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Dactylorhiza incarnata group in the Slovak Karst Mts (Slovakia) and the Aggtelek Karst Mts (Hungary)

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Abstract: Three taxa of *Dactylorhiza incarnata* group were found out in the Slovak Karst Mts and the Aggtelek Karst Mts during 2007–2008. *Dactylorhiza incarnata* subsp. *incarnata* was found in the Aggtelek Karst Mts. in the surroundings of Jósvafö, Szógliget, Perkupa villages, as well as between the Tornanádaska and Komjáti villages. In the Slovak Karst Mts it was recorded in the Hrušov, Silica and Silická Jablonica villages. Two other taxa, *Dactylorhiza incarnata* subsp*. haematodes* and *Dactylorhiza incarnata* subsp. *pulchella*, were found only in the Pod Fabiánkou Nature Reserve near the village of Silica. Neither of these two taxa were published from this area up to this time. Vegetation with occurrence of *Dactylorhiza incarnata* group was arranged to the associations *Angelico sylvestris-Cirsietum oleracei*, *Filipendulo-Caricetum buekii*, *Agrostio stoloniferae-Deschampsietum cespitosae* (*Molinio-Arrhenatheretea*) and *Carici flavae-Cratoneuretum filicini* (*Scheuchzerio-Caricetea fuscae*). In Slovakia, the occurrence of taxa of the *Dactylorhiza incarnata* group in the first three above-mentioned communities was not recorded yet. Up to now, the most of phytosociological relevés with presence of *Dactylorhiza incarnata* group from the territory of Slovakia were

classified within the minerotrophic mire vegetation of the *Scheuchzerio-Caricetea fuscae* class and their successional stages.

Keywords: distribution, ecology, orchids, wetlands, plant communities, central Europe.

Introduction

Dactylorhiza Necker ex Nevski is a Eurasian genus, which includes seven different groups, with a total number of 49 taxa (DELFORGE 1995). The number of taxa is not stable and they are found in varying degrees of acceptance in national floras, for example *Dactylorhiza bohemica* in the Czech Republic (BUSINSKÝ 1989). *Dactylorhiza incarnata* group is the independent group within the genus involving seven closely related taxa (DELFORGE 1995). Five of them grow in Central Europe: *Dactylorhiza cruenta* (O. F. Müll.) Soó, *Dactylorhiza incarnata* subsp. *haematodes* (Rchb.) Soó, *Dactylorhiza incarnata* (L.) Soó subsp. *incarnata*, *Dactylorhiza incarnata* subsp. *pulchella* (Druce) Soó, and *Dactylorhiza ochroleuca* (Boll) Holub. All of the five taxa were recorded in Slovakia (VLČKO et al. 2003). In Hungary, only one species, *D. cruenta* (MOLNÁR et al. 1995, SÁNDOR 1999, VLČKO et al. 2000), has not been registered until now. The *Dactylorhiza* species are listed among rare taxa in varying degrees of threat in both countries (FERÁKOVÁ et al. 2001, KIRÁLY 2007).

VLČKO et al. (2003) published the recent distribution of *Dactylorhiza* taxa in Slovakia as well as their brief vegetation and ecological characteristics. The following information is provided in that paper: *Dactylorhiza cruenta* was distinguished only recently; its occurrence is restricted to a single site in the Spišská kotlina Basin. It grows in calcareous fen meadow. *Dactylorhiza incarnata* subsp. *haematodes* was known only from the lowlands (Záhorie region) and from Carpathian´s basins in the Turiec and Spiš regions up to now. It grows in fens with high content of base cations and in wet meadows. The taxon was found for the first time in the Borská nížina Lowland in the early seventies of the 20th century (PROCHÁZKA & POTŮČEK 1973).

Sites of *Dactylorhiza incarnata* subsp. *incarnata* distribution are scattered from the plains up to the foothills; the most localities are concentrated in the northern part of the territory. It occurs in calcareous fens with high level of groundwater, less often in wet meadows and very rarely in other habitats, e.g. dry grassland sites close to the city of Bratislava (MEREĎA 2003). *Dactylorhiza incarnata* subsp. *pulchella* is known to exist from the lowlands to the foothills. It occurs rarely as compared to the former taxon but these two taxa often grow together. *Dactylorhiza ochroleuca* has been discovered at a single site in the Borská nížina Lowland (ČAČKO 1995). It grows here in the wet meadows of the *Molinion caeruleae* alliance developed on drained mire.

During our research of wetland sites in both Slovak and Aggtelek Karst Mts. we found three taxa from *Dactylorhiza incarnata* group at several localities. However, only a single taxon, *Dactylorhiza incarnata* subsp. *incarnata*

(KARASOVÁ 1997, BAROSS 1998) was published from this area until now. The aims of this survey are (1) supplementing of data about distribution as well as phytosociology of *Dactylorhiza incarnata* group in the study area and (2) comparing them with the current distribution and coenotic affiliation in geographically larger region.

Material and methods

The field study was carried out during 2007–2008. The phytosociological relevés were sampled according to the Zürich-Montpellier approach using the adapted nine-grade Braun-Blanquet's scale (BARKMAN et al. 1964). All relevés were stored in the database, using the TURBOVEG software (HENNEKENS & SCHAMINÉE 2001). Nomenclature of flowering plants follows MARHOLD & HINDÁK (1998) and the names of syntaxa are according to HÁJEK & HÁBEROVÁ (2001), JANIŠOVÁ et al. (2007), DÍTĚ et al. (2007) and JAROLÍMEK et al. (2008). All syntaxa used are mentioned in the text at least once with full author citation. Phytogeographical regions were used according to FUTÁK (1980).

