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Guide to the Wild Germplasm of Brassica and Allied Crops

Part II

Centre for Land
and Biological Resources Research



Centre de recherches sur les
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Conception par le Service aux programmes de recherches.



Guide to the Wild Germplasm of Brassica and Allied Crops

Part II Chromosome Numbers in the Tribe Brassiceae (Cruciferae)

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INTRODUCTION TO THE GUIDE:

The Cruciferae family, which contains about 3500 species and 350 genera, is one of the ten most economically important plant families (Rich 1991). The tribe Brassiceae is one of the 13-19 tribes which have been recognized within the family and is one of the few tribes believed to constitute a natural group (Hedge 1976, Al-Shehbaz 1984, 1985). It is the most important economically and the most distinctive (Gómez-Campo 1980a, Al-Shehbaz 1985). It is distinguished on the basis of the presence of conduplicate cotyledons (i.e. the cotyledons are longitudinally folded around the radical) and/or two-segmented fruits (siliques) which contain seeds in one or both segments, and only simple hairs if present (Gómez-Campo 1980a, Al-Shehbaz 1985).

Crop brassicas display enormous diversity and are used as a source of oil, vegetables, mustard condiments, and fodder. Those of particular importance in Canada are: *Brassica napus*, *B. rapa*, and *B. juncea* as sources of canola oil, and *B. oleracea* as cole-crops. The genera *Raphanus* and *Sinapis* are also of major importance, the former cultivated for its edible roots and the latter as a source of mustard condiments along with *B. nigra*. Several species have become naturalized weeds in Canada and the United States [eg. *Sinapis arvensis* (wild mustard), *Raphanus raphanistrum* (wild radish), and *B. rapa* (wild rape)], representing both a potential source of germplasm and agricultural problems. In other areas of the world *Crambe* is cultivated as an industrial oil, and the leaves of other genera (eg. *Eruca* and *Diplotaxis*) are eaten as salad greens.

An understanding of the genetic potential of wild relatives of the crop species of *Brassica* and allied genera (members of the Tribe Brassiceae) is critical for the establishment of long-term breeding programs of these crops. In addition, it is clear that many of the wild species in the tribe have potential value as new crops, as sources of industrial oils (*Crambe*, *Eruca*), condiments (*Sinapis alba*), and other diverse products. Wild relatives also possess a number of useful agronomic traits which could be incorporated into breeding programs, including: cytoplasmic and nuclear male sterility; resistance to disease and insect and nematode pests; intermediate C₃-C₄ photosynthetic activity; and tolerance of cold, salt and drought conditions.

The last comprehensive taxonomic treatment on the tribe was conducted by Schulz (1919, 1923, 1936). The tribe Brassiceae contains approximately 217 species and 51 genera, 25 of which are monotypic (Table below). Geographically, it is centered in the southwestern Mediterranean region, particularly Algeria, Morocco and Spain, where c. 41 genera are either endemic or exhibit maximum diversity. The tribal range extends eastward into India and Pakistan and southward into South Africa, with a poor representation in the New World (Hedge 1976, Gómez-Campo 1980a, Al-Shehbaz 1985).

GENERA OF THE TRIBE BRASSICEAE (no. species in brackets)

Ammosperma (2)	Guiraoa (1)
Boleum (1)	Hemicrambe (2)
Brassica (35)	Henophyton (1)
Cakile (7)	Hirschfeldia (2)
Carrichtera (1)	Kremeriella (1)
Ceratocnemum (1)	Moricandia (9)
Chalcanthus (2)	Morisia (1)
Coincya (6)	Muricaria (1)
Conringia (6)	Otocarpus (1)
Cordylocarpus (1)	Physorrhynchus (2)
Crambe (26)	Pseuderucaria (2)
Crambella (1)	Pseudofortuynia (1)
Didesmus (2)	Psychine (1)
Diplotaxis (27)	Quezeliantha (1)
Dolichorhynchus (1)	Raffenaldia (2)
Douepia (1)	Raphanus (2)
Enarthrocarpus (5)	Rapistrum (2)
Eremophyton (1)	Rytidocarpus (1)
Eruca (3)	Savignya (1)
Erucaria (9)	Schouwia (1)
Erucastrum (19)	Sinapidendron (5)
Euzomodendron (1)	Sinapis (5)
Fezia (1)	Succowia (1)
Foleyola (1)	Trachystoma (3)
Fortuynia (2)	Vella (5)
	Zilla (1)

Within the tribe, Schulz (1919, 1923, 1936) also recognized, somewhat arbitrarily on the basis of morphological characters, seven subtribes: Brassicinae, Cakilinae, Moricandiinae, Raphaninae, Savignyinae, Vellinae, and Zillinae. Gómez-Campo (1980a) has since proposed a reduction to six subtribes with the inclusion of the Savignyinae in the Vellinae. The Brassicinae and Moricandiinae both include genera with elongated siliquose dehiscent fruit, while the other subtribes include those with reduced or "nucamentaceous" fruits.

Generic boundaries in the tribe are still somewhat arbitrarily drawn, and the establishment of clear-cut intergeneric relationships requires clarification. Unlike many of the small genera, the species are generally very distinct throughout the family, with fruit characters being the most reliably used structures for the proper identification of genera and species. Taxonomic debate in the tribe has centred most particularly upon the number of and relationships between the subtribes and genera (Hedge 1976, Al-Shehbaz 1985).

The genus *Brassica* is one of ten core genera in the subtribe Brassicinae, which also includes *Coincya*, *Diploaxis*, *Eruca*, *Erucastrum*, *Hirschfeldia*, *Raphanus*, *Sinapidendron*, *Sinapis*, and *Trachystoma*. The Brassicinae is defined primarily on the basis of elongated (siliquose) dehiscent fruits, presence of median nectaries, and usually seeded beaks. Although morphologically quite distinct from subtribes Cakilinae, Vellinae, and Zillinae, its separation from the Raphaninae and Moricandiinae is less clear. Current generic circumscriptions within the subtribe Brassicinae have also been considered to be highly artificial by many taxonomists, with generic delimitation based primarily on only one or two morphological traits.

