Syntaxonomical revision of the *Molinion* meadows in the Czech Republic

Syntaxonomická revize luk svazu *Molinion* v České republice

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A syntaxonomical revision of meadows of the *Molinion caeruleae* Koch 1926 alliance in the Czech Republic is presented. Of ten associations reported previously for the Czech Republic only two were distinguished using the Cocktail method – *Molinietum caeruleae* Koch 1926 and *Junco effusi-Molinietum caeruleae* Tüxen 1954. The former occurs on more base-rich soils, while the latter is found in more acidic habitats and characterized by the occurrence of species of *Nardus* grasslands. Results of this classification were compared with classifications of *Molinion* meadows for other countries of Central Europe. Main environmental gradients responsible for variation in species composition of Czech *Molinion* meadows were revealed by detrended correspondence analysis. For interpretation of these gradients correlations with Ellenberg indicator values and altitude were used. The main gradient positively correlates with soil base status, continentality, temperature and nutrients, and negatively with altitude.

K e y w o r d s : Cocktail method, formalized classification, grassland vegetation, phytosociology

Introduction

The alliance *Molinion caeruleae* Koch 1926 includes species-rich meadows in intermittently wet habitats where the groundwater table fluctuates considerably during the growing season. While in spring ground water often reaches the soil surface, in summer it is deep within the soil (Válek 1954, 1956, Balátová-Tuláčková 1966, Blažková 1973). These meadows are traditionally unmanured and mown usually once a year, or every second year, in late summer (Ellenberg 1996, Ellmauer & Mucina 1993, Kučera & Šumberová 2001). Due to extensive alterations to the water regime and intensification of agriculture in the past decades many of these meadows have been replaced by species-poor meadows or agricultural fields (Kučera & Šumberová 2001). Only fragments of this vegetation still exist.

Ten associations of *Molinion* alliance are reported for the Czech Republic (Blažková & Balátová in Moravec et al. 1995, Balátová-Tuláčková 2001). However, most of them are not clearly defined and lack diagnostic species. *Molinietum caeruleae* Koch 1926 includes vegetation with a dominance of *Molinia caerulea* agg. and occurs in base-rich sites (Klika 1947, Válek 1954, Kopecký 1960, Vicherek 1967). Also in *Junco-Molinietum caeruleae* Preising 1951 *Molinia caerulea* s.l. dominates, but this association is confined to acidic habitats (Balátová-Tuláčková 1983, 1994, 1997). *Selino-Molinietum* Kuhn 1937 is characterized by a high cover of *Molinia caerulea* agg. and *Selinum carvifolia* (Balátová-Tuláčková 1993a, 1994). *Gentiano pneumonanthis-Molinietum litoralis* Ilijanić 1968 is distinguished based on the dominance of *Molinia litoralis* (Balátová-Tuláčková 1993b, 2000, Balátová-Tuláčková & Hájek 1998, Vicherek et al. 2000), *Scorzonero-Molinietum*

Oberdorfer et Krause 1955 by a high cover of *Scorzonera humilis* (Balátová-Tuláčková 1983, 1991) and *Galio borealis-Cirsietum cani* Balátová-Tuláčková 2001 by a high cover of *Cirsium canum* (Balátová-Tuláčková 2001). Two associations were delimited by dominance of *Festuca rubra* agg.: *Sanguisorbo-Festucetum commutatae* Balátová-Tuláčková 1959 (in Balátová-Tuláčková & Zapletal 1959) and *Serratulo-Festucetum commutatae* Balátová-Tuláčková 1966 (Balátová-Tuláčková 1966). *Sanguisorbo-Festucetum pratensis* Blažková 1973 is characterized by a high cover of nutrient-demanding grasses (Blažková 1973, Kolbek et al. 1999) and *Silaëtum pratensis* Knapp 1954 by the dominance of *Silaum silaus* (Balátová-Tuláčková 1994, Balátová-Tuláčková & Hájek 1998, Vicherek et al. 2000, Balátová-Tuláčková 2001).

As most of these associations were distinguished by a high cover of some species, their diagnostic species often overlap and also the variability in species composition among them is very small. Assignment of relevés to these associations is often difficult because species composition of a relevé often corresponds to several associations.

The aims of this paper are: (1) to make a syntaxonomical revision of the *Molinion* associations reported for the Czech Republic and to define clear rules for the assigment of relevés to them; (2) to find the major environmental gradients responsible for variation in floristic composition of *Molinion* meadows in the Czech Republic.

