

## Expert system-based classification of semi-natural grasslands in submontane and montane regions of central Slovakia

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### Abstract

The main aim of this paper was to test the national electronic expert system for grassland classification in Slovakia as a tool for grassland classification on a regional data set from an area with high vegetation diversity. The study region comprised five orographic units located in central Slovakia (Starohorské vrchy Mts., Kremnické vrchy Mts., Veľká Fatra Mts., Nízke Tatry Mts. and Zvolenská kotlina Basin). The data set included 411 phytosociological relevés of all grassland types (xero-, subxero- and mesophilous grasslands as well as wet and fen meadows), recorded by the authors between 1980 and 2007. The relevés were classified to associations by the expert system formulated for the Slovak grassland vegetation either according to association definitions or (in case of relevés not matching any association definition) according to the Frequency-Positive Fidelity Index (FPFI). Wetland relevés were classified according to results of a cluster analysis. Diagnostic species from the regional data were compared to diagnostic species derived at the national level from the data including all vegetation units in Slovakia. According to the results, 49% of the relevés classified by the expert system were matched by the association definitions. Xerophilous grasslands were classified within three alliances of the class *Festuco-Brometea*: *Festucion valesiacae*, *Bromo pannonici-Festucion pallentis* and *Diantho lumnitzeri-Seslerion*. The occurrence of these communities in the region is rare, restricted to rocky habitats and steep slopes with shallow soil over calcareous bedrock. Sub-xerophilous grasslands were classified within four associations belonging to the two alliances *Cirsio-Brachypodium pinnati* and *Bromion erecti*. In the study region, these communities are widely distributed mainly in areas built by calcareous bedrock. Mesophilous grasslands are the most common communities in the study region. They were classified within eight associations belonging to four alliances: *Cynosurion cristati*, *Arrhenatherion elatioris* and *Polygono bistortae-Trisetion flavescens* (all of them belonging to the class *Molinio-Arrhenatheretea*) and *Nardo strictae-Agrostion tenuis* (belonging to the class *Nardetea strictae*). Wetland communities belonged to the classes *Phragmito-Magno-caricetea* (alliances *Phragmition communis* and *Glycerio-Sparganion*), *Molinio-Arrhenatheretea* (alliance *Deschampsion cespitosae*) and *Scheuchzerio-Caricetea fuscae* (alliance *Caricion davallianae*). The results demonstrate that the national expert system used can be successfully applied to a heterogeneous regional data set without discarding the particularities of the regional vegetation. The uniqueness of the regional vegetation is reflected in the set of diagnostic species determined at the regional level, which can differ strongly from those estimated at the national level.

### Zusammenfassung: Klassifikation des meso-hemeroben Grünlandes in submontanen Regionen der Zentral-Slowakei mit Hilfe eines elektronischen Expertensystems

Das Hauptziel der vorliegenden Arbeit war es, das nationale elektronische Expertensystem zur Grünlandklassifikation in der Slowakei als ein Mittel zur Klassifikation von Grünland-Vegetation an einem regionalen Datensatz aus einer Region mit hoher Diversität der Vegetation zu testen. Das Untersuchungsgebiet umfasste fünf Höheneinheiten der zentralen Slowakei (Starohorské vrchy Gebirge, Kremnické vrchy Gebirge, Veľká Fatra Gebirge, Nízke Tatry Gebirge und Zvolenská kotlina Becken). Der Datensatz bestand aus 411 pflanzensoziologischen Aufnahmen von allen Grünland-Typen (Trocken-, Halbtrockenrasen und mesophiles Grünland) sowie Feuchtwiesen und Sümpfe, die von den Autoren in den Jahren zwischen 1980 und 2007 aufgenommen wurden. Die Aufnahmen wurden mit Hilfe des Expertensystems Assoziationen zugeordnet, entweder direkt durch die Assoziations-Definitionen oder anhand des *Frequency-Positive Fidelity Index* (FPFI; für Aufnahmen, die von den Definitionen nicht erfasst wurden). Feuchtwiesen wurden mithilfe der Ergebnisse einer Cluster-Analyse klassifiziert. Die diagnostischen Pflanzenarten der regionalen Daten wurden mit den aus der nationalen Klassifikation aller Vegetationstypen der Slowakei abgeleiteten diagnostischen Arten verglichen. Insgesamt wurden 49 % der durch das Experten-System zugeordneten Aufnahmen auch durch die Assoziations-Definitionen erfasst. Die Trockenrasen wurden innerhalb der Klasse *Festuco-Brometea* den drei Verbänden *Festucion valesiacae*, *Bromo pannonici-Festucion pallentis* und *Diantho lumnitzeri-Seslerion*

zugeordnet. Die Vorkommen dieser Vegetationstypen sind in der Region selten und auf felsige Habitate sowie steile Hänge mit flachgründigen Böden über Kalkgestein beschränkt. Halbtrockenrasen wurden vier Assoziationen aus den beiden Verbänden *Cirsio-Brachypodium pinnati* und *Bromion erecti* zugeordnet. Diese Gesellschaften sind im Untersuchungsgebiet weit verbreitet, besonders in Bereichen mit Kalkgestein. Mesophiles Grünland ist im Untersuchungsgebiet am häufigsten. Hier wurden acht Gesellschaften unterschieden, die zu den vier Verbänden *Cynosurion cristati*, *Arrhenatherion elatioris* und *Polygono bistortae-Trisetion flavescens* (in der Klasse *Molinio-Arrhenatheretea*) sowie *Nardo strictae-Agrostion tenuis* (in der Klasse *Nardetea strictae*) gehören. Die Feuchtwiesen wurden den Klassen *Phragmito-Magnocaricetea* (Verbände *Phragmition communis* und *Glycerio-Sparganion*), *Molinio-Arrhenatheretea* (Verband *Deschampsion cespitosae*) und *Scheuchzerio-Caricetea fuscae* (Verband *Caricion davallianae*) zugeordnet. Die Ergebnisse zeigen, dass das nationale Expertensystem erfolgreich auf einen heterogenen, regionalen Datensatz angewendet werden kann, ohne dass dabei die Besonderheiten der regionalen Vegetation vernachlässigt werden. Die Einmaligkeit der regionalen Vegetation spiegelt sich in der Zusammensetzung der regionalen diagnostischen Arten, die sich stark von denen der Klassifikation auf nationaler Ebene unterscheiden können.

**Keywords:** diagnostic species, *Festuco-Brometea*, formalised classification, *Molinio-Arrhenatheretea*, *Nardetea strictae*, phytosociology, regional synthesis, supervised classification, Slovakia.

## 1. Introduction

The wide surroundings of the city Banská Bystrica in central Slovakia are characterised by a variety of landscape types with well-developed habitat diversity. Grasslands belong to the most diverse habitats reflecting the miscellaneous geological and topographical structures as well as the manifold ways of human impact. The broken relief in the area, unsuitable for grassland intensification, was an important condition for development and maintenance of valuable semi-natural grassland communities. Several of the local grassland types are specific of the Carpathian mountain ranges built by carbonates, e.g. *Carici albae-Brometum monocladi* (described by UJHÁZY et al. 2007 from Muránska planina Mts.), *Lilio bulbiferae-Arrhenatheretum elatioris* and *Campanulo glomeratae-Geranietum sylvaticae* (both described by RUŽIČKOVÁ 2002 from Starohorské vrchy Mts.). Together with the *Violo sudeticae-Agrostietum capillaris* (UJHÁZY & KLIMENT 2007), these associations have their distribution centres in central Slovakian montane regions. The diversity of grassland vegetation together with the abundance of numerous specific associations were the main motives to select the central Slovakian montane regions for this detailed phytosociological overview.

In spite of a long tradition of floristic research in this region (reviewed by FUTÁK 1943), a systematic phytosociological research has been performed here only during the last 30 years. Older phytosociological studies are available from areas partly intersecting the study region (SILLINGER 1933, GREBENŠČIKOV 1956, JURKO 1970). However, the collected phytosociological material has never been synthesised and presented in a comprehensive study. Only a stratified subset was included in the analyses during the national synthesis of the Slovak grassland vegetation (JANIŠOVÁ 2007). Moreover, several recent relevés have been published in local periodicals and workshop proceedings (KOCHJAROVÁ 1997, JANIŠOVÁ & UHLIAROVÁ 2008, JANIŠOVÁ 2009).

Since the rapid development of electronic tools for data analyses, the phytosociological research is focussing on the elaboration of objective, unequivocal and comprehensive methods to classify plant communities. An increasing formalisation of classification procedures resulted in the development of electronic expert systems for the identification of plant communities at the level of associations (CHYTRÝ 2007, JANIŠOVÁ 2007). These expert systems are based on association definitions based on the presence of sociological species groups (BRUELHEIDE 1995) and species dominance criteria. In the definitions, the formulated criteria are connected by logical operators (BRUELHEIDE 1997). During the identification procedure, each phytosociological relevé is ordered to an association either precisely (if it fulfils the definition criteria) or according to values of the similarity indices calculated for each of the defined associations. The application of an expert system reduces the role of the researcher to the critical assessment of classification results (in the case of relevés matched

by a definition) or the decision between several most similar associations (in the case of non-matching relevés), respectively.

To be effective and robust, the definitions should be prepared from a large data set including all vegetation types and covering an extensive geographical area. As it is known, classification results and delimitation of syntaxa depend on the geographical extent of the study (DIEKMANN 1997, JANDT 1999, KNOLLOVÁ & CHYTRÝ 2004, KUŽELOVÁ & CHYTRÝ 2004, KNOLLOVÁ et al. 2006). As a result, many local classifications of ecologically delimited units are not applicable on a regional scale, and vice versa, the geographically delimited vegetation units of broad-scale classifications are often difficult to recognise locally (KUŽELOVÁ & CHYTRÝ 2004). After the expert system for identification of grassland communities had been prepared at the national level (JANIŠOVÁ 2007), the demand for its application at lower than national level has risen. Both regional and local data sets provide valuable material for testing the appropriateness of this expert system for the evaluation of local and regional vegetation diversity. The application of broadly accepted criteria formulated at the national level to a regionally restricted data set brings important information on the quality and representativeness of these criteria. In this paper, we tried to apply the expert system for Slovak grassland vegetation on a regional data set. We provide indications for further formalisation of this application procedure in order to reduce or even to rule out subjective decisions during the classification process.

The aims of this paper can be summarised as follows:

1. to provide a synthesis of grassland vegetation in the study region and to characterise the occurring syntaxa floristically, ecologically and chorologically;
2. to test the national electronic expert system as a tool for grassland classification on a regional data set from an area with a high vegetation diversity;
3. to compare the delimitation of presented syntaxa by diagnostic species based on the national and regional classifications.

## 2. Material and methods

### 2.1. Study area

The study area is located in the wide surroundings of Banská Bystrica, situated on the right side of the Hron River, mainly towards the north and the west of the city (Fig. 1). Colline to montane areas of the following orographical units were included: Starohorské vrchy Mts., Kremnické vrchy Mts., Veľká Fatra Mts., Nízke Tatry Mts., Zvolenská kotlina Basin. The left side part of the Hron river valley was not included. The study area extends from 48° 39' 30" to 48° 59' 30" northern latitude and from 19° 00' 00" to 19° 19' 00" eastern longitude. The altitude of the studied grasslands ranges from 350 to 1225 m a.s.l., but the vast majority of relevés was collected between 400 and 900 m a.s.l. The study area has a diverse geological structure involving calcareous (limestone and dolomite), volcanic (andesite) and crystalline (orthogneiss) bedrock types as well as quartzite, claystone and diluvial and colluvial deposits of the Quaternary period. Among the soil types, cambisols and rendzinas are most common. In the colline part of the area, the climate is moderately warm (the average temperature during the growing season is 12–15 °C) and moderately wet (evapotranspiration exceeds precipitation during the growing season). The montane parts of the study area belong to regions with cold to very cold (the average temperature during the growing season is 10–13 °C) and wet climate (precipitation exceeds evapotranspiration during the growing season, DŽATKO et al. 1989).

### 2.2. Phytosociological sampling

A systematic phytosociological sampling was performed during 1996–2007 in selected regions within the study area (mostly Starohorské vrchy Mts., Kremnické vrchy Mts. and Zvolenská kotlina Basin). To encompass the overall variability of grassland communities in the study area, all semi-natural grassland communities have been recorded including dry and mesophilous grasslands, as well as wet and fen meadows. The main criterion for inclusion of given grassland types in our study was their occurrence

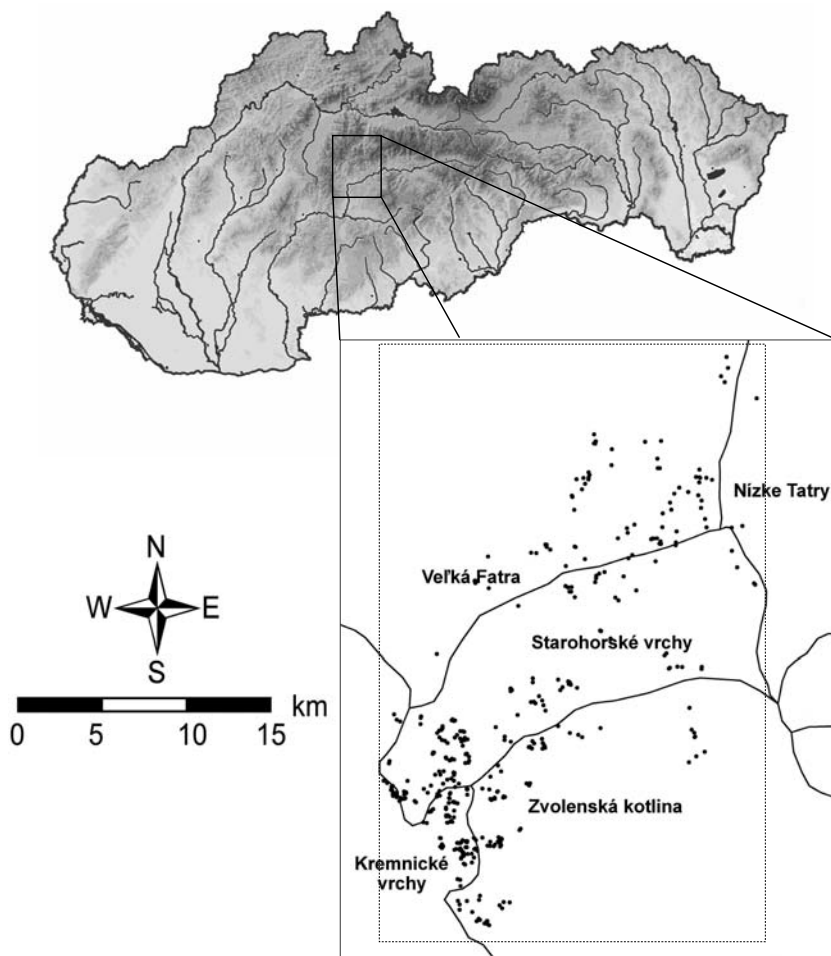


Fig. 1: Location of the phytosociological relevés (dots) in geomorphological districts of Slovakia. The broken line indicates the area presented in Figures 8, 9 and 10.

Abb. 1: Fundorte der pflanzensoziologischen Aufnahmen (Punkte) in den geomorphologischen Distrikten der Slowakei. Die gestrichelte Linie entspricht dem Kartenausschnitt der Abbildungen 8, 9 und 10.

within a spatial complex of semi-natural grasslands in the study region. Additionally, older relevés were included in our data set recorded by H. Ružičková between 1980 and 2001 in submontane and montane mesophilous grasslands of Veľká Fatra Mts. and Nízke Tatry Mts. Some of them were already published in RUŽIČKOVÁ (2002), where two new associations have been described, which are specific for this region. Three relevés were taken from KOCHJAROVÁ (1997). The joint data set contained 411 relevés of all dry, mesophilous and wet semi-natural grassland communities. Although the number of wetland relevés in our data set is considerably lower in comparison to other grassland types, we included them in our analyses because (i) they are rare in the study area and poorly documented; (ii) we aimed at presenting the full heterogeneity of semi-natural grassland communities in the study area.

All relevés were sampled according to the principles of Zurich-Montpelier school (BRAUN-BLANQUET 1964, DENGLER et al. 2008). Some older relevés lack precise geographical coordinates. Still, most relevés were marked on detailed maps of the scale 1:10,000 immediately after recording, so their location is rather precise. Plot size varied from 16 to 30 m<sup>2</sup>, most of the relevés being sampled on 25 m<sup>2</sup>. As non-vascular plants have been recorded in only 20% of the relevés, some statistical analyses (cluster analyses, detrended correspondence analyses) were based on vascular plant records only.

### 2.3. Data analysis

The relevé affiliation to associations of all xerophilous, sub-xerophilous and mesophilous grassland types was determined by an electronic expert system (JANIŠOVÁ 2007). This expert system is based on a classification scheme that was created after the critical revision of traditional classification (MUCINA & MAGLOCKÝ 1985) used for the grassland vegetation in Slovakia. The revision was based on the analysis of a large data set containing 32,729 phytosociological relevés 11,552 of which belonged to the grassland communities originally assigned to the *Molinio-Arrhenatheretea*, the *Festuco-Brometea* or the *Nardetea strictae*, respectively. The stratified data set was used to generate sociological species groups by the COCKTAIL method (BRUELHEIDE 2000). Sociological species groups together with dominance of important species have been used to formulate the definitions of associations using logical operators (BRUELHEIDE 1997). The definitions of the associations in the study area are given in Appendix A, while the relevant sociological species groups are listed in Appendix B.

For example, the formal definition of the association *Scabioso ochroleuca-Brachypodium pinnati* is:

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

Accordingly, a relevé will be assigned to this association if it contains either the group *Cirsium acaule* or the group *Scabiosa ochroleuca* and when the cover of the species *Brachypodium pinnatum* exceeds 5%. At the same time, none of groups *Carex humilis*, *Cirsium pannonicum*, *Onobrychis viciifolia* and *Polygala major* should be present, and the cover of species *Festuca rupicola* should not be higher than 25%. A sociological group is considered to be represented in the relevé if the relevé contains at least half of all species of the group.

Phytosociological relevés from the study region were identified according to the Slovak expert system in several steps. 1) Relevés matched by a single definition were assigned to the respective associations. 2) Relevés matched by more than one association definition were assigned to the association with the highest similarity according to the Frequency-Positive Fidelity Index (FPFI; TICHÝ 2005). 3) Relevés not matching the definitions were assigned to syntaxa according to their similarity (FPFI) in two possible ways: 3a) A relevé with the highest FPFI value to any association detected in the study region by an exactly identified relevé (i.e. one matched by definition) was ordered directly to this association. 3b) A relevé with the highest FPFI value to an association which was not documented from the study region by an exactly matched relevé was ordered to the association with either the second or the third highest FPFI value provided that this association was documented from the study region. This approach was selected in order to avoid the acceptance of syntaxa which are not typically developed in the region. On the other hand, we wanted to prevent the exclusion of transitional and untypical relevés from our data set and classification. As a result, we assigned the non-matching relevés according to similarity indices exclusively to syntaxa well documented from the region.

The wetland vegetation was classified with a numerical classification method because some of the wetland communities (communities of the alliances *Phragmition communis* and *Glycerio-Sparganion*) are not included in the recently developed expert systems (JANIŠOVÁ et al. 2007, DÍTĚ et al. 2007). We used the Bray-Curtis distance measure and  $\beta$ -flexible group linkage method with  $\beta = -0.25$  (PC-ORD 5; MCCUNE & MEFFORD 1999). Square-root transformed cover data of vascular plants were used for the analysis. The number of distinguished clusters was set to nine as at this division level most important relevé groups were separated and could be recognised as associations. The syntaxonomical position of individual clusters was identified according to the published literature (HAJEK & HABEROVÁ 2001, OŤAHELOVÁ et al. 2001, DÍTĚ et al. 2007). Not all clusters could be considered as associations. Two clusters were evaluated as transitional communities between wet and fen meadows (in the synoptic table – Table 1 – they are joined), and one cluster was assigned at the alliance level to the *Caricion davallianae* without distinguishing individual associations.

### 2.4. Evaluation of diagnostic species

Diagnostic species of identified syntaxa were determined from the regional data set with the program JUICE (TICHÝ 2002) after standardising the size of all relevé groups to  $1/n$  of the total size of data set (with  $n$  being the number of syntaxa, i.e.  $1/23 = 4\%$  for associations and  $1/14 = 7\%$  for alliances) and setting the phi coefficient threshold 0.20 (0.25 for alliances). Fisher's exact test ( $\alpha = 0.001$ ) was used to exclude those species from the lists of diagnostic species that only showed a non-significant concentration in the respective unit (CHYTRÝ et al. 2002, CHYTRÝ 2007). Species with a frequency higher than

70% were listed as constant, and species covering more than 25% in at least 5% of relevés were listed as dominant. In the characteristics of individual syntaxa and in the synoptic table, diagnostic species with  $\phi > 0.35$  (0.40 for alliances), constant species with a frequency above 85% and species dominant (i.e. cover over 25%) in more than 25% of relevés are printed in bold. The diagnostic species were determined only for associations with more than 7 relevés. The calculation of diagnostic species of an alliance was based on relevés assigned to individual associations of a given alliance; diagnostic species for monotypic alliances (with only one association in the region) were not presented. In the descriptions of the syntaxa, the diagnostic, constant and dominant species are listed alphabetically.

## 2.5. Main environmental gradients

To visualise the variability of the studied vegetation and relationships among individual associations and species, we performed detrended correspondence analyses (DCAs) with the program package CANOCO 4.5 (TER BRAAK & ŠMILAUER 2002). For the interpretation of the main environmental gradients, average non-weighted indicator values for light, temperature, continentality, soil reaction, moisture and nutrients (ELLENBERG et al. 1992) were calculated for the relevés, and these variables were used supplementary in the ordination graphs.

## 2.6. Nomenclature

Plant species nomenclature follows MARHOLD & HINDÁK (1998). Several species were merged to supraspecific taxa (agg., sect.) for the analyses: *Achillea millefolium* agg. (*A. collina*, *A. millefolium*, *A. pannonica*), *Campanula rotundifolia* agg. (*C. moravica*, *C. rotundifolia*), *Carex muricata* agg. (*C. pairei*, *C. spicata*), *C. flæva* agg. (*C. flæva*, *C. lepidocarpa*), *Dorycnium pentaphyllum* agg. (*D. germanicum*, *D. herbaceum*), *Drepanocladus revolvens* agg. (*D. cossonii*, *D. revolvens*), *Galium mollugo* agg. (*G. album*, *G. mollugo*), *Jacea phrygia* agg. (*J. phrygia*, *J. pseudophrygia*), *Koeleria pyramidata* agg. (*K. macrantha*, *K. pyramidata*), *Luzula campestris* agg. (*L. campestris*, *L. multiflora*), *Molinia caerulea* agg. (*M. arundinacea*, *M. caerulea*), *Myosotis scorpioides* agg. (*M. laxiflora*, *M. nemorosa*, *M. scorpioides*), *Poa pratensis* agg. (*P. angustifolia*, *P. pratensis*), *Potentilla arenaria* agg. (*P. arenaria*, *P. tabernaemontani*), *Scilla bifolia* agg. (*S. bifolia*, *S. bueckensis*). Nomenclature of syntaxa follows JANIŠOVÁ (2007) for dry and mesophilous grasslands and VALACHOVIČ (2001) for the wetland communities.

