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Taxonomy and Distribution of the *Cardamine pratensis* Group (*Brassicaceae*) in Slovenia

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With 4 Figures

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Summary

LIHOVÁ J. & MARHOLD K. 2003. Taxonomy and distribution of the *Cardamine pratensis* group (*Brassicaceae*) in Slovenia. – Phyton (Horn, Austria) 43 (2): 241–261, 4 figures. – English with German summary.

A taxonomic study based on karyological and morphometric analyses of the *Cardamine pratensis* group from Slovenia was performed. Three species were recognized in the area: the diploid *C. matthioli* MORETTI, the tetraploid *C. majovskii*

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MARHOLD & ZÁBORSKÝ and *C. pratensis* L. s.str; within *C. pratensis* L. two cytotypes were revealed, 2n = 30 and 2n = 44. We can confirm the morphological differences reported in previous studies between these taxa; however, morphometric analyses showed Slovenian samples of *C. majovskii* in a somewhat closer position to *C. pratensis* s.str. Diagnostic morphological characters, and a need of investigating several plants from a population for proper determination are stressed. The main distribution of *C. matthioli* lies in N.E. Slovenia, that of *C. majovskii* in Central, and of *C. pratensis* at higher altitudes in W. Slovenia. Some more general remarks on their overall distribution patterns are discussed.

Zusammenfassung

LIHOVÁ J. & MARHOLD K. 2003. Taxonomie und Verbreitung der *Cardamine pratensis*-Gruppe (*Brassicaceae*) in Slowenien. – Phyton (Horn, Austria) 43 (2): 241–261, 4 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Die Taxonomie der *Cardamine pratensis*-Gruppe in Slowenien wurde mittels karyologischer und morphometrischer Analysen studiert. Drei Arten konnten im Gebiet festgestellt werden: *C. matthioli* MORETTI (diploid), *C. majovskii* MARHOLD & ZÁBORSKÝ (tetraploid) und *C. pratensis* L. s.str., bei der zwei Zytotypen gefunden wurden – 2n = 30 und 2n = 44. Morphologische Unterschiede, die in früheren Arbeiten für diese Arten angegeben worden waren, konnten bestätigt werden, obwohl die slowenischen Populationen von *C. majovskii* in den morphometrischen Analysen *C. pratensis* s.str. näher stehen. Morphologische Differentialmerkmale dieser Arten werden angeführt. Für eine richtige Bestimmung sind jedoch immer mehrere Pflanzen aus einer Population zu untersuchen. Die Hauptverbreitung von *C. matthioli* liegt in NE-Slowenien, diejenige von *C. majovskii* in Zentral-, und die von *C. pratensis* in den höheren Lagen von W-Slowenien. Angaben zur allgemeinen Verbreitung werden diskutiert.

Introduction

The *Cardamine pratensis* group is a polyploid species complex widely distributed in Europe, extending eastwards to Asia and represented also in northern Africa and northernmost North America. It comprises perennials characterized by a usually short, vertical rhizome without stolons, dimorphic leaves (basal pinnate leaves form a rosette, cauline ones are usually pinnatisect), racemose inflorescence, white, reddish-violet to purple petals and conspicuous stigma (LÖVKVIST 1956, JONES & AKEROYD 1993). Ecologically they are confined to moist sites, they occur on wet meadows, pastures, stream and river banks or in flood-plain forests (LÖVKVIST 1956, MARHOLD 1994a). Taxonomic difficulty and confusion traditionally surrounding this complex is mainly due to its large chromosomal and morphological variation as well as its phenotypic plasticity. Studies performed on this group in the last decades using morphological, karyological, ecological and molecular approaches have provided insights into this polymorphic group of taxa, contributed to a more unequivocal taxa delimitation, and also brought phylogeny hypotheses (LÖVKVIST 1956, URBANSKA-

Worytkiewicz & Landolt 1974, Landolt 1984, Marhold 1994a, b, 1996, Franzke & Hurka 2000).

In a recent molecular study using several molecular markers (isozymes, RAPD, DNA-sequencing), three lineages were identified, and a historical biogeographic concept was proposed (Franzke & Hurka 2000). According this study, the basalmost lineage comprises two diploid species – *C. rivularis* Schur and *C. penzesii* Ančev & Marhold from the Balkan Peninsula, whereas an Iberian diploid *C. crassifolia* Pourr. represents another old lineage of the group. The rest of the *C. pratensis* group forms a poorly resolved phylogenetically young, derived group proposed to have been evolved in a postglacial time. The derived group includes several diploid to dodecaploid taxa: *C. pratensis* L. s.str. (2n = 2x–6x), *C. matthioli* Moretti (2n = 2x), *C. majovskii* Marhold & Záborský (2n = 4x), *C. dentata* Schult. (2n = 8x–12x), *C. nymanii* Gand. (2n = 8x–10x). Among them, *C. pratensis* s.str. is the most widespread taxon in Europe and composed of several cytotypes, including aneuploid and dysploid chromosome numbers as well (Guinochet 1946, Lövkvist 1956, Urbanska-Worytkiewicz & Landolt 1974, Marhold 1994b). Although attempts to split this highly variable species led to the recognition of an array of taxa (e.g., *C. nemorosa* Lej., *C. latifolia* Lej., *C. udicola* Jord., *C. rivularis* auct. non Schur, *C. pratensis* subsp. *picra* De Langhe & D'hose, *C. pratensis* subsp. *major* Tomšovic), these apparently cannot be regarded more than ecotypes or cytotypes without clear morphological differences or molecular divergence, and therefore should be included within *C. pratensis* s.str. (Landolt 1984, Marhold 1996, Franzke & Hurka 2000).

C. matthioli is a diploid species from the derived group occurring in Central and south-eastern Europe, i.e. in the Carpathians, Pannonia and extending from Piedmont eastwards to Romania and Bulgaria (Lövkvist 1956, Marhold 1994a). Morphometric analyses showed that it is characterized by appressed hairs on the rachis of rosette leaves, deflexed segments of cauline leaves and usually small white flowers (Marhold 1996). Recently, a tetraploid species *C. majovskii* was described, on morphological and molecular grounds supposed to be an autopolyploid derivative of *C. matthioli* (Marhold & Záborský 1986, Marhold 1996, Franzke & Hurka 2000). This taxon is known to occur in the eastern part of Pannonia, the West Carpathians, the East Carpathians (Slovakia, Ukraine, Hungary, Romania), and the South Carpathians (Romania) (Marhold 1994a), and recently it has been also recorded from eastern Austria (Marhold 1999a) and Slovenia (Marhold 1999b).

In the present study we focused on the representatives of the *C. pratensis* group in Slovenia. In the recent edition of Mala Flora Slovenije, the occurrence of *C. matthioli*, *C. majovskii* and *C. pratensis* s.str. is reported (Marhold 1999b), however, these have not been studied in more detail so

far. The objective of this study was to elucidate morphological variation and relationships of Slovenian populations of the *C. pratensis* group, to determine their chromosome numbers and to reveal the distribution patterns of the taxa.

Materials and Methods

For morphometric evaluation, 16 population samples of the *C. pratensis* group originating from Slovenia were collected in 1994 and 2001 (Table 1). Each population sample comprised 15–40 plants, i.e. a total of 390 individuals were investigated morphologically. Plants from each of these localities, and from some additional ones as well (see Table 1) were cultivated at the Institute of Botany, SAS, Bratislava, Slovakia for chromosome number determination. Based on the chromosome data and diagnostic morphological characters revealed in the previous study (Marhold 1996), out of these 16 samples, nine populations represented *C. majovskii*, four populations were identified as *C. matthioli*, and three as *C. pratensis* s.str.

Morphological characters measured or scored on the individual plants were those used in the previous paper dealing with the populations from the Carpathians and Pannonia (Marhold 1996): length of petals (mm), width of petals (mm), length of sepals (mm), length of filaments of longer stamens (mm), length of filaments of shorter stamens (mm), number of cauline leaves, number of segments on the third lowermost cauline leaf, average diameter of 30 pollen grains from flowers in the main inflorescence (μm), number of lateral inflorescences (longer than 1 cm), position of lower segments on the mid-cauline leaves (1 – at least some segments slightly deflexed, 2 – segments spreading in acute angles to the midrib), hairs on the rachis of the rosette leaves (1 – appressed, 2 – hairs absent, 3 – patent), colour of petals (1 – white, 2 – white with pale reddish-violet veins, 3 – reddish-violet or violet-red). For measurement of floral parts a randomly chosen flower from the main inflorescence was removed and its parts freshly attached on a transparent adhesive tape.

