

# 1 Taxonomy of grain legumes

R.M. Polhill and L.J.G. van der Maesen

## INTRODUCTION

The taxonomy of grain legumes is relatively uncomplicated compared to that of cereals, brassicas and some other groups of plants because, in general, only limited gene pools have been available for selection and subsequent plant breeding. Then again, intergeneric legume hybrids are not known in nature and artificial crosses attempting to create them are seldom, if ever, successful [64]. Indeed, the genetic barriers between species and species groups are often substantial [86,87]. The classification of interfertile species and infraspecific variants is inherently more difficult and the taxonomic situation in grain legumes is not exceptional. In some instances the available information would now seem to justify updating of the taxonomic framework.

## TRIBES

Most grain legumes belong to two tribes, the Viciaeae and the Phaseoleae. The Viciaeae and many Phaseoleae have the unusual combination of hypogeal germination and a herbaceous habit. Hypogeal cotyledons with large food reserves are characteristic of forest plants and the twining propensity of Phaseoleae and the tendrils of Viciaeae may represent residual traits of that ancestral association.

The interchange between epigeal and hypogeal germination involves major reorganisations of seed structure, composition and behaviour such that many families are restricted to one system or the other [102]. In legumes, both systems occur widely and, as shown in *Phaseolus* for example, the interchange is under fairly simple genetic control [30]. The most advanced tribes have tended to become predominantly herbaceous and most are obligately epigeal with small hard seeds produced in large numbers, with long viability and staggered opportunistic germination.

In classifications of the last century, Phaseoleae and Viciae have tended to be associated simply because of their comparable seed features [6,13]. In modern systems they are considered as end points of very different lines of evolution [75]. The Phaseoleae are well distributed through the tropics and subtropics, notably heterogenous and without any very obvious indications of their origin [53]. In contrast, the Viciae belong to a small group of tribes, all of which are centred in the Sino-Indian region and appear to have spread extensively into temperate regions, mainly of the northern hemisphere, during the late Tertiary era. *Cicer* used to be included in the Viciae, but an overall assessment reveals significant features shared with the Trifolieae. The way these characters are combined suggests that *Cicer* is a separate offshoot and best placed in a special tribe Cicereae [49]. The contiguity between these north temperate tribes is also evident.

The most notable grain legume genus outside these tribes is *Arachis*, which is morphologically very distinct. Once included in the Hedysareae, which was an artificial assemblage of papilionoid genera with segmented fruits, it is now placed in Aeschynomeneae subtribe Stylosanthinae, but with the proviso that a separate tribe Stylosantheae may become justified in due course [83]. The tribe and subtribe have their main centre of development in Central and South America. *Arachis* is unique in its tribe because

of obligately geocarpic fruits and an exceptional seed structure which is functionally linked to that fruiting habit.

The Mediterranean species of *Lupinus* are a recent addition to the list of major grain legumes. *Lupinus* is traditionally included in the Genisteae, but represents a distinctive herbaceous line of evolution in that tribe and warrants at least subtribal rank [9]. Like the Viciaeae, the Genisteae seem to have spread from the Sino-Indian region, but are developed from a quite different part of the subfamily. The seeds of the Mediterranean species of *Lupinus* are consistently larger than those of American species of the genus, but the range of variation is not exceptional in this group of tribes.

The main implication of these collective remarks is that the grain legume tribes have had a long and separate evolutionary history. Consequently, many functional syndromes differ significantly in detail and often quite consistently between the tribes, e.g. the structure and metabolism of root nodules (see Chapter 4), stem anatomy, chemical defence mechanisms, and pollen and seed chemistry. More than once the differences found between peas and beans have provided the starting point for taxonomic surveys that have moulded current concepts of tribal evolution in the Papilionoideae [75].

Whether to subdivide the legumes into families or subfamilies is not entirely agreed. The connections between the three main groups seem fairly well demonstrated, a view expressed by one family, the Leguminosae (or Fabaceae), with three subfamilies, viz. Caesalpinioideae, Mimosoideae and Papilionoideae (or Faboideae). The alternative of three families is expressed as Caesalpinaceae, Mimosaceae and Papilionaceae (or Fabaceae). The optional names Fabaceae and Faboideae became fashionable in North America at the beginning of this century and are equally correct.

## GENERA

The only recent generic changes affecting grain legumes have been in the Phaseoleae. This is a large tropical tribe to which many species have been added since the outlines of a generic classification were laid down in the last century. *Phaseolus* and *Vigna* have been redefined since 1970 with a rather narrowly delimited American genus *Phaseolus*, and a widespread genus *Vigna*, subdivided into a number of subgenera and sections [62,98]. The reorganisation is based on an extensive survey of morphological, chemical, cytological and palynological features; it is clearly displayed as well by taximetric methods using multivariate discriminant analysis to weight taxonomically important characters, and it seems resilient to criticism [61]. *Voandzeia*, the Bambara groundnut, is also included in *Vigna* [100].

The subtribe Cajaninae is distinctive in the Phaseoleae and has two generic groups, the Rhynchosiastrae with one- or two-seeded fruits, and the Cajanastrae with two, three or more seeds [3,4]. Traditionally, *Cajanus* has comprised only two species, *C. cajan* and *C. kerstingii* but there is good evidence that the species of *Atylosia* should now be added to this genus. *Atylosia* has a large aril (strophiole), but other supposed differences, namely the angle of grooves on pod walls between the seeds and persistence of the corolla, are no longer valid. A morphological link between the former genera is indicated by *Atylosia cajaniifolia* in particular. The contiguity between the two genera is emphasised by similar chromosome complements ( $2n = 22$ ), closely homologous seed protein profiles, viable hybrids and a continuity of morphological forms. A formal revision is in preparation in which the genera will be united [96]. There are links with *Dunbaria* and *Rhynchosia* also, but more flattened fruits and only one or two ovules, respectively, provide clear differences from *Cajanus*. The recent analysis of Australian Cajaninae

indicates other implications for the generic realignment [74].

