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Diagnostic species of mesophylous and xerophylous grassland plant communities in Latvia

Mezofīto un kserofīto zālāju augu sabiedrību diagnostiskās sugas Latvijā

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Hitherto species defined as diagnostic for particular vegetation units in other European regions were used as a diagnostic in the classification of Latvian grassland plant communities. However large scale comparative phytosociological investigations have shown that diagnostic species should not be simply overtaken from one to another region without detailed geographical and ecological analysis. Instead, diagnostic species should be delimited preferably in large data sets with formalized, consistent and repeatable methods.

In this paper diagnostic species were delimited in a data set of 1,373 relevés of mesophilous and xerophilous grassland vegetation. Firstly, sociological species groups were formed by means of JUICE software using the H.Bruelheide's u-value algorithm. As a result 23 sociological species groups were delimited. Logic combinations of these groups were used to divide relevés into five higher vegetation units – the class Molinio-Arrhenatheretea (order Arrhenatheretalia), Calluno-Ulicetea (order Nardetalia), Trifolio-Geranietea (order Origanetalia), Koelerio-Corynephoretea (order Festuco-Sedetalia), and Festuco-Brometea (order Brometalia). The u-value and the Indicator value index were calculated for each species in relation to each vegetation unit. Species with an u-value exceeding 6.0 were considered to be diagnostic for particular vegetation unit. The analysis yielded in 10 diagnostic species for the class Calluno-Ulicetea, 8 species for the class Trifolio-Geranietea, 26 species for the class Festuco-Brometea, 28 species for the class Koelerio-Corynephoretea, and 53 species for the class Molinio-Arrhenatheretea. Several species in each set of diagnostic species can be used as a diagnostic at the class or order level only for particular data set; these cases are discussed in details.

Keywords: diagnostic species, semi-natural grassland vegetation, class, Braun-Blanquet method, sociological species group.

Introduction

Semi-natural grasslands (pastures and meadows) are very important for the conservation of biological diversity in Europe. They are the most species-rich habitats at small spatial scales (0.01 to 1 m^2) (Kuul, Zobel 1991; Klimeš 1999). Grasslands belong to the most endangered vegetation types because the characteristic structure and species composition can be maintained only by traditional management or imitating it (Gibson et al. 1987; Berendse et al. 1992; Ryser et al. 1995; Myklestad, Saetersdal 2003 etc.). This is the reason for active phytosociological as well as conservation research in this field.

In Latvia, along with the sweeping changes in nature protection (harmonization with the EU legislation, inventory and conservation of protected habitats of the European Union, etc.), there is an increasing need for information on diversity and structure of grassland plant communities, their similarities and differences from bordering regions. The vegetation classification has to be harmonized with the European Union.

The geographical position of Latvia on the eastern shore of the Baltic Sea and consequently on the continental gradient from the west to the east determines peculiarities of species distribution, as well as the differences in plant community structure and floristic composition in the territory of Latvia (Kupffer 1925; Laiviņš, Melecis 2003). Therefore biogeographically, some regions of Latvia are more similar to the vegetation found in Central Europe, others to that of Eastern Europe.

The biogeographical differences are also clearly expressed in grassland vegetation. Already G. Sabardina (1957) found that though the greatest part of grassland plant communities are distributed all over Latvia, others occur only in some regions. For example, the *Sesleria caerulea* community is known only in Western Latvia (Сабардина 1957), but the *Centaurea scabiosa-Fragaria vesca* community only in Eastern Latvia (Jermacāne, Laiviņš 2002). However, a detailed comparative biogeographical analysis of the grassland vegetation of Latvia in the Baltic and European context have not been carried out yet. Only starting with a vegetation description and classification using Braun-Blanquet approach has such analysis became available (Jermacāne, Laiviņš 2001).

The basis for the floristic-ecological classification is floristic features – species composition, frequency, abundance etc. The main criterion is a diagnostic species, character species and differential species. Hitherto species considered as character species in other European regions (Poland, Lithuania, Germany) were used as a diagnostic also in the classification process of Latvian grassland communities (Jermacāne 1999; Jermacāne Laiviņš 2002). However, such an approach often leads to a dead-end classification. Along with a broader use of syntaxonomy initially worked out on the basis of the Central European vegetation in other parts of Europe, particularly in Northern and Eastern Europe, it was found that plant communities frequent in Central Europe in the northern and eastern direction became species poor and with less character species. So the floristic differences among the different syntaxa become less apparent. It is difficult to classify such communities into the existing classification schema (Diekmann 1995; Jermacāne, Laiviņš 2002; Bambe 2003 etc.).

During the last few years, there has been an increasing interest in the comparative regional analysis of vegetation in large territories (Bruelheide 1995; Dierschke 1997, Evers 1997; Jandt 1999; Bruelheide, Chytry 2000). This leads to new ideas and conclusions. It was ascertained that certain diagnostic species groups defined for a particular region can not be applied without changes to another region unless it is known what set of plant communities the author of original research used for determining these diagnostic species (i. e. pertaining to what diversity of vegetation this group of diagnostic species is associated with) and whether the researcher had taken into account a large enough geographical or simply a local ecological context (Chytry et al. 2002a).

Usually diagnostic species are determined in the data set containing only one vegetation class, order or alliance. Such diagnostic species turn out not to be diagnostic in a larger context, if several vegetation classes are to be compared (Chytry et al. 2002b). It should be specifically taken into account concerning grassland classification. Semi-natural grasslands are very heterogeneous and most grassland vegetation classes are characterized as «bad» in terms of stability of character species combinations and their quality in delimitation of vegetation units, especially in the periphery of a class distribution area (Pignatti et al. 1995).

Commonly, the distribution area of a species is larger than of a plant community, and vice versa – the species is a good diagnostic species for a particular plant community only in a small part of the distribution area of the plant community. In some cases the species has a wide ecological amplitude in the centre of its distribution area, but it uses only very specific habitats in the periphery of this area, allowing it to be used as a good diagnostic species for particular plant communities (Diekmann 1995; Diekmann, Lawesson 1999; Bruun, Ejrnaes 2000). This is the reason why diagnostic species are divided into groups according to the scale in which these species can be used as a diagnostic. Local (diagnostic only in small part of plant community distribution area), regional (the major part of diagnostic species – they can be used as diagnostic all over the uniform physiogeographic or climatic region), over-regional (in several regions or a part of the world) and absolute diagnostic species can be distinquished (Dierschke 1994).

Numerical classification methods are becoming increasingly advanced and make it possible to proof the validity of different diagnostic species groups over a larger regional scale, as well as to determine such species for regions not yet investigated (Bruelheide 2000; Chytry et al. 2002a, b). Such investigations can provide a larger geographic perspective and result in new ideas for how to explain species co-occurrences as well as ecological and geographical differentiation of plant communities (Diekmann 1997; Ewald 2003).

The aim of this paper is to determine the diagnostic species for higher vegetation units of mesophilous and xerophilous semi-natural grasslands in Latvia.

Material and methods

Vegetation data

Traditionally, mesophilous and xerophilous grasslands are included into five non-forest vegetation classes. The order Arrhenatherealia of the class Molinio-Arrhenatheretea joins the mesophilous grasslands on weak acid and neutral soils, the order Nardetalia of the class Calluno-Ulicetea – mesophilous grasslands on very acid soils. Xerophilous sandy grasslands are included into the class Koelerio-Corynephoretea, order Festuco-Sedetalia, but xerophilous calcareous grasslands are in the class Festuco-Brometea, order Brometalia. This data set also includes thermophilous fringe vegetation from the class Trifolio-Geranietea. Further in the text, vegetation units will be refered as *classes*, bearing in mind that the paper deals only with grassland vegetation and consequently named orders and not with the classes on the whole.

1,373 phytosociological relevés collected by the author in the period of 1997 to 2003 all over Latvia have been used in this analysis. Vegetation description follows the Braun-Blanquet approach (Braun-Blanquet 1964; Dierschke 1994). The numbers of relevés in different vegetation classes differ significantly. This is a common situation for such data sets, because the regional distribution as well as territories covered with different plant communities are highly uneven.