In order to get insights into the phenetic relationships among the studied Slovenian populations, cluster analyses based on populations and discriminant analyses based on individual plants as OTUs (operational taxonomic units) were performed. For the cluster analyses, Euclidean distance coefficient was used and different clustering algorithms were applied on populations characterized by average values of character states. Prior to the analyses, the characters were standardized by having zero means and unit standard deviations (Everitt 1986).

Based on the results of the clustering and data on chromosome numbers, canonical and classificatory discriminant analyses were performed using individuals as OTUs and the taxa (*C. matthioli*, *C. majovskii, C. pratensis* s.str.) as groups. The canonical discriminant analysis, an ordination method which weighs characters to maximize between-groups differences, was applied to reveal the level of morphological separation among the taxa. Besides this, we also used non-parametric classificatory discriminant analysis based on the cross-validation procedure to determine how effectively the taxa can be discriminated from each other (Klecka 1980, Krzanowski 1990).

The Slovenian samples were also subjected to comparative morphometric analysis including 84 other-European populations (from the Carpathians and Pannonia), those studied in Marhold 1996: *C. matthioli* (19 samples), *C. majovskii* (23 samples),

Table 1. List of localities of the populations from Slovenia used for morphometric (denoted with codes) and karyological studies.

Cardamine matthioli MORETTI, 2n = 16

MT-sb, Subpanonsko območje, Štajerska, valley between Slovenska Bistrica and Klopce, 275 m, 9659/2, 13 April 1994.

MT-ptu, Subpanonsko območje, Štajerska, between Ptuj and Placar, 240 m, 9561/1, 20 April 2001.

MT-sj, Predalpsko območje, vicinity of Celje, between the Šmartinsko jezero lake and Prekorje, 260 m, 9757/2, 20 April 2001.

MT-cp, Predalpsko območje, vicinity of Celje, between Čeplje and Prekopa, 310 m, 9756/3, 13 April 1994.

Subpanonsko območje, Štajerska, at the road from Majšperk to Rogatec, 300 m, 9760/1, 13 April 1994.

Subpanonsko območje, Štajerska, Slovenske Gorice, Hrastovec, 240 m, 9460/2, 13 April 1994.

Subpanonsko območje, Štajerska, Prlekija, at the road between Ljutomer and Ormož, Pavlovci near Ormož, 205 m, 9563/3, 13 April 1994.

Subpanonsko območje, vicinity of Slovenske Konjice, between Tepanje and Pobrež, 280 m, 9658/2, 20 April 2001.

Subpanonsko območje, Prekmurje, between Bratonci and Dokležovje, 180 m, 9363/3, 13 April 1994.

Cardamine majovskii MARHOLD & ZÁBORSKY, 2n = 32

MJ-ri, Preddinarsko območje, Dolenjska, at the road between Novo Mesto and Ljubljana, near Orkljevec, 250 m, 0156/2, 13 April 1994.

MJ-lb, Predalpsko območje, Ljubljansko Barje, at the road between Ljubljana and Ig, near the fork to Matena, 290 m, 0053/1, 14 April 1994.

MJ-d, Predalpsko območje, vicinity of Ljubljana, Dob near Domžale, 310 m, 9853/1, 13 April 1994, 18 April 2001.

MJ-top, Predalpsko območje, vicinity of Ljubljana, Topole near Mengeš, 340 m, 9853/1, 18 April 2001.

MJ-sod, Dinarsko območje, Sodražica, 540 m, 0253/1, 17 April 2001.

MJ-ss, Preddinarsko območje, Šmarje-Sap, 360 m, 0053/1, 17 April 2001.

MJ-bb, Predalpsko območje, Ljubljansko Barje, Blatna Brezovica, 300 m, 0052/1, 17 April 2001.

MJ-uni, Predalpsko območje, Ljubljana, Rožna dolina, 320 m, 9952/2, 19 April 2001.

MJ-tac, Predalpsko območje, vicinity of Ljubljana, Tacen, 320 m, 9852/3, 18 April 2001.

Predalpsko območje, Poljanska valley, Trebija, 440 m, 9950/2, 15 April 1994.

Subpanonsko območje, Štajerska, Bukošek near Brežice, 162 m, 0059/4, 13 April 1994.

Predalpsko območje, vicinity of Ljubljana, Krumperk, 320 m, 9853/3, 18 April 2001.

Preddinarsko območje, Zgornij Log near Litija, at the river Sava, 240 m, 9954/2, 20 April 2001.

Dinarsko območje, Haasberg castle near Planina, at the river Unica, 460 m, 0151/3, 17 April 2001, (together with *C. pratensis* s.str.).

Predalpsko območje, Stražišče near Kranj, 385 m, 9752/3, 15 April 1994, (together with *C. pratensis* s.str.).

Cardamine pratensis L. s.str.

2n = 30

P30-ra, Predalpsko območje, Radomlje, 330 m, 9853/1, 18 April 2001.

P30-go, Alpsko območje, between Zg. Stranje and Godič, at the Kamniška Bistrica stream, 430 m, 9753/1, 18 April 2001.

Predalpsko območje, Gobovce near Podnart, at the river Sava, 9751/2, 18 April 2001.

2n = 44

P44-cj, Dinarsko območje, Notranjsko, Cerkniško jezero, near Otok, 560 m, 0252/3, 14 April 1994, 17 April 2001.

C. pratensis s.str. (2n = 16, an undescribed morphotype "ucranica" – 5 samples; 2n = 16, *C. rivularis* auct. non SCHUR – 8 samples; 2n = 30 – 12 samples; 2n = 38 – 4 samples; 2n = 44 – 13 samples). For this purpose, cluster analysis was performed in the same way as for the Slovenian populations alone (see above).

Cluster analyses were made using SYN-TAX 2000 (PODANI 2001) and discriminant analysis using the SAS package (SAS 1990a, b). The voucher specimens for both morphometric and karyological analyses are deposited at SAV.

A distribution map of the studied taxa in Slovenia was generated using our own collections (Table 1) and herbarium specimens deposited at LJU. Phytogeographical division follows that used in MARTINČIČ & al. 1999.

Results

Based on the chromosome numbers and evaluation of diagnostic morphological characters revealed in the previous study (MARHOLD 1996) (position of segments on mid-cauline leaves, hairs on the rachis of the rosette leaves), occurrence of three taxa from the *Cardamine pratensis* group was confirmed for Slovenia: *C. matthioli*, *C. majovskii* and *C. pratensis* s.str. (Table 1). Two populations were considered to represent mixed populations of *C. pratensis* s.str. and *C. majovskii* (localities the Haasberg castle and Stražišče), as both plants with appressed and patent hairs were found on these sites. These samples were excluded from further morphometric analyses. Among the populations of *C. pratensis* s.str. two cytotypes were found – a hypotetraploid one with 2n = 30 in three populations, and a single hypohexaploid population with 2n = 44. In the populations of *C. matthioli* only plants with 2n = 16 were found, thus no hyperdiploids were recorded, which can occasionally occur in otherwise euploid populations of this species (MARHOLD 1994b). Similarly, for *C. majovskii* we found invariably the tetraploid chromosome number 2n = 32.

In the cluster analysis using a complete linkage method (other methods gave only slightly different results) two main clusters can be seen on the dendrogram (Fig. 1). The first cluster comprised three populations of *C. matthioli*, whereas the second one included populations of *C. majovskii*, *C. pratensis* s.str. and one population of *C. matthioli*. Within the latter cluster, two subclusters can be recognized – in the first subcluster (left) four samples of *C. majovskii* and one of *C. matthioli* grouped together, in the second one (right) the samples of *C. pratensis* s.str. and remaining samples of *C. majovskii* were placed.

