

## The role of cryptogams in differentiation of plant communities on the shady rocks in Western Carpathians

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**Abstract:** On the basis of the example of two pioneer communities from the shady calcareous and silicate rocks (*Ctenidio-Polypodietum* and *Hypno-Polypodietum*) the function of cryptogams in the differentiation of the vegetation types is discussed. The species composition of these communities is very similar to the associations which were formerly described (*Cystopteridetum fragilis* and *Asplenio-Polypodietum*). The results of the TWINSpan classification of relevés with all species (A) and relevés without cryptogams (B) are compared. Similarities among communities are interpreted with regard to sampling methods, richness of lichens and mosses with low constancy (I-II), and various habitat.

**Keywords:** *Asplenieta trichomanis*, cryptogams, rock communities, syntaxonomy, Western Carpathians

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### Introduction

The vegetation of rock habitats in montane belt of Western Carpathians has been not sufficiently investigated up to now. The most frequently cited article concerning this subject in Slovakia, is that by JURKO et PECIAR (1963). It was focused on classification of plant communities growing on moist and shady rocks. The result of study was the description of new associations *Ctenidio-Polypodietum* and *Hypno-Polypodietum* as well as the proposal of higher syntaxonomical units *Ctenidio-Polypodietalia*, *Hypno-Polypodietalia* and *Polypodietea*. The names of the orders and the class were published

invalid by article 8 in Code of Phytosociological Nomenclature (BARKMAN, MORAVEC et RAUSCHERT 1986). The aim of this contribution is therefore a critical re-evaluation of the descriptions of both associations. The reason for the new examination are follows:

1. Floristic composition of communities. The phanerogamous composition of associations *Ctenidio-Polypodietum* and *Hypno-Polypodietum* seems to be very similar to the structure of the associations *Cystopteridetum fragilis* Oberd. 1938 and *Asplenio-Polypodietum* Firbas 1924, respectively. Could they be considered as floristically identical? If so, why is the number of cryptogams in some relevés strikingly higher?
2. Ecology. The habitats of shady rock communities are relatively uniform. Do the factors with the influence on differentiation of the rock vegetation really exist?
3. Phytogeographical variability. *Ctenidio-Polypodietum* and *Hypno-Polypodietum* were reported from the Western Carpathians and the Eastern Carpathians. Are the communities homogeneous in the whole area?

## Material and methods

The traditional Braun-Blanquet approach has been used in the field and during the synthetic phase of the work. All available published and unpublished phytocoenological relevés from the Western Carpathians (JURKO et PECIAR 1963; SIMON 1977; FOLTÝNOVÁ et MIADOK 1979; ELIÁŠ 1985; PETRÍK 1985 msc.; VALACHOVIČ 1992 msc.), relevés from Eastern Carpathians (FINK 1977; COLDEA 1990) have been compared with the original material from the Alps and Jura (OBERDORFER 1949; RICHARD 1975), and North Bohemia (FIRBAS 1924) using a polythetic divisive hierarchical program TWINSPAN (HILL 1979). Clustering analysis was run with default values of cut levels (0, 2, 10, 25, 50 %). Minimum group size for division was set at 5. Two data sets, 113 relevés (data from calcareous rocks), and 46 relevés (data from silicicolous rocks) were included in the analysis. In the first step relevés with all the taxa, were chosen (A). As the second step, the relevés without cryptogams were used (B). In this manner the result represents two pairs of TWINSPAN-dendrograms and tables, suitable for comparison and for answer of expressed questions. Nomenclature of taxa is in accordance with NEUHÁUSLOVÁ et KOLBEK (1982).

## Results

All phytosociological relevés used in the analysis are arranged in the following list (numbers of columns and relevés, and abbreviations are repeated in all tables and figures):

Column A (1-8): *Cystopteridetum fragilis* (Cf) and *Ctenidio-Polypodietum* (CP)

1. (1-11) OBERDORFER 1949 (Cf), Alps (Germany) altitude 550-1400 m.
2. (12-14) RICHARD 1975 (Cf), Jura (Switzerland)
3. (15-22) FINK 1977 (CP), Mt. Postavarul (Romania) 700-900 m.
4. (23-38) PETRÍK 1985 (CP), Slovenský kras (South Slovakia)
5. (39-54) VALACHOVIČ 1981 (CP), Slovenský kras (South Slovakia) 400-580 m.
6. (55-72) VALACHOVIČ, unpubl. (Slovakia)
7. (73-92) JURKO et PECIAR (CP), (Slovakia) 300-880 m.
8. (93-113) PETRÍK 1985 (Cf), Slovenský kras (South Slovakia)

Column B (9-15): *Asplenio-Polypodietum* (AP) and *Hypno-Polypodietum* (HP)

9. (1-4) ELIÁŠ 1985 (HP), Trbeč (West Slovakia)
10. (5-9) COLDEA 1990 (HP), Mt. Rodnei (Romania) 680-1230 m.
11. (10-14) SIMON 1971 (HP), Zempléni-hegy (Hungary) 420-550 m.
12. (15-24) VALACHOVIČ, unpubl. (Slovakia) 180-1210 m.
13. (25-30) JURKO et PECIAR 1963 (HP), (Slovakia) 290-835 m.
14. (31-40) FIRBAS 1924 (AP), (North Bohemia)
15. (41-46) FOLTÝNOVÁ et MIADOK 1979 (HP), Veporské vrchy Mts (Slovakia) 700 m.

The name *Ctenidio-Polypodietum* from the calcareous rocks, and the acidophilous *Hypno-Polypodietum* from quartz-diorite and quartzite rocks were used not only by Slovak authors (4, 5, 7, 9, 13, 15, see list) but some relevés were published in Northern Hungary from Zempléni-hegy Mts. under these names (SIMON 1971; 1977). Later on, these associations have been mentioned from Romania (BOSCAIU et al. 1966; POP 1968; BELDIE 1971; FINK 1977; COLDEA 1990). It is advisable to compare these associations with the similar and earlier published communities from the whole of Central Europe (1, 2, 14), which ought to have been done by JURKO and PECIAR before the description of new syntaxa.

## 1. Floristic composition

The number of species (phanerogams and cryptogams) in columns depends partly on the number of relevés in column (Fig. 1). Generally, more relevés in column include more species. Plant communities on silicate rocks (AP/HP) are characterized by smaller number of species, including the bryophytes and lichens. The ratio of the number of cryptogams to the total number of all taxa is especially higher in relevés in column 7 (46.01 %) and column 13 (56.41 %) both by JURKO and PECIAR (1963). Only in column 8 (54.5 % in Cf) and column 15 (54.8 % in HP) is the relation similar. In all other columns the ratio is lower and vary between 22.2-37.1 by Cf/CP or 23.8-38.9 by AP/HP.

In the relevés of the CP (PETRÍK 1985) the absence of *Ctenidium molluscum* is rather surprising. In the relevés by JURKO and PECIAR a low frequency of *Cystopteris fragilis* is conspicuous, though this taxon shows a common presence in the association Cf from the same localities.

