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Diversity of *Calthion* wet meadows in the western part of flysch Carpathians: regional classification based on national formal definitions

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Abstract: We classified vegetation of wet meadows in the western part of flysch Carpathians in Slovakia (Biele Karpaty Mts., Javorníky Mts., Kysuce and Orava region, Inner Carpathian Basins). We tried to classify wet meadow communities in the study area with respect to their diversity at a wider geographical range. For this purpose, we used the formal definitions based on combination of the species groups which were extracted from a large national database. This way the classification could be valid not only at a regional scale, but also for the whole territory of Slovakia. We distinguished six associations of the *Calthion* alliance (*Cirsietum rivularis, Chaerophyllo hirsuti-Calthetum, Angelico-Cirsietum palustris, Scirpetum sylvatici, Angelico-Cirsietum oleracei* and *Scirpo-Cirsietum cani*) by combining six species groups and the dominance of some species respectively. Principal gradients in species composition were interpreted using Ellenberg indicator values. The major gradient was associated with soil moisture and pH and the second most important gradient was associated with available nutrients. At last, we suggested two associations originally defined by the dominance of certain species (*Polygono-Cirsietum palustris* and *Trollio-Cirsietum rivularis*) to be only the synonymous of *Angelico-Cirsietum palustris* and *Cirsietum rivularis*, respectively.

Keywords: Ellenberg indicator values, environmental gradients, fen meadows, grassland vegetation, ordination, phytosociology, Slovakia, species groups.

Introduction

Wet *Calthion* meadows are still rather widespread types of hay meadows in Central Europe. If moisture is considered the main environmental gradient controlling species composition of European meadows (ELLENBERG 1996) then the *Calthion* meadows are placed on the wettest end of this gradient. As compared to other meadow types, wet *Calthion* meadows are usually classified into a great number of associations (RYBNÍČEK et al. 1984). This fact is probably caused by the high beta-diversity which increases towards waterlogged meadows (HAVLOVÁ et al. 2004). On the other hand, the high number of described associations is partially caused by common dominance of broad-leaved herbs (*Cirsium* spp., *Scirpus sylvaticus, Caltha palustris* etc.), which is often reflected in the classification. Therefore we attempt to define associations not only using dominant species but also using combinations of species groups.

While in some regions wet meadows are over-sampled (e.g. Czech Republic; cf. CHYTRÝ & RAFAJOVÁ 2003), in other regions they have been overlooked. In spite of the fact that wet meadows are rather common in the flysch part of Outer West Carpathians in Slovakia only scarce data are available from this area. Some published relevés of wet meadow vegetation are available from Slovakian East Carpathians, namely from the Bukovské vrchy Mts. (HADAČ et al. 1997, HÁJEK 1999). Concerning our study area, some relevés have been documented only from the Liptov Basin (BALÁTOVÁ-TULÁČKOVÁ & URVICHIAROVÁ 1992, RŮŽIČKOVÁ 1978, 1986). Most authors working in our study area have dealt with mire vegetation. Their papers contain data from wet meadows only scarcely (HÁJEK 1998, ŠMARDA 1961, VOZÁROVÁ 1981) or some of the relevés are even without bryophyte documentation (e.g. URBANOVÁ 1994). Moreover, from some particular regions no data have been published (e.g. Javorníky Mts. or the western part of the Kysuce Protected Landscape Area).

As the current agricultural landscape continually changes due to human activities, frequent species-rich wet meadows are step-by-step reduced by drainage, strong disturbance and in many cases also by the absence of any management. Due to these processes, wet meadow vegetation is often invaded by ruderal and nitrophilous species or it successionally changes to species-poor tall forb vegetation.

This study is aimed at (i) gathering missing data about *Calthion* meadows from the western part of flysch Carpathians; (ii) classifying wet meadow vegetation in the study area with respect to Slovak national classification; (iii) developing the formal definition for each association and (iv) analysing the major ecological gradients in species composition of the studied wet meadows.

Material and methods

Study area

The study area is located at the western, north-western and northern parts of the Slovak Republic (Fig. 1). Most of the study area lies on the Paleogene flysch bedrock with Magura Nappe as the most widespread geological unit. The entire study area belongs to the Outer West Carpathians. Flysch is bedrock where in each geological stratum (bed) sandstone and claystone alternate. The beds differ from each other both in chemistry and the proportion of sandstone and claystone. It is important to note that such structure is favourable for spring originating. The groundwater chemical composition reflecting the bedrock chemistry (RAPANT et al. 1996) is a very important factor controlling species composition of waterlogged meadows. Besides the Magura Nappe some other bedrock units locally present: Paleogene sediments of Inner-Carpathian Basins (Liptov, Spiš and Poprad Basins), iron-cemented sandstones of the Silesian Unit of Krosno Nappe (Kysuce region) and the Klippen Belt built from limestones of the secondary period (Biele Karpaty Mts.).

The study area comprises a high number of orographical units. South-western and western parts are formed by the Biele Karpaty Mts. with prevailing calcified claystone and the Javorníky Mts. The north-western part (Kysuce region) is composed of the Moravskosliezske Beskydy Mts. with prevailing non-calcified sandstone, the Turzovská vrchovina Mts., the Kysucké Beskydy Mts. and Kysucká vrchovina Mts. with prevailing calcified sandstone and claystone. The next region called Orava is the flysch area with a rather complicated geomorphological structure consisting of mountain ranges (Oravské Beskydy and Oravská Magura Mts.), uplands (i.e. Podbeskydská vrchovina, Skorušinské vrchy), undulated furrows (Podbeskydská brázda, Podtatranská brázda) and one flat inter-mountain basin (Oravská kotlina). The bedrock- and groundwater chemistry varied in this region, where both calcified and non-calcified sandstone and claystone occur. The easternmost localities belong to the Spišská Magura Mts. and to the Inner-Carpathians Basins (Liptov, Spiš and Poprad Basins). Only several localities are located at the foothill of the Inner West Carpathians (Nízké Tatry Mts., Malá Fatra Mts.) lying southwards from the studied flysch area.

