Phyton (Horn, Austria)	**Vol. 34**	Fasc. 1	19–34	30. 6. 1994

Chromosome Numbers of the Genus *Cardamine* L. *(Cruciferae)* in the Carpathians and in Pannonia

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Received May 19, 1993

Key words: *Brassicaceae, Cardamine, Cruciferae.* – Karyology, aneuploidy, chromosome numbers, dysploidy, polysomy. – Flora of Europe.

Summary

MARHOLD K.1994. Chromosome numbers of the genus *Cardamine* L. *(Cruciferae)* in the Carpathians and in Pannonia. – Phyton (Horn, Austria) 34 (1): 19–34. – English with German summary.

New chromosome counts in the genus *Cardamine* L. from the Carpathians and Pannonia are presented. Special attention has been paid to populations of the *C. pratensis* group (7 taxa including two informal units, chromosome numbers from 2x up to 10x, aneuploids, polysomics, dysploids) and *C. amara* (*C. a.* subsp. *amara* and subsp. *opicii*). Five further species are discussed briefly. For several taxa chromosome numbers from populations outside the Carpathians and Pannonia are also given. Some previous indications of chromosome numbers based on misidentified material are corrected.

Zusammenfassung

MARHOLD K. 1994 Chromosomenzahlen aus der Gattung *Cardamine* L. *(Cruciferae)* in den Karpaten und in Pannonien. – Phyton (Horn, Austria) 34 (1): 19–34. – Englisch mit deutscher Zusammenfassung.

Neue Chromosomen-Zählungen aus der Gattung *Cardamine* L. aus den Karpaten und aus Pannonien werden vorgelegt. Besonders wird auf die *C. pratensis*-Gruppe (7 Taxa einschließlich zweier informativer Einheiten, Chromosomenzahlen von 2x bis 10x, Aneuploidie, Polysomie, Dysploidie) und auf *C. amara* (*C. a.* subsp. *amara* und subsp. *opicii*) eingegangen. Fünf weitere Arten werden kurz diskutiert. Für einige Taxa werden auch Chromosomenzahlen von Populationen außerhalb des eigentlichen Untersuchungsgebietes angeführt. Einige frühere Chromosomenzahlen-Angaben, die auf falsch bestimmtem Material beruhen, werden korrigiert.

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1. Introduction

The chromosome numbers of the genus *Cardamine* L. have been studied in detail by several authors (including LÖVKVIST 1956, URBANSKA-WORYTKIEWICZ & LANDOLT 1974a, b, SPASSKAJA 1979). With the exception of the work of BANACH-POGAN (BANACH 1950, 1951, BANACH-POGAN 1955) and previous papers by the present author (MARHOLD 1984, 1991, MARHOLD & ZÁBORSKÝ 1986), there is only a small amount of data from the Carpathians and Pannonia.

The aim of the present study, which forms part of a taxonomic revision of the genus *Cardamine* in the Carpathians and Pannonia, was to ascertain the chromosome numbers of taxa occurring in this area. Special attention has been paid to populations of the *C. pratensis* and *C. amara* groups. Data for several taxa of this genus from populations outside the Carpathians and Pannonia are also presented.

The results of a multivariate morphometric study of the above-mentioned groups and a detailed taxonomical treatment, including distributional information, are presented elsewhere (MARHOLD 1992, 1993 and other papers in prep.).

2. Material and Methods

Wild collected mature plants were cultivated in the Institute of Botany, Bratislava, Slovakia. Mitotic figures were prepared from root-tips obtained form these plants using the squash method. The root tips were pretreated with 0.002 M aqueous solution of hydroxyquinoline for 3 hrs, then fixed for 10 min. to 24 hrs in a freshly prepared mixture of ethanol and acetic acid (3:1), hydrolysed for 5 min. in a mixture of hydrochloric acid and ethanol (1:1), washed in water, and then stained with propionic orcein. Unless otherwise stated, all plant material was collected by the author. Voucher specimens are deposited in SAV.

Voucher specimens for chromosome number counts published by BANACH 1950, 1951, BANACH-POGAN 1955, PASHUK 1987, PÉNZES & VIDA 1966 and SPASSKAJA 1979 were not available for examination. In most cases these data are cited as published by these authors. Voucher specimens of all other published records cited in this paper were consulted.

3. Results and Discussion

3.1. *Cardamine pratensis* Group

On the basis of different chromosome numbers, morphology and pattern of geographical distribution, the author has provisionally recognized within *C. pratensis,* apart from populations of *C. pratensis* s. str., two diploid 'types' (treated as informal taxonomic units): the 'ucranica' type, occurring in the East Carpathians (Gorgany and Schidni Beskydy j Nyz'ki Polonyny) and foothills of the East Carpathians (phytogeographical district Prykarpattja), and the 'rivularis auct.' type, widespread in the upper montane and subalpine belts of the East Carpathians.

