



## **10º CONGRESSO NACIONAL DE PESQUISA DE FEIJÃO**

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### **ANAIIS**

#### **10º CONGRESSO NACIONAL DE PESQUISA DE FEIJÃO**

**Inovações para a competitividade da  
cadeia produtiva do feijão**

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### **APRESENTAÇÃO**

A necessidade de se incorporar inovações às atividades produtivas é determinante para que se amplie a capacidade de inovação, inserindo os avanços do conhecimento em novas tecnologias, novos produtos e novos serviços. Como o feijão comum é um produto de fundamental importância na alimentação básica e diária dos brasileiros e para a agricultura brasileira, a comissão organizadora do 10º CONAFE considerou essencial e estratégico abordar aspectos relevantes das pesquisas com feijão no Brasil e no exterior, considerar a interdisciplinaridade original do sistema de produção, para conceber uma programação com foco em inovações para a competitividade da cadeia produtiva do feijão comum.

O objetivo principal do 10º CONAFE é proporcionar oportunidades para promover a integração e articulação entre pesquisadores, professores, extensionistas, consultores e acadêmicos, visando incentivar a disseminação de conhecimento e tecnologia.

Nova visão do feijão como alimento, oportunidades para exportação, tolerância à deficiência hídrica, eficiência da adubação nitrogenada, fixação biológica do nitrogênio, produção integrada, organização de recursos genéticos, genômica, feijão transgênico e mofo branco são os temas em destaque nas mesas-redondas programadas especialmente para os debates com especialistas.

As palestras vão abordar inovações na pesquisa agrícola, controle biológico de doenças do feijoeiro, nematóides e estudos de raízes, enquanto o painel está direcionado para apresentar a Câmara Setorial da Cadeia Produtiva do Feijão com sua agenda estratégica e a pesquisa e transferência de tecnologia pelas Redes de Referência.

A adesão ao 10º CONAFE está refletida na apresentação de 395 resumos expandidos, em 10 áreas temáticas, todos submetidos a revisão por comitê científico, sendo 9 resumos na área de Biotecnologia, 23 em Ciência de Alimentos, 14 em Entomologia, 37 em Fitopatologia, 120 em Genética e Melhoramento, 30 em Sementes e Armazenamento, 67 em Manejo da Cultura, 14 em Socioeconomia, 73 em Solos e Nutrição de Plantas e 8 em outras áreas mais específicas.

Agradecemos a participação de todos os congressistas nesse tradicional encontro científico brasileiro realizado na nossa bela cidade de Goiânia, GO.

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## Structure of bean genetic resources: its importance and applications.

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Bean genetic resources could be defined as the entire diversity made available to the farmers, public in general, agronomists and breeders in order to provide abundant, cheap and quality food to people, now and in the future. The definition has a bias, because it clearly presumes a use perspective, a bit expected since bean is the daily food of millions of people around the world (FAO 2011). And the nutritional value of beans, being progressively disclosed (Broughton et al. 2003; Bennink 2010; Thompson 2010), is one of the reasons behind that worldwide adoption. The definition also implies a time perspective, because that use for food has extended over the last eight millennia (Piperno & Dillehay 2008), and has gained further importance since the Great Food Exchange of the early 1500s, namely towards Europe and eastern Africa (McNeill 1991; Diamond 1997). Towards the future, in order to keep up as an important food resource, the bean crop has three challenges: higher yield, increased productivity at lower environmental impact, and capacity to respond to a diversity of consumer needs. High yield is important for farmers to make a living out of the bean crop, but also to provide urban populations with a protein-rich food item at affordable prices (Broughton et al. 2003). And yield in beans – as in pulses in general – has stayed behind as compared to the major cereals (Vandenberg & Nleya 1999). For lower environmental impact, the bean plant should be fully independent from artificial nitrogen sources (Ribet et al. 1997) (worse if based on fossil energy). Offering more food items than dry bean is a possibility yet poorly explored in the tropics, namely with green shelled beans, snap beans and popping beans (Singh 1999; Voysest 2000).