Delimitation of diagnostic species

The first step to determine diagnostic species for mesophilous and xerophilous grasslands was the creation of sociological species groups. For this purpose computer program JUICE was used (Tichy 2002). The theoretical basis has been developed by H.Bruelheide (1995; 2000). The program creates species groups by combining species which occur together more frequently than it would be if these species were distributed randomly in the data set. The tendency of the species co-occurrence is characterised by an u-value, which is derived from normal distribution and is complementary with the concept of fidelity. Joint fidelity (showing both the fidelity of species to the vegetation unit and the fidelity of vegetation unit to the species) is measured by u_{hyp}, where $_{hyp}$ denotes that the value is derived form hypergeometric distribution (Chytry et al. 2002b). Perfect joint fidelity is the case when the species occurs only in the vegetation unit and in all relevés of this unit. U-value changes in the interval form –% to + %, but in the JUICE program this interval is from –1000 to 1000. U-values larger than 1.96 are statistically significant at P<0.05 (Chytry et al., 2002b).

The maximum value of u_{hyp} depends on the size of the database: $u_{hyp} = \sqrt{N-1}$ The size of the current database was 1,373, so the maximum value of u_{hyp} can reach 37.04 showing the perfect joint fidelity of the species and the vegetation unit.

Two considerations were taken into account when optimising the species group (i. e. to determine the number of species to be included into the group): 1) the new species is not included into the group if its inclusion disintegrates the group; 2) the new species is rejected if its ecology is strongly different from the species already included into the group (Koči et al. 2003).

The sociological species group analysis resulted in 23 sociological species groups (further in text referred as SSG).

The second step to determine diagnostic species was to classify the relevés into vegetation classes. This was done by using logic combinations of SSG (for details see chapter *Results*). As a result five vegetation units corresponding to five syntaxa (Table 1) were developed. No SSG was present in 171 relevé, so they were omitted from the further analysis.

The final step was to calculate the species u_{hyp}-values once more but now for all five vegetation units. The species with the highest u_{hyp}-values for the corresponding vegetation unit are the diagnostic species for this unit. As diagnostic we used only species with u_{hyp}-value equal or higher to 6.0. Such u-value threshold was selected because species with lower u-values had the same u-values in several vegetation units, so they could not be used as diagnostic for one particular vegetation unit.

Species nomenclature: Gavrilova, Šulcs 1999.

Table 1

Number of relevés in higher grassland vegetation syntaxa classified by sociological species groups

Vegetation unit	Nr. of relevés
Class Calluno-Ulicetea, order Nardetalia	32
Class Trifolio-Geranietea, order Origanetalia	80
Class Festuco-Brometea, order Brometalia	374
Class Koelerio-Corynephoretea, order Festuco-Sedetalia	270
Class Molinio-Arrhenatheretea, order Arrhenatheretalia	446
Not classified (omitted from further analysis)	171

Results

Sociological species groups

As a whole 23 SSG were created in the data set of 1,373 relevés. 11 of them represent mesophilous grasslands (Table 2), another 12 – xerophilous grasslands (Table 3).

The most frequent SSG in the data set was the *Anthoxanthum odoratum* group (452 relevés), *Festuca pratensis* group (337), *Fragaria vesca* group (245), *Helictotrichon pratense* group (243), and *Festuca ovina* group (236).

At least one SSG was present in 1,202 relevés (88% of the all relevés in the database). Most of them contained only one or two SSG (Fig. 1). There was a weak relationship between the total number of species per relevé and the number of SSG per relevé (Fig. 2). So it can be concluded that the data set is differentiated fairly well by SSG and that SSG are ecologically and/or geographically meaningful. In other words, any SSG present in a relevé shows certain ecological or geographical affinities of the vegetation and are not drived only by trivial relationship that increasing species richness in a relevé will yield also more SSG in that relevé.

Table 2

Sociological species groups of mesophilous grasslands

* – the first figure in brackets is the number of relevés included into the (+) group of the data set, the second figure – the minimal number of sociological species group species to be present in a relevé to include it into the (+) group

Species	**u-value**	**Frequency in (+) group, %**	**Frequency in (-) group, %**
SSG of the class Molinio-Arrhenatheretea			
Anthoxanthum odoratum* group (452; 5)			
Anthoxanthum odoratum	25,57	83,8	13,0
Ranunculus acris	23,67	76,8	12,4
Alchemilla vulgaris	21,69	60,8	6,9
Luzula campestris	20,24	69,0	14,4
Rumex acetosa	19,03	74,3	21,0
Veronica chamaedrys	17,51	80,1	29,8
Deschampsia cespitosa	17,50	41,8	4,2
Plantago lanceolata	16,82	84,1	35,6
Agrostis tenuis	15,95	76,5	30,7
***Festuca pratensis* group (337; 3)**			
Festuca pratensis	22,10	78,9	14,9
Taraxacum officinale	20,89	78,0	16,8
Lathyrus pratensis	20,70	73,6	14,5
Dactylis glomerata	17,06	89,0	35,3
Tragopogon pratensis	13,78	29,7	3,6
***Primula veris* group (220; 3)** (the group is characteristic also for the class *Festuco-Brometea*)			
Leontodon hispidus	22,13	74,5	9,4
Primula veris	20,87	65,5	7,6
Plantago media	20,46	75,0	12,1
Leucanthemum vulgare	17,58	73,2	16,5
Medicago lupulina	17,12	59,5	10,5
Linum catharticum	15,60	30,5	1,9
***Cynosurus cristatus* group (136; 2)**			
Cynosurus cristatus	24,03	56,6	1,4
Prunella vulgaris	23,61	83,8	7,4
Trifolium repens	21,29	90,4	12,6
***Holcus lanatus* group (124; 2)**			
Holcus lanatus	22,68	62,9	22,68
Potentilla anserina	22,26	57,3	22,26

Species	u-value	Frequency in (+) group, %	Frequency in (-) group, %
Galium uliginosum	22,10	41,9	22,10
Deschampsia cespitosa	21,73	86,3	21,73
Anthriscus sylvestris **group (87; 2)**			
Heracleum sibiricum	20,64	82,8	7,4
Anthriscus sylvestris	20,01	74,7	6,1
Geranium pratense	16,20	28,7	0,6
Aegopodium podagraria	14,23	43,7	4,0
Cirsium heterophyllum **group (34; 2)**			
Trollius europaeus	28,66	79,4	0,5
Angelica sylvestris	21,80	76,5	2,0
Cirsium heterophyllum	21,55	50,0	0,4
Crepis paludosa	15,65	23,5	0,1
Geranium sylvaticum	12,61	38,2	1,7
Alopecurus pratensis **group (26; 2)**			
Alopecurus pratensis	20,33	88,5	2,9
Polygonum bistorta	19,89	65,4	1,3
Cirsium arvense	17,03	76,9	3,3
Succisa pratensis **group (17; 2)**			
Succisa pratensis	23,18	88,2	1,2
Cirsium palustre	19,42	64,7	0,9
Epipactis palustris	19,31	41,2	0,1
Listera ovata	11,90	47,1	1,6
SSG of the class Calluno-Ulicetea			
Nardus stricta **group (46; 2)**			
Nardus stricta	29,47	84,8	0,8
Sieglingia decumbens	23,07	67,4	1,4
Potentilla erecta	16,55	78,3	6,5
SSG of the class Trifolio-Geranietea			
Trifolium medium **group (144; 2)**			
Agrimonia eupatoria	21,23	81,3	9,9
Veronica teucrium	20,60	49,3	2,2
Trifolium medium	20,18	68,8	7,2
Origanum vulgare	18,15	38,9	1,7

Table 3

Sociological species groups of xerophilous grasslands

* – the first figure in brackets is the number of relevés included into the (+) group of the data set, the second figure – the minimal number of sociological species group species to be present in a relevé to include it into the (+) group

