DRY CALCAREOUS GRASSLAND COMMUNITIES (*FILIPENDULA VULGARIS-HELICTOTRICHON PRATENSE*) IN WESTERN AND CENTRAL LATVIA

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ABSTRACT - The dry calcareous grassland vegetation of Western and Central Latvia is described based on 93 relevés. All relevés could be assigned to one community type *Filipendula vulgaris-Helictotrichon pratense* named according to dominant species. Four variants were distinquished: *typicum*, *Viscaria vulgaris*, *Astragalus danicus* and *Carex flacca*. Ellenberg indicator values were calculated to study the ecology of communities. Floristic differences among variants are associated mainly with soil reaction (Ellenberg indicator values for soil pH range from 6.0 to 7.6), but conditions of moisture and fertility are similar among the variants. The calcareous grassland vegetation in Latvia represents transition vegetation between the classes Molinio-Arrhenatheretea and Festuco-Brometea. However, ecologically and floristically, these communities are closer to the class Festuco-Brometea and could be assigned to the order Brometalia. For designation to alliance and association, more data is required. The results are compared with similar communities in other European countries.

KEY WORDS - Calcareous grasslands, *Filipendula vulgaris*, *Helictotrichon pratense*, Syntaxonomy, Bromion, Latvia

INTRODUCTION

Calcareous grasslands floristically are the most diverse among European semi-natural vegetation. This type of grasslands is found throughout Europe where the bedrock consists of chalk or limestone and is near the soil surface (Willems 1982). Calcareous grasslands are included in the class Festuco-Brometea Br.-Bl. et. R.Tx. ex Klika et Hadač 1944. The class has Eurasiatic distribution (Pignatti *et al.*, 1995), but in Northern and Eastern Europe communities of the class become floristically impoverished and many character species are absent or the species composition of different syntaxa becomes similar (Diekmann, 1995).

Approximately 42% (1/3 of them are very rare or alien) of the 43 character species of the class Festuco-Brometea and order Brometalia erecti Br.-Bl. 1936, and 46% of the character species of the alliance Bromion erecti Koch 1926 (1/2 of them

are very rare) mentioned by R.Pott (1995) and H.Ellenberg (1996), are found in Latvia. Dry calcareous grasslands in Latvia are spread through out, but they are rare and distributed unevenly. Floristically, communities are associated with the class Molinio-Arrhenatheretea R.Tx. 1937 em. R.Tx. 1970.

Traditionally classification of grasslands in Latvia has followed the method of dominant species (Russian school), but no researches has been conducted since the 1960 when a monograph on grassland vegetation was published by G. Sabardina (Sabardina, 1957) (vegetation relevés were not puhlished). The study of grassland vegetation researches using the Braun-Blanquet approach was initiated in recent years in Latvia.

The aim of the present paper is to describe floristical and ecological features of dry calcareous grasslands in Latvia, in relation to Central European syntaxa.

Material and methods

Study area

Latvia is located near the eastern coast of the Baltic Sea between 55°40'-58°05' N latitude and 20°58'-28°14' E longitude. The area of the territory is 64 589 km^2.

The climate is relatively mild maritime becoming slightly continental inland. The frost-free period lasts 150-160 days near the sea and 130-140 days in the east. The average precipitation is 600-650 mm per year, with less precipitation (500) in the Zemgale Lowland (Central Latvia) and more (800) in the Vidzeme Upland (North-eastern Latvia). The vegetation period extends for about 180-200 days, and the average temperature is 6 °C. Mean temperature of the coldest month January is - 4°C, the warmest month is July (+17°C). In the beginning (till the end of May) and the end of the growing season (end of September), plants are exposed to frost during nights (Kalnina, 1995; 1998). Forests cover ~45% of the country, mires – 6%, agricultural lands – 38%, and semi-natural grasslands occupy only about 1% of the territory (Anon. 1998).

Grasslands of the class Festuco-Brometea are situated mainly in valleys of large rivers (Daugava, Gauja, Venta etc.), where the distribution of these communities is favoured by substrate and microclimatic conditions. On the terrace slopes of rivers, carbonate deposits (mostly dolomite) lay close to the ground surface and the parent soil is calcareous. Microclimatic conditions are determined by relief forms and substrate. Steep (up to 45°) and high slopes (in the Abava River the height of the valley slopes reaches 30 m) are common in large river valleys. Southern and western exposure as well as calcareous substrate result in more continental microclimates (high soil and ground surface air temperatures, sharper temperature fluctuation and less moisture) than on northern and eastern slopes (Kalnina, 1965; 1977). Plant cover usually is short and open therefore having less impact on temperature regime than for a well developed herb layer on moist soils (Kalnina, 1966).

Traditionally, calcareous grasslands have been managed by sheep grazing, but due to land use changes in recent decades, the majority of them have been abandoned

for 5-10 years, and the others have been extensively grazed by cattle or horses and mowed.

Methods

93 relevés (area 4-25 m^2) were collected in 1997-1999. Investigations were carried out in areas where the calcareous bedrock lies close to the soil surface, mainly in the river valleys (Venta, Abava with tributaries Imula and Amula in Western Latvia, Maza Jugla and Gauja with tributaries Amata and Ligatne in Central Latvia). Descriptions of the relevés were conducted according to the Braun -Blanquet approach (Braun-Blanquet, 1964; Dierschke, 1994). Both ordination (DECORANA) and classification (TWINSPAN) methods were used for vegetation analysis. Ellenberg indicator values (Ellenberg et al. 1992) were used to explore vegetational trends. The spectrum of phytogeographical elements (species distribution area types) was calculated using initial data from Meusel et al. (1965, 1978) and Hulten, Fries (1986), Ellenberg values were calculated weighted by coverage. Both for phytogeographical elements and Ellenberg values, only species with a constancy above 10% were used.