The climate of the study area varies with respect to particular regions. The Biele Karpaty Mts. in the south-western part of the study area have warmer (annual mean temperature in the station Myjava, 1951-1980, 8.1°C) and drier climate (annual mean precipitation in the station Nová Bošáca, 1951-1980, 717 mm) (DOSTÁL & PETRŮJOVÁ 1992). On the contrary, the climate of the north-western part (Kysuce region) is more humid and cooler. The mean annual precipitation often reaches more than 1400 mm; the mean annual temperature locally decreases to 5°C (VESECKÝ 1961). The climatic conditions of the Orava region are similar, but the mean annual precipitation is quite higher than that of the Kysuce region and varies between 1100 - 1400 mm. The precipitation is especially high across the main mountain ridges at the northern margin of the region and at the foothill of the Vysoké Tatry Mts. Climate of Inner-Carpathians Basins (Liptov, Spiš and Poprad Basins) is rather continental due to the rain shadow of the Vysoké Tatry Mts.

Field data sampling

All relevés from the study area were collected in the vegetation seasons 2000 – 2004 in order to complete phytosociological data about *Calthion* wet meadows in Slovakia. For an estimate of abundance and dominance of plant species (vascular plants, bryophytes) the nine-grade scale (VAN DER MAAREL 1979) was used. Most of the relevés have been taken from a plot size of 16 m^2, which is the recommended size for the sampling of grassland vegetation (CHYTRÝ & OTÝPKOVÁ 2003).

Data analysis

The 4966 phytosociological relevés from the Central Phytosociological Database of Slovakia (www.ibot.sav.sk/cdf) (*Molinio-Arrhenatheretea*, *Scheuchzerio-Caricetea fuscae*, *Festuco-Brometea* and *Nardo-Calunetea* classes) were exported into JUICE software (TICHÝ 2002). In the next step, we tried to define vegetation types of wet meadows which are reported from Slovakia and other Central- European countries (BURKART et al. 2004, ELLMAUER & MUCINA 1993, MORAVEC et at. 1995, RYBNÍČEK et al. 1984). We characterised these vegetation types by the formal definitions using the combination of defined groups of species with the statistical tendency of joint occurrences in vegetation (KOČÍ et al. 2003). The species groups were created by the Coctail method (BRUELHEIDE 2000), using the phi-coefficient (SOKAL & ROHLF 1995, CHYTRÝ et al. 2002). The species group is present in the relevé if at least one half of its members are presents. The resulting groups were combined by logical operators AND, OR and AND NOT; the strong dominance of some species was also used as a character in some cases. Further, we kept only our own relevés from the study area (Western flysch Carpathians), deleted the other relevés and then recalculated fidelity of each species to each vegetation type (CHYTRÝ et al. 2002) in resulting small data set from the study area. The species in the table were then sorted according to their fidelity to vegetation type and the species with fidelity above 0.25 (phi-coefficient > 0.25) in any association were regarded as diagnostic. Relevés that remained unclassified were subsequently assigned to the associations by calculating similarity to relevé groups that had already been assigned to the associations using the Positive fidelity-Frequency index (TICHÝ 2005) and by the number of diagnostic species. Finally, the diagnostic species were recalculated. Only species with fidelity higher than 25 and simultaneously with a probability of non-random occurrence yielded by Fischer's exact test above 1.10^{-2} (Chytrý et al. 2002) were included to the synoptic table. Due to using this approach we can regard the resulting classification to be valid for the entire Slovakian territory.

Major gradients in species composition of wet meadow vegetation were analysed by the ordination of data set from the study area using detrended correspondence analysis (DCA) in the CANOCO 4.5 package (TER BRAAK & ŠMILAUER 2002). For ecological interpretation of the ordination axes, average Ellenberg indicator values (ELLENBERG et al. 1992) for relevés were plotted onto DCA ordination diagram as supplementary environmental data. These environmental variables were correlated with ordination axes (the Pearson correlation coefficient) using the SPSS 8.0.0. software.

Nomenclature follows MARHOLD & HINDÁK (1998) for both vascular plants and bryophytes.

Results

We distinguished six species groups (see Tab. 1), which we have used for creating the formal definitions of six wet meadow associations. Species that differentiate particular associations are shown in the shortened synoptic table (Tab. 2). The study wet meadow vegetation was classified within the following associations:

Cirsietum rivularis NOWIŃSKI 1927 (Tab. 3, rel. 1-67)

definition: [(group Valeriana simplicifolia AND group Lychnis flos-cuculi) OR Cirsium rivulare cover > 5%] NOT (Scirpus sylvaticus cover > 50% OR group Eriophorum latifolium)

Cirsietum rivularis is the most common type of wet meadow vegetation and it occurs over the entire study area. It prefers alkaline, calcareous soils (subass. ***eriophoretosum latifolii***) or circumneutral soils (subass. ***chaerophylletosum hirsuti*** and ***typicum***). Most of the habitats are species-rich, only those unmanaged for a long time are rather species-poor.

subass. *trollietosum altissimae* comb. nova (Tab. 3, rel. 29-31; nomenclature type: rel. 31) is differentiated from the other subassociations by the dominance of *Trollius altissimus* and, in our case, also by the presence of *Carex umbrosa* and some *Molinion* species (e.g. *Succisa pratensis, Sanguisorba officinalis* and *Scorzonera humilis*). Its distribution in Slovakia is restricted to the Inner-Carpathian Basins (RŮŽIČKOVÁ 1978) and to the Poľana Mts (BALÁTOVÁ-TULÁČKOVÁ & KONTRIŠOVÁ 1999). This vegetation was described from Germany as the *Trollio-Cirsietum rivularis* association (OBERDORFER 1957). Our opinion is that this vegetation should be evaluated only at the subassociation level, because all characteristics of this vegetation fit well to the definition of the *Cirsietum rivularis* association. This conception is in accordance with the new national surveys of the Central-European countries (BURKART et al. 2004, CHYTRÝ 2005), which consider *Trollio-Cirsietum rivularis* to be the synonymous of the *Cirsietum rivularis* association.

Chaerophyllo hirsuti-Calthetum palustris BALÁTOVÁ-TULÁČKOVÁ 1985 (Tab. 4, rel. 1-11)

definition: group Cardamine amara. This definition is valid only within non-forest vegetation.

This association scarcely occurs in the Javorníky Mts. and in the Kysuce and Orava regions. The vegetation prefers acidic to neutral soils, running water and moderate shading. The number of species is rather low. *Caltha palustris* and *Chaerophyllum hirsutum* are often dominant species in the vascular plant layer.

