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SHARPNESS AND UNIQUENESS OF THE PHYTOSOCIOLOGICAL CLASSES OF SLOVAKIA

Jarolímek I.[1], Šibík J.[1], Tichý L.[2], Kliment J.[3]

[1]*Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 14, SK-845 23 Bratislava, Slovak Republic, e-mail: ivan.jarolimek@savba.sk, jozef.sibik@savba.sk*
[2]*Department of Botany and Zoology, Masaryk University, Kotlárská 2, CZ-611 37 Brno, Czech Republic, e-mail: tichy@sci.muni.cz*
[3]*Botanical Garden of Comenius University, SK-038 15 Blatnica, Slovak Republic, e-mail: kliment@rec.uniba.sk*

Abstract - This study extracts the diagnostic, constant and dominant species of Slovak vegetation types based on statistical analysis of phytosociological data stored in the national vegetation database. The affinities of vascular plant, bryophyte and lichen species to the major syntaxa (alliances and classes) were calculated using a statistically defined coefficient of fidelity.
Additionally, the evaluation of vegetation units by the criteria of sharpness and uniqueness was created. These criteria allow us to identify well-delimited alliances and classes or to point out those, for which delimitation is problematic and which are more difficult to define by statistical principles. The syntaxonomical revision and delimitation of some units with low values of sharpness and uniqueness should be considered in the future.

Key words - database, phytosociology, plant communities, syntaxonomy, Turboveg, vegetation survey

Introduction

From the beginning, the concept of diagnostic species has always been linked to the concept of fidelity – the concentration in occurrence or abundance of species in a particular vegetation unit. The first approaches to assess fidelity values were rather intuitive (Szafer & Pawlowski, 1927). These were later replaced, as the development of more powerful computers and software for vegetation data analysis progressed, by more objective statistical analyses and methods (cf. Chytrý & Tichý, 2003).

A publication written by our colleagues from Masaryk University in Brno (Chytrý & Tichý, 2003) about the diagnostic species of alliances and classes of the Czech Republic was the main inspiration for the book *Diagnostic, constant and dominant species of the higher vegetation units of Slovakia* (Jarolímek & Šibík, 2008) which has been recently published. We decided to analyse phytosociological relevés, stored in the Slovak national vegetation database – SNVD (Šibíková *et al.*, 2009) in the database program TURBOVEG (Hennekens & Schaminée, 2001), using the same methodology and then to present the results of statistical analyses of phytosociological data from Slovakia to general public.

The aims of the monograph were a) to evaluate the

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affinity of individual taxa occurring in Slovakia to particular vegetation units (alliances and classes) using statistically defined fidelity values (Chytrý *et al.*, 2002); b) to evaluate the quality of delimitation of individual higher syntaxa (alliances and classes) included in the syntaxonomical scheme presented in this book (and recently used in SNVD) and at the same time to point out its strong as well as weak spots.

The aim of this paper is to acquaint the general public with the publication by Jarolímek *et al.* (2008a), which is available at the Institute of Botany Slovak Academy of Sciences.

Material and Methods

The data set of 43,222 phytosociological relevés from the SNVD was analysed in the program JUICE, version 6.4.6 (Tichý, 2002). The species with a fidelity of above 24 ($\Phi > 0.24$) were considered as diagnostic. Constant species are those with a high occurrence frequency in the given vegetation unit. Different threshold frequency values for constant species were applied for classes (25 %) and alliances (40 %). Dominant species were defined as those having a percentage cover higher than 50 % in at least 3 % of the relevés in the given vegetation unit.

Sharpness is defined as the number or quality of diagnostic species in a vegetation unit, relative to the average species richness of its stands. A vegetation unit is sharp if a large proportion of its species are confined to it, being mostly absent or rare in other vegetation units, while it is progressively less sharp if most of its species are generalists frequently found also in other vegetation units (Chytrý & Tichý, 2003).

Uniqueness was used for the first time in the paper of Chytrý & Tichý (2003) to identify unique vegetation units in the data set. It "expresses whether or not there are similar vegetation units of the same rank (e.g., class or alliance). A vegetation unit is unique if none of its diagnostic species has simultaneously diagnostic status in other vegetation units, while its uniqueness decreases if it shares its diagnostic species with other vegetation units."

For more information concerning the methods see Chapter 1 (Jarolímek *et al.*, 2008a) in the publication by Jarolímek & Šibík (2008).