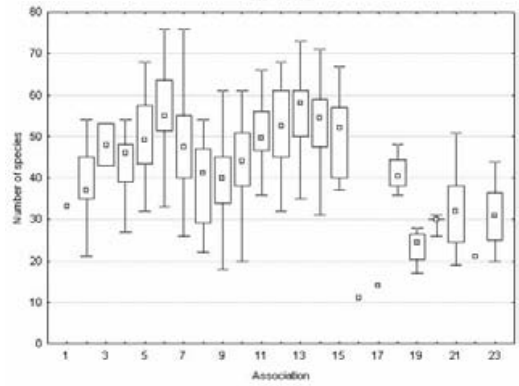
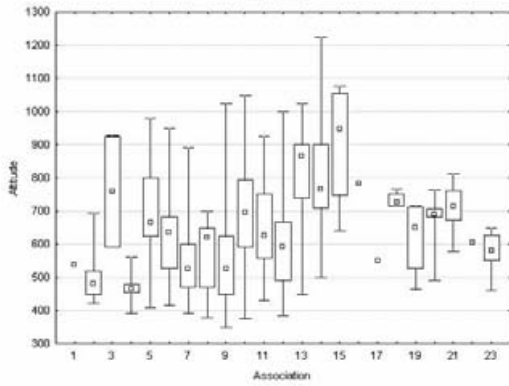
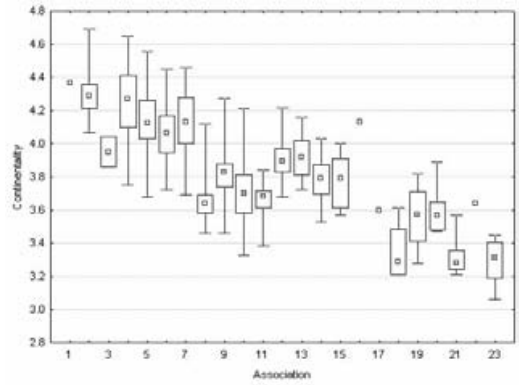
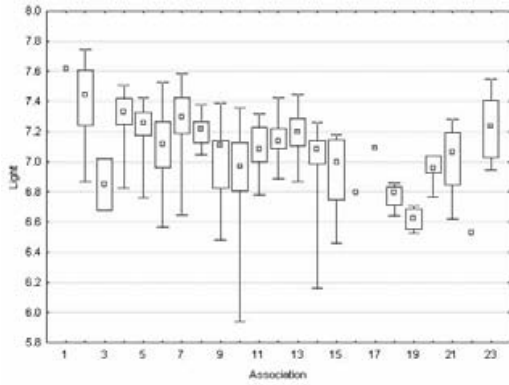
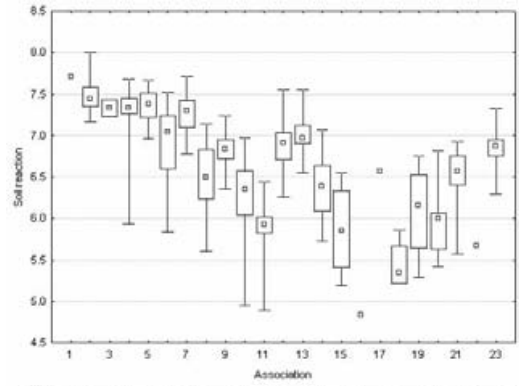
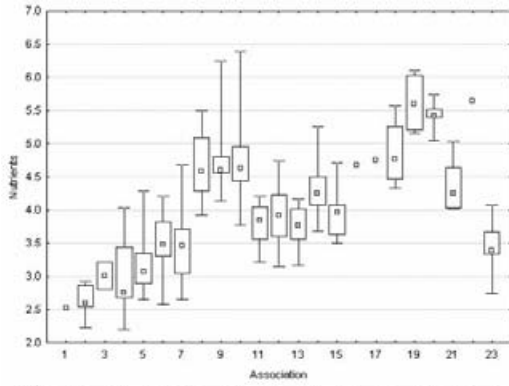
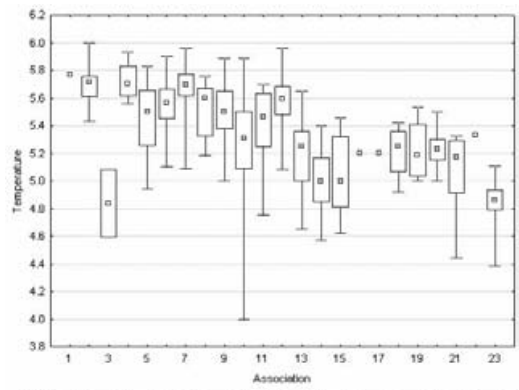
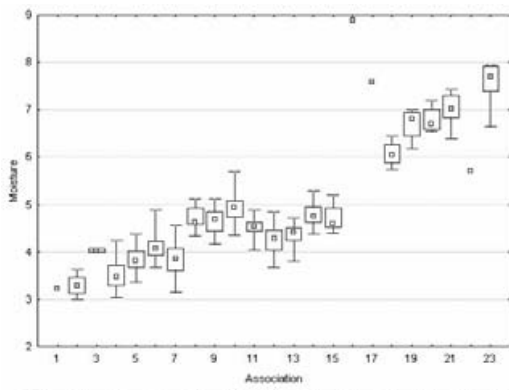
## 3. Results

### 3.1. Application of the expert system to the studied data set

Out of 379 relevés of xero-, sub-xero- and mesophilous grasslands, 187 (49%) were matched by at least one association definition (two of them were concurrently matched by two associations). Out of 192 non-matching relevés, 165 were assigned to associations based on the FPGI similarity index as these relevés showed the highest similarity to associations

Fig. 2: Comparison of the studied associations with respect to non-weighted Ellenberg indicator values calculated for relevés, to altitude (in m a.s.l.) and species richness (of vascular plants per 16–30 m<sup>2</sup>). Median values, quartiles and ranges are shown. Associations are numbered as follows: 1 *Festuco rupicola*-*Caricetum humilis*, 2 *Festuco pallentis*-*Seslerietum calcariae*, 3 *Orphantho luteae*-*Caricetum humilis*, 4 *Scabioso ochroleuca*-*Brachypodietum pinnati*, 5 *Carici albae*-*Brometum monocladi*, 6 *Brachypodio pinnati*-*Molinietum arundinaceae*, 7 *Onobrychido vicifoliae*-*Brometum erecti* (all *Festuco*-*Brometea*), 8 *Lolio perennis*-*Cynosuretum cristati*, 9 *Pastinaco sativae*-*Arrhenatheretum elatioris*, 10 *Poo-Trisetetum flavescentis*, 11 *Anthoxantho odorati*-*Agrostietum tenuis*, 12 *Ranunculo bulbosi*-*Arrhenatheretum elatioris*, 13 *Lilio bulbiferi*-*Arrhenatheretum elatioris*, 14 *Campanulo glomeratae*-*Geranietum sylvatici* (all *Molinio*-*Arrhenatheretea*), 15 *Violo sudeticae*-*Agrostietum capillaris* (*Nardetea strictae*), 16 *Typhetum latifoliae*, 17 *Glycerietum nemoralis-plicatae* (both *Phragmito*-*Magnocaricetea*), 18 *Poo trivialis*-*Alopecuretum pratensis*, 19 *Cirsietum rivularis*, 20 *Scirpetum sylvatici*, 21 *Filipendulo ulmariae*-*Menthetum longifolia* (all *Molinio*-*Arrhenatheretea*), 22 transitional stands between wet and fen meadows, 23 *Caricion daxallianae* (*Scheuchzerio*-*Caricetea*).

Abb. 2: Vergleich der untersuchten Assoziationen im Hinblick auf Ellenberg-Zeigerwerte (ungewichtete Mittel je Aufnahme berechnet), Meereshöhe (in m. ü. NN) und Artenzahl (Gefäßpflanzen pro 16–30 m<sup>2</sup>). Dargestellt sind jeweils Median, Quartile und Spannweite. Zur Bedeutung der Assoziationsnummern vgl. englische Abbildungsunterschrift.



confirmed for the region by at least one relevé matched by the definition. The rest of the data set – 27 relevés (7%) – exhibited the highest similarity to associations which were not documented for the study region in the published literature and whose recent occurrence in the region was also not confirmed unequivocally by a matched relevé. Most of these disputable relevés belonged to montane grasslands and showed the highest similarity to the *Geranio sylvatici-Trisetetum flavescens* (20 relevés) or to the *Campanulo rotundifoliae-Dianthetum deltoidis* (6 relevés). As none of these associations were recorded in the study region or its vicinity (HEGEDŮŠOVÁ & RUŽIČKOVÁ 2007, UJHÁZY 2007), the relevés under consideration were assigned to the association with the second or the third highest FPF value, provided that this association is well documented in the study region.

Altogether, the xero- to mesophilous grasslands in our data set were assigned to 15 associations by the expert system used, belonging to nine alliances and three classes. The xerophilous grasslands were classified within three alliances of the *Festuco-Brometea*: *Festucion valesiacae*, *Bromo pannonici-Festucion pallentis* and *Diantho lumnitzeri-Seslerion*. The occurrence of these communities in the region is rare, restricted to rocky habitats and steep slopes with shallow soil over calcareous bedrock. The only association with slightly higher frequency is the *Orthantho luteae-Caricetum humilis*. Sub-xerophilous grasslands were classified within four associations belonging to the two alliances *Cirsio-Brachypodium pinnati* and *Bromion erecti* of the *Festuco-Brometea*. In the study region, these communities are widely distributed mainly in areas with calcareous bedrock. Mesophilous grasslands are the most common communities in the study region. They were classified within eight associations belonging to four alliances: *Cynosurion cristati*, *Arrhenatherion elatioris* and *Polygono bistortae-Trisetion flavescens* (all of them belonging to the class *Molinio-Arrhenatheretea*) and *Nardo strictae-Agrostion tenuis* (belonging to the class *Nardetea strictae*). Most relevés were assigned to the *Poo-Trisetetum flavescens* and *Ranunculo bulbosi-Arrhenatheretum elatioris*, which are the two most common grassland communities in the study region.

Wetland communities were classified according to the results of the cluster analysis. They belong to the classes *Phragmito-Magnocaricetea* (alliances *Phragmition communis* and *Glycerio-Sparganion*), *Molinio-Arrhenatheretea* (alliance *Deschampsion cespitosae*) and *Scheuchzerio-Caricetea fuscae* (alliance *Caricion davallianae*).

## 3.2. Description of the syntaxa

### 3.2.1. Xerophilous and mesophilous grassland communities

**Class *Festuco-Brometea*** (Table 1: 1–7, Table 2, Figs. 2, 3, 4 and 5)

**Alliance *Festucion valesiacae***

**Association *Festuco rupicola-Caricetum humilis***

Number of relevés: 1 (1 matched by the definition)

Table 1: 1, Table 2, relevé 1, Fig. 5A (black triangle).

This association represents the transition of typical dry grasslands of the *Festucion valesiacae* to sub-xerophilous communities of the *Bromion erecti* and *Cirsio-Brachypodium pinnati*. Only one relevé fulfilled the criteria of this association, thus the diagnostic species were neither ascribed to the association nor to the alliance. The only stand occurred on dolomite covered by rendzina soil, rich in gravel. The stand is rather open (cover 60%) and dominated by *Festuca rupicola* and *Koeleria macrantha*. In general, this association is poor in diagnostic species, most of them being common dry grassland species diagnostic also for the class *Festuco-Brometea* (JANIŠOVÁ 2007). In our relevé, the following diagnostic species of the national level occurred: *Asperula cynanchica*, *Bothriochloa ischaemum*, *Festuca rupicola*, *Koeleria macrantha*, *Sanguisorba minor*, *Scabiosa ochroleuca* and *Teucrium chamaedrys*. Other more abundant species were *Carex caryophylla*, *Helianthemum ovatum*, *Jovibarba globifera*, *Poa compressa* and *Potentilla arenaria* agg. The moss layer was well developed (30% cover). Although this association is rare in the study area (Fig. 5A), it frequently occurs in the adjacent region situated at lower altitudes on the left side of Hron River in the Zvolenská kotlina Basin (MICHÁLKOVÁ 2007).



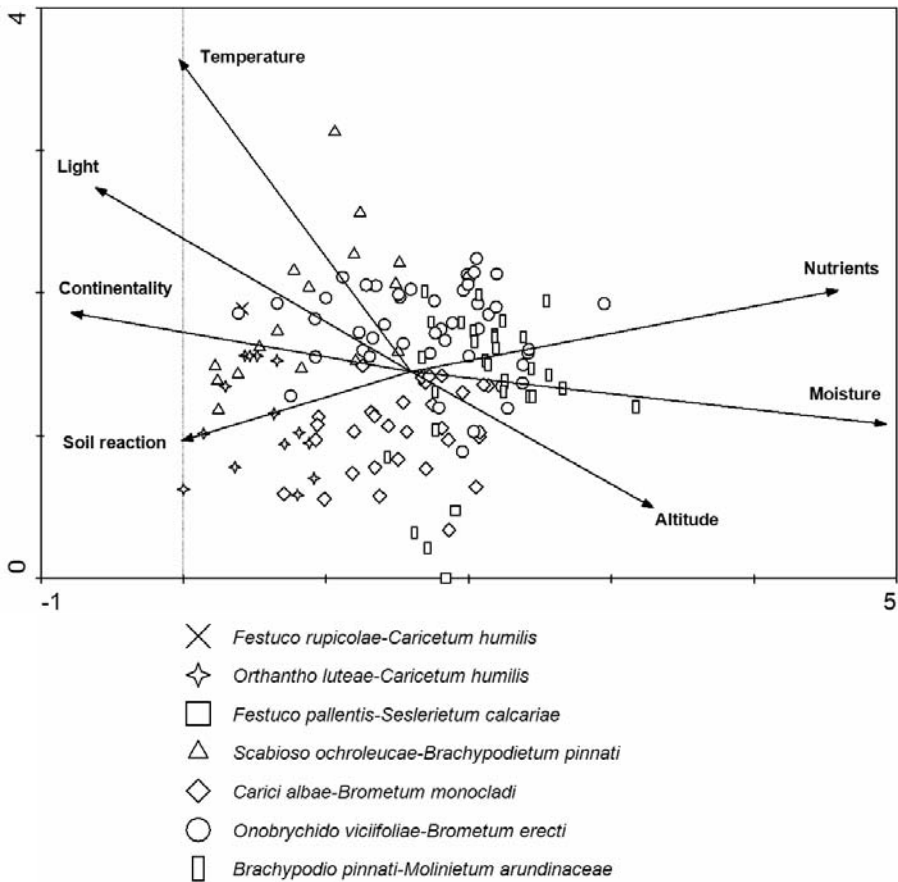


Fig. 3: Detrended correspondence analysis (DCA) of dry and semi-dry grasslands belonging to the class *Festuco-Brometea* based on square-root transformed cover data of the herb layer. Supplementary environmental variables represent unweighted average Ellenberg indicator values and altitude.

Abb. 3: Trendbereinigte Korrespondenzanalyse (DCA) der Trocken- und Halbtrockenrasen der Klasse *Festuco-Brometea*, basierend auf den quadratwurzel-transformierten Deckungsgraden der Krautschicht. Die zusätzlichen Umweltvariablen sind ungewichtete mittlere Ellenberg-Zeigerwerte sowie Höhenlage.

### Alliance *Diantho lumnitzeri-Seslerion*

#### Association *Festuco pallentis-Seslerietum calcariae*

Number of relevés: 2 (2 matched by the definition)

Table 1: 2, Table 2, relevés 2–3, Fig. 5A (black diamonds).

The stands of this association represent a relict community dominated by *Sesleria albicans*. In the study region, they are very rare (Fig. 5A), and they are documented by only two relevés in our dataset. From the diagnostic species of the national level, the following also occurred in our relevés: *Acinos alpinus*, *Galium pumilum* agg., *Genista pilosa*, *Hippocrepis comosa*, *Leontodon incanus*, *Phyteuma orbiculare*, *Polygala amara* ssp. *brachyptera*, *Sesleria albicans* and *Teucrium chamaedrys*. The occurrence of *Bellidiastrum michelii* and *Pulsatilla subslavica* in the region is restricted to this association. Likewise, in all Slovakia, this community is bound to calcareous bedrock. The localities in the study region are situated at the eastern border of the overall distribution of the association. Several other localities can be found in the adjacent part of the Horehronské podolie Valley (BALAŽ 1991).

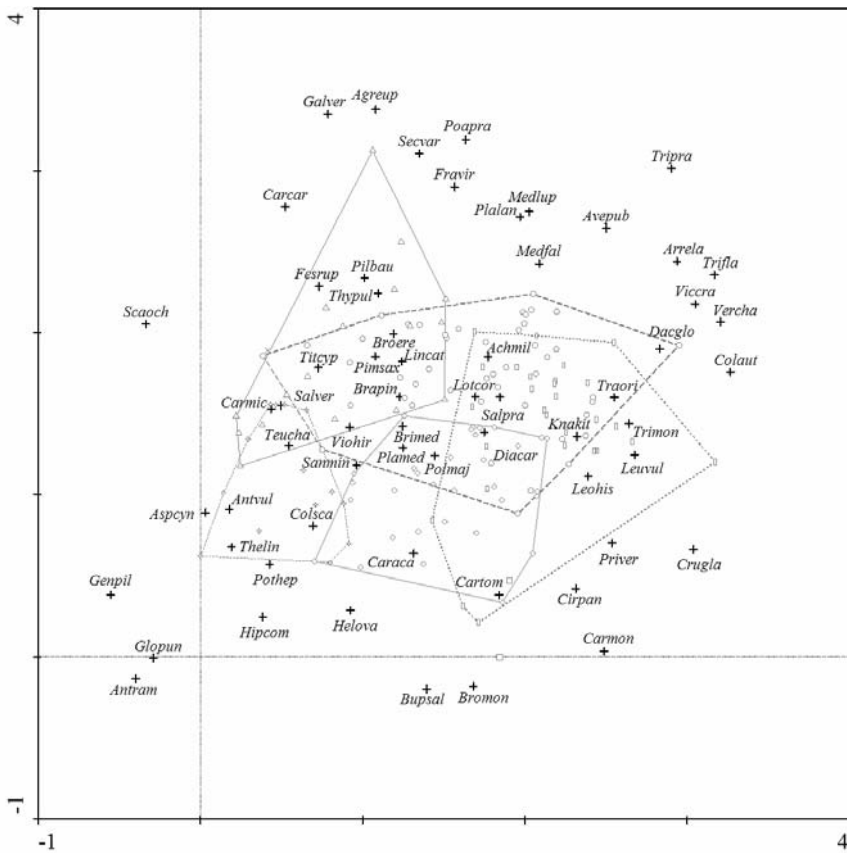


Fig. 4: Detrended correspondence analysis (DCA) of dry and semi-dry grasslands belonging to the class *Festuco-Brometea*. Envelopes are drawn around relevés belonging to individual associations (see Fig. 3 for symbols explanation). 61 species with weight over 12 are shown, the abbreviations are as follows: Agreup – *Agrimonia eupatoria*, Achmil – *Achillea millefolium* agg., Antram – *Anthericum ramosum*, Antvul – *Anthyllis vulneraria*, Arrela – *Arrhenatherum elatius*, Aspbyn – *Asperula cynanchica*, Avepub – *Avenula pubescens*, Brapin – *Brachypodium pinnatum*, Brimed – *Briza media*, Broere – *Bromus erectus*, Bromon – *Bromus monocladus*, Bupsal – *Bupthalmum salicifolium*, Caraca – *Carlina acaulis*, Carcar – *Carex caryophylla*, Carmic – *Carex michelii*, Carmon – *Carex montana*, Cartom – *Carex tomentosa*, Cirpan – *Cirsium pannonicum*, Colaut – *Colchicum autumnale*, Colscabiosa – *Colymbada scabiosa*, Crugla – *Cruciata glabra*, Dacglo – *Dactylis glomerata*, Diacar – *Dianthus carthusianorum*, Fesrup – *Festuca rupicola*, Fravir – *Fragaria viridis*, Galver – *Galium verum*, Genpil – *Genista pilosa*, Glopun – *Globularia punctata*, Hipcom – *Hippocrepis comosa*, Knakit – *Knautia kitabelii*, Leohis – *Leontodon hispidus*, Leuwul – *Leucanthemum vulgare*, Lincat – *Linum catharticum*, Lotcor – *Lotus corniculatus*, Medfal – *Medicago falcata*, Medlup – *Medicago lupulina*, Pilbau – *Pilosella baubii*, Pimsax – *Pimpinella saxifraga*, Plalan – *Plantago lanceolata*, Plamed – *Plantago media*, Poapra – *Poa pratensis* agg., Polmaj – *Polygala major*, Pothep – *Potentilla heptaphylla*, Priver – *Primula veris*, Salpra – *Salvia pratensis*, Salver – *Salvia verticillata*, Sanmin – *Sanguisorba minor*, Scaoch – *Scabiosa ochroleuca*, Secvar – *Securigera varia*, Teucha – *Teucrium chamaedrys*, Thelin – *Thesium linophyllum*, Thypul – *Thymus pulegioides*, Titcyp – *Tithymalus cyparissias*, Traori – *Tragopogon orientalis*, Trifla – *Trisetum flavescens*, Trimon – *Trifolium montanum*, Triptra – *Trifolium pratense*, Vercha – *Veronica chamaedrys*, Viccra – *Vicia cracca*, Viobir – *Viola hirta*.

Abb. 4: Trendbereinigte Korrespondenzanalyse (DCA) der Trocken- und Halbtrockenrasen der Klasse *Festuco-Brometea*. Die eingezeichneten Gruppen zeigen die Zugehörigkeit der Aufnahmen zu den einzelnen Assoziationen (Erläuterung der Symbole s. Abb. 2). 61 Arten mit Artwerten über 12 sind dargestellt, für die Erklärung der Abkürzungen vgl. englische Abbildungsunterschrift.

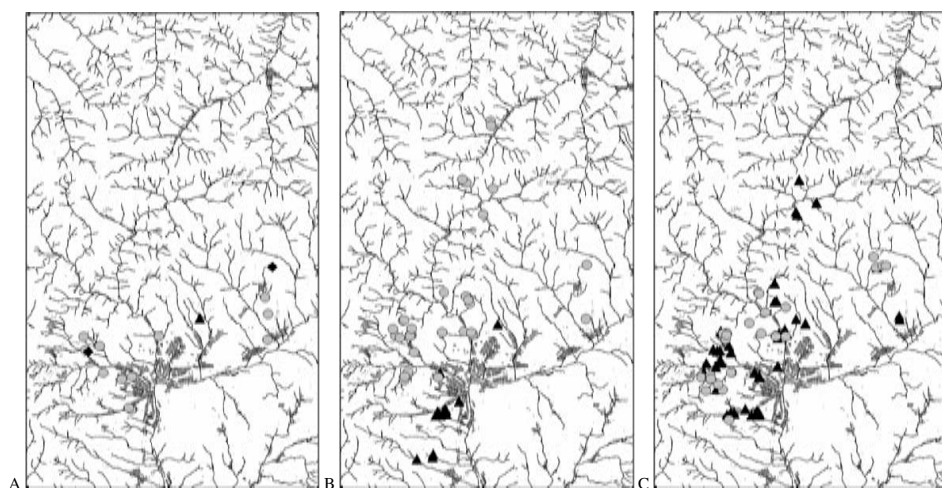


Fig. 5: Distribution of associations in the study area I: A) *Festuco rupicolae*-*Caricetum humilis* (black triangle), *Orthantho luteae*-*Caricetum humilis* (grey circles) and *Festuco pallentis*-*Seslerietum calcariae* (black diamonds); B) *Scabioso ochroleuca*-*Brachypodietum pinnati* (black triangles) and *Carici albae*-*Brometum monocladi* (grey circles); C) *Onobrychido viciifoliae*-*Brometum erecti* (black triangles) and *Brachypodio pinnati*-*Molinietum arundinaceae* (grey circles).

Abb. 5: Verbreitung der Assoziationen im Untersuchungsgebiet I: A) *Festuco rupicolae*-*Caricetum humilis* (schwarze Dreiecke), *Orthantho luteae*-*Caricetum humilis* (graue Kreise) und *Festuco pallentis*-*Seslerietum calcariae* (schwarze Rauten); B) *Scabioso ochroleuca*-*Brachypodietum pinnati* (schwarze Dreiecke) und *Carici albae*-*Brometum monocladi* (graue Kreise); C) *Onobrychido viciifoliae*-*Brometum erecti* (schwarze Dreiecke) und *Brachypodio pinnati*-*Molinietum arundinaceae* (graue Kreise).

### Alliance *Bromo pannonici*-*Festucion pallentis*

#### Association *Orthantho luteae*-*Caricetum humilis*

Number of relevés: 14 (1 matched by the definition)

Table 1: 3, Table 2, relevés 4–17, Fig. 5A (grey circles), Fig. 6.

**Diagnostic species:** *Anthericum ramosum*, *Asperula cynanchica*, *Bupleurum falcatum*, *Carex humilis*, *Carlina vulgaris*, *Colymbada scabiosa*, *Genista pilosa*, *Globularia punctata*, *Helianthemum ovatum*, *Hippocrepis comosa*, *Leontodon incanus*, *Linum flaxum*, *Pinus sylvestris*, *Potentilla arenaria* agg., *Pseudolysimachion spicatum*, *Scabiosa ochroleuca*, *Seseli annuum*, *Teucrium chamaedrys*, *Thesium lino-phylon*, *Tithymalus cyparissias*.

**Constant species:** *Anthericum ramosum*, *Asperula cynanchica*, *Brachypodium pinnatum*, *Colymbada scabiosa*, *Festuca rupicola*, *Genista pilosa*, *Globularia punctata*, *Helianthemum ovatum*, *Hippocrepis comosa*, *Salvia pratensis*, *Sanguisorba minor*, *Scabiosa ochroleuca*, *Teucrium chamaedrys*, *Thesium lino-phylon*, *Tithymalus cyparissias*.

**Dominant species:** *Anthericum ramosum*, *Bromus erectus*, *Genista pilosa*.

The occurrence of this community is restricted to the warmest regions in the close vicinity of the Hron River valley at altitudes between 420 and 700 m a.s.l. (Fig. 5A). The bedrock is nearly always dolomitic; only in the vicinity of village Riečka, the community also occurs on quartzites. The localities are typically situated on south- or southwest-facing slopes. The stands are not entirely closed: the cover of the herb layer reaches usually about 80%, the moss layer is usually species-rich with a cover of up to 80%. In the past, stands of this association commonly have been grazed at least occasionally. Recently, most localities are abandoned, and the succession by woody species contributes to their slow, but continuous degradation. As this community is relict and infrequent also within the whole Slovakia (JANIŠOVÁ 2007), it urgently requires effective conservation.



Fig. 6: The *Orphantho luteae-Caricetum humilis* inhabits steep slopes and rocky hills protruding from the agriculturally used landscape. It is common near the village Slovenská Lupča in the Zvolenská kotlina Basin (Photo: M. Janišová, 7 August 2006).

Abb. 6: Das *Orphantho luteae-Caricetum humilis* besiedelt steile Hänge und felsige Hügel, die aus der landwirtschaftlich genutzten Landschaft herausragen. Die Assoziation ist in der Umgebung des Ortes Slovenská Lupča im Zvolenská kotlina Becken häufig (Foto: M. Janišová, 7. August 2006).



Fig. 7: The of *Scabioso ochroleucae-Brachypodium pinnati* has developed on pastures. Even after abandonment it forms species-rich stands full in colours during summer. Flowering *Dianthus carthusianorum*, *Galium verum*, *Salvia verticillata* and *Securigera varia* in the locality Malachovské skalky (Photo: Eva Uhliarová, 9 July 2006).

Abb. 7: Das *Scabioso ochroleucae-Brachypodium pinnati* hat sich auf beweideten Flächen entwickelt. Auch nach Nutzungsaufgabe bildet es artenreiche Bestände, die im Sommer sehr farbenfroh sind. Blühende *Dianthus carthusianorum*, *Galium verum*, *Salvia verticillata* und *Securigera varia* am Fundort Malachovské skalky (Foto: Eva Uhliarová, 9. Juli 2006).

## Alliance *Cirsio-Brachypodium pinnati*

Number of relevés: 49.

Diagnostic species: *Anthyllis vulneraria*, *Brachypodium pinnatum*, *Bromus monocladus*, *Buphtalmum salicifolium*, *Carex michelii*, *Carex tomentosa*, *Cirsium pannonicum*, *Colymbada scabiosa*, *Cuscuta epithymum*, *Falcaria vulgaris*, *Festuca rupicola*, *Inula salicina*, *Plantago media*, *Salvia verticillata*, *Sanguisorba minor*, *Teucrium chamaedrys*, *Thesium linophyllum*, *Tithymalus cyparissias*, *Vincetoxicum hirundinaria*, *Viola collina*, *Viola hirta*.

Constant species: *Brachypodium pinnatum*, *Briza media*, *Dianthus carthusianorum*, *Festuca rupicola*, *Plantago media*, *Sanguisorba minor*, *Teucrium chamaedrys*, *Thymus pulegioides*, *Tithymalus cyparissias*, *Viola hirta*.

Dominant species: *Anthericum ramosum*, *Bromus erectus*, *Bromus monocladus*, *Genista pilosa*.

In comparison to the *Bromion erecti*, the communities of the *Cirsio-Brachypodium pinnati* are more xerophilous, and their sites are poorer in nutrients and particularly lime-rich (Fig. 3). Both associations of the alliance have developed on localities traditionally used as pastures. They can be regarded as vicariants, with the *Carici albae-Brometum monocladi* replacing the more termophilous *Scabioso ochroleucae-Brachypodietum pinnati* at higher altitudes (Fig. 5B) and thus hosting numerous additional montane species.

## Association *Scabioso ochroleucae-Brachypodietum pinnati*

Number of relevés: 17 (9 matched by the definition)

Table 1: 4, Table 2, relevés 18–34, Fig. 5B (black triangles), Fig. 7.