Angelico sylvestris-Cirsietum palustris DARIMONT ex BALÁTOVÁ-TULÁČKOVÁ 1973 (Tab. 4, rel. 12-27)

definition: [(group Carex echinata AND group Lychnis flos-cuculi) OR Cirsium palustre cover > 5%] NOT (Cirsium rivulare cover > 5% OR group Eriophorum latifolium)

This association occurs mostly on non-calcified bedrock. It is often found at margins of the acidic *Sphagnum*-dominated fens, with which it harbours joint species (group *Carex echinata*). This vegetation is relatively rare in Slovakia.

subass. _polygonetosum bistortae_ comb. nova (Tab. 4, rel. 22-27; nomenclature type: rel. 24) is differentiated by the subdominance of *Bistorta major* and is restricted to the Orava region in our study area. This vegetation has been evaluated as the separate association by some authors (e.g. BALÁTOVÁ-TULÁČKOVÁ 1974), but excepting subdominance of *Bistorta major* no differences exist as against to *Angelico-Cirsietum palustris*. In other European national surveys, the *Polygono-Cirsietum palustris* is mentioned as a synonymous of the *Angelico-Cirsietum palustris* (ELLMAUER & MUCINA 1993, CHYTRÝ 2005).

Scirpetum sylvatici RALSKI 1931 (Tab. 4, rel. 28-34)

definition: Scirpus sylvaticus cover > 25% and absence of all other species groups.

Scirpetum sylvatici is traditionally defined as an association with a strong dominance of *Scirpus sylvaticus*, which mostly reaches more than 50% cover (RYBNÍČEK et al. 1984, ŠPÁNIKOVÁ 1982). This association is not differentiated along the first "pH axis" in DCA, because it can develop on both alkaline and sub-acidic soils. However, it is better delimited along the second ordination axis through the increased supply of nutrients (cf. Fig. 2). This vegetation is extremely species-poor because of a strong competition of the dominant *Scirpus sylvaticus*.

Angelico sylvestris-Cirsietum oleracei TÜXEN 1937 (Tab. 4, rel. 35-40)

definition: Cirsium oleraceum cover > 5% NOT Filipendula ulmaria cover > 25%

In the study area, this locally rare association is confined to the area of the Biele Karpaty Mts. It occurs at low altitudes (350-450 m a.s.l.) on alkaline and mostly nutrient-rich soils. The association is rather common in the Bohemian Massif and its Carpathian distribution range is restricted to nutrient-richest, mostly alluvial, soils (HÁJEK & HÁJKOVÁ 2004).

***Scirpo sylvatici-Cirsietum cani* BALÁTOVÁ-TULÁČKOVÁ 1973 (Tab. 4, rel. 41-45)**

definition: [(group Caltha palustris OR group Lychnis flos-cuculi) AND Cirsium canum cover > 5%] NOT Deschampsia cespitosa cover > 5%.

Scirpo-Cirsietum cani is the rarest association not only in the study area but also in Slovakia as a whole. The association exhibits a continental tendency and it mostly occurs at low altitudes (Biele Karpaty Mts.). In one case, we recorded this vegetation at a higher altitude in the Poprad Basin having a rather continental climate. The association prefers mineral-rich, nearly subhalophilic soils with a fluctuating water level. *Scirpo-Cirsietum cani* is the association with the lowest presence of hydrophilous *Calthion* species within all *Calthion* meadows. It stays close to floodplain vegetation of the *Deschampsion* alliance along the moisture gradient (BOTTA-DUKÁT et al. 2005).

Principal gradients in species composition

The scatter-plot of detrended correspondence analysis (DCA) shows distribution of particular vegetation types along the first and second ordination axes (Fig. 2). Average Ellenberg indicator values for relevés, plotted *a posteriori* onto the ordination diagram, show which environmental factors are probably responsible for the most important variation in species data. The first vegetation gradient is clearly connected with pH, moisture and temperature, the second one with nutrients and light conditions (for Pearson correlations see head to Figure 2). In the right part of the scatter, the relevés of the *Angelico-Cirsietum oleracei* and *Scirpo-Cirsietum cani* associations are placed. These associations occur on alkaline soils at low altitudes in the regions with a high mean temperature. *Angelico-Cirsietum palustris* and *Chaerophyllo hirsuti-Calthetum* are situated at the opposite end of the ordination diagram and they prefer acidic and non-calcified soils. Two latter associations occur in the mountain areas with rather humid climate that causes, among others, high waterlogging all year round. *Scirpetum sylvatici* and *Angelico-Cirsietum oleracei* represent the most productive, nutrient-demanding vegetation types. The occurrence of *Chaerophyllo hirsuti-Calthetum* is negatively correlated with light amount, because the dominant herbs not only tolerate slight shading, but they themselves cause the light unavailability in lower vegetation layers.

Discussion

A search for the formal definitions of the associations based on combination of species groups extracted from a large national database seems to be a suitable method how to create an appropriate regional classification. Such classification is valid not only at the regional scale, but also for the entire territory of Slovakia. This could be a way how to cope with a discrepancy between national and regional vegetation classification occurring especially when numerical approaches are used (KUŽELOVÁ & CHYTRÝ 2004).

Using Ellenberg indicator values, we detected two major environmental gradients in the species composition of wet meadow vegetation; the first one is connected with acidity and the second one with nutrients (Fig. 2). This result is consistent with other analyses based on measured environmental data from the entire Czech Republic (HÁJEK & HÁJKOVÁ 2004).

As a syntaxonomical conclusion, we consider two associations originally defined by the dominance (*Polygono-Cirsietum palustris* and *Trollio-Cirsietum rivularis*) to be only the synonymous of *Angelico-Cirsietum palustris* and *Cirsietum rivularis*, respectively. No differences in environmental characteristics were detected by *Angelico-Cirsietum palustris* and *Polygono-Cirsietum palustris* (HÁJEK & HÁJKOVÁ 2004). Further, the species composition of relevés with subdominant *Bistorta major* fits well to the definition of *Angelico-Cirsietum palustris*. This suggested reclassification is consistent with other European national surveys (BURKART et al. 2004, ELLMAUER & MUCINA 1993, CHYTRÝ 2005). *Cirsio palustris-Calthetum* BALÁTOVÁ-TULÁČKOVÁ, KONTRIŠOVÁ ET KONTRIŠ 1994 is the next association having nearly the same species composition as *Angelico-Cirsietum palustris* and we also suggest to regard it to be synonymous. It was described by BALÁTOVÁ-TULÁČKOVÁ (1994) from Poľana Mts. as a vicarious association of *Angelico-Cirsietum palustris*, but it differs only by different cover and constancy of several widespread species (e.g. *Angelica sylvestris, Geum rivale, Tephroseris crispa*). It is impossible to formally define this association. In addition, the author herself notes that similar vegetation is designated as *Angelico-Cirsietum palustris* in the Alps (BALÁTOVÁ-TULÁČKOVÁ & KONTRIŠOVÁ 1999).