## SPECIES

To integrate a sensible classification of crop plants with that appropriate for their wild relatives does present problems. Part of the difficulty relates to the different type of variation that arises from artificial selection of crop characteristics and the loss of a natural population structure, and part depends on the sort of material on which judgements have to be made.

In practice, it is relatively straightforward to revise groups of wild plants from specimens accumulated in herbaria and gardens, and the morphological, geographical and ecological patterns apparent from such studies can be verified to a greater or lesser extent by revisiting original populations. To piece together the evolution and domestication of crops is altogether more difficult (see Chapter 2). Some obsolete crop plant classifications have tended to persist, either because the materials needed for reassessment are not readily available or have often been lost from agricultural or other research institutes.

The extent to which the morphological species, based on visible differences related to patterns of geography, ecology and phenology, coincides with the biological species, determined by genetic barriers, is generally uncertain. As the gene pools of crop plants are explored for breeding purposes new information becomes available for taxonomic consideration. Grain legume gene pools seem to be fairly restricted in most cases. The concept of primary, secondary and tertiary gene pools advocated by Harlan and de Wet [38] can be integrated fairly easily, therefore, into a conventional framework. The primary gene pool includes the crop plant and freely interfertile spontaneous races, which may be appropriately ranked as subspecies; the secondary pool includes related species

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that hybridise with difficulty; and the tertiary pool includes the limits of gene transfer by artificial means.

The morphological hallmark of differentiation within the primary gene pool is similarity among attributes apart from the crop characteristics. In grain legumes, crop characteristics generally involve such features as larger plants, erect growth, loss of seed toxins, indehiscent fruits and larger seeds (see Chapter 2). If these predictable differences are associated with successful inter-fertility there seems no reason to exclude the wild and weedy forms from the crop species. Thus, *Glycine max* and *G. soja*, the cultivated and wild forms of the soyabean, seem appropriately ranked as subspecies, as suggested by Harlan and de Wet [38], but not yet generally adopted [43,44]. Similarly, the recent discovery of a wild chick-pea, *Cicer reticulatum* [54], interfertile with *C. arietinum*, and differing by a less erect habit, less persistent fruits and rougher seeds, is more appropriately ranked as a subspecies [65]. Subspecific ranking on similar criteria has been recommended recently for the lentil, where formerly *Lens orientalis* and *L. nigricans* were considered specifically distinct from *L. culinaris* [19,104].

In these three cases the broadened specific concept coincides with the primary gene pool, fertile hybrids not being produced with any other species. However, the genetic situation can be more complicated, and taxonomic guesses before the variations and breeding patterns are well known can lead to periods of some confusion. It has been suggested, for example, that *Vigna mungo* and *V. radiata* are independently derived from *V. radiata* var. *sublobata*, and the genetic barriers are considerable between all three [46]. If that is the case then var. *sublobata* is better treated as a separate species. Others have argued that material known as '*Phaseolus sublobatus*' includes two quite separate elements, one of which is the wild form of the mung bean, *Vigna radiata* var. *sublobata*, the other a wild form of the black gram, *V. mungo* var. *silvestris* [60].

## INFRASPECIFIC VARIANTS

The main subdivisions of the species, the subspecies and variety, are used in various senses. Sometimes they indicate just a decreasing scale of morphological differentiation, sometimes the subspecies is used for geographical, ecological or cytological segregates, and the variety for sporadic differences, and sometimes they are regarded as virtually synonymous (the varietal concept was exclusively preferred in much American literature for a considerable part of this century). The subspecies is also used to distinguish cultigens from wild relatives in the primary gene pool, and, formerly, the variety was used for what are now treated as forms (e.g. colour variants) and cultivars. Some latitude is actually desirable to allow for the range of possible biological situations, and to provide a provisional framework before the breeding behaviour is known.

The *Code of Botanical Nomenclature* insists only on the hierarchical sequence with respect to subspecies, variety and form, but allows for other categories to be intercalated if desired [88]. The *Botanical Code of Nomenclature for Cultivated Plants* encourages the use of the cultivar for any clearly recognisable assemblage of cultivated plants that reproduces its distinguishing features [12]. The cultivar or cultivar group may be co-extensive with the botanical subspecies or variety and designed for practical convenience. When there are two or more previously published epithets in Latin form, the epithet that best preserves established usage should be chosen without regard to the botanical category in which the epithet was published, or to priority.

The classification of *Vicia faba* has been overburdened by traditional nomenclature, and the cultivar groups Major, Equina and Minor might serve best for cultivated forms defined on seed size (continued use of var. *major* for var. *faba* is contrary to the rules of botanical nomenclature). The status of *V. faba* subsp. *paucijuga*

seems to need further elucidation [36,66], and subspecific rank may be appropriate for the present, even if only as an 'ignorance' category. Cubero [21] suggests that Paucijuga be added simply as a fourth cultivar or land-race group (and see Chapter 6).

The classification of *Arachis hypogaea* is a case where the cultivar groups have a recognisable geographical basis and the botanical categories have a shorter and simpler history, so that the two systems have been more easily equated [34]. Predictably, the botanical system should become redundant.

The classification of *Vigna unguiculata* is still being refined from several species at the beginning of the 1970s to five subspecies [98], then into a series of subspecies for spontaneous plants and cultivar groups, viz. Unguiculata, Biflora and Sesquipedalis for the cowpea, catjang and yard-long bean, respectively [62]. The name Biflora was chosen on the grounds of botanical priority, and, as indicated above, that is inappropriate and should be supplanted, presumably by cultivar group Catjang. There seems to be continuous variation between cultivar groups Unguiculata and Catjang, whereas Sesquipedalis has a distinctive morphology, origin, use and distribution; nonetheless it seems to have been developed from cultivar group Unguiculata [89].