Nomenclature: Gavrilova and Sulcs, 1999

Results

All analysed relevés could be assigned to the community *Filipendula vulgaris-Helictotrichon pratense* named according to constant and in the same time dominant species of the class Festuco-Brometea (Table 1). A total of 204 vascular plant species was recorded in the 93 relevés, including 17 tree and shrub species (*Juniperus communis, Malus sylvestris, Sorbus aucuparia, Rhamnus cathartica* etc.).

28 of the recorded species reach or are close to their northern (*Astragalus danicus, Festuca trachyphylla, Phleum phleoides, Veronica teucrium* etc.), eastern (*Carex flacca, Filipendula vulgaris, Pimpinella major, Ranunculus bulbosus, Sesleria caerulea* etc.) or western (*Gentiana cruciata, Orobanche elatior* etc.) distribution boundaries in Latvia (Fatare 1992). Some of these species occur only in calcareous grasslands in Latvia. The characteristic species composition is *Filipendula vulgaris* (dom.), *Helictotrichon pratense* (dom.), *Fragaria viridis* (subdom.), *Pimpinella saxifraga, Galium verum, Centaurea scabiosa, Briza media* and *Trifolium montanum,* representing class Festuco-Brometea, as well as some species of the class Molinio-Arrhenatheretea (*Achillea millefolium, Festuca rubra, Plantago lanceolata, Knautia arvensis* etc.). The species number varied from 17 to 44 per relevé, but the average number of species was 30.

Data analysis with TWINSPAN resulted in recognition of four variants: *typicum, Viscaria vulgaris, Astragalus danicus* and *Carex flacca*, which reflected slight floristical and ecological differences (Table 1 and 2).

Variant *typicum* represents typical calcareous grassland communities found in Latvia. These are polydominant grasslands where *Filipendula vulgaris* and *Helictotrichon pratense* are the most common dominants, in some relevés also *Festuca rubra, Fragaria viridis, Phleum phleoides* and *Poa angustifolia*. Communities of the

TABLE 1

Synoptic table of dry calcareous grassland *Filipendula vulgaris-Helictotrichon pratense* communities in Latvia

Species\Variants	var. *typicum*	var. *Viscaria vulgaris*	var. *Astragalus danicus*	var. *Carex flacca*
Number of relevés	28	21	17	27
Mean cover of herb layer, %	88	90	97	90
Mean cover of moss layer, %	18	14	27	9
Average number of species per relevé	31	28	33	33
Total number of species	152	112	123	136
Characteristic species of the *Filipendula vulgaris-Helictotrichon pratense* community				
Filipendula vulgaris Moench	V^{2}	V^{2}	V^{2}	$IV^{+,2}$
Helictotrichon pratense (L.) Bess.	V^{3}	III^{2}	V^{2}	IV^{3}
Differential species of variants				
Agrostis tenuis Sibth.	II+	$IV^{1,3}$	I	I
Viscaria vulgaris Bernh.	I	$IV^{1,2}$	I	.
Dianthus deltoides L.	I	IV^{+}	III+	.
Astragalus danicus Retz.	I	.	V^{2}	II
Arenaria serpyllifolia L.	I	I	III^{+}	.
Artemisia campestris L.	I	II^{-}	III^{+}	.
Carex flacca Schreb.	I	.	.	$IV^{2,3}$
Primula veris L.	III^{+}	I	II^{+}	IV^{+}
Cirsium acaule Scop.	I	.	.	$IV^{+,1}$
Ononis arvensis L.	II^{+}	.	II^{+}	$IV^{+,2,3}$
Carlina vulgaris L.	I	.	I	III^{+}
Character species of the A. Bromion erecti				
Carex caryophyllea Latourr.	II^{2}	II^{+}	III^{+}	II
Brachypodium pinnatum (L.) Beauv.	I	.	II^{-}	I^{3}
Gymnadenia conopsea (L.) R. Br.	I	.	.	II^{+}
Orobanche elatior Sutt.	I	.	.	.
Ranunculus bulbosus L.	I	.	.	.
Character species of the Cl. Festuco-Brometea, O.Brometalia				
Pimpinella saxifraga L.	IV^{+}	IV^{+}	V^{1}	III^{+}
Galium verum L.	$IV^{1,2}$	$II^{1,2}$	V^{2}	III^{+}
Centaurea scabiosa L.	IV^{+}	I	V^{1}	IV^{-}
Phleum phleoides (L.) Karst.	III^{2}	II^{2}	V^{2}	.
Briza media L.	$IV^{1,2}$	II^{1}	$IV^{1,2}$	V^{2}
Plantago media L.	$IV^{+,1}$	I	II^{+}	$III^{+,1}$
Poa angustifolia L.	II^{1}	$III^{1,2}$	IV^{2}	III^{+}
Trifolium montanum L.	$III^{+,1}$	IV^{+}	V^{+}	II^{+}
Campanula glomerata L.	II^{+}	II^{-}	II^{+}	II^{+}
Polygala comosa Schkuhr	II^{+}	.	II^{+}	III^{-}
Allium oleraceum L.	I	I	I	I
Anthyllis x *baltica* Juz. ex Kloczkova	.	I	.	I
Veronica spicata L.	I	II^{-}	I	.
Betonica officinalis L.	I	.	I	.
Medicago falcata L.	I	.	.	.
Gentiana cruciata L.	.	.	.	I
Character species of the Cl. Molinio-Arrhenatheretea				
Achillea millefolium L.	$V^{+,1}$	$V^{+,2}$	$V^{+,1}$	IV^{+}
Centaurea jacea L.	III^{+}	III^{+}	III^{+}	V^{1}
Dactylis glomerata L.	IV^{+}	II^{+}	IV^{+}	IV^{+}
Festuca rubra L.	$IV^{+,1}$	V^{2}	II^{2}	II^{+}
Phleum pratense L.	IV^{+}	IV^{+}	I	II^{+}
Plantago lanceolata L.	V^{+}	IV^{1}	III^{+}	III^{+}
Stellaria graminea L.	III^{+}	V^{1}	III^{+}	I
Vicia cracca L.	IV^{+}	III^{-}	IV^{+}	IV^{-}

