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HABITAT PREFERENCES OF A UNIQUE SPECIALIST PLANT SPECIES (*PRIMULA FARINOSA* SUBSP. *ALPIGENA*) IN HUNGARY

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Birdseye primrose (*Primula farinosa* subsp. *alpigena*) is a strictly protected plant species of the Hungarian flora. Natural occurrences of the species are known from two fen meadows situated in a tectonic depression accompanying Lake Balaton. The restoration and management of recipient vegetation have a great importance because of the wide range fluctuation in number of individuals of the species for several years. In 2001 coenological behaviour was examined in classical and meso scale. Field data were collected by modified Zürich-Montpellier method and 1 m × 1 m quadrats as transects marked by environmental gradients with cover estimation by eye collecting presence-absence and quantitative data. Examining the classical and transect quadrats ecological indication, preferences and significance between species and habitats were revealed focusing on Birdseye primrose. In addition 8 soil parameters were analysed in *Primula* rich and *Primula* free sites of the habitats. The aim of our investigation was to broaden the knowledge about the biotic and abiotic habitat preferences of Birdseye primrose. According to our results not only the textural features (e.g. species composition, abundance) are insufficiant to save this species from extinction but the pattern and physiognomy of vegetation have more significance. The tussock-fen window complex provides prominent situation with its nudum surfaces offering favourable abiotic conditions and low competition. The effects of other characteristics of preferential sites (e.g. gap size, litter or moss cover) in micro scale are substantial in all probability. With this knowledge restoration and managing plan were executed focusing on two aspects: the maintenance of population size via directed seed dispersion and plantation and controlling of biotic as well as abiotic factors in the natural habitats.

Key words: associations among species, ecological indication (TB, WB, RB, NB, CB, LB), phytosociological preferences, protection and management, soil preferences, spatial preferences, species frequency preferences, species preferences

INTRODUCTION

Birdseye primrose is a rare species of family Primulaceae in Hungary. It grows a flexible petiole variabled in length within a circle of bright green, oblanceolate to elliptical leaves usually with a white floury coating on the abaxial side. The stem carries an umbel of from 1–10 lilac-pink flowers of typical *Primula* structure (Tutin *et al*. 1972). Some features in its habit are represented like at species in the mountains, e.g. subcaulescentia and the extension of the umbel (Borbás 1900). The chromosome number of *Primula farinosa* subsp. *alpigena* is usually 2*n* = 18, rarely 2*n* = 36 (Soó 1968).

Birdseye primrose has a disjunct area with two bigger patches in Central and Northern Europe, subsp. *alpigena* mainly in the Alps and in the Carpathians at height of 370 to 2,900 m. Smaller areas are in the mountains of Southern Europe. This species has many extinct and synatrop occurrences in Europe as well (Meusel *et al*. 1978). Birdseye primrose is a circumpolar flora element (Horvát *et al*. 1995), typical in taiga belt, respectively, in montane needle-leaves forest zone in Hungary. This country is situated in oak forest zone, where elements of the taiga belt occurred as boreal relict plant species in special habitats (i.e. peat bogs and fen meadows) and the climatic gradient of oceanic influence in Europe measured by the vascular plants at stage of 4 (many subcontinental and occasional continental but still some suboceanic species) in the western part of the country (Ellenberg 1988). Owing to draining of boreal relict plant species' habitats for several decades in Hungary Birdseye primrose has been died out from numerous natural sites (e.g. Borbás 1900, Polgár 1912, Gáyer 1914, Csapody 1935).

On the basis of relative ecological indicator values (Borhidi 1995) Birdseye primrose is regarded as one of the species of montane needle-leaves forest or taiga belt (TB4), plants of moist soils tolerating short floods (WB8), basiphilous plants (RB8), light plants, photosynthetic minimum above 40% rel. intensity, less only in exceptional cases (LB8), suboceanic species, mainly in Central Europe but reaching to East (KB4), plants of habitats very poor in nitrogen (NB2). According to Ellenberg's indicator values *Primula farinosa* is classified as a L8, Tx, K4, F8, R9, N2 species (Ellenberg *et al*. 1991). The main differences are in values of temperature (T, TB) and that of soil reaction (R, RB).

In view of vegetation characteristics of Birdseye primrose in Central Europe (Ehrendorfer *et al*. 1973) it is occurring in Österreich, Lichtenstein, Czechoslovakia, Germany, Switzerland, northern Italy, northwest of Jugoslavia and western half of Hungary. This species lives in marshes and damp meadows, mainly in the mountains of Europe (Tutin *et al*. 1972).

This species is characteristic in Caricion davallianae (incl. *Orchio-Schoenetum nigricantis*, *Juncetum subnodulosi*, *Seslerietum uliginosae* and *Molinietum coeruleae caricetosum hostianae*) and known as the eponym of *Primulo-Schoenetum* in Hungary (Soó 1968). Natural occurrences of Birdseye primrose are on plane sites in stands of fen meadows (s. str. *Orchio-Schoenetum nigricantis*, *Seslerietum uliginosae*) and calcareous wet meadows (*Succiso-Molinietum hungaricae*) (Kovács 1962, Borhidi and Sánta 1999). Because of these reasons Birdseye primrose is a strictly protected and a unique specialist plant species in Hungary (Simon 1988, Borhidi 1995).

Nowadays this plant species is existing only with two populations near Lake Balaton. At present *Primula farinosa* subsp. *alpigena* is living in *Junco obtusiflori-Schoenetum nigricantis* and *Succiso-Molinietum hungaricae schoenetosum* in Kál- and Tapolca-basin (Salamon-Albert 1996, Salamon-Albert *et al*. 2002). These areas are distinguished from the point of nature conservation because of the hydrological and geological properties, soil types, large number of protected species and vegetation complexes: mosaic of wet meadows and dry grasslands. Owing to depression of karstic water level, fluctuation and yearly dynamics of precipitation, resulted changing in soil structure and human impacts these are potentially endangered areas (Salamon-Albert *et al*. 2001).

MATERIAL AND METHODS

Our aim was to reveal the biotic and abiotic preferences of Birdseye primrose in its two natural habitats in order to establish a broader basis for natural protection and management.

The study areas are situated in Kál-basin (A) and Tapolca-basin (B) in the middle of Transdanubia nearby Lake Balaton. Their lowest points rise only about 50–70 m above the surface of the lake (135–140 m a.s.l.). The base rock is Triassic limestone locally covered by pebble giving shelter to subterranean or outbursting springs through karstification processes. The subterranean karstic water as well as the precipitation distribution with two peaks in a year (6th–7th and 11th months) and the peat soil created the possibility of calcareous wet meadow community formation to come into exist. As a result of melioration activities in the early 1980s, the areas were cut by water canals by which rapid transformation of the vegetation was initiated.

In 2001 coenological behaviour was examined on classical and meso scale. Field data were collected by modified Zürich-Montpellier classical phytosociological method (4 m × 4 m) and quadrats (1 m × 1 m) as transects marked by environmental gradients with per cent cover estimation by eye collecting presence/absence and quantitative data (Kent and Coker 1992). Examining the phytosociological samples coenological preferences and ecological indication of the sites were revealed. Presence of species, their frequency and spatial preferences of Birdseye primrose were revealed parallel with the investigation of the differences in vegetation of the habitats.