Diagnostic species: *Acosta rhenana*, *Agrimonia eupatoria*, *Asperula cynanchica*, *Brachypodium pinnatum*, *Bromus erectus*, *Campanula rotundifolia* agg., *Carex caryophyllea*, *Carex michelii*, *Carlina vulgaris*, *Falcaria vulgaris*, *Festuca rupicola*, *Galium verum*, *Genista pilosa*, *Ononis spinosa*, *Picris hieracioides*, *Prunella laciniata*, *Scabiosa ochroleuca*, *Seseli annuum*, *Teucrium chamaedrys*, *Teucrium montanum*, *Thesium linophyllum*, *Tithymalus cyparissias*, *Vicia hirsuta*, *Viola collina*.

Constant species: *Agrimonia eupatoria*, *Achillea millefolium* agg., *Anthyllis vulneraria*, *Brachypodium pinnatum*, *Briza media*, *Bromus erectus*, *Campanula rotundifolia* agg., *Carex caryophyllea*, *Festuca rupicola*, *Galium verum*, *Linum catharticum*, *Pimpinella saxifraga*, *Plantago media*, *Scabiosa ochroleuca*, *Teucrium chamaedrys*, *Thymus pulegioides*, *Tithymalus cyparissias*, *Viola hirta*.

Dominant species: *Anthericum ramosum*, *Bromus erectus*, *Genista pilosa*.

This association comprises closed semi-dry grassland communities occurring predominantly on dolomites and limestones at lower altitudes between 390 and 560 m a.s.l. (Fig. 5B). They are moderately species-rich (usually 40–50 species of vascular plants per 16–25 m<sup>2</sup>) with a well-developed bryophyte layer (40–80%). In the past, these stands were used as pastures, and some of them have at least been slightly grazed until recent days, as indicated by the presence of pasture weeds like *Carlina vulgaris* and *Ononis spinosa*. However, most localities are endangered by succession and due to their attractive situation in the vicinity of Banská Bystrica also by building activities. Within Slovakia, the community is most common at lower altitudes throughout the Carpathian region (ŠKODOVÁ 2007b). Among the semi-dry grasslands detected in the study region, this association is the most xerophilous (Fig. 3), often growing in contact with dry grasslands of the *Orthantho luteae-Caricetum humilis*.

## Association *Carici albae-Brometum monocladi*

Number of relevés: 32 (10 matched by the definition)

Table 1: 5, Table 2, relevés 35–66, Fig. 5B (grey circles), Fig. 8.

Diagnostic species: *Anthericum ramosum*, *Anthyllis vulneraria*, *Brachypodium pinnatum*, *Bromus monocladus*, *Buphtalmum salicifolium*, *Carduus glaucinus*, *Carex michelii*, *Carex montana*, *Carex tomentosa*, *Cirsium pannonicum*, *Colymbada scabiosa*, *Globularia punctata*, *Helianthemum ovatum*, *Hippocrepis comosa*, *Inula ensifolia*, *Inula salicina*, *Knautia kitaibelii*, *Pilosella bauhini*, *Polygonatum odoratum*, *Potentilla heptaphylla*, *Primula veris*, *Prunella grandiflora*, *Pyrethrum corymbosum*, *Salvia pratensis*, *Salvia verticillata*, *Sanguisorba minor*, *Sorbus aria*, *Teucrium chamaedrys*, *Tithymalus cyparissias*, *Trommsdorfia maculata*, *Vincetoxicum hirundinaria*, *Viola hirta*.



Fig. 8: The *Carici albae-Brometum monocladi* occurs usually on steep slopes. Spring aspect with flowering *Salvia pratensis* and *Leucanthemum vulgare* in the village Skubín, Starohorské vrchy Mts. (Photo: M. Janišová, 10 June 2004).

Abb. 8: Das *Carici albae-Brometum monocladi* kommt normalerweise an steilen Hängen vor. Frühjahrsaspekt mit *Salvia pratensis* und *Leucanthemum vulgare* am Dorf Skubín, Starohorské vrchy Berge (Foto: M. Janišová, 10. Juni 2004).



Fig. 9: The *Brachypodio pinnati-Molinietum arundinaceae* belongs to the most species-rich grasslands in the study region. It has developed on deeper soils by regular mowing. Recently almost all localities are abandoned and these beautiful meadows are sentenced to gradual succession and degradation. The picture shows one of best preserved stands in locality near the village Jakub, Starohorské vrchy Mts. with most conspicuous species *Cirsium pannonicum*, *Colymbada scabiosa*, *Pyrethrum corymbosum*, *Rhinanthus serotinus* and *Salvia verticillata* (Photo: M. Janišová, 14 July 2007).

Abb. 9: Das *Brachypodio pinnati-Molinietum arundinaceae* gehört zu den artenreichsten Rasengesellschaften im Untersuchungsgebiet. Es hat sich auf etwas tieferen Böden mit regelmäßiger Mahdnutzung entwickelt. Inzwischen sind fast alle Fundorte ohne Nutzung und diese schönen Wiesen sind zur graduellen Sukzession und Degradation verurteilt. Das Bild zeigt einen der am besten erhaltenen Bestände in der Nähe des Dorfes Jakub, Starohorské vrchy Berge, mit den Arten *Cirsium pannonicum*, *Colymbada scabiosa*, *Pyrethrum corymbosum*, *Rhinanthus serotinus* und *Salvia verticillata* (Foto: M. Janišová, 14. Juli 2007).

Constant species: *Briza media*, *Bromus monocladus*, *Buphthalmum salicifolium*, *Carlina acaulis*, *Dianthus carthusianorum*, *Helianthemum ovatum*, *Knautia kitaibelii*, *Plantago media*, *Primula veris*, *Salvia pratensis*, *Sanguisorba minor*, *Teucrium chamaedrys*, *Viola hirta*.

Dominant species: *Bromus erectus*, *Bromus monocladus*.

In the study region, this association is commonly distributed at altitudes between 410 and 980 m a.s.l. (Fig. 5B), but most localities are above 600 m a.s.l. Thus, numerous montane and dealpine species are present in the stands (*Acinos alpinus*, *Buphthalmum salicifolium*, *Carduus glaucinus*, *Phyteuma orbiculare*, *Thesium alpinum*). The association inhabits steep slopes (mostly 20–40°), where it forms loose stands. The cover of the herb layer usually reaches about 80%, while that of the moss layer is very variable (1–70%). The bedrock is formed by dolomites and limestones (in the surroundings of Riečka village also quartzites); the soils are very shallow. This community is very species-rich (usually 50–60, and up to 68 species per 16–25 m<sup>2</sup>). In the study region, this association has the centre of its distribution. It is also known from Muránska planina Mts. (UJHÁZY et al. 2007), where it is much less frequent.

### Alliance *Bromion erecti*

Number of relevés: 74.

Diagnostic species: *Agrimonia eupatoria*, *Brachypodium pinnatum*, *Bromus erectus*, *Carex michelii*, *Cirsium pannonicum*, *Dianthus carthusianorum*, *Knautia kitaibelii*, *Lathyrus latifolius*, *Medicago falcata*, *Onobrychis viciifolia*, *Pimpinella saxifraga*, *Polygala major*, *Primula veris*, *Pseudolysimachion orchideum*, *Pyrethrum corymbosum*, *Salvia pratensis*, *Salvia verticillata*, *Senecio jacobaea*, *Tithymalus tommasinanus*, *Trifolium montanum*, *Trommsdorfia maculata*, *Viola hirta*.

Constant species: *Achillea millefolium* agg., *Arrhenatherum elatius*, *Bromus erectus*, *Carlina acaulis*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Knautia kitaibelii*, *Lotus corniculatus*, *Medicago falcata*, *Pimpinella saxifraga*, *Plantago media*, *Salvia pratensis*, *Sanguisorba minor*, *Trifolium montanum*.

Dominant species: *Bromus erectus*.

Associations of this alliance represent the most frequent semi-dry grasslands in the study region (Fig. 5C). They occur on deeper soils, rich in nutrients and retaining enough water even during extended droughts (see Fig. 3). In the past, these communities were regularly mown, and those with continued mowing until recent times belong to the most species-rich grasslands within the whole of Slovakia (cf. JANIŠOVÁ & UHLIAROVÁ 2008). The two associations of this alliance do not differ much in their ecological requirements and their species composition, and their distribution ranges overlap to a high extent (Fig. 4, Fig. 5C). If abandoned, the typically species-rich *Brachypodio pinnati-Molinietum arundinaceae* gradually transforms into the species-poorer *Onobrychido viciifoliae-Brometum erecti* (JANIŠOVÁ, ined.).

### Association *Brachypodio pinnati-Molinietum arundinaceae*

Number of relevés: 28 (27 matched by the definition)

Table 1: 6, Table 2, relevés 67–94, Fig. 5C (grey circles), Fig. 9.

Diagnostic species: *Betonica officinalis*, *Brachypodium pinnatum*, *Campanula persicifolia*, *Carex montana*, *Carlina acaulis*, *Cirsium pannonicum*, *Filipendula vulgaris*, *Hypericum perforatum*, *Lathyrus latifolius*, *Medicago falcata*, *Onobrychis viciifolia*, *Polygala major*, *Primula veris*, *Pyrethrum corymbosum*, *Salvia pratensis*, *Scorzonera hispanica*, *Thesium linophyllum*, *Tithymalus cyparissias*, *Trifolium montanum*, *Trommsdorfia maculata*.

Constant species: *Arrhenatherum elatius*, *Brachypodium pinnatum*, *Bromus erectus*, *Carex montana*, *Carlina acaulis*, *Cirsium pannonicum*, *Cruciata glabra*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Knautia kitaibelii*, *Leontodon hispidus*, *Lotus corniculatus*, *Plantago media*, *Primula veris*, *Salvia pratensis*, *Tragopogon orientalis*, *Trifolium montanum*, *Trisetum flavescens*, *Trommsdorfia maculata*.

Dominant species: *Brachypodium pinnatum*, *Bromus erectus*, *Carex montana*.

This community occurs at lower to middle altitudes from 400 to 800 m a.s.l. on gentle as well as steeper slopes (up to 40°). Its distribution is concentrated in the surroundings of the

villages Riečka, Tajov, Jakub and Uľanka, but there is also one isolated locality nearby Podkonice, where this community covers a large deforested mountain ridge at altitudes between 800 and 950 m a.s.l. (Fig. 5C). There is no clear preference to a specific bedrock type: The association develops on calcareous bedrock as well as on claystones and quaternary sediments. Most localities are former meadows, several of which have been mown regularly up to recent times. The stands are usually closed (the cover of the herb layer reaching 90–100%) and rather high (up to 120 cm). The moss layer is well developed with coverages up to 90%, with the species *Thuidium abietinum*, *Rhytidiadelphus squarrosus* and *R. triquetrus* being the most frequent. The stands are extremely species-rich; the number of vascular plant species per 16–25 m<sup>2</sup> commonly exceeds 70. In spite of the fact that this association has its distribution centre in the Biele/Bílé Karpaty Mts. (ŠKODOVÁ 2007a), central Slovakian localities belong to important biodiversity hotspots (HOBOHM 2005) and require strict and effective conservation (JANIŠOVÁ & UHLIAROVÁ 2008).

### Association *Onobrychido viciifoliae*-*Brometum erecti*

Number of relevés: 46 (38 matched by the definition)

Table 1: 7, Table 2, relevés 95–140, Fig. 5C (black triangles).

Diagnostic species: *Agrimonia eupatoria*, *Brachypodium pinnatum*, *Bromus erectus*, *Carex michelii*, *Dianthus carthusianorum*, *Festuca rupicola*, *Knautia kitaibelii*, *Medicago falcata*, *Onobrychis viciifolia*, *Pimpinella saxifraga*, *Polygala major*, *Primula veris*, *Pseudolysimachion orchideum*, *Salvia pratensis*, *Salvia verticillata*, *Sanguisorba minor*, *Securigera varia*, *Trifolium montanum*, *Viola hirta*.

Constant species: *Achillea millefolium* agg., *Arrhenatherum elatius*, *Bromus erectus*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Festuca rupicola*, *Knautia kitaibelii*, *Lotus corniculatus*, *Medicago falcata*, *Pimpinella saxifraga*, *Plantago media*, *Salvia pratensis*, *Sanguisorba minor*, *Trifolium montanum*.

Dominant species: *Bromus erectus*.

These semi-dry grasslands are distributed at altitudes ranging from 400 to 900 m a.s.l., inhabiting gentle to steep slopes (up to 45°) mainly in orchards or nearby human settlements (Fig. 5C). The herb layer typically covers 70–90% and is thus lower than in the former association. Most localities occur on carbonates, but occasionally the association develops on other bedrock, except andesites, where it is completely missing. If mown at least occasionally, the stands remain very species-rich (60–70 species per 16–25 m<sup>2</sup>), otherwise their diversity gradually declines. Abandonment is initially indicated by an increasing dominance of *Bromus erectus* and the loss of rare accessory species. In the later successional stages, *Bromus erectus* becomes mono-dominant, and woody species (mainly *Rosa canina* agg., *Acer pseudoplatanus* and *Carpinus betulus*) encroach the sites. This association represents the transition to mesophilous grasslands of the *Arrhenatherion elatius*, as numerous mesophilous species are constant here, e.g. *Arrhenatherum elatius*, *Dactylis glomerata*, *Trifolium pratense*, *Trisetum flavescens* (cf. Fig. 4). This association is widely distributed in Slovakia and Central Europe (ŠKODOVÁ 2007a).

**Class *Molinio-Arrhenatheretea*** (Table 1: 8–14, Table 3, Figs. 2, 10, 11, 12 and 13A)

**Alliance *Cynosurion cristati***

**Association *Lolio perennis-Cynosuretum cristati***

Number of relevés: 9 (4 matched by the definition)

Table 1: 8, Table 3, relevés 1–9, Fig. 12A (black triangles).

Diagnostic species: *Bellis perennis*, *Cynosurus cristatus*, *Lolium perenne*, *Plantago major*, *Potentilla anserina*, *Trifolium dubium*.

Constant species: *Agrostis capillaris*, *Achillea millefolium* agg., *Alchemilla* spec. div., *Cynosurus cristatus*, *Festuca pratensis*, *Festuca rubra*, *Plantago lanceolata*, *Plantago media*, *Ranunculus acris*, *Ranunculus bulbosus*, *Taraxacum* sect. *Ruderalia*, *Trifolium pratense*, *Trifolium repens*, *Trisetum flavescens*.

Dominant species: *Cynosurus cristatus*, *Festuca pratensis*, *Taraxacum* sect. *Ruderalia*, *Trifolium pratense*, *Trifolium repens*.



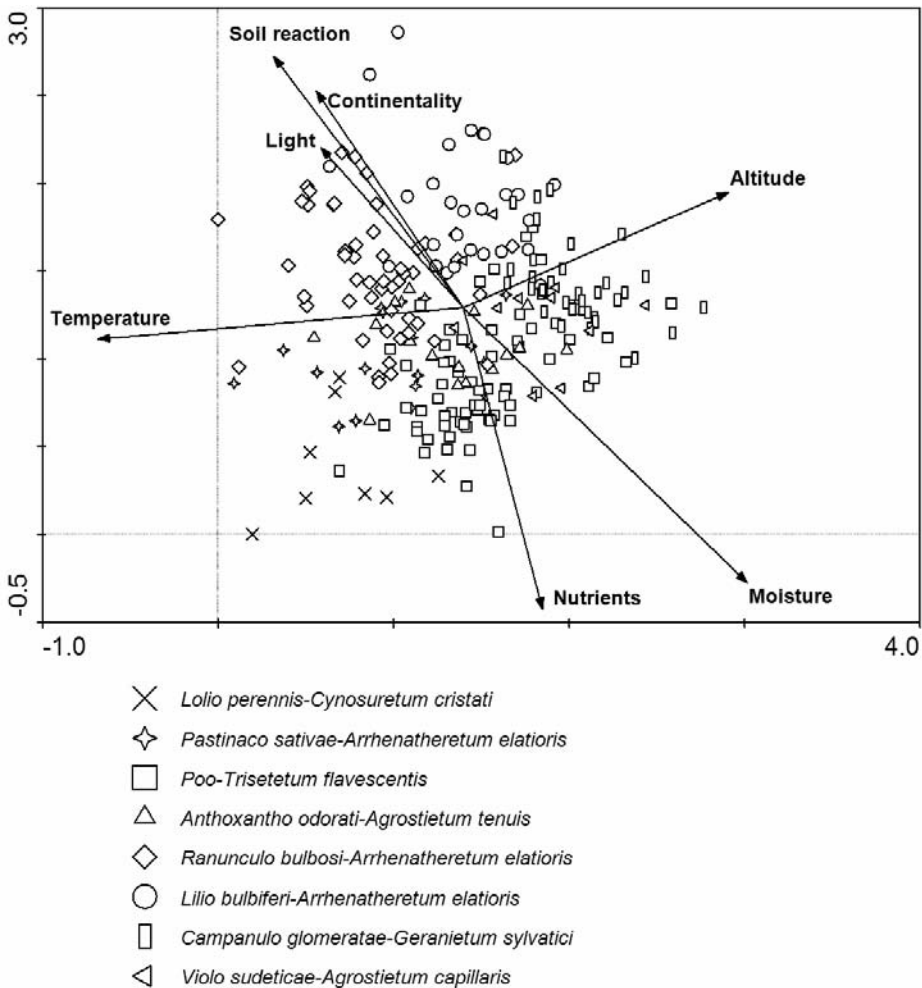


Fig. 10: Detrended correspondence analysis (DCA) of mesophilous grasslands belonging to the classes *Molinio-Arrhenatheretea* (excl. *Molinietalia*) and *Nardetea strictae*, based on square-root transformed species data of the herb layer. Supplementary environmental variables represent unweighted average Ellenberg indicator values and altitude.

Abb. 10: Trendbereinigte Korrespondenzanalyse (DCA) des mesophilen Grünlands der Klassen *Molinio-Arrhenatheretea* (ohne *Molinietalia*) und *Nardetea strictae*, basierend auf den Quadratwurzel transformierten Deckungsgraden der Krautschicht. Die zusätzlichen Umweltvariablen sind ungewichtete mittlere Ellenberg-Zeigerwerte sowie Höhenlage.

In the study region, this association belongs to the less frequent communities occurring in alluvia of smaller streams (Revúca) and in cooler and wetter sites, mainly at altitudes between 600–700 m a.s.l., occasionally also lower (380 m a.s.l., see Fig. 12A). The association inhabits plains or gentle slopes facing to N, NE and NW, independent of the bedrock type. The soils are moist, and the stands moderately species-rich. Grazing by sheep and cattle results in a disturbance of the sites followed by invasions of pasture weeds such as *Cirsium arvense*, *C. eriophorum*, *Tithymalus cyparissias* and *Elytrigia repens*. The moss layer is usually poorly developed with a cover of 20–40%. Within Slovakia, the community is widely distributed (JANIŠOVÁ 2007).

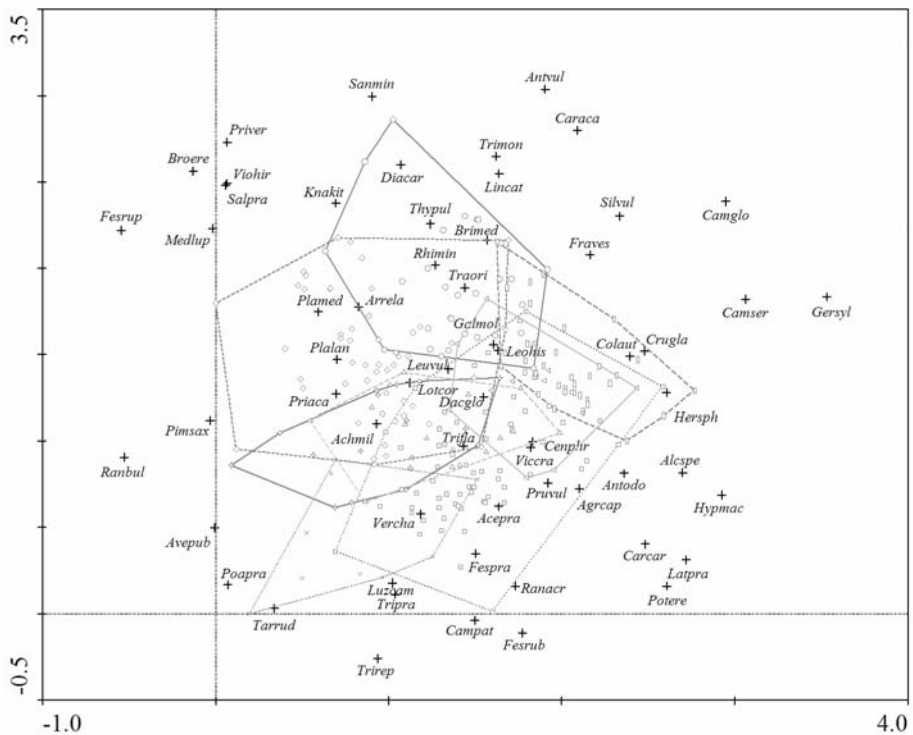


Fig. 11: Detrended correspondence analysis (DCA) of mesophilous grasslands belonging to the classes *Molinio-Arrhenatheretea* (excl. *Molinietalia*) and *Nardetea strictae*. Envelopes are drawn around relevés belonging to individual associations (see Fig. 10 for explanation of the symbols). 60 species with weight over 20 are shown, the abbreviations are as follows: *Acepra* – *Acetosa pratensis*, *Agrcap* – *Agrostis capillaris*, *Achmil* – *Achillea millefolium*, *Alcspe* – *Alchemilla* spec. div., *Antodo* – *Anthoxanthum odoratum*, *Antvul* – *Anthyllis vulneraria*, *Arrela* – *Arrhenatherum elatius*, *Avepub* – *Avenula pubescens*, *Brimed* – *Briza media*, *Broere* – *Bromus erectus*, *Camglo* – *Campanula glomerata*, *Campat* – *Campanula patula*, *Camser* – *Campanula serrata*, *Caraca* – *Carlina acaulis*, *Carcar* – *Carum carvi*, *Cenhph* – *Jacea phrygia* agg., *Colaut* – *Colchicum autumnale*, *Crugla* – *Cruciata glabra*, *Dacglo* – *Dactylis glomerata*, *Diacar* – *Dianthus carthusianorum*, *Fespra* – *Festuca pratensis*, *Fesrub* – *Festuca rubra*, *Fesrup* – *Festuca rupicola*, *Fraves* – *Fragaria vesca*, *Galmol* – *Galium mollugo* agg., *Gersyl* – *Geranium sylvaticum*, *Hersph* – *Heracleum sphondylium*, *Hypmac* – *Hypericum maculatum*, *Knakit* – *Knautia kitaibelii*, *Latpra* – *Lathyrus pratensis*, *Leobis* – *Leontodon hispidus*, *Leuvul* – *Leucanthemum vulgare*, *Lincat* – *Linum catharticum*, *Lotcor* – *Lotus corniculatus*, *Luzcam* – *Luzula campestris* agg., *Medlup* – *Medicago lupulina*, *Pimsax* – *Pimpinella saxifraga*, *Plalan* – *Plantago lanceolata*, *Plamed* – *Plantago media*, *Poapra* – *Poa pratensis* agg., *Potere* – *Potentilla erecta*, *Priaca* – *Primula acaulis*, *Priver* – *Primula veris*, *Pruvul* – *Prunella vulgaris*, *Ranacr* – *Ranunculus acris*, *Ranbul* – *Ranunculus bulbosus*, *Rhimin* – *Rhinanthus minor*, *Salpra* – *Salvia pratensis*, *Sanmin* – *Sanguisorba minor*, *Silvul* – *Silene vulgaris*, *Tarrud* – *Taraxacum* sect. *Ruderalia*, *Thypul* – *Thymus pulegioides*, *Traori* – *Tragopogon orientale*, *Trifla* – *Trisetum flavescens*, *Trimon* – *Trifolium montanum*, *Triptra* – *Trifolium pratense*, *Trirep* – *Trifolium repens*, *Vercha* – *Veronica chamaedrys*, *Viccra* – *Vicia cracca*, *Viobir* – *Viola hirta*.

Abb. 11: Trendbereinigte Korrespondenzanalyse (DCA) des mesophilen Grünlandes der Klassen *Molinio-Arrhenatheretea* (ohne *Molinietalia*) und *Nardetea strictae*. Die eingezeichneten Gruppen zeigen die Zugehörigkeit der Aufnahmen zu den einzelnen Assoziationen (Erläuterung der Symbole s. Abb. 2). 60 Arten mit Artwerten über 20 sind dargestellt, für die Erklärung der Abkürzungen vgl. englische Abbildungsunterschrift.

## Alliance *Arrhenatherion elatioris*

Number of relevés: 183.

Diagnostic species: *Anthriscus sylvestris*, *Arrhenatherum elatius*, *Avenula pubescens*, *Campanula patula*, *Jacea phrygia* agg., *Cruciata glabra*, *Dactylis glomerata*, *Daucus carota*, *Galium mollugo* agg., *Leontodon hispidus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Plantago lanceolata*, *Primula acaulis*, *Taraxacum* sect. *Ruderalia*, *Tragopogon orientalis*, *Trifolium pratense*, *Trifolium repens*, *Trisetum flavescens*, *Vicia cracca*.

Constant species: *Acetosa pratensis*, *Achillea millefolium* agg., *Arrhenatherum elatius*, *Cruciata glabra*, *Dactylis glomerata*, *Festuca pratensis*, *Leontodon hispidus*, *Leucanthemum vulgare*, ***Lotus corniculatus***, *Plantago lanceolata*, *Poa pratensis* agg., *Taraxacum* sect. *Ruderalia*, *Trifolium pratense*, ***Trisetum flavescens***, *Veronica chamaedrys*.

Dominant species: *Festuca rubra*.

This alliance includes the most wide-spread types of mesophilous meadows in the region. All five associations distinguished within this alliance in the national survey (JANIŠOVÁ 2007) occur in the study region. Recently, the floristic composition of these mesophilous communities is gradually rebuilding due to decreasing utilisation intensity and re-establishment of numerous species sensitive to intensive utilisation. Moreover, keeping small livestock herds retreated, and the remote areas with the most diverse grassland vegetation remained abandoned.

## Association *Pastinaco sativae-Arrhenatheretum elatioris*

Number of relevés: 17 (4 matched by the definition)

Table 1: 9, Table 3, relevés 10–26, Fig. 12B (black triangles).

Diagnostic species: *Campanula rapunculooides*, *Poa pratensis* agg., *Taraxacum* sect. *Ruderalia*.

Constant species: *Achillea millefolium* agg., *Arrhenatherum elatius*, *Dactylis glomerata*, *Festuca pratensis*, *Lotus corniculatus*, *Plantago lanceolata*, *Poa pratensis* agg., *Taraxacum* sect. *Ruderalia*, *Tragopogon orientalis*, ***Trifolium pratense***, ***Trisetum flavescens***.