The above examples are cited to indicate the flexibility of the taxonomic framework, which can be extended as necessary. It is not for us to specify the appropriate system for taxa we have not studied personally, but it seems that some sensible recent updating could be adopted more widely without fear of nomenclatural instability.

We accept the axiom that an infraspecific classification aims to represent the geographical and ecological variation and the history of domestication and subsequent breeding. Any expedient to group cultivars into groups or higher categories on the basis of artificial criteria, such as the discreteness of alternative character-



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states [42,73], is liable to be internationally unacceptable, as well as scientifically retrograde.

We conclude this chapter with a more formal synopsis of the grain legumes based on a number of recent handbooks and floras, together with some further data from contributors to this volume [1,25,26,35,41,47,77,85,94,103]. Here, authorities for species and infraspecific variants are cited as these are often required by editors of scientific publications. That imposition is part of an emphasis on the critical need for meaningful names and correctly identified experimental material. The importance of voucher specimens and reliable naming cannot be over-emphasised, but the citation of authorities, except for homonyms or other confused names, has little relevance beyond strictly taxonomic papers. Authorities for genera and tribes can be found readily elsewhere [75].

### *ARACHIS HYPOGAEA* (AESCHYNOMENEAE)

#### Specific classification

Pending the long-awaited revision by Krapovickas and Gregory many unpublished names are in circulation since the wild relatives play an important role in the improvement of the groundnut (*Arachis hypogaea* L.). Up to early 1983 twenty-two species had been formally described and another forty to fifty awaited publication [34,78,81]. All are native to South America and some are restricted to small areas. Tribal placement has been discussed by Rudd [83]. *Arachis* is placed in Stylosanthinae, a subtribe of Aeschynomeneae. Other genera of Stylosanthinae are not considered to be close relatives at present.

Gregory and Krapovickas have proposed the following infrageneric classification [34] but the names have yet to be validated; some of the names are not correctly formed:

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- Sect. 1 *Arachis* Series *Annuae*, *Perennes* and *Amphiploides*
- Sect. 2 *Erectoides* Series *Trifoliolatae*, *Tetrafoliolatae* and *Procumbensae*
- Sect. 3 *Caulorhizae*
- Sect. 4 *Rhizomatosae* Series *Prorhizomatosae* and *Eurhizomatosae*
- Sect. 5 *Extranervosae*
- Sect. 6 *Ambinervosae*
- Sect. 7 *Triseminale*

The sections are associated with the drainage systems of the South American river basins. Most series have a chromosome number of  $2n = 20$ , but series *Amphiploides* (including *Arachis hypogaea*) and *Eurhizomatosae* have  $4n = 40$  chromosomes. Genetic isolation is not marked between most species of section *Arachis*. Several possible antecedents of *A. hypogaea* have been collected in recent years from the East Andean region [35].

Infraspecific classification

There have been many more or less detailed, formal and informal classifications below the species level. Earlier systems were based on growth habit, later ones on branching patterns and positions of the fruiting branches. A recent system [81] is summarised in Table 1.1.

Table 1.1 Infraspecific classification of *Arachis* [81]

Subspecies	Variety	Cultivar groups*
<i>hypogaea</i>	<i>hypogaea</i> ( <i>A. africana</i> , <i>A. procumbens</i> )	Braziliano Virginia
	<i>hirsuta</i> Kohler ( <i>A. asiatica</i> )	Peruano p.p.
<i>fastigiata</i> Waldron	<i>fastigiata</i>	Peruano p.p. Valencia
	<i>vulgaris</i> Harz	Spanish

\* Designated 'types'.

*CAJANUS CAJAN* (PHASEOLEAE-CAJANINAE)Specific classification

As mentioned earlier, *Cajanus* will be expanded to include *Atylosia* in a forthcoming revision [96]. The combined genus has its main distribution in South and South-East Asia and in Australia [82,96]. The nearest relative to the pigeonpea, *Cajanus cajan* (L.) Millsp. (*C. indicus* Sprengel), is the West African *C. kerstingii* Harms, the only other species considered congeneric in recent times. Among the species formerly included in *Atylosia*, *A. cajanifolia* Haines from India is perhaps morphologically the most similar and produces fairly fertile hybrids with *C. cajan*. The pigeonpea, now cultivated pantropically, reached Africa from its origin in India before 4000 BP and was introduced into the Americas, mainly from Africa, with European settlement.

Infraspecific classification

Although some varieties can be distinguished in wild species of Cajaninae, infraspecific taxa are difficult to discern in pigeonpea. With a large germplasm at hand the continuum is more evident than ever. *C. bicolor* DC. and *C. flavus* DC., the first species described in *Cajanus* to cover the 'Arhar' and 'Tur' groups of North and Central to South India, respectively, with yellow-red and plain yellow flowers, are conspecific and not distinguishable even as varieties [90,103]. The differential characters are governed by only a few genes [24,96]. Furthermore, the phenotype of pigeonpea is greatly influenced by responses to day length and temperature, which can entirely change plant appearance, so that a classification into meaningful cultivar groups is difficult [90]. Maturity criteria should be adhered to and ICRISAT (see Chapter 18) maintains the maturity groups shown in Table 1.2 [96].

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Table 1.2 Maturity groups of pigeonpea [96]

Group	Days to 50% flowering	Reference cultivars
0	<60	Pant A-3
I	61 - 70	Prabhat; Pant A-2
II	71 - 80	UPAS-120; Baigani
III	81 - 90	Pusa Ageti; T-21
IV	91 - 100	ICP-6
V	101 - 110	No. 148; BDN-1
VI	111 - 130	ICP-1; 6997; ST-1; C-11
VII	131 - 140	HY-3C; ICP-7035
VIII	141 - 160	ICP-7065; 7086
IX	>160	NP(WR)-15; Gwalior-3; NP-69

Elsewhere the same groups can be discerned, albeit with modified flowering dates. The two major usage groups are pigeonpeas for dry seed (pulse) and 'dhal' preparation, and cultivars as green vegetables [77].