Systematists are continuing to re-evaluate relationships within the tribe Brassiceae by way of morphological, cytological, hybridization, isozyme and molecular analyses (studies reviewed in Warwick and Black 1991, 1993). Such research has confirmed many proposed species relationships, but has also indicated new relationships between genera and species. In particular, these studies have identified new potential sources of germplasm for *Brassica* crops, indicating that the range of germplasm important to the genus is much greater than previously recognized.

The following Guide to the wild germplasm of *Brassica* and allied crops (Tribe Brassiceae, family Cruciferae) will be divided into five parts as indicated below:

- I. **Taxonomy and Genome Status** - [Complete list of genera and species in the tribe and their genomic status, containing cross references for commonly confused names];
by S.I. WARWICK
- II. **Chromosome Numbers**;
by S.I. WARWICK & J.K. ANDERSON
- III. **Interspecific and Intergeneric Hybridizations**;
by S.I. WARWICK & L.D. BLACK
- IV. **Wild Species as Sources of Agronomic Traits** - [List of potentially useful agronomic traits and possible wild germplasm sources in the tribe];
by S.I. WARWICK
- V. **Life History Data** [Summary of habitat and geographical distributions of all species indicated in part I.]
by S.I. WARWICK

The information provided in this guide is intended to be useful in providing direction for future genebank needs for these crops and for assisting biotechnologists and breeders wishing to utilize these genetic resources in their research programs.

PART II: CHROMOSOME NUMBERS IN THE TRIBE BRASSICEAE (Cruciferae)

The following publication is the second part of a guide to the wild germplasm of *Brassica* and allied crops (Tribe Brassiceae, family Cruciferae).

This checklist contains the haploid chromosome numbers (n) for taxa of the tribe Brassiceae for which information is available. The compilation updates the list provided by Gómez-Campo and Hinata (1980). Since the latter publication, an additional 159 counts have been reported. Seven counts are reported here for the first time as Warwick, Black & Anderson (unpubl.). Counts are required for 45 of the 217 species and seven of the 51 genera [*Ammosperma*, *Dolichorhynchus*, *Douepia*, *Eremophyton*, *Henophyton*, *Pseuderucaria*, and *Quezelianthus*].

Progress in this field has been as follows:

	New counts	Accumulative
Several authors between 1916 and 1932	59	59
Several authors between 1933 and 1972	84	143
Several authors between 1973 and 1980	100	243
Several authors between 1981 and 1993	159	402

In the family Cruciferae a continuous series of base chromosome numbers from 4 to 13 exists (Al-Shehbaz 1984), with 37% of the species having a base chromosome number of 8 (range $2n = 8$ eg. *Physaria* spp. to $2n = 256$ *Cardamine* spp.). Approximately 37% of species in the family are polyploid. It is believed that aneuploidy (i.e. the gain or loss of individual chromosomes) and diminution in chromosome size have played a more important role in the evolution of the family than polyploidy.

Chromosome number has been particularly well documented within the tribe Brassiceae with 171 (79%) of the 217 species counted. Gametic chromosome numbers range from $n = 6$ in *Erucaria cakiloidea* to $n = 75$ in *Crambe gordjagini*. No single chromosome number appears to be dominant within the tribe. The gametic chromosome numbers 7, 8, 9, and 15 occur in 14-18% of the species, while 10, 11, and 12 occur at frequencies ranging from 6-9% (Al-Shehbaz 1985).

In the tribe, species with gametic chromosome numbers greater than 13 are believed to be polyploid (Gómez-Campo and Hinata 1980). Based on this premise, 37% of the 171 species counted should be polyploid. Half of the 51 genera would appear to contain some polyploid species. So far, the hexaploid level has been observed in four genera (*Boleum*, *Erucastrum*, *Moricandia*, and *Crambe*). Indeed, many genera (e.g., *Crambe*, *Moricandia*, *Vella*, *Boleum*,

Zilla, and *Euzomodendron*) appear to be entirely polyploid. In the genus *Erucastrum*, there is a continuous series from diploids to octoploids. Allopolyploidy has been reported in the tribe. The most familiar crop examples are *Brassica carinata* ($\underline{n} = 8+9$), *B. juncea* ($\underline{n} = 10+8$), and *B. napus* ($\underline{n} = 10+9$), combinations of the basic chromosome numbers $\underline{n} = 8, 9, 10$ of *B. nigra*, *B. oleracea*, and *B. rapa*, respectively. Three other natural allopolyploid taxa have also been reported: *Diplotaxis muralis* ($\underline{n} = 11+10$), *Erucastrum elatum* ($\underline{n} = 7+8$) and *Erucastrum gallicum* ($\underline{n} = 7+8$). Aneuploidy is also proposed as having a profound impact on the evolution of *Diplotaxis*, *Brassica*, and other genera in the tribe (Al-Shehbaz 1985).

Chromosome number in diploid species of the genus *Brassica* varies from $\underline{n} = 7-11$. On the basis of cytological studies, Röbbelen (1960) proposed $\underline{x} = 6$ as the basic chromosome number of the genus *Brassica* and the above range in chromosome numbers an aneuploid series. However, molecular studies do not provide support for the ancestral status of $\underline{n} = 7$, as it has been found to have multiple origins in separate lineages (Warwick & Black 1991, 1993). In addition, recent isozyme studies have shown evidence for genome duplication in some species with chromosome numbers as low as $\underline{n} = 7-10$ (Quiros 1987, Warwick & Black 1993). This has led some researchers to suggest $\underline{x} = 3$ as the basic chromosome number for the genus *Brassica* (Chen & Heneen 1991).

In the checklist below, taxa are arranged alphabetically and correspond to the taxonomic framework for the tribe indicated in part I of this guide.