Results

The publication *Diagnostic, constant and dominant species of the higher vegetation units of Slovakia* (Jarolímek & Šibík, 2008) consists of two chapters. The first one (Jarolímek *et al.*, 2008a) deals with statistical analysis of data stored in Slovak national vegetation database (Šibíková *et al.*, 2009); the second one (Jarolímek *et al.*, 2008b) represents a revised list of syntaxa (vegetation units) of Slovakia. The discussion on complex evaluation of vegetation, based not only on floristic composition, but also on the qualitative and quantitative participation of all components (cf. Rejmánek, 1977; Theurillat *et al.*, 1995) is appended, as well.

On the basis of the results published in Jarolímek *et al.* (2008a), we decided to present the evaluation of classes as an example of analysed data. For the evaluation of alliances, see the Chapter 1.3.2 in the publication by Jarolímek *et al.* (2008a).

Table 1 comprises all classes ordered by decreasing value of sharpness index (S). In this manner, the classes are ranked by decreasing proportion of quality of diagnostic species relative to the average species richness of vegetation stands (Chytrý & Tichý, 2003).

The pairs of the most similar classes are presented in Table 2. Couples of classes are ranked by decreasing value of index T, which expresses similarity of the classes in the left column to the classes in the right column.

Discussion

Classes with the highest sharpness index comprise rare communities occurring in extreme habitats, such as species-poor halophytic communities of the *Thero-Suaedetea* and communities on blown sands of the *Festucetea vaginatae*, together with species-poor water pioneer communities of classes *Charetea fragilis*, *Potametea* and *Lemnetea*. The latter two were also identified within the sharpest groups in the analysis of Czech data (Chytrý & Tichý, 2003), due to the specific ecological conditions of aquatic environments in comparison with terrestrial habitats. The relict communities from the most extreme mountain habitats with an occurrence of many arctic-alpine taxa (class *Carici rupestris-Kobresietea*) and relict pine communities of canyons and limestone cliffs (class *Erico-Pinetea*) reach high values of the sharpness index, as well.

Conversely, tall-herb and nitrophilous communities of the classes *Mulgedio-Aconitetea* and *Galio-Urticetea* are the least sharp, due to the occurrence of numerous taxa with a wide ecological range. The class *Thlaspietea rotundifolii* in Slovakia, similar to the Czech Republic (cf. Chytrý & Tichý, 2003), seems to be one of the least sharp classes, probably owing to its pioneer character and the fact these communities often occur on rocky and gravelly microsites among another vegetation types, where the species are mixed. The class *Rhamno-Prunetea*, which belongs to syntaxa that are difficult to define by diagnostic taxa, has a low sharpness index, too. The main reason is the transition character of these mosaic or ecotone communities, occurring on transition sites between open land and forest vegetation.

Classes *Vaccinio-Piceetea* and *Querco-Fagetea* represent natural and semi-natural vegetation. Whereas they belong to the sharpest syntaxa in the Czech Republic (Chytrý & Tichý, 2003), they show lower sharpness in Slovakia. This difference might result from unclear classification of spruce communities of lower altitudes, which grow secondarily in beech habitats and are included in the class *Vaccinio-Piceetea*. The other reason of their lower sharpness might be the different ecological amplitude of herbs, trees and shrubs. While herbs accurately reflect soil, microclimatic and other properties of habitats, the ecological amplitude of most trees and shrubs is much wider (Sillinger, 1935) and reflects mainly meso- and macroclimatic conditions. In this manner, we can explain the floristic similarity of subalpine nitrophilous tall-herb communities of the *Adenostylion alliariae* and dwarf-pine and spruce vegetation occupying similar habitats with available nutrients and soil moisture (Šibík, 2007).

Values of uniqueness (U) of classes partially correlate with the values of sharpness index, which is different from the results obtained by the analysis of the Czech national phytosociological database (Chytrý & Tichý, 2003). A high value of the U index shows high uniqueness of a given unit. The unit is considered unique when any of its diagnostic taxa (defined by Phi value > 0.05, see Chytrý & Tichý, 2003) is not concurrently diagnostic in any other unit. The uniqueness of a unit decreases if it shares some diagnostic taxa with other units. In general, rare vegetation units represented by a small number of relevés and/or species-poor syntaxa occupying extreme habitats appear to form a group of the most unique units. The further group of units with the lowest values of the U index includes the classes occurring mostly in the subalpine belt – *Mulgedio-Aconitetea*, *Loiseleurio-Vaccinietea* and *Roso pendulinae-Pinetea mugo*, in which occur many taxa with positive fidelity to several syntaxa. The low frequency or absence of narrow specific forest-alpine transition zones or treeline-ecotone species (cf. Körner, 2003) might be explained by the sharing of numerous diagnostic species with several different syntaxa occurring in the subalpine belt.

