

Taxonomy of *Beta* Section *Beta*

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ABSTRACT

The taxonomic histories of the genus *Beta* and of section *Beta* within this genus are summarised. The subdivision of the genus agrees largely with (im)possibilities to produce hybrids. Classification within section *Beta* has been very variable, with examples of overclassification and severe lumping of taxa. The present study includes a morphometric analysis of variation, research on the patterns of allozyme differentiation, and studies of available herbarium specimens. After a description of the taxonomic criteria used, and after the stabilisation of four Linnaean names through typification, the results of the various studies are combined and used to formulate a revision of *Beta* section *Beta*. It is proposed to distinguish three species: *B. vulgaris*, a large and variable species containing both cultivated and wild materials; *B. macrocarpa*; and *B. patula*. *B. vulgaris* is subdivided into three subspecies: subsp. *vulgaris*, containing all cultivated materials; subsp. *maritima*, a large and variable group of plant types; and subsp. *adanensis*. Further subdivision is considered to be of little or no use. The so-called weed beets are classified as subsp. *maritima*. A key to the species and subspecies of section *Beta* is presented. Allozyme studies indicate that the development of self-compatibility and autogamy might have been important in the formation of taxa. Results are also discussed in relation to sampling strategies for gene banks.

Additional Key Words: cultivated beet, wild beet, morphometrical analysis, allozyme variation.

The species of *Beta* section *Beta* form a complex group, in which both wild and cultivated plants are included. Various taxonomic treatments of this group have been proposed, and no entirely satisfactory classification exists. Confusion was created partly because wild and cultivated taxa occur in the same section, which resulted in classifications by both plant breeders and taxonomists. For the breeders, the interest arose from the wish to introduce alien genes from wild taxa into cultivated materials. Thus, crossability and gene transfer were important items. For the taxonomists, the wide (and mainly man-made) variability in the cultivated materials caused confusion. Knowledge of the pattern of variation of the wild taxa over a large distribution area was lacking or incomplete. As a result, minor variants became important in the early taxonomic treatments of section *Beta*.

In the latest major revision of section *Beta*, Ford-Lloyd (1986) amalgamated all taxa into one species: i.e., *B. vulgaris* L., with four subspecies and no formal classification below the level of subspecies. Thus, section *Beta* was considered to be a morphological continuum of biotypes, instead of a collection of distinct morphological and geographical entities. Also, the absence of any genetical crossing barrier between taxa was used as evidence of close evolutionary affinities. Ford-Lloyd (1986) proposed two cultivated subspecies, subsp. *vulgaris*, including sugar beet, fodder beet, mangel and garden beet, and subsp. *cicla* (L.) Koch, with chard and spinach beet. For the wild taxa a geographical separation was used. The northern provenances were regarded as a distinct infraspecific taxon and called subsp. *maritima* (L.) Arcang., whereas the more southern Mediterranean ecotypes were included in a common gene pool, for which Ford-Lloyd (1986) chose the rank of subspecies and the name subsp. *macrocarpa* (Guss.) Thell. However, the relation between this new subsp. *macrocarpa* and *B. vulgaris* subsp. *maritima* var. *macrocarpa* (Guss.) Moq. in the classification of Ford-Lloyd & Williams (1975), or with the original *B. macrocarpa* Guss. remained unclear.

The lumping of taxa can be useful or even necessary, but it should be done with great care. The present study was undertaken to acquire more insight into the taxonomic structure and the genetic diversity of the wild taxa of *Beta* section *Beta*, and to use such knowledge to critically analyse the various taxonomic treatments of this group. A detailed description of the results was presented in Letschert (1993). In the present paper, the taxonomic part of the study will be summarised, including the presentation of a revision of the classification and a key to the proposed wild species and subspecies of section *Beta*.

