On-line database of the chromosome numbers of the genus *Cardamine* (Brassicaceae)

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Abstract: Chromosome numbers of 101 taxa of the genus *Cardamine* (altogether 3020 records) are included in an on-line karyological database, which is presented in this paper. Information about chromosome numbers is taken from 234 literature sources. Each database record includes name of taxon, data on chromosomes, data on the origin of the material, data on the voucher specimen and place of publication. More than half of the species for which chromosome data are available is either entirely polyploid or contains both diploid and polyploid populations. There is an apparent geographical bias in the available data as most of the chromosome counts were done on material from Europe.

Key words: chromosome numbers, karyological database, polyploidy,*Cardamine*, Cruciferae

Introduction

With approximately 200 species, the genus *Cardamine* is one of the largest genera of the family Brassicaceae (Al-Shehbaz, 1988 and the data by the present authors). It is distributed worldwide except the Antarctic continent. As shown by numerous studies, polyploids play a key role in the evolution of this genus. Several polyploid complexes have been revised recently, especially those occurring in Europe (e.g. Marhold, 1999; Urbanska & Landolt, 1999; Franzke & Hurka, 2000; Lihová et al., 2000, 2003, 2004a,b; Marhold et al., 2002; Perný et al., 2005). These studies have shown complex patterns of reticulate evolution, which complicate any evolutionary reconstruction (Marhold et al., 2004). Therefore, for any aspect of the study of this genus it is very important to have reliable data on ploidy levels and chromosome numbers of the studied taxa.

During the last few years we have collected almost complete dataset on the published chromosome numbers of the taxa of this genus. Apart from the search in published papers and chromosome indices, we have used also the database of the chromosome numbers of the Brassicaceae family by Warwick & Al-Shehbaz (2005). Original sources were consulted in all cases. We also made an attempt to revise the identification of at least some part of the analysed material. The result of our work, the on-line database of the chromosome numbers of the genus *Cardamine*, is presented in this paper, together with some statistical data, which we retrieved from the database.

There are numerous databases on chromosome numbers available on-line. The most important and most comprehensive one is the Index to Plant Chromosome Numbers available as part of the w^{3}TROPICOS database of the Missouri Botanical Garden (Missouri Botanical Garden, 2005).

This on-line database gathers data from published indices to plant chromosome numbers from 1984 onwards (Goldblatt, 1988; Goldblatt & Johnson, 1990, 1991, 1994, 1996, 1998, 2000, 2003). The data are presented as they were published, without any attempt to make taxonomic revision of the analysed plant material. Other type of databases includes those covering certain geographical areas. Here, PhytoKaryon, the database covering European and Mediterranean area, developed by the University of Patras, should be mentioned (Kamari, 2003). Other examples of the geographically restricted databases are those for the United Kingdom and Ireland, presented by the Botanical Society of British Isles (Botanical Society of the British Isles, 2005); Chromosome numbers for the Italian flora, edited by Garbari (2002); and the currently developed Karyological database of ferns and flowering plants of Slovakia (Marhold et al., 2005). Few on-line databases or data sets are devoted to certain taxonomic groups. Here, the dataset on the genus *Hieracium* by Schuhwerk (1996), or dataset devoted to *Asclepiadoideae*, *Periplocoideae* and *Secamonoideae* of the family Asclepiadaceae (Albers & Meve, 2001) can be mentioned. The database of the chromosome numbers of the whole family Brassicaceae by Warwick & Al-Shehbaz (2005) is in the final stage of its development.

Description of the database

The database is created and designed in Microsoft Access 2000. For searching and viewing the data on the Internet there is a web interface written in PHP4 available on the site http://147.213.100.117/cardamine/.

In construction of the database structure we generally followed the model suggested by BERENDSOHN et al. (1997). Each record in the database includes the following data (some of them are optional, depending on their availability in the original source or possibility of inquiries from the original author):

Name of the taxon: includes the name of the taxon as published in the original source, the standardised name of the taxon (authorship of the name is corrected, as well as possible typing errors), and the currently accepted name of the taxon;

Data on chromosomes: mitotic or meiotic chromosome number, the name of the person who counted chromosomes, number of the analysed plants, number and place of the deposit of the microscopic slide, presence or absence of karyotype, idiogram, photograph of chromosomes or drawing in the original publication;

Detailed data on the locality where material was collected, including its position in the World Geographical Scheme for Recording Plant Distributions (BRUMMITT, 2001);

Data on the voucher specimen: the collector(s) name(s), date of the collection, specimen number and the herbarium collection where it is deposited (herbarium collections acronyms follow HOLMGREN et al. 1990 with updates available on-line; in the case that acronym was not available, the full name of the institution is provided, together with the city and country);

Place of publication: the authorship and title of the paper, name of the journal, its volume and pages, for books corresponding information is provided as well;

Data on the revision of the record or its voucher herbarium specimen.

For all data original sources were consulted and in some cases voucher specimens were checked for the correct identification of the analysed material.