Juice programme (TICHÝ 2002) and modified TWINSPAN algorithm (HILL 1979) were used for the numerical classification and tables adjustment of relevés from Slovak Karst Mts. and Aggtelek Karst Mts. Five pseudospecies cut levels (0, 2, 5, 10, 25) have been applied. As a fidelity measure we applied the modified *phi* coefficient (Tichý & Chytrý 2006). We used 11 relevés with presence of *Dactylorhiza incarnata* group taxa; the results of numerical classification are summarized in Table 1. Relevé No. 4 was moved manually on the basis of species similarity with relevé No. 3. The local diagnostic species were selected subjectively, applying two selection criteria: constancy of diagnostic species was higher than 75% and fidelity was higher than 0.40.

We used both published (KLIKA 1958, ŠMARDA 1961, HÁBEROVÁ 1967, BOSÁČKOVÁ 1974, VLČKO et al. 1996, KAŇOVÁ 1997, HÁJEK 1998, UJHÁZY et al. 1998, KLIMENT et al. 2000a, DÍTĚ & PUKAJOVÁ 2002) and unpublished data of D. DÍTĚ, M. HÁJEK, R. HRIVNÁK, R. ŠUVADA and J. VLČKO from the territory of Slovakia with presence of *Dactylorhiza incarnata* group. We used this data set for analysis of phytosociological affiliation of the mentioned taxa (Tab. 2). In the data set, we merged some narrowly defined species or subspecies as follows: *Alchemilla* sp. (*A. crinita*, *A. micans*, *A. vulgaris*, *A*. sp.), *Carex flava* agg. (*Carex flava*, *C. lepidocarpa*), *Dactylorhiza incarnata* agg. (*D. incarnata*, *D. incarnata* subsp. *pulchella*), *Dactylorhiza majalis* s. lat. (*D. majalis*, *D. lapponica*), *Eleocharis palustris* agg. (*E. palustris*, *E. uniglumis*), *Galium album* s. lat. (*G. album*, *G. mollugo*), *Glechoma hederacea* agg. (*G. hederacea*, *G. hirsuta*), *Gymnadenia conopsea* s. lat. (*G. conopsea*, *G. densiflora*), *Molinia caerulea* (*M. caerulea*, *M. arundinacea*), *Myosotis palustris* agg. (*M. nemorosa*, *M. palustris*, *M. scorpioides*), *Sphagnum recurvum* s. lat. (*S. fallax*, *S. flexuosum*), *Taraxacum* sp. (*T*. sect. *Ruderalia*, *T. palustre*, *T.* sp.), *Valeriana officinalis* agg. (*V. sambucifolia*, *V. officinalis*). We classified our data set using cluster analysis in the PC-ORD 4 program (MCCUNE & MEFFORD 1999), with the relative Sørensen distance as a measure of dissimilarity and the beta-flexible linkage method with

coefficient β = -0.25; species percentage covers were square-root transformed. Crispness of classification procedure (BOTTA-DUKÁT et al. 2005), as available in the JUICE program, was used to determine the optimal number of clusters. Diagnostic species of each cluster were determined using the phi coefficient of association (TICHÝ & CHYTRÝ 2006; $\Phi > 0.2$, Fisher´s exact test at level $P < 0.05$). Detrended correspondence analysis (DCA; centred by species) performed in the CANOCO 4.5 package (TER BRAAK & ŠMILAUER 2002) was used to explain major environmental gradients in species composition. Species percentage covers were square-root transformed and rare species were downweighted. Unweighted Ellenberg indicator values (ELLENBERG et al. 1992) for relevés were plotted onto DCA ordination diagram as supplementary variables.

Results and Discussion

Distribuiton of *Dactylorhiza incarnata* group

Taxa of *Dactylorhiza incarnata* group were recorded at 8 localities (Fig. 1). The most common subspecies was *Dactylorhiza incarnata* subsp. *incarnata*, which grew at all study sites (sites 1–8). *Dactylorhiza incarnata* subsp. *pulchella* occurred only in the Pod Fabiánkou Nature Reserve (locality 5). The most interesting finding was *Dactylorhiza incarnata* subsp. *haematodes*; its occurrence was also found in this area during our research in 2007 (locality 5). It was the first confirmed occurrence of this taxon in Matricum area of Pannonian region in Slovakia. On the Hungarian side of the karst area only nominate subspecies of *Dactylorhiza incarnata* was found.

In Slovakia, the distribution of studied taxa is concentrated in the Carpathian region, but they were dispersively found in the Pannonian region, too (mainly in the Borská nížina Lowland and rarely in the Podunajská nížina Lowland). A substantial part of the sites was located in the central and western part of Slovakia, while the occurrence is extremely rare in the eastern part (POTŮČEK 1990, VLČKO et al. 2003). For this reason, the discovery of new sites in the Slovak Karst is remarkable. While *Dactylorhiza incarnata* subsp. *incarnata* has been reported from this area in the past (KARASOVÁ 1997), the other two taxa identified during our research (*D. incarnata* subsp. *pulchella* and *D. incarnata* subsp. *haematodes*) are new for the territory. All newly recorded sites represent the eastern limit of the known distribution of the species in the Pannonian region. The closest known localities of *Dactylorhiza incarnata* subsp. *incarnata* are in the Drienčany Karst Mts (valley of the Drienok stream), which is located at the border of Pannonian and Carpathian phytogeographical regions (KLIMENT et al. 2000b). The other two taxa have created isolated populations in the Slovak Karst, relatively far from other sites in Slovakia (cf. POTŮČEK 1990, VLČKO et al. 2003). However, only a few kilometres from this place is located the locality in the north-eastern Hungary (Zempléni-hegység) near the village of Regéc (VLČKO et al. 2003). The occurrence of *Dactylorhiza incarnata* group in Hungary has been found in the central (the Danube valley) and the western part of the country, fewer sites were reported in the eastern part. The taxa of this group also