Materials and methods

First, a data set of phytosociological relevés including all vegetation types of the Czech Republic was prepared using relevés from the Czech National Phytosociological Database (Chytrý & Rafajová 2003). From this data set relevés of extreme size (i.e. < 50 m^2 or > 1000 m^2 for forests, < 10 m^2 or > 100 m^2 for scrub, and < 4 m^2 or > 100 m^2 for herbaceous vegetation), relevés not assigned to syntaxa and relevés without accurate indication of locality were deleted. Because the geographical distribution of the relevés was irregular, the data set was geographically stratified and resampled (Knollová et al. 2005). Only one relevé of each syntaxon (according to original author's assignment) per grid square of 1.25 longitudinal $\times$ 0.75 latitudinal minute (ca 1.5×1.4 km) was chosen. If two or more relevés of the same syntaxon were found in the same grid square, that which included records of cryptogams or was the more recent was selected. If this selection yielded more than one relevé, one of them was selected at random. By this procedure, 27,223 relevés were chosen and used in the subsequent analysis.

Classification was prepared using the Cocktail method (Bruelheide 1995, 2000) in the JUICE 6.3 program (Tichý 2002). This method enables the creation of sociological species groups and defines associations by a combination of these groups. Sociological species groups were created subjectively based on expert knowledge. First one species characteristic of the target vegetation unit was chosen and then the program calculated which of the other species occur most frequently with the chosen species, using the phi coefficient of association (Sokal & Rohlf 1995, Chytrý et al. 2002). Then the first chosen species was grouped with the most similar species, and similarity was calculated between the occurrence of the two-species group and the other species. The same procedure was repeated with a three-species group etc. In this way sociological groups of species, which have a statistical tendency to co-occur in a large data set of relevés, were created.

After defining several species groups relevant for the *Molinion* alliance and similar vegetation units, formal definitions of associations were created by combinations of these species groups using logical operators such as AND, OR and NOT (Bruelheide 1997, Kočí et al. 2003, Lososová 2004). For example, if an association is defined as "A group AND B group NOT C group", then a relevé is assigned to it if it contains at least half of the species of A group and at the same time at least half of the species of B group and does not contain half of or more species of C group.

The basic reference for creating definitions of associations was the list of associations reported for the Czech Republic (Blažková & Balátová in Moravec et al. 1995, Balátová-Tuláčková 2001). Using the Cocktail method attempts were made to create definitions of all these associations, but these attempts were unsuccessful in most cases.

After defining associations by the Cocktail method, their diagnostic species were determined using the phi coefficient of association (Sokal & Rohlf 1995, Chytrý et al. 2002) in program JUICE 6.3 (Tichý 2002). The threshold phi value for a species to be considered as diagnostic was set to 0.15. Species fidelities were calculated on the basis of comparison of the relevés of each association with all the other relevés in the data set of 27,223 relevés.

To study variability within associations and to create distribution maps, all relevés meeting the requirements of the formal definitions were selected from the Czech National Phytosociological Database. Internal variation within the associations was assessed by cluster analysis of the relevés assigned to these associations, using the PC-ORD 4 program (McCune & Mefford 1999), with relative Euclidean (chord) distance as a resemblance measure and flexible beta group linkage method with parameter $\beta = -0.25$. Diagnostic species of variants were calculated using the phi coefficient, on the basis of a comparison of the relevés of the target variant with all other relevés assigned to the association; the relevés not assigned to this association were not considered. The informal rank of variant, instead of the formal rank of subassociation, was used according to the guidelines of the project Vegetation of the Czech Republic.

Major gradients in species composition of *Molinion* meadows were analysed using detrended correspondence analysis (DCA) from the CANOCO 4.5 package (ter Braak & Šmilauer 2002). For ecological interpretation of these gradients, average Ellenberg indicator values (Ellenberg et al. 1992) and altitude were plotted onto a DCA ordination diagram as supplementary environmental variables.

Nomenclature follows Kubát et al. (2002) for vascular plants and Frey et al. (1995) for bryophytes.

Results

Five species groups were created using the Cocktail method (Table 1) and used to create formal definitions of two associations – *Molinietum caeruleae* Koch 1926 and *Junco effusi-Molinietum caeruleae* Tüxen 1954. Other associations reported from the Czech Republic could not be characterized by any combination of these or any other species groups.

The formal definition of the *Molinietum caeruleae* association is "*Serratula tinctoria* group AND *Succisa pratensis* group". Species of both groups are characteristic of intermittently wet habitats. Species of *Succisa pratensis* group occur in both associations, while species of *Serratula tinctoria* group, which are typical of base-rich sites, are almost missing in *Junco effusi-Molinietum caeruleae*.

Table 1. – Sociological species groups created by the Cocktail method.

Group name	List of species in groups
Serratula tinctoria	*Betonica officinalis, Galium boreale, Potentilla alba, Serratula tinctoria*
Succisa pratensis	*Molinia caerulea* agg., *Scorzonera humilis, Selinum carvifolia, Succisa pratensis*
Lychnis flos-cuculi	*Alopecurus pratensis, Cardamine pratensis, Festuca pratensis, Holcus lanatus, Lathyrus pratensis, Lychnis flos-cuculi, Ranunculus acris, Ranunculus auricomus* agg., *Rumex acetosa, Sanguisorba officinalis*
Nardus stricta	*Carex pilulifera, Nardus stricta, Potentilla erecta*
Caltha palustris	*Angelica sylvestris, Caltha palustris, Galium uliginosum, Myosotis palustris* agg., *Scirpus sylvaticus*

Three variants were distinguished using cluster analysis within *Molinietum caerulae*. The variant of *Carex hostiana* is characterized by the occurrence of species of the *Caricion davallianae* alliance. Species composition of this variant corresponds to subassociation *caricetosum hostianae,* which was described by Koch (1926) from NE Switzerland. Only eight relevés from the Czech Republic were assigned to this variant. In the past it was common in lowlands of the river Elbe (Klika 1947, Válek 1954, Kopecký 1960), but most of its localities have been destroyed.