The Zürich-Montpellier samples were represented in summarising coenological tables displaying main phytosociological groups, constancy values (I–V) of the species and the range of cover both of the habitats comparing

Primula rich and *Primula* free sites. Moreover these samples were analysed by the Ellenberg's ecological indicator values modified for the Hungarian flora (TB, WB, RB, NB, CB, LB) (Borhidi 1995) considering presence and quantitative data. Spectra were established making a comparison among *Primula* rich, *Primula* poor and *Primula* free sites. The 1 m × 1 m quadrats were statistically analysed by crosstabs calculated Pearson's correlation to express significance between species distribution of two natural habitats; by chi-square test (χ^2) including Yate's correction (Kent and Coker 1992) as a measure of association between Birdseye primrose and other species in meso scale calculating 2 × 2 contingency tables. Factor analysis was carried out taking into consideration the abundancy of the species, the frequency of which is substantial from the viewpoint of the occurrence of Birdseye primrose. All of statistical analysis was carried out by SPSS 11.0 program package. These quadrats as transects are running across the patches of Birdseye primrose in which spatial distribution of several dominant and typical species were represented.

In addition 8 soil parameters were examined like pH (in diluted solution), humus content (with $K_2Cr_2O_7$, spectrophotometry), $CaCO_3$ content (with Scheibler calcimeter, MSZ 1980), hy_1 (Kuron method with H_2SO_4), capillarity rise, P_2O_5 (Egner–Riehm–Domingo method with ammonium-lactate solution, MSZ 1988), total nitrogen (by H_2SO_4 destruction), and total salt content (by electric conductivity, MSZ 1978) (Buzás 1988). Results are displaying by the means and significance of *Primula* rich and *Primula* free sites in the habitats.

Syntaxonomic nomenclature is based on Borhidi (2003).

RESULTS

Characterisation of the recipient vegetation

Recipient vegetation type of *Primula* rich sites (Table 1) are in the stands of *Orchio-Schoenetum nigricantis* characterised by different representation of various phytosociological groups in the two habitats. There are species displaying with high constancy (V = constant species) in the group of Caricion davallianae, Molinion, Molinietalia and Phragmition in habitat A. In habitat B there are species with high constancy only in Caricion davallianae and one species in the Quercetea robori-petraeae group. This species has a special role in wet meadow communities in habitat succession as a substitution of wet character species (*Molinia hungarica* and *Schoenus nigricans*). A dry grassland contact is represented by the species of Festuco-Brometea group in habitat B like *Holoschoenus romanus*, *Dorycnium herbaceum*, *Anthericum ramosum*. Besides this group an Isoëto-Nanojuncetea species is occurring indicating the extrem-

Table 1

Summarised coenological tables of *Primula* rich and *Primula* free sites in the habitats with phytosociological groups, constancy values (I–V) and cover range of species

Primula rich site (habitat A) cover (%)		95–98	*Primula* rich site (habitat B) cover (%)		75–98	*Primula* free site (habitat A) cover (%)		90–98
Caricion davallianae			Caricion davallianae			Caricion davallianae		
Schoenus nigricans	V	1–4	*Schoenus nigricans*	V	2–5	*Parnassia palustris*	I	+
Primula farinosa	V	+–1	*Primula farinosa*	V	+–1			
Parnassia palustris	IV	+	*Carex lepidocarpa*	III	+			
Carex lepidocarpa	III	+–1						
Carex hostiana	II	+						
Molinion			Molinion			Molinion		
Allium suaveolens	V	+–1	*Sanguisorba officinalis*	I	+	*Sanguisorba officinalis*	IV	1–2
Sanguisorba officinalis	IV	+–3				*Deschampsia caespitosa*	III	1–2
Juncus subnodulosus	IV	+–1				*Allium suaveolens*	II	+–1
Dactylorhiza incarnata	I	+				*Allium angulosum*	I	+–1
						Juncus subnodulosus	I	+–1
Molinietalia			Molinietalia			Molinietalia		
Molinia hungarica	V	2–4	*Equisetum palustre*	IV	+	*Molinia hungarica*	V	+–2
Juncus atratus	V	+–4	*Polygala comosa*	IV	+	*Cirsium rivulare*	V	1–2
Succisa pratensis	V	1–2	*Molinia hungarica*	III	2	*Cirsium canum*	IV	+–2
Valeriana dioica	V	+–1	*Achillea millefolium*	III	+	*Ranunculuc acris*	IV	+–1
Carex panicea	V	+–1	*Succisa pratensis*	II	+	*Carex panicea*	II	+–2
Linum catharticum	III	+	*Carex panicea*	I	2	*Succisa pratensis*	II	+
Centaurea jacea	II	+	*Achillea millefolium*	I	+	*Juncus atratus*	I	+–1
Centaurium uliginosum	II	+	*Juncus atratus*	I	+	*Genista tinctoria*	I	+
Cirsium canum	II	+	*Linum catharticum*	I	+	*Holcus lanatus*	I	+
Thalictrum flavum	II	+				*Linum catharticum*	I	+
Briza media	I	+–1				*Lychnis flos-cuculi*	I	+
Colchicum autumnale	I	+				*Valeriana dioica*	I	+
Phragmition			Phragmition			Phragmition		
Cladium mariscus	V	+–2	*Cladium mariscus*	IV	+–2	*Phragmites australis*	V	+
Phragmites australis	V	+–1	*Oenanthe aquatica*	III	+–1	*Lythrum salicaria*	IV	+–1

Table 1 (continued)

Lythrum salicaria	IV	+	*Equisetum fluviatile*	III	+	*Equisetum fluviatile*	I	+
Equisetum fluviatile	I	+	*Epilobium tetragonum*	II	+			
			Lythrum salicaria	I	+			
			Phragmites australis	I	+			
Festuco-Brometea			Festuco-Brometea			Festuco-Brometea		
Chrysanthemum leucanthemum	I	+	*Dorycnium herbaceum*	II	+–1	*Koeleria cristata*	I	+–1
			Holoschoenus romanus	II	+–1	*Arabis hirsuta*	I	+
			Anthericum ramosum	I	+–1	*Centaurea sadlerana*	I	+
			Dianthus pontederae	I	+	*Cerastium brachypetalum*	I	+
			Thesium linophyllon	I	+	*Filipendula vulgaris*	I	+
Quercetea robori petraeae			Quercetea robori petraeae			Quercetea robori petraeae		
Molinia arundinacea	I	3	*Molinia arundinacea*	V	+–3	*Molinia arundinacea*	V	4–5
Artemisietea			Artemisietea			Artemisietea-Chenopodietea		
Sonchus arvensis	III	+–1	*Solidago canadensis*	III	+–1	*Solidago canadensis*	IV	+–2
Solidago canadensis	I	+				*Cirsium vulgare*	III	+–1
Tanacetum vulgare	I	+				*Sonchus arvensis*	III	+–1
						Calystegia sepium	I	+
						Carduus acanthoides	I	+
						Chenopodium strictum	I	+
Indifferent species			Indifferent species			Indifferent species		
Potentilla erecta	V	+–2	*Eupatorium cannabinum*	V	+–1	*Eupatorium cannabinum*	V	+–2
Serratula tinctoria	V	+–2	*Galium verum*	V	+–1	*Lysimachia vulgaris*	V	+–1
Cirsium palustre	V	+–1	*Potentilla erecta*	V	+	*Potentilla erecta*	V	+–1
Mentha aquatica	V	+–1	*Serratula tinctoria*	V	+	*Serratula tinctoria*	IV	1–3
Galium verum	IV	+–1	*Inula salicina*	IV	+–1	*Cirsium arvense*	IV	+–1
Inula salicina	IV	+–1	*Tetragonolobus maritimus*	IV	+–1	*Galium verum*	IV	+–1
Agrostis stolonifera	III	+	*Mentha aquatica*	IV	+	*Agrostis stolonifera*	III	+–2
Eupatorium cannabinum	III	+	*Festuca arundinacea*	III	+–1	*Angelica sylvestris*	III	+–2
Carex distans	II	+–1	*Calamagrostis epigeios*	II	+	*Mentha aquatica*	III	+–2
Carex flacca	II	+–1	*Juncus effusus*	II	+	*Allium scorodoprasum*	II	+–1
Juncus compressus	II	+–1	*Leontodon hispidus*	II	+	*Poa angustifolia*	II	+–1
Tetragonolobus maritimus	II	+–1	*Agrostis stolonifera*	I	1	*Ambrosia elatior*	II	+