occurred rarely in the north-eastern region of the country, including area of the Aggtelek Karst Mts (MOLNÁR et al. 1995, SÁNDOR 1999).

Synopsis of detected plant communities in the studied karst area, their short characteristics and comparison with phytosociological data at national scale

Molinio-Arrhenatheretea R. Tx. 1937
Molinietalia Koch 1926
Calthion palustris R. Tx. 1937
Angelico sylvestris-Cirsietum oleracei Tüxen 1937 (Tab. 1, rels. 3–4)
Filipendulo-Caricetum buekii Háberová ex Balátová-Tuláčková in Rybníček et al. 1984 (Tab. 1, rels. 5–6)
Deschampsion cespitosae Horvatić 1930
Agrostio stoloniferae-Deschampsietum cespitosae Ujvárosi 1947 (Tab. 1, rels. 7–11)
Scheuchzerio-Caricetea fuscae R. Tx. 1937
Caricetalia davallianae Br.-Bl. 1949
Carici flavae-Cratoneuretum filicini Kovács et Felföldy 1960 (Tab. 1, rels. 1–2)

We have found taxa of the *Dactylorhiza incarnata* group especially in vegetation of wet meadow of the *Calthion palustris* and *Deschampsion caespitosae* alliances. The most common vegetation type with occurrence of the above mentioned taxa were alluvial meadows belonging to the *Agrostio stoloniferae-Deschampsietum cespitosae* association (Table 1, rels. 7–11). These relatively species-rich alluvial meadows were characterised by higher coverage of several grasses (*Festuca pratensis, Deschampsia caespitosa,* and *Poa pratensis*) and dominance of *Cirsium canum*.

Less common were mostly abandoned wet meadows (ass. *Angelico sylvestris-Cirsietum oleracei* and *Filipendulo-Caricetum buekii*), where robust plant species predominated (e.g. *Carex buekii*, *Cirsium oleraceum*, *Filipendula ulmaria* and *Mentha longifolia*). Individuals of the *Dactylorhiza incarnata* group have survived here only due to their massive growth and a relatively good competitive ability. Taxa of the *Dactylorhiza incarnata* group was found rarely in the fen-spring vegetation of the *Carici flavae-Cratoneuretum filicini* association, too (Table 1, rels. 1–2). However, relevé No. 1 represents a significantly changed floristic composition, where several species of close related vegetation of wet meadows occurred (e.g. *Cirsium oleraceum*, *Deschampsia caespitosa*, *Equisetum palustre*, *Mentha longifolia*).

The results of numerical classification of relevés from the territory of the Slovak Karst Mts and Aggtelek Karst Mts showed that taxa of *Dactylorhiza incarnata* group grew in communities of the alliances *Deschampsion caespitosae* (*D. incarnata* subsp. *incarnata*), *Calthion palustris* (*D. incarnata* subsp. *incarnata*, *D. incarnata* subsp. *haematodes* and *D. incarnata* subsp. *pulchella*), and occasionally in the communities of *Caricion davallianae* (*D. incarnata* subsp.

incarnata). However, rare occurrence of the above-mentioned *Dactylorhiza* taxa in the communities of the *Caricion davallianae* alliance was related more to the sporadic presence of the community in the karst regions of Slovakia, than its phytosociological unsuitability for the studied taxa. Vegetation of this alliance occurred on open slope springs saturated by rich mineralized water, where the calcareous sediments are usually created. We can identify several differences comparing the recorded plant communities of *Dactylorhiza incarnata* group with similar vegetation on the territory of Slovakia (Table 2). The dominant type of fen meadow vegetation in Slovakia (clusters 2 – 4) belongs to the *Scheuchzerio-Caricetea fuscae* class or successional types of fen vegetation closely related to the *Calthion* alliance (*Molinio-Arrhenatheretea*). Very rich populations of taxa of the *D. incarnata* group were also recorded in the stands of extremely rich fens with high content of salts in the Spišská kotlina Basin [the *Caricion davallianae* alliance, ass. *Glauco-Trichophoretum pumili* (Šmarda 1961) Vicherek 1973 – see cluster 4]. Most of the phytosociological relevés from this group, however, were obtained in the Carpathian region, particularly from Inner-Carpathian basins and several limestone mountains. In general, presence of this vegetation type is rare in the Pannonian region at present (HÁJEK & HÁBEROVÁ 2001). In Hungary, the taxa of *Dactylorhiza incarnata* group usually occur (similarly to the situation in Slovakia) in calcareous fen and fen meadows (MOLNÁR et al. 1995). On the other hand, vegetation of *Calthion palustris* with the occurrence of studied taxa is rare in Slovakia (Table 2, cluster 1) and they were found only in Drienčany Karst Mts so far (KLIMENT et al. 2000). Climatic, geological and geographical conditions in the Drienčanský kras Mts are similar in several respects to the Slovak Karst Mts. Both areas are characterised by several common phytogeographical and floristic features (KLIMENT et al. 2000b). The occurrence of *Dactylorhiza incarnata* group in vegetation of the *Deschampsion caespitosae* alliance is the first record from the territory of Slovakia at the moment. In the central European region or in Europe in general, *Dactylorhiza incarnata* group grows in diverse vegetation units: the occurrence is rare in plant communities of relatively dry stands and more frequent in plant communities of wet or flooded habitats (PROCHÁZKA & VELÍSEK 1983, DELFORGE 1995, MOLNÁR et al. 1995, SÁNDOR 1999, VLČKO et al. 2003, MIREK & PIĘKOŚ-MIRKOWA 2008, VAKHRAMEEVA et al. 2008).