The variant *Bromus erectus* includes species of the *Bromion erecti, Cirsio-Brachypodion pinnati* and *Arrhenatherion elatioris* alliances and is found in the driest sites. It was also described by Koch (1926) as *caricetosum tomentosae* subassociation.

The last variant, *Scorzonera humilis* occurs in more acidic habitats than the previous two and represents a transition to *Junco effusi-Molinietum caeruleae*. Its species composition is very similar to the *Scorzonero-Molinietum* association described by Oberdorfer & Krause (in Oberdorfer 1957) from SW Germany.

Distribution of *Molinietum caeruleae* in the Czech Republic is shown in Fig. 1. It is common in southern and central Bohemia and scattered occurrences are found in the Bohemian-Moravian Uplands, White Carpathians and, unlike *Junco effusi-Molinietum caeruleae*, also in lowlands of the rivers Elbe, Morava and Dyje.

The definition of the *Junco effusi-Molinietum caeruleae* association is "*Succisa pratensis* group AND *Nardus stricta* group AND *Lychnis flos-cuculi* group NOT (*Serratula tinctoria* group OR *Caltha palustris* group)". This definition is more complex because species group *Succisa pratensis* also occurs in other vegetation units, such as the *Caricion fuscae* and *Calthion palustris* alliances; therfore, without its negative part this definition would include a broad range of different grassland habitats. *Junco effusi-Molinietum caeruleae* is confined to nutrient-poor, acidic habitats and characterized by acidophilous species, some of which are included in the *Nardus stricta* group. *Lychnis flos-cuculi* group contains species of the *Molinietalia* order, which are missing in the *Caricion fuscae* alliance. Relevés assigned to this association were not allowed to contain species of the *Caltha palustris* group in order to eliminate relevés of the *Angelico-Cirsietum palustris* association (*Calthion* alliance), and species of *Serratula tinctoria* group to eliminate relevés of *Molinietum caerulae*.

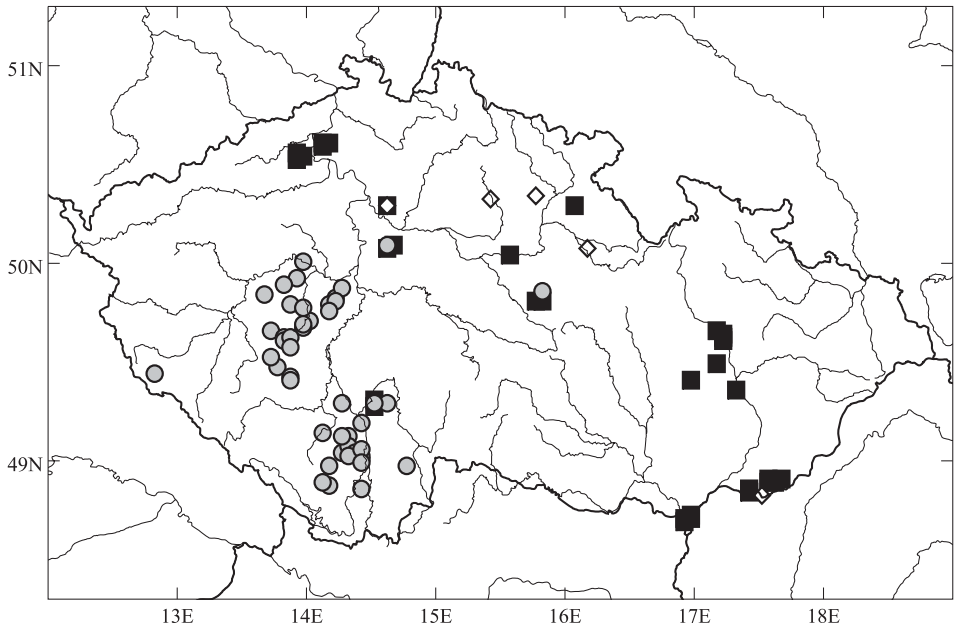

Fig. 1. Distribution of the *Molinietum caeruleae* association in the Czech Republic. Symbols: ■ – *Molinietum caeruleae* var. *Bromus erectus*, ◇ – *Molinietum caeruleae* var. *Carex hostiana*, ◯ – *Molinietum caeruleae* var. *Scorzonera humilis*

Junco-Molinietum caeruleae was described by Preising (in Tüxen & Preising 1951) from W Germany. However, Preising's description is invalid because it contains neither phytosociological relevés nor a synoptic table. Relevés with the same association name, corresponding to Preising's description, were published by Tüxen (1954), so the valid name of this association is *Junco effusi-Molinietum caeruleae* Tüxen 1954. In the same year Klapp et al. (1954) also published relevés with the name *Junco-Molinietum caeruleae*, but their relevés contained *Juncus acutiflorus*, so this name should read *Junco acutiflori-Molinietum caeruleae*. This vegetation represents a transitional type to the *Crepido-Juncetum acutiflori* association and belongs to the *Calthion* alliance.

