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REVIEW

Current knowledge and phytosociological data on the high-altitude vegetation in the Western Carpathians – a review

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Abstract: Presented survey summarizes the results of the studies published predominantly after 2000, dealing with the plant communities around and above the timberline in (montane) subalpine to alpine (subnival) belt of the Western Carpathians. All of these communities underwent a critical syntaxonomical and nomenclatorical revision, hence the demonstrated overview of high-mountain vegetation of Western Carpathians (mostly from Slovakia, less from Poland border areas) represent the current state of knowledge. The high-altitude vegetation database, which is the part of Slovak National Vegetation Database, SNVD (http://ibot.sav.sk/cdf/index.html), incorporated 8,160 published relevés on 15 May 2007 (of the total of 30,469 published relevés in the SNVD). Concerning the unpublished relevés, the individual authors have provided more than 18,400 of them to be stored in SNVD; 2,301 of all unpublished relevés could be assigned to high-altitude vegetation. Mountain and alpine vegetation is in SNVD presented by 15 classes; the most frequent class is *Mulgedio-Aconitetea*. With its quantity and also the quality of relevés, the high-altitude database, as well as the whole SNVD, represents the unique database within Slovakia, which provides information not only about the locality, floristic composition and variability of individual vegetation types, but also about several environmental variables such as inclination, aspect, geology or soil type, characteristic for individual relevés. Together with other Central European databases, SNVD takes up the leading position in Europe.

Key words: classification; plant communities; syntaxonomy; Slovak National Vegetation Database; Turboveg; vegetation survey

Introduction

Phytosociologists became interested in the high-altitude vegetation since the establishment of vegetation research at the beginning of the 20th century. Several vegetation studies in the high mountains became classical in phytosociology (e.g. Rübel 1911; Braun-Blanquet & Jenny 1926).

Specific conditions in the high mountains gave rise to a diverse mosaic of vegetation types, with an abundance of rare, relic and endemic taxa. Complex topography, a variety of geological bedrock and variable climatic and soil features all contribute to an exceptional variability of habitats, including refuges that provide high-mountain plants with optimal conditions.

In the Western Carpathians, detailed research dealing with vegetation of the highest mountains above the timberline began in the 1920s in the Tatra Mts (highest mountains of the Carpathian mountain range). In their pioneer studies, Polish authors (Szafer et al. 1923, 1927; Pawłowski & Stecki 1927; Pawłowski et al. 1928, 1929; Pawłowski 1925, 1935) recorded a number of relevés from different alpine communities of the Tatra Mts. Czech authors continued with this research (Domin 1929, 1930; Krajina 1933; Hadač 1956; Hadač et al. 1969; Šmarda et al. 1971; Unar et al. 1984, 1985), and later many Slovak authors published valuable data in manuscripts and theses (Dúbravcová et al. 1976, 1980, 1990; Šeffer et al. 1989; Dúbravcová 1996). Some vegetation research was also carried out in the Nízke Tatry Mts (Sillinger 1933; Miadok 1995), the Malá and Veľká Fatra Mts (Klika 1932; Grebenščikov et al. 1956; Bělohlávková 1980), and in some other regions, e.g. Mt. Babia hora (Walas 1933). Numerous data have been scattered in local studies, diploma and dissertation theses, unpublished research reports, etc.

The electronic databases for archiving and processing of phytosociological data started to expand simultaneously with the development of database programs. The milestone came in with the program TURBOVEG (Hennekens 1995). TURBOVEG provides an environment for input, import, selection, export and subsequent processing of relevés. This program was adopted as the standard computer package for the European Vegetation Survey (Rodwell et al. 1995). Currently, it has been used in more than 25 countries throughout the world (Hennekens & Schaminée 2001). Slovak phytosociologists started to use the program in the late 1990s to build up the "Central Database of Phytosociological Samples", which aim was intended to assemble all available phytosociological relevés from the territory of Slovakia for the purpose of processing of synoptic tables of all vegetation types and their publishing within the survey of plant communities of Slovakia (Valachovič 1996, 1999). The constant improvement of the program TURBOVEG by its author and particularly the compatibility of TURBOVEG with number of available programs for statistic evaluation and visualisation of phytosociological data resulted in an almost complete replacement of the previously used programs such as Fytopack (Jarolímek & Schlosser 1997). This development was also driven by the flexible linkage of TURBOVEG with the Juice program (Tichý 2002), which now represents the most used program for numerical classification and analysis of phytosociological data in former Czechoslovakia.