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TAXON	n	REFERENCE
<i>Ammosperma cinereum</i> (Desf.) Hook. f.	?	
<i>Ammosperma variabile</i> Nègre & Le Houérou	?	
<i>Boleum asperum</i> (Pers.) Desv.	51	Gómez-Campo & Hinata (1980)
<i>Brassica assyriaca</i> Mouton	?	
<i>Brassica balearica</i> Pers.	16	Gómez-Campo & Hinata (1980)
.....	16	Cardona (1991)
<i>Brassica barrelieri</i> (L.) Janka	10	Gómez-Campo & Hinata (1980)
.....	10	Martín Ciudad (1990)
.....	9	Snogerup et al. (1990)
<i>Brassica bourgeauii</i> (Webb) Kuntze	?	
<i>Brassica cadmea</i> Heldr. ex O.E. Schulz	17	Gómez-Campo & Hinata (1980)
<i>Brassica carinata</i> A. Braun	9	Gómez-Campo & Hinata (1980)
<i>Brassica cretica</i> Lam.	7	Gómez-Campo & Hinata (1980)
<i>Brassica deflexa</i> Boiss.	?	
<i>Brassica deserti</i> Danin & Hedge	10	Gómez-Campo & Hinata (1980)
<i>Brassica desnottesii</i> Emb. & Maire	11	Gómez-Campo & Hinata (1980)
<i>Brassica elongata</i> Ehrh.	8	Gómez-Campo & Hinata (1980)
<i>Brassica fruticulosa</i> Cyr.	16	Gómez-Campo & Hinata (1980)
ssp. <i>cossoniana</i> (Boiss. & Reut.) Maire	16	Gómez-Campo & Hinata (1980)
ssp. <i>glaberrima</i> (Pomel) Batt.	16	Gómez-Campo & Hinata (1980)
ssp. <i>mauritanica</i> (Coss.) Maire	16	Gómez-Campo & Hinata (1980)
ssp. <i>numidica</i> (Coss.) Maire	16	Gómez-Campo & Hinata (1980)
ssp. <i>radicata</i> (Desf.) Batt.	16	Gómez-Campo & Hinata (1980)
.....	16	Geslot (1984)
.....	12	Laribi et al. (1987)
<i>Brassica glabrescens</i> Poldini	?	
<i>Brassica gravinae</i> Ten.	10	Gómez-Campo & Hinata (1980)
var. <i>brachyloba</i> (Boiss. & Reut.) O.E. Schulz	20	Gómez-Campo & Hinata (1980)
<i>Brassica hilarionis</i> Post	9	Snogerup et al. (1990)
<i>Brassica incana</i> Ten.	9	Gómez-Campo & Hinata (1980)
<i>Brassica insularis</i> Moris	9	Gómez-Campo & Hinata (1980)
.....	9	Verlaque et al. (1992)
<i>Brassica jordanoffii</i> O.E. Schulz	11	Gómez-Campo & Hinata (1980)
<i>Brassica juncea</i> (L.) Czern. & Coss.	18	Gómez-Campo & Hinata (1980)
<i>Brassica macrocarpa</i> Guss.	9	Gómez-Campo & Hinata (1980)
<i>Brassica maurorum</i> Durieu	8	Gómez-Campo & Hinata (1980)
<i>Brassica montana</i> Pourret	9	Snogerup et al. (1990)
(Includes <i>B. roberiana</i> J. Gay)	9	Gómez-Campo & Hinata (1980)
<i>Brassica napus</i> L.	19	Gómez-Campo & Hinata (1980)
.....	20	Michael Hill (1982)
<i>Brassica nigra</i> (L.) Koch	8	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Brassica nivalis</i> Boiss. & Heldr. [Reported as <i>Rhynchosinapis nivalis</i> (Boiss. & Heldr.) Heywood]	10	Strid & Franzén (1981)
<i>Brassica oleracea</i> L.	9	Gómez-Campo & Hinata (1980)
[Includes <i>B. alboglabra</i> Bailey]	9	Gómez-Campo & Hinata (1980)
<i>Brassica oxyrrhina</i> (Coss.) Willk. & Lange	9	Gómez-Campo & Hinata (1980)
.....	9	Martín Ciudad (1990)
<i>Brassica procumbens</i> (Poiret) O.E. Schulz	?	
<i>Brassica rapa</i> L.	10	Gómez-Campo & Hinata (1980)
<i>Brassica repanda</i> (Willd.) DC.	10	Gómez-Campo & Hinata (1980)
ssp. <i>almeriensis</i> Gómez-Campo	10	Gómez-Campo & Hinata (1980)
ssp. <i>blancoana</i> (Boiss.) Heywood	10	Gómez-Campo (1980b)
ssp. <i>cantabrica</i> (Font Quer) Heywood	10	Gómez-Campo & Hinata (1980)
ssp. <i>confusa</i> (Emb. & Maire) Heywood	10	Gómez-Campo & Hinata (1980)
.....	10	Arista & Talavera (1990)
ssp. <i>latisiliqua</i> (Boiss. & Reuter) Heywood	10	Gómez-Campo (1980b)
ssp. <i>maritima</i> (Rouy) Heywood	10	Gómez-Campo & Hinata (1980)
ssp. <i>nudicaulis</i> (Lag.) Heywood	10	Gómez-Campo & Hinata (1980)
ssp. <i>saxatilis</i> (DC.) Heywood	10	Gómez-Campo & Hinata (1980)
<i>Brassica rupestris</i> Raf.	9	Gómez-Campo & Hinata (1980)
<i>Brassica souliei</i> (Batt.) Batt.	11	Gómez-Campo & Hinata (1980)
ssp. "dimorpha" (Coss. & Durieu) Saleem		
[Reported as <i>B. dinorpha</i> Coss. & Dur.]	22	Gómez-Campo & Hinata (1980)
<i>Brassica spinescens</i> Pomel	8	Gómez-Campo & Hinata (1980)
<i>Brassica tournefortii</i> Gouan	10	Gómez-Campo & Hinata (1980)
.....	10	Al-Shehbaz & Al-Omar (1982)
.....	10	Martín Ciudad (1990)
<i>Brassica villosa</i> Biv.	9	Snogerup et al. (1990)
[Includes <i>B. drepanensis</i> (Carnel) Damanti]	9	Gómez-Campo & Hinata (1980)
<i>Cakile arabica</i> Velen. & Bornm.	9	Rodman (1978)
.....	9	Al-Shehbaz (1978)
.....	9	Gómez-Campo & Hinata (1980)
<i>Cakile arctica</i> Pobedimova	9, 18	Gómez-Campo & Hinata (1980)
<i>Cakile constricta</i> Rodman	9	Gómez-Campo & Hinata (1980)
<i>Cakile edentula</i> (Bigelow) Hook.	9	Rodman (1978)
.....	9	Gómez-Campo & Hinata (1980)
.....	9	Chinnappa & Chmielewski (1987)
ssp. <i>harperi</i> (Small) Rodman	9	Rodman (1978)
.....	9	Gómez-Campo & Hinata (1980)
<i>Cakile geniculata</i> (Robinson) Millsp.	9	Rodman (1978)
.....	9	Al-Shehbaz (1985)

