: *Polygala major*, *Aster amellus*, *Linum flavum*, *Inula ensifolia*
- group **Scabiosa ochroleuca**: *Scabiosa ochroleuca*, *Asperula cynanchica*, *Teucrium chamaedrys*
- group **Securigera varia**: *Securigera varia*, *Medicago falcata*, *Colymbada scabiosa*, *Tithymalus cyparissias*
- group **Viola canina**: *Viola canina*, *Polygala vulgaris*, *Luzula campestris* s.lat.

FBD01 Brachypodium pinnati-Molinietum arundinaceae Klika 1939

Semidry grasslands with *Carex montana* and *Cirsium pannonicum*

Formal definition (181 relevés):

group **Cirsium pannonicum** NOT group **Bromus monocladus** NOT group **Calamagrostis varia** NOT *Nardus stricta* cover >5 %

These grasslands are exceedingly species-rich (59 species per relevé in average) hosting numerous rare and vulnerable species of vascular plants. Communities are characterized by the common occurrence of species adapted to intermittently wet soils (diagnostic species of the alliance *Molinio caeruleae*, e.g. *Betonica officinalis*, *Serratula tinctoria*, *Sanguisorba officinalis*) and thermophilous species of the class *Festuco-Brometalia* (e.g. *Helianthemum ovatum*, *Chamaecytisus supinus*, *Dianthus carthusianorum*). Stands are usually dominated by several more abundant grasses (*Bromus erectus*, *Brachypodium pinnatum*, *Carex montana*). These grasslands are utilized as meadows by regular mowing or occasional grazing. They occur mostly over the flysch and calcareous bedrock on deeper soils at altitudes ranging from 300 to 800 m.

The variability of the association *Brachypodium pinnati-Molinietum arundinaceae* depends predominantly on soil properties. Dry variant with *Teucrium chamaedrys* occurs on shallower calcareous soils. Diagnostic species are *Inula ensifolia*, *Teucrium chamaedrys*, *Genista pilosa*, *Sanguisorba minor*, *Asperula tinctoria*, and *Anthericum ramosum*. On deeper soils, on limestone or flysch bedrock, the variant with *Lathyrus latifolius* occurs. Mesophilous species like *Lathyrus latifolius*, *Cerastium holosteoides*, *Dactylis glomerata*, *Tragopogon orientalis*, *Daucus carota* and *Trifolium pratense* are diagnostic. The variant with *Potentilla erecta* (with diagnostic species *Potentilla erecta*, *Luzula luzuloides*, *Hypericum maculatum*, *Anthoxanthum odoratum* agg., *Phyteuma spicatum* and *Nardus stricta*) was recorded on moderately acid soils.



© M. Janišová: FBD01 Brachypodium pinnati-Molinietum arundinaceae

FBD02 Onobrychido vicifoliae-Brometum erecti T. Müller 1966

Dry Bromus erectus meadows

Formal definition (112 relevés):

group **Onobrychis vicifolia** AND (group *Festuca rupicola* OR group *Galium verum* OR group *Securigera varia*) AND *Bromus erectus* cover >25 % NOT group **Carex humilis** NOT group **Cirsium pannonicum** NOT group **Heracleum sphondylium** NOT group *Viola canina*

The association includes stands strongly dominated by *Bromus erectus*. They constantly contain both xerophilous species of the *Festuco-Brometalia* (*Salvia pratensis*, *Galium verum*, *Pimpinella saxifraga*, *Plantago media*, *Sanguisorba minor*, and *Trifolium montanum*) and the species of mesic meadows of the *Molinio-Arrhenatheretalia* (*Trifolium pratense*, *Veronica chamaedrys*, *Leucanthemum vulgare*, and *Tragopogon orientalis*). They were traditionally mown once a year in the past. These grasslands occur on dry and warm sites at altitudes ranging from 200 to 800 m. The bedrock is built mostly by limestone, dolomite or calcareous flysch, occasionally by volcanic rocks.

Within the community, two variants were distinguished using the numerical methods. The warmer variant with *Teucrium chamaedrys* with diagnostic species *Teucrium chamaedrys*, *Asperula cynanchica*, *Eryngium campestre* and *Tithymalus cyparissias* occurs predominantly on south, southwest or southeast slopes. Diagnostic species of the more moist variant with *Leucanthemum vulgare* are: *Trisetum flavescens*, *Leucanthemum vulgare* agg., *Campanula glomerata* agg., *Campanula patula*, *Tragopogon orientalis*, *Galium mollugo* agg., *Trifolium pratense*, *Veronica chamaedrys* agg., *Anthoxanthum odoratum*, *Acetosa pratensis* and *Crepis biennis*.