Dominant species: *Rhynchodes trifolii*, *Trifolium pratense*, *Trisetum flavescens*.

The meadows of this association grow at sites well supplied by both water and nutrients. Usually they occur at altitudes between 350 and 750 m a.s.l., but on steeper south-facing slopes they occasionally reach even higher altitudes (e.g. Donovaly 1025 m a.s.l., Fig. 12B). The bedrock usually consists of limestones, claystones or quaternary sediments. In the study region, this association occurs in orchards and gardens, sporadically also on fallows which are manured or fertilised. Diversity and physiognomy of the stands are strongly affected by both soil type and management. On steeper slopes over limestones, the species richness can reach 61 species per 16–25 m<sup>2</sup>, including several rare species (*Lilium martagon*, *Ophioglossum vulgatum*). However, stands that have developed on former fields or recultivated grasslands are usually poorer in species. Sufficiency of water and nutrients in soil enables the occurrence of broad-leaved forbs such as *Heracleum sphondylium*, *Anthriscus sylvestris*, *Aegopodium podagraria*, *Crepis biennis* and *Colchicum autumnale*. In Slovakia, the community is widely distributed (JANIŠOVÁ 2007).

## Association *Poo-Trisetetum flavescens*

Number of relevés: 69 (22 matched by the definition)

Table 1: 10, Table 3, relevés 27–95, Fig. 12B (grey circles).

Diagnostic species: *Anthriscus sylvestris*, *Campanula patula*, *Carum carvi*, *Dactylis glomerata*, *Festuca rubra*, *Chaerophyllum aromaticum*, *Phyteuma spicatum*, *Taraxacum* sect. *Ruderalia*, *Trifolium pratense*, *Trifolium repens*, *Vicia cracca*, *Viola tricolor*.

Constant species: *Acetosa pratensis*, *Agrostis capillaris*, *Achillea millefolium* agg., *Alchemilla* spec. div., *Campanula patula*, *Jacea phrygia* agg., *Cruciata glabra*, *Dactylis glomerata*, *Festuca pratensis*, *Festuca rubra*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Plantago lanceolata*, *Poa pratensis* agg., ***Ranunculus acris***, *Taraxacum* sect. *Ruderalia*, ***Trifolium pratense***, *Trifolium repens*, *Trisetum flavescens*, *Veronica chamaedrys*, *Vicia cracca*.

Dominant species: *Agrostis capillaris*, *Festuca rubra*.

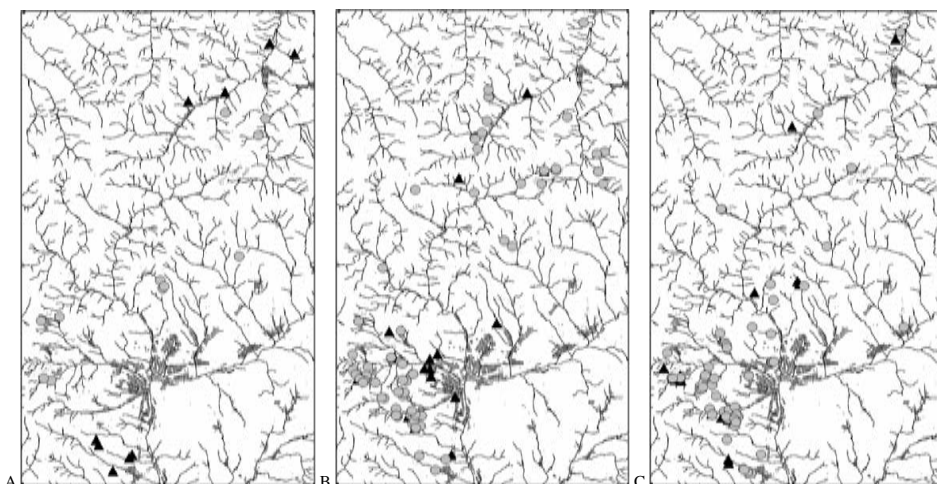


Fig. 12: Distribution of associations in the study area II: A) *Lolio perennis*-*Cynosuretum cristati* (black triangles) and *Violo sudeticae*-*Agrostietum capillaris* (grey circles); B) *Pastinaco sativae*-*Arrhenatheretum elatioris* (black triangles) and *Poo-Trisetetum flavescens* (grey circles); C) *Anthoxantho odorati*-*Agrostietum tenuis* (black triangles) and *Ranunculo bulbosi*-*Arrhenatheretum elatioris* (grey circles).

Abb. 12: Verbreitung der Assoziationen im Untersuchungsgebiet II: A) *Lolio perennis*-*Cynosuretum cristati* (schwarze Dreiecke) und *Violo sudeticae*-*Agrostietum capillaris* (graue Kreise); B) *Pastinaco sativae*-*Arrhenatheretum elatioris* (schwarze Dreiecke) und *Poo-Trisetetum flavescens* (graue Kreise); C) *Anthoxantho odorati*-*Agrostietum tenuis* (schwarze Dreiecke) und *Ranunculo bulbosi*-*Arrhenatheretum elatioris* (graue Kreise).

This association is the most frequent grassland type in the study region distributed mainly on moderately steep slopes (20°) at altitudes between 500 and 800 m a.s.l. (Fig. 12B). The prevailing geological bedrock types are andesites and quaternary sediments. The stands occur in the vicinity of settlements, in orchards, on alluvia or on slopes. In the past, they used to be mown once or twice a year and manured. Since recently, some localities are grazed. The stands are closed (coverage 75–100%) and moderately species-rich (20–43 species per 16–25 m<sup>2</sup>), with well-developed moss layers covering up to 95%. Traditionally managed stands can host rare or endangered species, e.g. *Campanula serrata*, *Lilium bulbiferum* and *Aquilegia vulgaris*. In Slovakia, the community is widely distributed (JANIŠOVÁ 2007).

#### Association *Anthoxantho odorati*-*Agrostietum tenuis*

Number of relevés: 16 (13 matched by the definition)

Table 1: 11, Table 3, relevés 96–111, Fig. 12C (black triangles).

**Diagnostic species:** *Acetosa pratensis*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Avenula pubescens*, *Briza media*, *Campanula patula*, *Danthonia decumbens*, *Dianthus deltoides*, *Festuca rubra*, *Hypochaeris radicata*, *Leucanthemum vulgare*, *Luzula campestris* agg., *Nardus stricta*, *Polygala vulgaris*, *Thymus pulegioides*, *Trifolium repens*, *Viola canina*.

**Constant species:** *Acetosa pratensis*, *Agrostis capillaris*, *Achillea millefolium* agg., *Alchemilla* spec. div., *Anthoxanthum odoratum*, *Avenula pubescens*, *Briza media*, *Campanula patula*, *Jacea phrygia* agg., *Cruciata glabra*, *Festuca rubra*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Luzula campestris* agg., *Pimpinella saxifraga*, *Plantago lanceolata*, *Polygala vulgaris*, *Thymus pulegioides*, *Trifolium pratense*, *Trifolium repens*, *Veronica chamaedrys*, *Viola canina*.

**Dominant species:** *Agrostis capillaris*, *Festuca rubra*.

This association involves slightly managed pastures and grazed meadows on shallower and more acidic soils. In the study region, it grows on various bedrock types on slopes at altitudes between 438 and 925 m a.s.l. (Fig. 12C). The herb layer is usually closed, and the moss layer well developed. Moderately high grasses and lower herb species usually dominate the stands. This community belongs to the most species-rich ones with 33–68 species per 16–25 m<sup>2</sup>. Several rare and endangered species occur here, e.g. *Campanula serrata* and *Ophioglossum vulgatum*. In Slovakia, the community is widely distributed (JANIŠOVÁ 2007).

#### Association *Ranunculo bulbosi-Arrhenatheretum elatioris*

Number of relevés: 52 (16 matched by the definition)

Table 1: 12, Table 3, relevés 112–163, Fig. 12C (grey circles)

Diagnostic species: *Arrhenatherum elatius*, *Avenula pubescens*, *Dactylis glomerata*, *Daucus carota*, *Dianthus carthusianorum*, *Festuca rupicola*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Plantago lanceolata*, *Ranunculus bulbosus*, *Salvia pratensis*, *Thlaspi perfoliatum*, *Trisetum flavescens*.

Constant species: *Agrostis capillaris*, *Achillea millefolium* agg., *Arrhenatherum elatius*, *Avenula pubescens*, *Briza media*, *Bromus erectus*, *Cruciata glabra*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Festuca rupicola*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Pimpinella saxifraga*, *Plantago lanceolata*, *Plantago media*, *Poa pratensis* agg., *Salvia pratensis*, *Tragopogon orientalis*, *Trifolium pratense*, *Trisetum flavescens*, *Veronica chamaedrys*.

Dominant species: –

These meadows are widely distributed in the study region except the area of the Nízke Tatry Mts. (Fig. 12C). They occur in old orchards, on dry fallows and slightly managed pastures at altitudes between 385 and 1000 m a.s.l., but the centre of their distribution is between 400 and 600 m a.s.l. The geological bedrock is usually built by limestones, dolomites and quaternary sediments. In the case of the latter bedrock type, the association is restricted to steeper slopes. The stands are frequently open with lower coverages of herb and moss layers than in the former communities of the *Arrhenatherion elatioris*. Most stands are very species-rich (commonly more than 60 species per 16–25 m<sup>2</sup>). In Slovakia, the community is widely distributed (JANIŠOVÁ 2007).

#### Association *Lilio bulbiferi-Arrhenatheretum elatioris*

Number of relevés: 29 (24 matched by the definition)

Table 1: 13, Table 3, relevés 164–192, Fig. 13A (black triangles).

Diagnostic species: *Anemone ranunculoides*, *Aquilegia vulgaris*, *Arabis hirsuta*, *Arrhenatherum elatius*, *Campanula glomerata*, *Campanula serrata*, *Carduus glaucinus*, *Carlina acaulis*, *Dianthus carthusianorum*, *Fragaria vesca*, *Gentiana cruciata*, *Lilium bulbiferum*, *Medicago lupulina*, *Phyteuma orbiculare*, *Plantago lanceolata*, *Ranunculus nemorosus*, *Rhinanthus minor*, *Rhinanthus serotinus*, *Sanguisorba minor*, *Silene nutans*, *Silene vulgaris*, *Tragopogon orientalis*, *Trifolium montanum*.

Constant species: *Achillea millefolium* agg., *Arrhenatherum elatius*, *Briza media*, *Campanula glomerata*, *Carlina acaulis*, *Jacea phrygia* agg., *Colchicum autumnale*, *Cruciata glabra*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Lilium bulbiferum*, *Lotus corniculatus*, *Medicago lupulina*, *Plantago lanceolata*, *Plantago media*, *Salvia pratensis*, *Sanguisorba minor*, *Thymus pulegioides*, *Tragopogon orientalis*, *Trifolium montanum*, *Trisetum flavescens*.

Dominant species: *Arrhenatherum elatius*, *Trifolium pratense*, *Trisetum flavescens*.

This association has the centre of its overall distribution in the study region (Starohorské vrchy Mts., partly Kremnické vrchy Mts. and Veľká Fatra Mts., Fig. 13A). It occurs at higher altitudes (up to 1025 m a.s.l.) on moderately steep to steep slopes, mostly on limestones. It is very species-rich (commonly over 60 species per 16–25 m<sup>2</sup>), hosting numerous rare and endangered species. It is distributed in the vicinity of settlements, but also in the valleys, in the mountain saddles and in steeper mountain ridges.

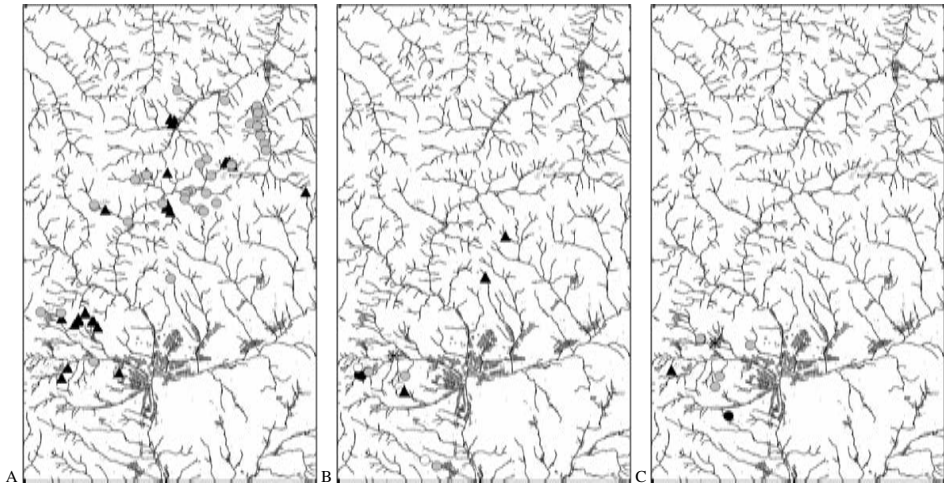


Fig. 13: Distribution of associations in the study area III: A) *Lilio bulbiferi*-*Arrhenatheretum elatioris* (black triangles) and *Campanulo glomeratae*-*Geranium sylvaticum* (grey circles); B) wet meadows of the *Cirsietum rivularis* (black circles), *Scirpetum sylvaticum* (grey circles), *Filipendulo ulmariae*-*Menthetum longifoliae* (white circles) and transitional stands between wet and fen meadows (black triangles and asterisk); C) *Typhetum longifoliae* (black triangle), *Glycerietum nemoralis-plicatae* (asterisk), *Poo trivialis*-*Alopecuretum pratensis* (black circle) and fen meadows of the *Caricion davallianae* (grey circles).

Abb. 13: Verbreitung der Assoziationen im Untersuchungsgebiet III: A) *Lilio bulbiferi*-*Arrhenatheretum elatioris* (schwarze Dreiecke) und *Campanulo glomeratae*-*Geranium sylvaticum* (graue Kreise); B) Feuchtwiesen des *Cirsietum rivularis* (schwarze Kreise), *Scirpetum sylvaticum* (graue Kreise), *Filipendulo ulmariae*-*Menthetum longifoliae* (weiße Kreise) und Übergangs-Bestände von Feuchtwiesen und Niedermoores (schwarze Dreiecke und Stern); C) *Typhetum longifoliae* (schwarzes Dreieck), *Glycerietum nemoralis-plicatae* (Stern), *Poo trivialis*-*Alopecuretum pratensis* (schwarzer Kreis) und Kalksümpfe des *Caricion davallianae* (graue Kreise).

### Alliance *Polygono bistortae*-*Trisetion flavescens*

#### Association *Campanulo glomeratae*-*Geranium sylvaticum*

Number of relevés: 36 (15 matched by the definition)

Table 1: 14, Table 3, relevés 193–228, Fig. 13A (grey circles), Fig. 14.

**Diagnostic species:** *Campanula glomerata*, *Campanula serrata*, *Cirsium erisithales*, *Colchicum autumnale*, *Crepis biennis*, *Crepis mollis*, *Crocus discolor*, *Cruciata glabra*, *Dactylis glomerata*, *Galium mollugo* agg., *Geranium sylvaticum*, *Heracleum sphondylium*, *Hypericum maculatum*, *Jacea phrygia* agg., *Knautia arvensis*, *Knautia maxima*, *Leontodon hispidus*, *Lilium bulbiferum*, *Luzula luzuloides*, *Phleum hirsutum*, *Phyteuma spicatum*, *Pimpinella major*, *Polygala vulgaris*, *Primula elatior*, *Pyrethrum clusii*, *Ranunculus polyanthemus*, *Silene dioica*, *Silene vulgaris*, *Stellaria graminea*, *Tragopogon orientalis*, *Trisetum flavescens*, *Vicia cracca*, *Vicia sepium*.

**Constant species:** *Acetosa pratensis*, *Agrostis capillaris*, *Achillea millefolium* agg., *Alchemilla* spec. div., *Briza media*, *Campanula glomerata*, *Campanula serrata*, *Carlina acaulis*, *Jacea phrygia* agg., *Colchicum autumnale*, *Cruciata glabra*, *Dactylis glomerata*, *Festuca pratensis*, *Geranium sylvaticum*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Pimpinella major*, *Primula elatior*, *Silene vulgaris*, *Tragopogon orientalis*, *Trifolium pratense*, *Trisetum flavescens*, *Vicia cracca*.

**Dominant species:** *Agrostis capillaris*, *Alchemilla* spec. div., *Cruciata glabra*, *Geranium sylvaticum*, *Trisetum flavescens*.

These montane meadows belong to the most specific associations in the study region. They grow in contact to the last-mentioned association *Lilio bulbiferi*-*Arrhenatheretum elatioris*, but are restricted to the cooler and wetter microhabitats (valleys in the vicinity of forests or mountain ridges). They inhabit steep slopes at altitudes up to 1225 m a.s.l., mostly



Fig. 14: The thriving stand of the *Campanulo glomeratae*-*Geranietum sylvatici* in the Bukovská dolina Valley, Starohorské vrchy Mts. with the typical species *Lilium bulbiferum*, *Cirsium erisithales*, *Hypericum maculatum*, *Arrhenatherum elatius*, *Silene vulgaris*, etc. (Photo: K. Hegedüšová, 18 July 2007).

Abb. 14: Der gut entwickelte Bestand des *Campanulo glomeratae*-*Geranietum sylvatici* im Tal von Bukovská dolina, Starohorské vrchy Berge, mit den typischen Arten *Lilium bulbiferum*, *Cirsium erisithales*, *Hypericum maculatum*, *Arrhenatherum elatius*, *Silene vulgaris*, etc. (Foto: K. Hegedüšová, 18. Juli 2007).

over limestones and quartzites. They are especially species-rich (32–79 species per 16–25 m<sup>2</sup>), mainly if managed in traditional manner up to these days. Due to the occurrence of numerous rare and endangered species (*Aquilegia vulgaris*, *Campanula serrata*, *Crocus discolor*, *Lilium bulbiferum*), they need strict conservation. Most localities occur within the Velká Fatra Mts. and Starohorské vrchy Mts. (Fig. 13A).

**Class *Nardetea strictae*** (Table 1: 15, Table 3, Figs. 2, 10, 11 and 12A)

**Alliance *Nardo strictae-Agrostion tenuis***

**Association *Violo sudeticae-Agrostietum capillaris***

Number of relevés: 11 (1 matched by the definition)

Table 1: 15, Table 3, relevés 229–239, Fig. 12A (grey circles).

Diagnostic species: *Campanula serrata*, *Hypericum maculatum*, *Luzula luzuloides*, *Pbleum hirsutum*, *Potentilla aurea*, *Ranunculus polyanthemus*, *Ranunculus pseudomontanus*, *Veronica officinalis*.

Constant species: *Agrostis capillaris*, *Achillea millefolium* agg., *Alchemilla* spec. div., *Anthoxanthum odoratum*, *Briza media*, *Campanula serrata*, *Carlina acaulis*, *Cruciata glabra*, *Dactylis glomerata*, *Dianthus carthusianorum*, *Festuca rubra*, *Hypericum maculatum*, *Leontodon hispidus*, *Leucanthemum vulgare*, *Lotus corniculatus*, *Luzula luzuloides*, *Plantago lanceolata*, *Ranunculus acris*, *Ranunculus polyanthemos*, *Thymus pulegioides*, *Veronica chamaedrys*, *Veronica officinalis*.

Dominant species: *Festuca rubra*.

This community is distributed mainly at higher altitudes, while at lower altitudes it is restricted to cooler microhabitats on north-, west- or east-facing slopes. In the study region, it occurs at the lower altitudinal limit of its overall distribution (UJHÁZY & KLIMENT 2007), and thus the stands are not typically developed. It grows on limestones and quaternary sediments. The stands are closed, with well-developed moss layers, and moderately to very species-rich. Most localities occur in the Starohorské vrchy Mts. and Veľká Fatra Mts. (Fig. 12A), where they inhabit slopes and the upper parts of the higher mountains including the downhill courses.

### 3.2.2. Wetland communities

(Table 1: 16–23, Table 4, Figs. 2, 13B, 13C, 15 and 16)

**Class *Molinio-Arrhenatheretea***

**Alliance *Deschampsion cespitosae***

**Association *Poa trivialis-Alopecuretum pratensis***

Number of relevés: 1

Table 1: 18, Table 4, relevé 3, Fig. 13C (black circle).

In the study region, the alluvial plains were mostly transformed into arable land, and thus the alluvial meadows became very rare. In our data set, they are represented by a single relevé recorded near the village Pršany in the Kremnické vrchy Mts. (Fig. 13C). The stand was dominated by *Alopecurus pratensis* with high cover of *Poa pratensis* agg., *Dactylis glomerata* and *Ranunculus acris*. This type of meadow is rather species-poor, but highly productive. In Slovakia, it is common in regularly flooded nutrient-rich sites (HAJKOVÁ 2007b).

**Alliance *Calthion palustris***

Number of relevés: 21.

Diagnostic species: *Caltha palustris*, *Carex echinata*, *Carex flava*, *Carex hirta*, *Carex nigra*, *Carex ovalis*, *Carex panicea*, *Carex paniculata*, *Cirsium rivulare*, *Crepis paludosa*, *Dactylorhiza majalis*, *Equisetum arvense*, *Ficaria bulbifera*, *Filipendula ulmaria*, *Galium aparine*, *Galium palustre*, *Galium rivale*, *Juncus effusus*, *Lathyrus pratensis*, *Lychnis flos-cuculi*, *Lysimachia nummularia*, *Mentha longifolia*, *Myosotis scorpioides* agg., *Poa trivialis*, *Ranunculus repens*, *Rumex obtusifolius*, *Scirpus sylvaticus*, *Urtica dioica*.

Constant species: *Festuca pratensis*, *Lathyrus pratensis*, *Lysimachia nummularia*, *Myosotis scorpioides* agg., *Ranunculus acris*.

Dominant species: *Carex paniculata*, *Filipendula ulmaria*, *Mentha longifolia*, *Scirpus sylvaticus*.

This alliance comprises the majority of the wetland stands in the study region. Although they usually contain a basic set of diagnostic species of the alliance (*Caltha palustris*, *Cirsium rivulare*, *Crepis paludosa*, *Equisetum palustre*, *Lathyrus pratensis*, *Mentha longifolia*, *Myosotis scorpioides* agg., *Poa trivialis*, *Ranunculus repens*, *Scirpus sylvaticus*, etc., Fig. 16), the other species present indicate the transition to other wetland syntaxa. A large group of relevés represents a transition to fen meadows of the *Caricion davallianae* alliance. The stands of the *Calthion palustris* inhabit mostly non-calcareous habitats with a higher content of nutrients (Fig. 15).



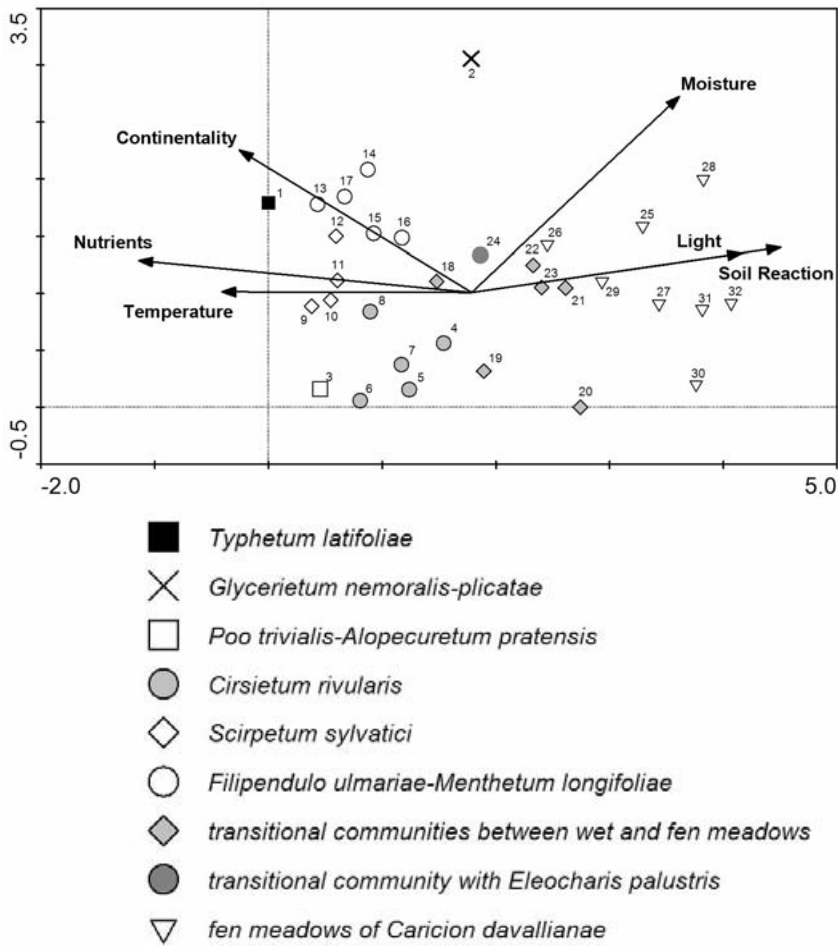


Fig. 15: Detrended correspondence analysis (DCA) of wetland communities (*Molinio-Arrhenatheretea*: *Molinetalia*, *Scheuchzerio-Caricetea*, *Phragmito-Magno-caricetea*), based on square-root transformed species data of the herb layer. Arrows represent the post-hoc correlated non-weighted averages of Ellenberg indicator values calculated for relevés. The first axis (eigenvalue 0.571) correlates mostly with nutrients ( $r = -0.90$ ), the second axis (eigenvalue 0.345) correlates mostly with moisture ( $r = 0.69$ ). Relevé numbers follow Table 4.

Abb. 15: Trendbereinigte Korrespondenzanalyse (DCA) der Feuchtwiesen-Gesellschaften (*Molinio-Arrhenatheretea*: *Molinetalia*, *Scheuchzerio-Caricetea*, *Phragmito-Magno-caricetea*) basierend auf den quadratwurzel-transformierten Deckungsgraden der Krautschicht. Die Pfeile stellen die post-hoc Korrelation der pro Aufnahme berechneten, nicht gewichteten Mittelwerte der Ellenberg Zeigerwerte dar. Die erste Ordinationsachse (Eigenwert 0.571) korreliert am stärksten mit der Nährstoff-Zahl ( $r = -0.90$ ), die zweite Achse (Eigenwert 0.345) korreliert am stärksten mit der Feuchte-Zahl ( $r = 0.69$ ). Die Aufnahmenummern entsprechen denen der Tabelle 4.