TAXON	n	REFERENCE
<i>Cakile lanceolata</i> (Willd.) O.E. Schulz	9	Gómez-Campo & Hinata (1980)
ssp. <i>fusifformis</i> (Greene) Rodman	9	Michael Hill (1984)
ssp. <i>pseudoconstricta</i> Rodman	9	Rodman (1978)
<i>Cakile maritima</i> Scop.	9	Gómez-Campo & Hinata (1980)
ssp. <i>egyptiaca</i> (Willd.) Nyman	9	Rodman (1978)
ssp. <i>baltica</i> (Jordan ex Rouy & Foucaud) Hyl. ex P.W. Ball	9	Gómez-Campo & Hinata (1980)
ssp. <i>euxina</i> (Pobedimova) E.I. Nyárády	9	Carrique & Martínez (1984)
<i>Carrichtera annua</i> (L.) DC.	8	Martín Ciudad (1990)
	16	Gómez-Campo & Hinata (1980)
	8	Sikka & Sharma (1979)
	8	Gómez-Campo & Hinata (1980)
	8	Al-Shehbaz & Al-Omar (1982)
	8	Martín Ciudad (1990)
	8	Diosdado et al. (1993)
<i>Ceratocnemum rapistroides</i> Coss. & Bal.	8	Gómez-Campo & Hinata (1980)
<i>Chalcanthus renifolius</i> Boiss.	7	Gómez-Campo & Hinata (1980)
<i>Chalcanthus tuberosus</i> Kom.	?	Gómez-Campo & Hinata (1980)
<i>Coincya longirostra</i> (Boiss.) Greuter & Burdet	12	Leadlay & Heywood (1990)
[Reported as <i>Hintera longirostra</i> (Boiss.) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
<i>Coincya monensis</i> (L.) Greuter & Burdet	12	Leadlay & Heywood (1990)
[Reported as <i>Hintera monensis</i> (L.) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
ssp. <i>hispidula</i> (Cav.) Leadlay	12	Leadlay & Heywood (1990)
[Reported as <i>Hintera hispidula</i> (Cav.) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
ssp. <i>nevadensis</i> (Willk.) Leadlay	12	Leadlay & Heywood (1990)
[Reported as <i>Hintera cheiranthos</i> ssp. <i>nevadensis</i> (Willk.) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
ssp. <i>puberula</i> (Pau) Leadlay	12	Leadlay & Heywood (1990)
ssp. <i>recurvata</i> (All.) Leadlay	12, 24	Leadlay & Heywood (1990)
[Includes <i>Hintera cheiranthos</i> (Vill) Gómez-Campo]	12, 24	Gómez-Campo & Hinata (1980)
[Includes <i>Hintera coincyoides</i> (Humb. & Maire) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
[Includes <i>Hintera johnstonii</i> (Samp.) Gómez-Campo]	24	Gómez-Campo & Hinata (1980)
[Includes <i>Hintera psenderucastrum</i> (Brot.) Gómez-Campo]	12, 24	Gómez-Campo & Hinata (1980)
[Includes <i>Hintera psenderucastrum</i> (Brot.) Gómez-Campo ssp. <i>ciuitiana</i> (Coutinho) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
[Includes <i>Hintera psenderucastrum</i> (Brot.) Gómez-Campo ssp. <i>setigera</i> (Gay ex Lange) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
<i>Coincya richeri</i> (Vill.) Greuter & Burdet	12	Gómez-Campo & Hinata (1980)
[Reported as <i>Hintera richeri</i> (Vill.) Gómez-Campo]	12	Leadlay & Heywood (1990)
	12	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Coincya rupestris</i> Porta & Rigo ex Rouy		
ssp. <i>leptocarpa</i> (González-Albo) Leadlay	12	Leadlay & Heywood (1990)
[Reported as <i>Hutera leptocarpa</i> González-Albo]	12	Gómez-Campo & Hinata (1980)
ssp. <i>rupestris</i> Porta & Rigo	12	Leadlay & Heywood (1990)
[Reported as <i>Hutera rupestris</i> Porta]	12	Gómez-Campo & Hinata (1980)
<i>Coincya transtaganana</i> (Coutinho) Clemente & Hernández-Bermejo		
[Reported as <i>Hutera hispida</i> (Cav.) Gómez-Campo ssp. <i>iransitaganana</i> (Coutinho) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
<i>Coincya wrightii</i> (O.E. Schulz) Stace	12	Leadlay & Heywood (1990)
[Reported as <i>Hutera wrightii</i> (O.E. Schulz) Gómez-Campo]	12	Gómez-Campo & Hinata (1980)
<i>Conringia austriaca</i> (Jacq.) Sweet	14	Feráková & Murin (1978)
.....	14	Gómez-Campo & Hinata (1980)
<i>Conringia clavata</i> Boiss.		
[Reported as <i>C. perfoliata</i> (C.A. Mey.) Busch.]	9	Gómez-Campo (1980b)
[Reported as <i>C. perfoliata</i> (C.A. Mey.) Busch.]	7	Al-Shehbaz & Al-Omar (1982)
<i>Conringia grandiflora</i> Boiss. & Heldr.	?	
<i>Conringia orientalis</i> (L.) Andrzejowski ex DC.	7	Gómez-Campo & Hinata (1980)
<i>Conringia persica</i> Boiss.	7	Gómez-Campo & Hinata (1980)
<i>Conringia planisiliqua</i> Fischer & C.A. Meyer	9	Gómez-Campo & Hinata (1980)
<i>Cordylocarpus muricatus</i> Desf.	8	Gómez-Campo & Hinata (1980)
<i>Crambe abyssinica</i> Hochst. ex O.E. Schulz	45	Gómez-Campo & Hinata (1980)
<i>Crambe cordifolia</i> Steven	60	Gómez-Campo & Hinata (1980)
ssp. <i>kotschyana</i> (Boiss.) Jafri, Nasir & Ali		
[Reported as <i>C. kotschyana</i> Boiss.]	15	Gómez-Campo & Hinata (1980)
<i>Crambe edentula</i> Fischer & C.A. Meyer	?	
<i>Crambe filiformis</i> Jacq.	15	Gómez-Campo & Hinata (1980)
.....	15	Pastor Díaz (1984)
.....	15	Martín Ciudad (1990)
<i>Crambe fruticosa</i> L. f.	15, 30	Gómez-Campo & Hinata (1980)
<i>Crambe gordjagini</i> Sprygin & Popov	75	Gómez-Campo & Hinata (1980)
<i>Crambe grandiflora</i> DC.	60	Gómez-Campo & Hinata (1980)
<i>Crambe hispanica</i> L.	30	Sikka & Sharma (1979)
.....	30	Gómez-Campo & Hinata (1980)
.....	15	Gómez-Campo & Hinata (1980)
var. <i>glabrata</i> (DC.) Coss.	?	
<i>Crambe kilimandscharica</i> O.E. Schulz	15	Gómez-Campo & Hinata (1980)
<i>Crambe koktebelica</i> (Junge) N. Busch	15, 30, 45	Gómez-Campo & Hinata (1980)
<i>Crambe kralikii</i> Coss. ex Reboud	15	Gómez-Campo & Hinata (1980)
<i>Crambe laevigata</i> DC. ex Christ	15, 30	Gómez-Campo & Hinata (1980)
<i>Crambe maritima</i> L.	15	Gómez-Campo & Hinata (1980)
.....	15	Ančev (1981)
<i>Crambe mitridatis</i> Juz.	?	