Results

Contemporary knowledge

The study of the Western Carpathian montane to subnival vegetation led to a complete overview of the high-mountain vegetation of Slovakia (Kliment & Valachovič 2007), forming a part of the monographic series Plant Communities of Slovakia. The overview was preceded by the syntaxonomical revisions of the plant communities of the alliances *Petasition officinalis* (Kliment & Jarolímek 1995, 2002; Jarolímek et al. 2002), *Calamagrostion arundinaceae* (Kliment & Jarolímek 2003), *Caricion firmae* (Šibík et al. 2004), orders *Calamagrostietalia villosae*, *Adenostyletalia alliariae* (Kliment et al. 2004), classes *Elyno-Seslerietea* (Kliment et al. 2005), *Carici rupestris-Kobresietea bellardii* (Petrík et al. 2005, 2006), *Loiseleurio-Vaccinietea* (Šibík et al. 2006, 2007b), *Roso pendulinae-Pinetea mugo* (Šibík et al. 2005; Šibík 2007b), as well as by parallel comparisons of plant communities of several classes (Dúbravcová et al. 2005), in which the previous knowledge was revised with respect to new methodological advances and new information about the diversity of high-altitude vegetation in the surrounding mountain regions. These publications provided a comprehensive description of mountain vegetation, as well as an assessment of its uniqueness and vulnerability. They also present a valuable basis for larger syntheses across European high mountain ranges.

An important part of the data used in these studies is composed of unpublished phytosociological relevés, taken from diploma, RNDr. and PhD. thesis, manuscripts and reports. A number of new phytosociological relevés was newly made in insufficiently explored high-mountain plant communities and areas. In several cases, such an additional survey led to the description of new syntaxa.

All syntaxa being presented in this article underwent syntaxonomical and nomenclatural revision according to the International Code of Phytosociological Nomenclature (Weber et al. 2000). The most recent Volume 4 of Plant Communities of Slovakia (Kliment & Valachovič 2007) represents the most complete publication on high-altitude vegetation in Slovakia. This book provides comprehensive phytosociological characteristics of high-altitude plant communities of tall-forb vegetation (*Mulgedio-Aconitetea*; Kliment et al. 2007a), communities of deciduous subalpine shrubs along river banks (*Betulo carpaticae-Alnetea viridis*; Kliment 2007b), montane and alpine calcareous grasslands (*Elyno-Seslerietea*; Kliment et al. 2007a, and *Carici rupestris-Kobresietea bellardii*; Šibík et al. 2007c), snow-bed communities (*Salicetea herbaceae*; Dúbravcová 2007), arctic-boreal dwarf-shrub heathlands (*Loiseleurio-Vaccinietea*; Šibík et al. 2007a) and alpine acidophilous grasslands (*Caricetea curvulae*; Dúbravcová & Jarolímek 2007). The volume closes with descriptions of the characteristics of high-mountain mat-grass swards of the alliance *Nardion strictae* (Kliment 2007a), although the other communities of the class*Nardetea strictae* [alliances *Nardo-Agrostion tenuis* Sillinger 1933 and *Violion caninae* Schwickerath 1944, possibly also *Nardo-Juncion squarrosi* (Oberd. 1957) Passarge 1964] will be included in the next volume dedicated to meadow and pasture vegetation.

Several vegetation types occurring at higher altitudes were characterised in previous volumes of the monographic series Plant Communities of Slovakia. Mountain and alpine communities of rocky fissures and screes – classes *Asplenietea trichomanis* and *Thlaspietea rotundifolii*, were described in Volume 1 (Valachovič et al. 1995), particularly with regard to their pioneering character and occurrence also in lower altitudinal belts. Mountain spring vegetation of the class *Montio-Cardaminetea* (Valachovič 2001a) and ombrotrophic raised bogs of the *Oxycocco-Sphagnetea* (Šoltés et al. 2001) were elaborated as a part of wetland vegetation (Valachovič 2001b). Nitrophilous communities of the *Carduo-Urticion dioicae* (class *Galio-Urticetea*) were described in Volume 2 (Jarolímek et al. 1997) dealing with ruderal and anthropogenic vegetation. Ruderal plant communities occurring near the shepherd's huts (*Rumicion alpini*) were studied by Kliment & Jarolímek (1995). Mountain vegetation with dwarf pine (*Roso pendulinae-Pinetea mugo*) is also not dealt with in Volume 4, but will be revised in the final volume of this series, devoted to forest and shrub vegetation. Recently, subalpine *Pinus mugo* communities were elaborated in detail by Šibík (2007b). New knowledge about *Pinus mugo* scrub on peaty soils in the subalpine belt (the *Eriophoro-Piceion abietis*) is elaborated by Šibík (2007b) and Šibík et al. (2008).