Two variants were distinguished in *Junco effusi-Molinietum caeruleae*. The variant *Valeriana dioica* occurs in wetter sites and often contains species of *Caricion fuscae* and *Calthion* alliances. The variant *Leucanthemum vulgare* is found in drier sites and is characterized by the occurrence of species typical of *Nardus* grasslands or mesic meadows. Both variants were described by Tüxen (1954) – the variant *Valeriana dioica* as *Comarum palustre* form and the variant *Leucanthemum vulgare* as *Sieglingia decumbens* form.

Fig. 2 shows the distribution of *Junco effusi-Molinietum caeruleae* in the Czech Republic. It is frequent in southern and central Bohemia and in the summit area of the N Bohemian-Moravian Uplands. It is also scattered in the mountains along the national border, but is very rare in Moravia.

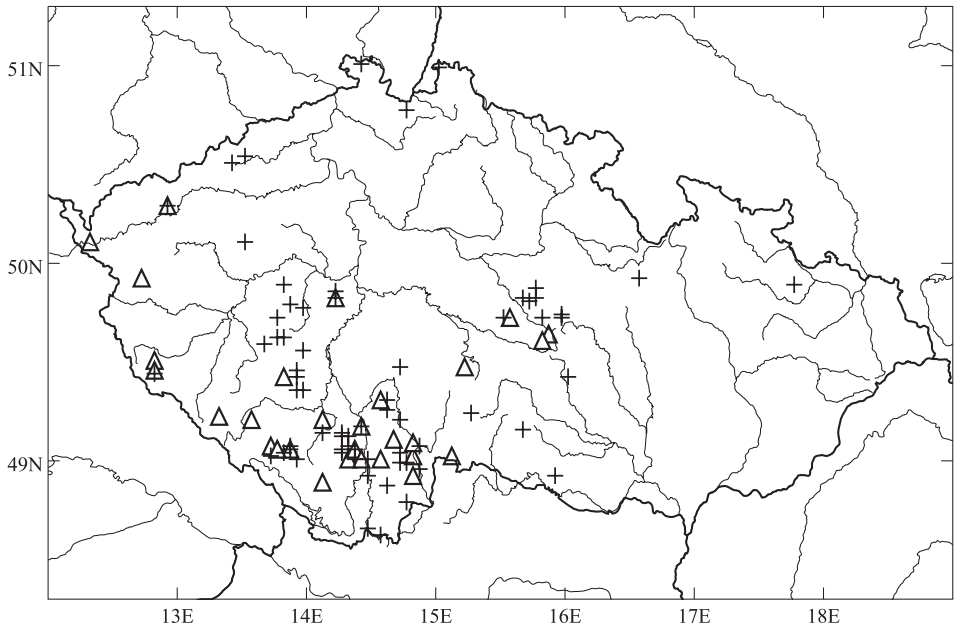

Fig. 2. Distribution of the *Junco effusi-Molinietum caeruleae* association in the Czech Republic. Symbols: + – *Junco effusi-Molinietum caeruleae* var. *Leucanthemum vulgare*, △ – *Junco effusi-Molinietum caeruleae* var. *Valeriana dioica*.

The diagnostic species of the *Molinion* alliance, its two associations and their variants are shown in a synoptic table (Table 2). They are sorted by decreasing percentage species frequencies. While the diagnostic species of *Molinietum caerulae* include species typical of base-rich soils (e.g. *Betonica officinalis, Galium boreale, Potentilla alba* and *Serratula tinctoria*), diagnostic species of *Junco effusi-Molinietum caeruleae* contain species typical of acidic habitats (e.g. *Luzula campestris* agg. and *Nardus stricta*).

Fig. 3 shows a scatter plot of detrended correspondence analysis based on individual relevés (eigenvalues of the first two axes are 0.427 and 0.226). Ellenberg indicator values and altitude, plotted a posteriori onto ordination diagram, revealed that the major compositional gradient in the Czech *Molinion* meadows positively correlates with soil base status, continentality, temperature and nutrients, and negatively with altitude. It is also reflected in the accepted syntaxonomical classification. Distribution of relevés in the ordination diagram shows a continuous transition between the associations. Relevés of the *Scorzonera humilis* variant (*Molinietum caeruleae* association), which represent this transitional type, contain both species typical of base-rich and acidic soils, the latter being characteristic of *Junco effusi-Molinietum caeruleae*. Although the relevés of the *Carex hostiana* variant occur in base-rich habitats they are also found in the middle part of ordination diagram. This is due to the absence of dry grassland species. This variant occurs in wetter habitats and therefore is shifted along the second axis, which correlates with moisture.