From the presented TWINSPAN-dendrograms (Fig. 2-3) it is obvious that the complete data result in clusters are mainly composed of the relevés by the same authors and by the related phytogeographical regions (A). After elimination of the cryptogams the clusters are mainly composed of mixed data of various authors (B). It means that the differentiation between the clusters is effected more often by the presence of several lichens and mosses with very low constancy (I-II) than by different floristical composition of dominant plants. From the position of relevés on the dendrogram it can be suggested, that the authors used the names of associations (Cf/CP and AP/HP) a little too freely.

## 2. Ecology of communities

Association *Ctenidio-Polypodietum* becomes different with striking physiognomic cover-abundance values of *Polypodium vulgare* and *Ctenidium molluscum*. These plants have optimal conditions on the top of calcareous rocks (rock towers and outcrops) with relatively low inclination (under 40°) and with well developed soil. Therefore the slope is an important ecological factor reflected in the species diversity. The raw humus with higher acidity allows the local occurrence of partly acidophilous mosses *Hylocomium splendens* and *Hypnum cupressiforme*. The degree of shading determine the presence of sciophilous and hygrophilous species, especially liverworts. The character of associations showed some differences in presence and cover-abundance of the ferns. *Polypodium vulgare* prefers the slate rocks in contrast to fissures with the *Cystopteris fragilis* and *Asplenium viride*. Many other species have a regular occurrence in all relevés.

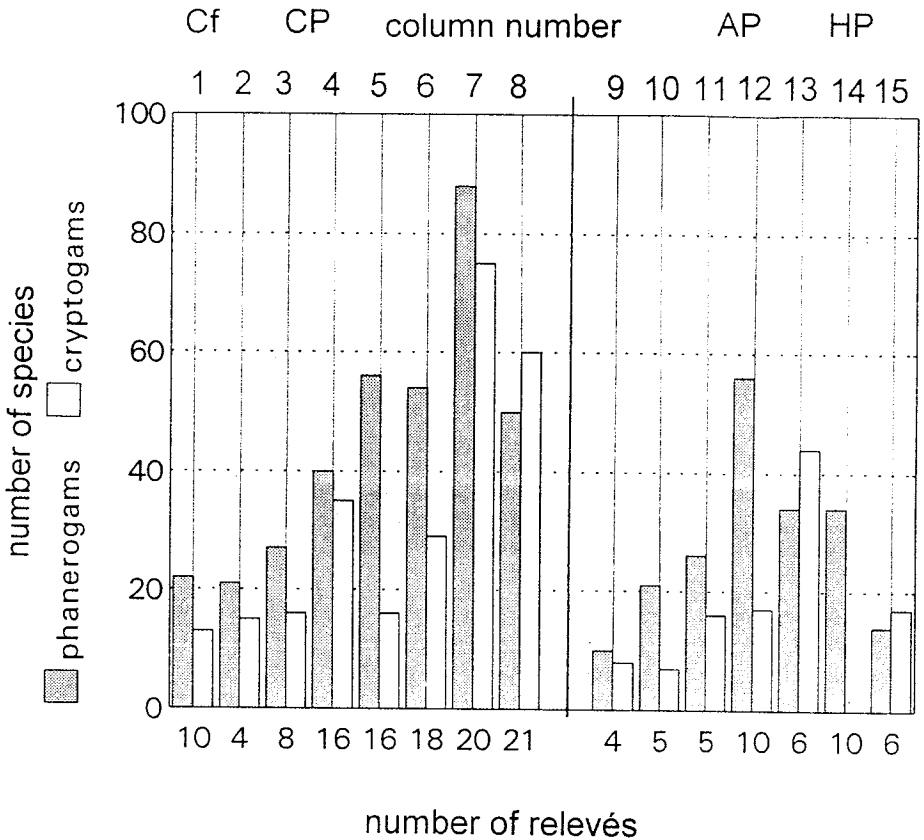


Fig. 1. The relation between number of vascular plants and cryptogams in the selected phytosociological tables. Columns are ordered in the same way as the list.

Floristical structure and the habitat of *Hypno-Polypodietum* is very similar to *Asplenio-Polypodietum*, well known in North Bohemia. The dominant ferns *Asplenium trichomanes* and *Polypodium vulgare* are associated with many nitrophilous species such as *Epilobium collinum*, *Geranium robertianum*, *Luzula luzuloides*, *Mycelis muralis*. The acidophilous mosses *Hypnum cupressiforme*, *Dicranum scoparium* and some *Polytrichum* species have the absolute dominance in the moss layer.

### 3. Phytogeographical variability

Small floristical differences of the communities in the East Carpathians are represented by the presence of *Ceterach officinarum* and *Sedum hispanicum* (BOSCAIU et al. 1966) or *Cardaminopsis halleri* (COLDEA 1990). Conspicuous quantitative differences in the occurrence of some ferns, primarily *Cystopteris fragilis* have been found as well (see FINK 1977). The coenoses from Northern Hungary (SIMON 1971; 1977) have practically the same structure and habitat as the relevés from Southern Slovakia. All floristical differences are given in synoptic table (Tab. 5).

## Discussion

The main principle of Zürich-Montpellier school says that two communities are distinguished according to qualitative floristic content which documents different ecological character of habitats. The general physiognomy of communities was obviously one of the motives for description of the new associations, discussed above, but the floristic differences are evident only in cryptogamous layer. The low presence or absence of some constant species could sometimes be a result of choice of plot already in the field - the stands "with" or "without" dominant species. The field methods of sampling could be various. While geobotanists usually are able to determine the dominant and otherwise remarkable cryptogams, certain mosses and lichens can be overlooked. In the case when the author of relevés is a specialist-bryologist it results in enormous increase in number of mosses in the relevés. The bryologists have a tendency to sample all taxa directly in plots or in their neighbourhood. Unfortunately, JURKO (geobotanist) and PECIAR (bryologist) gave no information on the size of their plots. This fact might have also influenced the reported species diversity in both layers.

In addition, the classification based on presence of easily spreading mosses and ferns (often with circumpolar occurrence and high ecological plasticity) is very treacherous. The associations have no really unambiguous association character species. Especially in relict rock plant communities is this phenomenon more seldom than in other groups (MUCINA 1986).

As regards the differences in the relation between lithophytic species (i. e. exochomophytes from the group of algae, lichens, and mosses growing on the flat of rocks) and epilithic species (from fissures), we failed to find any taxa confined to either of the one microhabitat. A variable mixture of microhabitats (combination of slopes, exposition and small rocks structures) allow the various ecological conditions and

coalition between plant species. The same epilithic lichens are growing into cushions of mosses in the cracks. In the same time the chasmophytic ferns grow outside of fissures where the mosses and soil on the rocks with lower slope prepare suitable conditions for their germination and growth. The forest herbs and wood seedlings (*Acer pseudoplatanus*, *Fagus sylvatica*, *Sorbus aucuparia*) penetrate into rock communities in the same way.