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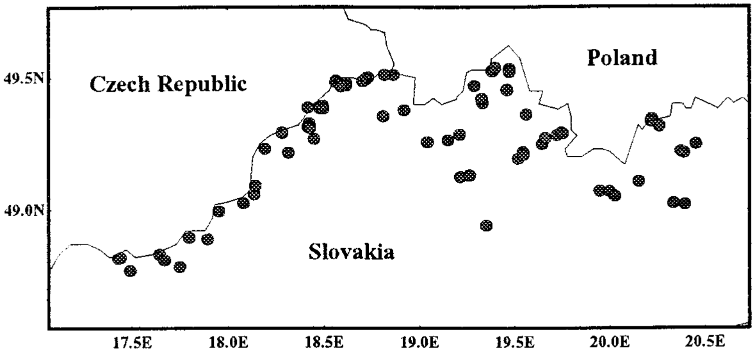

Fig. 1. Distribution of all studied localities in western and northern Slovakia. Coordinates presented at frame are in WGS 84 system.

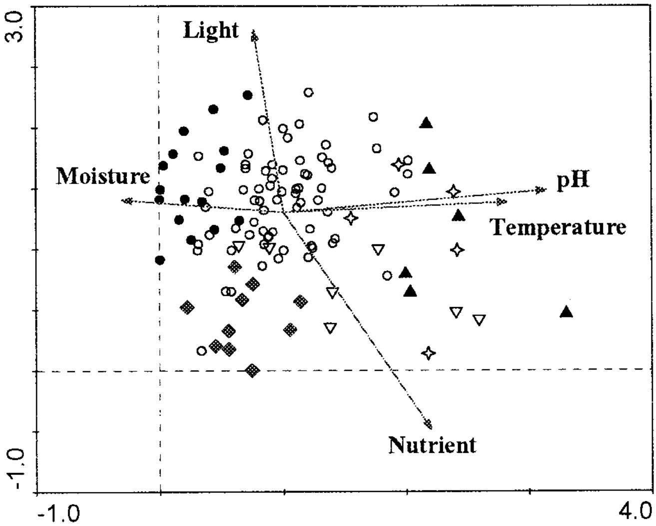

Fig. 2. Detrended correspondence analysis (DCA) ordination diagram of sites (eigenvalues of the first two axes are 0.276 and 0.184). Average Ellenberg indicator values for relevés were plotted onto DCA ordination diagram as supplementary environmental data. Pearson correlation coefficients: the 1st ordination axis correlates with pH (0.815), temperature (0.686) and moisture (-0.510); the 2nd ordination axis correlates with nutrients (-0.742) and light (0.605); all these correlations are significant at $P < 0.001$ level.

Explanations: full circles – *Angelico sylvestris-Cirsietum palustris*; empty circles – *Cirsietum rivularis*; grey diamonds – *Chaerophyllo hirsuti-Calthetum palustris*; stars – *Scirpo sylvatici-Cirsietum cani*; down empty triangels – *Scirpetum sylvatici*; up full triangles – *Angelico sylvestris-Cirsietum oleracei*.

Tab. 1. The species groups created by the Coctail method using a large data set from the Slovak Phytosociological Database (*Molinio-Arrhenatheretea*, *Scheuchzerio-Caricetea fuscae*, *Festuco-Brometea* and *Nardo-Callunetea* classes).

name of sp. group	species
Caltha palustris	*Caltha palustris, Myosotis nemorosa, Scirpus sylvaticus*
Cardamine amara	*Cardamine amara, Chaerophyllum hirsutum, Chrysosplenium alternifolium, Glyceria notata, Stellaria alsine, Stellaria nemorum*
Carex echinata	*Agrostis canina, Aulacomnium palustre, Carex echinata, Carex nigra, Cirsium palustre, Eriophorum angustifolium, Viola palustris*
Eriophorum latifolium	*Campylium stellatum, Carex davalliana, Carex flava, Drepanocladus cossonii, Eriophorum latifolium, Parnassia palustris, Pinguicula vulgaris, Primula farinosa*
Lychnis flos-cuculi	*Acetosa pratensis, Alopecurus pratensis, Cardamine pratensis, Festuca pratensis, Lathyrus pratensis, Lychnis flos-cuculi, Ranunculus acris, Ranunculus auricomus* agg.
Valeriana simplicifolia	*Cirsium rivularis, Crepis paludosa, Dactylorhiza majalis, Equisetum palustre, Geum rivale, Plagiomnium elatum, Valeriana simplicifolia*

Tab. 2. Shortened synoptic table with percentage frequency values. Diagnostic species of the particular associations (defined as those with phi > 0.25*, phi > 0.40*) are shaded and ranked by decreasing phi values, i.e. decreasing fidelities to each columns. Only diagnostic species with a probability of non-random occurrence yielded by Fischer's exact test above 1. 10^{-2} are presented.**

Group number	1	2	3	4	5	6
Number of relevés	9	68	16	8	6	5
1. *Chaerophyllo hirsuti-Calthetum palustris*						
Chaerophyllum hirsutum	100***	34	19	12	.	.
Cardamine amara	100***	9	.	12	.	.
Glyceria notata	78***	1	.	25	.	.
Stellaria alsine	44***	.	.	.	.	.
Stellaria nemorum	22***	.	.	.	.	.
2. *Cirsietum rivularis*						
Cirsium rivulare	67	100***	12	62	83	40
Briza media	22	66***	31	12	17	40
Listera ovata	.	29*	.	12	.	.
Carex davalliana	.	28*	.	.	17	.
Eriophorum latifolium	.	31*	6	.	17	.
Alchemilla vulgaris agg.	56	68*	44	38	17	.
Plagiomnium elatum	89	81*	50	25	67	20
Cruciata glabra	33	65*	38	38	33	20
Carex panicea	33	84*	81	50	50	60
Primula elatior	22	32*	.	25	.	.
Vicia cracca	.	38*	12	12	17	40