Species	u-value	Frequency in (+) group, %	Frequency in (-) group, %
SSG of the class Festuco-Brometea			
Fragaria vesca* group (245; 3)			
Centaurea scabiosa	23,56	85,3	12,6
Medicago lupulina	22,48	69,0	7,4
Agrimonia eupatoria	20,41	62,4	7,6
Polygala comosa	18,74	41,6	2,6
Pimpinella saxifraga	15,96	86,9	31,3
Fragaria vesca	15,95	33,5	2,6
***Helictotrichon pratense* group (243; 3)**			
Filipendula vulgaris	22,69	64,2	5,4
Helictotrichon pratense	21,54	58,8	5,0
Phleum phleoides	20,96	47,3	2,2
Trifolium montanum	19,58	59,7	7,6
Fragaria viridis	19,34	72,8	13,9
Galium verum	16,83	80,2	23,7
***Carex flacca* group (49; 3)**			
Carex flacca	25,28	95,9	3,3
Cirsium acaule	22,24	59,2	1,1
Festuca arundinacea	18,02	67,3	3,8
Inula salicina	17,11	40,8	1,1
Carlina vulgaris	16,54	51,0	2,3
Sesleria caerulea	16,54	61,2	3,8
SSG of the class Koelerio-Corynephoretea			
***Festuca ovina* group (236; 2)**			
Dianthus deltoides	24,48	80,1	8,6
Festuca ovina	23,53	73,3	7,4
Rumex acetosella	21,58	63,1	6,2
Campanula rotundifolia	15,20	29,2	1,9
***Artemisia campestris* group (118; 4)**			
Arenaria serpyllifolia	21,24	66,9	4,8
Berteroa incana	20,00	44,9	1,5
Sedum acre	19,36	73,7	8,4
Trifolium arvense	19,20	72,0	8,1
Artemisia campestris	17,90	88,1	16,0
Acinos arvensis	15,98	38,1	2,5

Species	**u-value**	**Frequency in (+) group, %**	**Frequency in (-) group, %**
Cerastium semidecandrum	14,34	37,3	3,3
Potentilla argentea	13,02	61,0	13,1
Carex arenaria **group (90; 2)**			
Carex arenaria	23,99	54,4	0,8
Festuca ovina	18,07	91,1	13,6
Deschampsia flexuosa	17,95	35,6	0,9
Thymus serpyllum	17,84	53,3	3,6
Festuca trachyphylla **group (23; 2)**			
Festuca trachyphylla	24,17	91,3	1,6
Potentilla arenaria	22,00	82,6	1,6
Vicia tetrasperma	17,27	78,3	3,0
Equisetum hyemale **group (23; 2)**			
Equisetum hyemale	23,00	73,9	1,0
Hylothelepium maximum	22,54	56,5	0,4
Oenothera biennis	17,83	47,8	0,7
Veronica spicata	17,74	95,7	4,5
Saxifraga granulata **group (15; 2)**			
Trifolium dubium	29,53	93,3	0,4
Saxifraga granulata	20,18	80,0	1,3
Vicia hirsuta	15,38	93,3	3,9
Saxifraga tridactylites **group (11; 4)**			
Saxifraga tridactylites	27,38	63,6	0,0
Erophila verna	22,85	63,6	0,2
Vincetoxicum hirundinaria	18,85	90,9	1,5
Anthemis tinctoria	17,23	100,0	2,5
Myosotis micrantha	13,66	36,4	0,3
Jovibarba globifera	13,09	72,7	2,3
Allium vineale	12,26	54,5	1,3
Armeria maritima **group (9; 3)**			
Festuca sabulosa	27,68	66,7	0,0
Armeria maritima	25,30	77,8	0,2
Dianthus arenarius	24,64	100,0	0,7
Pulsatilla pratensis	20,59	77,8	0,6
Koeleria glauca	18,76	77,8	0,8
Tragopogon heterospermus	17,76	33,3	0,0
Silene otites **group (3; 3)**			
Astragalus arenarius	22,66	66,7	0,0
Koeleria glauca	12,50	100,0	1,1
Helichrysum arenarium	11,85	100,0	1,2
Silene otites	10,66	33,3	0,0
Pulsatilla patens	10,66	33,3	0,0

Figure 1

Distribution of relevés according to the number of sociological species groups per relevé

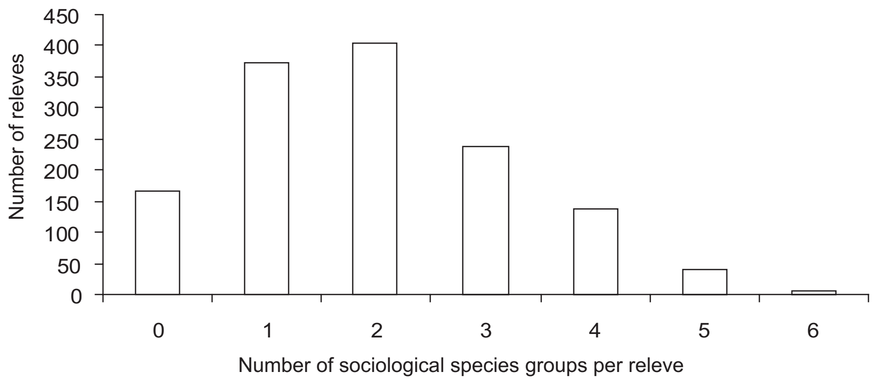
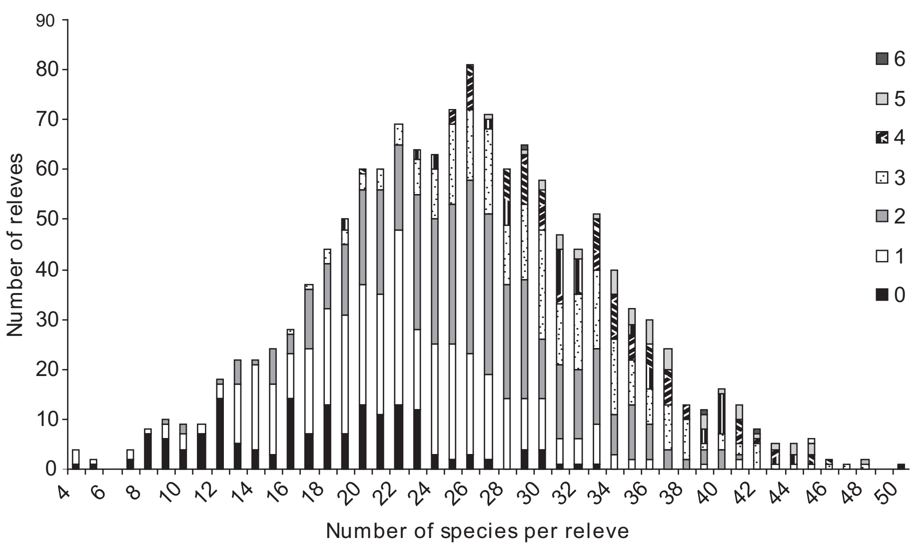


Figure 2

Distribution of relevés according to the total number of species per relevé and the number of sociological species groups per relevé



Classification of relevés into higher grassland vegetation units

All the SSG according to their species ecology and sociology were ascribed to the particular vegetation class (Table 2, 3). Relevés were classified according to the set of SSG present in them. Analysis of the occurrence of different SSG in a data set led to the conclusion that only a presence of a species is not yet a satisfactory diagnostic feature. It is particularly true for contact communities of xerophilous and mesophilous grasslands where the number of character species of several vegetation classes are rather equal but in the same time the dominants are species faithful to a particular class. Therefore, to determine such relevés and ascribe them to the right vegetation class, the dominance of a particular species was used as an additional criterion for classification.

Relevés containing the *Nardus stricta* group and at the same time containing one or more dominants like *Nardus stricta, Sieglingia decumbens* or *Festuca ovina* were joined into the class Calluno-Ulicetea.

Relevés of the class Trifolio-Geranietea were delimited mainly according to the dominant species, because only one SSG characteristic for this class – *Trifolium medium* group – was present throughout the data set, especially in the relevés of the classes Molinio-Arrhenatheretea and Festuco-Brometea. Therefore only those relevés with *Trifolium medium* group were taken which dominants were typical fringe species – *Trifolium medium, Veronica teucrium, Geranium sanquineum, Brachypodium pinnatum, Vicia cassubica* etc. Consequently, also relevés without *Trifolium medium* group but with named dominants were included into this vegetation unit. For relevés containing the class Festuco-Brometea SSG an additional criterion was applied – dominants should not be typical Festuco-Brometea species like *Helictotrichon pratense* or *Filipendula vulgaris*.

For a relevé to be classified into the class Festuco-Brometea one of following SSG should be present: *Carex flacca* group, *Helictotrichon pratense* group and *Fragaria vesca* group. For relevés containing the class Molinio-Arrhenatheretea SSG as an additional criterion was: a relevé should not contain *Festuca pratensis* and *Anthoxanthum odoratum* group simultaneously, but, if one of them is present then dominants should be typical Festuco-Brometea species.