## Conclusion

The proposal of class *Polypodietea* and others subordinate units by JURKO and PECIAR was redundant because the higher syntaxa of rock communities had been described before 1948. A detailed analysis of the associations *Ctenidio-Polypodietum* and *Hypno-Polypodietum* shows little floristical differences between Middle European or Alpine units and are similar to earlier and validly described phytocoenoses *Cystopteridetum fragilis* and *Asplenio-Polypodietum*. Therefore, the younger names can be relegated to synonymy. According to BRAUN-BLANQUET approach the floristic principle for differentiation of plant communities is the most decisive one. The differences between habitats (ecological and geomorphological stands peculiarities such as slope inclination, degree of weathering and structure of rock surface) can be evaluated only as ecological variants or races. The Eastern Carpathian habitats have no important phyto-geographical differences and belongs to the same communities as these described from Slovakia.

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Figures 2-3 and tables 1-5 on p. 138-152.

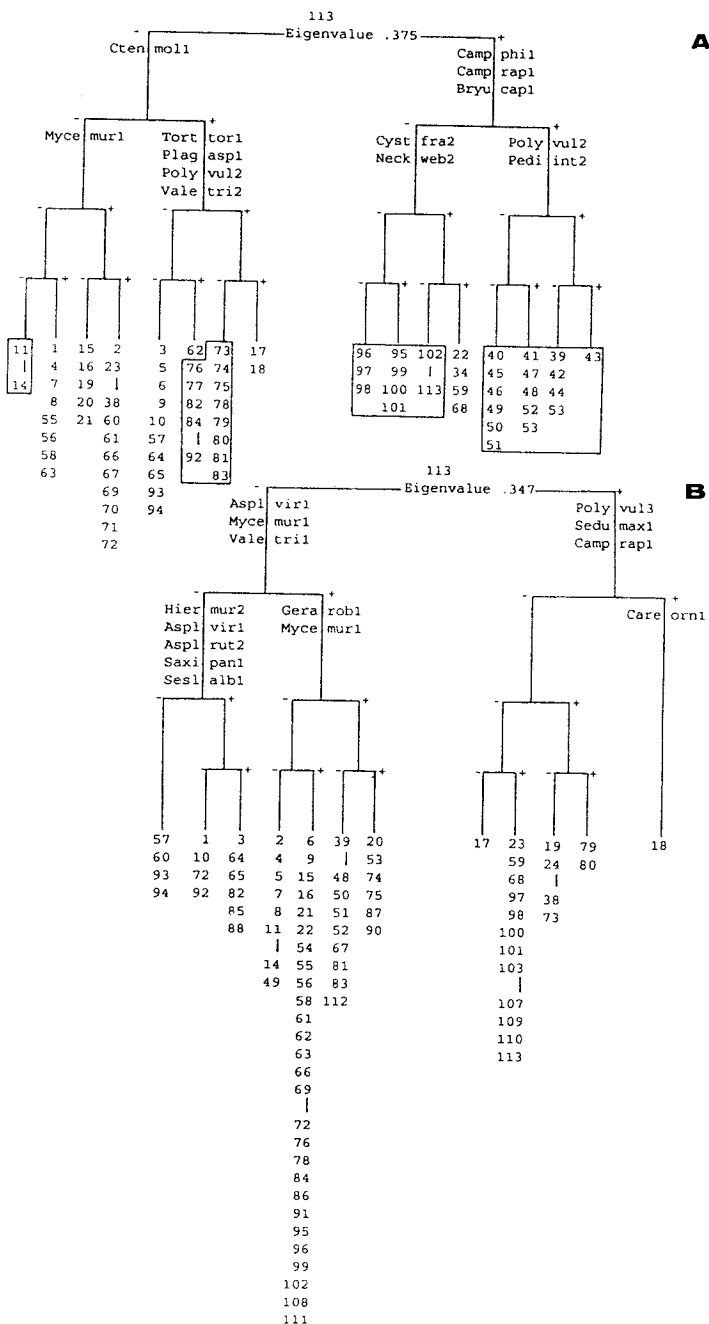


Fig. 2. TWINSPLAN-dendrogram from 113 relevés of calcareous communities (Cf/CP). A - with all taxa included; B - vascular taxa only. The number of relevés see in list.



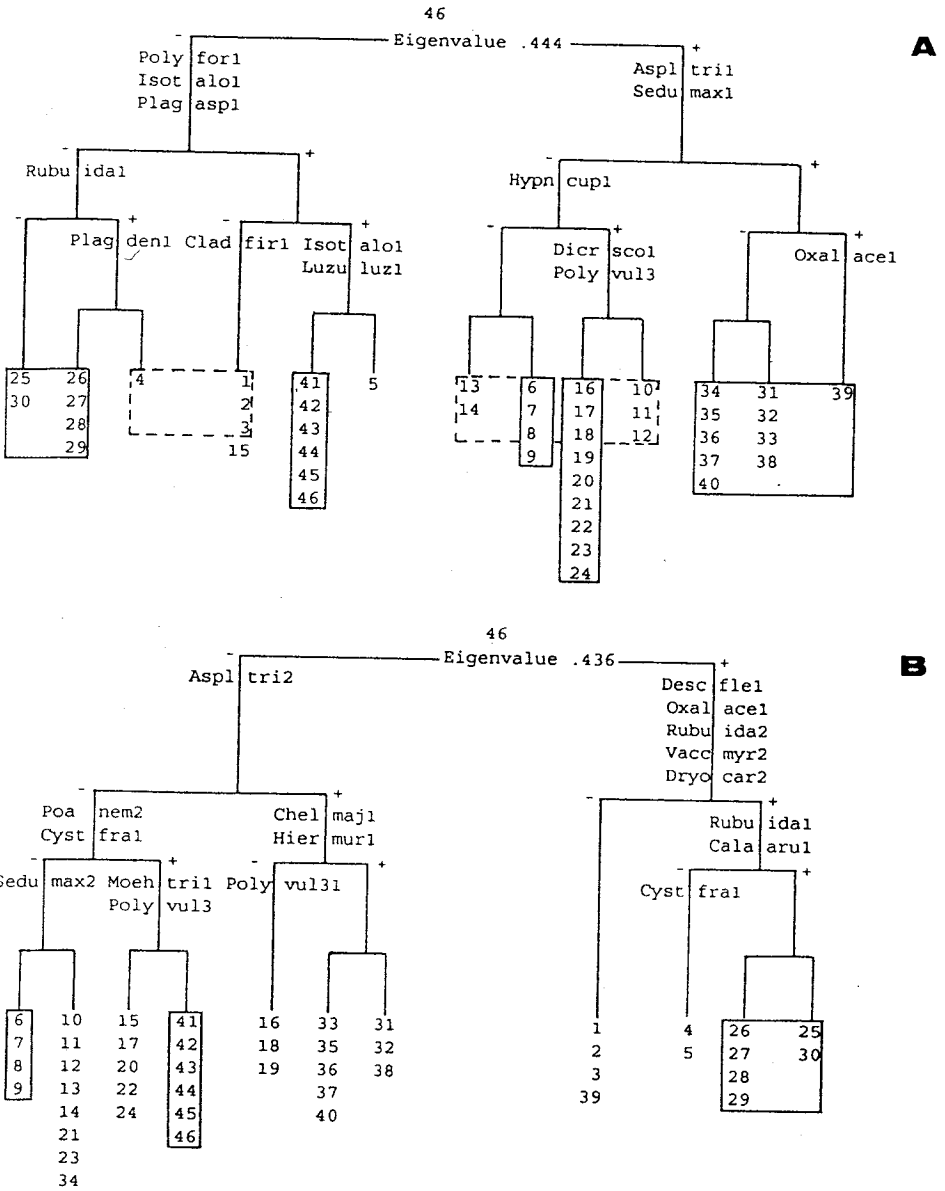


Fig. 3. TWINSpan-dendrogram from 46 relevés of succicolous communities (AP/HP). A - all taxa included; B - vascular taxa only.