Rumex acetosa L.	II^{+}	III^{+}	III^{+}	I
Veronica chamaedrys L.	II^{+}	II^{1}	III^{+}	II
Trifolium pratense L.	II^{+}	II$^{+,1}$	I	III^{+}
Anthoxanthum odoratum L.	II^{+}	III^{2}	I	.
Leontodon hispidus L.	II^{+}	II^{-}	I	III^{+}
Cerastium holosteoides Fries	I	II^{+}	III^{-}	I
Lathyrus pratensis L.	II^{+}	II^{+}	I	I
Ranunculus acris L.	II^{+}	II^{+}	I	II^{+}
Poa pratensis L.	II^{+}	I	.	II^{+}
Festuca pratensis Huds.	I	II^{+}	I	I
Character species of the O. Arrhenatheretalia, A. Arrhenatherion				
Galium album Mill.	V^{+}	IV$^{-,1}$	II$^{+,1}$	V^{-}
Knautia arvensis (L.) Coult.	V^{+}	V^{-}	V^{+}	IV^{+}
Medicago lupulina L.	II^{+}	I	II^{-}	IV^{+}
Helictotrichon pubescens (Huds.) Pilg.	II^{+}	III^{+}	II^{+}	I
Tragopogon pratensis L.	II^{+}	II^{1}	II^{+}	I
Heracleum sibiricum L.	II^{+}	I	I	.
Leucanthemum vulgare Lam.	II^{+}	I	I	II^{+}
Leontodon autumnalis L.	II^{+}	.	I	II^{+}
Carum carvi L.	I	.	.	II^{+}
Lotus corniculatus L.	I	II^{+}	.	I
Rhinanthus serotinus (Schoenh.) Oborny	I	.	.	I
Arrhenatherum elatius (L.) J. et C. Presl	.	I	.	I^{+}
Campanula patula L.	I	I	I	I
Crepis biennis L.	I	.	.	II^{1}
Character species of the Cl. Trifolio-Geranietea				
Fragaria viridis Duch.	IV^{2}	IV^{2}	V^{2}	IV$^{+,1}$
Agrimonia eupatoria L.	III$^{+,1}$	I	I	V$^{+,1}$
Veronica teucrium L.	II^{1}	.	III^{+}	II^{-}
Campanula rapunculoides L.	I	.	I	III^{+}
Hypericum perforatum L.	I	I	.	II^{+}
Origanum vulgare L.	I	.	.	II^{+}
Accompanying species				
Galium boreale L.	II^{+}	III^{2}	IV^{2}	II$^{+,1}$
Calamagrostis epigeios (L.) Roth	.	II^{1}	III$^{-,2}$	II^{+}
Equisetum arvense L.	III^{+}	II^{+}	IV^{+}	II^{+}
Ranunculus polyanthemos L.	III^{+}	IV^{-}	III^{-}	II^{+}
Hieracium pilosella L.	III^{+}	II^{+}	II^{+}	I
Luzula campestris (L.) DC.	II^{+}	II^{+}	III^{+}	.
Sesleria caerulea (L.) Ard.	I	.	III^{2}	III^{2}
Festuca arundinacea Schreb.	I	I	I	III^{+}
Filipendula ulmaria (L.) Maxim.	I	.	.	I
Potentilla erecta (L.) Raeusch.	.	I	.	I
Tussilago farfara L.	.	.	.	II^{+}
Thymus pulegioides L.	I	II^{1}	.	.
Anchusa officinalis L.	.	.	II^{+}	.
Angelica sylvestris L.	.	.	.	I
Carex contigua Hoppe	I	I	I	I
Carex hirta L.	II^{+}	I	I	I
Carex pallescens L.	I	I	.	I
Cirsium x *rigens* (Aiton) Wallr.	.	.	.	I
Convolvulus arvensis L.	I	I	I	II^{+}
Dactylorhiza baltica (Klinge) Orlova	.	.	.	I
Daucus carota L.	I	.	I	III^{+}
Deschampsia cespitosa (L.) Beauv	I	.	I	I
Equisetum pratense L.	I	I	II^{+}	.
Erigeron acris L.	I	.	I	I
Festuca ovina L.	I	II$^{+,1}$	II^{+}	I
Hypericum maculatum Crantz	.	I	I	I
Inula salicina L.	.	.	I	I^{2}
Juniperus communis L.	I	.	I	I
Linum catharticum L.	I	.	.	II^{-}
Pinus sylvestris L.	I	I	I	I
Poa compressa L.	I	.	.	II^{+}
Polygala vulgaris L.	I	I	I	II^{+}
Potentilla reptans L.	I	.	.	II^{+}
Prunella vulgaris L.	I	.	.	II^{+}