Relevés containing at least one SSG of the class Koelerio-Corynephoretea were classified into this class. From these – the relevés containing also some of the class Molinio-Arrhenatheretea SSG were included only if their dominants were species characteristic for the class Koelerio-Corynephoretea (*Poa angustifolia, Festuca ovina, Thumus serpyllum, Carex arenaria*). Also relevés containing only *Anthoxanthum odoratum* group but having *Poa angustifolia* as dominant species were included into this vegetation unit.

All the other relevés not fulfilling the demands of previously described vegetation units and having at least one of the class Molinio-Arrheantheretea SSG were included into this class.

Diagnostic species

Diagnostic species (species with u_{hyp}-value exceeding 6.0) are listed in the Table 4.

Table 4

Diagnostic species of the higher mesophilous and xerophilous grassland units

* --- dashes indicate negative u-value

CU – Calluno-Ulicetea, Nt –Nardetalia
TG – Trifolio-Geranietea, Tm – Trifolion medii, Gs – Geranion sanquinei
FB – Festuco-Brometea, Bt – Brometalia, Bo – Bromion
KC – Koelerio-Corynephoretea, Ct – Corynephoretalia, Co – Corynephorion, St – Sedo-Scleranthetalia, Ft – Festuco-Sedetalia, PlF – Plantagini-Festucion, Ko – Koelerion glaucae
MA – Molinio-Arrhenatheretea, Mt – Molinietalia, Mo – Molinion, At – Arrhenatheretalia, Ao – Arrhenatherion, Cy –Cynosurion, Cal – Calthion, Al – Alopecurion, De – Deschampsion
References: 1 – Ellenberg 1996; 2 – Schaminee et al. 1996; 3 – Pott 1995; 4 – Dierssen 1996; 5 – Mucina et al. 1993; 6 – Balevičiene et al. 1998; 7 – Matuszkiewicz 1981

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
	u-value					**Frequency, %**					**Indicator value index**			
Vegetation unit	**CU**	**TG**	**FB**	**KC**	**MA**	**CU**	**TG**	**FB**	**KC**	**MA**	**Vegetation unit**	**Indicator value index**	**Statistical signifi-cance**	**Reference where the species is named as a character species**
Number of relevés in vegetation unit	**32**	**80**	**374**	**270**	**446**	**32**	**80**	**374**	**270**	**446**				
Nardus stricta	**27,0**	---*	---	---	---	**94**	.	.	3	2	CU	93,3	0,001	Nt 1;3-7
Sieglingia decumbens	**16,5**	---	---	---	---	**59**	.	1	4	3	CU	57,6	0,001	CU 1;3-5;7
Potentilla erecta	**14,9**	---	---	---	5,2	**84**	8	5	0	15	CU	74,4	0,001	CU 1;3-5;7
Carex nigra	**10,1**	---	---	---	5,9	**38**	.	0	.	8	CU	30,5	0,001	Cal 3
Vaccinium vitis-idaea	**9,5**	---	---	---	---	**16**	.	.	0	1	CU	15,2	0,001	
Succisa pratensis	**8,2**	---	---	---	---	**25**	2	3	.	2	CU	22	0,001	Mt 1;3;5 Mo 5;6;7
Carex pilulifera	**7,7**	---	---	---	---	**16**	1	1	1	1	CU	11	0,001	CU 1;3-5;7
Cirsium palustre	**6,9**	---	---	---	2,7	**19**	.	1	.	3	CU	15,9	0,001	Mt 1;3-5;7
Selinum carvifolia	**6,4**	---	---	---	---	**16**	.	1	.	2	CU	10,2	0,001	Mt 1;7 Mo 3-6 At 3
Calluna vulgaris	**6,2**	---	---	1,6	---	**16**	1	1	3	1	CU	11,6	0,001	CU 1;3-5

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Veronica teucrium	---	**17,8**	4,0	---	---	.	**58**	12	.	1	TG	53,7	0,001	Gs 1;5;7
Trifolium medium	---	**14,3**	---	---	---	12	**68**	15	1	12	TG	62,3	0,001	Tm 3-5;7
Origanum vulgare	---	**11,5**	4,9	---	---	.	**35**	11	1	0	TG	28	0,001	TG 1-5;7
Agrimonia eupatoria	---	**11,4**	**10,3**	---	---	.	**65**	**35**	1	9	TG	33,2	0,001	Tm 1-5;7
Brachypodium pinnatum	---	**9,5**	1,4	---	---	.	**19**	3	.	.	TG	17,1	0,001	
Bromopsis inermis	---	**8,5**	---	---	---	.	**19**	2	.	2	TG	17,6	0,001	
Geranium pratense	---	**7,2**	---	---	1,4	.	**15**	2	.	3	TG	12,6	0,002	Ao 1;3;4;6;7
Quercus robur	---	**6,6**	---	---	---	6	**14**	3	1	1	TG	11,1	0,001	
Helictotrichon pratense	---	---	**15,5**	---	---	9	14	**39**	8	3	FB	27,3	0,001	FB 2;4;5;7
Fragaria viridis	---	4,0	**15,5**	---	---	3	44	**54**	12	11	FB	26,9	0,001	
Filipendula vulgaris	---	1,5	**15,3**	---	---	9	22	**41**	4	6	FB	25,1	0,001	FB 1;4-7
Trifolium montanum	---	---	**14,8**	---	---	.	21	**41**	11	4	FB	23,7	0,002	FB 1;3;4;6
Phleum phleoides	---	---	**14,7**	---	---	.	8	**30**	6	.	FB	25,8	0,001	FB 1;5 PlF 4
Centaurea scabiosa	---	5,8	**14,3**	---	---	.	54	**53**	10	13	FB	27,9	0,001	FB 1;2;4-7
Polygala comosa	---	---	**13,2**	---	---	.	8	**27**	4	2	FB	16,1	0,001	FB 1;2;4;6;7
Pimpinella saxifraga	---	2,5	**11,6**	---	---	3	55	**67**	40	25	FB	30	0,007	FB 1;4;5
Medicago lupulina	---	---	**11,2**	---	---	.	15	**38**	6	16	FB	20	0,001	Bt 4 Bo 1
Carex caryophyllea	---	---	**10,3**	1,3	---	3	6	**28**	15	2	FB	14,6	0,002	FB 3-7
Ranunculus polyanthemos	---	---	**9,6**	---	---	6	15	**30**	11	7	FB	13,6	0,006	
Carlina vulgaris	---	1,3	**9,6**	---	---	.	8	**13**	1	.	FB	7,1	0,012	Bt 3
Poa angustifolia	---	2,3	**8,7**	**6,5**	---	3	59	**65**	**63**	18	*KC*	*28*	*0,001*	FB 1;4;5
Galium verum	---	1,3	**8,6**	1,6	---	12	41	**52**	38	18	FB	18,3	0,009	FB 1;5
Daucus carota	---	---	**8,4**	---	---	.	5	**18**	1	6	FB	11,7	0,003	At 7
Knautia arvensis	---	---	**8,4**	---	---	31	51	**69**	44	42	FB	20	0,028	At 1;5 Ao 3;4;7