**Tab. 1. The shortest result of TWINSPAN classification of 113 relevés. The cryptogamic taxa are marked with zero.**

relevé number	1111	555611122	222222333333366666777
<i>Asplenium trichomanes</i>	1234147856835690123456789012356780167901235		
<i>Geranium robertianum</i>	525222.255322225.	.32232322353333541532.572.	
<i>Cystopteris fragilis</i>	3333..22575..23..	233322.22337222323522322.2	
<i>Polypodium vulgare</i>	23222223522....	222233.1.12111..5252..3322	
<i>Cardaminopsis arenosa</i>	.....453725.1..1.....	7.3..1.2..3...	
<i>Tortella tortuosa</i> 0	.....225.....	223321....21..2..22..	
<i>Mycelis muralis</i>	2.....323523.....	.....3.....37.....22	
<i>Neckera crispa</i> 0	2212....23223.2..	23222315.231.2222312333..	
<i>Ctenidium molluscum</i> 0	7373.....7778.....	.....33....3.333.58.....	
<i>Anomodon viticulosus</i> 0	5.3..23..3.3..523..	3..3.3.3..353..598..	
<i>Valeriana tripteris</i>	.....52.....2.....	.....3.....3..9.....	
<i>Sedum maximum</i>	.....2.....211..	5....3.2.76...55222	
<i>Poa nemoralis</i>	.....22..12..1.2.....	3....3....1..	
<i>Fissidens cristatus</i> 0	.....25..2.5..22.2.2.	2311533..	
<i>Encalypta straptocarpa</i> 0	2..2....88.3.....	3..333.....2....3...	
<i>Asplenium viride</i>	....2322...2.....	2.....2.....3....4..7....23	
<i>Camptothecium philippeanum</i> 0	2.2.232253.3....	2.....2.....3323	
<i>Hypnum cupressiforme</i> 0	.....7.....	.....3.....56.....	
<i>Porella platyphylla</i> 0	2.....2.....	.....3.....3.....	
<i>Plagiochila asplenioides</i> 0	.....33.....	.....3.....2..	
<i>Oxalis acetosella</i>	..553.....	.....	
<i>Neckera webbiana</i> 0	.222....545.52.2....	2.....2.....3.2...323..	
<i>Hieracium murorum</i>	2.....22.2.....	.....2...1...2	
<i>Camptothecium sericeum</i> 0	.....5.....	.....	
<i>Campanula rapunculoides</i>	.....22.....	.....2..	
<i>Apometzgeria pubescens</i> 0	..22.....	.....	
<i>Moehringia muscosa</i>	.2.2...23374222.2.....	.....433.75..	
<i>Bryum capillare</i> 0	.....	.....	
<i>Plagiopus oederi</i> 0	..52.....	.....	
<i>Rhytidadelphus triquetrus</i> 0	..2.....2.....	.....	
<i>Campanula carpatica</i>	.....22..5535523322.....	.....	
<i>Neckera complanata</i> 0	.333.....33.....	.....	
<i>Saxifraga paniculata</i>	.....2.....2.2.2.....	.....	
<i>Arabis turrita</i>	..2.....1....1222..	31..2.....	
<i>Moehringia trinervia</i>	.....	.....	
<i>Ditrichum flexicaule</i> 0	.....3.....	.....2	
<i>Grossularia uva-crispa</i>	.....1..1...1.2.....	2..	
<i>Metzgeria furcata</i> 0	.....	.....	
<i>Dicranum scoparium</i> 0	.....3.....	.....	
<i>Asplenium ruta-muraria</i>	....2.....1.....	.....5.....	
<i>Carex digitata</i>	.....2.....	.....1...1..	
<i>Pedinophyllum interruptum</i> 0	.....	.....	
<i>Sesleria albicans</i>	.....2.3.....	2..	
<i>Phyllitis scolopendrium</i>	3755.....5.1.2.5.5.2...	33.....	
<i>Mnium stellare</i> 0	.....	.....	
<i>Cladonia fimbriata</i> 0	.....	.....	

Tab. 1. continued

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15669967788888889997777788881199999000000000111123564444554445534454
6907453426724567890123458901378678590123456789012324980569011782492433
...215..43223527333.3255533233.35323222532332332332233..21..1..2.21222
.2.2.4.3.3.2353...22..322..323.2.31232.22.2222222332.....3222.322221
333.53.2222.532.23332.32233222.3323235233233.53253.263....1.....
.22..3.2322.5535323557377785725..2.1.....1.1..1.21..7788888787858787
...253.532.22.5233222.2211.31..3322.2213332..5..32.12.322.1....2.53..
232632223323335335533223322.3.532253.2.....32.....223.2.2211.....
..32...3.2323.3.33..21..2..2..22..2.2.222.22.2.....2...2.....
2..5..8877875773573732.877773275877775.....2.....1.2....1.....1
...4223.375755335553555355333.3222.....7.32335327578775757...322..2..1..22.1.
.....2.33.7..3..38732553..7.32335327578775757...322..2..1..22.1.
22.85371.5.532.22232...232.53..5555.....5.....2.....
.....22.....323.21..2.112....23222..12.21..5.11.21....323332
.....2.....2.....2.2..1..2..1.2..232.2.....23.2.2..23..22.233.
...3252..522333235233.511..2...3222.....2.....
322..32.22..22.2..2..2..2...3223323.....32.2....42.....
222244.22323522.32533...2.....
.....6.....7.5233227.31.12..223783..51522.2222.3..2.
.....3.2.323.23..8332.22.....2..1.....575...2..588858
....3.....2.7.22...12.....2..877777232555...1.2.....222..
...325..3323332353332223533553.....
...2.....535..35533...2..23.....
.....5.....313.352...5.23775272333352353.....1...
.232232.322.22..3.....1.....22.....2.2..2.....
2.....2...3...23.23533333..3...23.32...375753.....
.....2232222.2.3.2.2.2.22.32.12.332...23.2.
.....35523272355...52232.....5.....535...3.2.....
.....6..65..2.32.....5.....
.....2.....1.2....22.21..2221...32.....3353..525
.....232333233.33.11.....2..3.....2.....2.....
.....2.223123222.2725...3.....22..
.....3.2222...2..3.....
...376.2.....23.5.....2.2.2.....2.....3.....
...2122..2..3.32.2.2.22.....3...
.....3.....1.....1.....1.1.222..232.3.....1232...5..
.....3..233222332333.1.....
.....1...2..2.2...232.....1.....1...2.2.....
.....2...2.2..223...3.....2.....22...32.2522.
.....222.2.2.335..1.....3.....3.....2...5...3
...22.22..2.2..2.....2..22.....22.....
.....22..2.2.....2.....22.....2.222.2.....
.....222.2.2...23.2...23.....3.....
.....222.2.2...23.2...23.....1.....3.....
.....2.2.22..222222.22.....2.1.....7589.733.52525.
.....2.2.22..222222.22.....