Table 1 (continued)

Angelica sylvestris	II	+	*Lysimachia vulgaris*	I	+	*Taraxacum officinale*	II	+
Dactylis glomerata	II	+	*Plantago media*	I	+	*Inula salicina*	I	3
Daucus carota	II	+	*Silene vulgaris*	I	+	*Calamagrostis epigeios*	I	1
Galium mollugo	II	+	*Taraxacum officinale*	I	+	*Carex distans*	I	1
Lysimachia vulgaris	II	+				*Caltha palustris*	I	+
Taraxacum officinale	II	+				*Carex flacca*	I	+
Thalictrum lucidum	II	+				*Daucus carota*	I	+
Juncus articulatus	I	+–1				*Festuca arundinacea*	I	+
Allium scorodoprasum	I	+				*Galium mollugo*	I	+
Calamagrostis epigeios	I	+				*Lotus corniculatus*	I	+
Centaurea pannonica	I	+				*Lycopus europaeus*	I	+
Cirsium arvense	I	+				*Ranunculus repens*	I	+
Festuca arundinacea	I	+				*Stenactis annua*	I	+
Leontodon hispidus	I	+				*Trifolium repens*	I	+
Lycopus europaeus	I	+				*Vicia cracca*	I	+
Plantago lanceolata	I	+						
Achillea asplenifolia (Festuco-Puccinellietea I, +)			*Samolus valerandi* (Isoëto-Nanojuncetea I, +)			*Rosa canina* (Prunetalia spinosae II, +–1)		
Achillea collina (Festuco-Puccinellietea I, +)			*Alnus glutinosa* (Alnetea glutinosae I, 1–2)			*Rubus caesius* (Prunetalia spinosae II, +–1)		
Rosa canina (Prunetalia spinosae I, +)						*Crataegus monogyna* (Prunetalia spinosae I, +)		
Ligustrum vulgare (Querco-Fagetea III, +)								

ity of the habitat. Appearance of the small shrubs (*Rosa canina*, *Ligustrum vulgare*) in habitat A and the bigger ones (*Alnus glutinosa*) in habitat B is a marking for change. The Festuco-Puccinellietea group including *Achillea asplenifolia* and *A. collina* verifies a greater movement of the water table in habitat A. This is a big set of indifferent species with high constancy (V, IV), especially in habitat A in which many species have small values of abundance (I, II).

In the vegetation of *Primula* free sites in habitat A there is only one of Caricion davallianae species (*Parnassia palustris*) with very low constancy. Elements of Molinion and Molinietalia are more numerous than in *Primula* rich sites. There are more and mass species in the group of Artemisietea-Chenopodietea like *Solidago canadensis*, *Cirsium vulgare*. The Quercetea robori-petraeae species (*Molinia arundinacea*) is a "monopolist" in this vegetation.

Ecological indication in classical scale: TB, WB, RB, NB, CB, LB histograms

Ecological indicator spectra by presence data show similar appearance in the case of *Primula* free *(A) and Primula* poor (A) or rich (A, B) sites (Fig. 1). The difference appears only in the category of WB10 (plants of frequently flooded soils) which has a higher importance in *Primula* rich habitats. This category is

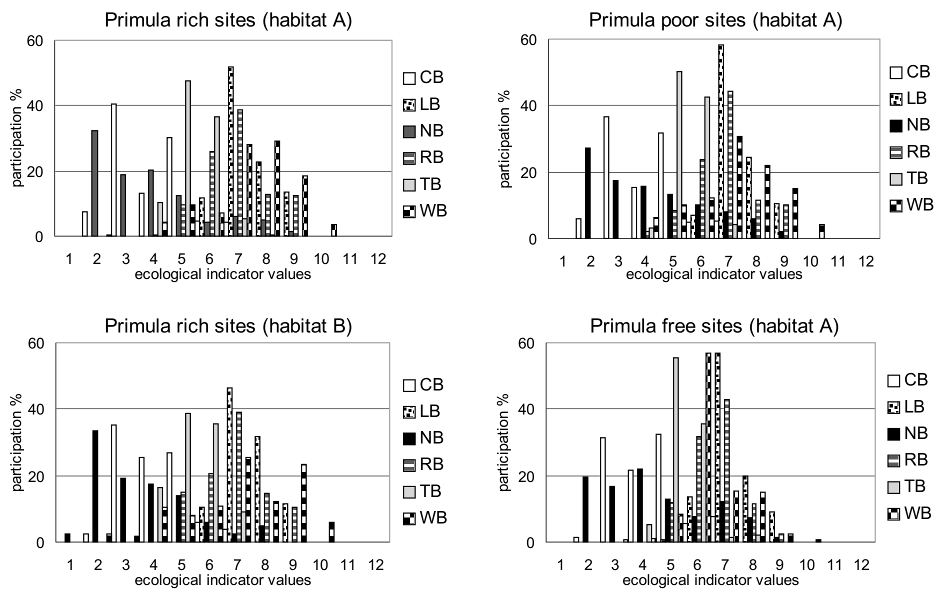

Fig. 1. Spectra of relative ecological indicator values by presence/absence data (TB = temperature value, WB = soil moisture value, RB = soil reaction value, NB = nitrogen value, CB = continentality value, LB = light value)

represented with different sets of species in the two natural sites: *Phragmites australis* in habitat A, *Equisetum fluviatile* and *Oenanthe aquatica* in habitat B.

In spectra by quantitative data (Fig. 2) the participation of NB2 (plants of habitats very poor in nitrogen) is increasing from A to B indicating a poor habitat in nutrition, the rate of NB6–7–8 are gradually decreasing. The participation of CB3 (oceanic-suboceanic species, area in whole Central Europe) has a relative high value and the peaks of LB9 (full light plants of open habitats), RB9 (explicitly calciphilous plants and ultra-alkaline specialists) and WB9 (plants of wet not well aerated soils) are the most important in the *Primula* rich habitat (B).

Considering the ecological indicator values of Birdseye primrose (TB4, WB8, RB8, LB8, CB4, NB2) the nitrogen figure (NB2) is closely adjusting the *Primula* rich vegetation spectra. In these sites the *Primula*'s figures related to relative soil moisture, soil reaction, relative light intensity, the continentality and the temperature are differing from the main value of spectra of recipient vegetation (WB9, RB9, LB9, CB3, TB6).