From the ecological point of view, meadow vegetation of karst areas in southeastern Slovakia and northern Hungary is richer in nutrients, drier, more thermophilic and shade tolerant than vegetation in other parts of Slovakia. In contrast, dominant minerotrophic mire vegetation preferred wetter and sunny habitats, poorer in nutrient content (Fig. 2). Generally, full sun or only slightly shaded habitats with diverse nutrients content in soils are typical for *Dactylorhiza incarnata* group (DELFORGE 1995, VAKHRAMEEVA et al. 2008).

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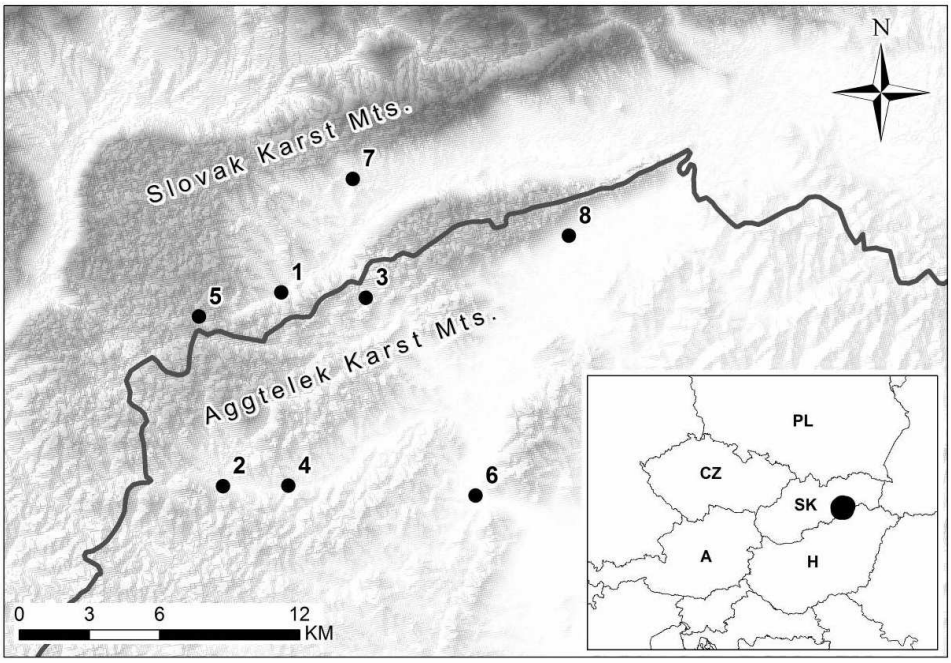

Fig. 1. Map of localities with occurrence of *Dactylorhiza incarnata* group in the Slovak Karst Mts. and the Aggtelek Karst Mts.

Tab. 1. Results of numerical classification of relevés with species of the *Dactylorhiza incarnata* group from the Slovak Karst Mts and the Aggtelek Karst Mts.