Quercus robur L.	I	I	.	I
Rhamnus cathartica L.	I	.	I	II⁺
Rubus caesius L.	.	I	.	I
Rumex thyrsiflorus Fingerh.	II⁺	II⁺	II⁺	.
Scorzonera humilis L.	I	.	.	I
Silene vulgaris (Moench) Garcke	I	I	I	I
Solidago virgaurea L.	I	II⁺	II⁺	I
Succisa pratensis Moench	.	.	.	II⁺
Tanacetum vulgare L.	I	I	II⁺	.
Trifolium repens L.	I	.	I	I
Veronica longifolia L.	.	I	I	.
Vicia angustifolia Reichard	I	II⁻	I	I

Sporadic species with constancy I: *Elytrigia repens* (L.) Newski (1), *Aegopodium podagraria* L. (1, 4), *Agrostis gigantea* Roth (2), *Alchemilla heptagona* Juz. (3), *Alchemilla hirsuticaulis* Lindb. fil. (2), *Alchemilla monticola* Opiz (4), *Alnus incana* (L.) Moench. (1), *Anthemis tinctoria* L. (1, 3), *Artemisia vulgaris* L. (1, 3), *Berteroa incana* (L.) DC. (1), *Betula pendula* Roth (1, 2), *Botrychium lunaria* (L.) Sw. (3), *Bromopsis inermis* (Leys.) Holub (2), *Calystegia sepium* (L.) R. Br. (1, 4), *Campanula persicifolia* L. (1, 4), *Campanula rotundifolia* L. (1) *Carex hartmanii* Cajand. (1, 2), *Carex leporina* L. (1), *Carex panicea* L. (4), *Carex reichenbachii* Bonnet (1, 3), *Chaerophyllum aromaticum* L. (4), *Cirsium arvense* (L.) Scop. s. str. (4), *Convallaria majalis* L. (3), *Coronuria flos-cuculi* (L.) A. Br. (2), *Cynosurus cristatus* L. (4), *Echium vulgare* L. (1, 3), *Epipactis palustris* (L.) Crantz (4), *Equisetum hyemale* L. (1, 2), *Equisetum sylvaticum* L. (5), *Equisetum variegatum* Schleich. ex Web. et Mohr (3), *Euonymus europaea* L. (3), *Fallopia convolvulus* (L.) A. Loeve (2), *Festuca trachyphylla* (Hack.) Krajina (2), *Fragaria vesca* L. (1,4), *Frangula alnus* Mill. (4), *Fraxinus excelsior* L. (4), *Geranium palustre* L. (3, 4), *Geranium sylvaticum* L. (3,4), *Geum rivale* L. (2, 4), *Gladiolus imbricatus* L. (1), *Glechoma hederacea* L. (3), *Herniaria glabra* L. (2), *Hieracium umbellatum* L. (3), *Hypochoeris radicata* L. (1, 2), *Listera ovata* (L.) R. Br. (5), *Lotus balticus* Min. (2), *Maianthemum bifolium* (L.) F. W. Schmidt (1), *Malus sylvestris* Mill. (3), *Medicago sativa* L. (3, 4), *Melandrium dioicum* (L.) Coss. et Germ. (3), *Melica nutans* L. (5), *Melilotus albus* Medik. (4), *Myosotis arvensis* (L.) Hill (3), *Oenothera biennis* L. (1), *Picea abies* (L.) Karst. (4), *Pimpinella major* (L.) Huds. (1, 4), *Plantago major* L. (2), *Pulsatilla pratensis* (L.) Mill. (3), *Ranunculus auricomus* L. (1), *Ranunculus repens* L. (3, 4), *Rosa canina* L. (1), *Rumex crispus* L. (4), *Salix caprea* L. (1), *Salix cinerea* L. (1, 4), *Salix purpurea* L. (1), *Salix starkeana* Willd. (4), *Saponaria officinalis* L. (2), *Sedum telephium* L. s. str. (2), *Selinum carvifolia* (L.) L. (4), *Senecio jacobaea* L. (1), *Sieglingia decumbens* (L.) Bernh. (2), *Sorbus aucuparia* L. (4), *Thalictrum flavum* L. (1), *Thalictrum simplex* L. (3), *Trifolium hybridum* L. (4), *Trollius europaeus* L. (2), *Tromsdorfia maculata* (L.) Bernh. (3), *Turritis glabra* L. (2), *Verbascum nigrum* L. (4), *Veronica arvensis* L. (2), *Veronica officinalis* L. (2), *Vicia hirsuta* (L.) S. F. Gray (1, 2), *Vicia tetrasperma* (L.) Schreb. (3), *Viola rupestris* F. W. Schmidt (3, 4), *Viola tricolor* L. (2, 3).

variant *typicum* are found in all of the investigated areas and are situated mainly on west and south facing slopes. Ellenberg indicator values show these communities to be found mainly in neutral to basic soils, dry and poor in nutrients (Table 2).