Favourable state of plant communities

The formal definition of the *Brachypodium pinnati-Molinietum arundinaceae* was tested on the set of 30 phytosociological relevés representing the succession stages of this community from a selected locality in the Biele Karpaty Mts. 66.7 % of the relevés with shrub cover between 0 – 10 % has fit the formal definition. When the cover of shrubs reached 15 – 25 %, almost 85.7 % of relevés has met the conditions of definition. Even in the advanced succession stadium, when the shrub cover reached 30 – 50 %, still 62.5 % of relevés fulfilled the definition criteria, because the diagnostic species were still present in the community. The mean probability that the expert system will be able to determinate the phytosociological relevé is about 40 – 50 % (cf. Chytrý 2007, Janišová et al. 2007).

For the evaluation of a grassland community's favourable state from the succession point of view not only the compliance of the relevé with the formal definition is important, but also the shrub-cover relevance.

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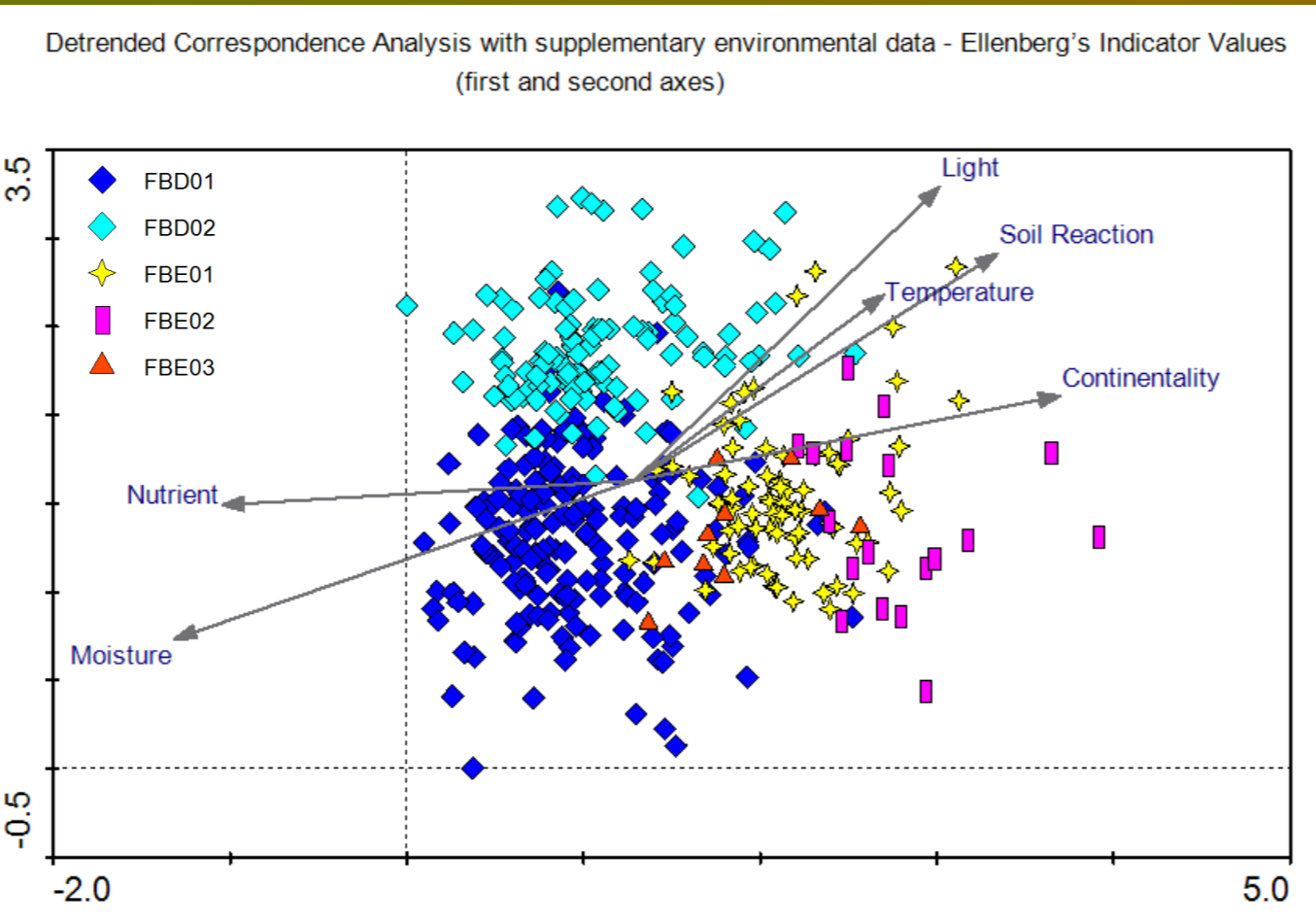
Methods