~~CICER ARIETINUM~~ (CICEREAEE)

Specific classification

A recent monograph of *Cicer* presents descriptions and keys for most species [92]. A treatment for *Flora Iranica* is also available [93]. Until recently *Cicer* was placed in the Viciaeae but, as noted earlier, now seems to warrant a monotypic tribe [15,45,48,49,50,58,59]. It comprises nine species of annual herbs and thirty-five species of small perennial shrubs [92,94], including four newly described ones [16,23,54,95]. ~~It is an Old World genus with many species in two major regions: Iran and Turkey; Central Asia and Afghanistan.~~

The closest relatives of the chickpea, *C. arietinum* L., are the annual species of section *Monocicer* M. Pop.: *C. bijugum* K.H. Rech., *C. echinospermum* P.H. Davis, *C. reticulatum* Ladiz. (morphologically the closest [54] and now regarded as a subspecies [65]), *C. judaïoum* Boiss., *C. pinnatifidum* Jaub. & Spach, *C. cuneatum* Hochst. ex A. Rich. and *C. yamashitae* Kitam.. Section *Chamaecicer* M. Pop.

also contains an annual species, *C. chorassanicum* (Bunge) M. Pop.. Viable and fertile hybrids involving *C. arietinum* have so far been obtained only with *C. reticulatum*, indicating a possible role as an ancestor, and ranking as a subspecies of *C. arietinum* has been proposed [65]. When crossed with *C. echinospermum* the hybrids were viable but infertile.

In contrast to most annual species, the perennial species (sections *Polycicer* M. Pop. and *Acanthocicer* M. Pop.[92]) are extremely difficult to cultivate and study outside their natural habitats. Characters such as drought resistance, high-altitude adaptation and multi-seeded fruits are present so that introgression into chickpea cultivars could be valuable. Disease resistance has been established in several species (see Chapter 8) and incorporation of blight resistance proved possible from a source in subsp. *reticulatum*.

Further taxonomic studies are needed in *Cicer* to elucidate the position of rare species such as *C. aphyllum* Boiss., collected only once, *C. paucijugum* Nevski, *C. balcaricum* Galushko and several other Central Asian species [92], *C. heterophyllum* Contandr. et al. [16] and *C. multi-jugum* van der Maesen. An urgent but difficult task is to obtain all species in a live collection for hybridisation studies and seed distribution, as many species are physically and/or politically inaccessible [94].

Most *Cicer* species have chromosome complements of  $2n = 16$ , but *C. pungens* Boiss., *C. microphyllum* Benth. and possibly *C. anatolicum* Alef. have  $2n = 14$ , while some cells of *C. montbretii* Jaub. & Spach were triploid (24 chromosomes) [50,92]. Detailed cytological studies have revealed degrees of homology between *C. arietinum*, *C. reticulatum* and *C. echinospermum* whereas *C. bijugum* was more distant [50].

Infraspecific classification

After earlier varietal classifications by Jaubert and Spach, and Alefeld, the Russian botanists working with Vavilov's collections then produced detailed formal infraspecific classifications. The systems of Prosorova, and Popova and Pavlova, inconsistent for Afghan and Turkish chickpeas, were followed in modified form by Popova's work in the *Flora of Cultivated Crops of the USSR* [92]. In India, eighty-four 'Pusa' types were distinguished by Shaw and Khan [92]. These classifications tend to attract few followers, except for Koinov who even extended Popova's work. Probably the taxa described by Popova need to be reconsidered, regarding subspecies as races, the proles as subraces, and the varieties as cultivar groups [38,92]. Infraspecific taxonomy is in need of further elucidation, if not simplification.

Eight characters were evaluated by numerical taxonomy at two locations in India for 5477 chickpea lines [67]. The analysis showed six clusters, each covering material from one or more arbitrary geographical groups. This exercise usefully pointed out, at least for the characters studied, the strong natural and human selective pressures that exist in conjunction with geographical isolation.

Moreno and Cubero [65] reduced the wild *C. reticulatum* to *C. arietinum* subsp. *reticulatum* (Lad.) Cubero & Moreno, and proposed two races, *macrosperma* and *microsperma*, in the cultivated subsp. *arietinum*.

GLYCINE MAX (PHASEOLEAE-GLYCININAE)

Specific classification

*Glycine* now comprises two subgenera, subgen. *Glycine* with seven perennial species in Australia and the Pacific, and subgen. *Soja* (Moench) F.J. Herm., with the soyabean, *G. max* (L.) Merrill, and its wild and weedy forms in East

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Asia [40,43,44,69,97]. The breeding barriers between subgenus *Soja* and subgenus *Glycine* are strong and hybrids have been obtained between *G. max* and *G. tomentella* Hayata only by the use of *in vitro* ovule culture [70,105]. The species of subgen. *Glycine*, which, like the soyabean, are self-compatible, are rarely interfertile and sterility barriers exist between isolated populations of certain species [71]. *G. wightii* (R. Grah. ex Wight & Arn.) Verdc. (*G. javanica* auctt.) is now referred to *Neonotonia* as *N. wightii* (R. Grah. ex Wight & Arn.) Lackey [52].

*G. max* differs from the wild *G. soja* Sieb. & Zucc. (*G. ussuriensis* Regel & Maack) only by features expected of a domesticate and there are few if any cytogenetic barriers to hybridisation [43]. *G. soja* seems best treated as a subspecies of the crop plant, *G. max* subsp. *soja* (Sieb. & Zucc.) Ohashi [38,51,72]. The weedy *G. gracilis* may have evolved as a consequence of outcrossing between *G. max* and *G. soja* since it is found wherever the other two overlap in their distribution [43]; if it seems sufficiently distinct to warrant a name, then subsp. × *gracilis* could be validated.