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Poa compressa	---	---	**8,2**	---	---	.	5	**17**	7	1	FB	6,2	0,045	FB 7
Primula veris	---	2,5	**7,8**	---	---	.	28	**30**	3	18	FB	12,2	0,027	Bo 3;4;6
Carex flacca	---	2,4	**7,7**	---	---	.	14	**15**	.	4	FB	9,2	0,008	
Cirsium acaule	---	1,9	**7,4**	---	---	3	8	**9**	.	1	FB	4,1	0,049	Bo 1;3;4
Briza media	1,9	---	**7,3**	---	**6,1**	56	25	**54**	16	**50**	FB	17,3	0,027	Bt 4;5
Campanula rapunculoides	---	3,2	**7,2**	---	---	.	16	**15**	1	3	FB	9,3	0,01	Gs 1;3;4;7
Plantago media	---	---	**6,8**	---	2,7	.	24	**35**	8	27	FB	12,3	0,046	FB 7
Fragaria vesca	---	1,3	**6,5**	---	---	6	12	**16**	3	6	FB	10,3	0,009	
Astragalus danicus	---	---	**6,2**	---	---	.	5	**7**	.	.	FB	6,5	0,007	
Sesleria caerulea	---	---	**6,1**	---	---	3	5	**12**	.	7	FB	8,3	0,015	
Rumex acetosella	1,6	---	---	**16,9**	---	28	1	9	**50**	5	KC	28,8	0,001	KC 1;3;5;7 Ct 4 St 5
Sedum acre	---	---	---	**15,7**	---	.	1	11	**44**	1	KC	36,9	0,001	KC 1;3-5;7 St 3
Artemisia campestris	---	---	---	**15,6**	---	6	5	24	**58**	2	KC	40,4	0,001	KC 1 PlF 3;4
Dianthus deltoides	---	---	---	**15,5**	---	12	1	19	**56**	10	KC	39,8	0,001	PlF 1;3;4;7
Festuca ovina	7,1	---	---	**15,3**	---	**69**	4	13	**51**	7	*CU*	*40,1*	*0,001*	Ct 1 KC 7
Trifolium arvense	---	---	---	**14,2**	---	.	1	15	**40**	1	KC	30,9	0,001	KC 1;5;7 Ft 2 Ct 3;4
Potentilla argentea	---	---	---	**13,8**	---	.	11	15	**46**	4	KC	26,8	0,001	KC 1; 4; 5; 7 Ft 2
Berteroa incana	---	---	---	**11,4**	---	.	.	4	**19**	0	KC	16	0,001	
Carex arenaria	1,0	---	---	**11,3**	---	9	.	1	**17**	0	KC	14,7	0,001	Ct 1-4; 7 KC 2
Arenaria serpyllifolia	---	---	1,5	**10,4**	---	.	1	12	**27**	.	KC	12,2	0,015	KC 3-5; 7
Potentilla impolita	---	---	---	**9,8**	---	.	1	2	**15**	0	KC	12,4	0,001	
Jasione montana	---	---	---	**9,3**	---	.	.	3	**15**	0	KC	12,1	0,001	KC 3; 4; 7
Pilosella officinarum	1,2	---	3,5	**8,9**	---	34	15	31	**45**	7	KC	22,8	0,001	KC 7

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Veronica spicata	---	---	---	**8,9**	---	3	.	6	**18**	0	KC	12,6	0,002	FB 1; 3; 6; 7
Koeleria glauca	---	---	---	**8,3**	---	.	.	.	**7**	.	KC	6,7	0,004	Ko 1; 3; 4; 7
Vicia hirsuta	---	---	---	**8,3**	---	.	2	3	**15**	2	KC	10,7	0,005	
Thymus serpyllum	---	---	2,9	**8,1**	---	.	.	10	**18**	0	KC	12,6	0,001	Ct 1; 3-5 Ft 7
Festuca trachyphylla	---	---	---	**8,0**	---	.	.	2	**11**	0	KC	9,6	0,002	Ft 7 PlF 1
Cerastium semidecandrum	---	---	1,0	**7,7**	---	.	.	7	**17**	1	KC	11	0,002	Ct 3; 4 KC 2; 7
Veronica verna	---	---	---	**7,6**	---	.	.	1	**9**	0	KC	8,3	0,003	KC 1; 4; 5; 7
Deschampsia flexuosa	3,6	---	---	**7,4**	---	16	1	1	**10**	0	*CU*	*9,5*	*0,003*	
Dianthus arenarius	---	---	---	**7,1**	---	.	.	1	**6**	.	KC	5,6	0,004	Ko 7
Acinos arvensis	---	---	2,1	**7,0**	---	.	4	8	**14**	.	KC	8,1	0,015	KC 1; 4; 5
Oenothera biennis	---	---	---	**6,6**	---	.	.	0	**6**	0	KC	5,5	0,012	
Scleranthus perennis	---	---	---	**6,5**	---	.	.	1	**5**	.	KC	4,7	0,018	KC 1; 3; 4; 7 Ft 2; St 5
Hylothelepium maximum	---	---	---	**6,5**	---	3	.	1	**6**	.	KC	3,5	0,022	Ft 3;7
Vicia tetrasperma	---	---	---	**6,1**	---	.	.	5	**11**	1	KC	8,2	0,006	
Armeria maritima	---	---	---	**6,0**	---	.	.	.	**4**	.	KC	3,7	0,019	
Ranunculus acris	3,3	---	---	---	**20,6**	62	6	17	12	**72**	MA	38,1	0,001	MA 1; 3-7
Alchemilla vulgaris	---	---	---	---	**16,7**	31	11	13	10	**53**	MA	38	0,001	MA 4; 5 At 1
Poa pratensis	---	---	---	---	**16,3**	31	9	9	9	**53**	MA	38,9	0,001	MA 1; 4-7 At 5
Lathyrus pratensis	---	---	---	---	**16,0**	16	29	22	5	**57**	MA	33,3	0,001	MA 1; 3-7
Deschampsia cespitosa	4,4	---	---	---	**16,0**	47	8	4	2	**40**	*CU*	*24,5*	*0,001*	Mt 3-5; 7 MA 5; 6
Geum rivale	---	---	---	---	**15,4**	19	5	3	0	**32**	MA	21,9	0,001	Mt 1 Cal 3-5
Anthoxanthum odoratum	**7,0**	---	---	---	**15,1**	**97**	5	20	29	**65**	*CU*	*37,7*	*0,001*	Cy 6
Trifolium pratense	---	---	---	---	**14,9**	12	8	26	4	**52**	MA	32,2	0,001	MA 1; 3-7

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Festuca pratensis	---	---	---	---	**13,6**	9	35	30	4	**55**	MA	35	0,001	MA 1; 3-7
Veronica chamaedrys	1,0	---	---	---	**13,5**	56	24	35	31	**73**	MA	31,5	0,003	
Taraxacum officinale	---	---	---	---	**13,2**	6	21	26	13	**56**	MA	39,9	0,001	MA 3-5 At 7
Rumex acetosa	---	---	---	---	**12,9**	47	18	29	30	**63**	MA	25,6	0,022	MA 1; 3-7 At 5
Cerastium holosteoides	---	---	---	---	**12,3**	19	5	17	7	**42**	MA	19,1	0,002	MA 1; 3; 5; 7
Trifolium repens	---	---	---	---	**11,7**	6	.	14	12	**39**	MA	22,6	0,001	MA 3; 5 Cy 1; 3-5; 7
Cynosurus cristatus	---	---	---	---	**11,6**	3	.	3	.	**18**	MA	16,5	0,001	Cy 1; 3-5; 7 At5 MA5
Carex pallescens	1,7	---	---	---	**11,4**	22	5	6	1	**25**	*CU*	*14,1*	*0,002*	
Filipendula ulmaria	2,2	---	---	---	**11,3**	22	8	4	.	**22**	MA	15,4	0,002	Mt 3; 5-7 Cal 1; 4; 5
Hypericum maculatum	2,4	---	---	---	**11,1**	25	4	4	1	**24**	*CU*	*11,2*	*0,008*	Cal 4 CU 1 Nt 3; 5-7
Lychnis flos-cuculi	---	---	---	---	**10,7**	3	.	2	.	**15**	MA	12	0,002	Mt 1; 4-7 MA 5 Mo3
Heracleum sibiricum	---	2,0	---	---	**10,4**	.	20	6	1	**26**	MA	14,3	0,005	MA 5; 6 At 1; 3; 4
Potentilla anserina	2,2	---	---	---	**10,4**	19	1	2	1	**18**	MA	10,1	0,01	
Phleum pratense	---	---	---	---	**10,2**	16	30	35	24	**57**	MA	28,4	0,001	MA 6; 7 At5 Cy1; 4; 5
Anthriscus sylvestris	---	1,5	---	---	**10,1**	.	16	4	1	**23**	MA	12	0,013	At 1; 7 MA 5
Agrostis tenuis	3,9	---	---	2,6	**9,7**	81	20	27	53	**65**	MA	27	0,001	MA 5 Cy 6
Luzula campestris	3,5	---	---	1,4	**9,6**	62	5	23	36	**50**	MA	16,9	0,026	CU 1; 4; 5; 7
Plantago lanceolata	---	---	---	---	**9,4**	59	20	49	51	**70**	MA	30,5	0,001	MA 1; 4-7
Stellaria graminea	---	---	---	---	**9,4**	34	12	22	30	**48**	MA	17,5	0,012	MA 4; 5 At 5
Alopecurus pratensis	---	---	---	---	**9,3**	.	1	0	2	**12**	MA	10,7	0,005	MA 3-5; 7 Al 6
Ranunculus repens	---	---	---	---	**9,2**	9	1	1	0	**13**	MA	8,9	0,013	MA 5
Prunella vulgaris	---	---	1,6	---	**8,9**	9	9	18	1	**27**	MA	15,3	0,004	MA 1; 3; 5; 6 Cy 4; 5