TAXON	n	REFERENCE
<i>Crambe orientalis</i> L.	15	Al-Shehbaz (1978)
.....	15, 30	Gómez-Campo & Hinata (1980)
<i>Crambe parviflora</i> Huber-Morath & Reese	?	
<i>Crambe persica</i> Boiss.	?	
<i>Crambe pritzeli</i> Bolle	15	Gómez-Campo & Hinata (1980)
<i>Crambe scaberrima</i> Webb ex Bramwell	15	Gómez-Campo & Hinata (1980)
<i>Crambe schughnana</i> Korsh.	15	Gómez-Campo & Hinata (1980)
<i>Crambe scoparia</i> Svent.	15	Gómez-Campo & Hinata (1980)
<i>Crambe sinuato-dentata</i> Hochst. ex Petri	?	
<i>Crambe steveniana</i> Rupr.	?	
<i>Crambe strigosa</i> L'Hér.	15	Gómez-Campo & Hinata (1980)
[Reported as <i>C. arborca</i> Webb ex Christ]	15	Gómez-Campo & Hinata (1980)
[Reported as <i>C. gomeraca</i> Webb ex Christ]	15	Gómez-Campo & Hinata (1980)
<i>Crambe sventenii</i> B. Petters ex Bramwell & Sundell	15	Gómez-Campo & Hinata (1980)
<i>Crambe tatarica</i> Sebeók	15	Váchová & Májovský (1978)
.....	15, 30, 60	Gómez-Campo & Hinata (1980)
<i>Crambella teretifolia</i> (Batt. & Trabut) Maire	11	Gómez-Campo & Hinata (1980)
<i>Didesmus aegyptius</i> (L.) Desv.	?	
<i>Didesmus bipinnatus</i> (Desf.) DC.	8	Warwick, Black & Anderson (unpub.)
<i>Diplotaxis acris</i> (Forssk.) Boiss.	11	Al-Shehbaz (1978)
.....	11	Martínez-Laborde (1988)
<i>Diplotaxis assurgens</i> (Del.) Gren.	9	Gómez-Campo & Hinata (1980)
<i>Diplotaxis berthautii</i> Braun-Blanq. & Maire	9, 10?	Gómez-Campo & Hinata (1980)
<i>Diplotaxis brachycarpa</i> Godr.		Martínez-Laborde (1988)
[Includes <i>Diplotaxis delagei</i> Pom. ex Batt.]	9	Martínez-Laborde (1988)
<i>Diplotaxis brevisiliqua</i> (Coss.) Martínez-Laborde	8	Martínez-Laborde (1991)
<i>Diplotaxis catholica</i> (L.) DC.	9	Gómez-Campo & Hinata (1980)
<i>Diplotaxis cossoniana</i> (Reut. ex Boiss.) O.E. Schulz	7	Martínez-Laborde (1988)
<i>Diplotaxis cretacea</i> Kotov	11	Gómez-Campo & Hinata (1980)
<i>Diplotaxis erucooides</i> (L.) DC.	7	Al-Shehbaz (1978)
.....	7	Sikka & Sharma (1979)
.....	7	Gómez-Campo & Hinata (1980)
.....	7	Martín Ciudad (1990)
<i>Diplotaxis gomez-campoii</i> Martínez-Laborde	8	Martínez-Laborde (1991)
<i>Diplotaxis gracilis</i> (Webb) O.E. Schulz	13	Gómez-Campo & Hinata (1980)
<i>Diplotaxis griffithii</i> (Hook f. & Thomson) Boiss.	?	