Number of relevé:	1	2	3	4	5	6	7	8	9	10	11
Area of relevé m^2	16	16	16	16	16	16	16	16	16	16	16
Total coverage %	90	85	95	100	95	100	85	90	85	75	80
Coverage E_1 %	85	90	90	100	95	100	85	90	75	75	70
Coverage E_0 %	70	80	15	40	60	30	2	2	20	7	15
Number of species:	17	27	31	25	31	26	28	32	39	34	33
Cratoneuron commutatum	**3**	**1**	.	.	.	.	.	.	.	.	.
Eupatorium cannabinum	**a**	**1**	r	.	.	.	.	.	+	.	a
Plagiomnium elatum	**1**	**+**	.	1	.	.	.	.	a	1	1
Equisetum palustre	**4**	**a**	**+**	**3**	+	.	.	.	.	.	.
Mentha longifolia	**1**	**1**	**a**	**1**	.	1	.	.	.	.	1
Galium aparine	.	r	**1**	**1**	.	.	1	1	.	1	.
Scirpus sylvaticus	.	+	**3**	**1**	.	.	.	.	1	+	b
Lathyrus pratensis	.	r	**a**	**b**	a	.	.	.	.	.	.
Lythrum salicaria	.	r	**1**	**1**	.	.	.	+	1	.	.
Carex hirta	a	.	**+**	**a**	.	a	.	.	1	.	1
Rumex acetosa	.	.	**+**	**1**	**1**	**1**	.	+	.	.	.
Filipendula ulmaria	.	+	.	.	**3**	**a**	.	+	.	.	.
Carex buekii	.	.	.	.	**b**	**a**	.	.	.	.	.
Geranium palustre	.	.	.	.	**b**	**1**	.	.	.	.	.
Poa trivialis	1	.	1	.	**a**	**1**	.	.	.	.	.
Ajuga reptans	.	.	+	.	**1**	**1**	.	.	.	.	.
Glechoma hederacea	.	r	+	.	**+**	**1**	.	.	.	.	.
Alchemilla species	.	.	.	.	**1**	**1**	.	.	.	.	.
Cirsium canum	.	.	+	.	.	.	**4**	**3**	**3**	**3**	**a**
Festuca pratensis	.	.	1	b	1	a	**a**	**a**	**1**	**a**	**a**
Deschampsia cespitosa	a	.	.	.	1	.	**a**	**1**	**1**	**a**	**1**
Ranunculus acris	.	.	.	3	1	1	**a**	**1**	**1**	**1**	**1**
Potentilla reptans	.	.	.	.	.	.	**1**	**1**	**+**	**1**	**+**
Poa pratensis	.	.	a	1	.	.	**1**	**1**	**+**	**1**	**1**
Carex vulpina	.	.	.	1	.	.	**+**	**1**	**a**	**+**	**1**
Galium album	.	+	1	.	.	.	**+**	**+**	**1**	**1**	**1**
Lysimachia vulgaris	+	1	.	a	.	.	**+**	**+**	**+**	**+**	**a**
Calliergonella cuspidata	3	3	b	b	4	3	1	1	a	1	a
***Dactylorhiza incarnata* agg.**	**1**	**+**	**+**	**+**	**1**	**r**	**+**	**+**	**1**	**+**	**r**
Lysimachia nummularia	a	.	a	a	a	a	.	3	1	.	1
Ranunculus repens	1	.	a	1	+	1	.	1	a	.	1
Cirsium oleraceum	1	+	a	1	.	3	.	3	.	.	a
Angelica sylvestris	.	+	.	1	+	a	r	3	.	.	+
Lychnis flos-cuculi	.	.	1	.	+	1	1	.	1	1	1
Carex panicea	.	3	.	.	a	.	1	+	+	.	+
Carex acuta	.	.	a	.	.	.	.	+	1	.	+
Trifolium pratense	.	.	.	.	+	.	.	+	1	1	.
Juncus inflexus	.	.	.	.	.	+	.	.	1	a	1
Medicago lupulina	.	.	.	.	.	.	.	+	+	1	+

Occurrence of *Dactylozhiza incarnata* group in relevés: *D. i.* subsp. *incarnata* – 1–11, *D. i.* subsp. *pulchella* – 5, *D. i.* subsp. *haematodes* – 5–6.

Species recorded in three relevés only: *Achillea millefolium agg.* 1 (8), 1 (9), + (11); *Caltha palustris* b (3), + (5), + (10); *Carex tomentosa* + (8), + (9), + (11); *Dactylis glomerata* b (6), 1 (8), 1 (9); *arvense* a (9), 1 (10), 1 (11); *Holcus lanatus* 1 (8), a (9), a (11); *Juncus compressus* + (7), 1 (8), 1 (11); *Equisetum Ononis arvensis* 1 (7), + (9), 1 (10); *Valeriana officinalis agg.* b (4), 1 (7), + (9).

Species recorded in two relevés only: *Alopecurus pratensis* 1 (3), 1 (7); *Brachythecium mildeanum* b (4), 1 (9); *Briza media* 1 (9), 1 (10); *Campylium stellatum* 3 (2), 1 (10); *Cardamine pratensis* r (6), + (11); *Carex acutiformis* 1 (7), 1 (10); *C. flava* + (2), b (5); *Centaurea phrygia* agg. + (3), 3 (10); *Cerastium holosteoides* 1 (6), + (9); *Epilobium hirsutum* + (9), 1 (11); *Festuca rubra* agg. 1 (7), 1 (10); *Galium palustre* + (3), + (10); *Leucanthemum vulgare* agg. + (5), + (9); *Potentilla anserina* 1 (7), 1 (10); *Plantago lanceolata* + (8), 1 (9); *Salix aurita* 1 (1), + (8); *Selinum carvifolia* 1 (7), a (10); *Taraxacum* sp. 1 (6), + (7); *Trifolium repens* 1 (5), + (9).

Species recorded in one relevé only: *Aneura pinguis* 1 (2); *Avenula pratensis* + (5); *Bryum pseudotriquetrum* 1 (2); *Carex distans* + (11), *C. otrubae* a (4); *C. paniculata* 1 (10); *C. praecox* 1 (4); *C. vesicaria* 1 (3); *Cruciata glabra* + (6); *Drepanocladus cossonii* 1 (1); *Epipactis palustris* a (2); *Eriophorum angustifolium* b (2); *E. latifolium* 1 (2); *Fissidens adianthoides* a (2); *Galium rivale* a (5); *G. verum* + (10); *G. uliginosum* + (5); *Juncus conglomeratus* r (5); *Lotus corniculatus* + (10); *Luzula campestris* 1 (5); *Mentha aquatica* + (5); *Mentha arvensis* + (10); *Myosotis palustris* agg. + (3); *Orchis laxiflora* subsp. *elegans* r (7); *Pastinaca sativa* + (9); *Pulmonaria murinii* 1 (3); *Salix fragilis* r (8); *Serratula tinctoria* a (10); *Stellaria graminea* + (8); *Succisa pratensis* 1 (2); *Thalictrum lucidum* r (7); *Trifolium hybridum* 1 (7); *Tussilago farfara* a (1); *Veronica hederifolia* + (6); *V. chamaedrys* r (3); *Vicia cracca* 1 (7); *V. tetrasperma* 1 (4).