Slovak National Vegetation Database

This review presents current information from 15th May 2007 about contemporary state of the Slovak National Vegetation Database (SNVD) and focuses on relevés obtained from higher altitudes (mountain database). To this date, 30,469 phytosociological relevés (i. e. almost sevenfold number of relevés stored in SNVD in 1999; see Fig. 1) were included in the TURBOVEG database (Hennekens & Schaminée 2001); 8,160 (27%) of them being classified as mountain vegetation. They

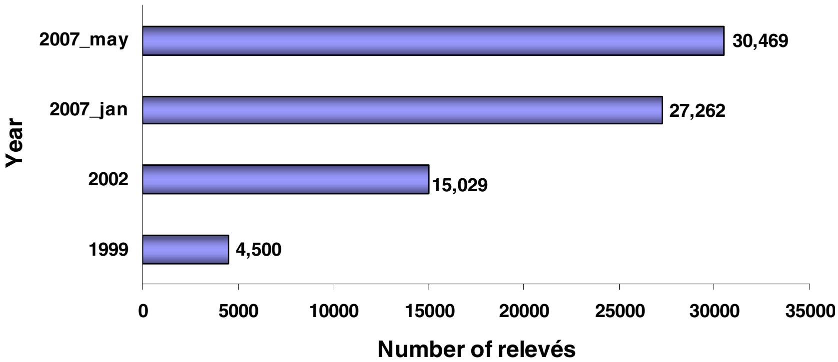

Fig. 1. The numbers of relevés stored in the Slovak National Vegetation Database (SNVD) since 1999. Sources: Valachovič (1999) – Year 1999; Hrivnák et al. (2003) – Year 2002; http://ibot.sav.sk/cdf/stav_CDF.htm – January 2007; Šibíková et al. (hoc loco) – May 2007. Unpublished relevés from private databases are not included in the statistics.

Table 1. Number, bibliographical sources (references) and authors of relevés included in the Slovak National Vegetation Database (SNVD).
All-publ: Number of all published (including not only papers and monographs, but also manuscripts, reports and theses) relevés in the SNVD; HA-publ: Number of published high-altitude (HA) relevés stored in the mountain part of the SNVD; All-unpubl: Number of all unpublished relevés stored in private databases of individual authors; HA-unpubl: Number of all unpublished relevés representing the mountain vegetation types stored in private databases of individual authors.

Number of	All-publ	HA-publ	All-unpubl	HA-unpubl	Total
relevés	30469	8160	18475	2301	48944
references	1122	290	–	–	1122
authors	587	125	51	30	587

were taken from various scientific journals, proceedings or diploma, PhD. and Candidate of Science thesis, final reports or other manuscripts. A total of 1,122 biblioreferences were computerized, out of them 290 dealt also with mountain or alpine vegetation (Table 1). Moreover, more than 18,400 unpublished relevés with 2,301 of them being from high altitudes were included in the database (private databases of individual authors).

There are 125 contributors of the phytosociological relevés to the mountain database (30 researchers of them rendered also their unpublished relevés). 30 contributors each provided more than 100 relevés, what makes 74% of all published relevés in the mountain database (Table 2).

The database reflects history of mountain vegetation research in Slovakia. The oldest high-altitude relevés come from the 1920s. The very first one was made by Karel Domin on 10 September 1919; it is perhaps the first phytosociological relevé made in the territory of the Slovak Republic. This relevé represents the association *Oxyrio digynae-Saxifragetum carpaticae* Pawłowski et al. 1928. The smallest proportion of relevés comes from the 1940s, while most relevés were made in the 1970s, when numerous vegetation studies were done mainly in the Tatra Mts (Fig. 2).