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Dactylis glomerata	---	4,8	---	---	**8,4**	3	75	49	21	**65**	MA	28,7	0,003	At 3; 4; 6; 7 MA 5
Helictotrichon pubescens	---	---	---	---	**8,4**	31	20	27	29	**49**	MA	27,8	0,002	At 1; 3-6 MA 7
Rhinanthus minor	---	---	---	---	**8,1**	.	1	2	1	**12**	MA	9,2	0,009	MA 4; 5; 7 At 5
Holcus lanatus	**6,9**	---	---	---	**8,0**	**44**	5	.	5	**17**	*CU*	*14,7*	*0,002*	MA 1; 3-5; 7
Vicia cracca	---	1,7	2,6	---	**7,9**	53	69	65	32	**74**	MA	21,6	0,061	MA 1; 3-7
Centaurea jacea	---	---	5,0	---	**7,8**	28	38	45	7	**49**	MA	20,2	0,017	MA 3-7
Campanula patula	---	---	---	---	**7,7**	6	.	7	2	**18**	MA	9,6	0,011	At 5; 6 Ao 1; 3-5; 7
Galium uliginosum	**6,5**	---	---	---	**7,7**	**28**	.	1	.	**10**	*CU*	*19,6*	*0,001*	Mt 1; 3-7
Leucanthemum vulgare	---	---	2,5	---	**7,5**	12	16	30	11	**38**	MA	13,3	0,056	At 1; 3; 7 MA 4; 5
Rumex crispus	---	---	---	---	**7,3**	.	.	1	1	**9**	MA	7,6	0,006	
Carex leporina	4,5	---	---	---	**7,2**	22	.	0	1	**10**	*CU*	*12,3*	*0,001*	
Carum carvi	---	---	---	---	**7,1**	.	6	10	0	**16**	MA	9,7	0,015	MA 4; 5 At 1; 7 Cy 6
Leontodon hispidus	---	---	4,0	---	**7,0**	19	11	27	4	**31**	MA	12,1	0,044	MA 4-7
Vicia sepium	---	1,1	---	---	**6,9**	.	8	2	0	**10**	MA	5,4	0,035	At 4; 5
Juncus conglomeratus	4,1	---	---	---	**6,8**	16	.	.	.	**7**	*CU*	*6,4*	*0,012*	Mt 1; 4; 5; 7 Cal3 De5
Carex panicea	5,8	---	---	---	**6,8**	38	4	6	1	**15**	*CU*	*25,1*	*0,001*	
Cirsium heterophyllum	---	---	---	---	**6,7**	.	.	.	.	**5**	MA	5,2	0,012	
Ophioglossum vulgatum	---	---	---	---	**6,6**	3	.	1	.	**7**	MA	5	0,043	Mt 1 Mo 1; 4; 5; 7
Ranunculus auricomus	1,4	---	---	---	**6,6**	9	1	1	0	**8**	*CU*	*4*	*0,065*	Mo 3
Angelica sylvestris	2,1	---	---	---	**6,4**	12	2	2	.	**9**	MA	4,3	0,065	Mt 1; 4; 5; 7 Cal 1; 3
Cirsium arvense	---	---	---	---	**6,3**	.	2	2	.	**10**	MA	7,9	0,004	
Polygonu)m bistorta	3,0	---	---	---	**6,3**	12	.	1	.	**7**	MA	4,7	0,028	Mt 5; 6 MA 5 Cal 1; 3
Leontodon autumnalis	2,3	---	---	---	**6,1**	19	2	6	3	**13**	*CU*	*6*	*0,061*	Cy 1; 4-6

Discussion

As it is shown in Table 2, 3 and 4, not all the species of SSG are also diagnostic for the class level vegetation units. There are only some SSG that could be used as a diagnostic species group at the class level. One of these SSG is *Nardus stricta* group whose u-value is 30 for the class Calluno-Ulicetea. It means that the group is present almost only in the class Calluno-Ulicetea and in all of these relevés. There are no one so faithful SSG for other classes.

To develop SSG which reliably produce higher syntaxa are possible only if these syntaxa would be highly differentiated one from another without spatial or temporal continuum and consequently without common species. These syntaxa should be also homogeneous with their character species frequent in all the lower syntaxa.

Grassland vegetation posses none of these features (Pignatti et al. 1995). As a rule, different grassland vegetation types have tight spatial and temporal links. For example, in a catena across of a floodplain both the moist Molinietalia and wet Caricetalia nigrae as well as fresh Arrhenatheretalia and dry sandy Festuco-Sedetalia or calcareous Brometalia can be found within a mosaic pattern (Šeffer, Stanova (eds.) 1999; Сабардина 1952). Therefore gradual transition from one class to another is a common feature both in floristic as well as in structural terms. The same is true for temporal changes. For example, abandonment of dry calcareous grasslands leads to development of forest fringe communities (Brometalia → Trifolio-Geranietea), but intensive grazing in formerly mowed fresh grasslands drives to formation of heathly plants (Arrhenatherion → Cynosurion → Nardetalia) (Dierschke 1993; Сабардина 1957).

As an alternative for the classification of the higher syntaxa, SSG corresponding to lower syntaxa and their combinations with particular dominant species are used instead of trying to develop the class or order level SSG.

Diagnostic species derived a posteriori for the five vegetation units delimited by such an approach corresponded well to the diagnostic species of these vegetation units mentioned in literature for different regions of Europe. Observed discrepancies can be explained, firstly, by the character of the database, secondly, by regional differences in the ecology and sociology of species and communities.

The influence of the database character on the classification result is well known (Bruelheide, Jandt 1994; Dufrene, Legendre 1997; Chytry et al. 2002b). Diagnostic capacity of the species strongly varies depending on the degree of representation of the target vegetation and other closely related vegetation types where the species is present.

The specific feature of the current database is that no one vegetation class is fully represented (see Material and Methods) with the only exception of Festuco-Brometea communities. For this reason, diagnostic species delimited in this research can be extrapolated only in the frame of mesophilous and xerophilous grasslands. By enlarging the database with other grassland types (for instance, low sedge beds or pioneervegetation on sands) the diagnostic capacity of many species will change. For example, it is clear that the species *Succisa pratensis, Cirsium palustre* and *Selinum carvifolia* which are a diagnostic for the class Calluno-Ulicetea in this paper reach their ecological optimum in the Molinietalia communities. The same is true for the species

Angelica palustris, Polygonum bistorta, Galium uliginosum and *Lychnis flos-cuculi*, which are diagnostic for the mesophilous grasslands of the order Arrhenatheretalia in the current database.

To characterize the ecological and geographical peculiarities of diagnostic species in details vegetation surveys of several European countries were used. To be short, references will be mentioned further in the text as follows: [1] – Ellenberg 1996 (Central Europe); [2] – Schaminee et al. 1996 (The Netherlands); [3] – Pott 1995 (Germany); [4] – Dierssen 19996 (Nothern Europe); [5] – Mucina et al. 1993 (Austria); [6] – Balevičiene 1998 (Lithuania); [7] – Matuszkiewicz 1981 (Poland).

Diagnostic species of the class Calluno-Ulicetea, order Nardetalia

Half of the class Calluno-Ulicetea diagnostic species are mentioned as diagnostic for the class or order also in other European countries – *Nardus stricta, Sieglingia decumbens, Potentilla erecta, Carex pilulifera,* and *Calluna vulgaris* (Table 4). *Potentilla erecta* is rather problematic in Latvia. One of its ecological optimum is also the class Molinio-Arrhenatheretea (it is confirmed also by rather high u-value for the cluster of this class in the current database). Therefore, *Potentilla erecta* can not be used in differentiation of classes Molinio-Arrhenatheretea and Calluno-Ulicetea.

Three species – *Succisa pratensis, Cirsium palustre* and *Selinum carvifolia* are the diagnostic for the class Calluno-Ulicetea only in the current database, because they reach the real ecological optimum in the class Molinio-Arrhenahteretea order Molinietalia [1; 3; 4; 5; 6; 7].