### Infraspecific classification

There are many soyabean cultivars and thirteen maturity groups are now recognised in the USA [8,39]. Adaptation ranges from very early, compact cultivars for the short summers and long days of extreme latitudes in areas such as North China, southern Canada and the northern United States (Groups 000-I), to the late and tall cultivars of the southern United States (Groups VIII-X).

### *LENS CULINARIS* (VICIEAE)

### Specific classification

*Lens* is a small and principally Mediterranean genus

comprising until recently only five species [14,50]. Barulina [2] wrote a classical monograph of the genus in 1930. A recent overview is given by Cubero [19] who also discusses the close relation to *Vicia*. *Lens culinaris* Medic., the cultivated lentil, has a primary gene pool that includes what were formerly regarded as two closely-related wild species, namely *L. orientalis* (Boiss.) Handel-Mazzetti and *L. nigricans* (M. Bieb.) Godron [19, 55]. Principal component analysis and interspecific hybridisation support the more recent arrangement of *L. orientalis* as a subspecies of *L. culinaris* [104], namely subsp. *orientalis* (Boiss.) Ponert. Hybrids between *L. culinaris* and *L. nigricans* are also normal but meiosis is more irregular. Despite differences in karyotype and pollen exine morphology, *L. nigricans* is now also considered to be a subspecies of *L. culinaris*, as subsp. *nigricans* (M. Bieb.) Thell. *L. ervoides* (Brign.) Grandé, which is native in tropical Africa as well as around the Mediterranean, does not produce viable hybrids with *L. culinaris* and retains its specific status [19]. *L. cyanea* (Boiss. & Hohen.) Alef. is considered a separate species in *Flora Iranica* [14] and as a synonym of *L. orientalis* elsewhere.

*L. montbretii* (Fisch. & Mey.) P.H. Davis & Plitm., a rare species from Turkey and Iran, has been transferred to *Vicia* recently [56].

*Lens* generally has a chromosome complement of  $2n = 14$ , although some counts of  $2n = 12$  exist [19,50].

#### Infraspecific classification

Barulina [2] classified *Lens culinaris* into two sub-species, *macrosperma* and *microsperma*, which can be considered as races. In *microsperma* six groups (greges) were distinguished, now reconcilable as subraces. The many formal varieties described within the grex are at the most cultivar groups [19].



*LUPINUS* (GENISTEAE-LUPININAE)Specific classification

*Lupinus* is a taxonomically isolated genus currently referred to a special subtribe of Genisteeae [9]. The genus comprises about 200 species in two major groups; a cluster of twelve large-seeded species around the Mediterranean south to East Africa, and the rest principally in the Andes and Rockies the length of the Americas and extending thinly into eastern South America. Gladstones has revised the Mediterranean species and clarified earlier misconceptions [31].

The main commercial species [32] belong to the Mediterranean group, viz. *L. albus* L., *L. luteus* L. and *L. angustifolius* L. The South American species *L. mutabilis* Sweet is a small-scale subsistence crop in the Andes. The Mediterranean species *L. cosentinii* Guss. is now being developed as a crop in Australia.

Like other genera in the Genisteeae, *Lupinus* has a complicated aneuploid and polyploid series, with different chromosome numbers reported for all the cultivated species [9,32]. The Mediterranean species are separated by strong genetic barriers whereas the American species tend to introgress readily in nature.

Infraspecific classification

*L. albus* has a wild variant in Greece, Turkey and the Aegean, which Gladstones [32] prefers to call var. *graecus* (Boiss. & Spruner) Gladst., though subsp. *graecus* (Boiss. & Spruner) Franco & Silva is also available [25,41]. Wild forms are detectable too in the other cultivated species but do not warrant taxonomic status. Commercial breeding dates from only about fifty years ago, and extensive cultivation began only within the last thirty years [32].

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### *PHASEOLUS LUNATUS* (PHASEOLEAE-PHASEOLINAE)

#### Specific classification

*Phaseolus* has been reduced in recent years to about fifty species in the New World [53,63,98]. The principal grain legume species, *P. coccineus* L., *P. vulgaris* L. and the Lima bean, *P. lunatus* L. belong to section *Phaseolus*. *P. lunatus* is rather distantly related to the other two species [62]. Morphological comparisons and crossing experiments [5,57] suggest that *P. ritensis* Jones, *P. polystachyus* (L.) Britt., Sterns & Pogg. and *P. pedicellatus* Benth. are closer to *P. lunatus* than *P. acutifolius* A. Gray and *P. filiformis* Benth.. *P. pachyrrhizoides* Harms from Peru is also very similar to *P. lunatus* var. *silvester* Baudet [62] and might be ancestral to at least part of the Lima bean complex.

#### Infraspecific classification

The infraspecific classification has been reviewed by Baudet, who suggests [3] the following arrangement:

Var. <i>silvester</i> Baudet	Wild forms
Var. <i>lunatus</i>	Cultivated forms, with three cultivar groups: Potato, Sieva and Big Lima

#### Geography

Lima beans are native to tropical America and may have originated separately in Central America (Mexico, Guatemala) and in South America (Peru) [3]. Var. *silvester* occurs both in Central America, principally from southern Mexico to Guatemala, and in South America in northern Argentina.

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### *PHASEOLUS VULGARIS* AND *P. COCCINEUS* (PHASEOLEAE-PHASEOLINAE)

#### Specific classification

As indicated above, the common (haricot) bean, *P. vulgaris* L., and the scarlet runner bean, *P. coccineus* L., form part of a complex relatively distant from *P. lunatus* in section *Phaseolus* [62]. In recent years a number of supposedly related species have been reduced to infraspecific variants. Apart from the Mexican *P. glabellus* Piper, which is doubtfully distinct from *P. coccineus*, this leaves the Tepary bean, *P. acutifolius* A. Gray, which forms infertile hybrids with both *P. coccineus* and *P. vulgaris*, as the apparently nearest species, and thereafter *P. filiformis* Benth., *P. angustissimus* A. Gray and *P. wrightii* A. Gray, all from southern North American and Central America. The other species of the section are more similar to *P. lunatus*.