The pairs of the most similar classes presented here are often composed of floristically similar, but structurally different units (e.g., *Mulgedio-Aconitetea* and *Betulo carpaticae-Alnetea viridis*, *Loiseleurio-Vaccinietea* and *Caricetea curvulae*, *Elyno-Seslerietea* and *Erico-Pinetea*) or between successively ensuing vegetation types (*Thlaspietea rotundifolii* and *Carici rupestris-Kobresietea bellardii*, *Asplenietea trichomanis* and *Elyno-Seslerietea*). Some authors (e.g., Westhoff, 1967; Pignatti *et al.*, 1995) do not reflect the differences in structure of floristically similar vegetation units in the syntaxonomical system of higher units (classes). Therefore, some vegetation surveys strictly follow the floristic criterion for delimitation of higher syntaxa (cf. Mucina 1997). However, these authors also apply this principle only to a certain extent and only in some cases (Šibík, 2007). For example, Pignatti *et al.* (1995) give several examples in their work of "ecoclinal classes", but they prefer the ecological differentiation to vertical (and climatic) limits of certain communities. In one case, the authors accept the differences between forest communities, based on different stages of succession and, hence, they accept the class *Rhamno-Prunetea*; in another case, they merged subalpine shrub and spruce vegetation (Šibík, 2007). According to the methodological concept of Dengler *et al.* (2004), the character species should be determined only within the structural types; separately for herbaceous vegetation (including dwarf shrubs), shrub and woodland vegetation. Herbaceous plants and cryptogams can thus be evaluated as character species in both structural types at the same time.

Similarly to the Czech Republic (Chytrý & Tichý, 2003), it was also shown in Slovakia that the most similar are the structurally different communities of aquatic vegetation, *Potametea* (submerged vegetation) and *Lemnetea* (pleustonic vegetation). Communities defined on different plot sizes also appear similar – *Sedo-Scleranthetea* and *Festuco-Brometea*. Chytrý & Otýpková (2003) point out that in some situations, sampling in either small or large plots may result in assignment of relevés to different phytosociological classes or habitat types. Therefore, defining vegetation and habitat types as scale-dependent concepts is needed. The similarity between *Elyno-Seslerietea* and *Erico-Pinetea* also could be interpreted by a different scale of sample plots. Relevés of *Sedo-Scleranthetea* and *Elyno-Seslerietea* are usually sampled in smaller plots than their adjacent classes. Interesting insight and precise description of the structural diversity of the plant community and its dynamics according to both spatial and temporal scales has been proposed by Gillet & Gallandat (1996).

In addition, few structurally homogeneous vegetation units show high similarity (e.g., *Koelerio-Corynephoretea* and *Festucetea vaginatae*, *Quercetea robori-petraeae* and *Pulsatillo-Pinetea*). In these cases, we might consider merging them into a single class (cf. Chytrý & Tichý, 2003). It is also important to take into account the fact that some vegetation units are at the border of their distributional range in Slovakia and they are represented by fragmentary stands that lack some specific floristic elements. In a wider geographical context, it is possible that the differentiation of particular syntaxa would be confirmed.