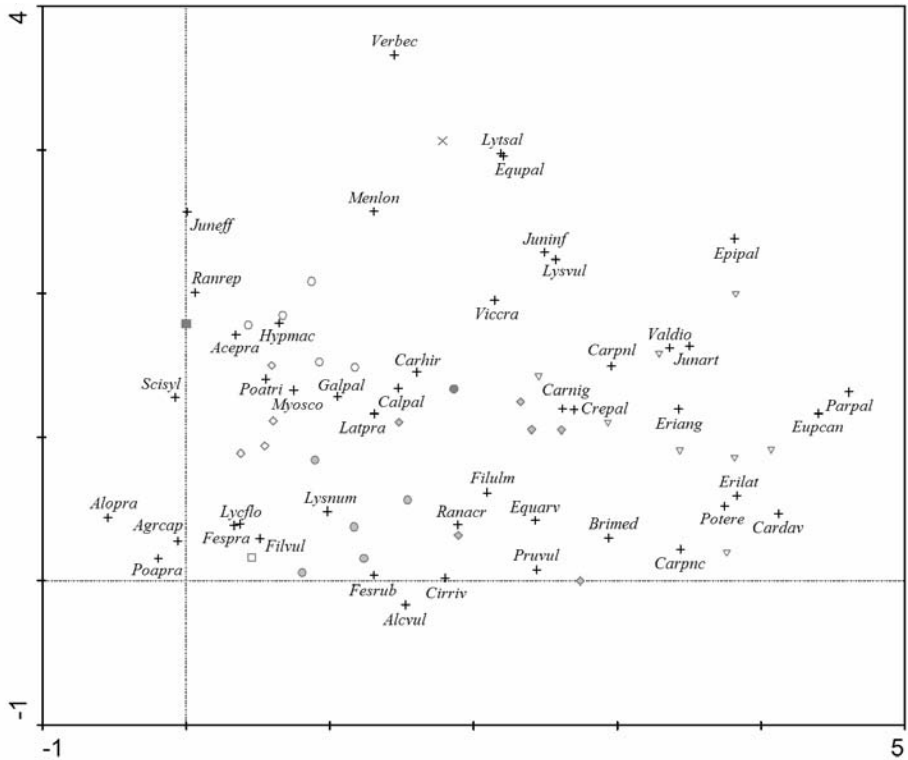


Fig. 16: Detrended correspondence analysis (DCA) of wetland communities (*Molinio-Arrhenatheretea*: *Molinietalia*, *Scheuchzerio-Caricetea*, *Phragmito-Magnocaricetea*). Fifty species with the highest weight (over 19) and relevé position are shown. Species abbreviations: *Acepra* – *Acetosa pratensis*, *Agrcap* – *Agrostis capillaris*, *Alcvul* – *Alchemilla* spec. div., *Alopra* – *Alopecurus pratensis*, *Brimed* – *Briza media*, *Calpal* – *Caltha palustris*, *Cardav* – *Carex davalliana*, *Carhir* – *Carex hirta*, *Carpnc* – *Carex panicea*, *Carpnl* – *Carex paniculata*, *Cirriv* – *Cirsium rivulare*, *Crepal* – *Crepis paludosa*, *Epipal* – *Epipactis palustris*, *Equarv* – *Equisetum arvense*, *Equipal* – *Equisetum palustre*, *Eriang* – *Eriophorum angustifolium*, *Erilat* – *Eriophorum latifolium*, *Eupcan* – *Eupatorium cannabinum*, *Fespra* – *Festuca pratensis*, *Fesrub* – *Festuca rubra*, *Filulm* – *Filipendula ulmaria*, *Filvul* – *Filipendula vulgaris*, *Galpal* – *Galium palustre*, *Hypmac* – *Hypericum maculatum*, *Junart* – *Juncus articulatus*, *Juneff* – *Juncus effusus*, *Juninf* – *Juncus inflexus*, *Latpra* – *Lathyrus pratensis*, *Lycflo* – *Lychnis flos-cuculi*, *Lysnum* – *Lysimachia nummularia*, *Lysvul* – *Lysimachia vulgaris*, *Lytsal* – *Lythrum salicaria*, *Menlon* – *Mentha longifolia*, *Myosco* – *Myosotis scorpioides* agg., *Parpal* – *Parnassia palustris*, *Poapra* – *Poa pratensis* agg., *Poatri* – *Poa trivialis*, *Potere* – *Potentilla erecta*, *Pruvul* – *Prunella vulgaris*, *Ranacr* – *Ranunculus acris*, *Ranrep* – *Ranunculus repens*, *Scisyl* – *Scirpus sylvaticus*, *Valdio* – *Valeriana dioica*, *Verbec* – *Veronica beccabunga*, *Viccr* – *Vicia cracca*. For explanation of relevé symbols, see Fig. 15.

Abb. 16: Trendbereinigte Korrespondenzanalyse (DCA) der Feuchtwiesen-Gesellschaften (*Molinio-Arrhenatheretea*: *Molinietalia*, *Scheuchzerio-Caricetea*, *Phragmito-Magnocaricetea*). 50 Arten mit den höchsten Artwerten (über 19) sind dargestellt, für die Erklärung der Abkürzungen vgl. englische Abbildungsunterschrift.

### Association *Cirsietum rivularis*

Number of relevés: 5

Table 1: 19, Table 4, relevés 4–8, Fig. 13B (black circles).

This community comprises wet meadows dominated by *Cirsium rivulare*, *Scirpus sylvaticus*, *Festuca pratensis* or *Festuca rubra*. In the study region, it is atypically entered by *Carex echinata*, which can also reach a high cover value. The species composition of these meadows is rather heterogeneous; their common attributes are their topography (terrain depressions) and regular management by mowing, which is reflected by high constancy of species of moist meadows (*Agrostis capillaris*, *Anthoxanthum odoratum*, *Cruciata glabra*, *Lathyrus pratensis*, *Lychnis flos-cuculi*, *Lysimachia nummularia*, *Prunella vulgaris*, *Ranunculus acris*, *Ranunculus auricomus*, etc). The association is best documented from the orchards in the village Králíky in the Kremnické vrchy Mts. (Fig. 13B) at altitudes between 715–770 m a.s.l. on claystones or limestones.

### Association *Scirpetum sylvatici*

Number of relevés: 4

Table 1: 20, Table 4, relevés 9–12, Fig. 13B (grey circles).

This community comprises wet meadows with strong dominance of *Scirpus sylvaticus*. *Lysimachia nummularia* and *Myosotis scorpioides* agg. are constantly present, and other species of the *Calthion palustris* are frequent, e.g. *Galium palustre*, *Juncus effusus*, *Lathyrus pratensis*, *Poa trivialis* and *Ranunculus repens*. This community occurs at lower altitudes (465–715 m a.s.l.) mostly over quaternary sediments in Kremnické vrchy Mts. in the close vicinity of villages (Fig. 13B). Formerly, the stands were utilised as meadows.

### Association *Filipendulo ulmariae-Menthetum longifoliae*

Number of relevés: 5

Table 1: 21, Table 4, relevés 13–17, Fig. 13B (white circles).

This is a tall-herb community dominated by *Mentha longifolia* and *Juncus effusus*. The presence of other wetland and nitrophilous species, such as *Caltha palustris*, *Cirsium arvense*, *Juncus conglomeratus*, *Lycopus europaeus*, *Lythrum salicaria*, *Myosotis scorpioides* agg., *Ranunculus repens*, *Rumex crispus* and *Urtica dioica* is typical. In the study region, this association occupies wet terrain depressions over andesites and quaternary sediments in the Kremnické vrchy Mts. at altitudes of 490–765 m a.s.l. (Fig. 13B).

### *Calthion palustris* – transitional stands between wet and fen meadows

Number of relevés: 7

Table 1: 22, Table 4, relevés 18–24, Fig. 13B (black triangles and asterisk).

Into this group, we include relevés classified to the *Calthion palustris* (based on the presence of numerous diagnostic species of this alliance), which also have transitional features of other wetland communities mostly of the *Caricion davallianae* alliance. Along with *Cirsium rivulare* and *Filipendula ulmaria*, *Carex paniculata* frequently dominates. Some other species are very frequent in the stands, e.g. *Crepis paludosa*, *Equisetum arvense*, *Lathyrus pratensis*, *Mentha longifolia*, *Myosotis scorpioides* agg., *Potentilla erecta* and *Valeriana dioica*. This transitional vegetation occurs at middle altitudes of the Starohorské vrchy Mts. (Fig. 13B), exclusively over quaternary sediments in regions with heterogeneous geological structure.

### Class *Scheuchzerio-Caricetea fuscae*

#### Alliance *Caricion davallianae*

Number of relevés: 8

Table 1: 23, Table 4, relevés 25–32, Fig. 13C (grey circles).

Diagnostic species: *Agrostis canina*, *Bryum pseudotriquetrum*, *Calamagrostis varia*, *Campylium stellatum*, *Carex acuta*, *Carex davalliana*, *Carex hostiana*, *Carex lepidocarpa*, *Carex nigra*, *Carex panicea*,

*Cirsium rivulare*, *Crepis paludosa*, *Dactylorhiza majalis*, *Drepanocladus revolvens* agg., *Epipactis palustris*, *Equisetum arvense*, *Equisetum palustre*, *Equisetum telmateia*, *Eriophorum angustifolium*, *Eriophorum latifolium*, *Eupatorium cannabinum*, *Fissidens adiantoides*, *Gymnadenia densiflora*, *Homalothecium nitens*, *Juncus articulatus*, *Juncus inflexus*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Mentha aquatica*, *Parnassia palustris*, *Pinguicula vulgaris*, *Plagiomnium elatum*, *Potentilla erecta*, *Primula farinosa*, *Succisa pratensis*, *Triglochin palustre*, *Tussilago farfara*, *Valeriana dioica*, *Viburnum opulus*.

Constant species: *Briza media*, *Bryum pseudotriquetrum*, *Carex davalliana*, *Carex panicea*, *Crepis paludosa*, *Equisetum palustre*, *Eriophorum latifolium*, *Eupatorium cannabinum*, *Juncus articulatus*, *Lythrum salicaria*, *Parnassia palustris*, *Potentilla erecta*, *Ranunculus acris*, *Valeriana dioica*.

Dominant species: *Campylium stellatum*, *Carex davalliana*, *Carex panicea*, *Carex paniculata*, *Cratoneuron commutatum*, *Drepanocladus revolvens* agg., *Eleocharis quinqueflora*, *Potentilla erecta*.

The stands belonging to this alliance are distributed mostly in the Starohorské vrchy Mts. on calcareous bedrock (Fig. 13C). Contrary to the communities of *Calthion palustris*, they occupy base-rich habitats, which are poorer in nutrients (Fig. 15). Numerous transitions to other wetland communities can be found in the study region. Due to the small number of relevés, we did not distinguish separate associations. The relevés can be classified within two associations. Typically developed fen meadows of the *Caricetum davallianae* are richer in species and typically include rare fen species such as *Primula farinosa*, *Epipactis palustris* and *Pinguicula vulgaris*. In Slovakia, this association belongs to rare and endangered communities developed mainly on calcareous bedrock and maintained to recent times only in fragments. Species-poorer stands with frequent occurrence of *Carex flacca*, *C. lepidocarpa*, *Juncus inflexus*, *Eupatorium cannabinum* and *Tussilago farfara* can be classified within the *Carici flavae-Cratoneuretum filicini*. They are often influenced by spring water as indicated by higher coverages of *Cratoneuron commutatum*. These communities are rather common on slope springs saturated by mineral water in most calcareous mountains of Slovakia (HÁJEK & HÁBEROVÁ 2001).

#### Class *Phragmito-Magnocaricetea*

##### Alliance *Phragmition communis*

##### Association *Typhetum latifoliae*

Number of relevés: 1

Table 1: 16, Table 4, relevé 1, Fig. 13C (black triangle).

This association occurs only rarely in the study region, and in our data set it is represented by only one relevé (Fig. 13C). The mono-dominant stand of *Typha latifolia* with subdominants *Equisetum fluviatile* and *Scirpus sylvaticus* was found near the village Králiky at 785 m a.s.l. (Fig. 13C).

##### Alliance *Glycerio-Sparganion*

##### Association *Glycerietum nemoralis-plicatae*

Number of relevés: 1

Table 1: 17, Table 4, relevé 2, Fig. 13C (asterisk).

This community is rare in the study region (Fig. 13C). It is dominated by *Equisetum palustre*, with the highly abundant *Veronica beccabunga* indicating spring water. The only stand was found near the village Riečka at an altitude of 550 m a.s.l. The community is sporadically distributed in the whole area of Slovakia, however, its syntaxonomical characteristics are not well-known yet (OTAHELOVÁ et al. 2001).

### 3.3. Comparison of regional and national delimitation of syntaxa

The delimitation of associations was evaluated according to their diagnostic species. Diagnostic species determined from the regional data were compared to diagnostic species derived at the national level from the data including all vegetation units in Slovakia. Three categories of diagnostic species were recognised: those diagnostic only at the regional level,

those common for the region and the whole Slovakia and those diagnostic only at the national level (Appendix D).

The following associations had the highest numbers of regional diagnostic species: *Campanulo glomeratae-Geranium sylvatici* (33), *Carici albae-Brometum monocladi* (30), *Scabioso ochroleuca-Brachypodietum pinnati* (24) and *Lilio bulbiferi-Arrhenatheretum elatioris* (24). At the national level, the following associations had the highest numbers of diagnostic species: *Carici albae-Brometum monocladi* (35), *Campanulo glomeratae-Geranium sylvatici* (26), *Lilio bulbiferi-Arrhenatheretum elatioris* (24), *Orthantho luteae-Caricetum humilis* (24) and *Brachypodio pinnati-Molinietum arundinaceae* (24). It is obvious that the specific regional associations (having the distribution centres in the study area) had the leading position in number of diagnostic species with high fidelity at both regional and national levels and belong to the floristically best delimited syntaxa. On the other hand, the *Lolio perennis-Cynosuretum cristati* and *Pastinaco sativae-Arrhenatheretum elatioris* were the worst delimited associations at both the regional (4 and 4, respectively) and the national levels (6 and 3, respectively). These communities belong to intensive grasslands utilised by grazing and/or mowing. Several associations that had small numbers of high fidelity species at the national level were rather rich in diagnostic species at the regional level, e.g. *Onobrychido viciifoliae-Brometum erecti* (6 vs. 18), *Poo-Trisetetum flavescens* (2 vs. 12) and *Anthoxantho odorati-Agrostietum tenuis* (4 vs. 17).

If the number of common diagnostic species (confirmed at both regional and national level) was expressed as percentage of the whole number of regional diagnostic species, the following associations belonged to syntaxa with the highest compatibility of diagnostic species sets (Appendix D): *Carici albae-Brometum monocladi* (73%), *Brachypodio pinnati-Molinietum arundinaceae* (63%), *Violo sudeticae-Agrostietum capillaris* (63%) and *Lilio bulbiferi-Arrhenatheretum elatioris* (57%). The lowest percentages of common diagnostic species were found in the *Pastinaco sativae-Arrhenatheretum elatioris* (no common diagnostic species at all), *Poo-Trisetetum flavescens* (8%) and *Anthoxantho odorati-Agrostietum tenuis* (17%).

Several species which were not diagnostic at the national level showed strict preferences for certain grassland communities in our study region, e.g. *Tithymalus cyparissias* indicated most dry and semi-dry grasslands (associations 1–4 in Appendix D), *Phleum hirsutum* and *Ranunculus polyanthemus* indicated montane grasslands (associations 12 and 13 in Appendix D).

## 4. Discussion

### 4.1. Application of the expert system to the studied data set

The identification of syntaxa by an electronic expert system is a formalised procedure easily applicable even without detailed knowledge of the local plant communities. It is based on the application of criteria formulated at a large geographical level (e.g. the national level) to a data set collected in a certain region or consisting of relevés without any geographical restriction. In our paper, an expert system was applied to a data set including all types of xero-, sub-xero- and mesophilous grasslands of a selected region irrespective of their syntaxonomical position. As a result, a regional classification was proposed, and regional diagnostic species were calculated.

When applying the national criteria to geographically restricted data, the question of scale becomes important. As the classification results are strongly dependent on the extent of study, the national classification might not be sufficiently sensitive to detect all regional particularities. This was demonstrated by KNOLLOVÁ et al. (2006), who showed that large-scale classifications usually include vegetation units with larger geographical ranges, while many of the traditional local associations disappear. This is caused mainly by the fact that classifications on different scales reflect different environmental and phytogeographical gradients. On a local scale, the most important gradients are usually those associated with small-scale heterogeneity in disturbance, light availability and soil properties such as mois-

ture, nutrient status and pH (KNOLLOVÁ et al. 2006). On a larger scale, macroclimatic gradients and differences in the evolutionary and migration histories of local floras become increasingly important (DIEKMANN 1997). These consequences seem to be lessened, if the criteria defined at a larger scale are applied to smaller areas which have a high habitat heterogeneity or which have a central position along the major large-scale gradients (KUŽELOVÁ & CHYTRÝ 2004). In our study, the relevés originated from a region with very diverse and heterogeneous habitat conditions (see Fig. 2). The main gradients in the xero- to mesophilous grassland subset (JANIŠOVÁ et al. 2010) included the macroclimatic characteristics (climatic water balance), phytochorological attributes (affiliation to phytochorions according to the presence of thermophilous species) as well as small-scale topographical and geological characteristics (slope, solar radiation and geological bedrock type). The data heterogeneity reflecting gradients on both macro- and micro-scale was the main prerequisite of a successful application of the national expert system to our regional data. In addition, the occurrence of several specific (local) associations in the region was not overlooked, as they were differentiated by numerous diagnostic species and were thus accepted as associations in the national classification.

The high percentage of relevés matched by the definitions as well as the sufficient sensitivity of the national classification to the particularities of the region studied proved the application of the expert system for Slovak grasslands to our data set as successful. In certain situations, e.g. in areas with low habitat diversity, an independent local classification based on, e.g., a numerical classification scheme, might be more appropriate. Local classifications can provide an accurate description of local vegetation diversity, which fits locally specific environmental gradients much better than a mechanical application of vegetation units defined on a national scale (KNOLLOVÁ et al. 2006). However, for sufficiently heterogeneous areas, such as our study region, the application of a national classification has the advantage of better serving applied purposes, e.g., nature conservation, which are organised within national boundaries. Moreover, this approach enables valuable comparisons of our study region with other regions of Slovakia.

The associations *Brachypodio pinnati-Molinietum arundinaceae*, *Lilio bulbiferi-Arrhenatheretum elatioris*, *Onobrychido viciifoliae-Brometum erecti* and *Anthoxantho odorati-Agrostietum tenuis* had the highest proportion of relevés matched by the association definition: 96%, 83%, 82% and 81%, respectively (Appendix D). These communities grow in habitats that are very common in the study region, and this could be a reason why they are so well and typically developed. On the other hand, in the *Orphantho luteae-Caricetum humilis* and *Violo sudeticae-Agrostietum capillaris* the proportion of matched relevés was very low: 7% and 9%, respectively. Interestingly, these associations inhabit habitats on the extreme poles of the moisture and temperature gradients detected in the study area. One possible explanation of their untypical floristic composition is that both associations occur here at the limits of their overall distribution. Other associations had either intermediate proportions of the matched relevés (23–53%, Appendix D), or they were too rare for this evaluation (e.g. *Festuco rupicolae-Caricetum humilis* and *Festuco pallentis-Seslerietum calcariae*). Several associations were detected only by the similarity indices, while they remained non-matched by the association definitions, e.g. *Geranio sylvatici-Trisetetum flavescens* and *Campanulo rotundifoliae-Dianthetum deltoidis*. Although we decided not to accept these associations, their occurrence in the study region can not be excluded. The different proportions of the matching relevés in various associations is probably related to both their distribution range and the scope of their definitions, so that more narrowly delimited units with distribution centres outside the study region had more non-matching relevés and were thus identified mostly by the similarity index. Frequently, the scope of the definition is related to the amount of phytosociological material in the national database, upon which the definitions are based.

The expert system used is based on sociological species groups and species dominance criteria combined in formal definitions by logical operators (BRUELHEIDE 1995, 1997). We chose this method to ensure stable classification results independent of size and composition

of the data set. Using this method, the relevés with transitional features and the poorly developed stands with small numbers of diagnostic species remain unassigned by the definitions. They do not affect the classification results as it is the case in other classification methods, e.g. TWINSPAN and numerical classification methods (BRUELHEIDE 1995, JANDT 1999, BRUELHEIDE & CHYTRÝ 2000). Moreover, the classification process is well formalised and reproducible. To eliminate the subjective decisions and to allow an unambiguous allocation of non-matching relevés to vegetation units, we propose to accept strict criteria also during the classification of non-matching relevés by the similarity indices. In our analysis, we classified the non-matching relevés by the FPGI only to those associations which were confirmed in the region by at least one other matched relevé. Such an approach has worked well in the study region, preventing us from accepting syntaxa which are not typically developed in the region and allowing the further formalisation of the classification process.

#### 4.2. Wetlands

Contrary to the xero- and mesophilous grasslands, the wetland communities of the study region were classified with a numerical classification method. Several attempts have been reported concerning the application of expert systems on regional data for mire vegetation (DÍTĚ et al. 2007, HRIVNÁK et al. 2008). Although some of the relevés recorded in our study region could be identified by the expert system for mires proposed by DÍTĚ et al. (2007), and some relevés of the *Calthion palustris* and *Deschampsion cespitosae* alliances could be identified by the definitions proposed by HÁJKOVÁ (2007a, 2007b), there were several wetland communities (belonging to the class *Phragmito-Magno caricetea*), for which the formalised definitions have not yet been formulated. For that reason and also to avoid the subjective choice of the proper expert system to be applied for the identification of wetland relevés, we decided on a joint classification of wetland communities by a cluster analysis. Another important fact in favour of a joint classification was that the wetland communities in the study region are rather sparse and restricted to small patches of suitable environmental conditions. They are often developed atypically or have a transitional character, hosting diagnostic species of several distinct classes and alliances. In our opinion, the joint evaluation of their species composition and variability better reflects their typical features and is thus more reasonable and comprehensive. The situation might change by developing a complete expert system (recently available only for the Czech Republic) in which all vegetation types will be defined (NOBLE 1987).

#### 4.3. Comparison of local and national delimitation of syntaxa

The comparison of two sets of diagnostic species (regional and national ones) was enabled by the fact that although the diagnostic species were calculated from different data sets, the same fidelity measure (phi coefficient) was used with the same threshold value ( $\phi = 0.20$ ). In most associations, the differences were rather large, and the number of diagnostic species common to both data sets did not exceed 50%. These differences can not be explained by the fact that the national diagnostic species were calculated merely from relevés matched by individual associations, while in the regional data set, also relevés classified by the FPGI were included. There is no correlation between the proportion of common diagnostic species and the proportion of the matched relevés (correlation coefficient  $-0.009$ ). Another reason for a low compatibility of regional and national diagnostic species sets could be differences in heterogeneity of the input data sets. Nevertheless, we think that the differences in diagnostic species can also be attributed to the particularities in the regional floristic compositions of the studied grasslands and can thus be used to demonstrate the uniqueness of the local vegetation.