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Tab. 1. continued

relevé number	1111	555611122	222222333333336666777
	1234147856835690123456789012356780167901235		
<i>Hylocomium sp.</i> 0			
<i>Bryoerythrophyllum sp.</i> 0			
<i>Plagiomnium undulatum</i> 0	.523		
<i>Conocephalum conicum</i> 0	2232		3 3 4
<i>Mercurialis perennis</i>		2	2 1 2 3
<i>Epilobium montanum</i>	2.22		1 1 2
<i>Glechoma hirsuta</i>		2	3 1 2 2 2 2 3
<i>Plagiochila porelloides</i> 0			
<i>Campanula xylocarpa</i>			
<i>Pseudoleskeella catenulata</i> 0			
<i>Metzgeria conjugata</i> 0			
<i>Peltigera canina</i> 0			3
<i>Peltigera sp.</i> 0			
<i>Lathyrus vernus</i>			1
<i>Brachythecium velutinum</i> 0			
<i>Senecio nemorensis</i>			2 1 2 2
<i>Cladonia sp.</i> 0			3 1
<i>Distichium capillaceum</i> 0		2	
<i>Schistidium apocarpum</i> 0			
<i>Mnium spinosum</i> 0			
<i>Galium schultesii</i>			2
<i>Galeobdolon luteum</i>			22
<i>Campanula cochleriifolia</i>	523 .232		3
<i>Hedera helix</i>	.2	5.5	5 2
<i>Barbilophozia barbata</i> 0			
<i>Dermatocarpon minutum</i> 0			
<i>Amphidium mougeotii</i> 0		2	
<i>Fissidens adianthoides</i> 0		22	2
<i>Salvia glutinosa</i>			1 1
<i>Calamagrostis varia</i>			
<i>Aster bellidiastrum</i>			
<i>Asarum europaeum</i>			2
<i>Arabis alpina</i>	3322	.2	2
<i>Thamnobryum alopecurum</i> 0	.738		
<i>Hylocomium splendens</i> 0	.52	2	
<i>Campanula trachelium</i>	.2		1 11
<i>Lamium maculatum</i>		22	11
<i>Acer pseudoplatanus</i>			3 1 1
<i>Convallaria majalis</i>			
<i>Rhizomnium punctatum</i> 0			2
<i>Fragaria vesca</i>			1
<i>Scapania nemorosa</i> 0			
<i>Sorbus aucuparia</i> 2			
<i>Encalypta vulgaris</i> 0			
<i>Rubus idaeus</i>			
<i>Chelidonium majus</i>			1 2 2
<i>Glechoma hederacea</i>			1 2 2 3
<i>Viola hirta</i>			1 12
<i>Plagiothecium sp.</i> 0			33 33
<i>Plasteurhynchium striatulum</i> 0			
<i>Leucodon sciuroides</i> 0			

Tab. 1. continued

1111111111111111	
15669967788888889997777888119999900000000111123564444554445534454	6907453426724567890123458901378678590123456789012324980569011782492433
.....2135525333.533.....	.....2.322.2.....22.22.32.....2.....
.....2.....	.....2.222.....1.2.2.222.....
.....22.3.....	.....22.....
.....2.2.2.2.....	.....2.....1.....2.....
.....2.2.2.2.....	.....1.....2.....
.....2.....	.....2.22223.....2.....3.....2.....
.....53.....	.....1222.....2122.....2.....
.....2.....	.....3.22.2533.2.22.3.....
.....2.5.2.2.....	.....3.255.72.....
.....222.2.....	.....22.221.....
.....2.....	.....2.2.22.....2.....2.22.23.....
.....2.....	.....1.....1.22.32.2.....2.....
.....2.....	.....2.....2.....3.....7.73.3332.....
.....2.....	.....2.....2.....2.....2.....2.22.....
.....2.....	.....2.2.....2.2.....
.....2.....	.....2.3.322.....2.....1.....1.....
.....2.....	.....2.2.2222.2.....
.....4.....	.....2.....2.....2.1.....
.....3.2.....	.....2.....1.....
.....2.....	.....2.2.....
.....2.....	.....523.....2.....22.....
.....2.....	.....2.22.2.....2.2.....
352.....	.....2.....2.....
.....22.....	.....2.....
.....2.....	.....32.2.....
.....332.....	.....3.2.....2.....
.....2.....	.....32.223.....
.....2.2.....	.....3.3.....2.....
.....2.....	.....2.....23.....
.....2.....	.....27.....
.....2.....	.....2.....22.....
.....2.....	.....1.....1.....112.35.....2.....
.....2.....	.....2.....2.....2.....
.....2.1.2.....	.....2.....2.....
.....2.....	.....2.22.2.....
.....3.....	.....3.....322.....
.....2222.2.....	.....2.....
.....2.22.22.....	.....3.....3.....
.....2.....	.....1.....
.....2.....	.....1.....3.....
.....3.....	.....1.2.53.....3.....
.....2355.2.....	.....2355.2.....

**Tab. 2** The classification with the same phytosociological relevés as in Tab. 1 after elimination of cryptogamic taxa.

relevé number	5699	179	668888	11114	11225555	66666777
<i>Asplenium trichomanes</i>	7034107234525892457812349695612456812369012					
<i>Asplenium viride</i>	24	222232443232233222	2	22	53	23
<i>Valeriana tripteris</i>	8771	2535222222	22	6	552	
<i>Hieracium murorum</i>	3232	2222	3	2	22	2
<i>Asplenium ruta-muraria</i>	2	222	2	222	5	
<i>Saxifraga paniculata</i>	222	22	21	32		
<i>Sesleria albicans</i>	23	2	222	3		
<i>Mycelis muralis</i>	32	2	223	22123	23	22
<i>Geranium robertianum</i>	22	3	425	2	22233337	2
<i>Cystopteris fragilis</i>	5	22322253	32322222322133	3522225	33	
<i>Polypodium vulgare</i>	2	225	3	532	25352	134
<i>Sedum maximum</i>		2				1
<i>Campanula rapunculoides</i>					2	
<i>Cardaminopsis arenosa</i>	22	5	2	532	33	22
<i>Poa nemoralis</i>			2		2	2
<i>Oxalis acetosella</i>		3	2	5535	222	52
<i>Moehringia muscosa</i>		6		2	2	2225
<i>Campanula carpatica</i>			322		337	6443
<i>Arabis turrata</i>				2		1
<i>Moehringia trinervia</i>						3
<i>Grossularia uva-crispa</i>			22		1	1
<i>Carex digitata</i>						12
<i>Phyllitis scolopendrium</i>				37555		3
<i>Mercurialis perennis</i>			2		2	23
<i>Epilobium montanum</i>			2	2	2	22
<i>Glechoma hirsuta</i>					2	2
<i>Campanula xylocarpa</i>		53				
<i>Lathyrus vernus</i>						
<i>Senecio nemorensis</i>		2	2	2		2
<i>Campanula cochlearifolia</i>				2332523		
<i>Galeobdolon luteum</i>					2	
<i>Galium schultesii</i>		2	4	2		
<i>Hedera helix</i>				2	5	
<i>Arabis alpina</i>			2	23322		
<i>Campanula trachelium</i>	2			2		
<i>Acer pseudoplatanus</i>					2	1
<i>Lamium maculatum</i>					1	
<i>Asarum europaeum</i>			2			2
<i>Calamagrostis varia</i>	2		3332			
<i>Aster bellidiastrum</i>			2	2		
<i>Salvia glutinosa</i>						
<i>Convallaria majalis</i>						
<i>Chelidonium majus</i>						
<i>Glechoma hederacea</i>						2
<i>Fragaria vesca</i>			12			
<i>Rubus idaeus</i>		2	222			