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	Tv Code	Class	Abb	n	a	S	U	hlU	sU
1	35	*Thero-Suaedetea*	*TS*	73	5	90,93	0,697	+ +	2
2	41	*Charetea fragilis*	*CF*	11	5	90,42	0,733	+ +	1
3	24	*Potametea*	*PO*	408	5	82,68	0,511	+ +	10
4	15	*Lemnetea*	*LE*	354	5	80,21	0,583	+ +	4
5	09	*Festucetea vaginatae*	*FV*	30	15	63,85	0,522	+ +	9
6	42	*Carici rupestris-Kobresietea bellardii*	*CK*	485	42	63,62	0,496	+	12
7	08	*Erico-Pinetea*	*EP*	266	55	57,13	0,462	+	15
8	12	*Isoeto-Nanojuncetea*	*IN*	161	16	54,66	0,540	+ +	5
9	32	*Scheuchzerio-Caricetea fuscae*	*SC*	2373	29	47,24	0,468	+	13
10	46	*Betulo carpaticae-Alnetea viridis*	*BA*	58	48	47,06	0,418	+	16
11	18	*Molinio-Betuletea pubescentis*	*MB*	48	26	47,01	0,417	+	17
12	23	*Polygono arenastri-Poetea annuae*	*PP*	240	10	41,91	0,510	+	11
13	50	*Franguletea*	*FR*	14	20	40,69	0,533	+ +	6
14	11	*Festuco-Puccinellietea*	*FP*	372	18	40,26	0,525	+ +	8
15	16	*Isoeto-Littorelletea*	*IL*	27	8	40,18	0,617	+ +	3
16	29	*Robinietea*	*RO*	48	18	40,17	0,533	+ +	7
17	49	*Vaccinio uliginosi-Pinetea sylvestris*	*VU*	54	15	39,61	0,343		27
18	25	*Pulsatillo-Pinetea*	*PU*	24	37	39,24	0,410	+	18
19	19	*Montio-Cardaminetea*	*MC*	678	17	38,60	0,463	+	14
20	40	*Oxycocco-Sphagnetea*	*OS*	146	15	37,89	0,341	–	28
21	14	*Koelerio-Corynephoretea*	*KC*	64	12	35,97	0,403	+	19
22	30	*Salicetea herbaceae*	*SH*	696	18	35,86	0,378		22
23	31	*Salicetea purpureae*	*SP*	344	26	33,45	0,386		21
24	13	*Caricetea curvulae*	*CC*	1133	20	33,15	0,286	–	35
25	01	*Alnetea glutinosae*	*AG*	380	28	27,53	0,337	–	29
26	10	*Festuco-Brometea*	*FB*	2375	37	27,36	0,378		23
27	04	*Bidentetea tripartitae*	*BT*	696	16	26,86	0,360		25
28	33	*Stellarietea mediae*	*SM*	2577	16	25,21	0,403	+	20
29	39	*Vaccinio-Piceetea*	*VP*	1409	31	25,21	0,279	–	36
30	03	*Asplenietea trichomanis*	*AT*	410	23	22,96	0,317	–	32
31	06	*Elyno-Seslerietea*	*ES*	1440	35	22,50	0,278	–	37
32	07	*Epilobietea angustifolii*	*EA*	356	29	22,38	0,308	–	33
33	02	*Artemisietea vulgaris*	*AV*	1725	21	20,90	0,364		24
34	45	*Loiseleurio-Vaccinietea*	*LV*	498	19	19,68	0,187	– –	46
35	17	*Molinio-Arrhenatheretea*	*MA*	7360	34	19,50	0,325	–	30
36	48	*Calluno-Ulicetea*	*CU*	67	17	15,66	0,293	–	34
37	47	*Nardetea strictae*	*NS*	984	25	15,42	0,260	– –	40
38	37	*Trifolio-Geranietea sanguinei*	*TG*	285	29	15,37	0,322	–	31
39	27	*Querco-Fagetea*	*QF*	5669	35	14,44	0,275	– –	38
40	44	*Roso pendulinae-Pinetea mugo*	*RP*	611	21	14,44	0,215	– –	45
41	34	*Sedo-Scleranthetea*	*SS*	128	17	13,27	0,347		26
42	26	*Quercetea robori-petraeae*	*QR*	221	23	10,51	0,257	– –	41
43	22	*Phragmito-Magnocaricetea*	*PM*	2754	14	10,35	0,256	– –	42
44	28	*Rhamno-Prunetea*	*RH*	402	26	10,30	0,266	– –	39
45	36	*Thlaspietea rotundifolii*	*TR*	571	20	5,53	0,233	– –	43
46	43	*Galio-Urticetea*	*GU*	1883	17	4,73	0,230	– –	44
47	20	*Mulgedio-Aconitetea*	*MU*	2314	29	2,57	0,181	– –	47

Table 1. *Left page.* **Sharpness Index (S) and Uniqueness Index (U) of vegetation classes of Slovakia,** ranked by decreasing values of the Sharpness index.

Explanations: Tv Code – Turboveg Code; **Abb** – Abbreviation of class name; **n** – No. of relevés; **a** – Average taxa No. rounded to the whole number; **hlU** – Ten (twenty) highest [+ + (+)] and lowest [– –(–)] values of the Index U; **sU** – Sequence of the classes ranked by decreasing values of the Index U.