PRIOR TAXONOMIC TREATMENTS

Genus *Beta*

The early taxonomic classifications of the genus *Beta* were confusing and mainly based on geographical distribution (De Bock, 1986). Transhel (1927) combined available knowledge on morphology, crossability, geographical distribution and ecology and proposed to divide the genus into three 'gruppa', viz. *Vulgares*, *Corollinae* and *Patellares*. Ulbrich (1934) elaborated on the work of Transhel (1927) and transformed the 'gruppa' into sections, concordant with the rules of botanical nomenclature. Ulbrich (1934) also proposed a fourth section, called *Nanae*, including the species *B. nana* Boiss. & Heldr. For unexplained reasons Ulbrich (1934) typified the section *Patellares* on *B. procumbens* Chr. Sm. and consequently renamed it into section *Procumbentes*. Williams et al. (1977) proposed to raise section *Procumbentes* to the generic level, naming it *Patellifolia*, but this view has not been widely accepted. Finally, Buttler (1977) pointed out that the correct name for the type section of the genus, which is Ulbrich's section *Procumbentes*, should be section *Beta*.

The plant breeders' interest in interspecific gene transfer in the genus *Beta*, where cultivated beet is the ultimate recipient parent, has led to a variety of studies (reviews by Bosemark, 1969; Coons, 1975; De Bock, 1986; Van Geyt et al., 1990). It is very difficult to hybridise the species of section *Procumbentes* with *B. vulgaris* L. Several authors (see the above reviews and Lange et al., 1990) reported lethality, hybrid sterility, irregular meiosis, inadequacy of chromosome pairing or crossing-over, and unstable sexual transmission of inserted alien chromosome material. Crosses of *B. nana* with *B. vulgaris* have not been reported so far. Hybridisations between *B. vulgaris* and species of section *Corollinae* are possible, but often difficult to make, due to the disparity of the numbers of chromosomes and to apomixis (for literature see the above mentioned reviews). There are conflicting reports about interspecific chromosome pairing in these hybrids (Bosemark, 1969; Jassem, 1976; Cleij et al., 1976). Clear evidence for gene transfer from species of section *Corollinae* into *B. vulgaris* is still lacking. Finally, it is generally accepted that hybridisation of cultivated beets with wild forms of section *Beta* results in hybrids that are generally fertile (see above mentioned reviews; McFarlane, 1975; Dale and Ford-Lloyd, 1983). The only exceptions occurred in crosses between cultivated beet and diploid or tetraploid *B. macrocarpa*. Part of the obtained seed was sterile, and sterility, hybrid dwarfness and hybrid chlorosis were observed in F₁ and F₂ (Abe et al., 1987; Lange and De Bock, 1989).

It can be concluded that the taxonomic classification in the genus *Beta*, at least with regard to the separation of section *Beta* from the rest of the genus, corroborates with (im)possibilities for the production of hybrids and transfer of alien genes into cultivated beet.

Section *Beta*

Linnaeus described three *Beta* species, which later were considered to belong to section *Beta*. In the first edition of *Species Plantarum*, Linnaeus (1753) listed one species, *B. vulgaris*, with eight varieties. One of these, var. *perennis*, was described to grow as a natural species in the coastal area of England and Belgium. In 1762 (*Species Plantarum*, 2nd Ed.) Linnaeus rendered the status of species to the wild material, and named this species *B. maritima*. In a following publication (*Systema Naturae*, 1767) the cultivated species was split into *B. vulgaris* and *B. cicla*.

For the wild forms of section *Beta*, the taxonomic history after Linnaeus starts with the work of Transhel (1927) and Ulbrich (1934). In Table 1, the most important references regarding this history are listed, together with names of species and subspecies used. The same names occur as species or as subspecies, and in some cases (e.g. Ford-Lloyd, 1986) old names have received a new contents.

The present study does not include a detailed record of the taxonomic history of cultivated beet. Helm (1957) has provided a treatment using the categories convar and provar. A modern treatment should conform to the rules of the International Code of Nomenclature of Cultivated Plants (Greuter, 1988), which Code is presently being rewritten and will provide rules on the use of the categories cultivar and cultivar group. For the present classification the separation between wild and cultivated materials is important. This separation has been treated in various ways. Several authors (see footnote in Table 1) made the separation at the species level. The other authors united the cultivated and some or all of the wild forms of the section into one species, *B. vulgaris*. The latter concept, which was proposed by Aellen (1938), Ernould (1945), Ford-Lloyd and Williams (1975), and Ford-Lloyd (1986), in fact made the section monotypic.

In some of the taxonomic treatments an overclassification took place, describing minor variants. The recognition of taxa at the species or the subspecies level, as well as the introduction of the ranks varietas and/or forma primarily appears to be a matter of personal opinion. Therefore, a careful study of the original type material, in combination with the sampling and study of new plant material, seems

Table 1. Taxonomic treatments of the wild taxa of *Beta* section *Beta*.