In the canonical discriminant analysis, *C. matthioli* and *C. majovskii* were separated along the first canonical axis (Fig. 2), which accounted for 89.18 % of the variation among groups. As can be seen from the values of total canonical structure, the diameter of pollen grains followed by floral parts sizes (width of petals, length of sepals) had the highest correlations with the first axis, thus these characters contributed most to the division between *C. matthioli* and *C. majovskii* (Table 2). Diploid *C. matthioli* had

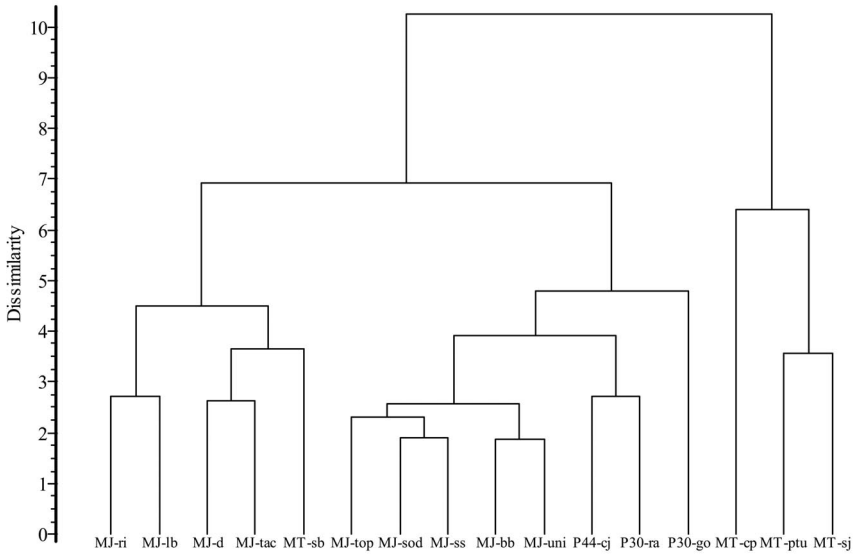


Fig. 1. Cluster analysis (complete linkage) of the Slovenian representatives of the *C. pratensis* group. MT – *C. matthioli*, MJ – *C. majovskii*, P30 – *C. pratensis* s.str. (2n = 30), P44 – *C. pratensis* s.str. (2n = 44). For population codes see Table 1.

smaller petals (8.3–12.4 mm long and 4.1-7.2 mm wide), shorter sepals (3.1–4.0 mm long) and smaller pollen grains (24.7–27.6 μm in average) than *C. majovskii* with petals 9.7–12.8 mm long and 5.6–7.6 mm wide, sepals 3.4–4.5 mm long and pollen grains 29.1–31.3 μm large. On the other hand,

Table 2. Values of the total canonical structure (expressing correlations of characters with canonical axes) obtained from the canonical discriminant analysis based on individual plants of *C. matthioli*, *C. majovskii* and *C. pratensis* s.str. from Slovenia.

character	Can 1	Can 2
diameter of pollen grains	0.950	0.248
number of cauline leaves	–0.117	0.272
number of segments on the third cauline leaf	–0.274	0.384
hairs on the rachis of rosette leaves	0.358	–0.747
position of lower segments on the mid-cauline leaves	0.295	–0.459
width of petals	0.433	–0.070
length of petals	0.300	0.049
length of sepals	0.388	0.026
length of filaments of shorter stamens	0.039	0.424
length of filaments of longer stamens	0.306	0.312
number of lateral inflorescences	–0.240	0.178
colour of petals	0.327	0.087

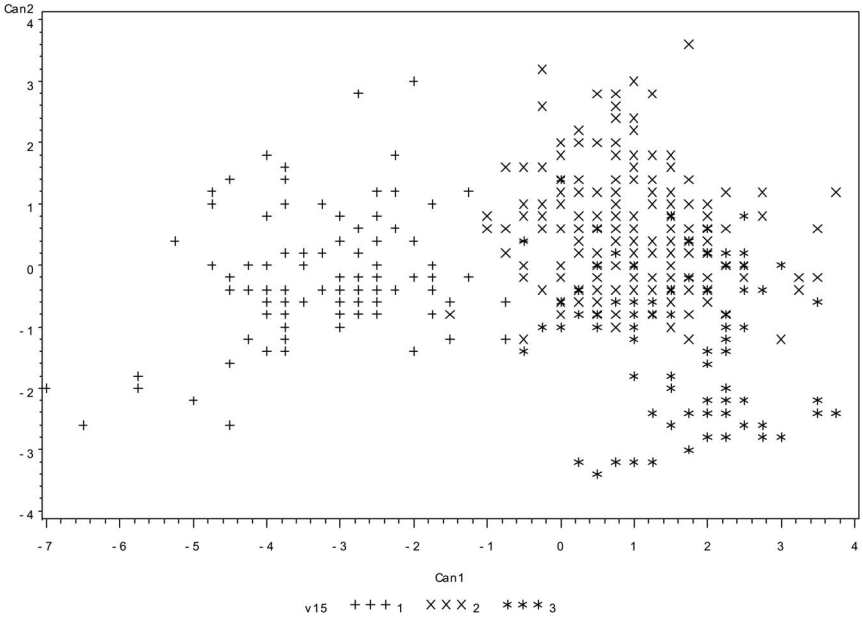


Fig. 2. Canonical discriminant analysis based on individuals of *C. matthioli* (+), *C. majovskii* (×) and *C. pratensis* s.str. (*) from Slovenia. Total canonical structure expressing correlations of the characters with the axes is given in Table 2.

individuals of *C. majovskii* and *C. pratensis* s.str. were intermingled in the ordination graph to a larger extent, although a shift along the second canonical axis between these two taxa was evident (Fig. 2). According to the values of total canonical structure, orientation of the hairs on the rachis of rosette leaves and position of segments on the mid-cauline leaves were the most important characters for differentiation between *C. majovskii* and *C. pratensis* s.str. (Table 2).

Classificatory discriminant analysis yielded results which were in concordance with the canonical ordination. The percentage of correct classification for *C. matthioli* was high, more than 96 % of the specimens were correctly assigned to the predetermined group. As for *C. majovskii* and *C. pratensis* s.str., the number of correctly classified plants was lower, as many as 35 plants out of 207 (17 %) belonging to *C. majovskii* were ascribed to *C. pratensis* s.str., and 11 plants out of 78 (14 %) of *C. pratensis* s.str. were classified as *C. majovskii* (Table 3).

The studied Slovenian populations were also compared with those from the Carpathians and Pannonia studied in detail by MARHOLD 1996. The result of the UPGMA clustering is shown in Figure 3. Two main clusters can be recognized on the dendrogram. Cluster 1 was formed by

Table 3. Classificatory discriminant analysis of Slovenian representatives of the *C. pratensis* group based on individual plants.

Actual group	Predicted group membership (number of individuals and percentage classified into groups)			
	C. matthioli	*C. majovskii*	*C. pratensis* s.str.	total
C. matthioli	**101**	2	2	105
	96.19 %	1.90 %	1.90 %	100.00 %
C. majovskii	1	**171**	35	207
	0.48 %	**82.61 %**	16.91 %	100.00 %
C. pratensis s.str.	0	11	**67**	78
	0.00 %	14.10 %	**85.90 %**	100.00 %

C. matthioli and diploid white-flowered *C. pratensis* ("ucranica" type) samples together with a few populations of *C. majovskii*. Cluster 2 included most of the *C. majovskii* populations from the Carpathians and Pannonia (subcluster 2a), and *C. pratensis* s.str. (2n = 30, 38, 44, *C. rivularis* auct. non SCHUR) together with Slovenian populations of *C. pratensis* s.str. and *C. majovskii* (subcluster 2b). Three populations of *C. matthioli* from Slovenia (MT-cp, MT-ptu, MT-sj) clustered together with other-European samples of this taxon (cluster 1), only one sample (MT-sb) was placed among the Slovenian populations of *C. majovskii* (see also Fig. 1). Two Slovenian populations of *C. pratensis* s.str. (P30-ra, P44-cj) were found morphologically closer to *C. majovskii* from Slovenia than to other *C. pratensis* s.str. populations. Although Slovenian samples of *C. majovskii* clustered at higher level together with *C. pratensis* s.str., they formed two small separate clusters (marked with arrows in Fig. 3).