The Central Phytosociological Database of Slovakia (<http://ibot.sav.sk/cdf/index.html>) served as a ground for the study (Hegedušová 2007). Geographically stratified data set (of 16 640 phytosociological relevés belonging to all syntaxa recorded in Slovakia) was used to generate sociological species groups over the COCKTAIL method (Bruehlheide 2000). Sociological species groups and the dominance of important species were used to formulate the definitions of associations with the help of logical operators (Bruehlheide 1997).

Diagnostic species for the clusters were determined by the calculation of fidelity of each species to each cluster, using the phi coefficient of the association (Chytrý et al. 2002) in the program JUICE 6.3.49 (Tichý 2002). Fidelity was calculated in the data set containing only relevés matched with the definitions of associations. We have standardized the size of relevé groups (except for the last one which contained all relevés not matched with the definitions) to 1 % of the data set total size. Statistical significance of fidelity was calculated using the Fisher's exact test (Chytrý et al. 2002). In synoptic table the diagnostic species were arranged according to the phi coefficient. The critical value of the phi coefficient was set to 0.20. The table contains the percentage frequency of species occurrence in the associations' relevés. Besides diagnostic species, only the species with the frequency higher than 15 % in at least one association, or the species with the frequency higher than 10 % in the alliance are presented in the table. The threshold frequency value for constant species was 40 % - in the synoptic table the frequency values of constant species are in a bold print.

The main gradients of species composition were analyzed by the detrended correspondence analysis (DCA) in the CANOCO 4.5 package (ter Braak & Šmilauer 2002). For the ecological interpretation of ordination axes, the average Ellenberg's indicator values (Ellenberg et al. 1992) for the relevés were plotted onto the DCA ordination diagram as the supplementary environmental data. The Ellenberg's indicator values for every association are illustrated in box-and-whiskers plots. They show the median, lower and upper quartiles – the interval containing 50% of observed values (box), minimum and maximum values (whiskers). The differences between environmental variables of associations were tested by the Kruskal-Wallis non-parametric ANOVA; then the multiple comparisons of mean ranks for all groups were performed.

The electronic expert system for the identification of syntaxa (Janišová et al. 2007) was used to test whether succession stages of grassland communities fulfil the criteria of formal definitions.



Comparison of environmental variables (mean Ellenberg's indicator values) for associations. Kruskal-Wallis test, post-hoc multiple comparison of mean ranks of all pairs of groups. The significant differences between associations are assigned by letters.

a - *Brachypodium pinnati-Molinietum arundinaceae*, b - *Onobrychido vicifoliae-Brometum erecti*, c - *Scabioso ochroleucae-Brachypodium pinnati*, d - *Polygalo majoris-Brachypodium pinnati*, e - *Carici albae-Brometum monocladii*

	Light	Temperature	Continuity	Moisture	Soil reaction	Nutrients
a	7.07 bcd	5.56 bcd	3.99 bcd	4.24 bcd	6.84 bcde	3.56 cd
b	7.34 a	5.70 ade	4.08 acd	3.98 acd	7.20 ad	3.58 cd
c	7.38 a	5.74 ade	4.27 abd	3.72 ab	7.24 ad	3.13 ab
d	7.35 a	5.94 abce	4.59 abce	3.44 abe	7.55 abc	2.96 ab
e	7.25	5.33 bcd	4.08 d	3.94 d	7.35 a	3.22

FBE01 Scabioso ochroleucae-Brachypodium pinnati Klika 1933

Dry Brachypodium pinnatum grasslands

Formal definition (79 relevés):