Tab. 2. Shortened synoptic table of the plant communities with the presence of *Dactylorhiza incarnata* in Slovakia, based on cluster analysis of relevés, with percentage frequency (constancy) values: 1 – wet meadows and pastures plant communities (*Calthion palustris* and *Deschampsion caespitosae*); 2 – mesotrophic mires, fen meadows with calcitolerant peat mosses and transition plant communities between fens and wet meadows (*Caricetalia fuscae*, *Sphagno warnstorfiani-Tomenthypnion* and *Caricion davallianae* / *Calthion palustris*); 3 – calcareous fens (*Caricion davallianae*); 4 – extremely rich fens, *Caricion davallianae*, as. *Glauco-Trichophoretum pumili*.

Group No.	1		2		3		4	
No. of relevés	13		25		18		2	
Diagnostic species								
Festuca pratensis	**85**	84.1	8	---	.	---	.	---
Lysimachia nummularia	**77**	81.5	4	---	.	---	.	---
Ranunculus repens	**77**	78.6	8	---	.	---	.	---
Lychnis flos-cuculi	**77**	73.4	16	---	.	---	.	---
Poa pratensis	**62**	70.4	4	---	.	---	.	---
Carex hirta	**62**	70.4	4	---	.	---	.	---
Poa trivialis	**54**	68.3	.	---	.	---	.	---
Carex acuta	**46**	62.6	.	---	.	---	.	---
Carex vulpina	**46**	62.6	.	---	.	---	.	---
Scirpus sylvaticus	**62**	60.5	12	---	6	---	.	---
Cirsium oleraceum	**54**	58.2	12	---	.	---	.	---
Potentilla reptans	**38**	56.5	.	---	.	---	.	---
Rumex acetosa	**46**	55.0	8	---	.	---	.	---
Galium album s.lat.	**46**	55.0	8	---	.	---	.	---
Lysimachia vulgaris	**69**	52.4	44	---	.	---	.	---
Mentha longifolia	**54**	51.7	16	---	6	---	.	---
Geranium palustre	**31**	50.0	.	---	.	---	.	---
Alopecurus pratensis	**31**	50.0	.	---	.	---	.	---
Angelica sylvestris	**46**	48.8	16	---	.	---	.	---
Calliergonella cuspidata	**92**	47.9	72	---	39	---	.	---
Carex acutiformis	**31**	45.2	4	---	.	---	.	---
Carex tomentosa	**31**	45.2	4	---	.	---	.	---
Galium rivale	**31**	45.2	4	---	.	---	.	---
Holcus lanatus	**31**	45.2	4	---	.	---	.	---

Tab. 2. – cont.

Group No.	1		2		3		4	
No. of relevés	13		25		18		2	
Juncus inflexus	**46**	45.0	16	---	6	---	.	---
Galium aparine	**38**	44.9	12	---	.	---	.	---
Cirsium canum	**69**	44.8	12	---	.	---	50	---
Ononis arvensis	**23**	42.9	.	---	.	---	.	---
Juncus compressus	**23**	42.9	.	---	.	---	.	---
Epilobium hirsutum	**23**	42.9	.	---	.	---	.	---
Carex otrubae	**23**	42.9	.	---	.	---	.	---
Caltha palustris	**46**	42.5	20	---	6	---	.	---
Ajuga reptans	**31**	41.1	8	---	.	---	.	---
Glechoma hederacea agg.	**31**	41.1	8	---	.	---	.	---
Lythrum salicaria	**46**	41.0	28	---	.	---	.	---
Myosotis palustris agg.	**31**	37.5	12	---	.	---	.	---
Calystegia sepium	**23**	37.5	4	---	.	---	.	---
Ranunculus acris	**77**	34.9	60	15.4	.	---	50	---
Trifolium repens	**15**	34.6	.	---	.	---	.	---
Jacea phrygia agg.	**15**	34.6	.	---	.	---	.	---
Carex buekii	**15**	34.6	.	---	.	---	.	---
Brachythecium mildeanum	**15**	34.6	.	---	.	---	.	---
Valeriana dioica	.	---	**48**	58.7	6	---	.	---
Linum catharticum	.	---	**28**	47.5	.	---	.	---
Carex flava agg.	8	---	**80**	45.3	78	---	.	---
Sesleria uliginosa	.	---	**32**	44.8	6	---	.	---
Equisetum fluviatile	8	---	**28**	38.6	.	---	.	---
Eriophorum latifolium	.	---	**52**	37.6	44	---	.	---
Equisetum palustre	38	---	**72**	35.7	56	---	.	---
Juncus articulatus	.	---	**40**	35.5	28	---	.	---
Jacea pratenis agg.	.	---	**16**	35.4	.	---	.	---
Anthoxanthum odoratum	.	---	**16**	35.4	.	---	.	---
Mentha aquatica	8	---	**24**	34.4	.	---	.	---
Mentha arvensis	15	---	**28**	31.8	.	---	.	---
Pinguicula vulgaris	.	---	.	---	**78**	85.1	.	---
Drepanocladus cossonii	8	---	16	---	**83**	73.8	.	---
Bryum pseudotriquetrum	.	---	28	---	**67**	58.4	.	---
Carex davalliana	.	---	52	---	**78**	55.9	.	---
Primula farinosa	.	---	12	---	**100**	54.4	100	---
Carex limosa	.	---	.	---	**33**	52.2	.	---
Eleocharis quinqueflora	.	---	12	---	**39**	45.3	.	---
Molinia caerulea	.	---	20	---	**44**	44.5	.	---
Carex dioica	.	---	8	---	**33**	43.6	.	---
Phragmites australis	.	---	4	---	**28**	42.3	.	---
Gymnadenia conopsea s. lat.	.	---	4	---	**28**	42.3	.	---
Fissidens adianthoides	.	---	16	---	**39**	42.2	.	---
Carex rostrata	.	---	36	---	**50**	40.1	.	---
Salix repens	.	---	20	---	**39**	39.4	.	---
Valeriana simplicifolia	.	---	4	---	**22**	36.5	.	---
Schoenus ferrugineus	.	---	.	---	**17**	36.1	.	---
Tofieldia calyculata	.	---	.	---	**17**	36.1	.	---
Betula pubescens	.	---	.	---	**17**	36.1	.	---
Parnassia palustris	.	---	32	---	**83**	34.2	100	---
Campylium stellatum	8	---	52	---	**72**	31.0	50	---
Plantago maritima	.	---	.	---	.	---	**100**	100.0
Trichophorum pumilum	.	---	.	---	.	---	**100**	100.0
Glaux maritima	.	---	.	---	.	---	**100**	100.0