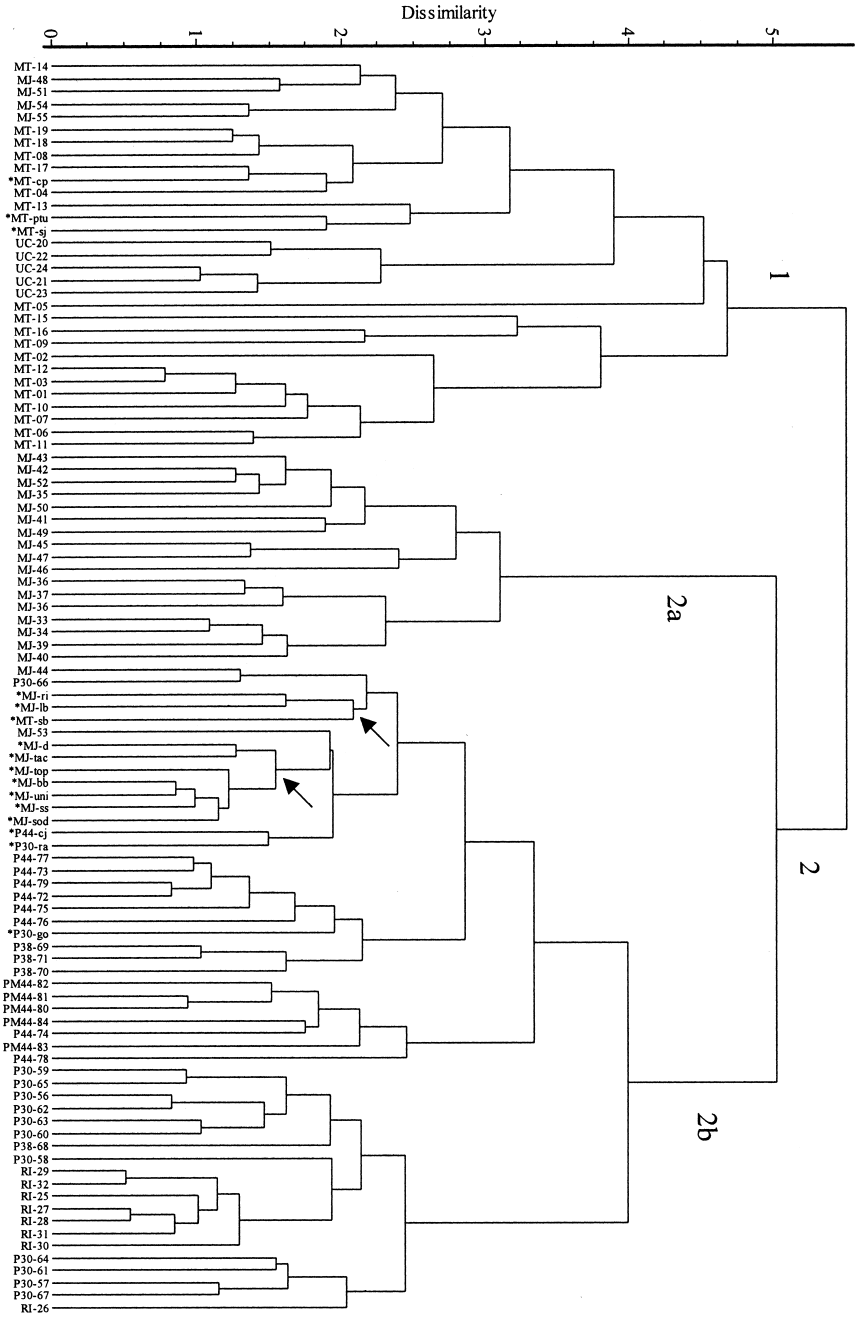
In the Figure 4, the distribution map based on our own collections (Table 1) and on the evaluation of herbarium specimens is presented. As can be seen, the occurrence of *C. matthioli* is concentrated in the Subpannonian north-eastern part of Slovenia, with a few localities extending more to the south (eastern Posavsko Hribovje, the Krka river basin, Bela Krajina). Two isolated localities of *C. matthioli* found in the Ljubljanska kotlina basin need to be mentioned. The tetraploid *C. majovskii* was found to occur mainly in Central Slovenia, south of the Alps (Predalpsko območje) and in the Predinaric region (Fig. 4). *C. pratensis* s.str. grows mostly at higher elevations in Julijske Alpe, Kamniško-Savinjske Alpe, in the mountains of Trnovski Gozd, Javorniki, Bloke and Gorjanci. An interesting region appears to be the Krka river basin between the town of Novo Mesto and the confluence of the rivers Krka and Sava, where all three taxa – *C. matthioli*, *C. majovskii* and *C. pratensis* s.str. meet (Fig. 4).

Herbarium specimens investigated

Cardamine pratensis L. s.str.

9649/1, Julijske Alpe, in paludosis Malo polje dictis ad radices meridionales montis Triglav, 1650 m, 14. 9. 1958, leg. T. Wraber (LJU 68041); 9649/1, Gorenjsko, Julijske Alpe, Velo polje, 1800 m, 22. 8. 1952, leg. E. Mayer & J. Lazar (LJU 59663); 9649/4, Julijske Alpe, Pokljuka, in turfosis Šijec dictis prope Mrzli Studenec, 1200 m, 12. 6. 1969, leg. T. Wraber (LJU 74642); 9650/1, Julijske Alpe, Pokljuka, in pratis prope "Dom na Pokljuki", 1250 m, 29. 5. 1958, leg. M. Wraber (LJU 68039); 9751/2, Gorenjska, na vlažnem travniku na levem bregu Save, 800 m JV od vasi Gobovce, SZ od Kranja, 4. 5. 1996, leg. M. Muhar (LJU 127408); 9751/2, Gorenjska, na košenem travniku na S od delu griča Brdo nad vasjo Podbrezje, SZ od Kranja, 470 m, 3. 4. 1994, leg. S. Teran (LJU 125541); 9752/3, na gojenem travniku pri naselju Čirče JV od Kranja, 370 m, 26. 4. 1995, leg. S. Rozman (LJU 126943); 9750/2, Julijske Alpe, Jelovica, Ledince, 1100 m, 14. 9. 1968, leg. A. Martinčič (LJU 63691); 9753/3, vlažni travnik ob gozdu v naselju Tunjiška mlaka, 50 m od glavne ceste proti J in 50 m od mostu čez Tunjščico v Tunjicah pri Kamniku, 380 m, 30. 4. 1998, leg. S. Primož (LJU 129115); 9653/4, Gorenjska, Dolina Kamniške Bistrice, južni travnik pri Domu v Kamniški Bistrici, 600 m, 28. 4. 1995, leg. N. Pollak (LJU 126949); 9753/2, Ljubljanska kotlina, okolica Kamnika, Godič, 430 m, 8. 5. 1994, U. Knuplež (LJU 125522); 9753/4, Kamnik, na močvirnem, vlažnem travniku v bližini vasi Sp. Palovče, 585 m, 19. 4. 1992, leg. M. Erdani (LJU 124423); 9753/4, Gorenjska, Kamnik, Bakovnik, 360 m, 14. 4. 1998, leg. N. Hrabar (LJU 129102); 9853/2, okolica Domžal, V od hriba Gorica (nad vasjo Rova), S od Radomelj, 335 m, 3. 4. 1994, leg. I. Jeretina (LJU 125600); 9853/2, okolica Domžal: na travniku zraven hiše v vasi Krtina pri Dobu, 15. 5. 1997, leg. M. Rode (LJU 127809); 0049/1, Trnovski gozd, Mala Lazna, 1100 m, 4. 6. 1969, leg. A. Martinčič (LJU 09390); 0049/1, Trnovski gozd, Mala Lazna, 5. 5. 1959, leg. A. Filipič (LJU 94245); 0151/4, Rakek, Planina, Planinsko polje, približno 1000 m S od gradu Haasberg, 460 m, 10. 5. 1998, leg. A. Šuštaršič (LJU 130543); 0252/2, in paludosis ad rivulum prope vicum Velike Bloke, 730 m, 14. 5. 1985, leg. P. Vrhunc & T. Wraber (LJU 111939); 0157/3, okolica Novega mesta, travnik ob reki Krki, 250 m V od mlina (Mlinarska pot) v Mačkovcu, 135 m, 15.4.1995, leg. S. Kirar (LJU 126456); 0258/1, Gorjanci, dolina Kobile, 2.5.1958, leg. V. Strgar (LJU 46150).

Fig. 3. Cluster analysis (UPGMA) of the populations of the *C. pratensis* group from the Carpathians, Pannonia and Slovenia. *C. matthioli*: Slovakia MT-01 – MT-09, Hungary MT-10 – MT-12, Ukraine MT-13 – MT-15, Romania MT-16 – MT-19. *C. majovskii*: Slovakia MJ-33 – MJ-44, Hungary MJ-45 – MJ-47, Ukraine MJ-48 – MJ-53, Romania MJ-54 – MJ-55. *C. pratensis* s.str. (2n = 30): Slovakia P30–56 – P30–65, Ukraine P30–66 – P30–67. *C. pratensis* s.str. (2n = 38): Slovakia P38–68 – P38–69, Ukraine P38–70 – P38–71. *C. pratensis* s.str. (2n = 44): Slovakia P44–72 – P44–76, PM44–80 – PM44–82, Poland P44–77 – P44–79, Czech Republic: PM44–83 – PM44–84. *C. pratensis*, type "ucranica": Ukraine UC-20 – UC-24. *C. rivularis* auct. non Schur: Ukraine RI-25 – RI-32 (for the exact localities see Marhold 1996: Table 1). Slovenian populations are marked with asterisks and codes as given in Table 1 are used.