Mountain and alpine vegetation is in SNVD presented by 15 classes (see App. 1, Table 3, Fig. 3); the most frequent class is *Mulgedio-Aconitetea* (with 2,444 relevés), the next are *Elyno-Seslerietea* (1,584 relevés), *Caricetea curvulae* (1,214 relevés), and *Nardetea strictae* (1,143 relevés). Fewest relevés were obtained

Table 2. Most frequent authors of the high-altitude relevés. These authors have contributed 74 % of all published relevés (i.e. 6,038 relevés) stored in the mountain part of SNVD.

	Author	Published relevés	Unpublished relevés	Total
1	Dúbravcová Z.	914	301	1215
2	Kliment J.	496	396	892
3	Petrík A.	242	260	502
4	Bělohlávková R.	113	380	493
5	Bernátová D.	188	168	356
6	Hadač E.	343	0	343
6	Krajina V.	343	0	343
6	Jarolímek I.	173	170	343
7	Valachovič M.	145	184	329
8	Šoltés R.	321	0	321
9	Šibík J.	123	169	292
10	Šmarda J.	260	0	260
11	Šoltésová A.	58	182	240
12	Unar J. + Unarová M.	227	0	227
13	Pawlowski B.	225	0	225
14	Hrabovcová J.	163	0	163
15	Szafer W.	160	0	160
16	Miadok D.	139	16	155
17	Štrba P.	147	0	147
18	Komárková V.	146	0	146
18	Mucina L.	53	93	146
19	Šomšák L.	143	0	143
20	Sillinger P.	132	0	132
21	Kremlová R.	126	0	126
22	Klika J.	122	0	122
23	Zlochová B.	120	0	120
24	Školek J.	112	0	112
25	Altmannová M.	110	0	110
26	Blažková D.	103	0	103
27	Walas J.	101	0	101

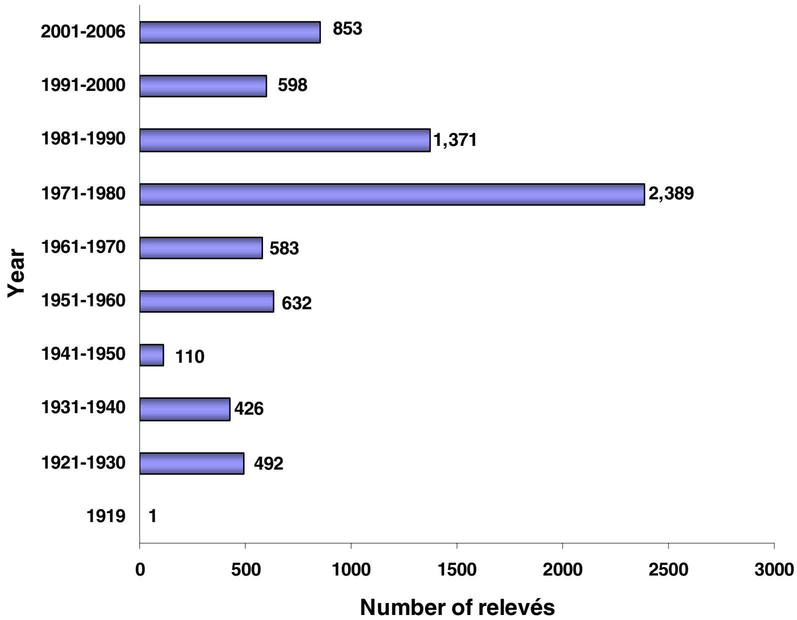

Fig. 2. The proportion of relevés stored in the mountain part of SNVD made in each decade between 1919 and 2006. Only relevés with an indication of the year of record are included in the statistics.

