

Chromosome numbers and distribution of *Cardamine amara* (Brassicaceae) in Slovenia

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Chromosome numbers and distribution of two subspecies of *Cardamine amara* in Slovenia are presented. Major part of Slovenia is occupied by tetraploid *C. amara* subsp. *austriaca*, the taxon with the distribution centered in the Eastern Alps. In Slovenia it prevails in the (Pre)alpine and (Pre)dinaric regions and approaches the southern limit of its known distribution area. Diploid *C. amara* subsp. *amara* is in Slovenia less frequent, it is concentrated in the northeastern Subpannonian region. Morphological differences between these two subspecies, especially those in the pollen grain size are mentioned. Distribution pattern found in Slovenia and the assumed evolutionary history of the tetraploid subspecies are discussed.

Key words: Alps, autopolyploidy, *Cardamine amara* subsp. *amara*, *Cardamine amara* subsp. *austriaca*, Dinaric region, distribution map, Subpannonian region.

Introduction

Cardamine amara L. is a morphologically highly variable species widespread in Europe and extending to Asia. It occupies moist to wet sites mainly on stream banks and springs from lowlands up to the alpine belt. Based on previous taxonomic studies, several diploid and two tetraploid subspecies are currently recognized within this species in Europe. The subspecies are morphologically and geographically well characterized (MARHOLD, 1992, 1998, 1999a; MARHOLD et al., 1996; LIHOVÁ et al., 2000).

The typical subspecies, diploid *C. amara* subsp. *amara*, is the most common and widespread subspecies, it is distributed in a major part of the species distribution area (JALAS & SUOMI-

NEN, 1994). Recently, the tetraploid subspecies *C. amara* subsp. *austriaca* MARHOLD was described, occurring in the Eastern Alps and neighbouring areas (MARHOLD, 1999a). Morphometric and molecular (isozymes, RAPDs, AFLPs) investigation showed that this represents most probably young autotetraploid derivative of *C. amara* subsp. *amara* (MARHOLD, 1999a, LIHOVÁ et al., 2000, MARHOLD et al., 2002). The tetraploid occupies a rather compact distribution area, where *C. amara* subsp. *amara* is generally lacking; these two subspecies only marginally overlap in the western (eastern Switzerland) and northern parts (southern Bohemia) of the area of subsp. Morphologically it is very close to *C. amara* subsp. *amara*, and only a combination of several morphological characters (number of leaves, length of sepals and

Table 1. List of localities of the *Cardamine amara* populations from Slovenia karyologically investigated in this study.

Cardamine amara subsp. *amara*

Subpanonsko območje, Trnovska vas, 250 m alt., MTB 9461/3, 20 April 2001, coll. J. LIHOVÁ & B. FRAJMAN. – $2n = 16$

Cardamine amara subsp. *austriaca* MARHOLD

Predalpsko območje, W of Ljubljana, between Stranska vas and Vrhovci, Gradaščica brook, 320 m alt., MTB 9952/2, 19 April 2001, coll. J. LIHOVÁ & T. BAČIČ. – $2n = 32$

Predalpsko območje, Zg. Log near Litija, at the river Sava, 240 m alt., MTB 9954/2, 20 April 2001, coll. J. LIHOVÁ & B. FRAJMAN. – $2n = 32$

Predalpsko območje, Celje, near Šmartinsko jezero, N of Prekorje, 260 m alt., MTB 9757/2, 20 April 2001, coll. J. LIHOVÁ & B. FRAJMAN. – $2n = 32$

Alpsko območje, Kamniška Bistrica valley, Stranje near Godič, 430 m alt., MTB 9753/1, 18 April 2001, coll. J. LIHOVÁ & T. BAČIČ. – $2n = 32$

Alpsko območje, Maribor, Brestrnica, at the Bresterniški potok brook, 350 m alt., MTB 9459/1, 21 April 2001, coll. J. LIHOVÁ & B. FRAJMAN. – $2n = 32$

filaments, branching of stem and especially diameter of pollen grains) separates it from this taxon (MARHOLD, 1999a).