Hybrids can be produced relatively easily between *P. vulgaris* and *P. coccineus* when the former is the female parent. Hybrids between *P. vulgaris* and *P. acutifolius* have been obtained and facilitated by embryo culture, but the F<sub>1</sub> hybrids are completely sterile [28].

#### Infraspecific classification

The interrelations between wild and cultivated forms of *Phaseolus* are still being actively explored, and the existing classifications are provisional and somewhat controversial.

Maréchal and co-workers [62] propose the following scheme:

<i>P. vulgaris</i>	var. <i>vulgaris</i>
	var. <i>aborigineus</i> (Burk.) Baudet
<i>P. coccineus</i>	subsp. <i>coccineus</i>

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- subsp. *obovallatus* (Schlecht.) Maréchal,  
Mascherpa & Stainier  
subsp. *formosus* (Kunth) Maréchal, Mascherpa & Stainier  
subsp. *polyanthus* (Greenman) Maréchal,  
Mascherpa & Stainier

Var. *aborigineus* (or subsp. *aborigineus* Burk.) is considered to be the wild (or at least the weedy) form of *P. vulgaris* in southern South America, but it is uncertain whether the Central American wild forms are distinguishable, and if so whether ancestral or one of two sources for the development of the common haricot. Recent comparisons support a separation of the mesoamerican wild form and support the supposition of two centres of origin for the cultivated forms (Vanderborcht, pers. comm.).

In *P. coccineus*, Maréchal and co-workers [62] found subsp. *obovallatus* from Mexico and Costa Rica most similar and freely interfertile with subsp. *coccineus*. They regard it as the most probable ancestral form. Subsp. *formosus*, from the same region, is similar and has also been suggested as ancestral. Subsp. *polyanthus* from the high plateaux of Central America south to Colombia, shares a number of features with *P. vulgaris*, but the conformation of hybrids suggests a closer connection with *P. coccineus*. Indeed, *P. coccineus* subsp. *darwinianus* Hernandez & Miranda is thought to be synonymous with subsp. *polyanthus*. Smartt [87] suggests that subsp. *polyanthus* and the Central American wild forms, which he refers to as *P. flavescens* Piper, may represent a distinct taxon, more readily distinguished from *P. coccineus* than *P. vulgaris*, and best ranked as a species. Further subspecies are likely to be described as taxonomic studies progress (Baudoin, pers. comm.).

*PISUM SATIVUM* (VICIEAE)Specific classification

There are now only two species recognised in *Pisum*, the cultivated pea, *P. sativum* L., and the eastern Mediterranean *P. fulvum* Sibth. & Smith [50]. Other epithets are either reduced to subspecific rank or to synonymy, even in *Lathyrus* [94]. The perennial wild *P. formosus* (Stev.) Alef. is now placed in a separate monotypic genus, as *Vavilovia formosa* (Stev.) Fed. [50].

*P. sativum* is sympatric with wild races in the eastern Mediterranean, but spontaneous hybridisation is apparently very rare despite the ability to produce partly fertile F<sub>1</sub> hybrids when crossed artificially [7].

Infraspecific classification

The authors of the *Flora Iranica* [80], *Flora of Turkey* [25] and *Flora of Iraq* [91] agree on the infraspecific taxa in *P. sativum* as follows:

Subsp. <i>sativum</i>	var. <i>arvense</i> (L.) Poir. (the Field pea)
	var. <i>sativum</i> (the Garden pea)
Subsp. <i>elatius</i> (M. Bieb.)	Aschers. & Graebn.
	var. <i>elatius</i> (M. Bieb.) Alef.
	<del>var. <i>pumilio</i> Meikle (<i>P. humile</i>)</del>
	Boiss. & Noë)
	var. <i>brevipedunculatum</i> Davis & Meikle

Ben-Ze'ev and Zohary [7] treat *P. sativum-humile-elatius* as a species aggregate of wild forms with essentially homologous chromosomes and practically interfertile. An earlier classification is that of Govorov [33]. Westphal [103] distinguishes the cultivar groups Abyssinicum and

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Sativum, the first with var. *elatius* forma *abyssinicum* (A. Br.) Gams as a synonym.

### *PSOPHOCARPUS TETRAGONOLOBUS* (PHASEOLEAE-PHASEOLINAE)

#### Specific classification

*Psophocarpus* appears to be a relatively isolated genus in Phaseoleae subtribe Phaseolinae [53,62]. The genus comprises nine species probably native only to Africa and Madagascar, though the winged bean, *P. tetragonolobus* (L.) DC., may have originated in Asia from an unknown progenitor. The genus has been revised recently by Verdcourt and Halliday [101].

*P. tetragonolobus* is related to *P. scandens* (Endl.) Verdc., a native of Africa and Madagascar, and also to the tropical African species *P. grandiflorus* Wilczek and *P. palustris* Desv. More wild material is needed for breeding experiments, but it has not been possible to cross *P. tetragonolobus* with *P. scandens* [27].

#### Infraspecific classification

The commercial production of the winged bean has been developed only recently and criteria for infraspecific classification have not yet been determined [68].

### ~~*VICIA-FABA*~~ (VICIEAE)

#### Specific classification

The taxonomic position of the faba bean, *Vicia faba* L., has met with considerable debate. Usually, *V. faba* is classified in section *Faba* (Miller) Ledeb., together with the closest morphological relatives, *V. narbonensis* L., *V. johannis* Tamamschjan, *V. galilaea* Plitm. & Zoh., and possibly *V. bithynica* L. and *V. hyaeniscyamus* Mout. [25,94].

Some authorities have ascribed the species to a genus of its own: *Faba*, with the species *F. vulgaris* Moench. [14].