Differential species of the **variant *Viscaria vulgaris*** are *Agrostis tenuis*, *Dianthus deltoides* and *Viscaria vulgaris*. The number of Festuco-Brometea species is not high

TABLE 2

Ellenberg indicator values

for variants of *Filipendula vulgaris-Helictotrichon pratense* community

Ecological factor\Variant	*Viscaria vulgaris*	*typicum*	*Astragalus danicus*	*Carex flacca*
Light	7.0	7.0	7.1	7.1
Continentality	4.2	4.2	4.7	3.9
Temperature	5.0	5.1	5.2	5.3
Reaction	6.0	7.3	7.4	7.6
Moisture	3.9	3.8	3.6	4.2
Nitrogen	3.1	3.0	2.9	3.3

and also constancy is lower, with the only *Filipendula vulgaris, Helictotrichon pratense, Poa angustifolia* and *Campanula glomerata* having high constancy. Many species of the class Molinio-Arrhenatheretea are present in the communities, including *Achillea millefolium, Phleum pratense, Stellaria graminea, Knautia arvensis, Galium album, Festuca rubra, Agrostis tenuis* and *Anthoxanthum odoratum*. The latter three species have rather high cover (up to 25%), and many acidophilous species (*Agrostis tenuis, Dianthus deltoides, Rumex acetosella, Luzula campestris* etc.) are frequent (Fig.1.). The species composition is determined by soil conditions: soils consisting of sandy material with relatively low calcium content. Other factor is abandonment - majority of these grasslands is not managed for 5 and more years therefore litter layer causes increase of moisture and nutrient contents. Due to mentioned factors, succession proceeds more rapidly towards shrubland than in other variants. These communities are found mainly in Central Latvia (only 4 relevés in Western Latvia), where they occur on terrace platforms and in some cases also on flat western and southern slopes.

The differential species of the **variant *Astragalus danicus*** are *Astragalus danicus, Arenaria serpyllifolia* and *Artemisia campestris*. Many forb species (*Astragalus danicus, Filipendula vulgaris, Galium boreale, G.verum, Fragaria viridis*) as well as some grasses (*Phleum phleoides, Poa angustifolia*) are dominants. The two latter species are more abundant in these communities compared with other variants. The communities occur only in the Abava River valley (Western Latvia). *Astragalus danicus* there reaches it's northern distribution boundary in Latvia. It is found mainly in synanthropic habitats (roadsides, railway embankments etc.); it grows abundantly in species rich semi-natural grasslands only in the Abava River valley (less in the Daugava River) (Fatare, 1992). The communities of the variant are situated in the central portion of floodplains where flood events are rare and on terrace platforms; only some fragments are found on south-facing terrace slopes. Ellenberg values show that the substrate is poor in nutrients and calcareous, and is slightly dryer than in other variants (Table 2). Dryness and sandy material in the upper soil layer, especially

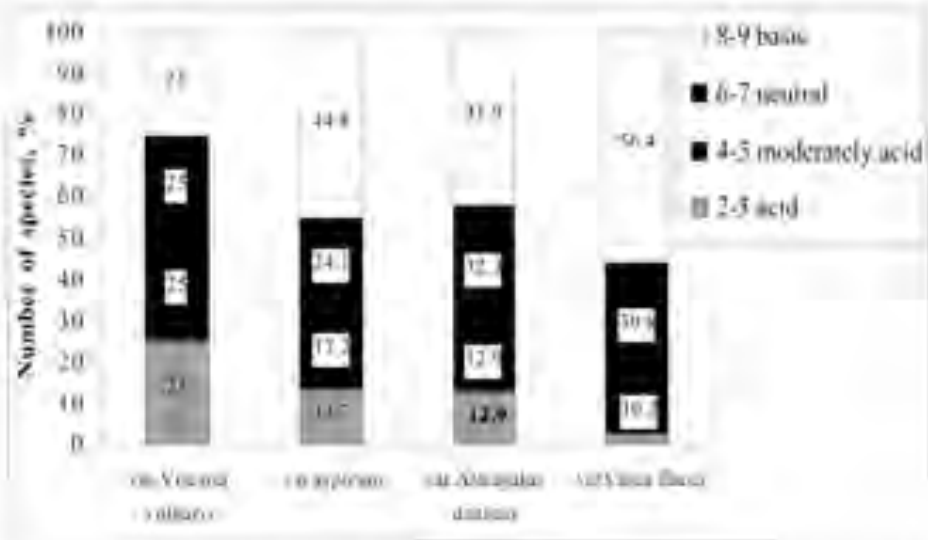

Fig. 1 - Spectrum of species groups in variants according to Ellenberg indicator values for soil reaction