Another tetraploid taxon from Catalonia, NE Spain traditionally treated as *C. amara* subsp. *olotensis* O. BOLÒS (BOLÒS, 1952; BOLÒS et al., 1993; RICO, 1993) has been recently shown to be distant from the core *C. amara*, and should be classified as a separate species – *Cardamine amporitana* SENNEN & PAU (LIHOVÁ et al., 2000; MARHOLD et al., 2002; LIHOVÁ et al., submitted). Other diploid subspecies are confined to certain European mountain ranges, namely *C. amara* subsp. *opicii* (J. PRESL & C. PRESL) ČELAK. to the Sudety Mts. and the Carpathians, *C. amara* subsp. *balcanica* MARHOLD, ANČEV & KIT TAN to the mountains of SW Bulgaria and NE Greece, and *C. amara* subsp. *pyrenaea* SENNEN to the Eastern Pyrenees (MARHOLD, 1992, 1998; MARHOLD et al., 1996; LIHOVÁ et al., 2000).

In Slovenia, occurrence of both *C. amara* subsp. *amara* and *C. amara* subsp. *austriaca* has been reported (MARHOLD, 1999a,b), but no detailed karyological or chorological investigation has been done here as yet. In the distribution atlas of Slovenia (JOGAN, 2001) only general distribution of *C. amara* was given, without subspecific separation. According to this, *C. amara* occurs throughout the whole area of Slovenia, but it is more concentrated in northern and northeastern parts of the country. The area of Slovenia seems to represent the southern limit of distribution of *C. amara* subsp. *austriaca*, thus its exploration was expected to bring more precise delimitation of the area occupied by this tetraploid. In this paper we deal with the detailed distribution pattern of *C. amara* subsp. *amara* and *C. amara* subsp. *austri-*

aca in the area studied.

Material and methods

For chromosome number determination, six samples of *Cardamine amara* originating from several phytogeographical regions in Slovenia were collected (Tab. 1). The plants collected in the field were cultivated at the Institute of Botany, Slovak Academy of Sciences, and their root tips were treated using the squash method (modified after MÁRTONFI et al., 1999). The root tips were pretreated in 0.002 mol/L aqueous solution of 8-hydroxyquinoline for 3 hrs at 4°C, fixed for 1 hr in a mixture of 96% ethanol and concentrated acetic acid (3:1), hydrolyzed in a mixture of concentrated hydrochloric acid and 96% ethanol (1:1) for 3 min, and finally squashed using a cellophane piece instead of the cover glass. The squashes were stained in 10% Giemsa stock solution in Sörensen phosphate buffer for 1 hr, and rinsed with distilled water. The voucher specimens of the karyologically examined populations are deposited at SAV (herbarium abbreviations follow HOLMGREN et al., 1990).

Chorological study was based on our own samples (Tab. 1), on the previously published data (MARHOLD, 1999a), and on herbarium specimens deposited at LJU and SAV (Appendix). The specimens from LJU were determined at the subspecific level by measuring pollen grain diameter. From each specimen, one flower bud was removed and pollen grains were stained using acetocarmine-jelly (KEARNS & INOUE, 1993). Thirty pollen grains were measured from one flower and average values of pollen grain diameter were calculated. These were compared with the values of karyologically investigated plants both from Slovenia (Tab. 1) and other regions (voucher specimens from the paper by MARHOLD, 1999a). For diploid *C. amara* subsp. *amara* we recorded pollen grains of 18.0–20.4 µm, whereas those of *C. amara* subsp. *austriaca* were 20.6–24.7 µm large (average values of 30 pollen grains per one plant). A slight shift of both these ranges compared