Tab. 2. continued

111	1	111111111
77889999001344444444455568812577891256990000000111222222333333337781		
6846156928190123456780127132034570739878013456790394567890123456783908		
3532.23322232232232235233323353557332335322532333332.1122.2..1..22.233.		
32523.....2.....5.....		
533.255....11...5....3..53..2.223...55.....2..		
3..2..2.....1.....2.....2.....2.....2.....		
.....1.....2.....22..22.....		
.....2.....2.....22232.....3.....		
.....22322..3.....		
31333222.2223222315.2.1.12.222.2.3.....2.2.22...2.....2.....		
323321222.222233.1.122112225..32.32.63323533233533.....1.....33.		
225233322.222233.1.122112225..32.32.63323533233533.....1.....33.		
27535..1..1..1...17.257123375325...2.....11..77887778788887887885		
.....1....12...1.2....3..223232.22.512..232221212..32311...21.33321.		
.....222..2.....23223222.3.22.2..23..12...33.2.....		
2125223.1..223321...1212313..2222..2.32223332.5.2.3.5.322..1..2.1..		
2...12...5..2.5...22.21.12...2...2..2.232.2..3..32.32...2232.2..		
23.3.....2.....23.....5.....2.....		
5.23.....3.....2.....2.....		
2.....5535523322...3..2..22.....2.....		
.....1...1222..2...3...2.31..1..2.22.....2.....		
.....1..2.....1.....1.....1222..233..3..5..2..12..1..		
2.....1..1.....2.....2.....1.....2.....1.2.....32.		
2.22.....2.....2.....22.....22.....2..22.....		
.....5.1.2.5.3.231.....		
2.2.2.....2.11..2.....2.....		
2.2.....1..1.....2..2.....2.....		
.....3.1..2.2.2123.....2.....		
.....21.2.....22..122..2.....		
2.....1.....1.....12.....2.22.3.2.....		
2.....2..1..2.....2.....2.....		
.....32.....2.2..2.....1.....		
2..1.....2.....2.....52.....2.....		
.....5.....2.....		
.....1.....11.....2.....		
.....1.....13...1.....22..1.....		
23.....2...3.....2.....		
.....2.....		
3.3.....2.....		
2.....1...1.....2.....32.....		
.....1.....2.....3..2.3.....1..12..35.2.....		
.....1.....2.....2.....1.....		
2.....1.....2.....		
.....2.....		

**Tab. 3. The shortest result of TWINSPAN classification of 46 relevés. The cryptogamic taxa are marked with zero.**

relevé number	232222	1444444	11	1111222221113333433333
	50678941	23512345	65346789	6789012340127567012389
<i>Polypodium vulgare</i>	7757557787	68888888	5535533887	78788388874554555554
<i>Hypnum cupressiforme</i> 0	5557777535	5775337538	7575988788	798322.....
<i>Polytrichum formosum</i> 0	2553333523	8.222.2.....	2.3.3.....	2.....
<i>Isoetecium alopecuroides</i> 0	3532.3.....	337773.....	2.....	3.....
<i>Plagiochila asplenioides</i> 0	2323.2.....	3.322.....		
<i>Rubus idaeus</i>	3222233.....		2.1.....	
<i>Plagiothecium denticulatum</i> 0	.23353.....	2.....	2.....	2.76.2.....
<i>Cladonia fimbriata</i> 0	.221.....	222.....		
<i>Luzula * luzuloides</i>	33.....	23.....	3.3322.....	2.....
<i>Asplenium trichomanes</i>	2.....	2.....	2.....	22335.322.22.562..4545334441
<i>Sedum maximum</i>	22.....		22.23.115.12.32222..11..	2111
<i>Poa nemoralis</i>		2333.23.....	223325.....	232322.2.11....111
<i>Dicranum scoparium</i> 0	3352353.....	7225523.....	55.775733222.....	
<i>Oxalis acetosella</i>	.33327.....		2.....	2.....
<i>Cystopteris fragilis</i>	.....	2.....	1.1..2222233.....	32251...2.....
<i>Calamagrostis arundinacea</i>	35353.....	5..35352.....	2.....	2.....
<i>Geranium robertianum</i>	.2...3.....		3..1..2332.2241.1.2..	
<i>Dryopteris filix-mas</i>	.2.....	2.....	2..2..12....23.....	3.22.21
<i>Hieracium murorum</i>	2.....	1.1.....	2.....	1...121.3.121.
<i>Cardaminopsis arenosa</i>	.....	2.....	2.....	32.222223.2.....
<i>Mycelis muralis</i>	.....	22.....		2.32...2212..12..
<i>Dryopteris carthusiana</i>	3.3222.....			32.15
<i>Sorbus aucuparia</i>	.....	2.1.....	22.....	1..1.....222.....
<i>Chelidonium majus</i>	.....		122.....	22.3122..
<i>Campanula rapunculoides</i>	.....		3.2.2.5.....	111...31
<i>Vaccinium myrtillus</i>	23...33..32.....			1...2
<i>Deschampsia flexuosa</i>	5...5235.3.....			23
<i>Cladonia squamosa</i> 0	.2223.....			222.....
<i>Brachythecium velutinum</i> 0	.....	552.35.....	3.5.....	
<i>Pleurozium schreberi</i> 0	322..2.....			333.....
<i>Moehringia trinervia</i>	.....	222.2.....		2.3.2.....
<i>Hylocomium sp.</i> 0	523322.....			
<i>Sorbus aucuparia</i> 2	322.13.....	3.....		
<i>Tortella tortuosa</i> 0	2..22.2.....		2.....	3.....
<i>Leucobryum glaucum</i> 0	2.252...3.....			
<i>Metzgeria conjugata</i> 0	.22.....	2.2.2.....		
<i>Epilobium collinum</i>	.....		2.2.2.....	22.....
<i>Bartamia sp.</i> 0	.522.5.....			
<i>Lophozia ventricosa</i> 0	.3333.....			