How to meet successfully these three challenges? An expected answer is: through breeding; a recent review (Singh et al. 2007) showing the gain of 35% in yield sustained over 54 years for common bean in the western USA seems to validate this approach. But the bottomline for this continuing genetic gain is access to a wider genetic diversity for both resistance to diseases and yield. Because of the market classes and the breeding methods used, genetic uniformity may happen in beans (Adams 1977), and will limit further progress or open the way to crop failure. Worth noting is the reduction of genetic uniformity when breeders use very diverse sources of germplasm for disease resistances or when they use interracial crosses for yield improvement (Voysest et al. 1994; Rosales-Serna et al. 2005). On the other hand, one should note the limited advance resulting from transgenesis in beans: transformation still remains difficult (Jacobsen 1999; Broughton et al. 2003), and traits for introgression are few (e.g. herbicide resistance: Aragão et al. 2002). After all, a prerequisite for making any progress is in organizing bean genetic resources, i.e. what is available?, is it diverse enough?, how does it relate with what I breed? The concept of organizing bean genetic resources has thus three implications. The first aspect is the knowledge about nature and extent of diversity offered by these plant resources, and incites us to raise questions such as how many bean species are there and which are they, and how these species relate to each other. We might examine also the mechanisms by which genetic diversity has been created in the wild and under cultivation, and their relative time scales. The third aspect deals with the practical use we make from these research advances for the conservation and use of these resources in agronomy, breeding and human nutrition.

### **Nature and extent of bean diversity**

In botanical terms the genus *Phaseolus* although created by Linnaeus in 1753 has been narrowly defined only two centuries later (Maréchal et al. 1978; Lackey 1983). This definition has proven robust however, and aptly applies to a group of legume species, naturally distributed in the New World, with most species present in Mexico and Central America (Delgado-Salinas 2000; Freytag & Debouck 2002). The exact number of species is still unknown, as new species continue to be discovered and described (e.g. Salcedo-Castaño et al. 2011), but likely to be of 75-85 (Table 1). The genus is monophyletic and has two clades, with approximately the same number of species (Delgado-Salinas et al. 2006) (Table 2). The five cultivated species fall all in the

same clade, and there are good morphological, ecological and genetical reasons for the recognition of fourteen sections with variable numbers of species, distributed almost equally between the two clades (Freytag & Debouck 2002; Delgado-Salinas et al. 2006). The genus might be 8-10 million years old (Lavin et al. 2005; Serrano-Serrano et al. 2010) or younger (3.4-5.8: Delgado-Salinas et al. 2006), and the clades might have separated from each other about 5 million years ago (Delgado-Salinas et al. 2006). Because of that early separation, clade A might be of no use in bean breeding or at least in a context of gene introgression with current technologies. The timing of separation of the *Phaseoli* from the *Paniculati* could go back as far as 4 million years ago (Delgado-Salinas et al. 2006), explaining why the introgression of genes from Lima bean into *P. vulgaris* has been unsuccessful (reviewed by Debouck 1999). Geographic isolation might have been another factor for preventing gene exchange between the *Phaseoli* with speciation in Central America (Debouck 2000; Chacón-Sánchez et al. 2007), and the *Paniculati* with one step of speciation in the northern Andes (Fofana et al. 1999; Serrano-Serrano et al. 2010). The age of these species has been estimated as of 1 million years (Delgado-Salinas et al. 2006; Chacón-Sánchez et al. 2007; Serrano-Serrano et al. 2010), but this may require additional studies.

Most species are herbaceous lianas sprouting from pluriannual roots (often tuberous), and thus live for 4-8 years, with annual flowering and pod setting (polycarpism); sometimes during the first year there will be only vegetative growth. A few species (e.g. *carteri*, *microcarpus*) are annual (or even completing their cycle from seed to seed in two months) and monocarpic (Freytag & Debouck 2002). Geographically the genus is distributed in the American tropics and subtropics, with extension into North America (below a line roughly extending from the extreme south of California to New York in USA) and in South America up to the Southern Cone (above a line extending from San Lu  s to Corrientes in Argentina). It is not known in the wild in Chile, nor from the Guyanas, and its presence is uncertain in Canada (no: Lackey 1983; yes: Delgado-Salinas et al. 2006). North of the equator, the genus is present from the Revillagigedo islands (i.e. *lunatus*) up to Bermuda (i.e. *lignosus*) (Debouck 2011). Close to the equator, it extends from sea level (eg. *mollis* in the Galapagos archipelago) to 3,000 m (Debouck 2011). There is a clear cline in density of species, with major concentration today in west-central Mexico (Nabhan 1990; Ram  rez-Villegas et al. 2010), less north- and northeastwards into North America, and less southeastwards, as we are passing successively through the geological barriers of Isthmus of Tehuantepec, Lake Nicaragua, and Isthmus of Panama (Table 1). The Caribbean islands might be an area of recent colonization by the genus with only one wild species (i.e. *lunatus*) and one weedy form (i.e. *dumosus*) (Freytag & Debouck 2002), but this needs additional studies (see Liogier 1988). Some 14 species can now be considered of a widespread distribution (e.g. *augusti*, *leptostachyus*, *vulgaris*), another 20 with an intermediate range (e.g. *esperanzae*, *pedicellatus*, *sinuatus*), and most species (43) have a restricted or endemic range of distribution (e.g. *amblyosepalus*, *macrolepis*, *smilacifolius*) (Debouck 2000; Freytag & Debouck 2002). Surely many populations have gone extinct because of human activities, and at an accelerating pace since 1493 with the introduction of domestic mammals (Bennett & Hoffman 1991); two species (i.e. *leptopyllus*, *persistentus*) have not been found again after first finding (Delgado-Salinas et al. 1999, 2006). The ranges of distribution are therefore estimates, but from the today distribution some inferences about ecological behavior and traits of possible interest selected therein, can be made.