Reference	Species	Subspecies	Varietas & formae
Ulbrich, 1934	<i>vulgaris</i> [†] <i>macrocarpa</i> <i>patula</i> [‡] <i>atriplicifolia</i> [‡]	<i>perennis</i>	6
Aellen, 1938 [§]	<i>vulgaris</i> [†]	<i>perennis</i> <i>orientalis</i> <i>lomatogonoides</i> <i>macrocarpa</i>	3 + 3
Ernould, 1945	<i>vulgaris</i> [†]	<i>maritima</i> <i>macrocarpa</i> <i>patula</i>	2
Coons, 1954 [†]	<i>maritima</i> <i>macrocarpa</i> <i>patula</i> <i>atriplicifolia</i>		
Krassochkin, 1959 [†]	<i>maritima</i> <i>patula</i> <i>orientalis</i>	<i>mediterraneum</i> <i>danica</i>	4
Tutin et al., 1964	<i>vulgaris</i> [†] <i>macrocarpa</i>	<i>maritima</i>	
Aellen, 1967 [†]	<i>maritima</i> <i>adanensis</i> <i>trojana</i>	<i>maritima</i> <i>pilosa</i> <i>grisea</i>	
Ford-Lloyd and Williams, 1975	<i>vulgaris</i> [†]	<i>maritima</i> <i>orientalis</i> <i>adanensis</i> <i>provulgaris</i> <i>lomatogonoides</i> <i>patula</i>	6
Ford-Lloyd, 1986	<i>vulgaris</i> [†]	<i>maritima</i> <i>macrocarpa</i>	

[†] Species *B. vulgaris* also includes cultivated plants.

[‡] Ulbrich (1934) placed this species in section *Corollinae*.

[§] Also used by Helm (1957), under renaming of ssp. *perennis* into ssp. *maritima*, and by Hegi (1979), unchanged.

[†] Author placed cultivated plants under *B. vulgaris*.

necessary for a better understanding of geographical variation patterns and for the evaluation of the names to be used.

TAXONOMIC CRITERIA

In this revision a species is defined as a group of individuals that share a set of morphological features different from those of other such groups (Grant, 1981; Stuessy, 1990). Generally, morphological similarity points to common ancestry and cohesion of the species due to sexual reproduction. Thus, the species is defined in terms of comparative morphology, and discontinuities in morphological features are used to distinguish species. The intraspecific category subspecies firstly is used to designate geographically coherent groups of populations, which morphologically are clearly distinguishable from the rest of the species, and secondly to separate the cultivated plants from the wild relatives. In this latter context the subspecies level does not indicate geographical entities in the biosystematic sense.

Populations sampled from a wide geographical range showed appreciable variability in their morphology. However, it was considered useless to classify the minor variants and arbitrarily delimited parts of the observed clinal variation patterns. It also was decided not to use categories below the level of subspecies. Using variation at allozyme loci, we studied population structures to obtain more insight in the patterns of variation and in the influence of the reproductive behaviour on these patterns. This allowed a comprehension of genetic isolation and of the potential for natural gene flow.

TAXONOMIC REVISION OF *Beta* SECTION *Beta*

Cultivated versus wild materials

In order to provide for a stable nomenclatural base for the classification of wild and cultivated materials, it was necessary to typify the Linnaean names. First two herbarium sheets, which were made in the time of Linnaeus and possibly were seen by him, were designated as lectotype for *B. vulgaris* L. and for its var. *cicla* L. Secondly, for *B. vulgaris* var. *rubra* L. and for *B. maritima* L. neotypification was realised using a figure in a book of Fuchs (1542), and a herbarium sheet of newly collected wild material of the Belgian coast, respectively (for details see Letschert, 1993). This strategy of typification led to the situation that *B. vulgaris* L. stands for cultivated material and *B. maritima* L. for the wild provenances. In this way the disruption of the use of the name *maritima* could be avoided.