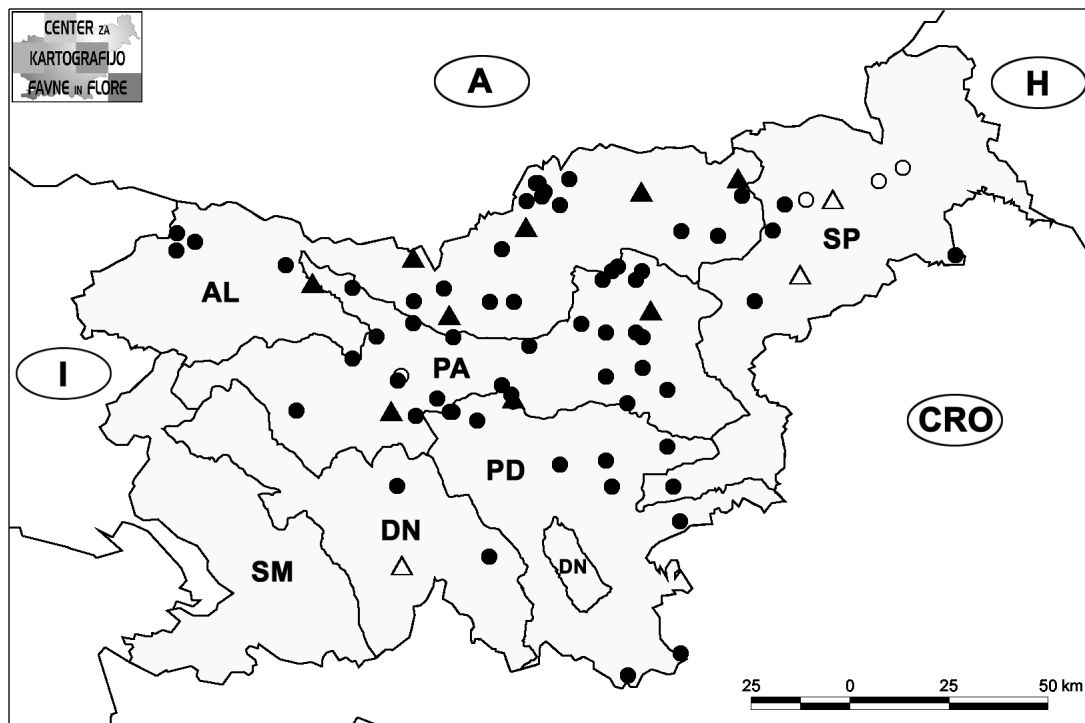


Fig. 1. Distribution of diploid *Cardamine amara* subsp. *amara* (empty symbols) and tetraploid *C. amara* subsp. *austriaca* (solid symbols) in Slovenia. Circles represent records based on investigation of herbarium specimens (see Appendix), triangles depict populations karyologically investigated in this study and that of MARHOLD (1999a). Phytogeographical regions: AL – Alpine, PA – Prealpine, SP – Subpannonian, PD – Predinarian, DN – Dinaric, SM – Submediterranean. A – Austria, H – Hungary, CRO – Croatia, I – Italy. The map was produced in the Center za kartografijo favne in flore, Ljubljana, Slovenia.

with the previously published data for these two subspecies (MARHOLD, 1999a,b) was caused most probably by the use of another measuring equipment.

Results and discussion

Out of six karyologically investigated populations from Slovenia, five were tetraploid ($2n = 32$) and a single one was diploid ($2n = 16$), corresponding to *Cardamine amara* subsp. *austriaca* and *C. amara* subsp. *amara*, respectively (Tab. 1). The diploid population of *C. amara* subsp. *amara* was found in the eastern Subpannonian part of the country (Subpanonsko območje: Trnovska vas), whereas the tetraploid populations of *C. amara* subsp. *austriaca* originated from Alpine and Prealpine regions (Alpsko območje, Predalpsko območje). MARHOLD (1999a) reported previously two localities of *C. amara* subsp. *amara* from eastern (Subpanonsko območje: Ptujška gora) and southern Slovenia (Dinarsko območje: Pudob),

and tetraploid *C. amara* subsp. *austriaca* from the northern Alpine region. Evaluation of herbarium specimens deposited at LJU and SAV (Appendix) revealed more detailed distribution pattern of the studied taxa. As can be seen from the map (Fig. 1), the area of Slovenia is mostly inhabited by tetraploid *C. amara* subsp. *austriaca*, which in few cases extends also to the most southern (Bela Krajina) and eastern regions (Ptujško polje). Diploid *C. amara* subsp. *amara* is concentrated in the northeastern Subpannonian area, except for two sites found in the Ljubljanska kotlina basin, and one, already mentioned site in the south. Similar distribution pattern was found for diploid *C. matthioli* MORETTI of the *C. pratensis* group, which in Slovenia occurs mainly in the Subpannonian region, partly extending to the most eastern parts of the Alpine, Prealpine and Predinarian regions, with a few localities in the Ljubljanska kotlina basin (LIHOVÁ & MARHOLD, submitted). Whereas diploid *C. amara* subsp. *amara* rep-

resents in Slovenia mainly Subpannonian floristic element, tetraploid subsp. *austriaca* overwhelmingly prevails in the regions of (Pre)alpine and (Pre)dinaric flora. When comparing our results with the general distribution of *C. amara* in Slovenia (JOGAN, 2001), there are few scattered records also in the Submediterranean region in the southwestern part of the country, which, however, lack in the map presented here (Fig. 1). We have not seen any herbarium specimen from that region, and search in several quadrants in 1994 was unsuccessful. More detailed exploration on the occurrence of *C. amara* in that area and its subspecific affiliation would be desirable.