(group **Cirsium acule** OR group **Scabiosa ochroleuca**) AND *Brachypodium pinnatum* cover >5 % NOT group **Carex humilis** NOT group **Cirsium pannonicum** NOT group **Onobrychis vicifolia** NOT group **Polygala major** NOT *Festuca rupicola* cover >25 %

These grasslands are dominated mostly by *Brachypodium pinnatum*, and rarely by *Bromus erectus*. The common feature is the presence of xerophilous and calcareous species (*Carex flacca*, *Teucrium chamaedrys*, *Scabiosa ochroleuca*, *Anthericum ramosum*, *Sanguisorba minor*). These stands were managed by grazing and contain numerous pasture species (*Carlina acaulis*, *Ononis spinosa*, *Anthyllus vulneraria*). Recently, many sites has become abandoned and overgrown by shrubs. These grasslands are distributed in the altitudes of 300 to 700 m, mainly situated on south-, east- or west-facing steeper slopes. Geological bedrock is usually formed by limestone, dolomite, calcareous sandstone, or flysch.



© I. Škodová: FBE01 Scabioso ochroleucae-Brachypodium pinnati

FBE02 Polygalo majoris-Brachypodium pinnati Wagner 1941

Dry pannonian Inula ensifolia grasslands

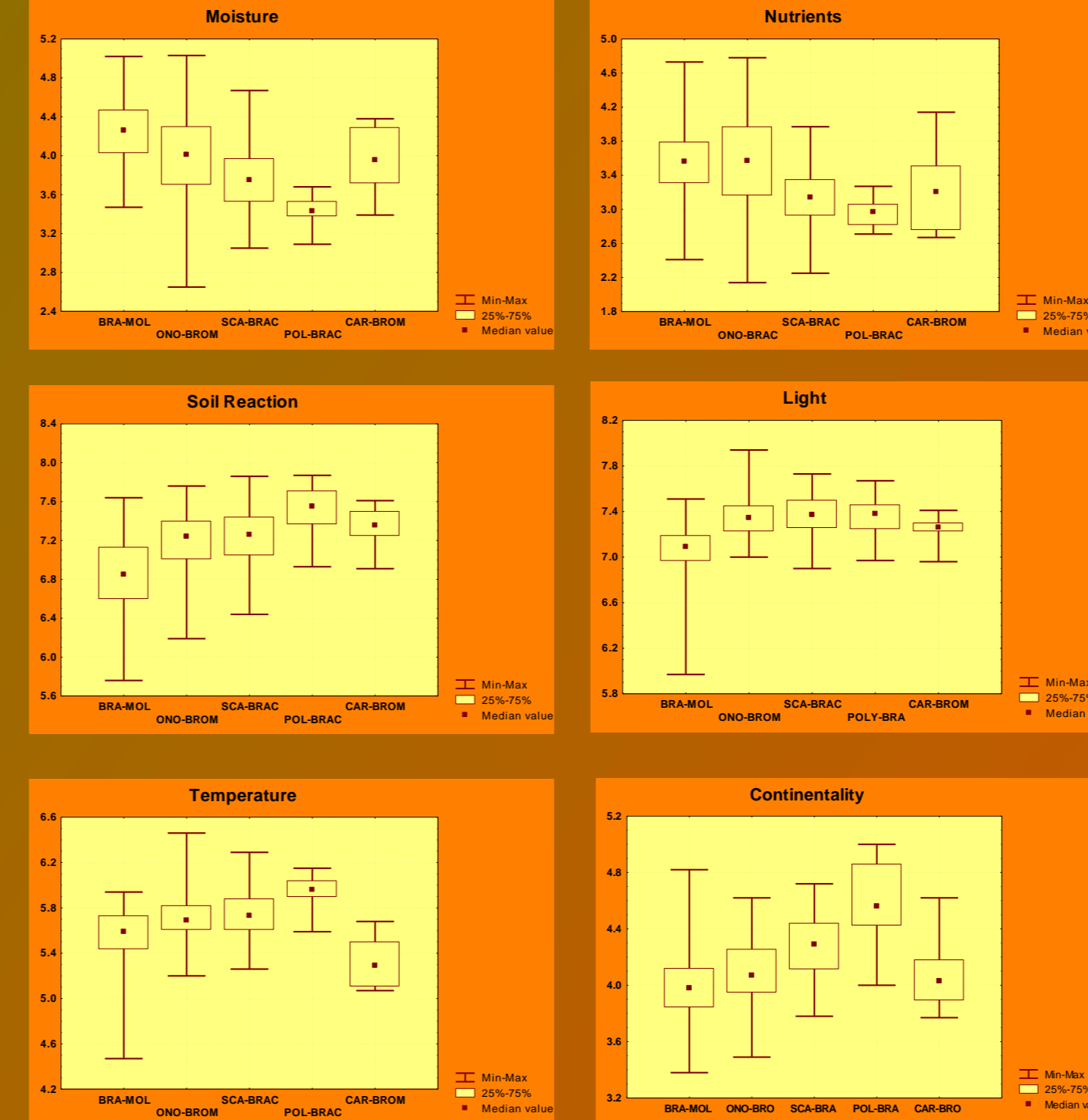
Formal definition (17 relevés):