Although various possible pathways for the domestication of cultivated beet have been proposed (Bosemark, 1979; De Bock, 1986; Fischer, 1989), there is general agreement that cultivated beet has direct relationships with the wild sea beet (*B. maritima* s.l.). Several authors (Harlan and De Wet, 1971; De Wet, 1981; Pickersgill, 1986) have advocated the proposal to link the cultivated plants with their wild relatives at the level of subspecies. The application of this proposal for *Beta* leads to the use of the name *B. vulgaris* subsp. *vulgaris* for all cultivated materials and *B. vulgaris* subsp. *maritima* for the related wild provenances.

Although the international discussion on the concept of nomenclature of cultivated plants is not yet finished, there is a strong tendency to use cultivar groups instead of a botanical intraspecific classification. In that case the groups proposed by Ford-Lloyd (1986) could serve the purpose, viz. garden beet, mangel, fodder beet, sugar beet, chard and spinach beet. In light of the present revision, all cultivar groups should be placed in *B. vulgaris* subsp. *vulgaris*, and the use of subsp. *cicla* (for chard and spinach beet) should be abandoned.

Wild plant material - morphological studies

This study included a morphometric analysis of variation and extensive studies of available herbarium specimens. In the present paper a summary of the major conclusions is presented, and a full record of the results can be found in Letschert (1993).

The morphometrical analysis included 79 accessions, obtained from gene banks and from newly made collections. The accessions originated from a wide geographical area. Eight to 24 plants per accession were grown under uniform conditions in the Netherlands and were evaluated for 19 variables (a.o. growth habit, pubescence, pigmentation, characters of inflorescence, characters of tepals and information on flowers and flowering). All data were analysed through multivariate cluster analysis and principal component analysis (SPSS/PC 4.0 statistical package).

Only part of the characters were found to be taxonomically useful: number, size and shape of flowers, and shape of the lid of the fruit (operculum). In the principal component analysis high factor loadings were obtained for type of inflorescence and flowering, and characters of tepals.

Cluster analysis revealed a total of four gross morphological groups. The majority of a group of accessions, which had been received under the name *B. macrocarpa*, clustered in one group, and within this group the tetraploid types were separated from the diploids. The only

accession received under the name *B. patula* Ait. clearly was separated from all other accessions. In addition, a principal component analysis yielded trends that were complementary to the results of the cluster analysis.

A second cluster analysis was carried out using the combined data of the materials that remained after excluding the data on *B. macrocarpa* and *B. patula*. Two groups were separated again. One of them was mainly composed of accessions which fitted the description of *B. adanensis* Pamuk. In the principal component analysis the *adanensis* types could clearly be separated from the other accessions. The second and largest group mainly consisted of accessions which were received as *B. maritima* or *B. atriplicifolia* Rouy. Neither the cluster analysis nor a principal component analysis presented evidence for a clear subdivision of this group, except for a number of Oriental accessions (from India, Pakistan and Iran), which partly clustered together. In the remaining material, no further morphological or geographical clustering could be demonstrated.

Patterns of allozyme differentiation

A selection of 76 accessions, which originated from all areas of geographic distribution of section *Beta*, was surveyed for allozyme variability. A total of eleven isozymes was studied and the data on 59 accessions and nine loci were suitable to calculate genetic variability coefficients (for details see Letschert, 1993).

In Table 2 the number of allozymes observed on ten loci in four wild taxa is presented. The greatest allozyme diversity was found in *B. vulgaris* subsp. *maritima*, and especially in the accessions from the Mediterranean Basin. Based on the most common allozyme, it can be concluded that the differences between subsp. *maritima*, subsp. *adanensis* and *B. patula* are small. However, subsp. *adanensis* expressed specific allozymes (e.g. for Got3) at high frequency and showed unique allozymes for Lap1 and Pgi2. The allozyme for Acpl in *B. patula* is not unique, but is further only found in some populations of subsp. *maritima* from the Atlantic coast. *B. macrocarpa* showed four unique allozymes, and two of them (for Lap1 and Pgm1) at high frequency. Several other authors (Abe and Tsuda, 1987; Nagamine et al., 1989; Abe and Shimamoto, 1989) also reported that *B. macrocarpa* has diverged at a number of loci. Genetic distances were calculated according to the formulae of Nei (1978), and were used for a cluster analysis (Fig. 1). The results confirm the grouping of the wild taxa of *Beta* section *Beta*, as it was found in the morphometrical analysis.