Cardamine amara subsp. *austriaca* has its distribution centre in the Eastern Alps in Austria, however it extends also to neighbouring regions. The eastern boundary of the distribution area was found in eastern Austria, where the area of this taxon only slightly overlaps with that of diploid *C. amara* subsp. *amara*. A somewhat larger overlap was observed in the west in eastern Switzerland (MARHOLD 1999a) and in the north (S Bohemia), where tetraploids reach as far as to the phytogeographical district Březnické Podbrdsko, to the south of the town of Příbram (MARHOLD, unpubl.). Nevertheless, in both regions of overlap *C. amara* subsp. *austriaca* tends to occupy higher altitudes than *C. amara* subsp. *amara* (MARHOLD, 1999a). This seems to be to certain extent also the case of Slovenian populations – diploid *C. amara* subsp. *amara* occurs mainly in the region of lower altitudes, seldom up to 570 m a.s.l., although the populations of *C. amara* subsp. *austriaca* in the most southern and eastern parts of the country grow also at rather low altitudes of ca. 180–200 m a.s.l. (see Appendix). The localities of *C. amara* subsp. *amara* in Slovenia continuously append to those in southeastern Austria (Burgenland and Styria) (MARHOLD, 1999a). There are no chromosome records for *C. amara* from the countries more to the south (Croatia, Bosnia and Herzegovina) so far, where both *C. amara* subsp. *amara* and *C. amara* subsp. *austriaca* could occur, as we assume from the distribution pattern in Slovenia. It is worth to mention that in the neighbouring regions of Upper Styria (Austria) and northern Italy populations currently classified as *C. amara* subsp. *austriaca* were previously misidentified as *C. amara* subsp. *opicii* (PIGNATTI, 1982; MAURER, 1996) and from Slovenia itself subsp. *opicii* was wrongly reported by LÖVE & LÖVE (1974) (as *C. opizii*).

Cardamine amara subsp. *amara* and subsp. *austriaca* are morphologically very close to each

other. Previous morphometric analyses revealed only minor morphological differences between them. Tetraploid *C. amara* subsp. *austriaca* tends to have more leaves, less branched stem, larger flowers (longer petals, sepals and filaments of stamens), and especially, larger pollen grains. The last mentioned character is the only one which reliably differentiates individual plants of subsp. *amara* and subsp. *austriaca* (MARHOLD, 1999a). When ploidy level is not known, measurement of pollen grain is often inevitable for proper determination of single plants, but prior this, calibration based on measurements of plants with known ploidy level is recommended (see Material and Methods).

In agreement with morphology, also molecular data (RAPDs, AFLPs, isozymes) have shown very close position of both subspecies, as even such sensitive markers as AFLPs and RAPDs have not provided sufficient differentiation between them, and samples of both subspecies appeared in an unresolved polytomy (LIHOVÁ et al., 2000; MARHOLD et al., 2002).

In recent years, arctic and alpine plants have been intensively studied in respect of their interglacial migrations and postglacial recolonization during the Quaternary (COMES & KADEREIT, 1998). The Alps represent a region covered to a large extent by ice sheets during the glacial periods, and plants occurring here, their distribution and genetic diversity, were strongly affected by these climatic changes (STEHLIK, 2000). Phylogeographic studies, based on exploration of geographic distribution of genetic diversity, aim to trace evolutionary history and diversification of various taxa, discussing in situ persistence on ice-free nunataks (e.g. STEHLIK et al., 2001) versus survival in peripheral refugial regions with subsequent recolonization (e.g. GUGERLI et al., 2001). *Cardamine amara* subsp. *austriaca* is one of the taxa confined to the Eastern Alps and adjacent regions, and its origin is believed to be strongly associated with Pleistocene glaciation of the Alps (MARHOLD, 1999a). Low genetic and morphological divergence from the typical subspecies suggests a recent autopolyploid origin of this taxon, originated from *C. amara* subsp. *amara* (MARHOLD, 1999a; LIHOVÁ et al., 2000; MARHOLD et al., 2002). Retreat of ice sheet after the last glaciation period offered uncovered areas with various unsettled habitats. This might have supported spread and establishment of tetraploid populations of *C. amara* subsp. *austriaca* in the Eastern Alps. However, as yet there is no information on possible colonization routes,

nor whether monotypic or polytypic origin of this subspecies should be considered. A more detailed phylogeographic study could elucidate these questions.