Tab. 2. – cont.

Group No.	1		2		3		4	
No. of relevés	13		25		18		2	
Schoenoplectus tabernaemontani	.	---	8	---	.	---	**100**	**94.9**
Blysmus compressus	.	---	.	---	11	---	**100**	**93.1**
Carex distans	8	---	4	---	.	---	**100**	**92.8**
Triglochin maritimum	.	---	8	---	17	---	**100**	**85.8**
Achillea millefolium agg.	31	---	8	---	.	---	**100**	**79.2**
Rhinanthus species	.	---	.	---	.	---	**50**	**65.5**
Odontites vulgaris	.	---	.	---	.	---	**50**	**65.5**
Other species with frequency more than 10% (E0)								
Plagiomnium elatum	38	---	40	---	33	---	.	---
Aneura pinguis	.	---	20	---	22	---	.	---
Aulacomnium palustre	.	---	12	---	28	---	.	---
Homalothecium nitens	.	---	12	---	28	---	.	---
Climacium dendroides	8	---	16	---	11	---	.	---
Cratoneuron filicinum	8	---	16	---	11	---	.	---
Other species with frequency more than 10% (E1)								
***Dactylorhiza incarnata* agg.**	**100**	---	**100**	---	**100**	---	**100**	---
Carex panicea	46	---	80	---	72	---	.	---
Potentilla erecta	.	---	72	**39.3**	83	**52.7**	.	---
Eriophorum angustifolium	15	---	52	---	50	---	.	---
Carex nigra	.	---	52	---	56	---	.	---
Festuca rubra agg.	15	---	48	**3.5**	17	---	100	---
Triglochin palustre	.	---	28	---	44	---	100	---
Briza media	15	---	44	**17.5**	11	---	50	---
Filipendula ulmaria	38	---	40	---	6	---	.	---
Galium uliginosum	15	---	28	---	39	---	.	---
Succisa pratensis	.	---	36	---	39	---	.	---
Cirsium palustre	.	---	32	---	44	---	.	---
Menyanthes trifoliata	.	---	36	---	39	---	.	---
Deschampsia cespitosa	54	**11.6**	16	---	6	---	100	---
Lathyrus pratensis	38	---	32	---	6	---	.	---
Cirsium rivulare	.	---	32	---	28	---	.	---
Sanguisorba officinalis	.	---	32	---	28	---	.	---
Epipactis palustris	.	---	24	---	33	---	50	---
Carex flacca	.	---	24	---	33	---	.	---
Eupatorium cannabinum	31	---	28	---	.	---	.	---
Dactylorhiza majalis s. lat	.	---	28	---	17	---	50	---
Valeriana officinalis agg.	23	---	16	---	17	---	.	---
Polygala amara	.	---	20	---	28	---	.	---
Galium palustre	31	---	16	---	6	---	.	---
Vicia cracca	8	---	24	---	11	---	.	---
Equisetum arvense	23	---	20	---	.	---	.	---
Leucanthemum vulgare agg.	15	---	12	---	17	---	.	---
Carex hostiana	.	---	12	---	28	---	.	---
Carex diandra	.	---	20	---	17	---	.	---
Trifolium pratense	31	**11.9**	8	---	.	---	50	---
Lotus corniculatus	8	---	20	---	6	---	.	---
Cardamine pratensis agg.	15	---	16	---	6	---	.	---
Selinum carvifolia	15	---	4	---	17	---	.	---
Medicago lupulina	31	**13.5**	4	---	.	---	50	---
Galium verum	8	---	20	**29.7**	.	---	.	---
Plantago lanceolata	15	---	16	---	.	---	.	---
Crepis paludosa	.	---	12	---	17	---	.	---
Eleocharis palustris agg.	.	---	12	---	11	---	50	---