TAXON	n	REFERENCE
<i>Diplotaxis harra</i> (Forssk.) Boiss.	13	Al-Shehbaz (1978)
..	13	Gómez-Campo & Hinata (1980)
..	13	Al-Shehbaz & Al-Omar (1982)
..	19?	Snogerup (1985)*
ssp. <i>crassifolia</i> (Raf.) Maire	13	Gómez-Campo & Hinata (1980)
[Reported as <i>D. crassifolia</i> (Rafin.) DC.]	13	Romano et al. (1986)
[Reported as <i>D. crassifolia</i> (Rafin.) DC.]	13	Martín Ciudad (1990)
ssp. <i>glauca</i> (J.A. Schmidt) Sobrino	13	Gómez-Campo & Hinata (1980)
[Reported as <i>D. glauca</i> (J.A. Schmidt) O.E. Schulz]	13	Gómez-Campo & Hinata (1980)
ssp. <i>hirta</i> (Cheval) Sobrino	13	Gómez-Campo & Hinata (1980)
[Reported as <i>D. hirta</i> (Cheval) Rusian & Borgen	13	Gómez-Campo & Hinata (1980)
ssp. <i>lagascana</i> (DC.) O. Bolòs & Vigo	13	Gómez-Campo & Hinata (1980)
[Reported as <i>D. lagascana</i> DC.]	8	Gómez-Campo (1981)
<i>Diplotaxis ibicensis</i> (Font Quer) Gómez-Campo	21	Gómez-Campo & Hinata (1980)
<i>Diplotaxis muralis</i> (L.) DC.	21	Ančev (1981)
..	?	
<i>Diplotaxis nepalensis</i> Hara	?	
<i>Diplotaxis ollivieri</i> Maire	?	
<i>Diplotaxis pitardiana</i> Maire	8	Gómez-Campo & Hinata (1980)
<i>Diplotaxis siettiana</i> Maire	10	Gómez-Campo & Hinata (1980)
<i>Diplotaxis siifolia</i> G. Kunze	10	Martínez-Laborde (1992)
..	10	
ssp. <i>vicentina</i> (Cout.) Martínez-Laborde	10	Fernandes & Queirós (1970-71)
[Reported as <i>D. vicentina</i> (P. Cout.) Rothm.]	10	Queirós (1973)
[Reported as <i>D. vicentina</i> (P. Cout.) Rothm.]	10	Gómez-Campo & Hinata (1980)
<i>Diplotaxis simplex</i> (Viv.) Spreng.	11	van Loon & de Jong (1978)
<i>Diplotaxis tenuifolia</i> (L.) DC.	11	Gómez-Campo & Hinata (1980)
..	11	Natarajan (1981)
..	11	Ančev (1981)
..	21?	Martínez-Laborde (1988)
..	11	Gómez-Campo & Hinata (1980)
<i>Diplotaxis tenuisiliqua</i> Del.	9	Gómez-Campo & Hinata (1980)
<i>Diplotaxis villosa</i> Boulos & Jallad	?	
<i>Diplotaxis viminea</i> (L.) DC.	10	Gómez-Campo & Hinata (1980)
<i>Diplotaxis virgata</i> (Cav.) DC.	9	Gómez-Campo & Hinata (1980)
<i>Diplotaxis vogelii</i> (Webb) O.E. Schulz	?	
<i>Dolichorhynchus arabicus</i> Hedge & Kit Tan	?	