Table 2. Synoptic table of *Molinion caeruleae* associations and their variants. Diagnostic species of alliance, associations and also of variants are shaded and ranked by decreasing percentage frequencies. Diagnostic species of associations were based on a comparison with all the other relevés in the data set, those of variants with all the other relevés of the association. 1 – *Molinietum caeruleae* var. *Carex hostiana*, 2 – *Molinietum caeruleae* var. *Bromus erectus*, 3 – *Molinietum caeruleae* var. *Scorzonera humilis,* 4 – *Junco effusi-Molinietum caeruleae* var. *Valeriana dioica*, 5 – *Junco effusi-Molinietum caeruleae* var. *Leucanthemum vulgare*.

Column	1	2	3	4	5
Number of relevés	8	54	66	31	82
Molinion caeruleae					
Succisa pratensis	88	76	76	81	94
Molinia caerulea agg.	100	87	85	77	70
Scorzonera humilis	.	11	53	39	41
Molinietum caeruleae					
Galium boreale	88	80	91	16	20
Betonica officinalis	25	80	73	3	10
Serratula tinctoria	100	72	55	.	.
Selinum carvifolia	25	67	45	29	27
Potentilla alba	.	33	3	.	.
Iris sibirica	.	11	15	6	1
Laserpitium prutenicum	.	15	3	3	5
Junco effusi-Molinietum caeruleae					
Potentilla erecta	75	37	77	100	100
Nardus stricta	.	4	44	97	96
Luzula campestris agg.	25	46	83	81	95
Carex pallescens	.	30	44	35	76
Viola canina	.	17	27	13	56
Danthonia decumbens	.	6	14	13	41
Molinietum caeruleae* var. *Carex hostiana					
Pimpinella major	75	9	20	6	10
Carex flacca	62	22	.	6	6
Carex flava agg.	50	4	6	13	6
Salix repens agg.	50	2	.	6	1
Carex davalliana	38	.	5	19	.
Daucus carota	38	6	2	.	.
Carex hostiana	25	.	.	.	.
Campylium stellatum	25	.	.	6	1
Fissidens adianthoides	25	.	.	6	.
Phyteuma orbiculare	25	.	.	.	4
Bupleurum falcatum	25	.	.	.	.
Cirsium acaule	25	.	.	.	.
Taraxacum sect. *Palustria*	25	.	.	.	.
Polygala amarella	25	.	.	.	.
Centaurium littorale	25	.	.	.	.
Inula britannica	25	2	.	.	.
Molinietum caeruleae* var. *Bromus erectus					
Dactylis glomerata	12	74	15	3	9
Galium verum	38	56	18	3	16
Colchicum autumnale	50	54	9	3	7
Filipendula vulgaris	.	54	12	.	1
Cirsium canum	62	50	5	3	1
Arrhenatherum elatius	.	41	5	6	7
Equisetum arvense	12	39	9	23	10
Inula salicina	25	37	.	.	.
Carex tomentosa	25	30	2	.	1
Cirsium arvense	.	30	5	.	1

Column	1	2	3	4	5
Number of relevés	8	54	66	31	82
Bromus erectus	25	30	.	.	.
Festuca rupicola	.	28	.	.	.
Primula veris	.	22	.	.	.
Fragaria viridis	.	20	.	.	.
Carex praecox	.	20	.	.	.
Molinietum caeruleae* var. *Scorzonera humilis					
Holcus lanatus	12	50	83	90	98
Lychnis flos-cuculi	.	44	74	87	90
Avenula pubescens	.	35	67	19	60
Cirsium palustre	12	9	59	84	63
Galium uliginosum	.	7	52	71	67
Carex nigra	.	4	50	77	50
Myosotis palustris agg.	12	.	44	68	50
Climacium dendroides	50	4	44	71	46
Rhytidiadelphus squarrosus	.	2	35	35	45
Anemone nemorosa	.	2	35	26	22
Carex hartmanii	.	.	32	23	4
Achillea ptarmica	.	2	27	16	22
Junco eftusi-Molinietum* var. *Valeriana dioica					
Valeriana dioica	62	2	23	65	23
Agrostis canina	.	2	5	65	24
Carex echinata	.	2	3	55	2
Dactylorhiza majalis	12	4	26	52	16
Juncus filiformis	.	.	3	29	4
Caltha palustris	50	4	14	16	.
Carex dioica	.	.	.	16	.
Tephroseris crispa	.	.	.	16	.
Junco effusi-Molinietum* var. *Leucanthemum vulgare					
Achillea millefolium agg.	62	83	71	45	90
Agrostis capillaris	12	44	44	23	80
Leucanthemum vulgare agg.	25	54	55	32	72
Veronica chamaedrys agg.	.	63	45	13	57
Stellaria graminea	.	43	42	3	48
Other species with higher frequency than 10 %					
Ranunculus acris	75	70	86	97	98
Sanguisorba officinalis	88	81	92	68	85
Rumex acetosa	.	72	83	74	95
Festuca rubra agg.	12	80	83	74	85
Deschampsia cespitosa	38	67	86	71	77
Anthoxanthum odoratum	12	61	77	77	87
Briza media	75	59	70	68	88
Plantago lanceolata	38	61	65	55	84
Centaurea jacea agg.	88	72	79	26	63
Carex panicea	88	28	61	90	77
Lathyrus pratensis	25	76	76	52	43
Ranunculus auricomus agg.	12	46	70	74	59
Cardamine pratensis	25	22	56	71	66
Alchemilla vulgaris agg.	.	33	56	48	63
Poa pratensis agg.	12	63	67	26	43
Festuca pratensis agg.	.	54	73	29	40
Trifolium pratense	12	35	42	45	44
Alopecurus pratensis	.	43	56	26	33
Lotus corniculatus	12	44	35	26	46