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References

- BOLÒS, O. 1952. Notas florísticas III. Collect. Bot. (Barcelona) **3**: 185–197.
- BOLÒS, O., VIGO, J., MASALLES, R. & NINOT, J. 1993. Flora manual dels països Catalans, Editorial Pòrtic s.a., Barcelona, 1247 pp.
- COMES, H. P. & KADEREIT, J. W. 1998. The effect of Quaternary climatic changes on plant distribution and evolution. Trends Ecol. Evol. **3**: 432–437.
- GUGERLI, F., SPERISEN, CH., BÜCHLER, U., MAGNI, F., GEBUREK, T., JEANDROZ, S. & SENN, J. 2001. Haplotype variation in a mitochondrial tandem repeat of Norway spruce (*Picea abies*) populations suggests a serious founder effect during postglacial re-colonization of the western Alps. Molec. Ecol. **10**: 1255–1263.
- HOLMGREN, P. K., HOLMGREN, N. H. & BARNETT, L. C. 1990. Index Herbariorum. Part I: The Herbaria of the World. ed. 8. Regnum Veg. 120.
- JALAS, J. & SUOMINEN, J. 1994. Atlas florae europaeae, vol. 10, Helsinki, 224 pp.
- JOGAN, N. (ed.) 2001. Gradivo za Atlas flore Slovenije/Materials for the Atlas of Flora Slovenia, Center za kartografijo favne in flore, Miklavž na Dravskem polju, pp. 443.
- KEARNS, C. A. & INOUE, D. W. 1993. Techniques for pollination biologist, University Press of Colorado, Colorado, 583 pp.
- LIHOVÁ, J., MARHOLD, K. & NEUFFER, B. 2000. Taxonomy of *Cardamine amara* (Brassicaceae) in the Iberian Peninsula. Taxon **49**: 747–763.
- LÖVE, Á. & LÖVE, D. 1974. Cytotaxonomical atlas of the Slovenian flora, J. Cramer, Lehre, pp. 1241.
- MARHOLD, K. 1992. Multivariate morphometric study of the *Cardamine amara* group (Cruciferae) in the Carpathians and Sudeten mountains. Bot. J. Linn. Soc. **110**: 121–135.
- MARHOLD, K. 1998. Morphometric comparison of diploid populations of *Cardamine amara* (Brassicaceae) from Central Europe and the Balkan Peninsula. Thaiszia – J. Bot. **8**: 19–32.
- MARHOLD, K. 1999a. Taxonomic evaluation of the populations of *Cardamine amara* (Brassicaceae) from the Eastern Alps and adjacent areas. Bot. Helv. **109**: 67–84.
- MARHOLD, K. 1999b. *Cardamine amara* & *Cardamine pratensis*, pp. 379–380. In: MARTINČIČ, A., WRABER, T., JOGAN, N., RAVNIK, V., PODOBNIK, A., TURK, B. & VREŠ, B., Mala Flora Slovenije, ed. 3, Tehniška založba Slovenije, Ljubljana.
- MARHOLD, K., ANČEV, M. E. & KIT TAN 1996. A new subspecies of *Cardamine amara* (Brassicaceae) from Bulgaria and Greece. Ann. Bot. Fenn. **33**: 199–204.
- MARHOLD, K., HUTHMANN, M. & HURKA, H. 2002. Evolutionary history of the polyploid complex of *Cardamine amara* (Brassicaceae): isozyme evidence. Pl. Syst. Evol. **233**: 15–28.
- MÁRTONFI, P., MICHÁLEK, J., HADINEC, J., MÁRTONFIOVÁ, L. & REPČÁK, M. 1999. *Hypericum dubium*, a new species for the Czech flora. Preslia **71**: 337–348.
- MAURER, W. 1996. Flora der Steiermark I, IHW Verlag, Eching, 311 pp.
- PIGNATTI, S. 1982. Flora d'Italia 1, Edagricole, Bologna, 790 pp.
- RICO, E. 1993. 22. *Cardamine* L., pp. 119–133. In: CASTROVIEJO, S. et al. (eds), Flora Iberica, vol. 4, Real Jardín Botánico, C.S.I.C., Madrid.
- STEHLIK, I. 2000. Nunataks and peripheral refugia for alpine plants during Quaternary glaciation in the middle part of the Alps. Bot. Helv. **110**: 25–30.
- STEHLIK, I., SCHELLER, J. J. & BACHMANN, K. 2001. Resistance or emigration: response of the high-alpine plant *Eritrichium nanum* (L.) Gaudin to the ice age within the Central Alps. Molec. Ecol. **10**: 357–370.

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Appendix. List of the specimens deposited at LJU and SAV investigated in the present study.