Ecological spectra of *Primula* free habitats are essentially different from *Primula* rich sites. The maximum of WB spectrum is at WB6 (plants of fresh soils) in addition to lower participation at higher values. The soil reaction's

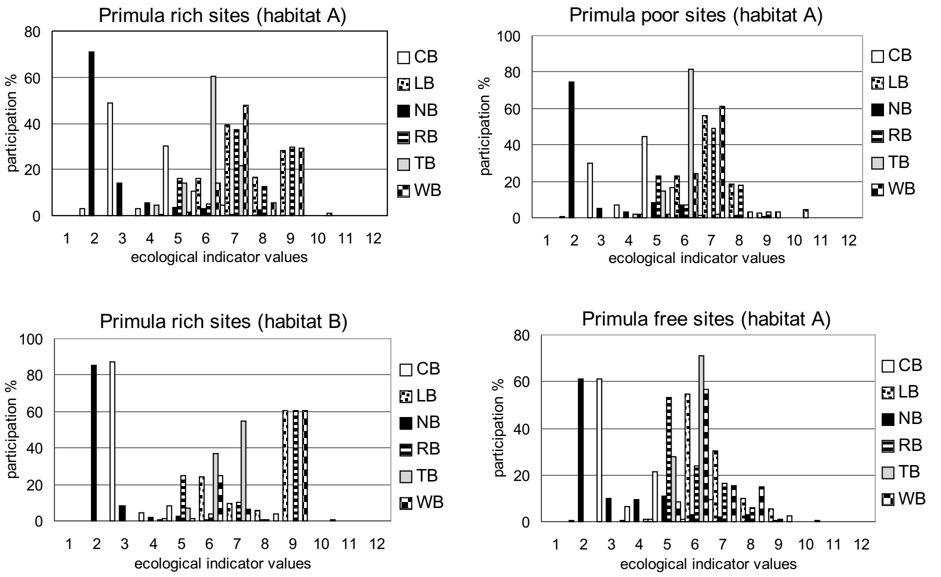

Fig. 2. Spectra of relative ecological indicator values by cover data (TB = temperature value, WB = soil moisture value, RB = soil reaction value, NB = nitrogen value, CB = continentality value, LB = light value)

maximum is displaying at RB5 (plants of slightly acid soils) opposite to the *Primula* rich habitats (RB8–9). Continentality figure's maximum is at CB4 (suboceanic species, mainly in Central Europe but reaching to East) instead of CB3 in the case of *Primula* rich sites.

Species preferences by the associations in meso scale

Analysing 1 m × 1 m quadrats by presence/absence data chi-square test was executed to point out associations between *Primula farinosa* subsp. *alpigena* and other species of the recipient vegetation. The level of significance (*$p < 0.05$, **$p < 0.01$), the observed and expected value of appearance and the type of association (positive or negative) are demonstrated in Table 2.

It is clearly perceptible that 8 species are positively associated at high level with Birdseye primrose in habitat A. *Schoenus nigricans*, *Molinia hungarica* and *Cladium mariscus* are the most important among dominant competitor species, *Valeriana dioica*, *Parnassia palustris* and *Succisa pratensis* are the most important at 0.01 level among the specialists. *Allium suaveolens* and *Juncus articulatus* as frequent species of the habitat are significant at the 0.05 level. Some species which has higher expected value than observed one in occurrence are negatively associated like *Molinia arundinacea*, *Eupatorium cannabinum*, *Solidago canadensis*, *Carex flacca*, *Galium verum* and *Cirsium canum*. There are further numerous positively and negatively associated species with Birdseye primrose at lower significance level (e.g. *Potentilla erecta*, *Angelica sylvestris, Sanguisorba officinalis*).

In habitat B there is no species being significant at high level with Birdseye primrose. *Schoenus nigricans* show the relatively strongest positive significance ($p < 0.2$) and *Equisetum fluviatile* appears as the relatively strongest negatively associated species ($p < 0.7$) in the vegetation.

Table 2

Associations between Birdseye primrose and other species in two habitats by chi-square association (N = 206+31; HAB = habitat: A = Kál basin, B = Tapolca basin; OBSVAL = observed value of appearance; EXPVAL = expected value of appearance; ASSOC = association of species: + = positive, – = negative; SPEC = species; SIGN = significance: ** = $p < 0.01$, * = $p < 0.05$ with one degree of freedom, ns = no significance)

HAB	OBSVAL	EXPVAL	ASSOC	SPEC	SIGN
A	39	33.59	+	*Allium suaveolens*	*
A	39	25.24	+	*Cladium mariscus*	**
A	19	13.20	+	*Juncus articulatus*	*
A	40	33.59	+	*Molinia hungarica*	**
A	11	3.69	+	*Parnassia palustris*	**
A	37	27.57	+	*Schoenus nigricans*	**

Table 2 (continued)

A	27	15.92	+	*Succisa pratensis*	**
A	22	9.71	+	*Valeriana dioica*	**
A	0	6.02	–	*Carex flacca*	**
A	0	4.27	–	*Cirsium canum*	*
A	3	14.37	–	*Eupatorium cannabinum*	**
A	4	11.07	–	*Galium verum*	**
A	8	19.61	–	*Molinia arundinacea*	**
A	1	8.35	–	*Solidago canadensis*	**
A	8	6.41	+	*Cirsium palustre*	ns
A	34	30.68	+	*Juncus atratus*	ns
A	16	15.15	+	*Juncus subnodulosus*	ns
A	2	1.17	+	*Linum catharticum*	ns
A	8	7.77	+	*Lythrum salicaria*	ns
A	28	27.77	+	*Mentha aquatica*	ns
A	40	36.70	+	*Potentilla erecta*	ns
A	35	34.76	+	*Serratula tinctoria*	ns
A	4	2.14	+	*Tetragonolobus maritimus*	ns
A	1	4.66	–	*Angelica sylvestris*	ns
A	0	2.14	–	*Calamagrostis epigeios*	ns
A	14	16.50	–	*Carex panicea*	ns
A	1	1.75	–	*Centaurea jacea*	ns
A	0	1.17	–	*Deschampsia caespitosa*	ns
A	0	1.17	–	*Juncus compressus*	ns
A	6	9.90	–	*Lysimachia vulgaris*	ns
A	26	29.90	–	*Phragmites australis*	ns
A	17	21.75	–	*Sanguisorba officinalis*	ns
A	0	2.33	–	*Thalictrum flavum*	ns
A	0	1.36	–	*Vicia cracca*	ns
B	1	0.58	+	*Centaurea jacea*	ns
B	2	1.45	+	*Eupatorium cannabinum*	ns
B	3	2.42	+	*Galium verum*	ns
B	3	2.71	+	*Molinia arundinacea*	ns
B	2	1.45	+	*Molinia hungarica*	ns
B	2	1.55	+	*Oenanthe aquatica*	ns
B	3	2.90	+	*Schoenus nigricans*	ns
B	2	1.74	+	*Serratula tinctoria*	ns
B	3	2.03	+	*Tetragonolobus maritimus*	ns
B	*1*	*0.48*	+	*Valeriana dioica*	ns
B	0	0.77	–	*Calamagrostis epigeios*	ns
B	1	1.16	–	*Cladium mariscus*	ns
B	0	1.06	–	*Equisetum fluviatile*	ns
B	1	1.84	–	*Inula salicina*	ns
B	0	0.68	–	*Juncus inflexus*	ns
B	2	2.23	–	*Potentilla erecta*	ns
B	1	1.06	–	*Solidago canadensis*	ns
B	1	1.06	–	*Succisa pratensis*	ns