Column	1	2	3	4	5
Number of relevés	8	54	66	31	82
Prunella vulgaris	50	39	33	61	34
Cerastium holosteoides	12	41	41	23	43
Festuca ovina agg.	25	13	27	32	59
Vicia cracca	38	50	32	13	29
Trifolium repens	12	13	41	39	34
Leontodon hispidus	12	19	20	32	46
Filipendula ulmaria	50	24	44	35	17
Carex leporina	.	7	32	35	38
Pimpinella saxifraga s.l.	.	22	21	6	41
Aulacomnium palustre	.	2	11	71	40
Juncus conglomeratus	.	13	29	26	33
Angelica sylvestris	12	15	26	45	26
Juncus effusus	.	9	24	42	29
Ajuga reptans	.	33	32	19	16
Rhinanthus minor	.	17	23	10	34
Hypericum maculatum	.	30	15	3	34
Polygala vulgaris	25	2	9	23	44
Campanula patula	.	41	17	.	26
Taraxacum sect. *Ruderalia*	.	35	23	6	22
Ranunculus repens	12	20	24	19	21
Persicaria bistorta	12	26	20	13	18
Carex pilulifera	.	.	2	23	46
Carex hirta	.	31	21	6	16
Lysimachia vulgaris	25	17	17	19	18
Poa trivialis	.	9	30	10	17
Lotus pedunculatus	.	4	23	19	21
Trisetum flavescens	12	31	17	3	7
Plagiomnium affine	.	20	15	.	18
Hieracium umbellatum	.	9	23	3	18
Equisetum palustre	50	6	14	23	13
Carex umbrosa	.	7	18	19	13
Trollius europaeus	38	13	24	3	7
Galium mollugo agg.	25	33	8	.	11
Linum catharticum	25	15	5	26	13
Knautia arvensis agg.	.	26	11	.	13
Cynosurus cristatus	.	7	27	23	2
Lysimachia nummularia	.	33	11	10	5
Thymus pulegioides	.	9	6	6	26
Carex caryophyllea	.	2	12	3	22
Thuidium delicatulum	12	6	15	6	15
Cirriphyllum piliferum	.	2	11	6	21
Crepis mollis s.l.	.	4	12	10	16
Calluna vulgaris	.	4	6	3	24
Ranunculus tuberosus	.	11	8	10	16
Calliergonella cuspidata	25	6	11	23	9
Leontodon autumnalis	25	11	8	13	11
Carex pulicaris	.	.	6	26	17
Trifolium dubium	.	13	11	10	9
Saxifraga granulata	.	2	26	3	6
Calamagrostis epigejos	.	30	9	3	2
Veronica officinalis	.	6	2	6	22
Pleurozium schreberi	.	4	3	10	22