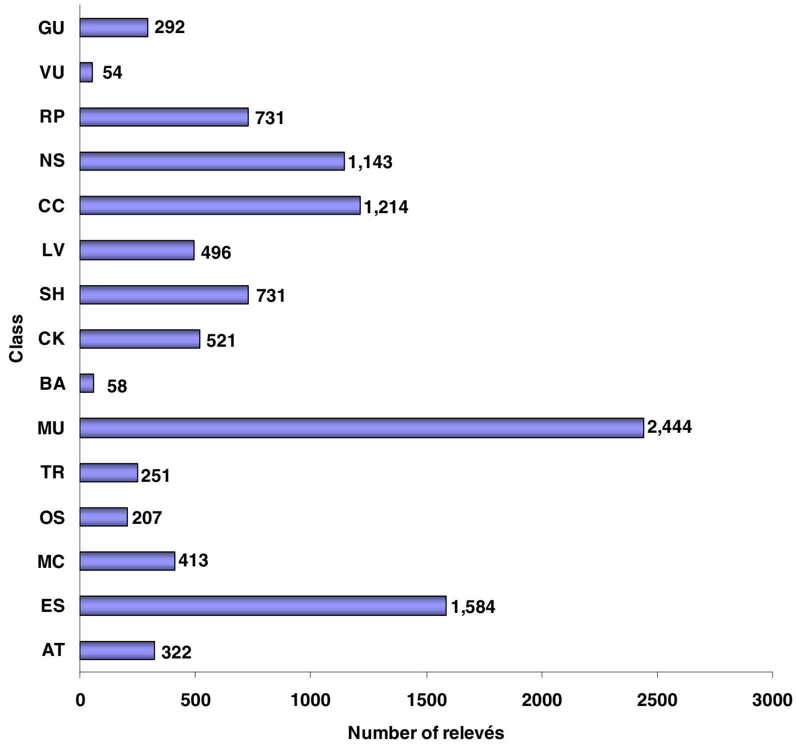

Fig. 3. The proportion of relevés stored in the mountain part of SNVD according to their assignment to individual classes. Only relevés with an indication of syntaxon are included. In the case of classes of azonal vegetation, only relevés from mountain and high-mountain plant communities are included (see App. 1). See Table 3 for the abbreviations of classes.

from the classes *Betulo carpaticae-Alnetea viridis* (58) and *Vaccinio uliginosi-Pinetea sylvestris* (ass. *Sphagno magellanici-Pinetum mugo*; 54), which are rare in the Western Carpathians.

The altitudinal distribution of the relevés stored in the database has rising tendency up to the range of 1,801–1,900 m a. s. l. The number of relevés then decreases indirectly with elevation (Fig. 4). The relevé from the highest altitude was recorded by Šoltés et al. (2006) on Lomnický štít Mt. at 2,632 m a. s. l. (association *Oxyrio digynae-Saxifragetum carpaticae*). The relevés included in the alliances *Petasition officinalis* and the *Cystopteridion* were recorded also at lower altitudes. In the former case, the stands are mostly confined to banks of the streams, and in the latter case to the shaded rock outcrops and narrow cold ravines

Table 3. Number of relevés included in the phytosociological classes comprising the mountain part of SNVD.
Hence the occurrence of several classes is not of zonal character, the total number of relevés in individual class (Class), as well as the number of mountain and high-altitude relevés alone (HA) is presented.

Class	HA-publ	Class-publ	HA-unpubl	Class-unpubl
Asplenietea trichomanes – AT	209	269	113	165
Elyno-Seslerietea – ES	1160	1160	424	424
Montio-Cardaminetea – MC	308	518	105	223
Oxycocco-Sphagnetea – OS	127	127	80	80
Thlaspietea rotundifolii – TR	215	487	36	118
Mulgedio-Aconietetea – MU	2060	2060	384	384
Betulo-Alnetea viridis – BA	58	58	0	0
Carici rupestris-Kobresietea – CK	403	403	118	118
Salicetea herbaceae – SH	634	634	97	97
Loiseleurio-Vaccinietea – LV	431	431	65	65
Caricetea curvulae – CC	1024	1024	190	190
Nardetea strictae – NS	740	740	403	403
Roso-Pinetea mugo – RP	576	576	155	155
Vaccinio uliginosi-Pinetea – VU	36	77	18	18
Galio-Urticetea – GU	179	461	113	1595