group **Polygala major** AND *Brachypodium pinnatum* cover >5 % NOT group **Cirsium pannonicum** NOT *Festuca rupicola* cover >25 %

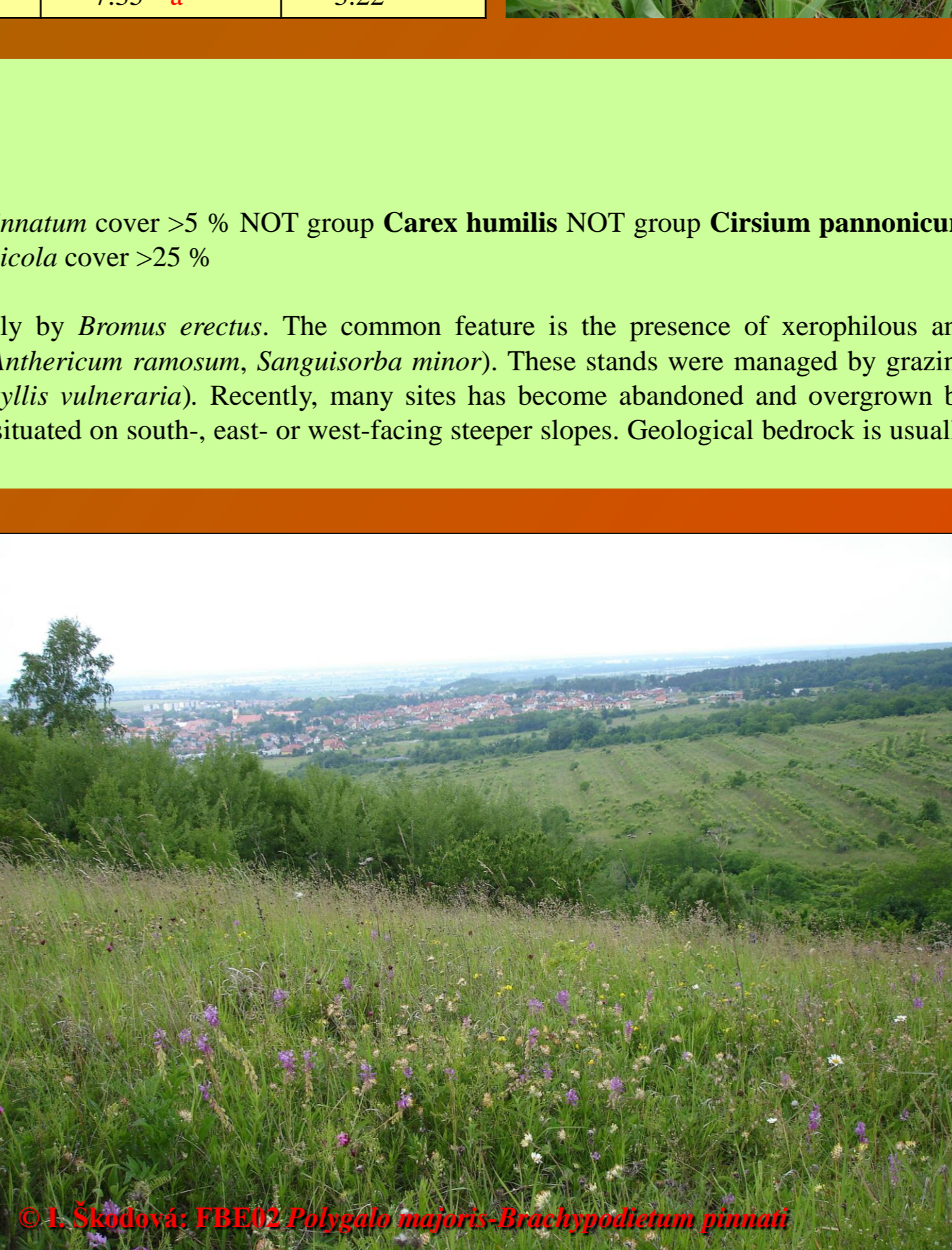
The association includes semi-closed to closed dry grasslands dominated by *Brachypodium pinnatum*, *Inula ensifolia* or *Anthericum ramosum*. During summer, several herb species (*Polygala major*, *Linum flavum*, *Aster amellus*) create expressive colourful aspects. In abandoned sites, *Geranium sanguineum* or *Peucedanum cervaria* may become dominant. Traditionally, these stands had been grazed extensively. Some stands have developed in former vineyards (Malé Karpaty Mts.). Today, many sites are abandoned and overgrown by shrubs. On steeper slopes, the succession is slower due to the soil erosion. This community is distributed at altitudes from 200 to 600 m, predominantly on south-facing slopes. The bedrock is built by calcareous sandstone, conglomerate or limestone. Soils are shallow or moderately deep.