Table 2. Number of allozymes observed in species of *Beta* section *Beta*.

Isozyme locus [†]	<i>B. vulgaris</i> subsp.		<i>B. macrocarpa</i>	<i>B. patula</i>
	<i>maritima</i>	<i>adanensis</i>		
Acp1	6 (a) [‡]	3 (b)	4 (c)	1 (d)
Lap1	3 (a)	4 (a)	2 (b)	1 (a)
Mdh1	4 (a)	3 (a)	2 (b)	1 (a)
Pgm1	3 (a)	2 (a)	2 (b)	1 (a)
Pgm2	3 (a)	1 (a)	1 (a)	1 (a)
Icd1	2 (a)	2 (a)	1 (a)	1 (a)
Pgi2	2 (a)	3 (a)	2 (a)	1 (a)
Skdh1	3 (a)	1 (a)	1 (a)	1 (a)
Got3	2 (a)	2 (b)	2 (b)	1 (a)
Px1	3 (a)	3 (b)	1 (b)	-
Number of accessions	56	8	11	1

[†] Acp = acid phosphatase; Lap = leucine aminopeptidase; Mdh = NAD depending malate dehydrogenase; Pgm = phosphoglucomutase; Icd = isocitrate dehydrogenase; Pgi = glucose phosphate isomerase; Skdh = shikimate dehydrogenase; Got = glutamate oxaloacetate transaminase; Px = peroxidase.

[‡] Similar letters across an isozyme annotate that the most common allozyme of that locus is the same.

It is interesting to note that the observed levels of heterozygosity can be related to the breeding systems. The taxa *B. macrocarpa*, *B. patula* and *B. vulgaris* subsp. *adanensis* expressed low levels of observed heterozygosity, thus confirming autogamy and self-compatibility. In *B. vulgaris* subsp. *maritima* a higher level of heterozygotic genotypes pointed to allogamous reproduction. These results generally are in agreement with studies of Bruun et al. (1994) on self-incompatibility, although the latter investigators observed incompatibility in *B. patula* and sometimes self-compatibility in *B. vulgaris* subsp. *maritima*. Nevertheless, it might be concluded that the breeding system, and especially the development of self-compatibility and autogamy, has been important in the development of taxa in *Beta* section *Beta*.

The patterns of differentiation also led to conclusions regarding sampling strategies. For *B. macrocarpa* and *B. vulgaris* subsp. *adanensis* it is essential to sample as many populations as possible from many different environments. For *B. vulgaris* subsp. *maritima* the distribution

of variation is more diffuse, with only weak differences between geographical regions. Therefore the sampling strategy of this taxon can be based on a wider grid.

Revision of *Beta* section *Beta*

The results of the morphometrical analysis and the allozyme studies, as well as the knowledge gained with the study of prior treatments and herbarium materials (including holotypes and isotypes of various taxa), were combined to formulate a revision of *Beta* section *Beta* (Table 3). Three groups are ranked as species. The largest and most variable, *B. vulgaris*, covers the whole area of distribution of the section and contains both wild and cultivated materials. The other two species, *B. macrocarpa* and *B. patula*, are readily separated from *B. vulgaris*, using both vegetative and generative morphological characters. Other studies (Frese et al., 1990) revealed that wild taxa of *B. vulgaris* and *B. macrocarpa*, if growing together in sympatric populations, maintained their identity. *B. patula*, which was studied using one accession and herbarium specimens, is a geographical isolate with substantial morphological differentiation from the other species.

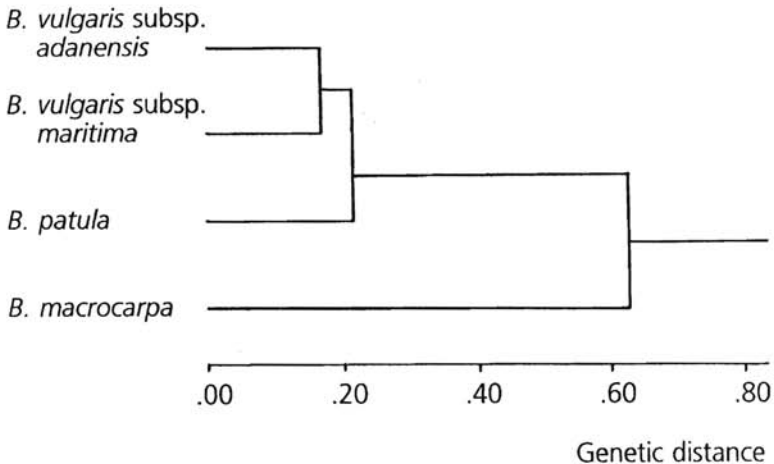


Figure 1. Cluster analysis and calculated genetic distances of the wild taxa of *Beta* section *Beta*, based on allozyme variation.