Dissimilarity
0
1
2
3
4
5
MT-14
MJ-48
MJ-51
MJ-54
MJ-55
MT-19
MT-18
MT-08
MT-17
*MT-cp
MT-04
MT-13
*MT-ptu
*MT-sj
UC-20
UC-22
UC-24
UC-21
UC-23
MT-05
MT-15
MT-16
MT-09
MT-02
MT-12
MT-03
MT-01
MT-10
MT-07
MT-06
MT-11
MJ-43
MJ-42
MJ-52
MJ-35
MJ-50
MJ-41
MJ-49
MJ-45
MJ-47
MJ-46
MJ-36
MJ-37
MJ-36
MJ-33
MJ-34
MJ-39
MJ-40
MJ-44
P30-66
*MJ-ri
*MJ-lb
*MT-sb
MJ-53
*MJ-d
*MJ-tac
*MJ-top
*MJ-bb
*MJ-uni
*MJ-ss
*MJ-sod
*P44-cj
*P30-ra
P44-77
P44-73
P44-79
P44-72
P44-75
P44-76
*P30-go
P38-69
P38-71
P38-70
PM44-82
PM44-81
PM44-80
PM44-84
P44-74
PM44-83
P44-78
P30-59
P30-65
P30-56
P30-62
P30-63
P30-60
P38-68
P30-58
RI-29
RI-32
RI-25
RI-27
RI-28
RI-31
RI-30
P30-64
P30-61
P30-57
P30-67
RI-26
1
2a
2
2b

Cardamine majovskii Marhold & Záborský

0250/1, vas Razdrto pri Postojni, ob glavni cesti, 575 m, 3. 5. 1991, leg. T. Čelhar (LJU 127231); 0250/2, Notranjska, Pivška kotlina, Z od Postojne, na vlažnem travniku blizu vasi Hrašče, 538 m, 28. 4. 1997, leg. A. Rebeca (LJU 127752); 0351/1, Klenik, 18. 4. 1920, leg. R. Justin (LJU 07629); 9850/3, Škofjeloško hribovje: in pratis humidis vallis rivuli Podpleščica, prope domum rusticum Joškovec, 600 m, 15. 5. 1980, leg. A. Podobnik (LJU 106676); 9752/4, Gorenjska, Spodnji Brnik, vlažen travnik SZ od vasi Sp. Brnik, v smeri vasi Zg. Brnik, 368 m, 18. 4. 1993, leg. K. Mihajl (LJU 125038); 9852/3, SV rob Polhograjskega hribovja, v vasi Vaše, 340 m, 3. 5. 1992, leg. T. Trošt (LJU 124427); 9952/1, Polhograjsko hribovje, Pobočje pod cerkvijo sv. Jurija, 360 m, 23. 5. 1992, leg. M. Pompe (LJU 124410); 9952/1, Hrastenice prope opp. Ljubljana, 320 m, 24. 4. 1955, leg. T. Wraber (LJU 68047); 9952/2, Koseze prope opp. Ljubljana, 17. 4. 1937, leg. A. Budnar (LJU 07627); 0051/2, vlažen travnik pod severnim pobočjem Ulovke, zahodno od Vrhnike, 630 m, 9. 5. 1992, leg. B. Rozman (LJU 124305); 0052/1, Ljubljansko barje, S od Blatne Brezovice, vlažen travnik med potokom Zrnica in makadamsko cesto, 289 m, 17. 5. 1996, leg. D. Koprivec (LJU 127570); 0052/3, Notranjska, južni rob Ljubljanskego barja, zahodni del vasi Goričica pod Krimom, 300 m, 27. 4. 1995, leg. U. Mazi (LJU 126482); 0052/1, Ljubljansko Barje, 1 km SV iz naselja Notranje Gorice, 292 m, 24. 4. 1994, leg. B. Hribar (LJU 125643); 0052/2, okolica Ljubljane, Ljubljansko Barje, Tomišeljski morost, J od vasi Lipe, 290 m, 13. 4. 1991, leg. M. Poje (LJU 124718); 0052/2, Ljubljansko Barje,

Fig. 4. Distribution map of *C. matthioli* (triangle), *C. majovskii* (circle) and *C. pratensis* s.str. (cross) in Slovenia.

travnik pri jezero (ob vasi Jezero), 293 m, 20. 4. 1989, leg. J. Lavrenčak (LJU 125073); 0053/1, Dolenjska, PD, Šmarje-Sap, ob Groznikovem mlinu, 340 m, 20. 5. 1995, leg. V. Grosnik (LJU 126490); 0053/4, Dolenjska, Ponova vas prope Grosuplje, 350 m, 18. 5. 1970, leg. M. Lovka (LJU 31465); 9953/3, Ljubljana-Rudnik, Lj. Barje, d. breg Ižice, 26. 4. 1988, leg. R. Bolješič (LJU 120792); 9953/3, Ljubljansko Barje, in pratis prope urbem Ljubljana, ad viam versus Ig ducentem, inter fluvios Ljubljanica et Iščica, 290 m, 10. 4. 1972, leg. T. Wraber (LJU 32756); 9953/1, Ljubljanska kotlina, Šmartno pod Šmarno goro, travnik med šmarskim ribnikom in avtocesto, 300 m, 7. 5. 1996, leg. S. Strgulc (LJU 127435); 9853/3, okolica Lj., Sp. Gameljne, 320 m, 12. 5. 1991, leg. M. Debeljak (LJU 127274); 9853/3, Domžale, Trzin, vlažen travnik za gostilno Trzinka v Trzinu, 300 m, 17. 4. 1992, leg. V. Gutman (LJU 124484); 9853/1, Domžale, Vir, Gozd med Dobom in Domžalami ob reki Rači, 300 m, 9. 5. 1994, leg. N. Gostič (LJU 125617); 9853/2, Dob prope Domžale, 5. 5. 1941, leg. E. Mayer (LJU 63050); 9954/3, dolina Besnice pri Zalogu, 500 m od Zg. Besnice 5 proti Trebeljevem, 400 m, 18. 4. 1998, leg. A. Škorjanc (LJU 129237); 9854/4, zahodno Posavsko hribovje, Gora pri Pečah, pri zaselku Dolina, 550 m, 2. 4. 1994, leg. Š. Baebler, (LJU 125590); 9954/2, Zasavje, vas Slivna, zahodno od Vač, severno od Litije, 500 m, 4.4.1994, leg. V. Grobelnik (LJU 125668); 9954/2, in pratis udis prope forum Litija, 240 m, 28. 4. 1928, leg. F. Dolšak, (LJU 07619); 0254/3, Ribnica, ob cesti na Ugar, v bližini mostu, ki vodi preko potoka Sajevec, 489 m, 4. 4. 1994, leg. B. Oven (LJU 125701); 0055/4, Velika Loka, vlažen travnik ob Temenici, 285 m, 18. 5. 1997, leg. B. Premrov (LJU 128669); 0056/3, na vlažnem travniku ob potoku Pravharica na Lanšprežu, 3 km SZ od Trebnjega, 280 m, 10. 4. 1992, leg. P. Zalar (LJU 124459); 0056/4, Trebelno, 30. 4. 1908, leg. R. Justin (LJU 07630); 0158/4, Kostanjevica na Dolenjskem, 2. 5. 1966, leg. R. Luštek (LJU 93041); 0159/2, vznožje Gorjancev, na vlažnem travniku na desni strani potoka Sklednika, JV od vasi Brvi, JZ od Brežic, 180 m, 7.4.1994, leg. M. Potokar (LJU 125581).

Cardamine matthioli Moretti

9853/3, bregovit, delno z drevesi porasel travnik SE od Potokarja na Rašici, 29. 4. 1952, leg. F. Šuštar (LJU 45550); 0053/1, Ljubljansko Barje, ob cesti Ig-Školjica, na vlažnem travniku 1 km od Iga, 290 m, 27. 4. 1989, leg. P. Trontej (LJU 121563); 0456/2, Bela krajina, ob bregu reke Dobličice 100 m severno od vasi Dobliče, 170 m, 26. 4. 1992, leg. J. Triplat (LJU 124554); 0457/1, Bela krajina, 1 m od reke – desni breg, J del Črnomlja, 15. 5. 1994, leg. S. Šebal (LJU 125546); 0157/1, okolica Novega mesta, na vlažnem travniku ob potoku Laknica v vasi Zbure pri Šmarjeških Toplicah, 178 m, 13. 4. 1990, leg. S. Zupanc (LJU 127120); 0158/1, Šentjakob pri Šentjerneju, 20. 3. 1966, leg. R. Luštek (LJU 93042); 0158/2, in silva Krakovski gozd dicta prope oppidum Kostanjevica, 150 m, 14. 4. 1973, leg. T. Wraber (LJU 41149); 9958/1, dolina Gračnice, med Mišjim Dolom in Kloštrom, 300 m, 5. 5. 1973, leg. T. Knez (LJU 35260); 9857/3, kompleks Kopitnika, pod Lordom, 350 m, 9. 5. 1971, leg. T. Knez (LJU 35261); 9857/1, Laško, 230 m, V. 1907, leg. J. Četina (LJU 07624); 9456/1, Koroška, Črneče, 360 m, 3. 5. 1984, leg. B. Vreš (LJU 110702); 9456/3, Koroška, Pameče pri Slovenj Gradcu, 409 m, 22. 4. 1994, leg. M. Čevnik (LJU 125640); okolica Slovenj Gradca, 520 m, 12. 5. 1996, leg. R. Štamulak (LJU 127397); 9556/2, Mislinjska Dobrava, med magistralno cesto in reko Mislinjo ter med Tomaško in Turiško vasjo, 462 m, 4. 4. 1994, leg. S. Gašper (LJU 125637); 9656/2, Velenje, 400 m, 24. 4. 1978, leg.