© M. Janišová: Succession stage of Brachypodium pinnati-Molinietum arundinaceae



© I. Škodová: FBE02 Polygalo majoris-Brachypodium pinnati



© I. Škodová: FBE03 Carici albae-Brometum monocladii



© I. Škodová: FBE03 Carici albae-Brometum monocladii

FBE03 Carici albae-Brometum monocladii Ujházy et al. 2007

Meadows with Bromus monocladus

Formal definition (10 relevés):

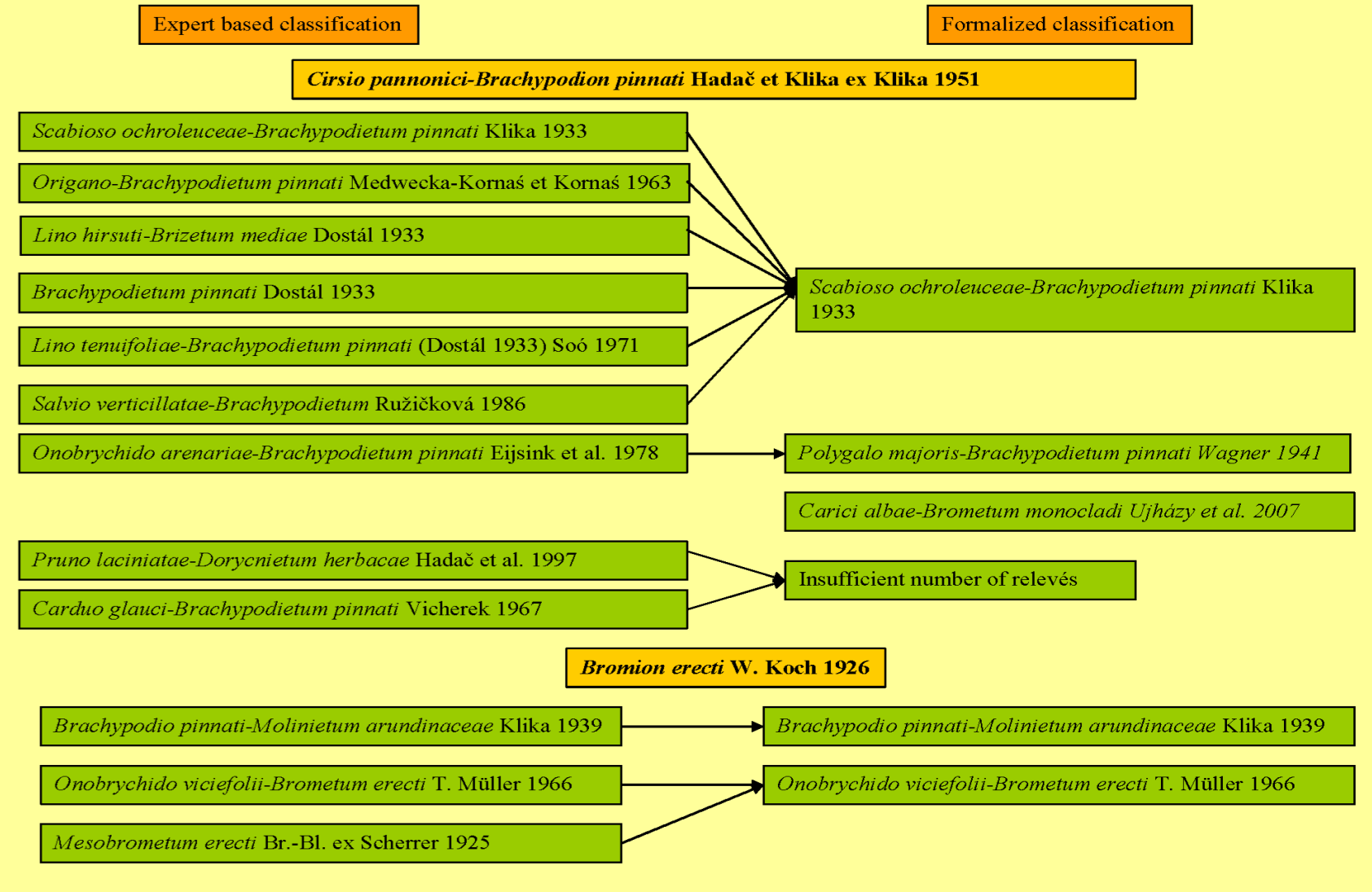
group **Bromus monocladus** AND (*Bromus monocladus* cover >25 % OR *Carex alba* cover >5 %) NOT group **Carex humilis** NOT *Sesleria albicans* cover >5 %