Tab. 3. continued

relevé number	232222	1444444	11	1111222221113333433333
	5067894123512345653467896789012340127567012389			
<i>Campanula rotundifolia</i>	2			112
<i>Galium schultesii</i>	2	2		2
<i>Cardaminopsis halleri</i>			2222	
<i>Chamerion angustifolium</i>				1213
<i>Pedinophyllum interruptum</i> 0	5	2	2	
<i>Tortella fragilis</i> 0	2	32		
<i>Scapania nemorosa</i> 0	32	3		
<i>Sphagnum quinquefarium</i>	222			
<i>Dicranum sp.</i> 0	358			
<i>Thuidium tamariscinum</i> 0	55	2		
<i>Bazzania tricrenata</i> 0	22	3		
<i>Festuca drymeja</i>		3	32	
<i>Phegopteris connectilis</i>	2		2	3
<i>Hylocomium splendens</i> 0		3	3	3
<i>Bartramia pomiformis</i> 0			7	22
<i>Valeriana tripteris</i>		3		2
<i>Fragaria vesca</i>	2		2	2
<i>Clematis alpina</i>	2		5	2
<i>Camptothecium sericeum</i> 0			22	2
<i>Aurinia saxatilis</i>			36	1
<i>Parmelia sp.</i> 0			23	2
<i>Veronica chamaedrys</i>				22
<i>Asplenium septentrionale</i>		2		3
<i>Galeopsis speciosa</i>			2	22
<i>Cladonia rangiferina</i> 0				222

Tab. 4. The classification with the same phytosociological relevés as in Tab. 3 after elimination of cryptogamic taxa.

relevé number	1	11	111	12	2	22	222	3	33	333	4	44	444	4444	1111	13	333	4	333	3	22	222	23	
<i>Polypodium vulgare</i>	553388753834687888888888887855545555787475575577																							
<i>Asplenium trichomanes</i>	335.2..22254.22.62....32.45453344...1....22.																							
<i>Sedum maximum</i>	.23.2222223..11.2.....15.1.11..21...1....22																							
<i>Poa nemoralis</i>	23322.2.2.....333.23...111...1...1.....																							
<i>Cystopteris fragilis</i>	2233...22252..3211..1.....22.....																							
<i>Geranium robertianum</i>	...332.....31.2.....2241.12.....3.2																							
<i>Calamagrostis arundinacea</i>	.2...3.....52.....3535.....2353.35																							
<i>Dryopteris filix-mas</i>	2..23.....2...2..12...3.222...1..2....																							
<i>Hieracium murorum</i>	.....1...1...1.12..221.3.11.....2.																							
<i>Luzula * luzuloides</i>	2..2.....2.3.332.....2..2333																							
<i>Cardaminopsis arenosa</i>	...3.2.222.23222.....2.....																							
<i>Mycelis muralis</i>	.....22..23...22..2212..1.....																							
<i>Sorbus aucuparia</i>	...22222..1.....1.1.....2.....																							
<i>Chelidonium majus</i>	.....2.....2.....122.22.312.....																							
<i>Campanula rapunculoides</i>	.....225.....3..111...3..1.....																							
<i>Moehringia trinervia</i>	.....232222.2.....25.333...525.																							
<i>Deschampsia flexuosa</i>	.....2.....1.23327.3																							
<i>Oxalis acetosella</i>	.....21.....3.222332																							
<i>Rubus idaeus</i>	.....1...322...3323																							
<i>Vaccinium myrtillus</i>	.....321...5..32223.																							
<i>Dryopteris carthusiana</i>	.....3.....2.1332																							
<i>Sorbus aucuparia 2</i>	2.2.22.2.....																							
<i>Epilobium collinum</i>	2222.....																							
<i>Cardaminopsis halleri</i>	.....2.....1.....12.....																							
<i>Campanula rotundifolia</i>	.....2.....2.....11...3.....																							
<i>Chamerion angustifolium</i>	.....23.....2..2.																							
<i>Galium schultesii</i>	.....222.....																							
<i>Fallopia dumetorum</i>	.....22.....2.....																							
<i>Galeopsis speciosa</i>	.....22..3.....																							
<i>Asplenium septentrionale</i>	.....2..2...2.....																							
<i>Veronica chamaedrys</i>	.....361.....																							
<i>Aurinia saxatilis</i>	.....32.2.....																							
<i>Valeriana tripteris</i>	.....3.32.....																							
<i>Festuca drymeja</i>	.....2.....2.....1.....																							
<i>Solidago virgaurea</i>	.....1.....1...1.....																							
<i>Campanula persicifolia</i>	.....2.....1...1.....																							
<i>Lilium martagon</i>	.....2.....1...1.....																							

Tab. 4. continued

	1	11	112	23	112	22	44	444	4441	113	33	34	333	3	2	22	223	
relevé number	6	7	8	9	0	1	2	3	4	5	6	6	8	9	3	5	6	7
<i>Clematis alpina</i>	.	5	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Fragaria vesca</i>	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Galium sylvaticum</i>	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	2	.	.
<i>Phegopteris connectilis</i>	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
<i>Digitalis grandiflora</i>	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Asplenium viride</i>	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Jovibarba * glabrescens</i>	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.
<i>Sedum krajiniae</i>	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.
<i>Glechoma hirsuta</i>	.	.	.	.	.	2	.	.	.	2	.	.	.	.	.	.	.	.
<i>Epilobium montanum</i>	.	.	.	.	.	2	.	2	.	.	.	.	.	.	.	.	.	.
<i>Myosotis sylvatica</i>	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.
<i>Carex digitata</i>	.	.	.	.	.	.	.	.	.	3	.	1	.	.	.	.	.	.
<i>Festuca ovina</i>	.	.	.	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.
<i>Silene vulgaris</i>	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.
<i>Stellaria media</i>	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.
<i>Senecio nemorensis</i>	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.
<i>Abies alba</i> 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
<i>Lonicera xylosteum</i> 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3
<i>Picea abies</i> 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
<i>Prenanthes purpurea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.

Tab. 5 Synoptic table of all used data in a order of columns 1-15.

Column	B															
	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Column number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of relevés		10	4	8	16	16	18	20	21	4	5	5	10	6	10	6
Other species		7	17	20	42	42	51	115	75	5	15	24	50	42	22	12
<b>Char. and dif. species of the class <i>Asplenetea trichomanis</i></b>																
<i>Polypodium vulgare</i>		I	.	V	V	V	II	V	II	4	V	V	V	V	V	V
<i>Asplenium trichomanes</i>		III	4	IV	III	V	V	V	V	.	III	IV	IV	IV	III	I
<i>Sedum maximum</i>		.	.	II	IV	II	I	II	II	.	II	V	IV	II	III	IV
<i>Plagiochila asplenioides</i>		.	3	I	I	.	I	V	II	.	.	.	.	V	-	IV
<i>Tortella tortuosa</i>		V	1	I	III	I	III	V	II	I	.	.	.	III	-	V
<i>Dicranum scoparium</i>		.	.	I	II	I	I	III	.	I	.	III	V	V	-	V
<b>Char. and dif. species of the <i>Potentilletalia caulescentis</i>, and <i>Cystopteridion</i></b>																
<i>Cystopteris fragilis</i>		V	4	I	I	IV	V	V	V	I	V	II	III	.	.	II
<i>Neckera crispa</i>		I	4	IV	II	III	II	V	II	.	.	.	.	I	-	I
<i>Ctenidium molluscum</i>		II	2	II	.	III	IV	V	I	.	.	.	.	.	-	.
<i>Anomodon viticulosus</i>		I	.	II	III	I	I	IV	V	.	.	.	.	.	-	.
<i>Cardaminopsis arenosa</i>		.	.	.	III	III	IV	IV	IV	.	.	III	IV	.	.	.
<i>Valeriana tripteris</i>		III	.	.	I	II	III	IV	II	.	.	II	II	.	.	.
<i>Saxifraga paniculata</i>		.	2	III	.	I	I	III	I	.	.	.	I	.	.	.
<i>Moehringia muscosa</i>		.	.	II	.	III	II	II	.	.	.	.	.	.	.	.
<i>Campanula carpatica</i>		.	4	.	.	III	I	I	.	.	.	.	.	.	.	.
<i>Phyllitis scolopendrium</i>		.	.	.	.	III	I	III	I	.	.	.	.	.	.	.
<i>Asplenium viride</i>		V	2	.	I	I	III	III	II	.	II	.	.	.	.	.
<i>Asplenium ruta-muraria</i>		I	.	.	I	I	I	II	II	.	.	.	.	.	.	.
<i>Fissidens cristatus</i>		.	2	.	.	II	II	IV	II	.	.	.	.	.	.	.
<i>Plagiomnium unchulatum</i>		.	3	I	.	II	II	III	.	.	.	.	.	.	.	.
<i>Camptothecium sericeum</i>		I	.	II	.	.	I	IV	II	.	.	II	.	.	.	.