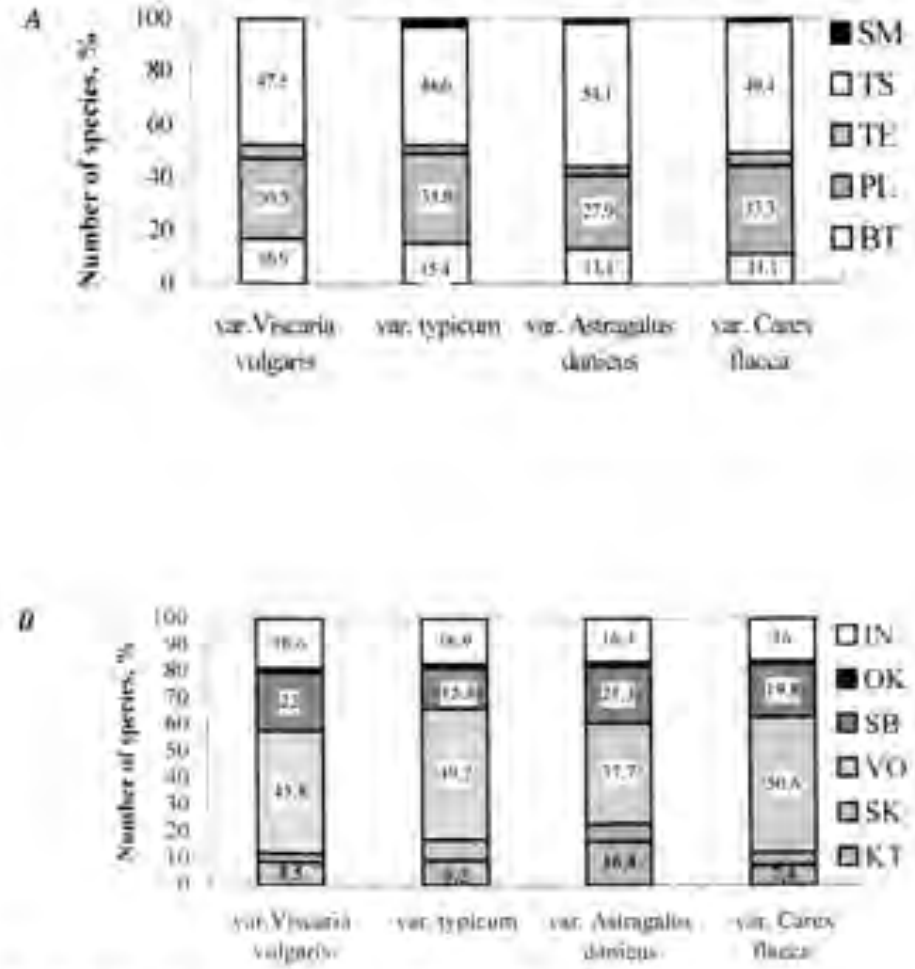

Fig. 2 - Species zonality (A) and continentality (B) group spectra in the
- *Filipendula vulgaris-Helictotrichon pratense* communities
Zonality: SM – submeridional, TS – temperate-submeridional, TE – temperate, PL – polyzonal, BT – boreo-temperate
Continentality: IN – indifferent, OK –oceanic, SB – suboceanic, VO –slightly oceanic, SK – subcontinental, KT – continental

in floodplains, results in the occurence of some acidophilous xerophytic plants: *Artemisia campestris, Arenaria serpyllifolia, Anchysa officinalis, Sedum acre, Pilosella officinarum, Thymus serpyllum, Festuca ovina* etc. There are also more continental and subcontinental species and species with temperate-submeridional distribution than in other variants (Fig. 2.).

Variant *Carex flacca* is also described from Western Latvia but communities occur on rather steep (up to 35°) south and west (rarely northeast) facing slopes and almost never on terrace platforms or floodplains. Differential species of the variant are *Primula veris, Cirsium acaule, Carex flacca, Ononis arvensis* and *Carlina vulgaris*. Dominating species are *Carex flacca, Ononis urvensis, Helictotrichon pratense, Filipendula vulgaris, Briza media* and *Sesleria caerulea*. Floristically, this variant is the most similar to the alliance Bromion erecti. Surprisingly, it occupies the moister

habitats if compared with other *Filipendula vulgaris-Helictotrichon pratense* communities (Ellenberg moisture value is 4.2). Species composition suggest a very high content of calcium in soil (Ellenberg soil reaction value is 7.6, for about half of relevés between 7.6 and 8.0), and there are almost no species associated with acid soils and only 10% of all species are associated with moderately acid soils (Fig. 1.). This variant contains more suboceanic and slightly oceanic species (together 70.4%) than others (Fig. 2.).

The eigenvalues of the four DCA axes (λ_1=0.35, λ_2=0.15, λ_3=0.12, λ_4=0.09) show that the 27% of the total variation is attributed to the first axis with lesser relative amounts attributed to the 2, 3 and 4 axis (12%, 9% and 7%). The vegetation gradient associated with DCA axis 1 reflects a trend from more acidic soils on the left to more basic soils on the right. The second axis can be interpreted as continentality gradient (Fig. 3.). On this axis relevés of the variant *Astragalus danicus*, which have the lowest scores, are more continental (Ellenberg value of continentality is 4.3-5.7). The variant *Carex flacca* (high and low scores on the second axis) contains relevés both with high and low Ellenberg values of continentality (from 3.3 to 4.6). Values of other climatic (temperature, light) and edaphic factors (moisture and soil fertility) are similar in all variants and they are not important in explanation of total variance (Table 2).

The relationship between vegetation and soils, suggested by Ellenberg values indicate that *Filipendula vulgaris-Helictotrichon pratense* communities grow in dry,