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## Appendix A: Classification scheme of the studied vegetation and formal definitions of associations

### Anhang A: Syntaxonomische Übersicht der behandelten Vegetationstypen und formale Definitionen der Assoziationen

#### Class *Festuco-Brometea* Br.-Bl. & Tx. ex Soó 1947

##### Order *Festucetalia valesiacae* Br.-Bl. & Tx. ex Br.-Bl. 1949

###### Alliance *Festucion valesiacae* Klika 1931

Association *Festuco rupicolae-Caricetum humilis* Klika 1939

**Definition:** Group *Festuca rupicola* AND (Group *Festuca valesiaca* OR Group *Scabiosa ochroleuca*) AND (*Carex humilis* cover >5% OR *Festuca rupicola* cover >5%) NOT Group *Jasione montana* NOT Group *Leucanthemum vulgare* NOT Group *Rhodax canus* NOT *Brachypodium pinnatum* cover >5% NOT *Bromus erectus* cover >5% NOT *Festuca valesiaca* cover >25%

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

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

Association *Festuco pallentis-Seslerietum calcariae* Futák 1947 corr. Janišová 2007

**Definition:** Group *Sesleria albicans* AND (Group *Galium verum* OR Group *Rhodax canus*) AND *Sesleria albicans* cover > 25%

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

Association *Orthantho luteae-Caricetum humilis* Kliment & Bernátová 2000

**Definition:** Group *Rhodax canus* AND (Group *Bromus monocladus* OR Group *Galium verum*) AND *Carex humilis* cover >5% NOT Group *Scabiosa lucida* NOT *Brachypodium pinnatum* cover >25% NOT *Sesleria albicans* cover >5%

##### Order *Brometalia erecti* Koch 1926

###### Alliance *Cirsio-Brachypodium pinnati* Hada & Klika ex Klika 1951

Association *Scabioso ochroleucae-Brachypodietum pinnati* Klika 1933

**Definition:** (Group *Cirsium acaule* OR Group *Scabiosa ochroleuca*) AND *Brachypodium pinnatum* cover >5% NOT Group *Carex humilis* NOT Group *Cirsium pannonicum* NOT Group *Onobrychis viciifolia* NOT Group *Polygala major* NOT *Festuca rupicola* cover >25%

Association *Carici albae-Brometum monocladi* Ujházy et al. 2007

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

###### Alliance *Bromion erecti* Koch 1926

Association *Brachypodio pinnati-Molinietum arundinaceae* Klika 1939

**Definition:** Group *Cirsium pannonicum* NOT Group *Bromus monocladus* NOT Group *Calamagrostis varia* NOT *Nardus stricta* cover >5%

Association *Onobrychido viciifoliae-Brometum erecti* T. Müller 1966

**Definition:** Group *Onobrychis viciifolia* 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*



Class *Molinio-Arrhenatheretea* Tx. 1937

Order *Arrhenatheretalia* Tx. 1931

Alliance *Cynosurion cristati* Tx. 1947

Association *Lolium perennis-Cynosuretum cristati* Tx. 1947

**Definition:** Group *Leontodon autumnalis* AND Group *Lolium perenne* NOT Group *Arrhenatherum elatius* NOT Group *Lychnis flos-cuculi* NOT *Deschampsia cespitosa* cover >5% NOT *Juncus tenuis* cover >25% NOT *Plantago major* cover >5% NOT *Prunella vulgaris* cover >15%

Alliance *Arrhenatherion elatioris* Luquet 1926

Association *Pastinaco sativae-Arrhenatheretum elatioris* Passarge 1964

**Definition:** Group *Arrhenatherum elatius* AND Group *Leucanthemum vulgare* NOT Group *Agrostis capillaris* NOT Group *Carlina acaulis* NOT Group *Festuca rupicola* NOT Group *Geranium sylvaticum* NOT Group *Securigera varia* NOT Group *Viola canina* NOT *Alopecurus pratensis* cover >50% NOT *Brachypodium pinnatum* cover >5% NOT *Bromus erectus* cover >5% NOT *Cirsium canum* cover >5%

Association *Poo-Trisetetum flavescens* Knapp ex Oberdorfer 1957

**Definition:** Group *Agrostis capillaris* AND Group *Leucanthemum vulgare* AND Group *Trisetum flavescens* NOT Group *Carlina acaulis* NOT Group *Festuca rupicola* NOT Group *Geranium sylvaticum* NOT Group *Leontodon autumnalis* NOT Group *Ranunculus bulbosus* NOT Group *Viola canina* NOT *Arrhenatherum elatius* cover >5% NOT *Brachypodium pinnatum* cover >5% NOT *Bromus erectus* cover >5% NOT *Cirsium rivulare* cover >5% NOT *Lolium perenne* cover >5%

Association *Anthoxantho odorati-Agrostietum tenuis* Sillinger 1933

**Definition:** Group *Agrostis capillaris* AND Group *Carlina acaulis* AND Group *Galium verum* AND Group *Leucanthemum vulgare* AND Group *Viola canina* NOT Group *Campanula serrata* NOT Group *Cirsium pannonicum* NOT Group *Geranium sylvaticum* NOT Group *Onobrychis vicifolia* NOT Group *Scabiosa ochroleuca* NOT *Festuca rupicola* cover >25% NOT *Nardus stricta* cover >5%

Association *Ranunculo bulbosi-Arrhenatheretum elatioris* Ellmauer in Mucina et al. 1993

**Definition:** Group *Agrostis capillaris* AND Group *Arrhenatherum elatius* AND Group *Leucanthemum vulgare* AND (Group *Festuca rupicola* OR Group *Ranunculus bulbosus*) NOT Group *Campanula glomerata* NOT Group *Cirsium pannonicum* NOT Group *Geranium sylvaticum* NOT Group *Hypericum maculatum* NOT Group *Leontodon autumnalis* NOT Group *Viola canina* NOT *Brachypodium pinnatum* cover >5% NOT *Bromus erectus* cover >25%

Association *Lilio bulbiferi-Arrhenatheretum elatioris* Ruži ková 2002

**Definition:** Group *Arrhenatherum elatius* AND Group *Campanula glomerata* AND (Group *Carlina acaulis* OR Group *Filipendula vulgaris*) NOT Group *Cirsium pannonicum* NOT Group *Geranium sylvaticum* NOT Group *Heracleum sphondylium* NOT Group *Nardus stricta* NOT Group *Viola canina* NOT *Brachypodium pinnatum* cover >25% NOT *Bromus erectus* cover >25% NOT *Geranium sylvaticum* cover >5%

Order *Poo alpinae-Trisetetalia* Ellmauer & Mucina 1993

Alliance *Polygono bistortae-Trisetion flavescens* Br.-Bl. & Tx. ex Marshall 1947

Association *Campanulo glomeratae-Geranietum sylvatici* Ruži ková 2002

**Definition:** Group *Campanula glomerata* AND (Group *Geranium sylvaticum* OR *Geranium sylvaticum* cover >5%) NOT *Festuca rupicola* cover >5% NOT *Sanguisorba officinalis* cover >5%

Order *Molinietales* Koch 1926

Alliance *Deschampsion cespitosae* Horvati 1930

Association *Poo trivialis-Alopecuretum pratensis* Regel 1925

Alliance *Caltbion palustris* Tx. 1937

Association *Cirsietum rivularis* Nowiński 1927

Association *Scirpetum sylvatici* Ralski 1931

Association *Filipendulo ulmariae-Menthetum longifoliae* Zlinská 1989

**Class *Nardetea strictae* Rivas Goday & Borja Carbonell 1961**

**Order *Nardetalia strictae* Oberd. ex Preising 1949**

**Alliance *Nardo strictae-Agrostion tenuis* Sillinger 1933**

Association *Violo sudeticae-Agrostietum capillaris* Ujházy in Janišová 2007

**Definition:** Group *Campanula serrata* AND Group *Carlina acaulis* AND Group *Hypericum maculatum* AND (Group *Veronica officinalis* OR Group *Vaccinium myrtillus*) AND *Agrostis capillaris* cover >5% NOT Group *Cardaminopsis halleri* NOT Group *Geranium sylvaticum* NOT Group *Poa alpina* NOT Group *Soldanella carpatica* NOT Group *Thymus alpestris*

**Class *Scheuchzerio-Caricetea fuscae* Tx. 1937**

**Order *Caricetalia davallianae* Br.-Bl. 1949**

**Alliance *Caricion davallianae* Klika 1934**

Association *Caricetum davallianae* Dutoit 1924

Association *Carici flavae-Cratoneuretum filicini* Kovács & Felföldy 1958

**Class *Phragmito-Magnocaricetea* Klika in Klika & Novák 1941**

**Order *Phragmitetalia* Koch 1926**

**Alliance *Phragmition communis* Koch 1926**

Association *Typhetum latifoliae* Lang 1973

**Order *Nasturtio-Glycerietalia* Pignatti 1953**

**Alliance *Glycerio-Sparganion* Br.-Bl. & Sissingh in Boer 1942**

Association *Glycerietum nemoralis-plicatae* Kopecký 1972

**Appendix B: Sociological species groups used in the formal association definitions**

Anhang B: Soziologische Artengruppen,  
die in den formalen Assoziationsdefinitionen Verwendung fanden

**Group *Agrostis capillaris*:** *Agrostis capillaris*, *Anthoxanthum odoratum* agg., *Festuca rubra* agg.

**Group *Arrhenatherum elatius*:** *Arrhenatherum elatius*, *Galium mollugo* agg., *Tragopogon orientalis*

**Group *Bromus monocladus*:** *Anthericum ramosum*, *Bromus monocladus*, *Buphthalmum salicifolium*

**Group *Calamagrostis varia*:** *Calamagrostis varia*, *Digitalis grandiflora*, *Laserpitium latifolium*

**Group *Campanula glomerata*:** *Aquilegia vulgaris*, *Campanula glomerata* agg., *Lilium bulbiferum*

**Group *Campanula serrata*:** *Campanula serrata*, *Potentilla aurea*, *Viola lutea*

**Group *Cardaminopsis halleri*:** *Cardaminopsis halleri*, *Crocus discolor*, *Primula elatior*

**Group *Carex humilis*:** *Carex humilis*, *Globularia punctata*, *Teucrium montanum*

**Group *Carlina acaulis*:** *Briza media*, *Carlina acaulis*, *Thymus pulegioides*

**Group *Cirsium acaule*:** *Cirsium acaule*, *Linum catharticum*, *Ononis spinosa*

**Group *Cirsium pannonicum*:** *Carex montana*, *Cirsium pannonicum*, *Lathyrus latifolius*, *Trommsdorffia maculata*

**Group *Festuca rupicola*:** *Agrimonia eupatoria*, *Festuca rupicola*, *Fragaria viridis*, *Sanguisorba minor*

**Group *Festuca valesiaca*:** *Bothriochloa ischaemum*, *Eryngium campestre*, *Festuca valesiaca*, *Koeleria macrantha*, *Thymus pannonicus*

**Group *Filipendula vulgaris*:** *Filipendula vulgaris*, *Primula veris*, *Ranunculus polyanthemos*

**Group *Galium verum*:** *Galium verum* agg., *Pimpinella saxifraga* agg., *Plantago media*, *Trifolium montanum*

**Group *Geranium sylvaticum*:** *Crepis mollis*, *Geranium sylvaticum*, *Phyteuma spicatum*

**Group *Heracleum sphondylium*:** *Anthriscus sylvestris*, *Chaerophyllum aromaticum*, *Crepis biennis*, *Geranium pratense*, *Heracleum sphondylium*

**Group *Hypericum maculatum*:** *Hypericum maculatum*, *Luzula luzuloides*, *Poa chaixii*

**Group *Jasione montana*:** *Jasione montana*, *Phleum phleoides*, *Orthantha lutea*, *Vicia lathyroides*

**Group *Leontodon autumnalis*:** *Cynosurus cristatus*, *Euphrasia rostkoviana* agg., *Leontodon autumnalis*

**Group *Leucanthemum vulgare*:** *Campanula patula*, *Leontodon hispidus*, *Leucanthemum vulgare* agg., *Lotus corniculatus* agg., *Plantago lanceolata*, *Rhinanthus minor*, *Trifolium pratense*

**Group *Lolium perenne*:** *Bellis perennis*, *Lolium perenne*, *Trifolium repens*

**Group *Lychnis flos-cuculi*:** *Acetosa pratensis*, *Alopecurus pratensis*, *Cardamine pratensis* agg., *Festuca pratensis*, *Lathyrus pratensis*, *Lychnis flos-cuculi*, *Ranunculus acris*, *Ranunculus auricomus* agg.

Group *Nardus stricta*: *Carex pallescens*, *Nardus stricta*, *Potentilla erecta*  
 Group *Onobrychis viciifolia*: *Bromus erectus*, *Onobrychis viciifolia* agg., *Salvia pratensis*  
 Group *Poa alpina*: *Ligusticum mutellina*, *Phleum rhaeticum*, *Poa alpina*  
 Group *Polygala major*: *Aster amellus*, *Inula ensifolia*, *Linum flavum*, *Polygala major*  
 Group *Ranunculus bulbosus*: *Daucus carota*, *Dianthus carthusianorum* agg., *Ranunculus bulbosus*  
 Group *Rhodax canus*: *Dorycnium pentaphyllum* agg., *Hippocrepis comosa*, *Potentilla heptaphylla*,  
*Rhodax canus*  
 Group *Scabiosa lucida*: *Carduus glaucinus*, *Phyteuma orbiculare*, *Scabiosa lucida*, *Thesium alpinum*  
 Group *Scabiosa ochroleuca*: *Asperula cynanchica*, *Scabiosa ochroleuca*, *Teucrium chamaedrys*  
 Group *Securigera varia*: *Colymbada scabiosa*, *Medicago falcata*, *Securigera varia*, *Tithymalus cyparissias*  
 Group *Sesleria albicans*: *Genista pilosa*, *Leontodon incanus*, *Sesleria albicans*  
 Group *Soldanella carpatica*: *Avenula planiculmis*, *Homogyne alpina*, *Soldanella carpatica*  
 Group *Thymus alpestris*: *Ranunculus nemorosus*, *Ranunculus pseudomontanus*, *Thymus alpestris*  
 Group *Trisetum flavescens*: *Dactylis glomerata*, *Taraxacum* sect. *Ruderalia*, *Trisetum flavescens*  
 Group *Vaccinium myrtillus*: *Avenella flexuosa*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*  
 Group *Veronica officinalis*: *Carex pilulifera*, *Danthonia decumbens*, *Pilosella officinarum*, *Veronica officinalis*  
 Group *Viola canina*: *Luzula campestris* agg., *Polygala vulgaris*, *Viola canina*

### Appendix C: Origin of the relevés in Tables 2–4

#### Anhang C: Herkunftsnachweis der Vegetationsaufnahmen in den Tabellen 2–4

The entries are organised as follows: Relevé number: Locality, Latitude, Longitude (both WGS84), Date (YYYY MM DD), Author(s), Reference if published before. Abkürzungen der Autoren: EU – Eva Uhliarová, HP – Helena Písarčíková, HR – Helena Ružičková, IŠ – Iveta Škodová, JK – Judita Kochjarová, JŠ – Ján Šeffer, MJ – Monika Janišová, ŠM – Štefan Maglocký, VS – Viera Stanová. Abbreviations of publications: #1 – JANIŠOVÁ (2009); #2 – KOCHJAROVÁ (1997); #3 – RUŽIČKOVÁ (2002); #4 – JANIŠOVÁ & UHLIAROVÁ (2008).

Die Einträge sind folgendermaßen organisiert: Aufnahmenummer: Aufnahmeort, geografische Breite, geographische Länge (beide WGS84), Aufnahedatum (JJJJ MM TT), Autor(en), Quellenangabe bei zuvor publizierten Aufnahmen. Abkürzungen der Autoren: EU – Eva Uhliarová, HP – Helena Písarčíková, HR – Helena Ružičková, IŠ – Iveta Škodová, JK – Judita Kochjarová, JŠ – Ján Šeffer, MJ – Monika Janišová, ŠM – Štefan Maglocký, VS – Viera Stanová. Abkürzungen der Publikationen: #1 – JANIŠOVÁ (2009); #2 – KOCHJAROVÁ (1997); #3 – RUŽIČKOVÁ (2002); #4 – JANIŠOVÁ & UHLIAROVÁ (2008).

**Table 2 – Rel. 1:** Zvolenská kotlina, Nemce, Kajchiar, 48°46'41" N, 19°11'15" E, 2006 06 03, MJ, #1; **Rel. 2:** Starohorské vrchy, Podkonice, Pleše, 48°48'50" N, 19°15'57" E, 2005 06 28, EU, #1; **Rel. 3:** Starohorské vrchy, Riečka, 48°45'17" N, 19°04'03" E, 2002 05 21, MJ, HP; **Rel. 4:** Zvolenská kotlina, Podkonice, 48°47'33" N, 19°15'30" E, 2006 08 07, MJ, #1; **Rel. 5:** Starohorské vrchy, Riečka, 48°45'54" N, 19°03'45" E, 2000 06 10, MJ; **Rel. 6:** Zvolenská kotlina, Jakub CHU, 48°45'55" N, 19°08'38" E, 2007 06 00, KH, MJ, IŠ; **Rel. 7:** Zvolenská kotlina, Banská Bystrica, Tichá ulica Street, 48°44'14" N, 19°06'52" E, 2001 07 11, MJ; **Rel. 8:** Starohorské vrchy, Riečka, 48°45'31" N, 19°04'48" E, 2001 05 23, MJ; **Rel. 9:** Starohorské vrchy, Tajov-Riečka, 48°45'20" N, 19°03'53" E, 2004 08 18, MJ; **Rel. 10:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'53" N, 19°06'50" E, 2006 08 23, EU; **Rel. 11:** Kremnické vrchy, Skubín, Mlynská ulica Street, 48°44'24" N, 19°05'01" E, 1996 05 21, MJ; **Rel. 12:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'52" N, 19°06'52" E, 2006 06 08, EU; **Rel. 13:** Zvolenská kotlina, Skubín, Pod Dúbravou, 48°44'07" N, 19°06'15" E, 2004 07 07, MJ; **Rel. 14:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'51" N, 19°06'51" E, 2006 07 18, EU; **Rel. 15:** Zvolenská kotlina, Slovenská Lupča, 48°46'51" N, 19°15'41" E, 2006 08 07, MJ; **Rel. 16:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'55" N, 19°06'42" E, 2006 08 23, EU; **Rel. 17:** Zvolenská kotlina, Slovenská Lupča, Mackov bok, 48°45'47" N, 19°15'40" E, 1996 06 26, JK, #2; **Rel. 18:** Zvolenská kotlina, Nemce, Bučičie, 48°46'25" N, 19°10'12" E, 2004 08 03, MJ, #1; **Rel. 19:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'52" N, 19°06'46" E, 2006 07 26, EU; **Rel. 20:** Zvolenská kotlina, Badín, 48°40'51" N, 19°05'59" E, 2002 06 19, EU; **Rel. 21:** Zvolenská kotlina, Skubín, 48°44'23" N, 19°06'28" E, 2001 07 21, MJ; **Rel. 22:** Zvolenská kotlina, Badín, 48°40'59" N, 19°06'01" E, 2002 06 19, EU; **Rel. 23:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'48" N, 19°06'45" E, 2006 07 18, EU; **Rel. 24:** Zvolenská kotlina, Banská

Bystrica, Malachovské skalky, 48°42'40" N, 19°06'51" E, 2006 07 28, EU; **Rel. 25:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'50" N, 19°06'45" E, 2006 08 23, EU; **Rel. 26:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'45" N, 19°06'19" E, 2006 07 25, EU; **Rel. 27:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'51" N, 19°06'47" E, 2006 08 01, EU; **Rel. 28:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'39" N, 19°06'50" E, 2006 07 18, EU; **Rel. 29:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'45" N, 19°06'49" E, 2006 07 24, EU; **Rel. 30:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'50" N, 19°06'50" E, 2006 07 14, EU; **Rel. 31:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'37" N, 19°06'12" E, 2001 10 02, EU; **Rel. 32:** Zvolenská kotlina, Badín, 48°40'46" N, 19°04'58" E, 2002 06 05, EU; **Rel. 33:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'37" N, 19°06'30" E, 2006 07 25, EU; **Rel. 34:** Zvolenská kotlina, Radvaň, 48°43'12" N, 19°07'42" E, 2001 08 12, EU; **Rel. 35:** Zvolenská kotlina, Jakub, 48°46'06" N, 19°08'00" E, 2006 07 06, MJ; **Rel. 36:** Starohorské vrchy, Baranovo, 48°47'17" N, 19°08'04" E, 2005 09 09, MJ, #1; **Rel. 37:** Starohorské vrchy, Riečka, 48°45'14" N, 19°04'49" E, 2000 05 20, MJ; **Rel. 38:** Zvolenská kotlina, Slovenská Lupča, 48°46'38" N, 19°15'53" E, 2006 08 07, MJ; **Rel. 39:** Veľká Fatra, Vyšné Revúce, 48°54'54" N, 19°09'45" E, 2006 08 08, MJ; **Rel. 40:** Starohorské vrchy, Riečka, 48°45'55" N, 19°03'36" E, 2000 06 10, MJ; **Rel. 41:** Starohorské vrchy, Riečka, 48°45'50" N, 19°03'53" E, 2000 05 27, MJ; **Rel. 42:** Veľká Fatra, Valentová, Prášnica, 48°52'23" N, 19°07'59" E, 2006 07 11, MJ; **Rel. 43:** Kremnické vrchy, Tajov, Zadný háj, 48°44'12" N, 19°04'11" E, 2001 06 27, EU; **Rel. 44:** Starohorské vrchy, Baranovo, Varta, 48°47'34" N, 19°08'09" E, 2004 06 18, MJ; **Rel. 45:** Starohorské vrchy, Riečka, Pod Dúbravou, 48°45'58" N, 19°04'39" E, 2001 06 08, MJ, ŠM; **Rel. 46:** Starohorské vrchy, Baranovo, Varta, 48°47'26" N, 19°08'19" E, 2005 09 09, MJ; **Rel. 47:** Starohorské vrchy, Uľanka, 48°47'45" N, 19°06'44" E, 2002 06 12, MJ, EU; **Rel. 48:** Starohorské vrchy, Podkonické Pleše, 48°48'54" N, 19°15'57" E, 2005 06 28, MJ; **Rel. 49:** Starohorské vrchy, Riečka, Pod Dúbravou, 48°45'58" N, 19°04'34" E, 2000 06 21, MJ, VS, JŠ; **Rel. 50:** Zvolenská kotlina, Skubín, 48°44'11" N, 19°06'22" E, 2004 06 09, MJ; **Rel. 51:** Starohorské vrchy, Ravasky, 48°46'04" N, 19°06'38" E, 2004 06 15, MJ; **Rel. 52:** Zvolenská kotlina, Jakub, 48°45'58" N, 19°08'36" E, 2004 08 06, MJ; **Rel. 53:** Starohorské vrchy, Riečka, Dedkovo, 48°46'34" N, 19°04'07" E, 2002 06 13, MJ; **Rel. 54:** Starohorské vrchy, Riečka, Dedkovo, 48°46'35" N, 19°04'10" E, 1998 06 28, HR; **Rel. 55:** Kremnické vrchy, Tajov, Zadný háj, 48°44'04" N, 19°04'10" E, 2001 06 27, EU; **Rel. 56:** Veľká Fatra, Šturec, 48°52'05" N, 19°09'53" E, 1988 07 14, HR, #3; **Rel. 57:** Veľká Fatra, Prášnica, 48°52'19" N, 19°08'10" E, 2006 07 11, EU; **Rel. 58:** Veľká Fatra, Prášnica, 48°52'28" N, 19°07'55" E, 2006 07 11, EU; **Rel. 59:** Starohorské vrchy, Tajov, Galovo, 48°44'26" N, 19°04'25" E, 2001 05 11, EU; **Rel. 60:** Starohorské vrchy, Riečka, Dedkovo, 48°45'55" N, 19°04'33" E, 1998 06 28, HR, #3; **Rel. 61:** Zvolenská kotlina, Jakub, 48°46'04" N, 19°08'30" E, 2004 09 06, MJ; **Rel. 62:** Veľká Fatra, Vyšné Revúce, 48°54'44" N, 19°09'46" E, 2006 08 08, MJ; **Rel. 63:** Kremnické vrchy, Tajov, Zadný háj, 48°44'14" N, 19°04'12" E, 2001 06 27, EU; **Rel. 64:** Starohorské vrchy, Riečanské sedlo, 48°46'14" N, 19°04'39" E, 1998 07 07, HR; **Rel. 65:** Starohorské vrchy, Hornojelenská dolina, 48°51'00" N, 19°09'15" E, 2001 06 26, HR; **Rel. 66:** Starohorské vrchy, Lučivnô, 48°46'13" N, 19°03'26" E, 1998 06 28, HR; **Rel. 67:** Zvolenská kotlina, Jakub, 48°45'53" N, 19°08'31" E, 2007 06 14, MJ, #4; **Rel. 68:** Starohorské vrchy, Riečka, 48°46'03" N, 19°04'42" E, 1998 06 28, HR; **Rel. 69:** Starohorské vrchy, Uľanka, 48°47'45" N, 19°06'45" E, 2003 05 09, EU, #4; **Rel. 70:** Kremnické vrchy, Malachov, 48°42'25" N, 19°04'52" E, 2001 06 05, EU; **Rel. 71:** Starohorské vrchy, Uľanka, 48°46'55" N, 19°07'11" E, 2007 06 10, MJ; **Rel. 72:** Zvolenská kotlina, Jakub, 48°45'55" N, 19°07'54" E, 2004 09 00, MJ, #4; **Rel. 73:** Starohorské vrchy, Riečka, 48°46'01" N, 19°04'29" E, 2001 07 08, HR; **Rel. 74:** Starohorské vrchy, Podkonice, Pleše, 48°49'14" N, 19°14'11" E, 2005 06 28, EU, #4; **Rel. 75:** Kremnické vrchy, Suchý vrch, 48°43'40" N, 19°04'27" E, 2002 06 20, EU; **Rel. 76:** Starohorské vrchy, Podkonice, 48°48'46" N, 19°14'22" E, 1996 07 15, JK, #2; **Rel. 77:** Starohorské vrchy, Riečka, Pod Dúbravou, 48°45'47" N, 19°04'38" E, 2001 06 08, MJ, HR, ŠM, #4; **Rel. 78:** Starohorské vrchy, Riečka, Pod Dúbravou, 48°45'58" N, 19°04'42" E, 2001 06 08, MJ, #4; **Rel. 79:** Starohorské vrchy, Ravasky, 48°46'02" N, 19°06'57" E, 2004 06 15, MJ; **Rel. 80:** Zvolenská kotlina, Jakub, 48°45'54" N, 19°07'54" E, 2004 09 10, EU, #4; **Rel. 81:** Kremnické vrchy, Skubín, Mlynská ulica Street, 48°44'23" N, 19°05'00" E, 1996 06 04, MJ, #4; **Rel. 82:** Kremnické vrchy, Tajov, Suchý vrch, 48°43'54" N, 19°04'10" E, 2001 06 27, EU, #4; **Rel. 83:** Kremnické vrchy, Tajov, Holý vršok, 48°43'38" N, 19°03'22" E, 2001 06 20, MJ; **Rel. 84:** Starohorské vrchy, Ravasky, 48°46'28" N, 19°06'10" E, 2004 06 15, MJ, #4; **Rel. 85:** Starohorské vrchy, Podkonice, Pleše, 48°48'51" N, 19°14'46" E, 2005 06 28, MJ, #4; **Rel. 86:** Starohorské vrchy, Podkonice, 48°48'51" N, 19°15'00" E, 1998 06 29, HR; **Rel. 87:** Kremnické vrchy, Skubín, Mlynská ulica Street, 48°44'23" N, 19°05'01" E, 1996 05 21, MJ, #4; **Rel. 88:** Starohorské vrchy, Tajov, Biela hlina, 48°44'11" N, 19°03'06" E, 2000 06 12, MJ; **Rel. 89:** Starohorské vrchy, vrchy, Uľanka, 48°47'42" N, 19°06'49" E, 2002 06 12, MJ, EU, #4; **Rel. 90:** Kremnické vrchy, Tajov, Brúsy, 48°44'07" N, 19°03'38" E, 2001 06 26, EU; **Rel. 91:** Starohorské