3.1.1. *Cardamine pratensis* L.

Poland:

Gorce, Rdzawka II, Mt. Kulakowy Wierch – 2n = 44
Kotlina Orawsko-Nowotarska, E of Długopole (W of Nowy Targ) – 2n = 44
Beskid Wyspowy, N of Kasina Wielka – 2n = 44
Data from outside the Carpathians:
Wyżyna Krakowsko-Częstochowska, Krzeszowice, Tenczynek – 2n = 30
— , N of Ojców – 2n = 38

Slovakia:

Záhorská nížina, Brodské, near the River Morava – 2n = 44
— , on the levee of the River Morava, between Skalica and Hodonín – 2n = 44
— , Holíč, in the Holíčsky les forest – 2n = 44
Kremnické vrchy, Kremnica, W slope of Mt. Kremnický štôs – 2n = 38
Poľana, Mt. Predná Poľana, near the chalet – 2n = 44
Slovenský raj, Dobšinská ľadová jaskyňa, near the railway station – 2n = 30
— , Mlynky, Biele Vody – 2n = 30
— , Dolina Bielej vody, S of Mt. Kopanec – 2n = 30
Nízke Tatry, Dolina Čierneho Váhu, near the Veľký Brunov forester's house – 2n = 30, 32
— , W edge of Heľpa – 2n = 30
— , W edge of Pohorelá – 2n = 30
— , Telgárt, near Telgárt-penzión railway station – 2n = 30
— , Pusté Pole – 2n = 30
— , S edge of Vernár – 2n = 30
— , Moštenica, valley of Kyslá stream – 2n = 44
— , SE edge of Vyšná Boca – 2n = 44
— , Demänová – 2n = 44
Západné Tatry, Zverovka – 2n = 44
— , Mt. Osobitá, W slope – 2n = 44
Turčianska kotlina, Príbovce, near the railway station – 2n = 44
— , Horná Štubňa, near the railway station – 2n = 44
Liptovská kotlina, E of Važec – 2n = 30
Spišské kotliny, SE edge of Spišská Teplica – 2n = 30
— , Huncovce, near the railway station – 2n = 30, 32
— , Strážky, near the railway station – 2n = 30
— , Spišská Belá, Belianske lúky state nature reserve (coll. H. Šípošová) – 2n = 30
Západné Beskydy, E of Zuberec – 2n = 44
Spišské vrchy, Reľov – 2n = 30
— , Majere – 2n = 30
Šarišská vrchovina, NW edge of Kamenica nad Torysou – 2n = 30
Nízke Beskydy, Čertižné, Mokré lúky state nature reserve – 2n = 38
— , E edge of Nižná Polianka – 2n = 44
Bukovské vrchy, SW edge of Nová Sedlica – 2n = 38

Czech Republic:

Dyjsko-svratecký úval, Tvrdonice, near the River Morava – 2n = 44
Dolnomoravský úval, Uherský Ostroh, in the Singulární les forest (type locality of *Cardamine pratensis* subsp. *major* TOMŠOVIC) – 2 n = 44
— , Veselí nad Moravou, park near the castle (coll. J. KOCHJAROVÁ & L. HROUDA) – 2n = 44, 48

Ukraine:

Prykarpattja, district Skolivs'kyj, near Pidhorodci – 2n = 30
— , district Drohobyc'kyj, Ždanivka – 2n = 38
— , district Starosambirs'kyj, Busovis'ko – 2n = 38
Schidni Beskydy j Nyz'ki Polonyny, district Turkivs'kyj, peatbog in Nyžne Vysoc'ke – 2n = 30
— , — , NE edge of Turka – 2n = 30
— , district Skolivs'kyj, Verchnyj Synovydnyj, near Korčyn (coll. A. KAHALO) – 2 n = 30
— , district Volovec'kyj, Nyžni Vorota, near Zavadka – 2n = 30
Gorgany, district Rožnjativs'kyj, Osmoloda – 2n = 30

3.1.2. *Cardamine pratensis* L. 'rivularis auct.' type

Ukraine:

Svydovec', district Rachivs'kyj, Polonyna Drahobrat – 2n = 16, 17
Čornohora, district Rachivs'kyj, Mt. Požyževs'ka, SW slope – 2n = 16
— , district Verchovins'kyj, between Mt. Maly Kozol and Mt. Velyky Kozol (coll. A. KAHALO & N. SYČAK) – 2n = 16, 24
— , district Verchovins'kyj, Mt. Turkul, N slope – 2n = 16
— , — , between Mt. Dančer and Mt. Turkul, NE slope – 2n = 16
— , district Nadvirjans'kyj, near the source of Arendarčyk stream – 2n = 16
— , — , near the source of Breskul'skyj stream – 2n = 16
— , — , between Mt. Breskul and Mt. Hoverla – 2n = 16
— , — , Mt. Hoverla, NE slope – 2n = 16