Table 3. Taxonomic revision of *Beta* section *Beta*.Genus *Beta* L.type of the genus: *B. vulgaris* L.Section *Beta* (syn. *Vulgares* Ulbrich)

Species and subspecies

B. vulgaris L.subsp. *vulgaris* (cultivated materials)subsp. *maritima* (L.) Arcang.subsp. *adanensis* (Pamuk.) Ford-Ll. & Will.*B. macrocarpa* Guss.*B. patula* Ait.

Within *B. vulgaris* three subspecies are proposed. One of them, subsp. *vulgaris*, covers all cultivated materials and has already been discussed. For the wild plants, the evidence allowed a separation in only two groups. In the Aegean distribution area, a group of early flowering, semi-annual plants, with large glomerules, succulent bracts and a reduced number of flowers per glomerule could be recognised. This group was ranked as subspecies and named subsp. *adanensis*. The remaining part of the wild plants of *B. vulgaris* were grouped together in the large and highly variable subsp. *maritima*. Although the pattern of variation in subsp. *maritima* revealed a certain degree of geographical distribution (Oriental types, Atlantic types), the separation was insufficient to propose more subspecies.

Key to the wild taxa of *Beta* section *Beta*

- 1 a. Operculum convex, sometimes thickened. Perianth segments thin, sometimes spongy. At maturity perianth segments bent, sometimes covering the operculum. Perennial, sometimes annual. 2
 1 b. Operculum depressed, margins elevated. Perianth segments erect, spongy, at maturity perianth segments patent or contiguous to the operculum. Glomerules (2-) 3 (-7) flowered. Glomerules spaced on the inflorescence. Bracts large, upper bracts sometimes 3-5x diameter of glomerule. Annual. *Beta macrocarpa*
 2 a. Perianth segments narrow, usually 1.5x longer than broad. After fructification tips of the segments bent, covering the operculum. Glomerules (1-) 3-7 (-12) flowered. Upper bracts small, 1.5-2x length of glomerule. 3
 2 b. Perianth segments short, between 2.2 and 3.2 mm, and relatively broad, between 2.0 and 2.8 mm. Segments generally not longer than broad (mean ratio tepal length/tepal width = 1.12). After fructification operculum rises up above the short perianth segments. Tips of perianth segments not contiguous in fruit. Glomerules (1-) 2 (-4) flowered. Glomerules spaced on inflorescence, proximal bracts large and succulent, distal bracts very small, hardly exceeding length of glomerule. *Beta vulgaris* subsp. *adanensis*

- 3 a. Glomerules with (1-) 3 (-7) flowers. 4
 3 b. Glomerules many flowered (2-) 7 (-12). Proximal glomerules usually with eight or more flowers. Glomerules spaced on inflorescence. Leaves and bracts linear or lanceolate, glabrous. *Beta patula*
 4 a. Glomerules usually crowded apically and the inflorescence compressed. Perianth segments bent in fruit, contiguous to the operculum, less than 7 mm long. Upper bracts small, linear or rhombic. Leaves ovate or deltoid, sometimes lanceolate or rhombic, glabrous or moderately pubescent, or occasionally densely covered with hairs. Leaves sometimes waxy. Glomerules crowded apically. Plants erect or decumbent. *Beta vulgaris* subsp. *maritima*
 4 b. Glomerules spaced on the inflorescence. Flowers large, perianth segments of proximal flowers erect, spongy, longer than 7 mm. At maturity, perianth segments patent or contiguous to the operculum. Upper bracts large, rhombic. Plants from the Canary Islands. Annual. *Beta macrocarpa*

Short characterisation of taxa

This paragraph contains part of the descriptions presented in Letschert (1993). In that paper also the synonyms and the herbarium specimens studied are listed, and representative illustrations are shown.