Species frequency differences of the habitats in meso scale

For the sake of participation specification of Birdseye primrose and other species in two habitats, frequency tables were created and compared with the help of SPSS program calculating Pearson's chi-square and significance (Table 3). According to our hypothesis *Primula farinosa* is associated with species having similar status in the recipient vegetation. In our results four groups were emerged by reason of occurrences in the habitats and its significance. 1: species occurring both of the habitats and frequencies are significantly different ($p < 0.05$); 2: species occurring both of the habitats and frequencies are not significantly different ($p > 0.05$); 3: species occurring only one of the habitats and frequen-

Table 3

Dissimilarity of species' frequency in two habitats by Pearson's correlation (N = 206+31; HAB = habitat: A+B = present in both of the habitats, A/B = present only in habitat A or B; SPEC = species; SIGN = significance: ** = $p < 0.01$, * = $p < 0.05$, ns = no significance; REL = relation: AgB = more frequent in habitat A, BgA = more frequent in habitat B, A = present only in habitat A, B = present only in habitat B)

HAB	SPEC	SIGN	REL	HAB	SPEC	SIGN	REL
A+B	*Allium suaveolens*	**	AgB	A/B	*Carex panicea*	**	A
	Calamagrostis epigeios	**	AgB		*Juncus articulatus*	*	A
	Cladium mariscus	*	AgB		*Juncus atratus*	**	A
	Juncus subnodulosus	**	AgB		*Mentha aquatica*	**	A
	Molinia arundinacea	**	AgB		*Sanguisorba officinalis*	**	A
	Molinia hungarica	**	AgB		*Dorycnium herbaceum*	**	B
	Phragmites australis	**	AgB		*Equisetum arvense*	**	B
	Potentilla erecta	**	AgB		*Equisetum palustre*	**	B
	Serratula tinctoria	**	AgB		*Holoschoenus romanus*	**	B
	Solidago canadensis	*	AgB		*Juncus effusus*	**	B
	Equisetum fluviatile	**	BgA		*Juncus inflexus*	**	B
	Galium verum	**	BgA		*Oenanthe aquatica*	**	B
	Inula salicina	**	BgA		*Ononis spinosa*	**	B
	Schoenus nigricans	**	BgA		*Polygala comosa*	**	B
	Tetragonolobus maritimus	**	BgA		*Samolus valerandi*	**	B
A+B	*Achillea asplenifolia*	ns		A/B	*Allium angulosum*	ns	A
	Agrostis stolonifera	ns			*Angelica sylvestris*	ns	A
	Calystegia sepium	ns			*Carex distans*	ns	A
	Carex lepidocarpa	ns			*Carex flacca*	ns	A
	Cirsium arvense	ns			*Carex hostiana*	ns	A
	Eupatorium cannabinum	ns			*Cirsium canum*	ns	A
	Linum catharticum	ns			*Cirsium palustre*	ns	A
	Lysimachia vulgaris	ns			*Cirsium rivulare*	ns	A
	Lythrum salicaria	ns			*Deschampsia caespitosa*	ns	A
	Primula farinosa	ns			*Eleocharis palustris*	ns	A
	Succisa pratensis	ns			*Iris sibirica*	ns	A
	Thalictrum flavum	ns			*Juncus compressus*	ns	A
	Valeriana dioica	ns			*Parnassia palustris*	ns	A

cies are significantly different ($p < 0.05$); 4. species occurring in only one of the habitats and frequencies are not significantly different ($p > 0.05$).

Birdseye primrose was attached to the group of species occurring both of the habitats and frequencies are not significantly different (group 2). Further species belonging to this group are e.g. *Valeriana dioica*, *Succisa pratensis*, *Eupatorium cannabinum*, *Carex lepidocarpa*. These species have no specific role in the vegetation. In the other group (group 1) which contains species occurring both of the habitats and frequencies are significantly different has several dominant and competitor elements like e.g. *Schoenus nigricans*, *Molinia hungarica*, *M. arundinacea*, *Phragmites australis*, *Solidago canadensis*, *Calamagrostis epigeios*. These frequencies are different conforming to the habitats, for instance *Juncus subnodulosus* is more frequent in habitat A and *Schoenus nigricans* is more frequent in habitat B. The third group consist species occurring only one of the habitats and frequencies are significantly different, these are the main characters of the vegetation. In the habitat A *Sanguisorba officinalis*, *Mentha aquatica*, *Carex panicea*, in the habitat B *Holoschoenus romanus*, *Juncus inflexus* and *Oenanthe aquatica* are present as the absolute differential species. In the last group can be principally found plants of the habitat A verifying species richness: e.g. *Carex flacca*, *C. hostiana*, *Deschampsia caespitosa*, *Iris sibirica*, *Parnassia palustris*.

Considering the difference between the two habitats in species composition, it can be registered that the set of absolute character species is greater in habitat B and that of the relative character species is greater in habitat A.

Associations among species in meso scale

Revealing associations among species in the habitats, structure detection by factor analysis were applied to examine the underlying relationship between the species as variables. Principal component analysis as extraction method and Varimax rotation with Kaiser normalisation were applied in data reduction. In preliminary variable selection were executed in order to reduce the number of factors describing the total variance. Species and their factor scores are summarised in a component and a rotated component matrix indicating the strength of species' joining to the group. Factor scores greater or equal than Birdseye primrose has are displayed. Species figuring this value with positive sign are well defined in this component group and species doing with a negative sign are essentially important in absence respect. Variables are mainly taking into consideration have values greater than 0.3 apart from their signs. Components have great importance in which *Primula farinosa* subsp. *alpigena* (PRIMFARI) is occurring with relative (at least 0.16) or absolute (greater than 0.3) big factor score with positive or negative sign. These species are essentially important in species preferences of Birdseye primrose in meso scale. The number of factor was determined by reason of Eigenvalue (< 1).

In habitat A (Table 4) Birdseye primrose has a relative great factor score in component 3 grouping with *Succisa pratensis*, *Juncus articulatus*, *Cladium mariscus* and *Valeriana dioica*. In component 1 and 5 with a smaller *Primula*'s factor score *Molinia hungarica*, *Schoenus nigricans*, *Potentilla erecta*, *Serratula tinctoria* and *Allium suaveolens* are associated with Birdseye primrose moreover. In *Primula* rich component (3) *Sanguisorba officinalis*, *Serratula tinctoria*, *Galium verum* and *Molinia arundinacea*, in *Primula* poor components (1 and 5) *Solidago cana-*

Table 4

Factor weights in component matrix of main species in habitat A (N = 206; extraction method: principal component analysis). The name of species are abbreviated with 8 characters derived from genus and species (e.g. PRIMFARI = *Primula farinosa* subsp. *alpigena*)

	Component					
	1	2	3	4	5	6
SOLICANA	–.793				–.191	
MOLIHUNG	.721		–.164		–.245	–.235
MOLIARUN	–.720	.181	–.371		.187	
EUPACANN	–.689	.268				–.216
SCHONIGR	.685	–.569				
LYSIVULG	–.584				.182	
PHRAAUST	–.526					.459
POTEEREC	.510	.336			.444	
SUCCPRAT	.457	–.282	.328	.234		.225
CAREPANI		.759	.255	–.262		
JUNCARTI		.699	.446		–.164	
JUNCATRA	.277	.546	.263	.187		
LYTHSALI		.506	.270	–.298	–.204	
GALIVERU		.503	–.453	.248		
ALLISUAV	.368	.503			.308	.428
MENTAQUA		.381		.339	.326	–.321
SANGOFFI	.234		–.829			
CLADMARI		–.433	.692			
SERRTINC	.543		–.573	–.259		
VALEDIOI	.322		.533		.243	–.238
PRIMFARI	.304	–.160	.475		.273	
CAREDIST		.252		.644	–.258	–.175
JUNCSUBN	–.508			.206	.523	
INULSALI		.233		.486	–.244	.582

densis, *Molinia arundinacea*, *Eupatorium cannabinum*, *Lysimachia vulgaris*, *Phragmites australis* and *Juncus subnodulosus* are significantly absent. Species absolute positively associated with *Primula farinosa* subsp. *alpigena* are *Valeriana dioica* and *Succisa pratensis*, species definitively negatively associated is *Molinia arundinacea*. Considering factor scores in components 1, 3 and 5, abundancy of e.g. *Solidago canadensis*, *Phragmites australis*, *Juncus subnodulosus*, *Galium verum*, *Sanguisorba officinalis* and *Serratula tinctoria* is correlated with frequency of Birdseye primrose in habitat A.