Carex nigra and *Vaccinium vitis-idaea* are good diagnostic species in Latvia. Although *Carex nigra* optimally grows in fens (it is the character species of the class Scheuchzerio-Caricetea nigrae), similarly to *Nardus stricta*, it is confined to very acid nutrient poor moist to wet soils (The Ellenberg figures for reaction is 3, nitrogen – 2, moisture – 8; for *Nardus stricta* these values are 2,2, and x~ (indifferent to moisture and tolerates periodical saturation)). Therefore, *Carex nigra* together with another Calluno-Ulicetea species clearly differentiate Calluno-Ulicetea communities from poorest and wettest Molinio-Arrhenatheretea communities.

Vaccinium vitis-idaea grows mainly in pine forests in Latvia (Laiviņš 1998). In Western and Northern Europe the second habitat group is brown dunes and heaths (class Calluno-Ulicetea, order Ulicetalia minoris). Also in Latvia, the species grow only in the class Calluno-Uliceta communities outside the forests. Some of the class and order character species – *Cuscuta epithymum* [1; 4; 7], *Botrychium lunaria* [1; 3; 4; 6; 7] and *Antennaria dioica* [1; 3; 4; 5; 7] are very rare in the current database (0, 7 and 12 relevés, respectively), so it is impossible to clarify the sociological status of these species.

Three more species are mentioned in literature as character species of the class or order – *Luzula campestris* [1; 4; 5; 7], *Carex pallescens* [1; 4; 5] and *Hypericum maculatum* [3; 5; 6; 7]. They appear as diagnostic for the class Molinio-Arrhenatheretea in the current database (u-values 9.6, 11.4 and 11.1, respectively). On the other hand they have positive u-values also for the class Calluno-Ulicetea but *Carex pallescens* and *Hypericum maculatum* also an indicator value index is the highest for the class Calluno-Ulicetea relevés. So these species can be used only for differentiation of the lower syntaxa inside the class but not between classes.

Diagnostic species of the class Trifolio-Geranietea order Origanetalia

Four out of eight fringe diagnostic species *Origanum vulgare, Trifolium medium, Agrimonia eupatoria* and *Veronica teucrium* are widely recognized as the diagnostic for the class Trifolio-Geranietea and its syntaxa. *Trifolium medium* and *Agrimonia eupatoria* traditionally are recognized as character species of the alliance Trifolion medii, but *Veronica teucrium* – of the alliance Geranion sanquinei. In Latvia, these species occur together frequently (Jermacāne, Laiviņš 2001b; Laiviņš, Rūsiņa 2002). Co-occurrence of the character species of both alliances is also documented in Scandinavia (Diekmann, 1997).

Brachypodium pinnatum has a double nature. The species is frequent in polydominant subcontinental steppe-like communities (class Festuco-Brometea, alliance Cirsio-Brachypodion) and is considered as a character species of this alliance (Mucina et al. 1993; Evers 1997). On the other hand, it expands in most of the mesophilous communities of Festuco-Brometea (alliance Bromion) after abandonment of mowing or grazing resulting in species poor derivate communities which turn gradually into fringe vegetation (Bobbink, Willems 1987; Bobbink 1991; Dierschke 1993). In Latvia *Brachypodium pinnatum* is observed only as expansive species in abandoned dry calcareous grassland, so it indicates the vegetation transformation process from grassland to fringe.

Bromopsis inermis is referred as a character species of the alliance Alopecurion (class *Molinio-Arrhenahteretea*) [7], and also as a character species of xerothermophilous perennial ruderal vegetation (class *Artemisietea vulgaris*, alliance *Convolvulo-Agropyrion repentis*) [5]. As the current database does not include optimum vegetation for *Bromopsis inermis,* the sociology of the species remains unclear.

It is uncommon that *Geranium pratense* appears as the diagnostic for the class Trifolio-Geranietea. In other regions of Europe it is mostly referred as a character species of the alliance Arrhenatherion, class Molinio-Arrheantheretea [1; 3; 4; 6; 7]. In the current database the species is more frequent in fringe vegetation (15% of the fringe relevés) than in mesophilous grasslands (3% of the class Molinio-Arrhenahteretea relevés). Nevertheless, the diagnostic capacity of *Geranium pratense* should be investigated further, especially because the frequency of occurrences of the species slightly decreases in Latvia from the east to the west (Табака и др. 1988; Gavrilova 2004), but it is rather atypical for all other Arrhenatherion species (for example, *Arrhenatherum elatius, Crepis biennis, Pastinaca sativa*) which frequency decreases in the direction from the west to the east.

Quercus robur is present as seedlings in most cases in the relevés of the database. As it is shown by Walker et al. (2003) also information on structure such as vertical layering of vegetation or life form spectra is of high importance for classification of forest/non-forest ecotones besides floristical features. So the occurrence of broad-leaved tree seedlings is helpful for delimitation of fringe communities.

Several fringe character species (*Astragalus glycyphyllos, Clinopodium vulgare, Lathyrus sylvestris, Anemone sylvestris, Seseli libanotis*) which are common both in Central Europe and in Latvia do not appear as such in the current paper. It can be explained by the rather small number of relevés in the fringe cluster and not with any differences in ecology of species comparing to Central Europe.

A different situation is with *Medicago falcata* which is treated as a character species of the class Trifolio-Geranietea by several authors [1; 3; 4]. In Latvia *Medicago falcata* is common in the class Festuco-Brometea (51 relevé) as well as in the class Molinio-Arrhenatheretea (28 relevés). It forms also almost monodominant derivate communities with unclear syntaxonomical status (29 relevés with *Medicago falcata* as dominant were omitted from the analysis because they did not include any SSG). So *Medicago falcata* can not be used as a diagnostic species at the class level.

Diagnostic species of the class Festuco-Brometea order Brometalia

17 out of 26 diagnostic species of the class Festuco-Brometea relevés are referred as the diagnostic also for other regions of Europe. In Latvia only the most mesophilous part of the class (alliance Bromion) is present. So it is not surprising that several species (*Cirsium acaule, Primula veris*) diagnostic for the alliance Bromion in Central Europe became diagnostic for the class in Latvia.

Analysing overall diagnostic capacity of these 17 species in European context it is evident that most of them are weak diagnostic species. Some of them (*Carlina vulgaris, Poa compressa, Plantago media*) are mentioned only in one, some (*Briza media, Phleum phleoides*) – in two literature sources (Table 4). The same appears within the current database – the highest u-value is only 15.5 (but for other classes it ranges from 16.9 to 27). For example, a weak diagnostic species is *Pimpinella saxifraga*- its frequency reaches 40% also in the cluster of the class Molinio-Arrhenahteretea, but in the class Koelerio-Corynephoretea – even 55%; there are some more such species – C*entaurea scabiosa, Galium verum, Briza media*. In my opinion, with the same importance as the floristic composition also the dominance of diagnostic species should be involved when delimiting communities of the class Festuco-Brometea.

Poa angustifolia should not be used as the class Festuco-Brometea diagnostic species. With almost the same frequency and u-values it is present both in the class Festuco-Brometea and Koelerio-Corynephoretea (65%, u_{hyp} = 8.7 un 63%, u_{hyp} = 6.5, respectively). Moreover, according to the Indicator Value Index (which takes the dominance of the species into account) it appears to be the diagnostic for the class Koelerio-Corynephoretea. It is true when considering the dominance tendency of the species, because it is a frequent dominant in dry sandy grasslands of the alliance Plantagini-Festucion in Latvia (Jermacāne 2000). Dierssen (1996) mentions it as characteristic dominant species for the same alliance in Northern Europe.

Several species are closely connected both with the class Festuco-Brometea and the class Trifolio-Geranietea. *Fragaria viridis* has the highest u-value (15.5) in the class Festuco-Broemetea. It has positive u-value also for the class Trifolio-Geranietea (4.0). *Agrimonia eupatoria* has almost the same diagnostic capacity for fringe as well as for dry calcareous communities (u_{hyp} = 11.4 and 10.3). *Campanula rapunculoides* and *Fragaria vesca* exceeds the threshold u-value of 6.0 for the class Festuco-Brometea, too. *Veronica teucrium* and *Origanum vulgare* has a high frequency and positive u-value both in fringe communities and in dry calcareous grasslands. All the mentioned species are referred as character species of the class Trifolio-Geranietea in Europe (Table 4).