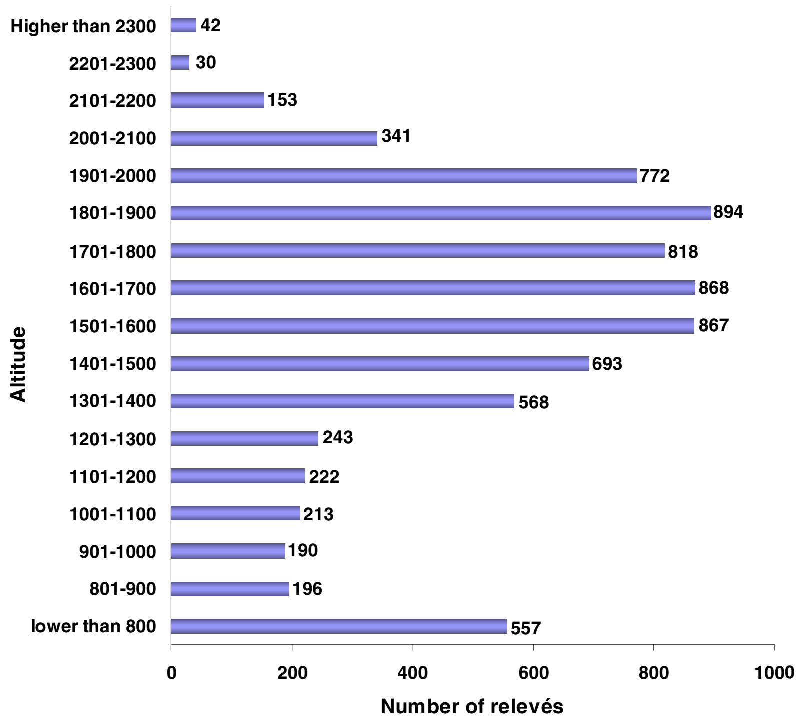

Fig. 4. Altitudinal distribution of relevés stored in the mountain part of SNVD. Only relevés with an indication of altitude are included.

with temperature inversion, which influences the floristic composition of the stands and causes its similarity across different altitudes.

Despite the great effort to excerpt as much information from literature sources as possible, it is striking how many variables are not recorded in a number of relevés (Table 4). The most frequently missing entries are geology (68%) and geographic coordinates (31%). For many relevés, the Greenwich coordinates (used format is WGS-84) were and are still being identified and added a posteriori. Many relevés lack also the information on cover or height of individual vegetation layers.

If we compare the number of relevés in individual phytosociological classes within the whole SNVD, 10 classes of high-mountain vegetation belong to 20 most frequent higher vegetation units (Tab. 5). These numbers point out not only the frequency of these biotopes in Slovakia, but also the attractiveness of high-mountain plant communities for botanists.

Conclusions and perspectives

According to its size and quality, SNVD, together with other Central European databases, takes up the leading position in Europe. By comparison, the Czech National Phytosociological Database (Chytrý & Rafajová 2003) with its size occupies the third place right after Dutch and French databases (Ewald 2001); at the end of 2005 it contained 72,476 phytosociological relevés (Chytrý 2007).

Table 4. The percentages of missing values of different variables in the relevés stored in the mountain part of SNVD. Missing variables of unpublished relevés from private databases are not included in the statistics.

Variable	Percentage of missing values
Year of sampling	8.6 %
Plot size	13.7 %
Altitude	6.0 %
Herb layer cover	24.2 %
Cryptogam layer cover	22.3 %
At least one of the above values is missing	42.7 %
Without geology	68 % (77 % in whole SNVD)
Without coordinates	31 % (15 % in whole SNVD)

Table 5. The order of individual classes found in the Western Carpathians based on the number of all relevés stored in SNVD. Of the classes not comprising the mountain part of SNVD, only those standing within the twenty most frequent of all are presented. Classes that represent mountain part of SNVD are depicted by asterisk (*).Only relevés with an indication of syntaxa are included in the statistics.

	Class	Rels-publ	Rels-unpubl	Total
1	*Molinio-Arrhenatheretea*	4174	4091	8265
2	*Querco-Fagetea*	5279	386	5665
3	*Festuco-Brometea*	1853	1116	2969
4	*Phragmito-Magnocaricetea*	2179	703	2882
5	*Stellarietea mediae*	199	2615	2814
6	*Scheuchzerio-Caricetea fuscae*	1780	993	2773
7	**Mulgedio-Aconitetea*	2060	384	2444
8	**Galio-Urticetea*	461	1595	2056
9	*Artemisietea vulgaris*	261	1572	1833
10	*Vaccinio-Piceetea*	1625	98	1723
11	**Elyno-Seslerietea*	1160	424	1584
12	**Caricetea curvulae*	1024	190	1214
13	**Nardetea strictae*	742	403	1145
14	**Montio-Cardaminetea*	518	223	741
15	**Salicetea herbaceae*	634	97	731
16	**Roso-Pinetea mugo*	576	155	731
17	*Bidentetea tripartiti*	104	588	692
18	**Thlaspietea rotundifolii*	487	118	605
19	*Trifolio-Geranietea sanguinei*	222	327	549
20	**Carici rupestris-Kobresietea*	403	118	521
22	**Loiseleurio-Vaccinietea*	431	65	496
26	**Asplenietea trichomanis*	269	165	434
33	**Oxycocco-Sphagnetea*	127	80	207
38	**Vaccinio uliginosi-Pinetea*	77	18	95
41	**Betulo-Alnetea viridis*	58	0	58

The high-mountain vegetation database, which is a part of the SNVD, provides information not only about the locality, floristic composition and variability of individual vegetation types, but also about several environmental variables such as inclination, aspect, geology or soil type, characteristic for individual relevés.