Cardamine amara subsp. *amara*

0352/2, Notranjsko, Loška dolina, river banks of Veliki Obrh, W of the village of Pudob, 570 m alt., 21 May 1996, leg. K. MARHOLD & N. JOGAN (SAV); 9852/4, ob studencu na prelomu NE od Povodja, 2 May 1952, leg. F. ŠUŠTAR (LJU 45551); 9852/4, Pod Šmarno goro ob Dukič, Ljubljansko okolica, 25 April 1937, leg. A. BUDNAR (LJU 07539); 9660/2, Štajerska, Haloze, Podložje pod Ptujsko Goro, 240 m alt., 13 April 1994, leg. K. MARHOLD & N. JOGAN (SAV); 9560/1, S of Maribor, Rače, 260 m alt., 20 April 2001, leg. J. LIHOVÁ (SAV); 9460/4, Štajerska, Slovenske Gorice, Z od poti Dolge njive – Hum, 340 m alt., 9 April 1994, leg. A. VALENČAK (LJU 125597); 9462/1, ob potoku Sovjak v gozdu JZ od Vidma ob Ščavnici, Prekija, 240 m alt., 29 April 1992, leg. S. KREFT (LJU 124530); 9362/4, Prekmurje, področje na levem bregu Mure, blizu broda

Vučja vas, peščena jasa ob mrtvici Mure, 180 m alt., 6 April 1974, leg. Š. ŠPILAK (LJU 117812).

Cardamine amara subsp. *austriaca* MARHOLD
9950/2, Žiri, Svetletov, travnik na Čevljarski ulici, središče Žirov, 495 m alt., 4 May 1996, leg. P. ANDREUZZI, (LJU 127488); 9548/1, Julian Alps, Kranjska Gora, Planica, Tamar valley, 15 June 1995, leg. K. MARHOLD (SAV); 9548/3, Julijske Alpe, Trenta, na povirnatih tleh "Na Mlakah", 26 May 1961, leg. T. WRABER (LJU 68037); 9548/4, Julijske Alpe, Prisojnik, Osogna polica, 1650 m alt., 8 July 1967, leg. T. WRABER (LJU 38845); 9650/1, vas Gorje blizu Bleda, 604 m alt., 29 April 1996, leg. T. KOBLAR (LJU 127390); 9651/3, Gorenjska, Radovljica, in an ox-bow-lake of the river Sava, 410 m alt., 15 April 1994, leg. K. MARHOLD & N. JOGAN (SAV); 9651/4, Gorenjska, okolica Tržiča, travnik pri gostišču Smuk, na levi strani smer Duplje – Križe, 490 m alt., 7 May 1995, leg. U. BIDOVEC (LJU 126507); Šk. Loka, travnik ob Vincarškem potoku, 360 m alt., 5 May 1991, leg. N. DEBELJAK (LJU 127333); 9752/3, Gorenjska, Kranj z okolico, Zavica, desni breg reke Sove pod naseljem Orehek blizu čistilne naprave, 360 m alt., 7 May 1994, leg. T. DEMŠAR (LJU 125550); 9752/3, ob Savi pri naselju Čirče jugovzhodno od Kranja, 370 m alt., 28 April 1995, leg. S. ROZMAN (LJU 126942); 9752/3, ob kamniti poti v gozd pri vasi Prebačevo pri Kranju, 366 m alt., 22 May 1993, leg. S. KOSTANJEVEC, (LJU 125066); 9952/2, okolice Ljubljane, JV od Bokalcu, ob sotočju Nalega Grabne in Gradaščiće, 300 m alt., 9 May 1991, leg. ŽENEV, (LJU 127195); 0052/4, Rakitna, 14 May 1931, leg. R. JUSTIN (LJU 07533); 9653/1, Gorenjska, Karavanke, Gornje Jezersko, 880 m alt., 22 May 1996, leg. K. MARHOLD & N. JOGAN (SAV); 9652/4, 150 m od hiše Celarjevih, od Zg. Celarja v dolino reke Kokre, v okoli vasi Zg. Kokra, v okolici Kranja, 850 m alt., 1 June 1997, leg. N. HOJNIK (LJU 127806); 9752/2, Gorenjska, Cerklje, travnik ob potoku Ušica, 400 m alt., 25 April 1998, leg. E. MOČNIK (LJU 129091); 9653/4, ad fontem prope refugium alpinum "Dom v Kamniški Bistrici", 600 m alt., 1 May 1953, leg. A. MARTINČIČ (LJU 07544); 9754/1, Savinjska dolina, v močvirju na severni strani vasi Nova Štifta, zahodno od Gornjega Grada, 500 m alt., 29 May 1994, leg. H. POTOČNIK (LJU 125634); 9753/4, in paludosis vallis fluvii Nevljica inter vicus Vrhpolje et Podhruška prope oppidum Kamnik, 400 m alt., 11 April 1972, leg. T. WRABER (LJU 43280); 9953/1, Kranjsko-Gorenjska, breg Save pri Št. Jakobu, 1883, leg. R. JUSTIN (LJU 07538); 9953/2, V okolice Ljubljane: ob robu ribnika na močvirnem travniku v Sp. Kašlju, 270 m alt., 25 April 1991, leg. J. DOLENC (LJU 127242); 9953/2, kraj grmovja ob vodi (Ljubljanci), 280 m, 11 May 1937, leg. ZALOKAR (LJU 07540); 9953/3, Ljubljana, breg Ljubljance pri Prulskem mostu, 300 m alt., 26 April 1991, leg. M. ZOREC (LJU 127217); 9952/4, Ljubljanska kotlina, Ljubljana-Brod, desni breg Save, 200 m naprej od konca Taborske ceste, 300 m alt., 28 April 1996, leg. S. STRGULC (LJU 127436); 9953/4, Ljubl-