Table 2. *Below*. **Classes with highest similarity to the other classes.** Couples of classes are ranked by decreasing value of index T, which expresses similarity of the classes in the left column to the classes in the right column. Only 40 pairs with the highest similarity are shown.

	Class 1	Class 2	T
1	20 *Mulgedio-Aconitetea*	46 *Betulo carpaticae-Alnetea viridis*	1.052
2	45 *Loiseleurio-Vaccinietea*	13 *Caricetea curvulae*	1.052
3	06 *Elyno-Seslerietea*	08 *Erico-Pinetea*	0.910
4	36 *Thlaspietea rotundifolii*	42 *Carici rupestris-Kobresietea bellardii*	0.882
5	45 *Loiseleurio-Vaccinietea*	42 *Carici rupestris-Kobresietea bellardii*	0.873
6	13 *Caricetea curvulae*	42 *Carici rupestris-Kobresietea bellardii*	0.866
7	14 *Koelerio-Corynephoretea*	09 *Festucetea vaginatae*	0.859
8	22 *Phragmito-Magnocaricetea*	01 *Alnetea glutinosae*	0.751
9	03 *Asplenietea trichomanis*	08 *Erico-Pinetea*	0.743
10	37 *Trifolio-Geranietea sanguinei*	10 *Festuco-Brometea*	0.712
11	40 *Oxycocco-Sphagnetea*	49 *Vaccinio uliginosi-Pinetea sylvestris*	0.675
12	44 *Roso pendulinae-Pinetea mugo*	39 *Vaccinio-Piceetea*	0.670
13	49 *Vaccinio uliginosi-Pinetea sylvestris*	40 *Oxycocco-Sphagnetea*	0.624
14	22 *Phragmito-Magnocaricetea*	31 *Salicetea purpureae*	0.615
15	13 *Caricetea curvulae*	45 *Loiseleurio-Vaccinietea*	0.560
16	43 *Galio-Urticetea*	31 *Salicetea purpureae*	0.558
17	44 *Roso pendulinae-Pinetea mugo*	46 *Betulo carpaticae-Alnetea viridis*	0.552
18	03 *Asplenietea trichomanis*	06 *Elyno-Seslerietea*	0.549
19	26 *Quercetea robori-petraeae*	25 *Pulsatillo-Pinetea*	0.533
20	06 *Elyno-Seslerietea*	42 *Carici rupestris-Kobresietea bellardii*	0.528
21	24 *Potametea*	15 *Lemnetea*	0.527
22	09 *Festucetea vaginatae*	14 *Koelerio-Corynephoretea*	0.520
23	34 *Sedo-Scleranthetea*	10 *Festuco-Brometea*	0.513
24	40 *Oxycocco-Sphagnetea*	18 *Molinio-Betuletea pubescentis*	0.505
25	28 *Rhamno-Prunetea*	27 *Querco-Fagetea*	0.500
26	43 *Galio-Urticetea*	02 *Artemisietea vulgaris*	0.471
27	27 *Querco-Fagetea*	25 *Pulsatillo-Pinetea*	0.468
28	04 *Bidentetea tripartitae*	12 *Isoeto-Nanojuncetea*	0.461
29	30 *Salicetea herbaceae*	42 *Carici rupestris-Kobresietea bellardii*	0.460
30	49 *Vaccinio uliginosi-Pinetea sylvestris*	18 *Molinio-Betuletea pubescentis*	0.435
31	15 *Lemnetea*	24 *Potametea*	0.432
32	01 *Alnetea glutinosae*	31 *Salicetea purpureae*	0.422
33	43 *Galio-Urticetea*	29 *Robinietea*	0.413
34	31 *Salicetea purpureae*	01 *Alnetea glutinosae*	0.408
35	13 *Caricetea curvulae*	30 *Salicetea herbaceae*	0.403
36	07 *Epilobietea angustifolii*	27 *Querco-Fagetea*	0.400
37	26 *Quercetea robori-petraeae*	27 *Querco-Fagetea*	0.393
38	02 *Artemisietea vulgaris*	33 *Stellarietea mediae*	0.392
39	39 *Vaccinio-Piceetea*	46 *Betulo carpaticae-Alnetea viridis*	0.390
40	10 *Festuco-Brometea*	37 *Trifolio-Geranietea sanguinei*	0.388