Tab. 5. continued

Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Rhytidadelphus triguerifolium</i>	.	1	II	I	I	I	IV	.	.	.	.	.	.	.	.
<i>Conocephalum conicum</i>	.	4	.	.	.	I	II	.	.	.	.	.	.	.	.
<b>Char. and dif. species of the <i>Androsacetalia vandellii</i>, and <i>Hypno-Polypodium</i></b>															
<i>Hypnum cupressiforme</i>	.	1	.	IV	I	I	IV	I	4	V	V	V	V	.	V
<i>Polytichum formosum</i>	.	.	.	.	.	.	I	.	4	.	I	II	V	.	IV
<i>Calamagrostis arundinacea</i>	.	.	.	.	.	.	.	.	.	II	I	I	V	.	IV
<i>Sorbus aucuparia</i>	.	.	.	I	.	.	II	.	1	.	V	II	V	.	.
<i>Rubus idaeus</i>	.	.	.	.	.	.	II	.	1	.	I	II	V	.	.
<i>Luzula hazuloides</i>	.	.	.	.	.	.	.	.	1	.	I	I	V	.	I
<i>Vaccinium myrtillus</i>	.	.	.	.	.	.	I	.	2	III	.	I	IV	.	IV
<i>Deschampsia flexuosa</i>	I	.	.	.	.	.	.	.	2	.	.	.	IV	I	.
<i>Epiobium collinum</i>	I	.	.	.	.	.	.	.	3	.	III	I	III	I	.
<i>Dryopteris carthusiana</i>	.	.	.	.	.	.	.	.	.	II	III	.	V	III	.
<i>Cardaminopsis halleri</i>	.	.	.	.	.	.	.	.	.	IV	.	.	.	.	.
<b>Other vascular species</b>															
<i>Oxalis acetosella</i>	.	3	II	.	I	II	III	.	.	II	.	.	V	I	.
<i>Geranium robertianum</i>	III	4	III	IV	V	IV	III	V	.	.	III	II	II	III	II
<i>Mycelis muralis</i>	.	4	III	I	IV	IV	III	II	.	.	II	II	III	III	III
<i>Poa nemoralis</i>	I	.	.	III	III	II	I	II	.	IV	III	IV	.	III	V
<i>Campanula rapunculoides</i>	.	.	I	III	III	I	.	IV	.	.	.	II	.	.	.
<i>Lathyrus vernus</i>	.	.	.	III	I	.	I	I	.	.	.	I	.	.	.
<i>Campanula moravica</i>	.	.	.	.	I	I	I	II	.	.	.	I	.	II	.
<b>Bryophytes and lichens</b>															
<i>Campolothecium philippaeum</i>	.	.	I	IV	I	II	.	IV	.	.	.	.	.	.	.
<i>Apometzgeria pubescens</i>	.	2	.	II	.	.	V	I	.	.	.	.	.	.	.
<i>Plagiopus oederi</i>	.	.	.	I	.	.	IV	I	.	.	.	.	.	.	.
<i>Meizgeria furcata</i>	.	.	.	III	.	.	III	I	.	.	.	.	I	.	.

Tab. 5. continued

Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Diurichum flexicaule</i>	I	.	.	.	I	.	III	I	.	.	.	.	.	-	.
<i>Mnium spinulosum</i>	.	.	.	.	.	I	III	.	.	.	.	.	II	-	III
<i>Metzgeria conjugata</i>	.	.	I	.	.	I	III	.	.	.	.	.	.	-	.
<i>Encalypta streptocarpa</i>	V	.	.	I	I	I	III	II	.	.	.	.	.	-	.
<i>Mnium stellare</i>	.	.	.	IV	.	I	.	I	.	.	.	.	.	-	.
<i>Neckera webbiana</i>	.	.	.	I	.	.	II	V	.	.	.	.	.	-	.
<i>Bryoerythrophyllum</i> sp.	.	.	.	I	.	.	.	II	.	.	.	.	.	-	.
<i>Bryum capillare</i>	.	.	.	III	.	.	I	II	.	.	.	I	.	-	.
<i>Cladonia fimbriata</i>	.	.	.	.	I	.	IV	.	3	.	.	.	III	-	.
<i>Pedinophyllum interruptum</i>	.	.	.	.	.	.	III	I	.	.	.	.	III	-	.
<i>Brachythecium velutinum</i>	.	.	.	V	.	.	.	I	.	I	.	I	I	-	V
<i>Hylocomium splendens</i>	.	.	.	III	.	.	IV	.	.	.	I	.	V	-	V
<i>Isoetecium alopecuroides</i>	.	.	.	.	.	.	.	.	.	.	III	I	V	-	.
<i>Pleurozium schreberi</i>	.	.	.	.	.	.	I	.	.	.	.	III	IV	-	.
<i>Plagiothecium denticulatum</i> .	.	.	.	.	.	I	.	2	.	.	.	IV	-	II	.
<i>Leucobryum glaucum</i>	.	.	.	.	.	.	.	.	1	.	.	.	IV	-	.
<i>Bartramia norvegica</i>	.	.	.	.	.	.	.	.	.	.	II	.	IV	-	II
<i>Cladonia squamosa</i>	.	.	.	.	.	.	.	.	.	.	III	.	IV	-	.
<i>Lophostia ventricosa</i>	.	.	.	.	.	.	.	.	.	.	.	.	IV	-	.
<i>Sphagnum quinquefarium</i>	.	.	.	.	.	.	.	.	.	.	.	.	III	-	.
<i>Thuidium tamariscinum</i>	.	.	.	.	.	.	.	.	.	.	.	.	III	-	.
<i>Scapania nemorea</i>	.	.	.	.	.	.	II	.	.	.	.	.	III	-	.
<i>Tortella fragilis</i>	.	.	.	.	.	.	.	.	.	.	.	.	III	-	.
<i>Dicranum montanum</i>	.	.	.	I	.	.	.	.	.	.	.	.	III	-	I