Regarding the low value of KMO measure of sampling adequacy (0.446) the results mentioned below are informing about the vegetation in habitat B

Table 5

Factor weights in rotated component matrix of main species in habitat B (N = 31; extraction method: principal component analysis and Varimax rotation with Kaiser normalisation-KMO). The name of species are abbreviated with 8 characters derived from genus and species (e.g. PRIMFARI = *Primula farinosa* subsp. *alpigena*)

	Component					
	1	2	3	4	5	6
TETRMARI	.772		–.190			.164
JUNCINFL	–.728		–.253	–.310		
CALAEPIG	–.724	–.172	–.288		.238	
EUPACANN	–.709			.378	.209	
OENAAQUA	.668	.192		–.169	. 360	
SOLICANA	–.608	–.268		.437		
MOLIARUN	.557	.180	.494	.224		
INULSALI	.514		.475		.202	–.218
SCHONIGR		–.813				
EQUIPALU	.222	.801			–.175	
MOLIHUNG	.445	.522	.321	–.226		.275
GALIVERU	.311		.677			
VALEDIOI			.677		–.259	
FESTARUN	–.285		–.600	–.166	–.189	–.226
SERRTINC		–.187	–.594			.398
PHRAAUST	–.195			.858		.178
CENTJACE		–.173		.732	.206	
CLADMARI	.413	.452		.607		–.173
EQUIARVE					.832	
EQUIFLUV		.414		–.275	–.699	
PRIMFARI	.214	–.185			.269	.709
SUCCPRAT		.287		–.190	–.298	.696
POTEEREC	.172	–. 528				–. 534

(Table 5). *Equisetum arvense, Serratula tinctoria, Succisa pratensis* are positively associated in the *Primula* rich component (6). In *Primula* poor component (1) e.g. *Molinia arundinacea, Cladium mariscus, Molinia hungarica, Oenanthe aquatica* and *Tetragonolobus maritimus* are the most important species which are positively associated. The lack of *Equisetum fluviatile* and *Potentilla erecta* in *Primula* rich component (6), the absence of *Juncus inflexus, Calamagrostis epigeios, Festuca arundinacea, Eupatorium cannabinum* and *Solidago canadensis* in *Primula* poor component (1) is characteristic. There is only one species (*Oenanthe aquatica*) absolute positively associated with *Primula farinosa* subsp. *alpigena*. The abun-

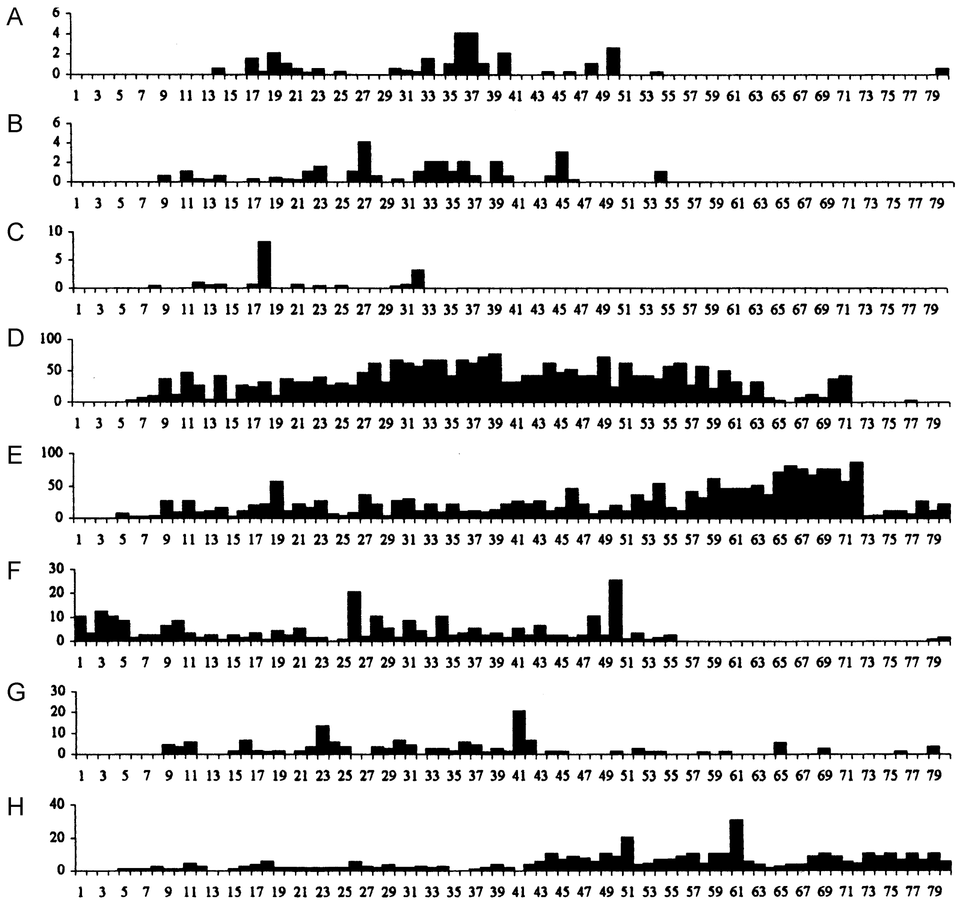

Fig. 3. A–H. Spatial distribution of abundant and specific species in habitat A. (A = *Primula farinosa*, B = *Valeriana dioica*, C = *Parnassia palustris*, D = *Schoenus nigricans* (1), E = *Molinia hungarica* (1), F = *Cladium mariscus* (1), G = *Succisa pratensis* (1), H = *Serratula tinctoria* (2))

dancy of all other positively and negatively associated species correlates with the frequency of Birdseye primrose in habitat B.