All species thrive in habitats where the rainy season coincides with the season of warmer temperatures making growth possible, followed by a dry season of at least two months, that allows pod dehiscence and seed dispersal. This explains the absence of *Phaseolus* from Mediterranean-like climates in the New World (California, central Chile), deserts (Atacama), Andean *paramos*, and from the rain forests (Amazonia, Ch  co). Interestingly, the sole spot with a Sonoran desert vegetation in southern California offers a home for the single population of *Phaseolus* (i.e. *filiformis*) in California (Isely 1993). Many species are short-day flowering, and a few (i.e. *polystachyus*) might be neutral or requiring long days first. The length of period between short days and first killing frosts limits the expansion of the genus towards higher latitudes (sometimes in combination with altitude). This explains the expansion of the genus up to New York (i.e. *polystachyus*), and only up to the northern border of Arizona (i.e. *angustissimus*) in the Rocky Mountains. Although some species can withstand subzero chilling temperatures for a few days (e.g. *angustissimus*:

Balasubramanian et al. 2004), most species do not; conversely, some species can withstand temperatures above 40° C for a few hours (e.g. *filiformis*), most species do not. Several species (in the sections *Acutifolii*, *Coriacei*, and *Rugosi*) display different mechanisms of drought tolerance; none would be tolerant to waterlogging (but check *pauciflorus*). While a few species may grow in areas less than 150 mm of rain/ year (i.e. *filiformis* on islands in Sea of Cortés), others (i.e. *dumosus*, *tuerckheimii*) may grow in areas with close to 3,000 mm of rain/ year, provided that there is a dry season and well drained soils. Because they thrive in coastal areas or even close to the beaches, some species might be salinity tolerant (e.g. *filiformis*, *lunatus*, *macvaughii*; Bayuelo-Jiménez et al. 2002), most species however are strictly glycophytes. Most species thrive in seasonal altitude forests or pine/ oak grasslands, less in moist forests (e.g. *hygrophilus*, *lunatus*, *viridis*), desert scrub (e.g. *angustissimus*), or tropical deciduous forests (e.g. *lunatus*, *microcarpus*) (Debouck 2000). Several of these habitats are not *per se* N or P deficient, nor excessively acidic, letting to conclude that positive reactions should be looked for at the population level.

### **Interferences by humans: multiple domestications**

Contrary to a common belief, there are seven bean crops, as two independent domestication events in Mesoamerica and in the Central Andes affected initially two bean species (i.e. *lunatus*, *vulgaris*), while the other three (i.e. *acutifolius*, *coccineus*, *dumosus*) were domesticated once (Debouck & Smartt 1995). One should note that three species (i.e. *coccineus*, *dumosus*, *vulgaris*) belong to the same section, each species serving as secondary genepool to the others (Table 2) (Debouck 1999). The secondary genepool of Lima bean is the largest (Table 2), and there are still possibilities of wide crossing with the *Coriacei* (Katanga & Baudoin 1990). The primary genepool for each of the five bean crops is made of the hundreds (perhaps only two dozens for *dumosus*) of populations of its respective wild form, all of them still (or up to year 1900) growing in the Neotropics. Because wild *lunatus* and *vulgaris* had time to expand in both Central and South America through contrasting floristic migrations (Serrano-Serrano et al. 2010; Chacón-Sánchez et al. 2007, respectively), they have accumulated a substantial genetic diversity, and have even initiated some genetic divergence (Gepts & Bliss 1985; Becerra-Velásquez & Gepts 1994). The diversity has been shown to be organized geographically, often by geological units (*lunatus*: Serrano-Serrano et al. 2010; *vulgaris*: Tohme et al. 1996, Chacón-Sánchez et al. 2007).