vrchy, Tajov, Brúsy, 48°44'16" N, 19°03'40" E, 2001 06 26, EU, #4; **Rel. 92:** Kremnické vrchy, Skubín, Mlynská ulica Street, 48°44'24" N, 19°04'59" E, 1996 05 21, MJ, #4; **Rel. 93:** Starohorské vrchy, Tajov, Brúsy, 48°44'07" N, 19°03'42" E, 2001 06 26, EU; **Rel. 94:** Starohorské vrchy, Baranovo, 48°47'07" N, 19°08'31" E, 2005 09 09, MJ, #4; **Rel. 95:** Starohorské vrchy, Tajov, 48°44'49" N, 19°04'19" E, 2004 05 21, MJ; **Rel. 96:** Starohorské vrchy, Hornojelenská dolina, 48°51'00" N, 19°09'15" E, 2001 06 26, HR, #3; **Rel. 97:** Kremnické vrchy, Suchý vrch, Galovo, 48°43'42" N, 19°04'03" E, 2001 08 09, EU, MJ, HP; **Rel. 98:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'44" N, 19°06'46" E, 2002 06 13, EU; **Rel. 99:** Kremnické vrchy, Malachov, 48°42'41" N, 19°05'11" E, 2001 05 30, EU; **Rel. 100:** Zvolenská kotlina, za Tichou ul., 48°44'15" N, 19°06'48" E, 2004 06 14, MJ; **Rel. 101:** Starohorské vrchy, Tajov, Riečka, 48°45'22" N, 19°03'51" E, 2004 08 18, MJ; **Rel. 102:** Zvolenská kotlina, Baranovo, 48°46'39" N, 19°09'11" E, 2001 07 24, MJ; **Rel. 103:** Zvolenská kotlina, Banská Bystrica, Tichá ulica Street, 48°44'13" N, 19°06'47" E, 2001 08 25, MJ; **Rel. 104:** Starohorské vrchy, Riečka, 48°45'32" N, 19°04'51" E, 2001 05 23, MJ, EU, HP; **Rel. 105:** Veľká Fatra, Šturec, 48°52'27" N, 19°09'23" E, 1988 07 17, HR; **Rel. 106:** Zvolenská kotlina, Skubín, Pod Strážnou Street, 48°44'24" N, 19°06'30" E, 2001 07 21, MJ; **Rel. 107:** Starohorské vrchy, Podkonice, 48°48'48" N, 19°14'24" E, 1996 07 15, JK, #2; **Rel. 108:** Kremnické vrchy, Malachov, 48°42'43" N, 19°05'12" E, 2001 05 30, EU; **Rel. 109:** Starohorské vrchy, Špania Dolina, 48°47'23" N, 19°07'55" E, 2004 06 18, EU; **Rel. 110:** Zvolenská kotlina Jakub, 48°45'52" N, 19°07'60" E, 2004 09 00, MJ; **Rel. 111:** Kremnické vrchy, Malachov, 48°42'38" N, 19°04'43" E, 2001 05 29, EU; **Rel. 112:** Zvolenská kotlina, Jakub, 48°45'60" N, 19°08'34" E, 2004 09 06, MJ; **Rel. 113:** Starohorské vrchy, Riečka, 48°45'19" N, 19°04'16" E, 2001 07 28, MJ; **Rel. 114:** Zvolenská kotlina, Laskomer, 48°44'40" N, 19°08'00" E, 2002 06 12, EU; **Rel. 115:** Zvolenská kotlina, Jakub, 48°46'02" N, 19°08'05" E, 2006 07 14, MJ; **Rel. 116:** Starohorské vrchy, Riečka, 48°45'18" N, 19°04'06" E, 2002 05 21, MJ; **Rel. 117:** Starohorské vrchy, Tajov, Kalvária, 48°44'39" N, 19°03'60" E, 2001 06 26, EU; **Rel. 118:** Zvolenská kotlina, Slovenská Ľupča, 48°46'45" N, 19°15'49" E, 2006 08 07, MJ; **Rel. 119:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'52" N, 19°05'55" E, 2001 05 29, EU; **Rel. 120:** Zvolenská kotlina, Jakub, 48°46'12" N, 19°06'87" E, 2004 09 06, MJ; **Rel. 121:** Starohorské vrchy, Špania Dolina, 48°48'08" N, 19°07'47" E, 2004 06 18, MJ; **Rel. 122:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'37" N, 19°06'49" E, 2006 07 18, EU; **Rel. 123:** Kremnické vrchy, Malachov, 48°42'41" N, 19°05'09" E, 2001 06 04, EU; **Rel. 124:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'37" N, 19°06'19" E, 2001 10 02, EU; **Rel. 125:** Starohorské vrchy, Baranovo, Várta, 48°47'22" N, 19°07'47" E, 2004 06 18, MJ, #1; **Rel. 126:** Starohorské vrchy, Tajov, Predné, 48°44'47" N, 19°03'24" E, 2001 06 15, EU; **Rel. 127:** Starohorské vrchy, Tajov, 48°44'50" N, 19°04'19" E, 2004 05 21, EU; **Rel. 128:** Kremnické vrchy, Malachov, 48°42'38" N, 19°04'53" E, 2001 06 04, EU; **Rel. 129:** Starohorské vrchy, Tajov, 48°44'54" N, 19°04'17" E, 2004 05 21, EU; **Rel. 130:** Starohorské vrchy, Bukovská dolina, 48°51'30" N, 19°10'30" E, 2001 06 26, HR, #3; **Rel. 131:** Zvolenská kotlina, Nemce, Bučičie, 48°46'27" N, 19°09'47" E, 2004 08 03, MJ; **Rel. 132:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'46" N, 19°06'41" E, 2002 06 18, EU; **Rel. 133:** Starohorské vrchy, Riečka, 48°46'07" N, 19°04'19" E, 2001 07 08, HR; **Rel. 134:** Starohorské vrchy, Riečka, 48°45'15" N, 19°04'58" E, 2000 05 19, MJ; **Rel. 135:** Zvolenská kotlina, Banská Bystrica, Malachovské skalky, 48°42'40" N, 19°06'33" E, 2001 10 02, EU; **Rel. 136:** Starohorské vrchy, Tajov, 48°44'53" N, 19°04'20" E, 2004 05 21, MJ; **Rel. 137:** Starohorské vrchy, Tajov, Biela hlina, 48°44'25" N, 19°03'14" E, 2000 06 12, MJ; **Rel. 138:** Kremnické vrchy, Malachov, 48°42'44" N, 19°04'58" E, 2001 05 30, EU; **Rel. 139:** Starohorské vrchy, Hornojelenská dolina, 48°51'08" N, 19°09'10" E, 2001 06 26, HR, #3; **Rel. 140:** Zvolenská kotlina, Slovenská Ľupča, 48°46'37" N, 19°15'51" E, 2006 08 07, MJ.

**Table 3 – Rel. 1:** Veľká Fatra, Liptovská Osada, 19°16'03" N, 48°58'08" E, 1980 06 25, HR; **Rel. 2:** Veľká Fatra, Nižná Revúca, 19°13'10" N, 48°56'05" E, 1980 07 02, HR; **Rel. 3:** Kremnické vrchy, Badín, 19°04'52" N, 48°41'28" E, 2002 06 05, EU; **Rel. 4:** Nízke Tatry, Liptovská Osada, 19°17'40" N, 48°57'41" E, 1980 06 25, HR; **Rel. 5:** Veľká Fatra, Stredná Revúca, Veľká Turecká, 19°10'48" N, 48°55'42" E, 1980 06 29, HR; **Rel. 6:** Zvolenská kotlina, Rakytovce, 19°07'11" N, 48°40'50" E, 2001 08 15, EU; **Rel. 7:** Kremnické vrchy, Badín, 19°05'02" N, 48°41'15" E, 2002 06 19, EU; **Rel. 8:** Zvolenská kotlina, Badín, 19°05'57" N, 48°40'09" E, 2001 08 14, EU; **Rel. 9:** Zvolenská kotlina, Rakytovce, 19°07'00" N, 48°40'43" E, 2002 06 21, EU; **Rel. 10:** Zvolenská kotlina, Nemce, 19°10'24" N, 48°46'21" E, 2006 06 01, MJ; **Rel. 11:** Veľká Fatra, Valentová, Prášnica, 19°07'57" N, 48°52'25" E, 2006 07 11, MJ; **Rel. 12:** Zvolenská kotlina, Skubín, 19°06'10" N, 48°44'08" E, 2000 06 02, MJ; **Rel. 13:** Kremnické vrchy, Malachov, 19°04'41" N, 48°42'26" E, 2001 05 28, EU; **Rel. 14:** Zvolenská kotlina, Skubín, 19°05'44" N, 48°44'27" E, 2004 06 11, MJ; **Rel. 15:** Starohorské vrchy, Donovaly, 19°13'30" N, 48°52'45" E, 1988 07 11, HR; **Rel. 16:** Kremnické vrchy, Králiky, 19°01'26" N, 48°44'00" E, 2001 06 19, EU; **Rel. 17:** Zvolenská kotlina, Rakytovce, 19°07'29" N,

48°40'50" E, 2001 08 15, EU; **Rel. 18:** Starohorské vrchy, Tajov, Predné, 19°03'28" N, 48°45'60" E, 2001 06 15, EU; **Rel. 19:** Kremnické vrchy, Malachov, Pršany, 19°05'07" N, 48°42'17" E, 2001 06 11, EU; **Rel. 20:** Kremnické vrchy, Malachov, 19°05'07" N, 48°41'59" E, 2001 06 11, EU; **Rel. 21:** Zvolenská kotlina, Podlavice, 19°06'05" N, 48°44'51" E, 2004 05 23, MJ; **Rel. 22:** Zvolenská kotlina, Radvaň, 19°07'44" N, 48°43'15" E, 2001 08 09, EU; **Rel. 23:** Starohorské vrchy, Tajov, Predné, 19°03'48" N, 48°44'55" E, 2001 06 15, EU; **Rel. 24:** Veľká Fatra, Nižná Revúca, 19°12'23" N, 48°56'01" E, 1980 07 02, HR; **Rel. 25:** Zvolenská kotlina, Laskomerská dolina, 19°06'35" N, 48°45'03" E, 2001 06 02, MJ; **Rel. 26:** Zvolenská kotlina, Skubín, 19°06'05" N, 48°44'26" E, 2004 06 11, MJ; **Rel. 27:** Veľká Fatra, Donovaly, 19°13'30" N, 48°52'45" E, 1998 07 11, HR, #3; **Rel. 28:** Starohorské vrchy, Motyčky, 19°14'15" N, 48°52'45" E, 1992 07 01, HR, #3; **Rel. 29:** Kremnické vrchy, Malachov, 19°03'60" N, 48°42'26" E, 2001 06 14, EU; **Rel. 30:** Starohorské vrchy, Donovaly, Sliachany, 19°12'00" N, 48°52'13" E, 1998 06 25, HR, #3; **Rel. 31:** Veľká Fatra, Vyšná Revúca, 19°09'01" N, 48°54'06" E, 1980 06 29, HR; **Rel. 32:** Veľká Fatra, Vyšná Revúca, Črtlas, 19°09'03" N, 48°54'04" E, 1980 06 29, HR; **Rel. 33:** Kremnické vrchy, Malachov, 19°04'53" N, 48°42'28" E, 2001 06 05, EU; **Rel. 34:** Kremnické vrchy, Králiky, Ruskov, 19°01'36" N, 48°44'07" E, 2001 06 14, EU; **Rel. 35:** Veľká Fatra, Nižná Revúca, Končitá, 19°15'00" N, 48°55'00" E, 1992 07 01, HR, #3; **Rel. 36:** Kremnické vrchy, Suchý vrch, 19°04'22" N, 48°43'18" E, 2001 06 27, EU; **Rel. 37:** Kremnické vrchy, Pršany, 19°04'58" N, 48°42'10" E, 2001 06 11, EU; **Rel. 38:** Kremnické vrchy, Malachov, 19°05'00" N, 48°42'22" E, 2001 06 05, EU; **Rel. 39:** Nízke Tatry, Korytnická dolina, 19°17'25" N, 48°53'32" E, 1980 07 01, HR; **Rel. 40:** Kremnické vrchy, Pršany, 19°04'58" N, 48°42'08" E, 2001 06 11, EU; **Rel. 41:** Zvolenská kotlina, Rakytovce, 19°07'08" N, 48°40'38" E, 2002 06 21, EU; **Rel. 42:** Kremnické vrchy, Pršany, 19°05'05" N, 48°42'14" E, 2001 06 11, EU; **Rel. 43:** Starohorské vrchy, Baláže, 19°10'56" N, 48°49'48" E, 2005 06 24, MJ; **Rel. 44:** Veľká Fatra, Vyšná Revúca, 19°09'29" N, 48°54'20" E, 1988 07 14, HR; **Rel. 45:** Starohorské vrchy, Tajovská chata, 19°01'07" N, 48°45'02" E, 2001 08 06, MJ; **Rel. 46:** Veľká Fatra, Liptovské Revúce, Veľká Turecká, 19°09'58" N, 48°55'50" E, 1982 07 02, HR; **Rel. 47:** Kremnické vrchy, Malachov, 19°05'12" N, 48°42'31" E, 2001 06 05, EU; **Rel. 48:** Starohorské vrchy, Riečka, Hodíkovo, 19°04'13" N, 48°46'02" E, 2000 06 20, MJ; **Rel. 49:** Starohorské vrchy, Tajov, Predné, 19°03'35" N, 48°44'54" E, 2001 06 15, EU; **Rel. 50:** Kremnické vrchy, Kordiky, 19°01'30" N, 48°46'25" E, 1998 06 28, HR; **Rel. 51:** Kremnické vrchy, Suchý vrch, 19°03'10" N, 48°43'12" E, 2001 08 09, MJ; **Rel. 52:** Kremnické vrchy, Suchý vrch, 19°04'15" N, 48°43'28" E, 2002 06 20, EU; **Rel. 53:** Veľká Fatra, Liptovské Revúce, Veľká Turecká, 19°09'54" N, 48°55'51" E, 1982 07 02, HR; **Rel. 54:** Starohorské vrchy, Tajov, Ortuťno, 19°02'34" N, 48°43'51" E, 2001 06 14, EU; **Rel. 55:** Zvolenská kotlina, Badín, 19°05'24" N, 48°40'47" E, 2002 06 17, EU; **Rel. 56:** Kremnické vrchy, Suchý vrch, 19°04'28" N, 48°43'27" E, 2001 06 27, EU; **Rel. 57:** Kremnické vrchy, Suchý vrch, 19°04'05" N, 48°43'28" E, 2002 06 20, EU; **Rel. 58:** Starohorské vrchy, Králiky, 19°02'05" N, 48°44'31" E, 1988 06 28, HR; **Rel. 59:** Kremnické vrchy, Králiky, Pod stádlom, 19°01'24" N, 48°44'09" E, 2001 06 14, EU; **Rel. 60:** Zvolenská kotlina, Badín, 19°06'27" N, 48°40'11" E, 2002 06 21, EU; **Rel. 61:** Starohorské vrchy, Králiky, Ruskov, 19°01'49" N, 48°43'57" E, 2001 06 14, EU; **Rel. 62:** Kremnické vrchy, Králiky, Stádlu, 19°01'20" N, 48°44'17" E, 2001 08 07, EU; **Rel. 63:** Kremnické vrchy, Malachov, 19°05'34" N, 48°42'28" E, 2001 05 28, EU; **Rel. 64:** Kremnické vrchy, Pršany, 19°05'30" N, 48°42'02" E, 2001 06 14, EU; **Rel. 65:** Starohorské vrchy, Tajov, Kalvária, 19°04'12" N, 48°44'42" E, 2001 06 26, EU; **Rel. 66:** Starohorské vrchy, Králiky, 19°01'60" N, 48°44'09" E, 2001 06 22, EU; **Rel. 67:** Veľká Fatra, Turecká, 19°05'10" N, 48°51'56" E, 2006 07 12, EU; **Rel. 68:** Starohorské vrchy, Králiky, 19°01'52" N, 48°43'55" E, 2001 06 22, EU; **Rel. 69:** Kremnické vrchy, Králiky, Kvartová, 19°01'06" N, 48°44'24" E, 2001 08 07, EU; **Rel. 70:** Kremnické vrchy, Pršany, 19°05'11" N, 48°41'57" E, 2001 06 11, EU; **Rel. 71:** Starohorské vrchy, Tajov, 19°04'20" N, 48°44'38" E, 2004 05 13, MJ; **Rel. 72:** Veľká Fatra, Hornojelenská dolina, 19°08'59" N, 48°51'49" E, 2006 07 11, EU; **Rel. 73:** Veľká Fatra, Donovaly, Mišúty, 19°14'15" N, 48°52'50" E, 1999 07 03, HR; **Rel. 74:** Kremnické vrchy, Králiky, Stádlu, 19°01'19" N, 48°44'11" E, 2001 08 07, EU; **Rel. 75:** Kremnické vrchy, Malachov, 19°04'01" N, 48°42'29" E, 2001 05 28, EU; **Rel. 76:** Kremnické vrchy, Podlavice, Uhliská, 19°04'35" N, 48°43'55" E, 2001 06 25, EU; **Rel. 77:** Kremnické vrchy, Malachov, 19°03'54" N, 48°42'45" E, 2001 05 29, EU; **Rel. 78:** Kremnické vrchy, Podlavice, Mlynská, 19°05'02" N, 48°44'13" E, 2001 06 20, EU; **Rel. 79:** Veľká Fatra, Liptovská Osada, Javoriská, 19°16'03" N, 48°58'57" E, 1980 06 25, HR; **Rel. 80:** Kremnické vrchy, Králiky, 19°01'34" N, 48°43'60" E, 2001 06 19, EU; **Rel. 81:** Kremnické vrchy, Malachov, 19°05'09" N, 48°42'31" E, 2001 06 05, EU; **Rel. 82:** Starohorské vrchy, Korytnica, Baba, 19°17'00" N, 48°52'42" E, 1980 07 01, HR; **Rel. 83:** Kremnické vrchy, Malachov, 19°04'56" N, 48°42'41" E, 2001 06 04, EU; **Rel. 84:** Nízke Tatry, Korytnica, 19°16'55" N, 48°53'27" E, 2006 07 20, MJ; **Rel. 85:** Veľká Fatra, Vyšná Revúca, Suchá dolina, 19°09'11" N, 48°53'39" E, 1980 06 29, HR; **Rel. 86:** Starohorské vrchy, Donovaly, Somárska lúka, 19°13'20" N, 48°52'11" E, 2006 07 20, MJ; **Rel. 87:** Kremnické vrchy, Králiky, pod Ortuťným, 19°01'46" N, 48°43'51" E, 2001 06 22, EU; **Rel. 88:** Kremnické vrchy, Suchý vrch,

Mútne, 19°03'00" N, 48°43'13" E, 2001 08 09, EU; **Rel. 89:** Kremnické vrchy, Malachov, 19°03'55" N, 48°42'28" E, 2001 06 14, EU; **Rel. 90:** Veľká Fatra, Dolný Harmanec, Bánik, 19°03'02" N, 48°48'40" E, 2006 06 14, EU; **Rel. 91:** Starohorské vrchy, Baláže, 19°11'25" N, 48°49'34" E, 2005 06 05, MJ, IŠ; **Rel. 92:** Veľká Fatra, Vyšná Revúca, Pilná dolina, 19°09'48" N, 48°54'49" E, 2006 08 08, MJ; **Rel. 93:** Nízke Tatry, Korytnica, 19°17'19" N, 48°52'11" E, 1980 07 01, HR; **Rel. 94:** Kremnické vrchy, Podlavica, Uhliská, 19°04'22" N, 48°43'57" E, 2001 06 25, EU; **Rel. 95:** Kremnické vrchy, Podlavica, Uhliská, 19°09'53" N, 48°56'08" E, 1982 07 02, HR; **Rel. 96:** Zvolenská kotlina, Badín, 19°05'05" N, 48°40'29" E, 2001 08 09, EU; **Rel. 97:** Zvolenská kotlina, Badín, 19°06'28" N, 48°40'05" E, 2002 06 17, EU; **Rel. 98:** Kremnické vrchy, Kraliky, Kvartová, 19°00'55" N, 48°44'28" E, 2001 08 07, EU; **Rel. 99:** Zvolenská kotlina, Badín, 19°05'04" N, 48°40'39" E, 2002 06 05, EU; **Rel. 100:** Starohorské vrchy, Panský diel, 19°09'39" N, 48°48'01" E, 2000 06 08, MJ; **Rel. 101:** Kremnické vrchy, Kraliky, Ruskov, 19°01'38" N, 48°43'60" E, 2001 06 14, EU; **Rel. 102:** Starohorské vrchy, Panský diel, 19°09'31" N, 48°48'07" E, 2006 08 05, MJ; **Rel. 103:** Kremnické vrchy, Malachov, 19°04'37" N, 48°42'24" E, 2001 05 28, EU; **Rel. 104:** Kremnické vrchy, Malachov, 19°03'59" N, 48°42'33" E, 2001 05 29, EU; **Rel. 105:** Starohorské vrchy, Králiky, 19°02'02" N, 48°43'57" E, 2001 06 22, EU; **Rel. 106:** Veľká Fatra, Liptovská Osada, 19°15'51" N, 48°58'19" E, 1980 06 25, HR; **Rel. 107:** Starohorské vrchy, Uľanka, 19°06'45" N, 48°47'40" E, 2002 05 28, EU; **Rel. 108:** Kremnické vrchy, Malachov, Pršany, 19°05'16" N, 48°42'18" E, 2001 06 06, EU; **Rel. 109:** Kremnické vrchy, Malachov, Pršany, 19°05'02" N, 48°42'20" E, 2001 06 06, EU; **Rel. 110:** Starohorské vrchy, Králiky, 19°01'57" N, 48°44'10" E, 2001 06 22, EU; **Rel. 111:** Veľká Fatra, Liptovské Revúce, Magura, 19°09'11" N, 48°54'39" E, 1982 07 02, HR; **Rel. 112:** Kremnické vrchy, Malachov, 19°04'48" N, 48°42'38" E, 2001 06 04, EU; **Rel. 113:** Starohorské vrchy, Králiky, 19°01'58" N, 48°44'04" E, 2001 06 22, EU; **Rel. 114:** Kremnické vrchy, Kraliky, 19°01'25" N, 48°44'04" E, 2001 06 19, EU; **Rel. 115:** Zvolenská kotlina, Laskomer, 19°07'52" N, 48°44'43" E, 2004 07 09, MJ; **Rel. 116:** Kremnické vrchy, Badín, 19°04'60" N, 48°41'27" E, 2002 06 05, EU; **Rel. 117:** Veľká Fatra, Liptovská Osada, 19°16'10" N, 48°58'36" E, 1980 06 25, HR; **Rel. 118:** Starohorské vrchy, Baláže, 19°11'25" N, 48°49'35" E, 2005 06 05, MJ; **Rel. 119:** Starohorské vrchy, Špania Dolina, 19°07'48" N, 48°48'00" E, 2004 06 18, EU; **Rel. 120:** Zvolenská kotlina, Badín, 19°06'34" N, 48°40'03" E, 2002 06 17, EU; **Rel. 121:** Veľká Fatra, Hornojelenská dolina, 19°04'38" N, 48°51'08" E, 2006 07 11, EU; **Rel. 122:** Starohorské vrchy, Riečka, 19°04'52" N, 48°45'32" E, 2001 05 22, MJ; **Rel. 123:** Zvolenská kotlina, Rakytovce, 19°07'11" N, 48°40'50" E, 2001 08 15, EU; **Rel. 124:** Kremnické vrchy, Malachov, 19°03'52" N, 48°42'45" E, 2001 05 29, EU; **Rel. 125:** Starohorské vrchy, Riečka, 19°04'33" N, 48°45'56" E, 2001 07 08, HR; **Rel. 126:** Kremnické vrchy, Malachov, 19°05'08" N, 48°42'43" E, 2001 06 04, EU; **Rel. 127:** Zvolenská kotlina, Jakub, 19°07'50" N, 48°45'54" E, 2004 09 10, EU; **Rel. 128:** Zvolenská kotlina, Badín, 19°06'20" N, 48°40'06" E, 2002 06 17, EU; **Rel. 129:** Starohorské vrchy, Ravasky, 19°06'38" N, 48°46'11" E, 2004 06 15, MJ; **Rel. 130:** Starohorské vrchy, Malý diel, 19°09'58" N, 48°47'56" E, 2004 08 17, MJ; **Rel. 131:** Zvolenská kotlina, Laskomer, 19°07'54" N, 48°44'43" E, 2002 06 12, EU; **Rel. 132:** Kremnické vrchy, Suchý vrch, Tajov, 19°04'03" N, 48°43'45" E, 2001 06 13, EU; **Rel. 133:** Zvolenská kotlina, Slovenská Ľupča, 19°16'24" N, 48°46'10" E, 2006 08 07, MJ; **Rel. 134:** Kremnické vrchy, Pršany, 19°05'30" N, 48°42'02" E, 2001 06 11, EU; **Rel. 135:** Kremnické vrchy, Malachov, Pršany, 19°05'03" N, 48°42'20" E, 2001 06 06, EU; **Rel. 136:** Kremnické vrchy, Suchý vrch, Tajov, 19°03'14" N, 48°43'34" E, 2001 06 20, EU; **Rel. 137:** Kremnické vrchy, Malachov, 19°05'43" N, 48°42'26" E, 2001 06 11, EU; **Rel. 138:** Veľká Fatra, Stredná Revúca, 19°10'50" N, 48°55'11" E, 2006 08 08, MJ; **Rel. 139:** Veľká Fatra, Turecká, 19°04'37" N, 48°51'08" E, 2006 07 12, MJ; **Rel. 140:** Starohorské vrchy, Tajovská chata, 19°01'08" N, 48°45'07" E, 2001 08 06, MJ; **Rel. 141:** Zvolenská kotlina, Medený Hámor, 19°08'02" N, 48°44'44" E, 2004 07 09, MJ; **Rel. 142:** Kremnické vrchy, Tajov, Brúsy, 19°03'49" N, 48°44'31" E, 2001 06 26, EU; **Rel. 143:** Kremnické vrchy, Malachov, 19°04'56" N, 48°42'26" E, 2001 06 04, EU; **Rel. 144:** Zvolenská kotlina, Badín, 19°06'02" N, 48°40'14" E, 2002 06 21, EU; **Rel. 145:** Zvolenská kotlina, Badín, 19°06'06" N, 48°40'12" E, 2002 06 21, EU; **Rel. 146:** Kremnické vrchy, Králiky, 19°01'29" N, 48°44'02" E, 2001 06 19, EU; **Rel. 147:** Kremnické vrchy, Tajov, Holý vršok, 19°03'20" N, 48°43'35" E, 2001 06 20, MJ; **Rel. 148:** Kremnické vrchy, Suchý vrch, Tajov, 19°03'26" N, 48°43'40" E, 2001 06 20, EU; **Rel. 149:** Veľká Fatra, Donovaly, 19°13'02" N, 48°52'53" E, 1999 07 01, HR; **Rel. 150:** Zvolenská kotlina, Malachov, 19°05'37" N, 48°42'46" E, 2001 05 29, EU; **Rel. 151:** Starohorské vrchy, Tajov, Brúsy, 19°03'34" N, 48°44'05" E, 2001 06 26, EU; **Rel. 152:** Kremnické vrchy, Malachov, 19°05'31" N, 48°42'50" E, 2001 05 30, EU; **Rel. 153:** Zvolenská kotlina, Skubín, 19°06'23" N, 48°44'09" E, 2004 06 10, MJ; **Rel. 154:** Starohorské vrchy, Špania Dolina, 19°08'00" N, 48°47'20" E, 2004 06 18, EU; **Rel. 155:** Kremnické vrchy, Tajov, Zadný háj, 19°04'11" N, 48°44'03" E, 2001 06 27, EU; **Rel. 156:** Starohorské vrchy, Riečka, 19°04'58" N, 48°45'27" E, 2000 05 17, MJ; **Rel. 157:** Starohorské vrchy, Riečka, 19°04'60" N, 48°45'19" E, 2001 05 23, MJ; **Rel. 158:** Kremnické vrchy, Malachov, 19°04'03" N, 48°42'30" E, 2001 05 28, EU; **Rel. 159:** Starohorské vrchy, Tajov,