We suppose that in the close future the mountain database will be further enlarged by adding new relevés, but also the relevés from different manuscripts and theses. One of our future plans is to fill in the Greenwich coordinates for the remaining non-georeferenced relevés, since only the exactly located relevés are appropriate for further analyses in GIS or for geographical stratification. The interconnection between the database and various geographical programs – such as Arc GIS (Esri 2005) create a new possible space for further usage.

In relation with the SynBioSys Europe initiative (www.synbiosys.alterra.nl/eu/) and the development of the Pan-European Ecological Network (PEEN), it is anticipated that an indicative map of an ecological network for the whole Europe, based on data from national databases, will be produced for spatially explicit identification of all major habitats in Europe (Mücher et al. 2005).

As the classification of high-mountain vegetation of Slovakia has been recently published (Kliment & Valachovič 2007), international syntheses represent the perspective future use of the mountain database. The first pan-European studies based on large vegetation datasets stored in several databases have already started (Botta-Dukát et al. 2005; Illyés et al. 2007; Šibík et al. in prep.), but their fast accrual in close future is supposed right with the development of large and quality national databases.

Very important is also the non-commercial use of the database not only by scientists (botanists, zoologists, ecologists etc.), but also by nature conservation institutions, since it contains high-quality floristic records of both vascular and non-vascular plants with exact localisation and basic environmental characteristics.

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Appendix 1: Checklist of higher syntaxa occurring in high altitudes of the Western Carpathians

***Montio-Cardaminetea* Br.-Bl. et Tx. ex Klika et Hadač 1944**
Plant communities of water-springs
Montio-Cardaminetalia Pawłowski in Pawłowski et al. 1928
Epilobio nutantis-Montion Zechmeister 1993
Philonotidion seriatae Hinterlang 1992
Cratoneuro filicini-Calthion laetae Hadač 1983
Cratoneurion commutati Koch 1928

***Oxycocco-Sphagnetea* Br.-Bl. et Tx. ex Westhoff et al. 1946**
Ombrotrophic and ombrosoligenic raised bogs, and extremely oligotrophic mires
Sphagnetalia medii Kästner et Flößner 1933
Oxycocco-Empetrion hermaphroditi Nordhagen ex Hadač et Váňa 1967
Sphagnion medii Kästner et Flößner 1933

***Asplenietea trichomanis* (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977**
Chasmophytic vegetation of rocky fissures and cliffs
Potentilletalia caulescentis Br.-Bl. in Br.-Bl. et Jenny 1926
Potentillion caulescentis Br.-Bl. in Br.-Bl. et Jenny 1926
Cystopteridion Richard 1972
Androsacetalia vandelii Br.-Bl. in Meier et Br.-Bl. 1934 corr. Br.-Bl. 1948
Androsacion vandelii Br.-Bl. in Br.-Bl. et Jenny 1926 corr. Br.-Bl. 1948

***Thlaspietea rotundifolii* Br.-Bl. 1948**
Plant communities of screes
Thlaspietalia rotundifolii Br.-Bl. in Br.-Bl. et Jenny 1926
Papaverion tatrici Pawłowski 1928 corr. Valachovič 1995
Androsacetalia alpinae Br.-Bl. in Br.-Bl. et Jenny 1926
Androsacion alpinae Br.-Bl. in Br.-Bl. et Jenny 1926
Galio-Parietarietalia officinalis Boşcaiu et al. 1966
Stipion calamagrostis Jenny-Lips ex Br.-Bl. et al. 1952 (only the *Rumicetum scutati*)
Arabidion alpinae Béguin 1972