Because domestication was undertaken by different peoples at different times, and given the presence of antinutritional factors in wild beans, just a few populations of the wild forms contributed to the genetic stock of the early domesticates. The resulting reduction of genetic diversity as compared to the entire wild genepool, called ‘founder effect’ has been shown in six of the seven bean crops (tepary: Schinkel & Gepts 1988; Lima bean: Motta-Aldana et al. 2010; common bean: Becerra-Velásquez & Gepts 1994; Chacón-Sánchez et al. 2005; year-bean: Schmit & Debouck 1991). It is possible that the original reduced genetic diversity has been widened by crossing with local populations of the respective wild form and/ or between landraces, through pollen mediated gene flow (Beebe et al. 1997; Andersson & de Vicente 2010). As a consequence, and unexpectedly in reportedly autogamous crops, races have been defined in common bean (Singh et al. 1991; Beebe et al. 2000; Díaz & Blair 2006), or cultigroups in Lima bean (Westphal 1974). But isolation might not have been long enough for the races to gain full differentiation. The duration of cultivation of the seven bean crops might be variable among them, but the scanty information at hand might indicate earlier dates in the Andes as compared to Mesoamerica. *P. vulgaris* and *P. lunatus* could have been domesticated 8,000 years ago in Peru (on the Coast, where no wild forms exist!) (Piperno & Dillehay 2008), while current dates for Mesoamerica indicate half that duration (Kaplan & Lynch 1999). The pre-ceramic context in Peru possibly for two thousands years suggests other uses than water cooking such as popping beans (Tohme et al. 1995). One should remember that the cultivated species have had 99% of their lifetime as wild forms (0.2-0.8% as cultivated) in the Neotropics, and the short duration of existence outside the Americas may have been conducive to only some mutations like snap beans (Myers & Baggett 1999). In this regard, pathogens of common bean continue to be linked to their original genepools with no much recombination because of the limited time of evolution (Mahuku et al. 2002), in contrast to what happened in the wild in the Americas (Guzmán et al. 1995; Sicard et al. 1997; Aguilar et al. 2004).

### Potential applications

Bean genetic resources are structured biologically, geographically, and hence genetically. As wild plants, beans did nothing else than try to expand, colonize new habitats, be exposed to natural selection, accumulate changes, and experiment speciation. The initial separation of two clades might be reflected again in the fate of the tropical wild Lima bean (Serrano-Serrano et al. 2010), when two groups of populations became disjunct. And the high number of endemic species in the genus might only result from extinctions of populations just as they have happened in the widely distributed taxa (Chacón-Sánchez et al. 2007; Serrano-Serrano et al. 2010), rather than spontaneous mutations given their age. The endemic species might be particularly rich in adaptations to local environments, and thus offer a genetic basis against abiotic stresses.

The limited possibilities under currently available technologies to introgress genes from the *Rugosi* or the *Paniculati* into the *Phaseoli* (reviewed by Debouck 1999) would indicate the lack of applications from clade A in favor of clade B. Parallel genome mapping between the two clades may reveal genes expressed in clade A but silenced in clade B and *vice versa*, and eventually the reasons for such activation or silencing. More immediately, one should take advantage of the five bean crops and their respective genepools (Table 2). For instance, one could exploit the lead of tepary bean or tropical Lima bean in relation to drought or heat stresses! In relation to an increasingly important market – the canning industry, it might be faster in terms of breeding progress to correct possible defects in seed qualities of these two bean crops rather than embarking on poor yielding introgressions (see Muñoz et al. 2004).