Epipactis palustris	.	21*	.	.	.	20
Festuca rubra agg.	11	81*	88	50	50	60
Climacium dendroides	22	65*	69	25	17	20
3. *Angelico sylvestris-Cirsietum palustris*						
Cirsium palustre	33	22	100***	38	.	.
Agrostis canina	22	16	88***	12	.	.
Aulacomnium palustre	.	7	62***	.	.	.
Sphagnum palustre	.	.	25***	.	.	.
Viola palustris	22	3	38***	.	.	.
Calliergon stramineum	.	.	19***	.	.	.
Nardus stricta	.	4	31*	.	.	.
Plagiomnium ellipticum	.	1	19*	.	.	.
Carex rostrata	.	6	31*	12	.	.
Bistorta major	.	10	38*	12	.	.
Galium palustre	67	43	81*	38	17	20
Epilobium palustre	56	22	56*	12	.	.
Potentilla erecta	33	78	100*	38	50	.
Anthoxanthum odoratum	22	57	88*	38	33	40
4. *Scirpetum sylvatici*						
Scirpus sylvaticus	78	51	19	100*	83	40
5. *Angelico sylvestris-Cirsietum oleracei*						
Cirsium oleraceum	.	6	.	12	100***	20
Ajuga reptans	22	18	6	50	100***	40
Lysimachia nummularia	22	12	.	25	83***	40
Cratoneuron filicinum	11	22	.	.	83*	40
Mentha longifolia	22	16	.	50	83*	40
Dactylis glomerata	22	12	.	38	67*	40
Lysimachia vulgaris	22	22	19	50	83*	20
Carex flacca	.	22	.	.	67*	40
6. *Scirpo sylvatici-Cirsietum cani*						
Cirsium canum	.	.	.	.	.	100***
Potentilla reptans	.	1	.	.	17	60***
Symphytum officinale	.	1	.	12	.	40***
Species diagnostic for more than one association						
Eurhynchium hians	11	1	.	25	83***	60*
Carex tomentosa	.	4	.	12	50*	40*

Tab. 3. Phytosociological relevés of the *Cirsietum rivularis* association. Explanations: cover m = 2m, a = 2a, b = 2b.

Relevé number	1111111111222222222	233	33333333444444	4444555555555566666666
	1234567890123456789012345678	901	23456789012345	6789012345678901234567
Area (m2)	1111121111111111112221111112	112	12112111111111	1121211111111111111111
	6666656662666666260008665665	660	05660666666666	5656060556260666665452
Cover of herb layer (E1)	1 1		111 1 1 1	1 1 1 11 11 11
	8989099887989887099899899789	999	00099099909089	0907988090097799009009
	5555005555058005055500080550	000	00008085805058	0000555050005005005005
Cover of moss layer (E0)	3899887526138188884377973496	576	19 15 764 315	77 1371718863 7691275
	0555000000000505000055005005	000	50250000007050	1005005000005020500000
Number of species	3543453463334244445435432435	344	44354543333422	3422242443444223353224
	9077669717960357342160188071	799	74933405623182	5251942694506907982296
subass. *eriophoretosum latifolii*				
Bryum pseudotriquetrum	.a1baa.a1..1a.a.11+...11a.aa	.+.	...+.1........	..+......111..........
Eriophorum latifolium	111a.++.+...b.a1++.++aa....+	.1.	+.............	....
Carex flava	1.1..a..+.....1+..1m1...11..	...	.+.+++........	............+.........
Carex davalliana	a...m.am.aaa.1a.+..aa.....+m	ma.	.+............	.r...+..++............
Epipactis palustris	.aa..+..+.+...a....1.a.aa..a	...	......+.......	....+...+.............
Campylium stellatum	+11.....++.++....+.a........	+b.	....	.+....+...............
Tomenthypnum nitens	.b+..........b4+.1........ar	.b.	....	...+......+...........
Parnassia palustris	1+....+...+...+..+..r.......	...	....	....
Carex paniculata	...................1.+..bb3a	+..	....	....1..+..............
Drepanocladus cossonii	.+..............+...1......+	...	....	....
subass. *trollietosum altissimae*				
Trollius altissimus	..........+.................	b34	....	a.....................
Succisa pratensis	..1.............aab.........	bb+	....	.....++...............
Sanguisorba officinalis	....	aa+	....	.....a................
Carex umbrosa	....	b.a	....	....
Scorsonera humilis	....	1..	....	....

subass. *chaerophylletosum hirsutae*				
Chaerophyllum hirsutum	.a...r......+...b.........b+	...	a3aabaaba3aab4	......+.............1
Equisetum sylvaticum	....	...	.1.....11.+1a1	+..........+.1..a...a.
Calthenion palustris				
Cirsium rivulare	b3b3bb3abababab1a33b3aab3ba+	1ba	33aa3b33a3a33a	ba4abaabba+bbaab33a534
Equisetum palustre	+1+1babb.11+a.b11a+a1a.ab1aa	1.+	.a+.am1+a.a1.+	aa3+++.aaaa.+..aaaa...
Caltha palustris	1+a++1ab.1.aba.+aaaa1a.+.a.a	+1+	.ab111.3ab+..a	ab..aaa1aa3a+.bab++...
Crepis paludosa	bb.+baaa.a3b1.baba1+a..b..bb	.1+	.b..ab..aa++a1	b..3+...1abb11ab3.31+.
Myosotis nemorosa	....1..++.+.++.1.++......r+.	.+.	+aa+.a+a+1+a+1	a+..1+.1.1.1.+++a+..1+
Scirpus sylvaticus	..+1.a..+...a1.+..1...1111.1	..+	..aa.1.+aab.b3	1.bb.a.a.1aa..a..a..b.
Geum rivale	a3..a..1.1.1.a.baa1.......+.	r.a	..b.+b1.a.a.r.	a...3a.ab3....3b..1...
Angelica sylvestris	.......+...a..+r.a1+1a.....+	a.a	.1a..+.1...b..	++...1.1++1.....1+a..1
Cirsium palustre	.++......+......+....a......	...	+.1....+......	.+....1a.....1....1.1+
Bistorta major	.............a...ab.........	.a.	..3.......3...	........1.............
Cirsium oleraceum	...................1.....1.+	...	....	...1..................
Filipendulenion				
Filipendula ulmaria	.+..+a.....+a.1.1+a1...+..a.	.+1	..1.a+a.......	.....a....a.a.....a...
Lysimachia vulgaris	..a..+..............+.....1..	...	....1.+.+..1..	...1..a...+.++....a..b
Mentha longifolia	......a..+..1........1.a....	...	...+....b.....	.a1...+...+...........
Lythrum salicaria	..+..................1.1+1..	...	....	.+.1..+.........a.....
Valeriana officinalis	r....................1......	..+	......1....+..	.+................+...+
Molinietalia				
Dactylorhiza majalis	++.++a++r++1.r1+++.+.a++..+1	r+.	1+++r..a.+..+r	.+....+...+a++.++r....
Lychnis flos-cuculi	.1..11.+++.+a+++1++.+.....+.	+.+	++++1++..+.1..	++..++.+1.11r..+.1...+
Galium palustre	+.+....+...+...1.+.++.r.....	...	..+.+.++.+.+.1	.+.....+1+r.+++a.+.+++
Deschampsia cespitosa	+........+.++a......+.......	+11	..+...+..+.+1.	...+.+.+..+...111+.+.1
Juncus effusus	.....1..+...............1....	...	1.+.+....+.mm+	+........a.1.++.+1+m.m
Galium uliginosum	.+..1.........1..+1....1..1.	.+.	.11....1.1...1	........+.+....11.1...
Juncus conglomeratus	.....1..a.....++..m...+.....	...	.1..1+..1.+...	........+a..+1..1.++...
Carex flacca	..1...1...a....+...1+...a1.a	.a.	....	...+1+.1+.............
Colchicum autumnale	.....+.+...........1..+..+..	+.1	....	1...+.......1....+....