This vegetation is dominated by *Bromus monocladus*, an endemic species in Western Carpathians, and sometimes also by *Carex montana* or *Anthericum ramosum*. The presence of numerous xerophilous species of the *Bromo-Festucion pallentis* (*Genista pilosa*, *Globularia punctata*, *Hippocrepis comosa*, etc.) and numerous calcareous species (*Phyteuma orbiculare*, *Buphtalmum salicifolium*, *Carex alba*) is remarkable. The community is exceedingly species-rich. These grasslands are mown once a year or grazed by forest animals or by horses. They occur over calcareous bedrock (mostly dolomites) at middle altitudes (up to 1000 m), often in the vicinity of forests. Their distribution is restricted to Central Carpathian mountain ridges.

The Comparison with Surrounding Countries

Illyés et al. (2007) compared semi-dry communities dominated by *Bromus erectus* and *Brachypodium pinnatum* having analysed the large amount of phytosociological relevés from the 1200 km long transect running from central Germany via the Czech Republic, Slovakia, NE Austria, and Hungary to NW Romania. In central Germany and in the western part of the Czech Republic the association *Carlino acaulis-Brometum erecti* Oberdorfer 1957 was distinguished. The association *Potentillo reptantis-Caricetum flacca* Studnička 1980 has a broad geographic range from central Germany through the Czech Republic and Slovakia to southern Hungary. In Slovakia, it was not possible to define this community formally because of the ambiguous original diagnosis of the association and not enough diagnostic species. The association *Brachypodium pinnati-Molinietum arundinaceae* Klika 1939 occurs particularly in the mountains on the border line between the Czech and Slovak Republics, as well as in some other localities of these two countries. Illyés et al. (2007) report the association *Scabioso ochroleucae-Brachypodium pinnati* Klika 1933 from the continental areas of Germany, Bohemia, Moravia, Slovakia and some isolated sites in Hungary and Romania. The association *Polygalo majoris-Brachypodium pinnati* Wagner 1941 occurs in Pannonia Region of central and northern Hungary, southern Slovakia and southern Moravia (in Hungary these grasslands were assigned to the *Salvia nemorosa-Festucion rupicolae* Zolyomy ex Soó 1964 (Borhidi 2003) or *Euphorbia pannonica-Brachypodium pinnati* Horváth 2002). All communities recognized by Illyés et al. (2007) in the Slovak Republic were formally defined, apart from the association *Potentillo reptantis-Caricetum flacca*. The formally defined association *Carici albae-Brometum monocladii* Ujházy et al. 2007 is a newly described community for Slovakia.