On the other hand, these genepools may contain the heterosis and building blocks for the commercial production of hybrid beans – a definitive way of meeting the hard challenge of yield. For common bean, sources of cytoplasmic male sterility and fertility restorers have been found in *vulgaris* and *coccineus*, respectively (Bannerot 1989), and later in *dumosus*. More immediately, some heterosis has been exploited within the species interracial crosses (Beaver & Kelly 1994; Singh & Urrea 1995). And the selection of parental materials can be accelerated with help of molecular markers (Singh et al. 1991). Another approach for increasing yield has been the inbred backcross with wild forms (Acosta-Gallegos et al. 2007), as done previously on tomato (Tanksley et al. 1996). In the long run, yield will be increased by improving its individual components such as photosynthesis where potential exists in wild common bean (Lynch et al. 1992).

At the species level, particularly for the widespread species (as the well studied *vulgaris*, and better as wild for longer durations), the genetic structure revealed in the plant populations (i.e. Khairallah et al. 1992, Tohme et al. 1996, Chacón-Sánchez et al. 2007) seems also present in the associated pathogens (angular leaf spot: Guzmán et al. 1995; anthracnose: Sicard et al. 1997), and symbionts (*Rhizobium etli*: Aguilar et al. 2004). If molecular markers can be associated with these traits – and it seems to be the case in both the bean genotypes and the microorganisms, the selection of appropriate materials as parents for breeding or for inoculation could be greatly accelerated (Miklas et al. 2006). Once yield has been dearly improved, there would be less gain in not planting the bean crop in the right pathological context! On the other hand, because of the founder effect referred to above, if wild forms have been exposed to local strains of diseases and pests, and have developed some resistance against them, statistically such resistances will be found first in the wild genepool (e.g. angular leaf spot: Mahuku et al. 2003; bruchids: Acosta-Gallegos et al. 1998).

The above is just an example of benefits from a better understanding of the structure of bean genetic resources. Interestingly, in times of change in bean breeding, Miklas et al. (2006 p. 123) rank second in seven research priorities “identify, share, and preserve sources of resistance to the important stresses”. This is where lies the reserve of all options, as well as all possibilities of lasting impact.

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Table 1 – Tentative list of possibly valid *Phaseolus* species and general indication about geographic distribution and qualification of their range R (E= endemic, I= intermediate, W= widespread).