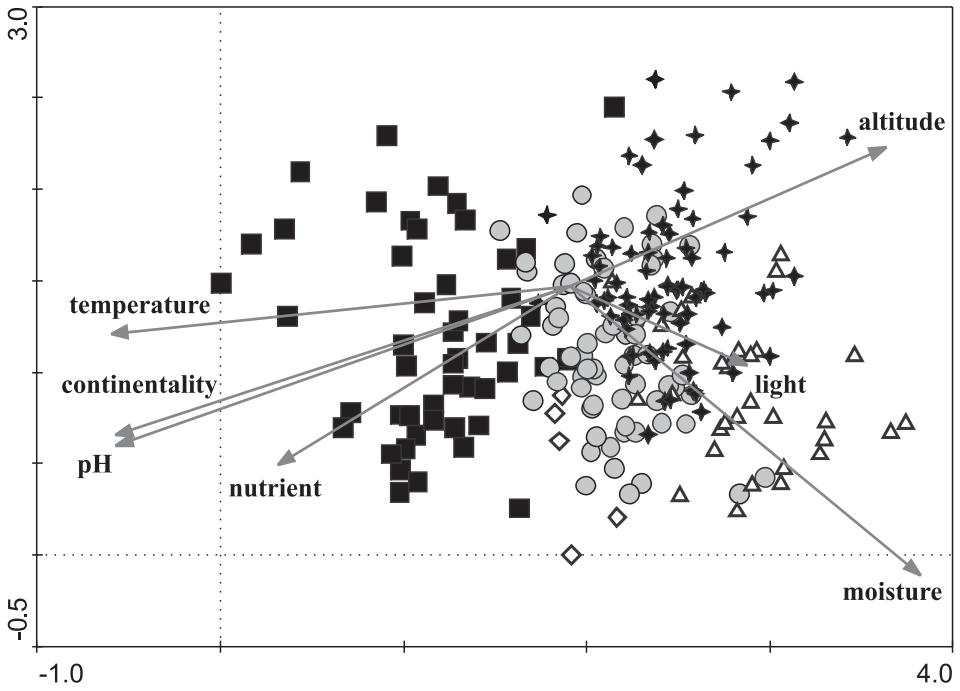

Fig. 3. Detrended correspondence analysis (DCA) ordination diagram of *Molinion caeruleae* relevés. Symbols: ■ – *Molinietum caeruleae* var. *Bromus erectus*, ◇ – *Molinietum caeruleae* var. *Carex hostiana*, ◯ – *Molinietum caeruleae* var. *Scorzonera humilis*, ✦ – *Junco effusi-Molinietum caeruleae* var. *Leucanthemum vulgare*, △ – *Junco effusi-Molinietum caeruleae* var. *Valeriana dioica*. To reveal ecological gradients mean Ellenberg indicator values and altitudes were plotted onto DCA ordination diagram as supplementary environmental variables.

Discussion

Syntaxonomical interpretation of the other Molinion associations reported from the Czech Republic

Besides *Molinietum caeruleae* and *Junco effusi-Molinietum caeruleae*, another eight associations are reported for the Czech Republic (Blažková & Balátová in Moravec et al. 1995, Balátová-Tuláčková 2001). These associations were distinguished by high cover of some species and in the present concept they are mostly synonyms of the two above mentioned associations.

Selino-Molinietum was described by Kuhn (1937) from S Germany. It occurs in base-rich sites and represents a transitional type between the *Molinietum caeruleae* and *Calthion* alliance. Czech authors (e.g. Balátová-Tuláčková 1993a, 1994) assign to this association relevés with a high cover of *Selinum carvifolia* and *Molinia caerulea* agg. However, these species can reach a high cover on both base-rich and acidic soils. Therefore the species composition of some relevés corresponds to *Molinietum caeruleae* and of others to *Junco effusi-Molinietum caeruleae*.

Silaëtum pratensis described by Knapp (1954) from central Germany was distinguished by presence of *Silaum silaus* and included vegetation that belongs to different vegetation units in the current phytosociological classification. Some Czech authors (e.g. Balátová-Tuláčková 1994, Balátová-Tuláčková & Hájek 1998, Vicherek et al. 2000, Balátová-Tuláčková 2001) include in this association relevés with a high cover of *Silaum silaus*. According to species composition some of these relevés belong to *Molinietum caeruleae* and some to *Deschampsion* alliance (Botta-Dukát et al. 2005).

Scorzonero-Molinietum was described by Oberdorfer & Krause (in Oberdorfer 1957) from SW Germany. Its species composition corresponds to *Molinietum caeruleae*, but it contains some montane species (e.g. *Gentiana verna*). Relevés with a high cover of *Scorzonera humilis* from the Bohemian Massif were assigned to this association by Balátová-Tuláčková (1983, 1991). Their species composition corresponds to *Molinietum caeruleae*.

Sanguisorbo-Festucetum commutatae was described by Balátová-Tuláčková (in Balátová-Tuláčková & Zapletal 1959) from N Moravia. Meadows dominated by *Sanguisorba officinalis* or *Festuca rubra* agg. were assigned to this association (e.g. Balátová-Tuláčková 1965, 1974, 1977, 1991, 1993a, 1994, Duchoslav 1997). According to the species composition most of these meadows are degraded or species-poor *Molinion* meadows. Meadows on base-rich soils can be assigned to *Molinietum caeruleae* and those on more acidic soils to *Junco effusi-Molinietum caeruleae*.

Serratulo-Festucetum commutatae was originally described by Balátová-Tuláčková (1966) from S Moravia and included degraded communities of inundated floodplain meadows of *Deschampsion* alliance, colonized extensively by *Festuca rubra* agg. and *Festuca rupicola*. Later on relevés with a high cover of *Festuca rubra* agg. and some *Serratula tinctoria* (usually without *Molinia caerulea* agg.) were assigned to this association (e.g. Balátová-Tuláčková 1975, Kovář 1981, Balátová-Tuláčková 1994, Balátová-Tuláčková & Hájek 1998). Species composition of some relevés assigned to this association correspond to *Molinietum caeruleae*. However, relevés from river floodplains are degraded types of the *Cnidio dubii-Deschampsietum cespitosae* association (*Deschampsion* alliance).