In total, six communities belonging to the alliance *Cirsio-Brachypodium pinnati*, i.e.: *Inuletum ensifoliae* Kozl. 1925, *Thalictrio-Salvietum pratensis* Medw.-Korn. 1959, *Adonido-Brachypodium pinnati* (Libb. 1933) Krausch 1960, *Seslerio-Scorzonetum purpureae* Kozl. 1927, *Carex glauca-Tetragelonopsis maritimus* sp. siliculosus Medw.-Korn. 1959, and *Origan-Brachypodium pinnati* Medw.-Korn. 1963 are recognized in Poland. The communities of the oceanic alliance *Bromion erecti* do not occur there (Matuszkiewicz 2007). Eastward from Slovakia, in Ukraine, Solomakhia 1996 distinguishes two communities belonging to the *Mesobromion* Br.-Bl. et Moor 1938 em Oberd. 1949: *Aro-Thalicetum* Korzh. et Kljukin 1987 and *Teucrio-Convolvuletum arvensis* Korzh. et Kljukin 1987. The alliance *Cirsio-Brachypodium pinnati* is not distinguished there. The communities with the dominance of *Brachypodium pinnati* are included to the other alliances: *Carici humilis-Brachypodium pinnati* Soó (1942) 1947 to the alliance *Festucion valesiacae* Klika 1931 and *Brachypodium pinnati-Seslerietum* to the alliance *Seslerio-Festucion glaucae* Klika 1931 em Kolbek 1983).



Synoptic table with percentage frequency and modified fidelity index phi coefficient

Group No.	Association	1 FBD01 81	2 FBD02 112	3 FBE01 79	4 FBE02 19	5 FBE03 10
Brachypodium pinnati-Molinietum arundinaceae						
<i>Lathyrus latifolius</i>		43 49.2	1	8	---	---
<i>Pimpinella saxifraga</i>		61 64.6	27 11.1	8	---	---
<i>Trifolium rubens</i>		25 25.0	1	---	5	---
<i>Betonica officinalis</i>		22 22.2	4	8	37	30
<i>Potentilla alba</i>		22 22.2	1	---	---	---
<i>Crepis praemorsa</i>		14 14.3	1	---	---	10
<i>Meibomia eriostrum</i>		13 13.3	---	---	---	---
Scabioso ochroleucae-Brachypodium pinnati						
<i>Scabiosa ochroleuca</i>		45 57.7	65 26.3	42 16.6	10	---
<i>Ononis spinosa</i>		23 23.6	23 9.6	24 9.6	11	---
<i>Stachys germanica</i>		26 26.3	23 9.6	23 9.6	11	---
<i>Linum catharticum</i>		52 50.0	39 18.4	75 29.7	42 11.6	40
<i>Carex aculeata</i>		1	---	10 4.1	---	---
Polygalo majoris-Brachypodium pinnati						
<i>Linum flavum</i>		1	2	---	74 74.6	---
<i>Aster amellus</i>		1	---	1	53 54.9	10
<i>Inula ensifolia</i>		1	4	10	84 42.7	20
<i>Veronica teucrium</i>		12 8.9	5	13	42 32.7	10
<i>Peucedanum cervaria</i>		1	---	---	11 38.6	---
<i>Carex pediformis</i>		1	---	---	16 28.9	---
<i>Epistichum pectinatum</i>		1	---	---	16 28.9	---
<i>Chamaecytisus albus</i>		1	4	11 10.4	10	---
<i>Picris hieracifolia</i> agg.		1	---	---	26 27.1	---
<i>Agropyron intermedium</i> agg.		1	5 4.1	3	32 28.5	---
<i>Asperula cynanchica</i>		1	---	---	16 28.9	---
<i>Campanula bononiensis</i>		1	---	2	16 28.9	---
<i>Nelapycium nemorosum</i>		1	---	1	24 22.6	---
<i>Stipa pennata</i>		1	---	1	16 28.9	---
<i>Nelapycium arvense</i>		1	---	2	16 28.9	---
<i>Limonium pyrenaicum</i>		1	---	---	21 26.4	---
<i>Chamaecytisus austriacus</i>		1	---	---	11 28.0	---
Carici albae-Brometum monocladii						
<i>Buphtalmum salicifolium</i>		1	3	---	5	70 69.0
<i>Carex comensis</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Inula salicina</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Carex alba</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Acinosa alpinus</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Gentiana cruciata</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Arabis hirsuta</i> agg.		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Allium clusianum</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Polygala amara</i> agg.		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Abietis viridifolia</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
<i>Chamaecytisus austriacus</i>		2 1.4	14 13.9	13 6.3	32 17.4	80 44.4
Diagnostical species for more than one cluster						
<i>Cirsium pannonicum</i>		75 49.4	12 11.2	1	---	70