jana vzhod, Podgrad Tov. Arbo, 50 m nižje v smeri Podgrad-Besnica, potok Besnica, 275 m alt., 2 May 1997, leg. M. OSANIČ (LJU 127901); 9954/3, dolina Besnice pri Zalogu, 500 m od Zg. Besnice 5 proti Trebeljevem, 400 m alt., 18 April 1998, leg. A. ŠKORJANC (LJU 129238); 9854/4, in uliginosis haud procul a viae ferreae statione "Kresnice", 250 m alt., 28 April 1928, F. DOLŠAK (LJU 07548); 9854/4, Zahodno Posavsko hribovje-Peče, vlažen travnik ob potoku Velika voda, 450 m alt., 21 April 1994, leg. Š. BAEBLER (LJU 125589); 9855/1, in locis udis ad rivulum prope vicum Št. Ožbald haud procul pagi Trojane, 520 m alt., 5 May 1968, leg. T. WRABER (LJU 62422); Zg. Savinjska dolina, na močvirnem travniku na zahodnem pobočju Homa (ob cesti Radmirje-Gornji Grad) jugozahodno od domačije Potočnik, 440 m alt., 16 April 1994, leg. M. PETKOVŠEK (LJU 125530); 9554/4, Savinjske Alpe, Raduha, pl. Loka, 30 May 1953, leg. L. GODICL (LJU 94494); 9555/3, Komen, Studenec, 1600 m alt., 10 August 1965, leg. D. DRUŠKOVIČ (LJU 94056); 9555/1, Koroška, Črna, in the Bistra valley, 630 m alt., 27 April 1994, leg. K. MARHOLD & N. JOGAN (SAV); 9455/3, Koroška, Mežiška dolina, Mežica, Starijevo, 500 m alt., 19 May 1998, leg. J. MAKUC (LJU 129108); 9455/3, Koroška, Prevalje, pri gostilni Stopar ob Šentanelski reki, vlažna prst ob robu potoka, 430 m alt., 25 April 1992, leg. R. VEROVNIK (LJU 124593); 9455/1, v obcestni muldi na zelo vlažnem rastišču ob poti proti Godčevi kmetiji, S nad Prevaljami na Koroškem, 680 m alt., 24 May 1992, leg. M. KERBLER (LJU 124382); 9455/4, Mežiška dolina, Prevalje, Račal, desni breg Kristanovega potoka, 440 m alt., 20 May 1994, leg. K. STOPAR (LJU 125724); 9455/4, levi breg železniške proge, pod kmetijo Tičler na Stražišču, vzhodno od Breznici, 400 m alt., 5 May 1996, leg. J. HUDRAP (LJU 127496); 9455/4, Koroška, Kotlje, vlažen travnik na SV strani naselje Kotlje, 444 m alt., 3 May 1998, leg. M. KOGELNIK (LJU 129125); 9456/1, Koroška, Črneče, V močvirju ob Dravi, 350 m alt., 3 May 1984, leg. B. VREŠ (LJU 110601); 9457/3, Štajerska, Pohorje, between Vuhred and Ribnica na Pohorju, 530 m alt., 22 May 1996, leg. K. MARHOLD & N. JOGAN (SAV); 9558/1, Pohorje, ob studencu pod Rogljo, 1300 m alt., 16 June 1954, leg. T. WRABER (LJU 68043); 9459/3, Štajerska, Hrastje pri Mariboru, zgornji del Ludmerske grabe, 320 m alt., 6 May 1995, leg. N. MORI (LJU 126451); 9460/3, Štajerska, ob gozda pri Dravi, 300 m Z od gamoznice v Zgornji Duplek, 240 m alt., 25 April 1997, leg. U. ČERVEK (LJU 127880); 9559/3, Pohorje, Smrečna, 850 m alt., 10 May 1986, leg. D. NAGLIČ (LJU 117446); 9659/4, Poljčane, Modraže, 250 m alt., melioracijski kanal ob reki Dravinji, 11 May 1996, leg. A. VREZEC (LJU 127543); 9663/2, Ptujsko polje, na desnem bregu Črnca pred sotočjem s Trnavo v zgornjem Osiščecu J od Središča ob Dravi, 180 m alt., 15 April 1995, leg. M. GOVEDIČ (LJU 126390); 9656/2, Paka pri Velenju, 410 m alt., 17 August 1976, leg. D. NAGLIČ (LJU 97496); 9657/2, Paški Kozjak, v soteski pod Brdcami, 750 m alt., 17 May 1985, leg. Z. KEGLEVIČ (LJU 116665); 9657/1, Dobrna, ob potoku v Hudičevem grabnu, 420 m alt., 9 May 1985, leg. Z.