3.1.3. *Cardamine pratensis* L. 'ucranica' type

Ukraine:

Prykarpattja, district Stryjs'kyj, between Dovholuka and Ulyčne – 2n = 16
— , district Dolyns'kyj, Bolechov, Hošiv – 2n = 16
— , — , Dolyna, S of Ševcvenkovo – 2n = 16
— , district Rožnjativs'kyj, Knjazivka, near the River Duba – 2n = 16
Schidni Beskydy j Nyz'ki Polonyny, district Dolyns'kyj, Vyškiv – 2n = 16
Gorgany, district Rožnjativs'kyj, Jasen' – 2n = 16
— , district Dolyns'kyj, Ljudvykivka – 2n = 16

Earlier reports for *C. pratensis* from the Carpathians and Pannonia: 2n = 16, 18, 20 (SPASSKAJA 1979, as *C. rivularis* SCHUR); 2n = 30–32 (HRUŠOVSKÁ–OSUSKÁ 1988); 2n = 32 (SPASSKAJA 1979, as *C. rivularis* SCHUR; MARHOLD 1984); 2n = 40

(PÉNZES & VIDA 1966, as *C. dentata* SCHULT.); 2n = 44 (BANACH 1950, 1951); 2n = 48 (MARHOLD 1984); 2n = 50 (BANACH 1951); 2n = 58 (BANACH 1951).

Apart from two diploid "types", three dysploid "chromosome races" (2n = 30, 38, and 44) forming discrete populations were found. The origin of populations with 2n = 30 was discussed by LAWRENCE 1931. On the basis of the presence of one pair of chromosomes approximately twice as long as any of the remainder in the karyotype, he concluded that the number 2n = 30 originated by chromosome fusion either in a normal tetraploid with 32 chromosomes, or in one of the diploid progenitors of *C. pratensis*. The "race" with 2n = 44 is said to have the genomic constitution 2 (7 + 7 + 8) with two pairs of long chromosomes (LÖVKVIST 1956). The origin of populations with 2n = 38 is unknown. Most probably chromosome fusion and hybridization took part in the process of their origin. Plants with 2n = 38 have also been reported from Great Britain, Sweden, Lithuania, France, Switzerland and Germany (LÖVKVIST 1956, URBANSKA-WORYTKIEWICZ & LANDOLT 1974b). These plants, however, do not form populations but occur sporadically as the product of hybridization of diploids, tetraploids, hexaploids, and higher polyploidy levels. LÖVKVIST 1956 suggested that 38-chromosomic plants in Sweden might represent subhaploids developed from decaploids with chromosome number 2n = 76. Only plants with 2n = 38, reported from Poland (in the vicinity of Krakow) by BANACH 1951, probably arose by the same process as those in the Carpathians. Besides the populations with 2n = 30, 38 and 44, individual plants with 2n = 32 or 2n = 48 were also found in the area studied. These plants probably represent polysomic types within populations of 2n = 30 and 2n = 44. Plants of *C. pratensis* s. l. with aneuploid chromosome numbers 2n = 50 and 58, reported by BANACH from the Tatry, most probably belong to *C. pratensis* s. str. as well as the plants with 2n = 40, reported by PÉNZES & VIDA 1966 from Hungary. The taxonomic position of plants with 2n = 32, refered to by SPASSKAJA 1979 as *C. rivularis* SCHUR, is unknown.

Within the "rivularis auct." type the numbers 2n = 16, 17 and 24 were found. In addition, the diploid (2n = 16) and hyperdiploid (2n = 18, 20) numbers, refered by SPASSKAYJA 1979 to *C. rivularis* SCHUR, most probably belong to this type. Plants with 2n = 17, 18 and 20 most probably represent polysomic types, while triploid plants could be explained as a result of the occurrence of unreduced gametes.

Within the populations of the "ucranica" type only plants with the diploid chromosome number were found.