Relevé number	1111111111222222222 1234567890123456789012345678	233 901	33333333444444 23456789012345	4444555555555566666666 6789012345678901234567
Ranunculus auricomus agg.	...........+.1............r.	m++	..rr..........	.....+................
Carex tomentosa	....	..+	....	+..+..................
Molinio-Arrhenatheretea				
Ranunculus acris	a11a1a1a++1+11++..a+a1+a1rr+	1++	+111+1a...1a1r	.+1..11a+1+a1+.+111.b+
Festuca rubra agg.	11+11m+11+m11m.mm++.m11m.+m.	.11	1+m11m.a+1+1m.	++...1+1m+.ma1.11mma+.
Acetosa pratensis	+..r++.+1+.++..+.++.1.r...+r	..+	+++1+111++++++	+.+..+.+1++.++r1++++++
Lathyrus pratensis	++.+1+.1+.+1a.11++..1...++1+	.++	b....+a1+1+1..	+.+.11+11a+1+.++1+...+
Briza media	a1+11+am1+a11.1m1am1111m.++1	++.	++.1+m1....+..	.1.....11+aa1..m.m....
Anthoxanthum odoratum	++.+mm..a++.m.m1.1m...1.....	...	+m+1+m1...11..	..++...m111m1m.m11.11+
Poa trivialis	+1..1.+1....m...11..1..m.+..	...	+1m1.1+m11.m..	..a....11m1...1m11.m.m
Cardamine pratensis agg.	...++.++.1.+...++++.++......	1+.	.++..+.+..+r..	.+..r+.+++r....1++..+r
Festuca pratensis	+...1+..1...+..+..1.........	...	1m.am1a...++..	..+..+.1..+.+..+1+.a..
Plantago lanceolata	.+.r++..+.....+.......+1....	...	...+..1.......	...........+++.....+..
Poa pratensis	+....1.1.+...+..............	..+	..........+...	.1..ma.+......+.......
Holcus lanatus	..+..+............++...+....	...	...+.+.....+..	..b............+.a.+..
Prunella vulgaris	.+r..+..+.+...+.......+.....	...	...1..........	.....r...........+....
Alopecurus pratensis	.........+..................	+..	1.1...........	.....+..........++...+
Cerastium holosteoides	......+.+...................	...	.....+.+......	..........r......r....
Rhinanthus minor	.r.....+..r.........r.......	...	....	.r....................
Arrhenatheretalia				
Alchemilla vulgaris agg.	.+.+3bm+ma..+.aa+.1..+a...+.	1r.	+bmb+a+..1a1a.	b....1.bb31aa1.mabm+3+
Vicia cracca	.mr1++1r1...+.1.1++........+	...	a1..+.+.......	.....+.+..+r+..+.+....
Luzula campestris agg.	.....r..m.+...+++.1...+.....	.+.	...++1.....+..	.......+...+++...+..+.
Achillea millefolium agg.	+.....+++.+.......r...+....+	...	r..+.r.....+..	.......+.........r+..+
Trifolium pratense	...b11.++...1.+......+.+...+	...	...a.+........	.......+...a.....+....
Galium mollugo agg.	+1....1..++.......++........	..+	....+......+..	..+...................
Lotus corniculatus	+.....+++..........r.......+	+..	.....+........	...........+1....+....
Jacea pratensis	.....+..+.......+.....+.....	..+	............+.	.....r......r.........
Dactylis glomerata	.......r.+..................	..1	1...+.1.......	.....+................
Knautia arvensis agg.	.1..............+..........+	...	.....1........	....

Phleum pratense	....+.......................	...	.+..+.........	..................+....
Avenula pubescens	.......1.....+..............	.++	....	....
Trisetum flavescens	....	...	....+.+....+..	.............+........
Leucanthemum vulgare agg.	........+.r.................	...	......+.......	..................+....
Scheuchzerio-Caricetea fuscae				
Carex panicea	aab1+aaab11+1.a+aamabmb1a111	11+	11111a...11.a.	.1..+1bm1+aa1a.1.am+a1
Carex nigra	1.baab11b..1b.1a11m.a11m.+aa	1+.	.mm11baa1+m1a.	1b..am4+aaaa1aa.11b+ma
Valeriana simplicifolia	ab..b.3b.aaa4.1a3bb.a.+a...a	1++	.11..b.baa1...	a...b..a1bb...b3ba...b
Eriophorum angustifolium	.11b1ama+1.m...11mma+1a1b1..	...	..+....m+.....	.m11a.1.a.aaa3+am.m...
Juncus articulatus	..+..+1.+.+.+.++++++.++..1..	++.	+...++........	....r.....++.........
Carex echinata	...1.+..+.....11.....+......	...	.........+1...	...........m.1....1.+.
Triglochin palustre	.1..+....r..+...+....+......	...	....	.+....................
Valeriana dioica	...................b.b..b...	...	....	.bb+.................1
Carex canescens	....	...	.......1.....1	.......m..1..........
Equisetum variegatum	...................m....+.	...	....	.m....................
Species with synanthropic tendency				
Equisetum arvense	.11+..1.1.+.+.+++..++..+.r+1	.+.	+1....a.+.....	.1..a.1.....+..a+....+
Carex hirta	..+...+r...............+....	..r	r..1......r...	.....+.r+1......++.1.+
Ranunculus repens	..+.++............+.+...a...	..+	...+..+1...+..	.1.....+........ra...+
Eupatorium cannabinum	..1.......1..........1..++.+	...	....	.a....+...............
Heracleum sphondylium	........+.........+.+.......	...	1.....+.......	....
Potentilla anserina	...................1a......	...	...+..........	.+..............r....
Vicia sepium	....	...	+.+...........	.......+..+......r....
Taraxacum sect. *Ruderalia*	.........................+..	..r	....	.....+...........+....
Other bryophytes				
Plagiomnium elatum	aa1+b33b13+b31a+3313b3+3++4b	.1a	+5.1+b..4a.b.1	.b.++11+1aaba..b3.1..b
Calliergonella cuspidata	+a4.+bbaa+aa111.1+.1aaa+b3+3	.++	.+.11a.+.++11.	.3a1ab4.b.aab..a1b...a
Climacium dendroides	131b3a.1+b.1a.bbbba...bb..a.	a1.	.1.+1a.1+.1++.	+...+...b+3b3a.a.b.baa
Brachythecium rivulare	.+...1+.....1a...1......a..+	..a	++1+...+.31.13	..3..1.++1.+..1+a+...a
Rhytidiadelphus squarrosus	...+.11.+.....+1.......a....1	...	.++r+1..1.1+..	.+.....ab..b3b...3aa4+