KEGLEVIČ (LJU 16628); 9656/4, Velenje, Kavče, Sp. Kavče, 400 m alt., 1 July 1991, leg. Z. MAZEJ (LJU 127304); 9656/4, Bevče pri Velenju, 400 m alt., 25 April 1977, leg. D. NAGLIČ (LJU 97868); 9757/2, Štajerska, Celje, 200 m J od Šmartinskega jezera, 240 m alt., 3 May 1996, leg. P. KAČIČNIK (LJU 127410); 9757/4, Celje-pri Petričku, 250 m alt., 16 April 1971, leg. T. KNEZ (LJU 86237); 9757/3, Celje, ob kanalu, ki se pri Celju izliva v Ložnico, 240 m alt., 23 April 1971, leg. T. KNEZ (LJU 86277); 9756/4, Štajerska, Šešče pri Preboldu, ob potoku Potočič, 275 m alt., 8 May 1996, leg. M. JEZERNIK (LJU 127184); Štajerska, Savinjska dolina, Prebold, Grajska vas, 350 m alt., 20 April 1994, leg. T. KORENT (LJU 125705); 9857/1, Laško, ob Savinji, 1 km JV od Laškega, 270 m alt., 29 April 1995, leg. I. TOMAŽIČ (LJU 126469); 9857/3, kompleks Kопitnika, Gore, 450 m alt., 17 May 1970, leg. T. KNEZ (LJU 35255); 9958/1, dolina Gračnice, med Mišjim Dolom in Kloštrom, 300 m alt., 5 May 1973, leg. T. KNEZ (LJU 35254); 0057/2, Loke v dolini Impoljskego

potoka pod vasjo Dolnje Orle, 250 m alt., 14 April 1989, leg. M. KAČIČNIK (LJU 121812); 0158/1, Hrvaški brod pri Šentjerneju, 30 April 1967, leg. R. LUŠTEK (LJU 93048); 0056/4, Kranjsko-Dolenjska, Ribjek pod Trebelnim, 3 May 1908, leg. R. JUSTIN (LJU 07536); 0156/2, Kranjsko-Dolenjska, v dolini Štatenberk pri Trebelnem, 12 May 1907, leg. R. JUSTIN (LJU 07534); 0056/3, ob potoka Pravharica na Lanšprežu, 3 km SZ od Trebnjega, 280 m alt., 10 April 1992, leg. P. Zalar (LJU 124459); 0258/1, Gorjanci, dolina Kobile, 2 May 1958, leg. V. STRGAR (LJU 46150); 0558/1, Bela krajina, Črnomelj, Miliči, vlažen travnik ob reki Kolpi, 200 m alt., 10 April 1998, leg. D. VUKČEVIČ (LJU 129112); 0557/3, Bela krajina, Damelj, in paludosis silvaticis ad fluvium Kolpa, 190 m alt., 16 May 1980, leg. A. PODOBNIK & T. WRABER (LJU 101782); 0254/3, Ribnica, Brezje (močvirno področje JZ od Nemške vasi), na desnem bregu potoka Šajevec, 491 m alt., 27 April 1994, leg. B. OVEN (LJU 125703).