3.1.4. *Cardamine matthioli* MORETTI

Slovakia:

Východoslovenská nížina, between Stanča and Úpor, near the railway – 2n = 16

— , between Poruba and Jovsa, Pod Hrabinami state nature reserve – 2n = 16, 17

— , Rad, Hrušov, near Kerestúr estate – 2n = 16, 17
Poľana, Vígľaš, Pstruša – 2n = 16
Slanské vrchy, NW edge of Slanské Nové Mesto – 2n = 16
— , S edge of Bačkovík – 2n = 16
— , N of Vyšný Čaj – 2n = 18
— , S edge of Slanec – 2n = 16
— , Slanská Huta, near the cemetery – 2n = 20, 21
— , N edge of Nový Salaš – 2n = 16
Vihorlatské vrchy, Modra nad Cirochou, SW of the railway station – 2n = 16
Čergov, E edge of Malcov – 2n = 16
Nízke Beskydy, E of Makovce – 2n = 16
— , S edge of Stročín – 2n = 16
— , N edge of Nižný Orlík – 2n = 16
— , E edge of Nižná Polianka – 2n = 16
— , Brekov, near the railway station – 2n = 16
Bukovské vrchy, Stakčín, SW of the railway station – 2n = 16

Czech Republic:

Dolnomoravský úval, Uherský Ostroh, edge of the Singulární les forest – 2n = 16

Austria:

Weinviertel, Rabensburg (coll. A. SCHRATT) – 2n = 16

Ukraine:

Schidni Beskydy j Nyz'ki Polonyny, district Svaljavs'kyj, N of Kerec'ky, near the River Boržava – 2n = 16
Vulkanični Karpaty, district Perečyns'kyj, N of Perečyn – 2n = 16
Zakarpats'ka rivnyna, district Užhorods'kyj, Užhorod, near the path to Onokivci – 2n = 16
— , — , near Mala Dobron', near the River Latorycja – 2n = 16, 17, 18, 19
— , — , N of Velyka Dobron', near the Serne-Močar canal – 2n = 16, 18
— , district Mukačivs'kyj, Mukačeve, in the Berezinka forest – 2n = 16

Romania:

Depresiunea Sibiului, Sibiu, Noul – 2n = 16
— , S of Veştem – 2n = 16
— , Christian – 2n = 16
Depresiunea Făgăraşului, Cîrţa, near the River Olt – 2n = 16
— , Avrig, near the railway station – 2n = 16, 17

Earlier reports from the Carpathians and Pannonia: 2n = 16 (MURÍN 1974, as *C. pratensis* L. subsp. *pratensis;* MURÍN & FERÁKOVÁ 1978; FERÁKOVÁ & UHRÍKOVÁ 1978; MARHOLD 1984, 1991; JAVŮRKOVÁ 1986); 2n = 18 (JAVŮRKOVÁ 1986; MARHOLD 1991).

This study has confirmed previous reports of 2n = 16 for this taxon. At some localities individual hyperdiploid plants were also found, most probably representing polysomic types. The occurrence of plants with aneu-

ploid chromosome numbers in otherwise euploid populations corresponds with URBANSKA-WORYTKIEWICZ & LANDOLT'S 1974 b statement that populations containing euploid and aneuploid plants occur most frequently in regions where the diploids come into contact with various polyploid types. In Moravian localities these polyploids are represented by *C. pratensis* (2n = 30) (JAVŮRKOVÁ 1986), while in Slovakian, Ukrainian, Hungarian and Romanian localities they are represented by *C. majovskii* (2n = 32). In Moravia (Czech Republic) the occurrence of hybrids has been reported by TOMŠOVIC 1986 although none were found during the present study.

3.1.5. *Cardamine majovskii* MARHOLD & ZÁBORSKÝ

Slovakia:

Východoslovenská nížina, Ptrukša, in the Mokraď forest – 2n = 32
— , Leles, near the bridge over the River Latorica – 2n = 32
— , Rad, Hrušov, near the Tica ox bow lake – 2n = 32
— , Veľký Horeš, 0.5 km W of the railway station – 2n = 32
— , Kuzmice, near the path from Čelovce to Kuzmice – 2n = 32
— , S of Úpor, near the railway – 2n = 32
— , Strážske, S of the railway station – 2n = 32
— , Nacina Ves, near the railway station – 2n = 32
— , NE of Laškovce – 2n = 32
— , W of Kusín – 2n = 32
Slanské vrchy, SE of Zlatá Baňa, near the memorial to the Slovak national uprising – 2n = 32
Vihorlatské vrchy, Modra nad Cirochou, SW of the railway station – 2n = 32
Nízke Beskydy, Ľubiša, N of the railway station – 2n = 32
— , Rokytovce – 2n = 32
— , NE of Krásny Brod – 2n = 32
Bukovské vrchy, E edge of Snina – 2n = 32
— , at the site of the former village of Dara – 2n = 32
— , Uličské Krivé – 2n = 32
— , 2 km NW of Ulič – 2n = 32

Ukraine:

Schidni Beskydy j Nyz'ki Polonyny, district Iršavsk'kyj, NE of Iršava, near Bron'ka – 2n = 32
Gorgany, district Mižgirs'kyj, Nehrovec' state nature reserve – 2n = 32
Vulkanični Karpaty, district Užhorods'kyj, Kam"janycja, near Nevyc'kyj Castle – 2n = 32
— , district Perečyns'kyj, N of Perečyn – 2n = 32
— , district Svaljavs'kyj, W of Svaljava, near Karpaty sanatorium – 2n = 32
— , district Iršavs'kyj, near Bilky – 2n = 32
— , — , between Iršava and Sil'ce – 2n = 32
Zakarpats'ke peredhir"ja, district Chusts'kyj, near Nankove – 2n = 32
— , — , NW of Steblivka – 2n = 32

— , — , NE of Iza, near Rika stream – 2n = 32
— , district Tjačivs'kyj, SW of Tereblja – 2n = 32
— , — , Drahove, near Tereblja stream – 2n = 32
Zakarpats'ka rivnyna, district Užhorods'kyj, near Strumkivka – 2n = 32
— , district Užhorods'kyj, E of Čop – 2n = 32
— , district Mukačivs'kyj, Pistrjalove – 2n = 32
— , — , Lalove – 2n = 32
— , — , Verchnij Koropec' – 2n = 34
— , — , Nyžnij Koropec' – 2n = 32
— , district Berehivs'kyj, E of Velyka Bakta – 2n = 32
— , between Berehy and Zmijivka – 2n = 32
— , — , Nyžni Remety – 2n = 32
— , district Vynohradivs'kyj, E of Vynohradiv, below Mt. Čorna hora – 2n = 32
— , — , N of Velyki Kom"jaty – 2n = 32

Romania:

Depresiunea Sibiului, Tălmaciu, in the valley of the River Sadu – 2n = 32
— , Sibiu, in the Pădurea Dumbrava forest – 2n = 32

Earlier reports from Pannonia: 2n = 32 (MARHOLD & ZÁBORSKÝ 1986; MARHOLD 1991).

The results of this study have confirmed the only known tetraploid chromosome number (2n = 32) for this species. In one locality the hypertetraploid number 2n = 34 was found. This most probably represents a polysomic type. Plants with 2n = 32 were not found at this locality, but, because only two plants were analysed, the posibility of the occurrence of plants with euploid numbers can not be excluded.

3.1.6. *Cardamine rivularis* SCHUR

Romania:

Mţii Făgăraşului, Valea Capra – 2n = 16
— , Valea Arpaşului (type locality of *C. rivularis* SCHUR) – 2n = 16, 24
— , Valea Bîlea – 2n = 16
— , Valea Doamnei – 2n = 16
— , near Bîlea Lac – 2n = 24

URBANSKA–WORYTKIEWICZ & LANDOLT 1974 b stated that, according to their analysis of pollen grain size, it may be assumed that the original material collected by SCHUR (in W) from the type locality comprises diploids, tetraploids and hybrids. The only chromosome number (2n = 16) recorded in the literature for *C. rivularis* s. str. (see MARHOLD 1993; MARHOLD & RAYNER, 1994) is from Mt. Vitoša in Bulgaria (KUZMANOV & KOŽUHAROV 1969). Records reported for this species from outside the South Carpathians and Bulgarian mountains (incl. URBANSKA-WORYTKIEWICZ & LANDOLT 1974b and TEPPNER 1980) belong to a different taxon (or taxa) of the

C. pratensis group. In the course of the present study only diploid and triploid chromosome numbers were confirmed for the type locality and for other localities in the Mţii Făgăraşului. Because no tetraploid plants were found here, it might be assumed that triploid plants are the result of the occurrence of unreduced gametes. At Bîlea Lac (2034 m) only sterile triploid plants were found to occur, the exceptionally short growing period probably favouring vegetative reproduction.

3.1.7. *Cardamine dentata* Schult.

Ukraine:

Zakarpats'ka rivnyna, district Užhorods'kyj, Mala Dobron', near the River Latorycja – 2n = c.80

Earlier reports from the Carpathians and Pannonia: 2n = 64 (Murín & Feráková 1976; Marhold 1984); 2n = c.80 (Marhold 1984); 2n = 80 (Pénzes & Vida 1966, as *C. fragmentosa* Pénzes & Vida).

Only octoploid and decaploid chromosome numbers were confirmed in the area studied. It is probably due to the rarity of this species that the extent of hybridization of plants from the different polyploid levels, and thus the number of aneuploid plants in the Carpathians and Pannonia, is not comparable with those reported by Lövkvist 1956 from northern Europe.

3.2. *Cardamine amara* L.