*Vicia* comprises 148 species. Other sections apart from *Faba* are sect. *Vicia* (which includes many of the cultivated vetches), sect. *Ervillea* (Link) W.D.J. Koch, sect. *Cracca* Dumort, and several more [14,59]. Detailed infrageneric accounts have been given by Kupicha [48].

Information from numerical taxonomy, breeding behaviour and chemical studies (e.g. nuclear DNA quantity) have placed the faba bean very remote from the species of the *V. narbonensis* complex [84] despite the close morphological similarity [17,18,21,36,37].

The stipules, stipular nectary, gynoeceium, inflorescence, leaflet size and habit agree with the *V. narbonensis* group, but *V. faba* has distinctive fruits with spongy partitions, seeds and leaflet mucro. The uniform testa configuration of several *Vicia* species has been reported in detail [58]. *V. faba* has more reduced papillae than other *Vicia* species. Like the seed coat, the pollen data are equivocal. *V. narbonensis* and *V. johannis* are minor grain legume crops in Portugal and Turkey.

No hybrids have been obtained between *V. faba* and other species of *Vicia* despite the many attempts and the desirability of introducing new characteristics. *V. faba* has  $2n = 12$  whereas  $2n = 14$  is the most common number in *Vicia* [49].

#### Infraspecific classification

Muratova [66] classified the cultivars of *V. faba* into two subspecies, subsp. *eufaba* (now *faba*) with three varieties, var. *major* Harz (now *faba*, the broad bean, with large flattened seeds), *equina* Pers. (the horse bean, with medium-sized seeds), and *minor* Beck (the tick bean, with small rounded seeds), and subsp. *paucijuga*, with less than four leaflets per leaf. The varieties were further subdivided into subvarieties.

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Hanelt [36] proposed the following scheme:

Subsp. <i>minor</i>	var. <i>minor</i>	subvar. <i>minor</i>
		subvar. <i>tenuis</i>
Subsp. <i>faba</i>	var. <i>equina</i>	subvar. <i>equina</i>
		subvar. <i>reticulata</i>
	var. <i>faba</i>	subvar. <i>faba</i>
		subvar. <i>clausa</i>

Subsp. *paucijuga* was treated as a race of subsp. *minor*.

All the groups are freely interfertile [20,21,22] and, as suggested earlier, current practice might be expressed more simply by recognising just four cultivar groups, viz. Major, Equina, Minor and Paucijuga [20].

*VIGNA RADIATA* AND *VIGNA MUNGO* (PHASEOLEAE-PHASEOLINAE)

Specific classification

*Vigna* has now been broadened to include about 150 species, mostly in Africa, with twenty-two species in India, sixteen in South-East Asia and a few in America and Australia. The genus comprises seven subgenera and a number of sections [62, 98, 99]. The mung bean (green gram) and black gram (urd), *V. radiata* (L.) Wilczek and *V. mungo* (L.) Hepper, respectively, belong to subgen. *Ceratotropis* (Piper) Verde. and probably both were domesticated in India.

Subgen. *Ceratotropis* forms a discrete group of about seventeen species largely confined to Asia and the Pacific. Most interspecific hybrids are sterile, largely due to embryo abortion, but gene transfer is possible in most cases if the appropriate female parent is used, or by embryo culture [46]. A detailed account of the subgenus would be valuable.

Verdcourt [98] broadened the concept of *V. radiata* to include two varieties, var. *glabra* (Roxb.) Verdc. and var.



## Taxonomy

*sublobata* (Roxb.) Verdc..Var. *glabra*, an amphidiploid, has since been raised to specific rank as *V. glabrescens* Maréchal, Mascherpa & Stainier [62].

### Infraspecific classification

*V. radiata* var. *sublobata* is accepted as the wild form of the mung bean and a probable progenitor. Recent accessions and crossing experiments have led to the suggestion that other forms of this taxon might be ancestral also to the black gram, *V. mungo*. On that basis Jain and Mehra [46] conclude that var. *sublobata* should be recognised as a separate species. Lukoki, Maréchal and Otoul [60], on the other hand, find that wild material of the black gram is clearly distinguishable from var. *sublobata* at specific level on the basis of morphological, biochemical and breeding evidence, and treat it as *V. mungo* var. *silvestris* Lukoki, Maréchal & Otoul (for further discussion see Chapter 13). Maréchal and co-workers [62] also recognise *V. radiata* var. *setulosa* (Dalzell) Ohwi & Ohashi as a further eastern variant, which overlaps to some extent the distribution and morphological features of var. *sublobata*.

Older classifications in the Indian subcontinent distinguished var. *typica* Prain, var. *aurea* Prain, var. *grandis* Prain and var. *bruneus* Bose in the mung bean [10], while in the black gram the subvarieties *viridis* Bose and *niger* Bose were proposed [11], mainly on seed characters. In line with other Indian pulses, mung and black gram were further subdivided into forty and twenty-five 'types', respectively, based on seed and pod wall characteristics, plant habit and maturity.

*VIGNA UNGUICULATA* (PHASEOLEAE-PHASEOLINAE)

Specific classification

The cowpea, *Vigna unguiculata* (L.) Walp., belongs to *Vigna* subgen. *Catjang* (DC.) Verdc. [98]. The species has been broadened to include the catjang and yard-long bean, first as subspecies [98] and then as cultivar groups [62]. Verdcourt [98] provisionally accepted several other species in the section, but subsequently [62] most of these have been reduced to variants of *V. unguiculata*, apart from *V. nervosa* Markotter from southern Africa and the poorly known *V. brachycalyx* Bak. from Madagascar.

Attempts to cross the cowpea with other species of *Vigna* have so far failed [89], and *V. nervosa* may be the only species likely to hybridise successfully.