Relevé number	1111111111222222222	233	33333333444444	4444555555555566666666
	1234567890123456789012345678	901	23456789012345	6789012345678901234567
Cirriphyllum piliferum	1.+..++.+.1.................	...	1..+1...1..11.	.....1.....+.....a..a+
Cratoneuron filicinum	..1....++.......b..+.+..a1..	.a.	+.............	..+.++....+.....a.....
Thuidium philibertii	a.......r...................	...	.....+...+....	...........+.....a..++
Hypnum pratense	.1.b.....1.....+.1..........	...	....++........	..........+...........
Aneura pinguis	.++.....1..................r	...	....+........+	......1...............
Aulacomnium palustre	...b.............++.........	.a.	....	........+.............
Palustriella decipiens	......1..1.................1	...	....	...............b......
Plagiomnium undulatum	......+.....................	...	a..+..........	..b...................
Fissidens adianthoides	..1................+........	.+.	....	....
Brachythecium mildeanum	...1..........a.............	...	.......b......	....
Other vascular plant species				
Potentilla erecta	aa1.11a1a1ba..aaaaaaa++a.+aa	+a+	++a+.++11+++1.	1...1.ar11..ab.aa.a11.
Cruciata glabra	1mr11a.11+a.++1a1.1+a+1...m+	.11	11+m.a..+.....	+...++.11++.m..++++..+
Agrostis stolonifera	+.+...+m.rm....1...11...1+.+	...	+..1..m.......	mmm+...+.m.......+....
Primula elatior	.......++.a+..+.1.....+...+1	1+a	.....1..1.....	1....+..+...+..+.1+...
Veronica chamaedrys	....1....++.......+....+....	...	1+1+.11....1..	1......1.+.++...+1...a
Mentha arvensis	....ar+.1....r......++.+...a	...	a+.+...a......	.....+..+.+....1+....+
Equisetum fluviatile	.a..a...........b+...+.1a...	...	.1.....b1+...+	.a......a.+.+...1....1
Listera ovata	.1.+.+..1.+...++1.+...++...+	...	++..++......+.	+...........+.........
Carex pallescens	.....1..+.....+...+.........	...	++.+++.....+m.	.......++....m....1.a.
Agrostis capillaris	.....+1........+............	...	1....11m+.1+..	.......r.+..+.....a+1.
Epilobium palustre	....1....+.+...+.r+...r.....	r..	..+....+.....+	.+......+.r...+.......
Ajuga reptans	.++.+.........+...........+.	...	......+..+....	+....+...........+.+..
Agrostis canina	.+................+..+......	...	.+.....a.+..1.	.+...........m....a..+
Lotus uliginosus	.....1.................a....	...	....a.a.1+...1	.............a.....+1.
Juncus inflexus	1.m......................+.1	...	1.............	...+....+.+......+....
Leontodon hispidus s.l.	.+.+...r1.+...+.......+.....	...	............+.	....
Lysimachia nummularia	..1..1......+...........+...	...	...+..........	..1...r..........1....
Senecio subalpinus	....+.....................+.	...	.1a.......a...	....1.....1.....1.....
Stellaria graminea	....+.......................	...	+1.1+.+.......	...........r.........+
Hypericum tetrapterum	.....................+..++..	...	...+.......+..	.++..................+

Trifolium medium	...............++...........	...	........+.....	........+aa...........
Anemone nemorosa	..........................++	..+	............+.	...........+......a...
Hypericum maculatum	....	...	1....r..+....r	........r.........+...
Cardamine amara	........+............r......	...	........+.....	.1............+.......
Fraxinus excelsior (juv.)	........r..............+1...	...	....	..++..................
Carex rostrata	.......+....................	...	..m.b.........	.......1..............
Senecio nemorensis agg.	........+...................	...	.........+..r.	..............r.......
Salix cinerea (juv.)	...................1.....+..	...	....++........	....
Lycopus europaeus	.....................r...+..	...	...r.....+....	....
Astrantia major	...........................a	..+	.....+........	+.....................
Carex ovalis	....	...	...+.+........	.........+.......1....
Ranunculus flammula	.....+......................	...	....	.............+......+.
Tussilago farfara	......1..................r.1	...	....	....
Nardus stricta	........+.............+.....	.+.	....	....
Cynosurus cristatus	............+...............	...	...+..+.......	....
Galium verum	.............+.............r	.+.	....	....
Menyanthes trifoliata	.................b.....3....	...	....1.........	....
Veratrum album	..................1.......+.	...	..........+...	....
Eleocharis uniglumis	.....................+.+....	...	....	........1.............
Luzula luzuloides	....	+..	.....r........	............+.........