3.2.1. *Cardamine amara* L. subsp. *amara*

Poland:

Pieniny, Zawiasy – 2n = 16
Gorce, the valley of the River Łopuszna – 2n = 16
— , Huba, N slope of Mt. Kotelnica – 2n = 16
— , Szczawa, the valley of the River Kamienica – 2n = 16
Beskid Makowski, N slope of Mt. Sularzówka, ca. 2 km from Stróża – 2n = 16
Data from outside the Carpathians:
Wyżina Krakowsko-Częstochowska, Krzesowice, Tenczynek – 2n = 16

Slovakia:

Záhorská nížina, Plavecký Štvrtok, Bezedné state nature reserve – 2n = 16
Malé Karpaty, Bratislava, Mt. Javorník – 2n = 16
— , Bratislava, Železná Studnička – 2n = 16
— , Modra, Piesok – 2n = 16
— , Horné Orešany, near Parná stream – 2n = 16
Kremnické vrchy, Kremnica, Keslo – 2n = 16
— , Kremnica, Bujačia lúka state nature reserve – 2n = 16

Slovenské rudohorie, Hriňová, Biele Vody - 2n = 16
— , Čierny Balog, Veľká Prostredná dolina – 2n = 16
— , Klenovec, near the reservoir – 2n = 16
Muránska planina, near the stream in Tisovec – 2n = 16
— , Zbojská, near the railway station – 2n = 16
Slanské vrchy, Kokošovce, 0.5 km NE of the reservoir – 2n = 16
Vihorlatské vrchy, N of Dúbrava – 2n = 16
Krivánska Malá Fatra, Strečno, E of the railway station – 2n = 16
Veľká Fatra, Ľubochnianska dolina, below the Raková forester's house – 2n = 16
— , between Belá and Dudice, Belianska dolina (coll. H. Šípošová) – 2n = 16
— , Gaderská dolina, near the lower forester's house – 2n = 16
— , Gaderská dolina, at the bottom of the Dedošova dolina – 2n = 16
— , Dedošova dolina – 2n = 16
Chočské vrchy, Zuberec, above the Biela Skala forester's house – 2n = 16
Nízke Tatry, Liptovské Kľačany, Kľačianska dolina – 2n = 16
— , Liptovský Hrádok, S of Borová Sihoť – 2n = 16
— , Ohnište state nature reserve, Svidovské sedlo – 2n = 16
— , Šumiac, S slope of Mt. Kráľova hoľa – 2n = 16
Západné Tatry, Zverovka – 2n = 16
— , Jamnická dolina (coll. H. Šípošová) – 2n = 16
Belianske Tatry, near the stream below Plesnivec chalet – 2n = 16
Pieniny, SE of the former settlement of Lesnická Huta – 2n = 16
Spišské vrchy, NE of Starina – 2n = 16
— , near the stream E of Spišská Stará Ves – 2n = 16
— , S of Chmeľnica – 2n = 16
Čergov, SE of Tarnov, near the River Topľa – 2n = 16
Bukovské vrchy, Starina, near the reservoir – 2n = 16
— , Ruský Potok – 2n = 16
— , Nová Sedlica, Stužica state nature reserve – 2n = 16
— , Nová Sedlica, Riaba skala state nature reserve – 2n = 16
— , NE of Ubľa – 2n = 16
— , between Uličˇ and Ubľa, on the state border – 2n = 16

Czech Republic:

Dyjsko-svratecký úval, Lanžhot, near the bridge over the river Morava – 2n = 16
Data from outside the Carpathians and Pannonia:
Jizerské hory, Malá Jizerská Louka, slope of Mt. Bukovec – 2n = 16
Krkonoše, Obří důl – 2n = 16
— , Pec pod Sněžkou, Modrý důl – 2n = 16
Králický Sněžník, above Vilemína – 2n = 16
Hrubý Jeseník, Malá Morávka, E slope of Mt. Temná – 2n = 16

Ukraine:

Prykarpattja, district Skolivs'kyj, Nyžnij Synovydnyj – 2n = 16
— , district Drohobyc'kyj, Pidbuž, Zolokot', near Bystrycja stream – 2n = 16
— , district Sambirs'kyj, Staryj Sambir, near Teršiv – 2n = 16
— , district Dolyns'kyj, Dolyna, S of Ševčenkovo – 2n = 16

Schidni Beskydy j Nyz'ki Polonyny, district Volovec'kyj, between Huklyvyj and Podobovec' – 2n = 16
Svydovec', district Rachivs'kyj, Jasynja, near the path to Polonyna Drahobrat – 2n = 16
— , — , Jasynja, Čorna Tysa, near the source of the River Čorna Tysa, slope of Mt. Okola – 2n = 16
Čornohora, district Nadvirjans'kyj, S slope of Mt. Dančer – 2n = 16
— , — , Cybul'nyk – 2n = 16
Gorgany, district Mižgirs'kyj, near Synevyr lake – 2n = 16
Data from outside the Carpathians and Pannonia:
District Mykolajivs'kyj, near Trostjanec' – 2n = 16
District Pustomytivs'kyj, near Rakovec' – 2n = 16