D. Naglič (LJU 97324); 9656/2, Velenje, 370 m, 25. 4. 1978, leg. D. Naglič (LJU 97326); 9757/2, Celje, močvirnat travnik za vasjo Dobrova, 250 m, 1. 4. 1989, leg. B. Kruhar (LJU 120813); 9757/2, Štajerska, okolica Celja, SV od centra Celja (med centrom Celja in Šmartinskim jezerom), 264 m, 27. 4. 1994, leg. A. Livio (LJU 125710); 9757/2, Štajerska, Celje, 200 m J od Šmartinskega jezera, 240 m, 3. 5. 1996, leg. P. Kačičnik (LJU 127410); 9658/3, in pratis humidis prope monasterium Žička kartuzija ad radices meridionales montis Konjiška gora, 450 m, 9. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79765); 9658/3, Polene pri Slov. Konjicah, 400 m, 10. 5. 1984, leg. D. Gilčvert (LJU 111715); 9659/1, Štajerska, Slov. Bistrica, vlažen travnik J od Kajuhove ul. v Slovenski Bistrici, 281 m, 17. 4. 1994, leg. K. Plajh (LJU 125664); 9658/2, SV okolica Slovenskih Konjic, ob jašku za vodo pri vasi Pobrež južno od Oplotice, 340 m, 4. 6. 1988, leg. T. Pliberšek (LJU 120780); 9658/4, Draža vas prope Slov. Konjice, 280 m, 10. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79753); 9658/4, Loče pri Poljčanah, 280 m, 17. 4. 1983, leg. D. Gilčvert (LJU 111713); 9760/3, in pratis paludosis vallis rivuli Draganja prope vicum Rogatec, 220 m, 7. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79592); 9359/2, zah. Slov. Gorice, Plač, 360 m, 7.4.1972, leg. L. Godicl (LJU 39861); 9359/3, Štajerska, Brestenica, cesta na Gaj, Log, 495 m, 28. 4. 1995, leg. B. Žegura (LJU 126568); 9459/1, Štajerska, Kozjak, Spodnji Slemen, travnik v bližini Školovega ulica, 413 m, 1. 5. 1994, leg. V. Arnuš (LJU 125716); 9459/2, Kamnica pri Mariboru, travnik ob poti na Hudičeve skale, 400 m, 19. 4. 1992, leg. A. Dukič (LJU 124400); 9460/1, Štajerska, Maribor, Pernica, JZ del jezera Pernica, 260 m, 3. 5. 1996, s. coll. (LJU 127559); 9460/1, Ložane prope Pernica in valle fluvii Pesnica, in pratis paludosis, 240 m, 10. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79746); Maribor, vlažen travnik pri spomeniku na Ledini, 300 m, 28. 6. 1996, leg. M. Zorovič (LJU 127553); 9460/3, ob Radvanjskem potoku pod Pohorsko vzpenjačo v Mariboru, 345 m, 10. 5. 1992, leg. A. Smodič (LJU 124321); 9460/3, Štajerska, ob Dravi na robu gozda, v Zg. Dupleku, 300 m SZ gramoznice, 240 m, 17. 5. 1997, leg. U. Červek (LJU 127885); 9560/1, SZ od Dravskega polja, močviren travnik v Skokak, JV od Maribora, 260 m, 20. 4. 1992, leg. T. Čuk (LJU 124432); 9559/2, okolica Maribora-Roza (Hočko Pohorje), 550 m, 8. 4. 1992, leg. P. Perša (LJU 124310); 9459/4, Štajerska, Maribor, Spodnje Radvanje, 290 m, 15. 4. 1994, leg. J. Šen (LJU 125651); 9559/2, Radizel prope oppidum Maribor, 270 m, 10. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79751); 9559/2, Štajerska, Podpohorje, Slivnica, 300 m Z od ceste Slivnica - Hoče, 280 m, 3. 4. 1994, leg. M. Žižek (LJU 125656); 9461/3, Trnovska vas - Čumlje, SZ od Ptuja, V od domačije Kronvogel, 210 m, 14. 5. 1988, leg. Hasenbichel (LJU 120791); 9561/1, Placar prope opp. Ptuj, 10. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79714); 9561/3, Štajerska, Ptuj, vlažen travnik pod S delom Meniških lesov, 260 m, 28. 4. 1996, leg. M. Hrenko (LJU 127059); 9561/3, Štajerska, Ptuj, Roganica pri Ptuju, SV (3 km) od Ptuja, 10. 4. 1998, leg. M. Klinc (LJU 129198); 9561/3, in pratis humidis prope vicum Spuhlja haud procul oppidi Ptuj, 220 m, 8. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79713); 9561/4, Ptuj, na vlažnem negojenem travniku na Štukih, med Rabeljčjo vasjo na V in Krčevino na Z., 240 m, 1. 5. 1991, leg. T. Potočnik (LJU 124431); 9662/1, in pratis paludosis prope vicum Zavrč, 220 m, 8. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79655); 9662/1, in paludosis ad silvae marginem inter Zavrč et Borl, 200 m, 8. 5. 1970, leg. M. Lovka & T. Wraber (LJU 79707); 9562/4, Štajerska, Ptuj, Polje, Ormož, Dobrava, travnik ob c. Ormož-Ljutomer, 245 m, 15. 5. 1997, leg. K. Šoštarič (LJU 127824); 9462/1, vlažen travnik J od Blaguškega jezera, pod vasjo Brezje pri

Vidmu ob Ščavnici, Prlekija, 240 m, 29. 4. 1992, leg. S. KREFT (LJU 124531); 9463/2, Prekmurje, in fossis prope vicum Črenšovci, 170 m, 18. 4. 1984, leg. T. WRABER (LJU 109882); 9363/3, Prekmurje, gojen travnik na V Beltinec ob potoku Črnec, 180 m, 30.5.1989, leg. B. GORŠAK (LJU 127145); 9362/2, Prekmurje, 1 km z od Polane, travnik ob gozdu, 195 m, 1. 5. 1997, leg. Z. ZRIM (LJU 127811); 9262/3, Cankova v blizici Korovec, Prekmurje, 220 m, 30. 4. 1991, leg. M. BAGOLA (LJU 127284); 9662/2, ob potoku Bajna, Grad SV od Mursku Sobote, 300 m, 3. 5. 1991, leg. I. ŠLAGEZ (LJU 127190); 9662/2, travnik ob potočku (Bajna), Grad SV od Mursku Sobote, 300 m, 13. 4. 1991, leg. I. ŠLAGEZ (LJU 127191); 9662/2, Grad, SV od Mursku Sobote, vlažen travnik ob poti (Bajna), 300 m, 13. 4. 1991, leg. I. ŠLAGEZ (LJU 127192); 9163/3, Prekmurje, Goričko travnik v bližini hiše št. 8 v Adrijancih, 8. 4. 1995, leg. A. ŽIŠKO (LJU 126971).