Species in less than 3 relevés:
Acer pseudoplatanus (juv.) 6: r; *Aegopodium podagraria* 31: +, 38: a; *Alnus incana* (juv.) 23: +, 27: +; *Amblystegium riparium* 1: r; *Arrhenatherum elatius* 38: +; *Asarum europaeum* 30: +, 46: r; *Atrichum undulatum* 66: +; *Betula pendula* (juv.) 3: r, 9: r; *Blysmus compressus* 9: +, 22: a; *Bromus erectus* 26: +; *Bryum weigelii* 4: +; *Calamagrostis canescens* 18: a; *Calamagrostis epigejos* 50: r; *Calamagrostis varia* 31: 1; *Calliergon cordifolium* 40: +, 56: 1; *Calliergon giganteum* 22: 1; *Campanula patula* 63: +; *Campylium chrysophyllum* 14: +; *Carex acuta* 25: 1; *Carex acutiformis* 14: a, 48: a; *Carex tumidicarpa* 57: +, 59: +; *Carex hostiana* 11: b, 20: m; *Carex lasiocarpa* 18: 1; *Carex lepidocarpa* 30: +; *Carex muricata* agg. 32: a; *Carex otrubae* 35: r; *Carex pilulifera* 23: +; *Carex sylvatica* 46: +; *Carpinus betulus* (juv.) 6: r, 26: r; *Carum carvi* 35: +, 51: +; *Cerastium arvense* 13: r, 51: r; *Cirsium arvense* 11: r, 32: +; *Comarum palustre* 18: +, 19: +; *Crocus discolor* 31: +; *Dactylorhiza maculata* agg. 64: +; *Danthonia decumbens* 4: +; *Dicranum bonjeanii* 23: 4; *Drepanocladus aduncus* 21: +, 47: +; *Eleocharis palustris* agg. 13: 1; *Elytrigia repens* 30: r, 67: +; *Epilobium hirsutum* 50: 1; *Epilobium montanum* 9: +, 43: +; *Epilobium parviflorum* 22: +, 47: 1; *Equisetum telmateia* 26: a, 46: 1;

Euphrasia rostkoviana agg. 32: r; *Eurhynchium hians* 31: +; *Festuca rupicola* 66: +; *Filipendula vulgaris* 23: +, 58: r; *Galium rivale* 3: r, 40: 1; *Geranium palustre* 12: +, 32: 1; *Glechoma hederacea* 35: +; *Glyceria nemoralis* 8: +; *Gymnadenia conopsea ssp. conopsea* 15: +, 58: r; *Gymnadenia densiflora* 20: +, 22: +; *Hamatocaulis vernicosus* 54: +; *Hylocomium splendens* 16: +, 54: +; *Hypnum lindbergii* 4: +; *Chaerophyllum aromaticum* 67: +; *Chiloscyphus polyanthos* agg. 9: +; *Jacea phrygia* agg. 11: 1, 29: 1; *Lophocolea bidentata* 16: +, 28: +; *Lophocolea heterophylla* 62: +; *Medicago lupulina* 8: +; *Melampyrum nemorosum* 12: +, 31: +; *Myosotis laxiflora* 48: +; *Melampyrum pratense* 46: +; *Mentha aquatica* 20: a, 25: a; *Molinia arundinacea* 26: 2, 49: 2; *Molinia caerulea* 19: 1, 31: +; *Ononis arvensis* 28: +; *Paludella squarrosa* 27: +; *Palustriella commutatum* 3: +, 26: +; *Pedicularis palustris* 22: +, 54: +; *Pedicularis sceptrum-carolinum* 12: +; *Petasites albus* 17: +; *Petasites hybridus* 20: +; *Philonotis calcarea* 23: +; *Philonotis fontana* 5: 1; *Phyteuma spicatum* 28: +; *Pilosella lactucella* 29: +; *Pimpinella major* 31: r, 37: +; *Plagiomnium affine* 29: b; *Plagiomnium ellipticum* 39: 3; *Plantago major* 22: r; *Plantago media* 57: +; *Platanthera bifolia* 67: +; *Polemonium caeruleum* 12: +, 31: +; *Polygala amarella* 2: +; *Polygala vulgaris* 9: +, 15: +; *Potentilla reptans* 67: r; *Pseudoscleropodium purum* 3: 1; *Ranunculus polyanthemos* 4: +; *Rhinanthus serotinus* 5: +, 47: +; *Rhytidiadelphus triquetrus* 46: a; *Rumex alpestris* 31: +; *Salix pentandra* (juv.)18: +; *Salix purpurea* (juv.) 25: +; *Scabiosa lucida* 11: r; *Scutellaria galericulata* 67: +; *Selinum carvifolia* 30: +; *Senecio erraticus* 35: +; *Sphagnum contortum* 19: 1; *Sphagnum warnstorfii* 19: a; *Symphytum officinale* 40: +; *Symphytum tuberosum* 49: r; *Taraxacum* sect. *Palustria* 23: r; *Thuidium recognitum* 46: +, 30: +; *Thuidium delicatulum* 51: +; *Trifolium repens* 22: 1; *Trifolium montanum* 20: r, 29: r; *Veronica beccabunga* 26: +; *Veronica officinalis* 66: +; *Viola canina* 30: r; *Viola palustris* 39: +, 59: +.

Table heads and localities (* before longitude = inaccurate values taken from Geobaze or En Carta software)

subass. *eriophoretosum latifolii*

1: slope 2°, exp. NW, 815 m a. s. l., Skorušinské vrchy Mts., Velké Borové village, southeastern margin of the village, rich fen complex, longitude 19°31´16´´, latitude 49°11´38´´. **2:** slope 5°, exp. WWJ, 719 m a. s. l., Podbeskydská vrchovina uplands., Klin village, Ťaskovka, longitude 19°27´39´´, latitude 49°27´14´´. **3:** slope 2°, exp. SW, 310 m a. s. l., Biele Karpaty Mts., mountain pass of the Vlára river, calcareous tufa-forming fen, longitude 18°04´54´´, latitude 49°01´29´´. **4:** slope 2°, exp. NE, 650 m a. s. l., Turzovská vrchovina uplands, Kelčov-Lieskov village, behind the house no. 1195, longitude 18°28´47´´, latitude 49°23´03´´. **5:** slope 1°, exp. -, 795 m a. s. l., Oravské Beskydy Mts., 4 km NW from Oravské Veselé village, longitude 19°23´11´´, latitude 49°31´30´´. **6:** slope 0°, exp. -, 490 m a. s. l., Javorníky Mts., Štiavnická dolina valley, Tisové settlement,, 4km NW from Štiavnik settlement, longitude 18°27´00´´, latitude 49°16´04´´. **7:** slope 5°, exp. W, 788 m a. s. l., Chočské vrchy Mts., Studničná village, southern margin of the village, along the small brook, longitude 19°15´55´´, latitude 49°07´53´´. **8:** slope 1°, exp. NE, 786 m a. s. l., Skorušinské vrchy Mts., Huty village, upper end of village, near the road, small spring fen, longitude 19°32´48´´, latitude