Infraspecific variation

The following classification has been proposed by Maréchal and co-workers [62]:

- |                                   |  |  |
|-----------------------------------|--|--|
| Subsp. <i>unguiculata</i>         | cultivar groups                        | Unguiculata                                |
|                                   |  | Biflora                                    |
|                                   |  | Sesquipedalis                              |
| Subsp. <i>dekindtiana</i> (Harms) | Verdc. var. <i>dekindtiana</i> (Harms) | Verdc.                                     |
|                                   | var. <i>mensensis</i>                  | (Schweinf.) Maréchal, Mascherpa & Stainier |
|                                   | var. <i>pubescens</i> (Wilczek)        | Maréchal, Mascherpa & Stainier             |
|                                   | var. <i>prostrata</i> (E. Mey.)        | Verdc.                                     |
| Subsp. <i>tenuis</i> (E. Mey.)    | Maréchal, Mascherpa & Stainier         |  |

## Taxonomy

Subsp. *stenophylla* (Harv.) Maréchal, Mascherpa  
& Stainier

As indicated earlier, *Biflora* is an inappropriate name for the Catjang as a cultivar group. Steele and Mehra [89] have no difficulty in accepting Catjang as a cultivar group of the cowpea, but feel there may be a case for maintaining subsp. *sesquipedalis* (L.) Verdc. for the yard-long bean because it is distinct in morphology, origin, use and distribution.

It has been suggested [89] that the cowpea was domesticated in Africa in Neolithic times from the wild/weed complex of subspp. *mensensis* and *dekindtiana*. Cultivar group Catjang and, less certainly, cultivar group *Sesquipedalis* were probably developed from cultivar group *Unguiculata* in India [29,79,89].

The diversity of cultivated forms is reflected in the IITA (see Chapter 18) *Cowpea Germplasm Catalogue* [76], including various agronomic and botanical characters.

## VERNACULAR NAMES

There are numerous common (vernacular, trivial) names of crop plants. Widely distributed plants have names in many languages, and even several in any one language. Grain legumes are no exception [47] and any further scanning of the literature will add more. For instance, the pigeonpea has about 335 common names [86] although some are mere orthographic variants. The difference of spelling between British and American English needs no explanation, but it tends to cause some confusion. The English 'soyabean' versus the American 'soybean' is one example, and there are many more.

Caution should be exercised in the use of vernacular names; indeed, the worldwide acceptance of Latin names stems from the confusion that would otherwise result. Nonetheless, conventions may be changed by mutual

agreement to solve part of the problem. Perhaps a list of preferred common names could be devised by an appropriate international body? Suggestions for such a list are given in Table 1.3; the choice is somewhat arbitrary but with the aim of avoiding confusion.

A few examples will illustrate some of the problems. Even the words 'pea' and 'bean' are equivocal, despite the common knowledge of the shapes of peas and beans. Chickpeas are called garbanzo beans in America, which is quite a misnomer apart from garbanzo, the Spanish vernacular. Cowpeas are often bean-shaped. *Vicia faba* has as English vernaculars (among others) field bean and broad bean (*V. faba* var. *faba*) and is internationally confused. By recent agreement (see Chapter 18) the crop is now called faba bean. The Portuguese name 'Frijoles de Costa' (beans of the coast) does not apply to beans, but to cowpeas (in Brazil). Some vernaculars of the cowpea are also used for *Phaseolus vulgaris* (common bean), *P. lunatus* (Lima bean), *Lathyrus sativus* (grass pea), *Vigna unguiculata* cultivar group *Sesquipedalis* (asparagus bean) and *Vigna subterranea* (Bambara groundnut). Many more of these examples are given elsewhere [47]. In India, chickpeas are called gram or Bengal gram, names more frequently used in the past than the name chickpea, which has become favoured only as a result of international usage.

Most scientific journals rightly insist on the mention of Latin names, and if regional or local vernaculars are included, the use of the commonest vernacular should also become mandatory in addition to the Latin.

#### SHORT GLOSSARY

- genotype: (a) The genetic make-up of an organism (all dominant and recessive genes).  
 (b) A group of organisms with the same genetic make-up.
- accession: Sample in a gene bank; its number is unique

Table 1.3  
A suggested list of preferred vernacular names for grain legumes

Latin	English	French	Spanish	German
<i>Arachis hypogaea</i>	groundnut	arachide	mani	gemeine erdnuss
<i>Cajanus cajan</i>	pigeonpea	pois d'Angole	guisante de paloma	kichererbse
<i>Cicer arietinum</i>	chickpea	pois chiche	garbanzo	hornkraut
<i>Glycine max</i>	soyabean	soja	soja	sojabohne
<i>Lens culinaris</i>	lentil	lentille	lenteja	linse
<i>Lupinus spp.</i>	lupins	lupines	lupino	lupines
<i>Phaseolus lunatus</i>	Lima bean	haricot de Lima	haba Lima	Limabohne
<i>Phaseolus vulgaris</i>	common bean	haricot commun	frijol	fisole
<i>Pisum sativum</i>	pea	pois	guisante	erbse
<i>Psophocarpus tetragonolobus</i>	winged bean	pois allé	sesquidilla	goabohne
<i>Vicia faba</i>	faba bean	fève	haba comun	ackerbohne
<i>Vigna mungo</i>	black gram	ambérique	judia de urd	urdbohne
<i>Vigna radiata</i>	mung bean	haricot doré	judia de mungo	mungobohne
<i>Vigna unguiculata</i>	cowpea	pois vache	chicaro de vaca	kuhbohne

and not re-used in cases where the sample is lost.

- landrace: A traditional cultivar not subject to scientific selection; often a population or a mixture of closely related genotypes.
- variety: Botanical variety; taxonomic level below the rank of subspecies, above the level of cultivar (see previous comments on infraspecific variants).
- cultivar: Cultivated variety; an assemblage of cultivated plants clearly recognisable from other cultivars of the same species by structural features and performance. Either a clone, a self- or open-pollinated cultivar, a synthetic or a hybrid.

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