Spatial distribution of the species in meso scale

Quadrats ordered in transects represent some site features (e.g. microrelief of the surface and soil moisture) so the distributions of dominant and indicator species could display them. The recipient vegetation in habitat A can

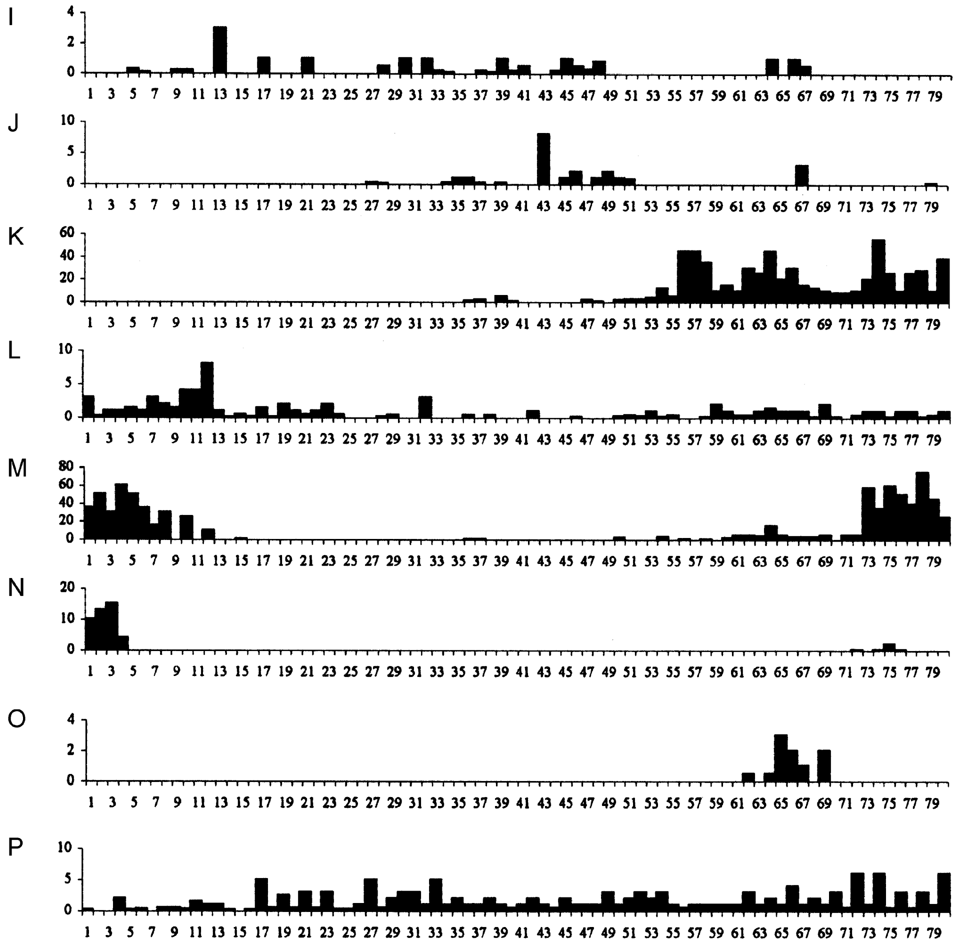

Fig. 3. I–P. Spatial distribution of abundant and specific species in habitat A. (I = *Juncus subnodulosus* (2), J = *Cirsium palustre* (2), K = *Sanguisorba officinalis* (2), L = *Phragmites australis* (2), M = *Molinia arundinacea* (3), N = *Solidago canadensis* (3), O = *Cirsium canum* (3), P = *Potentilla erecta* (4))

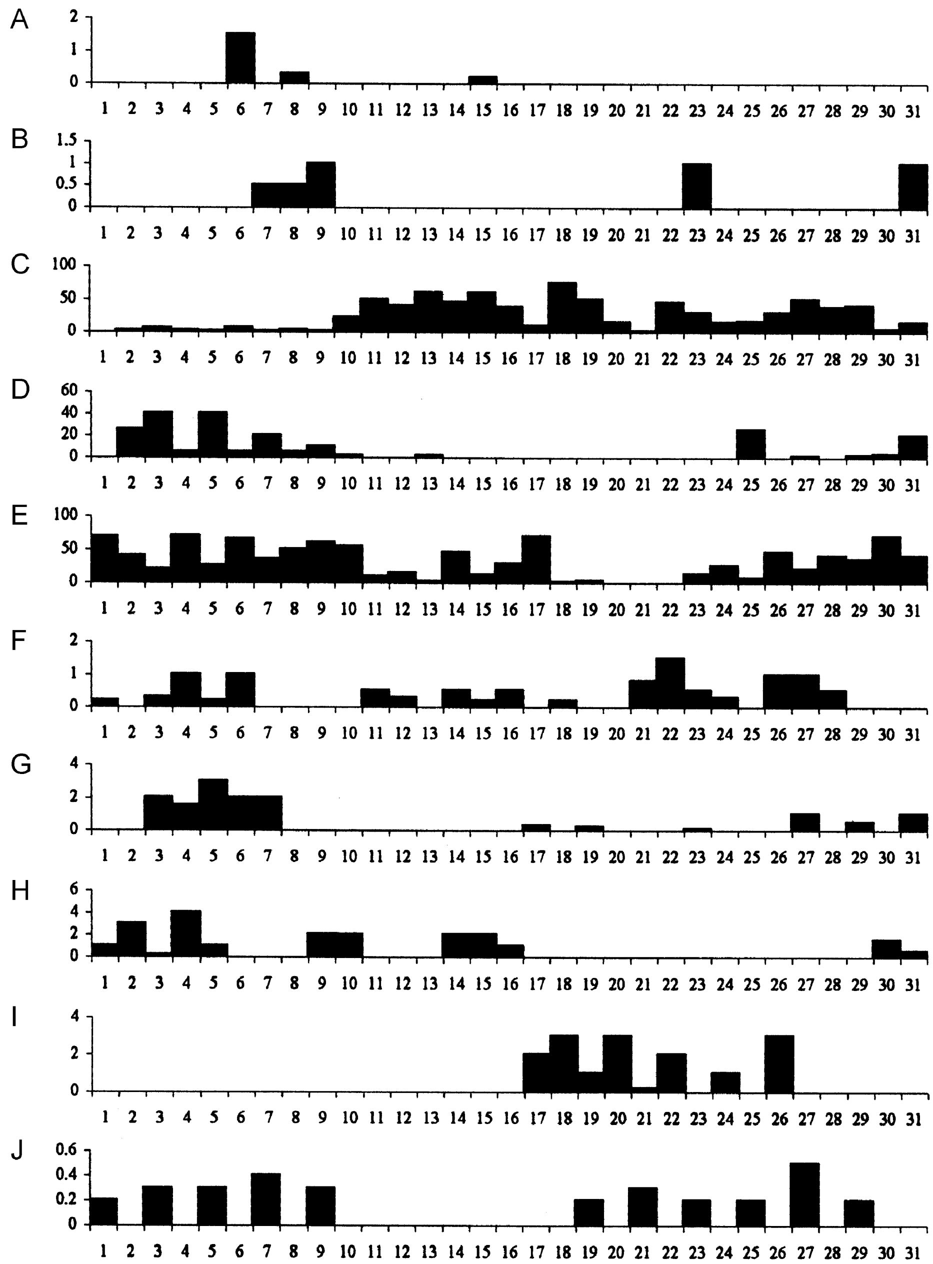

Fig. 4. Spatial distribution of abundant and specific species in habitat B. (A = *Primula farinosa*, B = *Valeriana dioica*, C = *Schoenus nigricans* (1), D = *Molinia hungarica* (1), E = *Molinia arundinacea* (1), F = *Serratula tinctoria* (2), G = *Succisa pratensis* (2), H = *Cladium mariscus* (2), I = *Calamagrostis epigeios* (3), J = *Equisetum fluviatile* (4))

be characterised by *Schoenus nigricans* and *Molinia hungarica* as indicators of higher soil moisture (Fig. 3). Occurrence and abundance of these species are coinciding with the patches of *Primula farinosa*. Some species could be represented with higher abundance (> 10%) like *Cladium mariscus*, *Succisa pratensis* and further more ones have occurred to *Primula farinosa*, like *Carex panicea, Juncus articulatus, J. atratus, J. subnodulosus*. Species occurring with smaller abundancy (< 10%) are *Juncus subnodulosus*, *Cirsium palustre*, *Serratula tinctoria*, *Sanguisorba officinalis* and *Phragmites australis*. Mass of the codominant *Molinia arundinacea* complementing the patches of *Molinia hungarica* shows an avoidance with the presence of Birdseye primrose as well as *Eupatorium cannabinum*, *Cirsium canum* and *Solidago canadensis* in this scale. Occurrence of *Primula farinosa* coincides with the patches of *Valeriana dioica* and *Parnassia palustris*. These species show similar spatial behaviour like Birdseye primrose does.