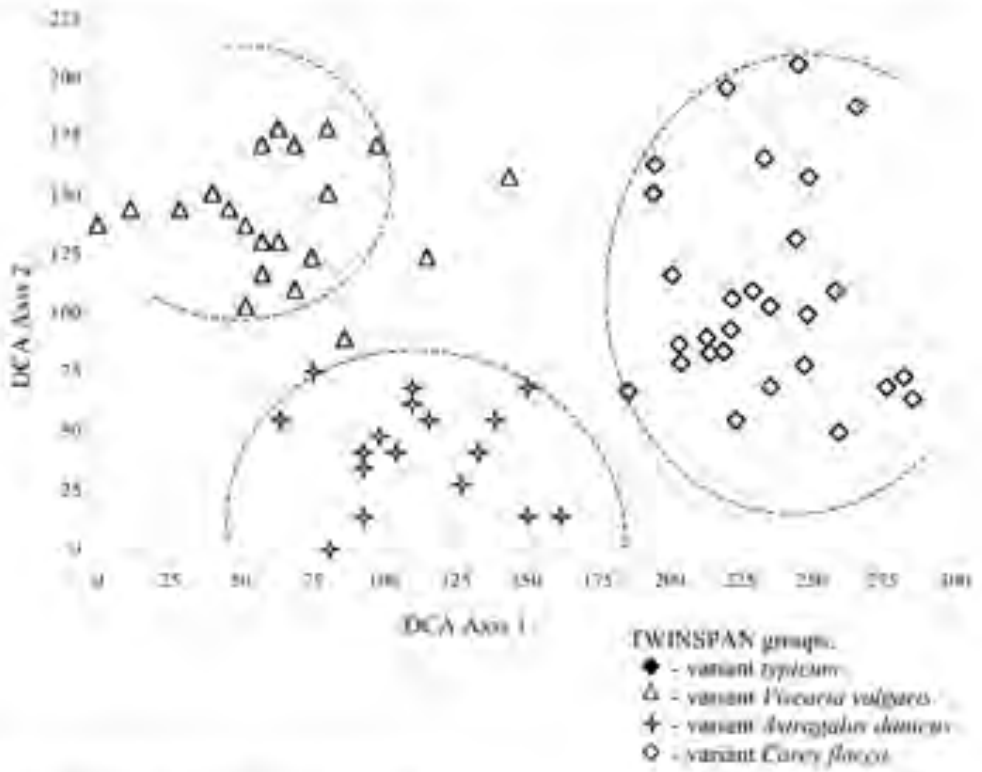

Fig. 3 - DECORANA ordination of relevés

poor and neutral to basic soils. Floristic differences among the variants can be explained by soil reaction, and fertility and moisture conditions have less importance. Species composition reflects a slight increase of calcium content from the variant *Viscaria vulgaris, typicum* and *Astragalus danicus* to the variant *Carex flacca*. Minor differences are observed also in phytogeographical spectrum: variant *Viscaria vulgaris* (more acid soils) contains a higher number of boreotemperate species and there are less continental and subcontinental, and more suboceanic and slightly oceanic species. However, the highest number of the latter are present in the variant *Carex flacca* (more basic and fresh soils) but the variant *Astragalus danicus* (dryer soils) contains the highest number of continental and subcontinental and temperate-submeridional species.

Discussion

The described *Filipendula vulgaris-Helictotrichon pratense* community represents transition vegetation between the classes Molinio-Arrhenatheretea and Festuco-Brometea. 20 character species of the class Festuco-Brometea and the order Brometalia are found in the communities, 12 of which have constancy above III at least in one variant. *Filipendula vulgaris, Helictotrichon pratense, Astragalus danicus, Galium verum, Phleum phleoides, Briza media* etc. are the most common dominants. On the other hand there are 17 character species of the class Molinio-Arrhenatheretea and order Arrhenatheretalia with constancy above III, for example, *Achillea millefolium, Centaurea jacea, Dactylis glomerata, Festuca rubra, Phleum pratense, Plantago lanceolata, Vicia cracca, Knautia arvensis*. However, the majority of these species is found rather frequently also in Central European (Oberdorfer, 1978; Schaminée *at al.*, 1996) and in Scandinavian calcareous grasslands (Hallberg, 1971; Ejrnaes, 1998). As it is discussed in the literature, simple counting of character species is not satisfactory for assigning communities to one or another syntaxon (Diekmann, 1997).

Character species of lower syntaxa of Molinio-Arrhenatheretea are present in the described communities but with low constancy. Only 3 character species of the order Arrhenatheretalia (*Galium album, Knautia arvensis, Medicago lupulina*) have high constancy (constancy ≥III), but constancy of the character species of the alliance Arrhenatherion Koch 1926 (*Arrhenatherum elatius, Carum carvi, Festuca pratensis, Campanula patula, Crepis biennis, Festuca pratensis, Pastinaca sativa, Tragopogon pratensis*) is only I-II. The same situation is with character species of Cynosurion R.Tx. 1947 (*Cynosurus cristatus, Leontodon autumnalis, Luzula campestris, Prunella vulgaris, Trifolium repens*), only variant *Viscaria vulgaris* bears some similarity with Cynosurion communities – constant species are *Agrostis tenuis, Plantago lanceolata* and *Anthoxanthum odoratum*.

The shallow depth of the calcareous deposits and southern and western exposure results in more xerothermic conditions, and therefore many continental and subcontinental species. This is clearly reflected in the phytogeographical spectrum (types of species distribution areas). 12-23% of all species in *Filipendula vulgaris-Helictotrichon pratense* communities have continental-subcontinental distribution (*Astragalus danicus, Arenaria serpyllifolia, Campanula glomerata, Orobanche elatior, Phleum phleoides, Ranunculus polyanthemos, Veronica teucrium, Ononis arvensis,*

Phleum phleoides, Gentiana cruciata, Polygala comosa etc.), and among the zonal groups the community has the largest contribution of temperate-submeridional species (45-54%). These figures are much lower for communities of the alliance Arrhenatheretalia. In Latvia, the association Anthoxantho-Agrostietum tenuis (Cynosurion) is phytosociologically close to the *Filipendula vulgaris-Helictotrichon pratense* community; the composition of character species of the class Molinio-Arrhenatherctea is rather similar between these communities especially with the variant *Viscaria vulgaris*. The association Anthoxantho-Agrostietum tenuis contains only 5-12% continental and subcontinental species and 32-42% temperate-submeridional species, but there are more boreotemperate species (18-25%) (Jermacane, 1999) in comparison to the *Filipendula vulgaris-Helictotrichon pratense* community where this group constitutes 11-17% of species.