Gentiano pneumonanthis-Molinietum litoralis was distinguished by Ilijanić (1968) from northeastern Croatia by the dominance of *Molinia litoralis*, which is a synonym of *Molinia arundinacea* (Dančák 2002). Also some Czech authors (e.g. Balátová-Tuláčková 1993b, 2000, Balátová-Tuláčková & Hájek 1998, Vicherek et al. 2000) assign to this association relevés with a high cover of the taxon that they determined as *Molinia litoralis*. However, species composition of these meadows corresponds to *Molinietum caeruleae*.

Sanguisorbo-Festucetum pratensis described by Blažková (1973) from S Bohemia developed from meadows of *Molinietum caeruleae* due to more intensive management (fertilization and more frequent mowing). Its species composition corresponds to *Molinietum caeruleae* and only a few nutrient-demanding grasses (e.g. *Alopecurus pratensis*, *Festuca pratensis* and *Poa pratensis*) become abundant.

Galio borealis-Cirsietum cani was described by Balátová-Tuláčková (2001) and includes relevés with a high cover of *Cirsium canum*. According to species composition some relevés can be assigned to *Molinietum caeruleae*, others represent a transitional type to other vegetation units.

Comparison with Molinion meadows in other countries of Central Europe

Different numbers of associations of the *Molinion* alliance are reported from Germany – six by Pott (1995), three by Schubert et al. (2001) and Rennwald (2000). In the newest syntaxonomical revision (Burkart et al. 2004) only one association (*Molinietum caeruleae* Koch 1926) was distinguished. The latter authors include in this association all other associations reported from Germany except *Junco-Molinietum caeruleae* Preising 1951 and *Cirsio dissecti-Molinietum* Sissingh et de Vries ex Westhoff 1949. The *Junco-Molinietum caeruleae* association was not accepted and relevés, which were assigned to this associations by previous authors, were assigned to the *Juncus-Succisa pratensis* community of *Cathion* alliance. According to Burkart et al. (2004) this association has no diagnostic species and its species composition is more similar to that of *Calthion* meadows. In the Czech data set, however, several diagnostic species of *Junco effusi-Molinietum caeruleae* were found (Table 2), so it is supposed that this association is well-founded and belongs to the *Molinion* alliance as it contains species of intermittently wet habitats (e.g. *Molinia caerulea* agg., *Scorzonera humilis* and *Succisa pratensis*), while species typical of *Calthion* meadows, which are included in the *Calthion palustris* group, are almost missing.

Nine associations of the *Molinion* alliance are reported for Austria (Ellmauer & Mucina 1993) and also for Slovakia (Mucina & Maglocký 1985). Most of these associations are the same as those previously reported from the Czech Republic or Germany, and it is possible that some of them will be merged after syntaxonomical revision.

In Hungary, *Molinion* vegetation was analysed by Kovács (1962) who distinguished three associations – *Molinietum caeruleae* Koch 1926, *Junco-Molinietum caeruleae* Preising 1951 and *Molinio-Salicetum rosmarinifoliae* Soó (1933) 1956. The third association includes vegetation in depressions between sand dunes, but its description and syntaxonomical position is not very clear. In addition to these three associations, Borhidi (2003) reported *Arrhenathero-Molinietum arundinaceae* Lájer 2002 association in Hungary. The vegetation of lowland *Molinion* meadows in Hungary, Slovakia and the Czech Republic was recently analysed by Botta-Dukát et al. (2005).

The same associations as reported here for the Czech Republic are reported by Matuszkiewicz (2001) from Poland, but the invalid name *Junco-Molinietum caeruleae* Preising 1951 is used for *Junco effusi-Molinietum caeruleae* Tüxen 1954.

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Souhrn

Byla provedena syntaxonomická revize vegetace luk svazu *Molinion caeruleae* Koch 1926 v České republice. Z původně deseti asociací, které byly z území České republiky uváděny, byly pomocí klasifikační metody Cocktail rozlišeny pouze dvě – *Molinietum caeruleae* Koch 1926 a *Junco effusi-Molinietum caeruleae* Tüxen 1954. Zatímco asociace *Molinietum caeruleae* se vyskytuje na bazičtějších stanovištích, asociace *Junco effusi-Molinietum caeruleae* je vázána na kyselejší stanoviště a je typická přítomností druhů smilkových trávníků. Výsledky této klasifikace byly porovnány s klasifikacemi bezkolencových luk v ostatních zemích střední Evropy.

Pomocí detrendované korespondenční analýzy byly vyhodnoceny hlavní gradienty prostředí, které nejvíce ovlivňují variabilitu druhového složení těchto luk v České republice. K interpretaci gradientů byly použity korelace s Ellenbergovými indikačními hodnotami a nadmořská výška. Hlavní gradient pozitivně koreloval s pH, kontinentalitou, teplotou a živinami a negativně s nadmořskou výškou.

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