Discussion

Previous karyological studies in *C. pratensis* s.str. have shown wide variation in chromosome numbers (see e.g., GUINOCHET 1946, LÖVKVIST 1956, URBANSKA-WORYTKIEWICZ & LANDOLT 1974, SPASSKAYA 1979, MARHOLD 1994b). Except different ploidy levels (2n = 2x–6x), also dysploid populations (2n = 30, 38, 44) have been reported. This variation is attributed to the existence of two basic chromosome numbers (x = 8, secondary x = 7) resulting from the chromosome fusion, and to the different combinations of 7- and 8-chromosome sets in a genome (LAWRENCE 1931, LÖVKVIST 1956). One of the most common cytotypes in Europe is a hypotetraploid with 2n = 30, which we also found in three localities in Slovenia. In its karyotype one pair of longer chromosomes was first observed by LAWRENCE 1931 and explained away as chromosome fusion. Euploid tetraploids with 2n = 32 have also been reported, however these seem to be less frequent (e.g., SPASSKAYA 1979, TEPPNER 1980, VYVEY & STIEPEREARE 1984). The hypohexaploid number 2n = 44 which we found in the population near Cerkniško jezero (Table 1) seems to be quite frequent, especially in Central Europe (MARHOLD 1994b), and believed to have the chromosomal constitution 2(7+7+8) (LÖVKVIST 1956). Populations of *C. pratensis* growing in the subalpine belts of the Alps, including Slovenia (and also in the Pyrenees, Vosges, Massif Central, Apennines, E. Carpathians) have been misinterpreted by several authors as *C. rivularis* SCHUR (e.g., URBANSKA-WORYTKIEWICZ & LANDOLT 1974, LANDOLT 1984, WRABER 1984: 137, BOLÒS & al. 1993: 330), which in fact is a different taxon confined to the S. Carpathians and Bulgaria (MARHOLD 1995, FRANZKE & HURKA 2000). These alpine populations (often referred to as *C. rivularis* auct. non SCHUR) have been reported to be either diploid or tetraploid with 2n = 16 and 32, respectively (URBANSKA-WORYTKIEWICZ & LANDOLT 1974, TEPPNER 1980, MARHOLD 1995, 1999a). Populations from the Julijske Alpe, N.W. part of Slovenia (see list of specimens) were not karyologically investigated in this study, but according to the pollen grain diameter of these specimens, they could be of a tetraploid le-

vel rather than of a diploid one. In the neighbouring region of Styria in southern Austria both diploids with 2n = 16 (the Koralpe Mts.) and tetraploids with 2n = 32 (the mountains of the Niedere Tauern, Wölzer Tauern and Seckauer Alpen) occur. In Carinthia only tetraploids (2n = 32) were recorded from the Gurktaler Alpen Mts. (MARHOLD 1999a).

WRABER 1969 reported "*C. palustris* (WIMM. & GRAB.) PETERM." for the northern part of Slovenia (Alpsko območje, Pohorje). In the later edition of Mala Flora Slovenije (WRABER 1984) he reported this taxon for S.E. Slovenia as well (Preddinarsko območje), most probably according to plants identified by Professor E. LANDOLT in the herbarium LJU in 1974 as "cf. *C. palustris* PETERM." (Trebelno, 30. 4. 1908, leg. R. JUSTIN, LJU 07630, identified by us as *C. majovskii*). *C. palustris* PETERM. is now considered to be a synonym of *C. dentata* SCHULT. (MARHOLD 1994a). We found neither in the field nor in the herbarium LJU any specimen which could correspond to this taxon. Therefore, we think, that the above-mentioned records are based on the misidentification of either *C. pratensis* s.str. or *C. majovskii*.

C. matthioli and *C. majovskii* show clearly different distribution patterns in Slovenia, the former species being concentrated to the Subpannonian north-eastern part of the country, while the distribution of the latter one is concentrated to Prealpine and Predinaric regions. The exceptions to this pattern are two isolated localities of *C. matthioli* in the Ljubljanska kotlina basin, as already reported by DRUŠKOVIČ & LOVKA 1995 (see also below) from Ljubljansko Barje also with the diploid chromosome number 2n = 16 determined. *C. matthioli* seems to represent one of very few taxa supporting the delimitation of the Subpannonian phytogeographic region from the rest of lowland Slovenia (N. JOGAN, in litt.). When comparing with the precipitation map of Slovenia, this taxon occurs mostly in regions of lower annual precipitation, i.e. 800–1200(–1400) mm/year (Centre for Cartography of Fauna and Flora, Slovenia, unpubl.). Similar distribution area can also be found for *Dipsacus pilosus* L., *Gagea spathacea* (HAYNE) SALISB., *Lindernia procumbens* (KROCK.) PHILCOX and *Moenchia mantica* (L.) BARTL., even with one or a few isolated localities in Central Slovenia in the case of the latter two taxa (JOGAN 2001). This area also largely corresponds to the area of potential occurrence of Castaneo sativae-Fagetum (Centre for Cartography of Fauna and Flora, Slovenia, unpubl.). Considering the more general distribution patterns of *C. matthioli*, the Slovenian records form a part of the continuous area spreading from Romania, Transcarpathian Ukraine, through Slovakia, neighbouring northern Hungary and eastern Austria (Burgenland, Styria), and extending to the west to northern Italy and Switzerland (URBANSKA-WORYTKIEWICZ & LANDOLT 1972, MARHOLD 1994a, 1999a). The southernmost occurrence was found in Greece (MARHOLD & TAN 1999).

The tetraploid populations (2n = 32) were reported in Slovenia in past for three localities – Ljubljansko Barje, Kranj and Pokljuka under the name *C. matthioli* (Druškovič & Lovka 1995). The first two records (Ljubljansko Barje, Kranj) certainly refer to *C. majovskii*, whereas that from Pokljuka seems to represent rather *C. pratensis* s.str. (see distribution pattern in the Fig. 4). Except for these, Druškovič & Lovka 1995 reported also diploid *C. matthioli* (2n = 16) from Ljubljansko Barje. *C. majovskii* occupies lowland to colline belts with higher annual precipitation (1100–) 1200–1500 mm (Centre for Cartography of Fauna and Flora, Slovenia, unpubl.), and an area which to certain extent reminds that of *Knautia fleischmannii* (Hladnik ex Rchb.) Pacher, *Piptatherum virescens* (Trin.) Boiss. and *Pseudolychimachion barrelieri* subsp. *nitens* (Host) M. A. Fisch. (Jogan 2001). Geographically closest confirmed populations of *C. majovskii* can be found in eastern Austria (Burgenland) (Gadella & al. 1970: 190 as *C. pratensis*, Marhold 1999a), and based on pollen grain size also on two sites in south-western Hungary (Marhold 1994a). This species seems to be especially common in a relatively small area of eastern Slovakia, Transcarpathian Ukraine and north-eastern Hungary, and also in the great part of the area of Romania (Marhold 1994a). However, regions more to the south (Serbia, Montenegro, Croatia) where this species might also occur and reach Slovenia, S.W. Hungary and Burgenland from south-east were not explored in this respect so far.

Distribution of both *C. matthioli* and *C. majovskii* has been poorly explored so far in the Balkan Peninsula, and this area surely requires more detailed investigation in future. For both Croatia and Bosnia and Hercegovina, only *Cardamine pratensis* s.str. is given (Beck 1916, Domac 1973, Trinajstić 1976, Plazibat 1997), however, it is highly probable that these records refer to a large extent to *C. matthioli* and *C. majovskii*. From the area of Serbia, "*C. pratensis* subsp. *hayneana* (Welw.) O.E. Schulz" [correctly *C. pratensis* subsp. *hayneana* (Rchb.) Podp. - see Marhold 1994a: 350] with two varieties, var. *hayneana* and var. *iliciana* (Fritsch) Hayek is reported (Jovanović-Dunić 1972). While *C. pratensis* subsp. *hayneana* var. *hayneana* is a synonym of *C. matthioli* and as such it seems to be interpreted by Jovanović-Dunić 1972, it is likely that at least part of the material treated as var. *iliciana* corresponds to *C. majovskii*. The lectotype of the name *C. hayneana* var. *iliciana* Fritsch, described from Serbia morphologically does not represent typical *C. majovskii* (Marhold 1994a: 355), although the size of the pollen grains indicates tetraploid level. As yet we have not counted chromosome numbers of plants from the classical locality in Jajna. For Montenegro, only the occurrence of *C. matthioli* is recorded (Rohlena 1942, Trinajstić 1976), but again, tetraploid populations currently classified as *C. majovskii* could be found in future. Interestingly, in the recent Flora of Macedonia, taxa belonging to the *C. pratensis* group

(*C. pratensis* s.str., *C. pratensis* subsp. *iliciana*, *C. pratensis* subsp. *matthioli* and *C. rivularis*) are reported only in a note as unconfirmed records (MICEVSKI & MATEVSKI 1995). For the area of Albania, *C. pratensis* s.str. and *C. matthioli* are given (PAPARISTO & al. 1988), but the taxonomic identity of these plants is not fully clear to us.

The diploid species *C. matthioli* and its presumable autotetraploid *C. majovskii* are morphologically very close to each other, and most of the differences between them are those associated with different ploidy level – pollen grain diameter, size of floral parts (MARHOLD 1996). In both canonical and classificatory discriminant analyses performed on Slovenian populations, clear separation was achieved between them by using the above-mentioned characters. However, as was mentioned by MARHOLD 1996, extreme ecological conditions can influence the size of the flowers and cause confusion in the proper identification of such plants when pollen grain diameter is not taken into account. This seems to be the case in the population near Slovenska Bistrica (MT-sb, Table 1), which clustered together with the *C. majovskii* samples (Fig. 1), because these plants had generally larger flowers.