Statistical data on chromosome numbers of the genus *Cardamine*

The database currently contains 3020 records for 96 species representing 101 taxa taken from 234 literature sources. Taking into account that the estimated number of *Cardamine* species is about 200, this represents approximately 48% of species for which at least one chromosome number record is known (96 records were published without exact locality and they are not considered in the following geographical statistics). There is a considerable bias in the geographical representation of the data (Fig. 1). While only 54 species of the genus *Cardamine* occur in Europe (LIHOVÁ & MARHOLD, 2005), as much as 89% of the chromosome number records (2597 in total) originate from this continent. Even within Europe the data are not equally distributed. 67% of the European records originate in Middle and Northern Europe (in the sense of BRUMMITT, 2001). This is somewhat proportional to the number of species. While 11 species occur in Northern and 24 in Middle Europe, they are represented by 540 and 1421 records, respectively. On the other hand, although 48 well-defined species occur in China (ZHOU et al., 2001) we have not been able to trace any chromosome number record for this area. Obviously, part of this geographical bias is caused by several papers in which a large amount of chromosome number records was published for Central and Northern Europe (LÖVKVIST, 1956; URBANSKA-WORYTKIEWICZ & LANDOLT, 1974; MARHOLD, 1994), nevertheless, unequal spread of the records throughout the total distribution area of the genus *Cardamine* is more than apparent. This points to the need of the deeper karyogeographical exploration of some areas, particularly in Asia. We suppose that similar pattern of unequal spread of information on chromosome numbers can be expected also in other cosmopolitan genera of vascular plants.

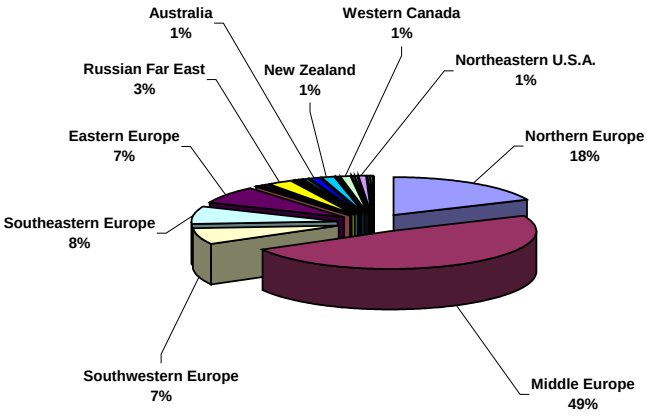

Fig. 1. Geographical distribution of the chromosome number records for the genus *Cardamine*. The geographical division of the world follows BRUMMITT (2001). Only areas gathering at least 1% of the chromosome number records are marked.

Another interesting comparison is the percentage of taxa, which are entirely diploid, those, which comprise both diploids and polyploids, and those, which are entirely polyploid. For the genus *Cardamine* we have found 32% diploid, 10% both diploid and polyploid, and 58% entirely polyploid taxa. For some other *Brassicaceae* genera the corresponding numbers are as follows (based on the database by WARWICK & AL-SHEHBAZ, 2005): *Draba* – 25% of diploid, 7% of both diploid and polyploid, 68% of entirely polyploid taxa, *Lepidium* – 34% of diploid, 14% of both diploid and polyploid, 52% of entirely polyploid taxa, *Rorippa* – 48% of diploid, 39% of both diploid and polyploid, and 13% of entirely polyploid taxa. Although these estimates are based on incomplete data they clearly point to the importance

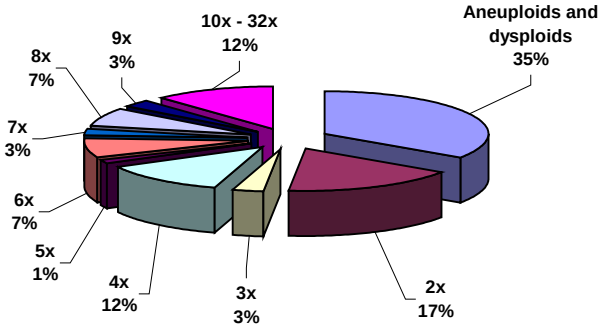

Fig. 2. Assignment of the chromosome number records for the genus *Cardamine* to the ploidy levels based on the base chromosome number $x = 8$.

of polyploidy for numerous genera of the family Brassicaceae.

Although the base chromosome number of the genus *Cardamine* is reported as $x = 6, 7, 8, 10, 12$ (Al-Shehbaz, 1988), it is likely that most of the species have the base number 8. The chromosome number lower than 16 was reported only for two species, namely *C. uliginosa* ($2n = 12$, Davlianidze, 1980) and *C. asarifolia* ($2n = 14$, Lawrence, 1931). Both these records are, according to our data, erroneous and the lowest reliable chromosome number in the genus is $2n = 16$ (*C. uliginosa* has the correct number $2n = 16$ and *C. asarifolia* $2n = 48$, for details see Lihová & Marhold, 2005). The highest chromosome number is $2n = 256$ reported for *Cardamine concatenata* and *C. diphylla* (Al-Shehbaz, 1988; Easterly, 1963) from North America.

The representation of different ploidy levels among the chromosome number counts (based on the base chromosome number 8) is as follows: 17% of diploids, 3% of triploids, 12% of tetraploids, 1% of pentaploids, 7% of hexaploids, 3% of heptaploids, 7% of octoploids, 3% of nonaploids, 12% of higher ploidy level (10–32x) and 35% of aneuploids and dysploids (Fig. 2). There are few published numbers in the genus *Cardamine*, which might be based on a different base number than $x = 8$, but still this statistics most probably well reflects the situation in the genus.

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