TAXON	n	REFERENCE
<i>Douepia tortuosa</i> Cambess.	?	
<i>Enarthrocarpus arcuatus</i> Labill.	?	
<i>Enarthrocarpus clavatus</i> Del. ex Godr.	10	Gómez-Campo & Hinata (1980)
<i>Enarthrocarpus lyratus</i> (Forsk.) DC.	10	Sikka & Sharma (1979)
	10	Gómez-Campo & Hinata (1980)
<i>Enarthrocarpus pterocarpus</i> (Pers.) DC.	10	Gómez-Campo & Hinata (1980)
<i>Enarthrocarpus strangulatus</i> Boiss.	10	Sikka & Sharma (1979)
	10	Gómez-Campo & Hinata (1980)
<i>Eremophyton chevallieri</i> (Barr.) Bég.	?	
<i>Eruca loncholoma</i> (Pomel) O.E. Schulz	?	
<i>Eruca setulosa</i> Boiss. & Reut.	?	
<i>Eruca vesicaria</i> (L.) Cav.	11	Gómez-Campo & Hinata (1980)
	11	Gómez-Campo (1980b)
ssp. <i>pinnatifida</i> (Desf.) Emb. & Maire	11	Gómez-Campo & Hinata (1980)
ssp. <i>sativa</i> (Mill.) Thell.	11	Gómez-Campo & Hinata (1980)
[Reported as <i>E. sativa</i> Mill.]	11	Sikka & Sharma (1979)
[Reported as <i>E. sativa</i> Mill.]	11	Al-Shehbaz & Al-Omar (1982)
[Reported as <i>E. sativa</i> Mill.]	11	Lan (1986)
<i>Erucaria bornmuelleri</i> O.E. Schulz	?	
<i>Erucaria cakioides</i> (DC.) O.E. Schulz	6	Al-Shehbaz (1978)
<i>Erucaria crassifolia</i> (Forsk.) Del.	?	
<i>Erucaria erucarioides</i> (Coss. & Durieu) C. Mueller	8	Warwick, Black & Anderson (unpub.)
[Reported as <i>Reboulia erucarioides</i> Coss. & Durieu]	8	Gómez-Campo & Hinata (1980)
<i>Erucaria hispanica</i> (L.) Druce	8	Al-Shehbaz (1978)
	8	Gómez-Campo & Hinata (1980)
	8	Ghaffari (1986)
[Reported as <i>Erucaria myagroides</i> (L.) Halácsy]	8	Sikka & Sharma (1979)
<i>Erucaria microcarpa</i> Boiss.	8	Warwick, Black & Anderson (unpub.)
[Reported as <i>Reboulia pinnata</i> (Viv.) O.E. Schulz]	8	Gómez-Campo & Hinata (1980)
<i>Erucaria ollivieri</i> Maire	8	Gómez-Campo & Hinata (1980)
<i>Erucaria pinnata</i> (Viv.) Täckh. & Boulos	7	Gómez-Campo & Hinata (1980)
[Reported as <i>E. aegiceras</i> Gay]	7	Gómez-Campo & Hinata (1980)
ssp. <i>uncata</i> (Boiss.) Greuter & Burdet	8	Sikka & Sharma (1979)
[Reported as <i>E. uncata</i> (Boiss.) Aschers & Schweinf.]	8	Gómez-Campo & Hinata (1980)
[Reported as <i>E. uncata</i> (Boiss.) Aschers & Schweinf.]	?	
<i>Erucaria rostrata</i> (Boiss.) Greuter & Burdet	?	
<i>Erucastrum abyssinicum</i> (A. Rich.) O.E. Schulz	16	Gómez-Campo & Hinata (1980)
<i>Erucastrum arabicum</i> Fischer & C.A. Meyer	8	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Erucastrum brevirostre</i> (Maire) Gómez-Campo	9	Gómez-Campo & Hinata (1980)
[Reported as <i>E. varium</i> Durieu ssp. <i>brevirostre</i> Maire]		
<i>Erucastrum canariense</i> Webb & Berthel.	9	Sikka & Sharma (1979)
.....	9	Gómez-Campo & Hinata (1980)
<i>Erucastrum cardaminoides</i> (Webb) O.E. Schulz	9	Gómez-Campo & Hinata (1980)
<i>Erucastrum elatum</i> (Ball) O.E. Schulz	15	Gómez-Campo & Hinata (1980)
<i>Erucastrum elgonense</i> Jonsell	?	
<i>Erucastrum gallicum</i> (Willd.) O.E. Schulz	15	Váchová & Feráková (1978)
.....	15	Sikka & Sharma (1979)
.....	15	Gómez-Campo & Hinata (1980)
.....	15	Váchová & Feráková (1980)
.....	15	Kirschner et al. (1982)
<i>Erucastrum ifniense</i> Gómez-Campo	9	Gómez-Campo (1984)
<i>Erucastrum leucanthum</i> Coss. & Durieu ex Coss.	8	Gómez-Campo & Hinata (1980)
var. <i>gaetulum</i> Maire	16	Gómez-Campo & Hinata (1980)
<i>Erucastrum littoreum</i> (Pau & Font Quer) Maire		
ssp. <i>brachycarpum</i> (Maire & Weiller) Gómez-Campo	24	Gómez-Campo (1983)
[Reported as <i>E. laevigatum</i> (L.) O.E. Schulz ar. <i>brachycarpum</i> Maire]	24	Gómez-Campo & Hinata (1980)
ssp. <i>glabrum</i> (Maire) Gómez-Campo	8	Gómez-Campo (1983)
[Reported as <i>E. laevigatum</i> (L.) O.E. Schulz ssp. <i>glabrum</i> Maire]	8	Gómez-Campo & Hinata (1980)
ssp. <i>littoreum</i> (Pau & Font Quer) Maire	16	Gómez-Campo (1983)
[Reported as <i>E. laevigatum</i> (L.) O.E. Schulz ssp. <i>littoreum</i> (Pau & Font Quer) Maire]	16	Gómez-Campo & Hinata (1980)
<i>Erucastrum meruense</i> Jonsell	32	Jonsell (1979)
<i>Erucastrum nasturtiifolium</i> (Poiret) O.E. Schulz	8, 16	Gómez-Campo & Hinata (1980)
.....	8	Kirschner et al. (1982)
.....	8	Gómez-Campo & Hinata (1980)
<i>Erucastrum pachypodium</i> (Chiov.) Jonsell		
<i>Erucastrum palustre</i> (Pirona) Vis.		
<i>Erucastrum rifanum</i> (Emb. & Maire) Gómez-Campo		
[Reported as <i>Brassicella erucastrum</i> (L.) O.E. Schulz]	8	Gómez-Campo (1982)
var. <i>grandiflorum</i> Gómez-Campo	8	Sikka & Sharma (1979)
<i>Erucastrum strigosum</i> (Thunb.) O.E. Schulz	16	Gómez-Campo (1982)
<i>Erucastrum varium</i> Durieu	8	Gómez-Campo & Hinata (1980)
ssp. <i>subsiifolium</i> Maire	7	Gómez-Campo & Hinata (1980)
<i>Erucastrum virgatum</i> (J.C. Presl) C. Presl	7	Gómez-Campo & Hinata (1980)
.....	7, 14	Gómez-Campo & Hinata (1980)
.....	7, 14	Gómez-Campo (1983)
[Includes <i>E. laevigatum</i> (L.) O.E. Schulz]	7, 14	Gómez-Campo & Hinata (1980)
<i>Euzomodendron bourgaeum</i> Coss.	17	Gómez-Campo & Hinata (1980)
.....	17	Martín Ciudad (1990)
.....	17	Diosdado et al. (1993)
<i>Fezia pterocarpa</i> Pitard	11	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Foleyola billotii</i> Maire	16	Warwick, Black & Anderson (unpub.)
<i>Fortuynia bungei</i> Boiss.	16	Gómez-Campo & Hinata (1980)