B. vulgaris L. subsp. *vulgaris*

Sugar beets, garden beets, and fodder beets. Leaf beets for the consumption of leaves: foliage beet with abundant leaf material, leaf beets with swollen midribs. Cultivated. $2n = 18, 27$ or 36 .

B. vulgaris subsp. *maritima* (L.) Arcang.

(basionym: *B. maritima* L.) Perennial, sometimes annual herb, which occurs along the Atlantic coasts of western Europe, including the British Isles, and on the Azores, and is common and widespread along the coasts of nearly all Mediterranean countries. It also occurs in the countries of the Middle East and extends to the Indian subcontinent. In the northern part of the distribution area the sea beet is found in a narrow band, usually within 10-20 m of the high water mark, on rocky cliffs, gravel beaches, and also on dense grass lands, sandy beaches, in salt marshes or on disturbed sites. The Mediterranean and Middle East habitats are primarily coastal but more diverse. Inland populations were reported from Sicily (Toll and Hendriksen, 1982) and from southeastern Spain (Frese et al., 1990). $2n = 18$.

B. vulgaris subsp. *adanensis* (Pamuk.) Ford-Ll. & Will.

(basionym: *B. adanensis* Pamuk.) Annual or perennial herb, which occurs in Greece (Peloponnesus and several Aegean islands), Cyprus, and west coast of Turkey and Syria. The subspecies is distinguished from subsp. *maritima* by its broader and shorter perianth segments, flatter flowers and generally bigerm glomerules.

Only a small rosette is formed, and flowering already starts from the seventh node. The glomerules are spaced on the inflorescence stem and not closely packed as in subsp. *maritima*. $2n = 18$.

B. macrocarpa Guss.

Annual herb with delicate plant morphology. It occurs in Portugal (south of Lisbon and Algarve), in the south and southeast part of Spain, on the Balears and the Canary Islands, in Morocco, Algeria, south of France, Sicily, Greece, Cyprus, Israel and Turkey. $2n = 18, 36$.

The natural tetraploid of *B. macrocarpa* was reported by Buttler (1977). This type only occurs on the Canary Islands and cannot easily be distinguished from the diploids. The morphological differences between diploids and tetraploids concern the size of the flowers and the form of the operculum, which is convex in the tetraploids. Evidence obtained on isozymes (Abe and Tsuda, 1987; Abe and Shimamoto, 1989; Letschert, 1993), on chloroplast DNA (Kishima et al., 1987) and on chromosome association (Lange and De Bock, 1989) makes it very likely that tetraploid *B. macrocarpa* is an allotetraploid in which diploid *B. macrocarpa* and possibly subsp. *maritima* are included.

B. patula Ait.

Perennial herb, also with a delicate plant morphology, and having glomerules with on average seven and up to twelve flowers. The species occurs on one or more islands of Madeira. $2n = 18$.

Weed beets

The term weed beets is used for three different types of plants: (1) cultivated beets that occur as a weed in other crops and originate from seed of early bolters in a preceding beet crop; (2) wild taxa of section *Beta* behaving as weeds in arable fields (cf. Ford-Lloyd and Hawkes, 1986); (3) products of recent hybridisation between wild and cultivated plants (Ford-Lloyd and Hawkes, 1986; Hornsey and Arnold, 1979; Ford-Lloyd, 1986). Such hybridisation is not wanted by breeders or seed producers. It may be followed by introgression into either the beet crop plant or the wild population (Evans and Weir, 1981).

Only the third category presents a need for taxonomical classification. It is proposed not to create a separate subspecies for this type of weedy plants. Because of the rather recent domestication of beet, and especially the selection of the sugar beet, the relationship between wild and cultivated *B. vulgaris* is still very close. Thus, the more or less permanent populations showing introgression from cultivated plants should be taxonomically treated as *B. vulgaris* subsp. *maritima*. Unwanted introgression of traits of subsp. *maritima* into the cultivated

gene pool will normally be removed through selection by breeders. The deliberate use of wild *Beta* species for the introduction of certain wanted traits, will always be followed by rigid selection to eliminate all unwanted 'wild' characters. Therefore, the breeders' activities will ensure the unambiguous status of the taxon *B. vulgaris* subsp. *vulgaris*.

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