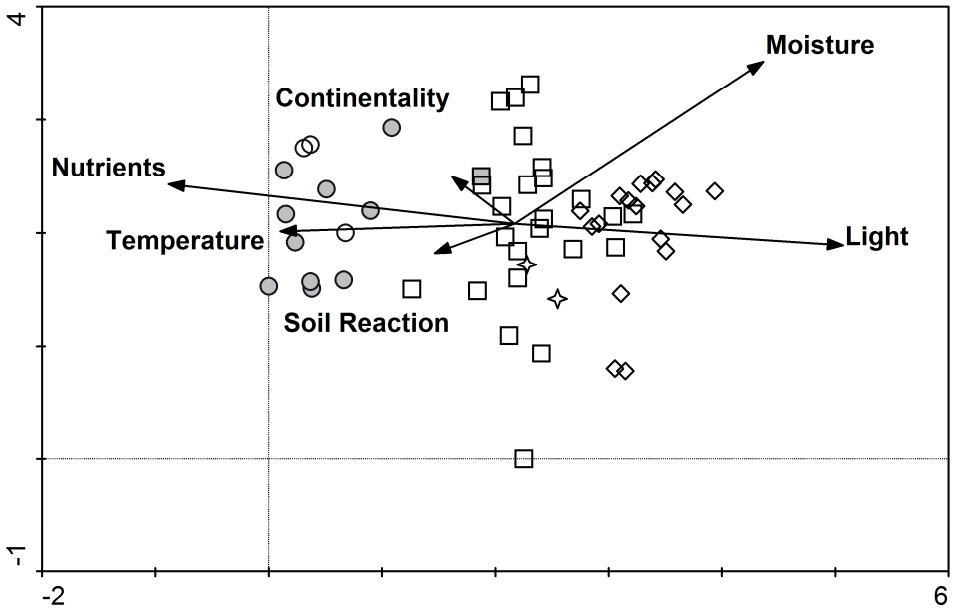

Fig. 2. Detrended correspodence analysis (DCA) ordination diagram of relevés (eigenvalues of the first two axes are 0.574 and 0.267; total inertia 4.626). Average Ellenberg indicator values for relevés were plotted onto DCA ordination diagram as supplementary variables (cumulative percentage variances of species-environment relation for the first two axes are 38.4 % and 50.9 %). Correlation coefficients with the first two DCA axes: Light (0.8888 and -0.0630), Temperature (-0.6332 and -0.0288), Continentality (-0.1687 and 0.1479), Moisture (0.6748 and 0.5222), Soil reaction (-0.2162 and -0.0956), Nutrients (-0.9355 and 0.1188). Empty circles – cluster 1 in Table 2, wet meadows and pastures plant communities (*Calthion palustris* and *Deschampsion caespitosae*); empty squares – mesotrophic mires, fen meadows with calcitolerant peat mosses and transition plant communities between fens and wet meadows (*Caricetalia fuscae*, *Sphagno warnstorfiani-Tomenthypnion* and *Caricion davallianae*/*Calthion palustris*); empty rhomboids – calcareous fens (*Caricion davallianae*); empty stars – extremely rich fens (*Glauco-Trichophorietum pumilii*); shaded symbols – relevés from the studied karst areas.

Appendix 1

A list of localities with presence of *Dactylorhiza incarnata* group species in the Slovak Karst Mts. and the Aggtelek Karst Mts. (see also Fig. 1):

1. Slovakia, Slovak Karst N.P., Silická Jablonica, spring area near gamekeeper's house west from the village; E 20°35'51.04", N 48°33 '13.89"; 4. 6. 2008, ass. *Carici flavae-Cratoneuretum,* relevé 1 in Tab.1.
2. Hungary, Aggtelek N.P., Jósvafö, slope spring area west from the village bellow the road, E 20°32'50.15", N 48°28'58.62"; 5. 6. 2008 , ass. *Carici flavae-Cratoneuretum,* relevé 2 in Tab.1.
3. Hungary, Aggtelek N.P., west from the village of Szögliget, underflooded meadow cca 380 m west from the Vidomáj-puszta site, E 20°38'45.77", N 48°32'49.39"; 5. 6. 2008, ass. *Angelico-Cirsietum oleracei,* relevé 3 in Tab.1.
4. Hungary, Aggtelek N.P., 5 km east from Jósvafó, right side of road in valley of the Jósva-patak stream, E 20°35'06.31", N 48°28'46.2 2"; 5. 6. 2008; ass. *Angelico-Cirsietum oleracei,* relevé 4 in Tab.1.
5. Slovakia, Slovak Karst N.P., Silická planina, Silica, Pod Fabiánkou Nature Reserve, E20°32'52.24", N 48°32'57.54"; 29.5.2007, 4 . 6. 2008; ass. *Filipendulo-Caricetum buekii,* relevés 5 and 6 in Tab.1.
6. Hungary, Aggtelek N.P., valley of the Bodva river near the willage of Perkupa, wet meadow, E 20°41'32.64", N 48°27'53.70"; 5. 6. 20 08; ass. *Agrostio stoloniferae-Deschampsietum cespitosae,* relevé 7 in Tab.1.
7. Slovakia, Slovak Karst N.P., Hrušov, a wetland north from fish ponds, E 20°38'55.40", N 48°35'36.16"; 4. 6. 2008; ass. *Agrostio stoloniferae-Deschampsietum cespitosae,* relevés 8, 9 and 11 in Tab.1.
8. Hungary, Aggtelek N.P., among Tornanádaska and Komjáti, large meadow north from the road, E 20°46'08.09", N 48°33'32.92"; 5. 6. 2008; ass. *Agrostio stoloniferae-Deschampsietum cespitosae,* relevé 10 in Tab.1.

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