<i>Fortuynia garcinii</i> (Burm.) Shuttl. ex Boiss.	?	Gómez-Campo & Hinata (1980)
<i>Guiraoa arvensis</i> Coss.	8	Gómez-Campo & Hinata (1980)
<i>Hemicrambe fruticosa</i> (C.C. Townsend) Gómez-Campo	?	Gómez-Campo & Hinata (1980)
<i>Hemicrambe fruticulosa</i> Webb	9	Gómez-Campo & Hinata (1980)
<i>Henophyton deserti</i> (Coss. & Durieu) Coss. & Durieu	?	Sikka & Sharma (1979)
<i>Hirschfeldia incana</i> (L.) Lagrèze-Fossat	7	Gómez-Campo & Hinata (1980)
	7	Al-Shehbaz & Al-Omar (1982)
	7	Al-Shehbaz & Al-Omar (1983)
ssp. <i>consobrina</i> (Pomel ex Batt.) Maire	7	Gómez-Campo & Hinata (1980)
ssp. <i>geniculata</i> (Desf.) Maire	7	Gómez-Campo & Hinata (1980)
<i>Hirschfeldia rostrata</i> (Balf. f.) O.E. Schulz	7	Gómez-Campo & Hinata (1980)
<i>Hutera</i> (see <i>Coincya</i>)	?	
<i>Kremeriella cordylocarpus</i> (Coss. & Durieu ex Coss.) Maire	12	Gómez-Campo & Hinata (1980)
<i>Moricandia arvensis</i> (L.) DC.	14	Sikka & Sharma (1979)
	14	Gómez-Campo & Hinata (1980)
	14	Martín Ciudad (1990)
	14	Diosdado et al. (1993)
<i>Moricandia foetida</i> Bourgeau ex Coss.	14	Gómez-Campo & Hinata (1980)
<i>Moricandia foleyii</i> Batt.	11	Warwick, Black & Anderson (unpub.)
<i>Moricandia longirostris</i> Pomel	?	
<i>Moricandia moricandioides</i> (Boiss.) Heywood	14	Gómez-Campo & Hinata (1980)
	14	Martín Ciudad (1990)
ssp. <i>giennensis</i> Valdés-Bermejo	14	Gómez-Campo & Hinata (1980)
<i>Moricandia nitens</i> (Viv.) Durieu & Barr.	14	Gómez-Campo & Hinata (1980)
<i>Moricandia sinaica</i> (Boiss.) Boiss.	14	Gómez-Campo & Hinata (1980)
<i>Moricandia spinosa</i> Pomel	42	Gómez-Campo & Hinata (1980)
<i>Moricandia suffruticosa</i> (Desf.) Coss. & Durieu	28	Gómez-Campo & Hinata (1980)
<i>Morisia monanthos</i> (Viv.) Asch.	7	Gómez-Campo & Hinata (1980)
<i>Muricaria prostrata</i> (Desf.) Desv.	12	Gómez-Campo & Hinata (1980)
<i>Otocarpus virgatus</i> Durieu	8	Gómez-Campo & Hinata (1980)
<i>Physorrhynchus brahuicus</i> Hook.	?	
<i>Physorrhynchus chamaerapistrum</i> (Boiss.) Boiss.	16	Gómez-Campo & Hinata (1980)
<i>Pseuderucaria clavata</i> (Boiss. & Reut.) O.E. Schulz	?	
<i>Pseuderucaria teretifolia</i> (Desf.) O.E. Schulz	?	
<i>Pseudofortuynia esfandiarii</i> Hedge	7	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Psychine stylosa</i> Desf.	15	Gómez-Campo & Hinata (1980)
	15	Gómez-Campo (1980b)
	15	Ruiz de Clavijo (1991)
<i>Quezeliantha tibestica</i> (H. Scholz) H. Scholz	?	
<i>Raffenaldia platycarpa</i> (Coss.) Stapf	14	Galland (1984)
<i>Raffenaldia primulooides</i> Godr.	7	Gómez-Campo & Hinata (1980)
<i>Raphanus raphanistrum</i> L.	7	Galland (1984)
	9	Sikka & Sharma (1979)
	9	Gómez-Campo & Hinata (1980)
<i>ssp. landra</i> (Moretti ex DC.) Bonnier & Layens	9	Kapoor & Ramcharitar (1982)
<i>ssp. maritimus</i> (Sm.) Thell.	9	Gómez-Campo & Hinata (1980)
<i>ssp. microcarpus</i> (Lange) Thell.	9	Gómez-Campo & Hinata (1980)
<i>Raphanus sativus</i> L.	9	Gómez-Campo & Hinata (1980)
	9	Sikka & Sharma (1979)
	9	Gómez-Campo & Hinata (1980)
	9	Al-Shehbaz & Al-Omar (1982)
	9	Michael Hill (1984)
[Includes <i>Raphanus caudatus</i> L.]	9	Gómez-Campo & Hinata (1980)
<i>Rapistrum perenne</i> (L.) All.	8	Gómez-Campo & Hinata (1980)
<i>Rapistrum rugosum</i> (L.) All.	8	Sikka & Sharma (1979)
	8	Gómez-Campo & Hinata (1980)
	8	Guinocet & Lefranc (1981)
<i>ssp. Linnaeanum</i> Rouy & Foucaud	8	Gómez-Campo & Hinata (1980)
[Reported as <i>Rapistrum hispanicum</i> (L.) Crantz]	8	Sikka & Sharma (1979)
<i>Reboudia</i> (see <i>Erucaria</i>)		
<i>Rytidocarpus moricandioides</i> Coss.	14	Sikka & Sharma (1979)
	14	Gómez-Campo & Hinata (1980)
<i>Savignya parviflora</i> (Del.) Webb	15	Al-Shehbaz & Al-Omar (1982)
	15	Al-Shehbaz & Al-Omar (1983)
<i>ssp. longistyla</i> (Boiss. & Reut.) Maire	15	Gómez-Campo & Hinata (1980)
<i>Schouwia purpurea</i> (Forssk.) Schweinf.	18	Warwick, Black & Anderson (unpub.)
<i>ssp. schimperi</i> (Jaub. & Spach) Maire		
[Reported as <i>S. thebaica</i> Webb ex. Parl.]	18	Sikka & Sharma (1979)
<i>Sinapidendron angustifolium</i> (DC.) Lowe	10	Sikka & Sharma (1979)
	10	Gómez-Campo & Hinata (1980)
<i>Sinapidendron bourgaei</i> Webb ex Christ	?	
<i>Sinapidendron frutescens</i> (Aiton) Lowe	10	Gómez-Campo & Hinata (1980)
<i>Sinapidendron palmense</i> (Kuntze) O.E. Schulz	?	
<i>Sinapidendron rupestre</i> Lowe	10	Gómez-Campo & Hinata (1980)

TAXON	n	REFERENCE
<i>Vella anremerica</i> (Litard. & Maire) Gómez-Campo	17	Gómez-Campo & Hinata (1980)
<i>Vella lucentina</i> M. B. Crespo	?	
<i>Vella mairei</i> Humbert	34	
<i>Vella pseudocytisus</i> L.	34	Gómez-Campo & Hinata (1980)
ssp. <i>glabrata</i> (Coss.) Greuter		
[Reported as <i>V. pseudocytisus</i> sp. <i>glabrescens</i> (Coss.) Lit. & Maire]		
ssp. <i>pau</i> Gómez-Campo	17	Gómez-Campo & Hinata (1980)
<i>Vella spinosa</i> Boiss.	17	Gómez-Campo & Hinata (1980)
	17	Silvestre (1986)
	17	Martín Ciudad (1990)
<i>Zilla spinosa</i> (L.) Prantl	16	Gómez-Campo & Hinata (1980)
ssp. <i>macroptera</i> (Coss.) Maire & Weiller	16	Al-Shehbaz & Al-Omar (1982)
[Reported as <i>Z. macroptera</i> Coss.]		
	16	Gómez-Campo & Hinata (1980)

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