Also some xerothermophilous species of the classes Trifolio-Geranietea and Koelerio-Corynephoretea, for example, *Fragaria viridis, Agrimonia eupatoria, Veronica teucrium, Origanum vulgare, Thymus serpyllum, Potentilla argentea* etc. are more associated with dry and warm habitats than with that of moist and cool in Latvia.

In our opinion the described floristical and ecological features of the *Filipendula vulgaris-Helictotrichon pratense* community are sufficient to include them into the class Festuco-Brometea, order Brometalia.

Although there remains little doubt about the syntaxonomical position of the Filipendula *vulgaris-Helictotrichon pratense* community in the class and order level, considering the alliance and association is more difficult. Only variant *Carex flacca* could be assigned to the alliance Bromion erecti, because character species of the alliance *Primula veris* and *Cirsium acaule* are constant and *Orobanche elatior, Gymandenia conopsea, Orchis mascula* and *Orchis militaris* are also found is these communities. Two latter species do not occur in relevés presented in this paper, but they are found rarely in Latvia and mainly in calcareous grassland habitats (Tabaka *et al.*, 1988). Other variants can not be assigned to this alliance due to lack or too low constancy of character species.

There are three groups of communities described in other European countries (Central European xerothermic grasslands in acid soils, Scandinavian alvars and Northwest European calcareous grasslands) that are similar to some extent in species composition to Latvian grasslands.

The Latvian *Filipendula vulgaris-Helictotrichon pratense* community bears some similarities with the associations Viscario-Avenetum pratensis Oberd. 1949 and Filipendulo-Helictotrichetum pratensis Mahn 1965 described in Southern and Central Germany (Oberdorfer, 1978; Mahn, 1965). Although there are some dominant species and species with high constancy (*Helictotrichon pratense, Filipendula vulgaris, Viscaria vulgaris, Pimpinella saxifraga, Galium verum* etc.) common for grasslands of both regions, a number of acidophilous species (*Sieglingia decumbens, Calluna vulgaris, Potentilla erecta, Genista sagittalis, Viola canina* etc.) having high constancy in communities of Viscario-Avenetum and Filipendulo-Helictotrichetum, but absent in the Latvian grasslands reflect base ecological and floristical differences among the compared communities. Also *Helictotrichon pratense* and *Filipendula vulgaris* almost never occur in acid soils in Latvia.

Calcareous grassland communities in Latvia can be compared also with communities described from alvar regions in Scandinavia. To some extent, Latvian

calcareous grasslands floristically are close to the association Fragario-Helicotrichetum Hallberg 1971 and Veronica spicata-Avenula pratensis community (Hallberg, 1971; Krahulec *et al.*, 1986). Composition of the frequent dominant species (*Fragaria viridis*, *Filipendula vulgaris* and *Helictotrichon pratense*) reveals rather high similarity among compared communities. On the other hand, in alvars there is a high number of endemic taxa and species with continental distribution (*Artemisia oelandica, Trifolium striatum, Ranunculus illyricus, Agrostis vinealis, Oxytropis campestris* etc.), reflecting specific climatic and edaphic conditions.

The Latvian grasslands showed the highest similarity with the most mesophilous Bromion communities described from Northern and Western Europe: the *Dactylis glomerata-Ranunculus bulbosus* community described from Denmark (Ejrnaes 1998), the association Gentiano-Koelerietum Knapp ex Bornkamm 1960 described from the Netherlands (Schaminée *et al.*, 1996) and the *Festuca ovina-Avenula pratensis* community described from Great Britain (Rodwell, 1992).

Common feature both for NW European and Latvian calcareous grasslands is the presence of mesophilous species such as *Achillea millefolium, Festuca rubra, Medicago lupulina, Dactylis glomerata, Centaurea jacea, Plantago lanceolata, Knautia arvensis* etc. as well as *Carex flacca* and *Cirsium acaule*. Less similar was the composition of the species of class Festuco-Brometea. *Gentianella germanica* and *Galium pumilum*, character species of the association Gentiano-Koelerietum, as well as *Koeleria macrantha, Sanguisorba minor* and *Scabiosa columbaria,* which are common in the Netherlands and in the British *Festuca ovina-Avenula pratensis* grasslands, and *Cynosurus cristatus, Armeria maritima, Festuca ovina, Ranunculus bulbosus, Cerastium fontanum* having high constancy in calcareous grasslands of Denmark, are rare or absent in Latvian grasslands. On the other hand *Trifolium montanum, Fragaria viridis, Galium boreale* and *Filipendula vulgaris* are sporadic or not present in NW European grasslands. It seems that the similarity between the Latvian calcareous grasslands and NW European grasslands is based mainly on species of the class Molinio-Arrhenatheretea, which are characterised by wide ecological range.

According to the present stage of knowledge the Latvian *Filipendula vulgaris-Helictotrichon pratense* community can be classified as a basal community of the class Festuco-Brometea, order Brometalia. To provide more definitive syntaxonomy, further investigations both on the vegetation structure of calcareous grasslands in Latvia and on comparative analysis of different regions of Europe should be carried out.

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