The recipient vegetation in habitat B can be characterised by *Schoenus nigricans, Molinia hungarica* and *Molinia arundinacea* (Fig. 4). Occurrence and abundance of these species are coinciding with the patches of *Primula farinosa*. Out of them there is no more species represented with higher abundance (> 10%) connecting with Birdseye primrose's patches. *Serratula tinctoria*, *Succisa pratensis* and *Cladium mariscus* are occurring with a smaller abundancy (< 10%). Agressive competitor species (i.e. *Solidago canadensis*, *Calamagrostis epigeios*) are not tolerated by Birdseye primrose. *Equisetum fluviatile* is independent from the occurrence of Birdseye primrose and other wet meadow fen species and presented as an indifferent species of spatial preferences in this scale.

Soil properties as the abiotic preferences

Eight soil properties were analysed and compared in *Primula* rich (PA, PB), *Primula* presence on pioneer surfaces along the channels (PCA) and *Primula* free sites of the habitats (PFA) (Table 6). One-way analysis of variance designed with a single factor was carried out for comparisons of all possible pairs of group and significancy level by pairs calculating mean, standard deviation and variance between and within groups. Result was considered as significant in case $p < 0.05$.

Considering our hypothesis between any of soil properties could be significant difference in PA–PFA, PB–PFA and PA– or PCA–PFA. The pH was slightly alkaline in all of the sites, PCA site was the most basic. Significant difference was proved in pH between PFA–PCA. It can be explained by the intensive vertical water movement accompanied by streaming up of basis along the water channels. In humus content was no significant difference in any sites of the habitats. Values of this parameter justify a high level of organic substance in the soil. In the case of total nitrogen, $CaCO_3$ content, hy_1, total salt content

Table 6

Means and significance of soil properties (pH = pH, HUM = humus %, TOTN = total nitrogen mg/kg, CALC = CaCO3 %, hy1 = hy1, TOTS = total salt %, CAP = capillarity rise mm, PHOS = P_2O_5 mg/kg, PA = *Primula* rich site in habitat A, PB = *Primula* rich site in habitat B, PFA = *Primula* free site in habitat A, PCA = *Primula* rich site along channels in habitat A, SIGN = significance of possible pairs e.g. between PA–PCA, $p < 0.05$, ns = no significance of any possible pairs)

	pH	HUM	TOTN	CALC	hy1	TOTS	CAP	PHOS
PA	7.93	5.97	16,215.65	34.84	6.65	0.54	140.57	39.93
PB	7.96	5.22	4,595.57	10.85	2.08	0.18	238.00	35.40
PFA	7.75	5.42	13,193.44	34.43	5.93	0.46	144.40	31.75
PCA	8.11	5.74	14,742.02	33.57	5.83	0.30	121.38	23.88
SIGN	PFA-PCA	ns	PA-PB	PA-PB	PA-PB	PA-PB	PA-PB	ns
			PA-PFA	PB-PFA	PB-PFA	PA-PCA	PB-PFA	
			PB-PFA	PB-PCA	PB-PCA	PB-PFA	PB-PCA	
			PB-PCA			PFA-PCA		

and capillarity rise many significant pairs were presented between sites and within the habitats. The quantity of total N (complex of organic and inorganic forms) varies on a large scale independing on frequency of Birdseye primrose in habitat A. The most significant difference is between the habitats by $CaCO_3$ content as well as by capillarity rise. In phosphate content was no significant difference any of the sites because of the great standard deviation among samples in a site.

Appearance of Birdseye primrose is not attached with any of studied soil properties. Differences in the habitats are quite frequent as well as the differences in sites of a habitat. Results suggest that *Primula* individuals are existing on pioneer position finding their micro habitats on more alkaline surface as well.

DISCUSSION

At classical scale in *Primula* rich and *Primula* free sites there were differences in participation of certain phytosociological groups as Caricion davallianae, Molinion and Artemisietea. Among ecological indicator values WB and RB scales calculated by quantitative data were confirmed as the differential categories in the case of *Primula* rich, poor and free sites.

By chi-square test as the species preferences at meso scale, there were numerous positively and negatively associated species with Birdseye primrose at high significance level in habitat A (e.g. *Schoenus nigricans*, *Molinia hungarica*, *Cladium mariscus*, *Valeriana dioica*, *Parnassia palustris*, *Molinia arundinacea*, *Eupa-*

torium cannabinum, *Solidago canadensis*), but there was no species being significant at high level with Birdseye primrose in habitat B. Species associated positively significant and are dominant in the habitats occur as a vegetation matrix from the point of *Primula farinosa*. Making allowance for the results of frequency differences and factor analysis Birdseye primrose shows the strongest association with *Valeriana dioica* in both habitats. A characteristic set of species was revealed by the samples of transects, presence (*Cirsium palustre, Molinia hungarica, Schoenus nigricans, Parnassia palustris, Valeriana dioica*) or lack (*Calamagrostis epigeios*, *Molinia arundinacea, Sanguisorba officinalis, Solidago canadensis*) of which has diagnostic value for the spatial occurrence. Besides the detailed knowledge of the classical phytosociological preferences of *Primula farinosa* and the special species composition which follow its population in meso scale.

Considering species preferences in micro scale (Salamon-Albert *et al*. 2001, 2002) *Primula farinosa* did not belong to any of the groups of the species in habitat A, and formed very strong spatial dependence only with seedlings of *Eupatorium cannabinum, Galium verum, Oenanthe aquatica, Solidago gigantea* in habitat B. In accordance with some ephemeral features of this species (e.g. weak competitor, spread by seeds, big reproductive allocation, short life span) establishment of Birdseye primrose's individuals seems to be independent of the species environment and they prefer such microhabitats that have no other plants in their immediate vicinity as seedlings do. Microhabitat preferences show that in habitat A where the canopy of the meadow is more or less closed and can be considered homogeneous from physiognomic point of view, *Primula farinosa* prefers bigger gaps. Comparing the components of the gaps of the random samples and of that ones preferred by *Primula farinosa* it is revealed that Birdseye primrose need a certain size of bare soil (or at the worst surface covered by brown mosses) to establish. Moreover, the individuals of the primrose avoid the gaps containing a considerable amount of litter and the brand new free spaces created by the running stream close to the water in habitat B.

Investigating the microhabitat preferences of the species achieved some remarkable results: parallel with the gradual closing of the canopy of the recipient vegetation caused by tendentious drying of the area because of the disappearing open and large enough gaps the habitat would turn into unsuitable for Birdseye primrose to live still before some significant changes could be detected in the textural features. Evaluating the results derived from the study of the gap components it can be stated that without any vegetation changes only because of the accumulation of the litter establishment of new *Primula*'s individuals could be prevented.

In accordance with our results Birdseye primrose is a special perennial species with a pioneer behaviour. Therefore at preserving of this species habitat parameters of receptive vegetation play a primary role. Protection and management must be focusing on the biotic and abiotic restoration of the habitat by means of increasing the water level, conserving and creating the gaps and decreasing disturbance indicator species.

*

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