Brúsy, 19°03'35" N, 48°44'10" E, 2001 06 26, EU; **Rel. 160:** Kremnické vrchy, Suchý vrch, 19°04'18" N, 48°43'18" E, 2001 06 27, EU; **Rel. 161:** Kremnické vrchy, Malachov, 19°05'37" N, 48°42'30" E, 2001 05 28, EU; **Rel. 162:** Kremnické vrchy, Malachov, Pršany, 19°05'28" N, 48°42'19" E, 2001 06 06, EU; **Rel. 163:** Kremnické vrchy, Malachov, Pršany, 19°05'35" N, 48°42'12" E, 2001 06 06, EU; **Rel. 164:** Veľká Fatra, Hiadel', Pod Prislplom, 19°18'15" N, 48°51'40" E, 2001 06 26, HR, #3; **Rel. 165:** Starohorské vrchy, Kordíky, Holé sedlo, 19°02'30" N, 48°46'23" E, 1998 06 28, HR, #3; **Rel. 166:** Starohorské vrchy, Riečka, Dedkovo, 19°04'00" N, 48°46'35" E, 1998 06 26, HR, #3; **Rel. 167:** Veľká Fatra, Motyčky, Biely potok, 19°09'20" N, 48°52'28" E, 1998 07 14, HR, #3; **Rel. 168:** Veľká Fatra, Donovaly, 19°13'32" N, 48°52'46" E, 2006 07 19, MJ; **Rel. 169:** Starohorské vrchy, Riečka, Dedkovo, 19°03'32" N, 48°46'15" E, 1998 06 28, HR, #3; **Rel. 170:** Starohorské vrchy, Hornojelenská dolina, 19°09'15" N, 48°51'00" E, 2001 06 19, HR; **Rel. 171:** Starohorské vrchy, Riečanské sedlo, 19°04'35" N, 48°46'15" E, 1998 06 28, HR, #3; **Rel. 172:** Starohorské vrchy, Hornojelenská dolina, 19°09'32" N, 48°50'50" E, 1992 07 09, HR, #3; **Rel. 173:** Starohorské vrchy, Riečka, Lučivno, 19°03'35" N, 48°46'22" E, 1998 06 28, HR, #3; **Rel. 174:** Veľká Fatra, Donovaly, 19°13'10" N, 48°52'55" E, 1998 06 25, HR, #3; **Rel. 175:** Starohorské vrchy, Tajov, Ortuť, 19°02'30" N, 48°43'53" E, 2001 06 14, EU, #3; **Rel. 176:** Starohorské vrchy, pod Dedkovom, 19°04'28" N, 48°46'15" E, 1998 06 28, HR; **Rel. 177:** Starohorské vrchy, Riečka, Lučivno, 19°03'21" N, 48°46'08" E, 1998 06 26, HR, #3; **Rel. 178:** Starohorské vrchy, Riečka, Lučivno, 19°03'34" N, 48°46'17" E, 1998 06 26, HR, #3; **Rel. 179:** Veľká Fatra, Valentová, Práňnica, 19°07'58" N, 48°52'28" E, 2006 07 11, MJ; **Rel. 180:** Veľká Fatra, Turecká, 19°05'19" N, 48°50'55" E, 2006 07 12, MJ; **Rel. 181:** Veľká Fatra, Výchne Revúce, 19°09'31" N, 48°54'42" E, 2006 08 08, MJ; **Rel. 182:** Starohorské vrchy, Hornojelenská dolina, 19°09'20" N, 48°51'00" E, 2001 06 26, HR; **Rel. 183:** Veľká Fatra, Výchne Revúca, 19°09'37" N, 48°54'31" E, 1999 07 03, HR, #3; **Rel. 184:** Veľká Fatra, Donovaly, Sliachany, 19°13'05" N, 48°52'55" E, 1999 07 01, HR; **Rel. 185:** Starohorské vrchy, Donovaly, 19°09'20" N, 48°51'09" E, 1999 07 01, HR; **Rel. 186:** Veľká Fatra, Donovaly, 19°13'19" N, 48°52'56" E, 2006 07 19, MJ; **Rel. 187:** Starohorské vrchy, Tajov, Zaprávka, 19°02'54" N, 48°44'18" E, 2001 06 14, EU; **Rel. 188:** Starohorské vrchy, Tajov, Zaprávka, 19°03'35" N, 48°46'18" E, 2001 06 14, HR; **Rel. 189:** Starohorské vrchy, Riečka, Dedkovo, 19°04'50" N, 48°46'00" E, 1998 06 28, HR; **Rel. 190:** Veľká Fatra, Výchne Revúca, 19°09'46" N, 48°54'40" E, 2006 08 08, MJ; **Rel. 191:** Zvolenská kotlina, Skubín, 19°06'13" N, 48°44'06" E, 1998 07 04, MJ; **Rel. 192:** Starohorské vrchy, Riečka, Dedkovo, 19°04'02" N, 48°46'37" E, 1998 06 28, HR; **Rel. 193:** Veľká Fatra, Donovaly, Sliachany, 19°12'10" N, 48°52'20" E, 1998 06 26, HR; **Rel. 194:** Veľká Fatra, Donovaly, Zvolen Hill, 19°15'10" N, 48°55'00" E, 1992 07 02, HR, #3; **Rel. 195:** Starohorské vrchy, Donovaly, Hrubý vrch, 19°12'30" N, 48°51'12" E, 1990 07 09, HR, #3; **Rel. 196:** Veľká Fatra, Revúcke podolie, 19°15'35" N, 48°53'40" E, 1982 07 01, HR, #3; **Rel. 197:** Veľká Fatra, Rybô, 19°07'30" N, 48°52'10" E, 1990 07 14, HR, #3; **Rel. 198:** Starohorské vrchy, Panský diel, 19°09'33" N, 48°48'02" E, 2000 06 08, MJ; **Rel. 199:** Veľká Fatra, Turecká, 19°04'39" N, 48°51'03" E, 2006 07 12, MJ; **Rel. 200:** Starohorské vrchy, Hornojelenská dolina, 19°09'02" N, 48°51'10" E, 1998 06 25, HR, #3; **Rel. 201:** Starohorské vrchy, Motyčky, Bukovská dolina, 19°11'30" N, 48°50'55" E, 2001 06 26, HR, #3; **Rel. 202:** Kremnické vrchy, Kordíky, 19°01'11" N, 48°46'38" E, 1988 07 07, HR; **Rel. 203:** Veľká Fatra, Korytnica, 19°15'10" N, 48°54'50" E, 1980 06 30, HR; **Rel. 204:** Veľká Fatra, Turecká, 19°04'36" N, 48°51'07" E, 2006 07 11, EU; **Rel. 205:** Veľká Fatra, Valentová, Práňnica, 19°07'59" N, 48°52'23" E, 1988 07 14, HR; **Rel. 206:** Veľká Fatra, Donovaly, Motyčkova hoľa, 19°11'52" N, 48°53'02" E, 1988 07 11, HR; **Rel. 207:** Starohorské vrchy, Staré Hory, 19°06'49" N, 48°50'25" E, 1998 06 26, HR; **Rel. 208:** Veľká Fatra, Korytnica, Žarnovka, 19°15'41" N, 48°53'24" E, 1980 07 01, HR; **Rel. 209:** Starohorské vrchy, Donovaly, Štubne, 19°10'53" N, 48°51'43" E, 1998 06 25, HR; **Rel. 210:** Veľká Fatra, Jelenská dolina, Rybô, 19°07'15" N, 48°52'10" E, 1988 07 11, HR; **Rel. 211:** Starohorské vrchy, Kordíky, 19°02'29" N, 48°46'35" E, 2001 05 29, MJ; **Rel. 212:** Veľká Fatra, Donovaly, 19°13'30" N, 48°52'50" E, 1998 06 25, HR, #3; **Rel. 213:** Veľká Fatra, Revúcke podolie, 19°14'40" N, 48°54'30" E, 1992 07 01, HR, #3; **Rel. 214:** Starohorské vrchy, Donovaly, Štubne, 19°10'38" N, 48°51'39" E, 1998 06 25, HR, #3; **Rel. 215:** Veľká Fatra, Revúcke podolie, Veľká Bzdová, 19°15'10" N, 48°54'25" E, 1992 07 02, HR, #3; **Rel. 216:** Veľká Fatra, Revúcke podolie, 19°15'30" N, 48°55'00" E, 1999 07 03, HR, #3; **Rel. 217:** Starohorské vrchy, Tajov, 19°04'35" N, 48°44'33" E, 2004 05 13, EU; **Rel. 218:** Veľká Fatra, Donovaly, 19°13'27" N, 48°52'46" E, 1999 07 01, HR; **Rel. 219:** Starohorské vrchy, Donovaly, Štubne, 19°10'30" N, 48°51'35" E, 1999 07 03, HR, #3; **Rel. 220:** Veľká Fatra, Donovaly, Mackova dolina, 19°11'25" N, 48°52'50" E, 1990 07 11, HR, #3; **Rel. 221:** Veľká Fatra, Korytnická dolina, 19°15'21" N, 48°54'01" E, 1980 07 01, HR; **Rel. 222:** Starohorské vrchy, Motyčky, Bukovská dolina, 19°11'40" N, 48°50'50" E, 1998 06 25, HR, #3; **Rel. 223:** Starohorské vrchy, Motyčky, Bukovská dolina, 19°10'28" N, 48°51'22" E, 1998 07 09, HR, #3; **Rel. 224:** Veľká Fatra, Liptovská osada, Kopiská, 19°15'08" N, 48°55'15" E, 1982 07 01, HR; **Rel. 225:** Veľká Fatra, Nižná Revúca, 19°13'03" N, 48°55'30" E, 1980 07 02, HR; **Rel. 226:** Veľká Fatra, Korytnická dolina, 19°15'12" N, 48°54'59" E, 1980 07 01, HR; **Rel. 227:**



Starohorské vrchy, Donovaly, 19°11'50" N, 48°51'37" E, 1999 07 03, HR, #3; **Rel. 228:** Veľká Fatra, Liptovské Revúce, VeľkáTurecká, 19°09'59" N, 48°55'55" E, 1982 07 02, HR; **Rel. 229:** Kremnické vrchy, Kordíky, 19°01'20" N, 48°46'28" E, 1998 06 28, HR; **Rel. 230:** Starohorské vrchy, Kordíky, 19°02'30" N, 48°46'38" E, 2002 07 08, MJ; **Rel. 231:** Veľká Fatra, Liptovská Osada, 19°15'47" N, 48°54'57" E, 2006 07 20, MJ; **Rel. 232:** Starohorské vrchy, Podkonice, Pleše, 19°14'06" N, 48°49'10" E, 2005 06 28, EU; **Rel. 233:** Veľká Fatra, Korytnická dolina, 19°15'21" N, 48°54'15" E, 1980 07 01, HR; **Rel. 234:** Starohorské vrchy, Králiky, 19°01'59" N, 48°43'56" E, 2001 06 22, EU; **Rel. 235:** Kremnické vrchy, Králiky, 19°01'29" N, 48°44'03" E, 2001 06 19, EU; **Rel. 236:** Starohorské vrchy, Panský diel, 19°09'10" N, 48°47'49" E, 2004 08 24, MJ; **Rel. 237:** Veľká Fatra, Nižná Revúca, 19°13'12" N, 48°55'12" E, 1980 07 02, HR; **Rel. 238:** Starohorské vrchy, Panský diel, 19°09'01" N, 48°48'09" E, 2001 06 13, MJ; **Rel. 239:** Starohorské vrchy, Panský diel, 19°09'16" N, 48°47'55" E, 2004 08 24, MJ.

**Table 4 – Rel. 1:** Kremnické vrchy, Králiky, Stádlo, 19°01'20" N, 48°44'13" E, 2001 08 07, EU; **Rel. 2:** Starohorské vrchy, Riečka, 19°04'09" N, 48°45'20" E, 2002 05 21, MJ; **Rel. 3:** Kremnické vrchy, Malachov, Pršany, 19°05'02" N, 48°42'17" E, 2001 06 06, EU; **Rel. 4:** Starohorské vrchy, Králiky, 19°02'03" N, 48°44'09" E, 2001 06 22, EU; **Rel. 5:** Starohorské vrchy, Králiky, 19°02'03" N, 48°44'07" E, 2001 06 22, EU; **Rel. 6:** Kremnické vrchy, Králiky, 19°01'37" N, 48°43'58" E, 2001 06 19, EU; **Rel. 7:** Starohorské vrchy, Králiky, 19°02'02" N, 48°44'08" E, 2001 06 22, EU; **Rel. 8:** Kremnické vrchy, Králiky, 19°01'27" N, 48°44'00" E, 2001 06 19, EU; **Rel. 9:** Zvolenská kotlina, Badín, 19°06'28" N, 48°40'11" E, 2002 06 21, EU; **Rel. 10:** Kremnické vrchy, Podlavice, Uhliská, 19°04'25" N, 48°43'57" E, 2001 06 25, EU; **Rel. 11:** Starohorské vrchy, Králiky, 19°02'04" N, 48°44'07" E, 2001 06 22, EU; **Rel. 12:** Kremnické vrchy, Suchý vrch, 19°04'09" N, 48°43'16" E, 2001 06 27, EU; **Rel. 13:** Kremnické vrchy, Suchý vrch, 19°04'05" N, 48°43'30" E, 2002 06 20, EU; **Rel. 14:** Zvolenská kotlina, Badín, 19°05'42" N, 48°40'26" E, 2002 06 17, EU; **Rel. 15:** Kremnické vrchy, Suchý vrch, 19°04'11" N, 48°43'16" E, 2001 06 27, EU; **Rel. 16:** Starohorské vrchy, Tajov, Predné, 19°03'39" N, 48°44'48" E, 2001 06 15, EU; **Rel. 17:** Starohorské vrchy, Králiky, Stádlo, 19°01'23" N, 48°44'19" E, 2001 08 07, EU; **Rel. 18:** Kremnické vrchy, Suchý vrch, 19°04'21" N, 48°43'20" E, 2001 06 27, EU; **Rel. 19:** Starohorské vrchy, Baláže, 19°10'53" N, 48°49'49" E, 2005 06 24, MJ; **Rel. 20:** Starohorské vrchy, Baláže, 19°10'54" N, 48°49'48" E, 2005 06 24, MJ; **Rel. 21:** Starohorské vrchy, Šachtičky, 19°09'34" N, 48°48'06" E, 2002 05 31, MJ; **Rel. 22:** Kremnické vrchy, Suchý vrch, 19°04'24" N, 48°43'18" E, 2001 06 27, EU; **Rel. 23:** Starohorské vrchy, Šachtičky, 19°03'36" N, 48°48'05" E, 2002 05 31, MJ; **Rel. 24:** Starohorské vrchy, Tajov - Predné, 19°03'39" N, 48°44'48" E, 2001 06 15, EU; **Rel. 25:** Kremnické vrchy, Suchý vrch, 19°04'10" N, 48°43'30" E, 2002 07 10, MJ; **Rel. 26:** Kremnické vrchy, Podlavice, Uhliská, 19°04'27" N, 48°43'56" E, 2002 06 20, EU; **Rel. 27:** Starohorské vrchy, Tajov, 19°03'12" N, 48°45'27" E, 2002 06 30, MJ; **Rel. 28:** Kremnické vrchy, Suchý vrch, 19°04'10" N, 48°43'30" E, 2002 07 10, MJ; **Rel. 29:** Starohorské vrchy, Riečka, 19°04'12" N, 48°45'19" E, 2002 05 21, MJ, HP; **Rel. 30:** Zvolenská kotlina, Laskomerská dolina, 19°06'25" N, 48°45'14" E, 2002 07 05, MJ; **Rel. 31:** Starohorské vrchy, Tajov, 19°03'15" N, 48°45'30" E, 2002 05 16, MJ; **Rel. 32:** Starohorské vrchy, Tajov, 19°03'13" N, 48°45'30" E, 2002 06 30, MJ.

Appendix D: Overview of species that are diagnostic of associations at regional level (●), at national level (○), or at both levels (⊙)

Anhang D: Übersicht der diagnostischen Arten von Assoziationen auf regionaler Ebene (●), auf nationaler Ebene (○) sowie auf beiden Ebenen (⊙)

1 *Orthantho luteae-Caricetum humilis*, 2 *Scabioso ochroleucaae-Brachypodietum pinnati*, 3 *Carici albae-Brometum monocladi*, 4 *Brachypodio pinnati-Molinietum arundinaceae*, 5 *Onobrychido viciifoliae-Brometum erecti* (all *Festuco-Brometea*), 6 *Lolio perennis-Cynosuretum cristati*, 7 *Pastinaco sativae-Arrhenatheretum elatioris*, 8 *Poo-Trisetetum flavescens*, 9 *Anthoxantho odorati-Agrostietum tenuis*, 10 *Ranunculo bulbosi-Arrhenatheretum elatioris*, 11 *Lilio bulbiferi-Arrhenatheretum elatioris*, 12 *Campanulo glomeratae-Geranium sylvatici* (all *Molinio-Arrhenatheretea*), 13 *Violo sudeticae-Agrostietum capillaris* (*Nardetea stricae*).

Association	1	2	3	4	5	6	7	8	9	10	11	12	13
<b>Sum of ●</b>	9	15	8	7	13	3	3	11	15	7	10	16	3
<b>Sum of ○</b>	15	4	13	10	1	1	4	1	1	2	11	9	18
<b>Sum of ⊙</b>	9	9	22	12	5	3	0	1	3	6	13	17	5
<b>% of ⊙ in (● plus ⊙)</b>	50	38	73	63	28	50	0	8	17	46	57	50	63
<b>% of matched relevés</b>	7	53	31	96	83	44	24	32	81	31	83	42	9
<i>Acetosa pratensis</i>									●				
<i>Acinos alpinus</i>			○										
<i>Acosta rhenana</i>		●											
<i>Agrimonia eupatoria</i>		⊙			●								
<i>Agrostis capillaris</i>									●		○		○
<i>Allium oleraceum</i>			○										
<i>Anemone ranunculoides</i>											●		
<i>Antennaria dioica</i>													○
<i>Anthericum ramosum</i>	⊙		⊙										
<i>Anthoxanthum odoratum</i>									●				
<i>Anthriscus sylvestris</i>								●					
<i>Anthyllis vulneraria</i>	○		⊙								○	○	
<i>Aquilegia vulgaris</i>			○								⊙	○	
<i>Arabis hirsuta</i>			○								●		
<i>Arrhenatherum elatius</i>					○		○			⊙	⊙	○	
<i>Asperula cynanchica</i>	⊙	⊙											
<i>Avenella flexuosa</i>													○
<i>Avenula praeusta</i>													○
<i>Avenula pubescens</i>									●	●			
<i>Bellis perennis</i>						⊙							
<i>Betonica officinalis</i>				⊙									
<i>Brachypodium pinnatum</i>	○	⊙	⊙	⊙	●								
<i>Briza media</i>									●				
<i>Bromus erectus</i>		●	○	○	⊙								
<i>Bromus monocladus</i>	○		⊙								○		
<i>Bupthalmum salicifolium</i>			⊙										
<i>Bupleurum falcatum</i>	●												
<i>Campanula glomerata</i>				○							⊙	⊙	
<i>Campanula patula</i>								⊙	●				
<i>Campanula persicifolia</i>				●									
<i>Campanula rapunculoides</i>							●						
<i>Campanula rotundifolia</i> agg.		●											
<i>Campanula serrata</i>											⊙	⊙	⊙
<i>Carduus glaucinus</i>			●								●		
<i>Carex alba</i>			○										
<i>Carex caryophyllea</i>		●											
<i>Carex humilis</i>	⊙												
<i>Carex michelii</i>		●	⊙		●								
<i>Carex montana</i>			⊙	⊙									
<i>Carex pilulifera</i>													○
<i>Carex tomentosa</i>			⊙										

Association	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Carlina acaulis</i>				⊙							⊙	○	○
<i>Carlina vulgaris</i>	•	⊙											
<i>Carum carvi</i>								•					
<i>Chaerophyllum aromaticum</i>								•					
<i>Chamaecytisus supinus</i>				○									
<i>Cirsium acaule</i>		○											
<i>Cirsium erisithales</i>												⊙	
<i>Cirsium pannonicum</i>			⊙										
<i>Colchicum autumnale</i>											○	⊙	
<i>Colymbada scabiosa</i>	⊙		○										
<i>Crepis alpestris</i>											○		
<i>Crepis biennis</i>							○					•	
<i>Crepis mollis</i>												•	
<i>Crepis praemorsa</i>				○									
<i>Crocus discolor</i>												⊙	
<i>Cruciata glabra</i>												•	
<i>Cuscuta epithymum</i>													
<i>Cynosurus cristatus</i>						⊙							
<i>Dactylis glomerata</i>								•		•		•	
<i>Danthonia decumbens</i>									•				
<i>Daucus carota</i>										⊙			
<i>Dianthus carthusianorum</i>			○		•					⊙	⊙	○	
<i>Dianthus deltoides</i>									•				○
<i>Falcaria vulgaris</i>		•											
<i>Festuca rubra</i>								•	•				
<i>Festuca rupicola</i>	○	⊙			⊙					•			
<i>Filipendula vulgaris</i>				⊙									
<i>Fragaria vesca</i>											•		
<i>Galium mollugo</i> agg.												•	
<i>Galium verum</i>		•											
<i>Genista pilosa</i>		⊙											
<i>Gentiana cruciata</i>			○								⊙		
<i>Geranium sylvaticum</i>												⊙	
<i>Globularia punctata</i>	⊙		⊙										
<i>Gymnadenia conopsea</i>													○
<i>Helianthemum ovatum</i>	•		•										
<i>Heracleum sphondylium</i>												•	
<i>Hippocrepis comosa</i>	⊙		⊙										
<i>Hypericum maculatum</i>												•	⊙
<i>Hypericum perforatum</i>				•									
<i>Hypochaeris radicata</i>									•				
<i>Inula ensifolia</i>			•										
<i>Inula salicina</i>			⊙										
<i>Jacea phrygia</i> agg.											○	⊙	
<i>Knautia arvensis</i>					•							⊙	
<i>Knautia kitaibelii</i>	○		⊙									○	
<i>Knautia maxima</i>												•	
<i>Koeleria pyramidata</i> agg.	○			○									
<i>Lathyrus latifolius</i>				⊙									
<i>Leontodon autumnalis</i>						○							
<i>Leontodon hispidus</i>										○		⊙	
<i>Leontodon incanus</i>	⊙												
<i>Leucanthemum vulgare</i>									•	•			
<i>Lilium bulbiferum</i>											⊙	⊙	
<i>Linum catharticum</i>		○											
<i>Linum flavum</i>	•												
<i>Linum tenuifolium</i>	○												
<i>Lolium perenne</i>						⊙							
<i>Lotus corniculatus</i>										•			
<i>Luzula campestris</i> agg.									•				

Association	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Luzula luzuloides</i>												•	⊙
<i>Medicago falcata</i>				•	⊙								
<i>Medicago lupulina</i>											•		
<i>Melampyrum cristatum</i>				○									
<i>Nardus stricta</i>									•				○
<i>Onobrychis viciifolia</i>				⊙	⊙								
<i>Ononis spinosa</i>		⊙											
<i>Ophrys insectifera</i>	○												
<i>Orchis militaris</i>	○												
<i>Orphantha lutea</i>	○												
<i>Phleum hirsutum</i>												•	•
<i>Phyteuma orbiculare</i>											•		
<i>Phyteuma spicatum</i>								•				•	
<i>Picris hieracioides</i>		•											
<i>Pilosella bauhini</i>			•										
<i>Pilosella officinarum</i>													○
<i>Pimpinella major</i>				⊙								⊙	
<i>Pimpinella saxifraga</i>					•								
<i>Plantago lanceolata</i>										•	•		
<i>Plantago major</i>						•							
<i>Plantago media</i>											○		
<i>Poa chaixii</i>													○
<i>Poa pratensis</i> agg.							•						
<i>Polygala amara</i> subsp. <i>brachyptera</i>			○										
<i>Polygala major</i>	○				•								
<i>Polygala vulgaris</i>									⊙			⊙	
<i>Polygonatum odoratum</i>			⊙										
<i>Potentilla alba</i>				○									
<i>Potentilla anserina</i>						•							
<i>Potentilla arenaria</i> agg.	•												
<i>Potentilla aurea</i>													⊙
<i>Potentilla heptaphylla</i>	○		⊙										
<i>Potentilla thuringiaca</i>											○		
<i>Primula acaulis</i>											○		
<i>Primula elatior</i>												⊙	
<i>Primula veris</i>			⊙	⊙	•								
<i>Prunella grandiflora</i>	○		•										
<i>Prunella laciniata</i>		•											
<i>Pseudolysimachion orchideum</i>					•								
<i>Pseudolysimachion spicatum</i>	•												
<i>Pyrethrum clusii</i>												⊙	
<i>Pyrethrum corymbosum</i>			•	•								○	
<i>Ranunculus bulbosus</i>										⊙			
<i>Ranunculus nemorosus</i>											•		
<i>Ranunculus polyanthemus</i>				○								•	•
<i>Ranunculus pseudomontanus</i>													•
<i>Rhinanthus minor</i>											•		
<i>Rhinanthus serotinus</i>			○								⊙		
<i>Salvia pratensis</i>			⊙	⊙	⊙					⊙			
<i>Salvia verticillata</i>		○	⊙		•								
<i>Sanguisorba minor</i>	○	○	⊙								⊙		
<i>Scabiosa ochroleuca</i>	•	⊙											
<i>Scorzonera hispanica</i>				•									
<i>Securigera varia</i>		○			•								
<i>Seseli annuum</i>	•	•											
<i>Silene dioica</i>												•	
<i>Silene nemoralis</i>											○	○	
<i>Silene nutans</i>											•		○
<i>Silene vulgaris</i>			○								⊙	⊙	

Association	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Stellaria graminea</i>												•	○
<i>Taraxacum</i> sect. <i>Ruderalia</i>							•	•					
<i>Teucrium chamaedrys</i>	⊙	⊙	⊙										
<i>Teucrium montanum</i>		•											
<i>Thesium linophyllum</i>	⊙	•		•									
<i>Thlaspi caerulescens</i>													○
<i>Thlaspi perfoliatum</i>										•			
<i>Thymus praecox</i>	○												
<i>Thymus pulegioides</i>									⊙				○
<i>Tithymalus cyparissias</i>	•	•	•	•									
<i>Tithymalus tommasinanus</i>													
<i>Tragopogon orientalis</i>				○			○				⊙	⊙	
<i>Trifolium dubium</i>						•				○			
<i>Trifolium montanum</i>			○	⊙	•				○		⊙	○	
<i>Trifolium pratense</i>								•					
<i>Trifolium repens</i>								•	•				
<i>Trifolium rubens</i>				○									
<i>Trisetum flavescens</i>							○	○		⊙	○	⊙	
<i>Trommsdorffia maculata</i>			⊙	⊙									○
<i>Veronica officinalis</i>													⊙
<i>Vicia cracca</i>								•				•	
<i>Vicia hirsuta</i>		•											
<i>Vicia sepium</i>												•	
<i>Vincetoxicum hirundinaria</i>			•										
<i>Viola canina</i>									⊙				○
<i>Viola collina</i>		•											
<i>Viola hirta</i>			⊙	○	•								
<i>Viola lutea</i>													○
<i>Viola tricolor</i>								•					

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