Based on previous morphometric analyses, both *C. matthioli* and *C. majovskii* clearly differ from *C. pratensis* s.str. by the appressed hairs on the rachis of the rosette leaves (versus patent hairs in *C. pratensis* s.str.), usually white petals with reddish-violet veins (versus reddish-violet to purple), and deflexed segments on the cauline leaves (versus ascending) (MARHOLD 1996). Nevertheless, among the Slovenian representatives the differences between *C. majovskii* and *C. pratensis* s.str. were not so strongly pronounced (see Fig. 2, Table 3), since in the classificatory discriminant analysis only 82–86 % of plants were correctly classified. In the cluster analysis of the pooled matrix, including also non-Slovenian samples (Fig. 3), Slovenian populations of *C. majovskii* even clustered at higher level together with *C. pratensis* s.str., and not with other-European samples of *C. majovskii*, as would be expected. Slovenian plants of *C. majovskii* have almost invariably reddish-violet petals or at least tinged ones, the fact already mentioned by URBANSKA-WORYTKIEWICZ & LANDOLT 1974 (they mentioned it for *C. matthioli*, however including populations from Central Slovenia currently treated under *C. majovskii* as well), and this character state brings them closer to *C. pratensis* s.str. Apart from this, the most reliable character distinguishing *C. majovskii* from *C. pratensis* s.str. – appressed hairs, was retained only in a few plants within each of the investigated populations. In most of the plants no hairs were found on the rachis. Thus, the same character state – absence of hairs expressed in most plants contributed to their close position in the morphometric analyses, what is partly misleading, as in this case the negative match should be considered rather as missing data. The statistical program used, however,

did not enable such option. Based on this observation, for proper determination of Slovenian populations, more plants from a population should be investigated for position of segments and hairs on the rachis of the rosette leaves. Close morphological relationships demonstrated also in this study and low molecular divergence found among taxa from the derived group of the *C. pratensis* complex (FRANZKE & HURKA 2000) argue for only recent diversification and speciation within this species group.

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Recensio

SITTE Peter, WEILE Elmar W., KADEREIT Joachim W., BRESINSKY Andreas & KÖRNER Christian 2002. Lehrbuch der Botanik für Hochschulen. Begründet von E. STRASBURGER, F. NOLL, H. SCHENCK & A. F. W. SCHIMPER. – 35. Auflage. – Lex. 8°, XIV + 1123 Seiten, ca. 1198 Abbildungen (schwarz-weiß und farbig), 2 farbige Karten auf 1 Falttafel; geb. Zusammen mit 1 CD. – Spektrum Akademischer Verlag Heidelberg, Berlin. – € 99,95. – ISBN 3-8274-1010-X.

Der neue STRASBURGER ist nicht nur von 1007 auf 1123 Seiten gewachsen, sondern enthält auch sonst weitreichende Veränderungen, da die Abschnitte Physiologie, Evolution und Methoden der Systematik, Systematik der Samenpflanzen und Ökologie neue Bearbeiter gefunden haben. Die vorausgegangene, 34. Auflage ist in Phyton 40(1): 113–114, 2000, besprochen worden.

Der erste Teil „Struktur“ (früher „Morphologie“) enthält nach wie vor die molekularen Grundlagen, Bau der Zelle, Gewebe, vegetative Morphologie und Anatomie der Sproßpflanzen und Gestaltungsprinzipien bei Thallophyten. Im zweiten Teil „Physiologie“ kam zu Stoffwechsel, Entwicklung und Bewegungen der neue Abschnitt „Allelophysiologie“ mit heterotropher Ernährung, Symbiose, Pathogene (inkl. Ti-Plasmid), Herbivorie und Allelopathie hinzu. Der dritte Teil „Evolution“ ist jetzt in Variation [der Rezensent würde Variabilität vorziehen], ihre Muster und Ursachen, Artbildung, Makroevolution und Methoden der Systematik gegliedert; dann folgt (p. 581–865) die Systematik von Bakterien, Pilzen und Pflanzen (Samenpflanzen, p. 750–865, von J. W. KADEREIT), sowie als Abschluß Stammes- und Vegetationsgeschichte (ebenfalls KADEREIT). Der vierte Teil „Ökologie“ umfaßt Grundlagen der Pflanzenökologie (6 Kapitel), Pflanzen im Lebensraum (9 Kapitel), Populations- und Vegetationsökologe (inkl. Pflanzenareale) und die Vegetation der Erde mit der Vegetation Mitteleuropas und den Biomen der Erde [16 Biome auf je einer Text-

und Bildseite und (exkl. 16, Küstenvegetation) mit Klimadiagrammen und Karte]. Durch die inkonsequente bis fehlende Numerierung der Abbildungen in diesem letzten Abschnitt läßt sich die Gesamtzahl der Abbildungen nicht genau angeben. Die systematische Anordnung der Samenpflanzen, insbes. der Angiospermen folgt nun erstmals in diesem Lehrbuch ganz den molekularen und kladistischen Kriterien. Dagegen wäre nichts einzuwenden, wenn bei vielen neuen Gruppierungen die Absicherungen schon besser wären und wenn zu den neuen, molekular begründeten Gruppen die morphologische Seite schon besser herausgearbeitet wäre. So zermürben die vielen „möglicherweise", „wahrscheinlich" und der häufige Gebrauch des Konjunktives ebenso wie z.B. ohne morphologische Begründung nebeneinander stehende *Fagales* und *Cucurbitales* oder bei den *Scrophulariaceae* p. 852 die Bemerkung: „. . . die hier dargestellten Familien lassen sich kaum mit morphologischen Merkmalen verstehen". Was soll man da aus didaktischer Sicht in der Lehre machen ? Man kann doch nicht DNA-Sequenzen als Familienmerkmale auswendig lernen lassen. Hier hätte im Moment weniger Progressivität wohl mehr gebracht. Daß es möglich ist, DNA-Merkmale mit den anderen Merkmalen in Einklang zu bringen, zeigen etwa *Carophyllales/Polygonales* und *Malvales*. Die Abbildung 11–189 (Stellung des Gynözeums zur Blütenachse) ist ein großer Rückschritt im Vergleich zur entsprechenden Abbildung 3-255 in der 34. Auflage. In der letzteren, p. 838, ist Biodiversität, dieser heute in der Öffentlichkeit bzw. Politik so zentral wichtige Terminus kurz (12 Zeilen), aber völlig klar definiert und sein Inhalt treffend beschrieben. Nun (p. 983) sind zwar 15 Zeilen beansprucht, aber die Formulierungen sind so kryptisch, daß sie für einen Anfänger kaum verständlich sein werden. Das ist betrüblich, denn heute sollte jeder Biologie in der Lage sein, Biodiversität konform zur Biodiversitätskonvention zu erläutern. Nach der 34. Auflage hätte das klappen können. Außerdem sollte das Übereinkommen über die Biologische Vielfalt (CBD) in diesem Kapitel mit korrektem Titel genannt sein und es würde nicht schaden anzugeben, daß sich die Unterzeichnerstaaten damit u.a. verpflichtet haben, die jeweilige Biodiversität in ihrem Hoheitsgebiet zu erhalten. Insgesamt waren Autoren und Verlag sehr um klare und übersichtliche Darstellung bemüht, wobei meines Erachtens Verbesserungen gelungen sind.

Eine ganz wesentliche Neueurng ist die CD, die es nun zum „STRASBURGER" gibt. Diese enthält die bisher in Buchform gelieferte „Studienhilfe Botanik" [zuletzt besprochen in Phyton 40(1): 56, 2000] und 700 Abbildungen, meist aus dem Lehrbuch, die beim Benützen der Studienhilfe als Ergänzung herangezogen werden können. Weiters findet sich auf der CD – das war eine sehr gute, nutzerfreundliche Idee – das um Termini aus Physiologie, Molekularbiologie und Ökologie erweiterte Wörterbuch der Botanik von G. WAGENITZ (vgl. dazu die Rezension in diesem Phytonheft, p. 379). Der Rezensent hat nie den Aufwand gescheut, zu verbesserungswürdigen Dingen, die ihm beim Studium von Büchern aufgefallen sind, in den Rezensionen entsprechende Vorschläge zu unterbreiten. Wenn diese aber nicht berücksichtigt werden, lohnt sich der große Aufwand allerdings nicht. Da z. B. die *Cucurbitaceae* noch immer Sproßranken besitzen, die *Malvaceae* bisporangiate Antheren aufweisen und das *Apiaceae*-Blütendiagramm völlig unverständlicherweise noch immer mit einer Kelchblattlücke nach median hinten orientiert ist [vgl. dazu die begründeten Änderungsvorschläge in Phyton 40(1): 114], hat der Rezensent hier auf solche Hinweise verzichtet, obwohl es auch diesmal noch manches zu verbessern gäbe.

H. TEPPNER