Occurrence of fringe species in calcareous grasslands are associated with the abandonment of grasslands that leads to expansion of fringe species and driving the community to the forest (Dierschke, 1993; Jandt, 1999).

In Latvia, this opinion can not explain the observed patterns. *Fragaria viridis* is the ninth most constant and the second most frequently dominating species in the data set of the class Festuco-Brometea cluster – so it is considered to be faithful diagnostic species of the class. Also in Northern Europe the species is particularly characteristic for dry calcareous grasslands and even the community *Fragario viridis-Helictotrichetum* is described (Hallberg, 1971). *Origanum vulgare, Agrimonia eupatoria* and especially *Fragaria vesca* are very frequent in dry calcareous grasslands of Eastern Latvia. Most of these grasslands are mowed and/or grazed until now. So this pattern is maintained due to climatic conditions rather than by management cessation.

Daucus carota and *Knautia arvensis* are mostly the character species of Arrhenatheretalia and Arrhenatherion [1; 3; 4; 5; 7]. They have positive u-values (for both species $u_{hyp} = 8.4$) only in the class Festuco-Brometea cluster in the current database. According to Hulten, Fries (1986) *Daucus carota* is growing close to the eastern border of its distribution range in Latvia. It is possible that this species changes its ecology and sociology on the border of distribution, but there are no detailed investigations carried out on this question.

Astragalus danicus has double nature in Latvia. In the Abava River valley it appears as typical dry grassland species, but in other parts it grows mostly in man-made habitats – roadverges and railway embankments (Fatare 1992; Табака, Клявиня 1981). In Central Europe it is supposed to be a character species of subcontinental calcareous grasslands of the order Festucetalia valesiacae, alliance Cirsio-Brachypodion [1; 5; 7]. So the occurrence of the species in Latvian calcareous grasslands indicates some affinities of these communities to subcontinental Festucetalia valesiacae communities.

Sesleria caerulea is very plastic in relation to moisture, but it strongly requires calcareous soils. Therefore, it is common both in moist Molinion and dry Bromion grasslands as well as in wet Caricion davallianae calcareous fens. So the species can be used as diagnostic for the class Festuco-Brometea only within the mesophilous and xerophilous grassland vegetation.

Diagnostic species of the class Koelerio-Corynephoretea, order Festuco-Sedetalia

Analysis yielded 29 diagnostic species. The most of them are character species of the class Koelerio-Corynephoretea and order Festuco-Sedetalia (rarely also Corynephoretalia) and alliance Plantagini-Festucion (rarely also Koelerion glaucae) in Europe (Table 3). Some of delimited diagnostic species have somewhat ruderal character. *Berteroa incana, Vicia hirsuta, Oenothera biennis* and *Vicia tetrasperma* occur more commonly in thermophilous ruderal communities such as the class Artemisietea vulgaris order Onopordetalia. Therefore without broader phytosociological investigations these species can not be included into the diagnostic species group of the class Koelerio-Corynephoretea.

Festuca ovina and *Deschampsia flexuosa* have high u-value both in the class Koelerio-Corynephoretea and Calluno-Ulicetea, Indicator value index for these species shows their close affinity to the class Calluno-Ulicetea. So these species can not be used as diagnostic at the class level.

Armeria maritima is a character species of saline marshes (the class Asteretea tripolii, alliance Armerion maritimae) [1; 2; 3]. This data set contains only relevés from Vecdaugava where the species abundantly grows in sandy grasslands, so this species can be considered as diagnostic only for the current data set.

From species named as character species for this class at least in three literature sources used in current comparison only four species do not appear as diagnostic in Latvia's data set. *Androsace septentrionalis* is represented only in one relevé and *Myosotis micrantha* in eight relevés. Possibly, these species are found more frequently in dry grasslands in Latvia but their frequency is underestimated due to their phenology – they are spring ephemera disappearing already in June. Other two species are more frequent (*Helichrysum arenarium* in 20 relevés and *Trifolium campestre* in 22 relevés) but they are distributed with the same constancy both in the class Koelerio-Corynephoretea and Festuco-Brometea.

Diagnostic species of the class Molinio-Arrhenatheretea order Arrhenatheretalia

The class Molinio-Arrhenatheretea is the most representative grassland vegetation in Latvia and it contains the highest number of relevés in this data set. Consequently, the number of diagnostic species is the highest – 53 species. All of them with exception of *Carex pallescens, Potentilla anserina, Luzula campestris, Rumex crispus, Carex leporina, Carex panicea, Hypericum maculatum, Cirsium heterophyllum* and *Cirsium arvense* are widely used as diagnostic for the class Molinio-Arrhenatheretea and lower syntaxa.

Carex pallescens, Luzula campestris, and *Hypericum maculatum* have been discussed in previous sections. *Rumex crispus* and *Cirsium arvense* are ruderal species, so they are diagnostic for the class Molinio-Arrhenatheretea only in the current data set.

Several species, for example, *Filipendula ulmaria, Geum rivale, Ophioglossum vulgatum, Carex panicea* etc., have their ecological optimum in hygrophylous part of the class (order Molinietalia) or even in low sedge communities. So complementing the data base with relevés of corresponding vegetation will result in decreasing of diagnostic capacity of these species in the class level.

Some species traditionally used as the diagnostic for the class Molinio-Arrhenatheretea can not be used as such in Latvia. *Achillea millefolium* (as class character species used in 1; 5; 7) has positive but very low u-value and high frequencies in three classes – Molinio-Arrhenatheretea (u_{hyp}= 1.8; frequency 76%), Koelerio-Corynephoretea (u_{hyp}= 2.4; frequency 79%) and Festuco-Brometea (u_{hyp}= 1.6; frequency 76%). The same situation is with *Festuca rubra* (as class character species mentioned in 4; 5; 7) and *Galium album* (as Arrhenatherion character species mentioned in 1; 3; 5, Arrhenatheretalia – 4; 6).

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Mezofīto un kserofīto zālāju augu sabiedrību diagnostiskās sugas Latvijā

Kopsavilkums

Līdz šim Latvijas zālāju augu sabiedrību klasifikācijā izmantoja diagnostisko sugu kopas, kas bija izdalītas un lietotas citos Eiropas reģionos. Tomēr pēdējo gadu Eiropas mēroga fitosocioloģiskie pētījumi ir pierādījuši, ka bez atbilstošas ģeogrāfiskas un ekoloģiskas analīzes diagnostisko sugu kopas nedrīkst pārņemt no viena reģiona un lietot cita reģiona veģetācijas pētījumos. Tās katrā reģionā ir jāizdala, izmantojot formalizētas un atkārtojamas metodes un pamatojoties uz plašu un reprezentatīvu datu materiālu.

Šajā rakstā diagnostiskās sugas nodalītas, izmantojot 1373 mezofīto un kserofīto zālāju veģetācijas aprakstu datu bāzi. Vispirms ar datorprogrammas JUICE (tās pamatā ir H. Bruelhaides u-vērtības algoritms) izveidotas socioloģiskās sugu grupas (kopskaitā 23). Šo grupu loģiskas kombinācijas izmantotas, lai sagrupētu veģetācijas aprakstus lielākās fitosocioloģiskās vienībās – klasē *Molinio-Arrhenatheretea* (rinda *Arrhenatheretalia*), *Calluno-Ulicetea* (rinda *Nardetalia*), *Trifolio-Geranietea* (rinda *Origanetalia vulgaris*), *Koelerio-Corynephoretea* (rinda *Festuco-Sedetalia*) un *Festuco-Brometea* (rinda *Brometalia*). Katrai augu sugai aprēķināta u-vērtība un indikatorvērtības indekss. Sugas, kurām u-vērtība pārsniedza 6.0 slieksni, izdalītas kā diagnostiskas sugas. Rezultātā klasei *Calluno-Ulicetea* noteiktas 10 diagnostiskas sugas, klasei *Trifolio-Geranietea* – 8 sugas, klasei *Festuco-Brometea* – 26 sugas, klasei *Koelerio-Corynephoretea* – 28 sugas un klasei *Molinio-Arrhenatheretea* – 53 sugas. Vairākas sugas var izmantot kā diagnostiskas klases un rindas līmenī tikai šajā rakstā izmantotā datu masīva ietvaros. Šie gadījumi rakstā apskatīti detālāk.

Atslēgvārdi: diagnostiskas sugas, dabisko zālāju veģetācija, klase, Brauna-Blankē metode, socioloģiskā sugu grupa.