Romania:

Mţii Făgăraşului, Valea Arpaşului – 2n = 16
Depresiunea Făgăraşului, in Cîrţa – 2n = 16
Depresiunea Sibiului, Tălmaciu, Valea Sadu – 2n = 16
— , Sibiu, Pădurea Dumbrava forest – 2n = 16

Earlier reports from the Carpathians and Pannonia: 2n = 16 (BANACH 1950; BANACH-POGAN 1955; MURÍN & FERÁKOVÁ 1978; UHRÍKOVÁ & SCHWARZOVÁ 1978; SPASSKAJA 1979); 2n = 32 (HINDÁKOVÁ 1974).

3.2.2. *Cardamine amara* subsp. *opicii* (J. PRESL & C. PRESL) ČELAK.

Poland:

Tatry Wschodnie, near Litworowy Staw – 2n = 16
Tatry Zachodnie, Dolina Kondratowa, NW of Mt. Myślenickie Turnie – 2n = 16

Slovakia:

Kremnické vrchy, Kordícke sedlo – 2n = 16
Poľana, Mt. Predná Poľaná, near the chalet – 2n = 16
— , Mt. Predná Poľana, near the path to the chalet – 2n = 16
Muránska planina, Muránska Huta, valley of Župkov stream (coll. J. KOCHJAROVÁ & L. HROUDA) – 2n = 16
Veľká Fatra, Ľubochnianska dolina, above the Raková forester's house – 2n = 16
Nízke Tatry, Železnô, near Tlstý stream – 2n = 16
— , Lomnistá dolina, NE of Struhárske sedlo – 2n = 16
— , Mt. Ďurková, N slope, valley of Ďurková stream (coll. H. ŠÍPOŠOVÁ) – 2n = 16
— , Mt. Ďurková, S slope, Šifrová dolina – 2n = 16
— , near the former chalet Pod Chabencom – 2n = 16
— , Dolina Štiavnica Valley, E of Bocianske sedlo – 2n = 16
— , Dolina Štiavnica, S of Mt. Konský grúň – 2n = 16
— , Sedlo Čertovica – 2n = 16
— , Mt. Kráľova hoľa, Martalúzka, near the River Hnilec – 2n = 16
— , Mt. Kráľova hoľa, near the source of the River Čierny Váh – 2n = 16

Západné Tatry, Zverovka, Spálený žľab – 2n = 16
— , Látaná dolina, near the edge of Kotlov žľab state nature reserve – 2n = 16
— , Mt. Osobitá, W slope – 2n = 16
— , above Dolné Jamnické pleso – 2n = 16
Vysoké Tatry, Vyšné Temnosmrečianske pleso (coll. K. ZAHRADNÍKOVÁ & H. PIĘKOŚ-MIRKOWA) – 2n = 16
— , Mlynická dolina, near the right tributary of Mlynica stream – 2n = 16
— , Velická dolina, near Dlhé (Kvetnicové) pleso – 2n = 16
— , Veľká Studená dolina – 2n = 16
— , Gerlachovské lúky (coll. I. HODÁLOVÁ) – 2n = 16
— , Zadné Meďodoly, below elevation point 1293.2 – 2n = 16

Czech Republic:

Data from outside the Carpathians:
Krkonoše, Mt. Studniční hora, NW slope (type locality of *Cardamine opicii* J. PRESL & C. PRESL) 2n = 16
Králický Sněžník, SW slope of Mt. Králický Sněžník, above the saddle between Mt. Králický Sněžník and Mt. Malý Sněžník – 2n = 16
Hrubý Jeseník, Velká kotlina, Šmardova stěna – 2n = 16

Ukraine:

Gorgany, district Rožnjativs'kyj, valley of the River Limnycja, near the path to Mt. Grofa – 2n = 16
Svydovec', district Rachivs'kyj, E slopes of Mt. Blyznycja, Polonyna Hropa (coll. A. KAHALO & N. SYČAK) – 2n = 16
Čornohora, district Verchovyns'kyj, between Mt. Velyky Kozol and Mt. Maly Kozol (coll. A. KAHALO & N. SYČAK) – 2n = 16
— , district Nadvirjans'kyj, valley of Arendarčyk stream – 2n = 16
— , — , between Mt. Dančer and Mt. Turkul – 2n = 16
— , — , Mt. Turkul, NE slope – 2n = 16
— , — , between Mt. Hoverla and Mt. Breskul – 2n = 16
— , district Rachivs'kyj, NW slope of Mt. Hoverla – 2n = 16
— , — , Mt. Požyževs'ka, S slope – 2n = 16

Romania:

Mţii Făgăraşului, Valea Doamnei – 2n = 16

Earlier reports from the Carpathians: 2n = 16 (BANACH 1950; BANACH-POGAN 1955; SPASSKAJA 1979; MARHOLD 1987; PASHUK 1987); 2n = 32 (BANACH-POGAN 1955).