***Mulgedio-Aconitetea* Hadač et Klika in Klika 1948**
Tall forb vegetation in the montane to alpine belt
Calamagrostietalia villosae Pawłovski et al. 1928
Calamagrostion villosae Pawłowski et al. 1928
Trisetion fusci Krajina 1933
Calamagrostion arundinaceae (Luquet 1926) Jeník 1961
Calamagrostion variae Sillinger 1932 em. Hadač et al. 1969
Festucion carpaticae Bělohlávková et Fišerová 1989
Adenostyletalia alliariae Br.-Bl. 1930
Adenostylion alliariae Br.-Bl. 1926
Adenostylenion alliariae Klika in Klika et Hadač 1944
Delphinenion elati (Hadač ex Hadač et al. 1969) Boşcaiu et Mihăilescu 1997
Petasito-Chaerophylletalia Morariu 1967
Petasition officinalis Sillinger 1933

***Betulo carpaticae-Alnetea viridis* Rejmánek in Huml et al. 1979**
Subalpine communities of deciduous shrubs along river banks
Alnetalia viridis Rübel ex Huml et al. 1979
Salicion silesiacae Rejmánek et al. 1971

***Elyno-Seslerietea* Br.-Bl. 1948**
Montane and alpine calcareous grasslands
Seslerietalia coerulae Br.-Bl. in Br.-Bl. et Jenny 1926
Astero alpini-Seslerion calcariae Hadač ex Hadač et al. 1969
Astero alpini-Seslerienion calcariae Kliment et al. 2005
Pulsatillo slavicae-Caricenion humilis Uhlířová in Kliment et al. 2005
Seslerion tatrae Pawłowski 1935 corr. Klika 1955
Caricion firmae Gams 1936

***Carici rupestris-Kobresietea bellardii* Ohba 1974**
Arctic-alpine grasslands and dwarf-shrub heaths of wind-exposed ridges and edges of the highest summits on neutral soils
Oxytropido-Elynetalia Oberdorfer ex Albrecht 1969
Oxytropido-Elynion Br.-Bl. 1949
Festucion versicoloris Krajina 1933

***Salicetea herbaceae* Br.-Bl. 1948**
Snow-bed communities
Salicetalia herbaceae Br.-Bl. in Br.-Bl. et Jenny 1926
Salicion herbaceae Br.-Bl. in Br.-Bl. et Jenny 1926
Festucion picturatae Krajina 1933 corr. Dúbravcová in Kliment et al. 2007
Arabidetalia caeruleae Rübel ex Br.-Bl. 1948
Arabidion caeruleae Br.-Bl. in Br.-Bl. et Jenny 1926

***Loiseleurio-Vaccinietea* Eggler ex Schubert 1960**
Arctic-boreal dwarf-shrub heathlands
Rhododendro-Vaccinietalia Br.-Bl. in Br.-Bl. et Jenny 1926
Loiseleurio-Vaccinion Br.-Bl. in Br.-Bl. et Jenny 1926
Vaccinion myrtilli Krajina 1933 (non *Vaccinion* Böcher 1943)

***Caricetea curvulae* Br.-Bl. 1948**
Acidophilous grasslands in the (sub)alpine belt
Caricetalia curvulae Br.-Bl. in Br.-Bl. et Jenny 1926
Juncion trifidi Krajina 1933

Nardetea strictae **Rivas Goday et Borja Carbonell 1961**
Alpine and subalpine (montane) mat-grass meadows and pastures
Nardetalia strictae Oberd. ex Preising 1949
Nardion strictae Br.-Bl. 1926
Nardo-Agrostion tenuis Sillinger 1933

Roso pendulinae-Pinetea mugo **Theurillat in Theurillat et al. 1995**
Zonal subalpine prostrate shrub-communities dominated by *Pinus mugo* s. str.
Junipero-Pinetalia mugo Boşcaiu 1971
Pinion mugo Pawłowski in Pawłowski et al. 1928

Vaccinio uliginosi-Pinetea sylvestris **Passarge 1968**
Azonal, oligotrophic, more or less peaty coniferous tree- and shrub-communities
Eriophoro-Pinetalia Passarge 1968
Eriophoro-Piceion abietis Passarge 1968 (only the *Sphagno magellanici-Pinetum mugo* Hadač et al. 1969 nom. conserv. propos.)

Galio-Urticetea **Passarge ex Kopecký 1969**
Nitrophilous ruderal and semi-natural fringe communities of perennials on moderately moist to wet soils
Lamio albi-Chenopodietalia boni-henrici Kopecký 1969
Rumicion alpini Rübel ex Klika in Klika et Hadač 1944
Carduo-Urticion dioicae Hadač ex Hadač et al. 1969