Only the diploid chromosome number (2n = 16) was confirmed in the present study for both subspecies of *C. amara* from the Carpathians, Pannonia and the Sudeten mountains. Only two tetraploid chromosome numbers have been published for these taxa from this area. The first of these, published by BANACH-POGAN 1955 for *C. amara* subsp. *opicii*, was considered the result of somatic polyploid mutation. The second record, published by HINDÁKOVÁ 1974, has not been confirmed in the present study either for

material collected at the original locality or from localities around it. This tetraploid number could be either an artefact or due to a polyploid mutation. The tetraploid chromosome numbers recorded from the Alps by HABELER 1963 and other authors, most probably refer to a different, as yet undescribed, taxon (MARHOLD, ined.).

3.3. *Cardamine flexuosa* WITH

Slovakia:

Bukovské vrchy, Uličˇ, Mt. Vysoký vrch, S slope – 2n = 32
— , N of Ubľa – 2n = 32

Ukraine:

Svydovec', district Rachivs'kyj, Jasynja, near the path to Polonyna Drahobrat – 2n = 32

Earlier reports from the Carpathians: 2n = 32 (BANACH-POGAN 1955; HINDÁKOVÁ & MÁJOVSKÝ 1974, as *C. impatiens* L.; SPASSKAJA 1979).

The results of the present study have confirmed previous reports for this species.

3.4. *Cardamine hirsuta* L.

Slovakia:

Nízke Tatry, Moštenica, valley of Kyslá stream – 2n = 16

Ukraine:

Gorgany, district Rožnjativs'kyj, valley of the River Limnycja, near the path to Mt. Grofa – 2n = 16

Earlier report from the Carpathians: 2n = 16 (BANACH 1950, BANACH-POGAN 1955).

The diploid chromosome numer (2n = 16) is probably the only correctly reported number for this species. The study of voucher specimens of the published tetraploid numbers for this taxon from Afghanistan (in M) (PODLECH & BADER 1974) and the Canary Islands (in O) (BORGEN 1975), shows that they belong to taxa other than *C. hirsuta*. Voucher specimens of other tetraploid and octoploid number counts for *C. hisuta* (MORTON 1961, SHARMA 1970, MUKHERJEE 1975) were not available for study.

3.5. Cardamine parviflora L.

Slovakia:

Východoslovenská nížina, W of Leles, near the Tica ox bow lake – 2n = 16
— , Vojany, near the path from Vojany to Veľké Raškovce, by the path to Drahňov – 2n = 16

Earlier report from Pannonia: 2n = 16 (KRAHULCOVÁ 1990).

The results of the present study have confirmed previous reports for this taxon.

3.6. *Cardamine impatiens* L.

Slovakia:

Malé Karpaty, Pezinok, Mt. Pezinská Baba – 2n = 16
— , Horné Orešany, Rybnikárka – 2n = 16
— , Kremnické, vrchy, Kremnica, slope of Mt. Kremnický štôs – 2n = 16

Earlier reports from the Carpathians: 2n = 16 (BANACH 1950; BANACH-POGAN 1955; MURÍN & FERÁKOVÁ 1978; SPASSKAJA 1979).

The results of the present study have confirmed previous reports for this species. Voucher specimens of the published tetraploid numbers for *C. impatiens* from Kashmir (GOLHIL & al. 1982, JEE & al. 1983) were not available for study. These records may refer to the another taxon.

3.7. *Cardamine trifolia* L.

Poland:

Tatry Zachodnie, Dolina Białego – 2n = 16

Slovakia:

Nízke Tatry, Mt. Ľupčianska Magura, NE slope, S of Mt. Preslovec – 2n = 16
Západné Tatry, Zverovka – 2n = 16
Pieniny, SE of the former settlement of Lesnická Huta – 2n = 16

Earlier reports from the Carpathians: 2n = 16 (BANACH-POGAN 1955; HINDÁKOVÁ 1976; MIGRA 1982)

The results of the present study have confirmed previous reports for this species.

4. Acknowledgments

I am indebted to Doc. Dr. Viera FERÁKOVÁ for her valuable comments on the manuscript. I would also like to thank to Drs. C. DRAGULESCU, L. HROUDA, A. KAHALO, N. SYČAK, J. J. WÓJCICKI and M. ZAGULSKIJ for their help with my field studies. This work was supported by the Grant Agency for Science, Bratislava, Slovakia (Grant No. 2/41/92).

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