Bean species (only as wild plants, and year)	Area of geographic distribution	R
1. <i>acutifolius</i> Asa Gray (1850)	SW USA, NW Mexico down to Neo-volcanic axis	I
2. <i>albescens</i> McVaugh ex Ramírez & Delgado (1999)	W of Neo-volcanic axis of Mexico	E
3. <i>albiflorus</i> Freytag & Debouck (2002)	N of Sierra Madre Oriental in Mexico	E
4. <i>albinervus</i> Freytag & Debouck (2002)	Chihuahua of Mexico	E
5. <i>albiviola</i> Freytag & Debouck (2002)	Sierra Madre Oriental in Mexico	E
6. <i>altimontanus</i> Freytag & Debouck (2002)	Sierra Madre Oriental in Mexico	E
7. <i>amabilis</i> Standley (1940)	Sierra Madre Occidental in Mexico	E
8. <i>amblyosepalus</i> (Piper) Morton (1944)	Durango and Sinaloa border in Mexico	E
9. <i>angustissimus</i> Asa Gray (1853)	SW USA and NW Mexico	W
10. <i>anisophyllus</i> (Piper) Freytag & Debouck (2002)	Durango of Mexico	E
11. <i>augusti</i> Harms (1921)	Andes, from S Ecuador to NW Argentina	W
12. <i>campanulatus</i> Freytag & Debouck (2002)	W end of Neo-volcanic axis of Mexico	E
13. <i>carteri</i> Freytag & Debouck (2002)	S end of Baja California of Mexico	E
14. <i>chiapasanus</i> Piper (1921)	Parts of Veracruz, Oaxaca and Chiapas in Mexico	I
15. <i>coccineus</i> L. (1753)	From Chihuahua, Mex., down to Jalapa, Guatemala	W
16. <i>costaricensis</i> Freytag & Debouck (1996)	Central and E Costa Rica to W Panama	I
17. <i>dasycarpus</i> Freytag & Debouck (2002)	S end of Sierra Madre Oriental	E
18. <i>dumosus</i> Macfadyen (1837)	Volcanic mountains of SW Guatemala	E
19. <i>esperanzae</i> Seaton (1893)	Central and E of Neovolcanic axis of Mexico	I
20. <i>esquincensis</i> Freytag (2002)	Central Chiapas of Mexico	E
21. <i>filiformis</i> Benthams (1844)	Gulf of California to NW Mexico to Texas	W
22. <i>glabellus</i> Piper (1926)	Gulf of Mexico, Tamaulipas to Chiapas	W
23. <i>gladiolatus</i> Freytag & Debouck (2002)	San Luís Potosí and Hidalgo of Mexico	E
24. <i>grayanus</i> Wootton & Standley (1913)	NW to N Mexico to Arizona through Texas	W
25. <i>hintonii</i> Delgado (2000)	Central W Mexico	E
26. <i>hygrophilus</i> Debouck (2011)	Central S Costa Rica	E
27. <i>jaliscanus</i> Piper (1926)	S Sierra Madre Occidental of Mexico	I
28. <i>juquilensis</i> Delgado-Salinas (2000)	Central S Oaxaca of Mexico	E
29. <i>laxiflorus</i> Piper (1926)	E of Neovolcanic axis of Mexico	E
30. <i>leptophyllus</i> G. Don (1832)	Central Guerrero of Mexico	E
31. <i>leptostachyus</i> Benthams (1837)	Arizona through Mexico to Central Costa Rica	W
32. <i>lignosus</i> Britton (1918)	Bermuda	E
33. <i>lunatus</i> L. (1753)	Central and South America, Caribbean	W
34. <i>macrolepis</i> Piper (1926)	Central and SW Guatemala	E
35. <i>maculatifolius</i> Freytag & Debouck (2002)	N of Sierra Madre Oriental in Mexico	E
36. <i>maculatus</i> Scheele (1848)	Arizona through Texas to Puebla of Mexico	W
37. <i>macvaughii</i> Delgado-Salinas (2000)	Coastal W Mexico from Sinaloa down to Guerrero	I
38. <i>magnilobatus</i> Freytag & Debouck (2002)	Central W Mexico	E
39. <i>marechalii</i> Delgado-Salinas (2000)	Central and E of Neovolcanic axis of Mexico	E
40. <i>micranthus</i> Hooker & Arnott (1838)	W of Neovolcanic axis of Mexico	I
41. <i>microcarpus</i> Mart. (1831)	Central Mexico, from Durango down to Nicaragua	W
42. <i>mollis</i> Hooker (1847)	Archipelago of Galapagos Islands	E
43. <i>montanus</i> Brandegees (1893)	Arizona down to E Guatemala through W Mexico	I
44. <i>neglectus</i> Hermann (1948)	N of Sierra Madre Oriental	E
45. <i>nelsonii</i> Maréchal, Mascherpa & Stainier (1978)	Central and southern Mexico to Chiapas	I
46. <i>nodosus</i> Freytag & Debouck (2002)	W of Neovolcanic axis of Mexico	E

47. <i>novoleonensis</i> Debouck (2006)	N of Sierra Madre Oriental	E
48. <i>oaxacanus</i> Rose (1903)	Central Oaxaca of Mexico	E
49. <i>oligospermus</i> Piper (1926)	Chiapas of Mexico to central Costa Rica	I
50. <i>pachyrrhizoides</i> Harms (1921)	Andes of northern and central Peru	I
51. <i>parvulus</i> Greene (1881)	SW of USA and Sierra Madre Occidental of Mexico	I
52. <i>pauciflorus</i> Sessé & Mociño ex G. Don (1832)	Northern and central Mexico	I
53. <i>pedicellatus</i> Benthams (1837)	Neovolcanic axis, Sierra Madre Oriental of Mexico	I
54. <i>persistentus</i> Freytag & Debouck (2002)	Central volcanoes of Guatemala	E
55. <i>plagiocylix</i> Harms (1921)	Eastern central Nuevo León of Mexico	E
56. <i>pluriflorus</i> Maréchal, Mascherpa & Stainier (1978)	Western central Mexico	I
57. <i>polymorphus</i> Sereno Watson (1882)	Northern and eastern central Mexico	I
58. <i>polystachyus</i> (L.) Britton, Stern & Poggenberg (1888)	Eastern USA from New York to Florida to E Texas	W
59. <i>purpusii</i> Brandege (1912)	Western San Luis Potosí of Mexico	E
60. <i>reticulatus</i> Freytag & Debouck (2002)	SW of Durango in Mexico	E
61. <i>ritensis</i> Jones (1908)	SW of USA and NW of Mexico	W
62. <i>rotundatus</i> Freytag & Debouck (2002)	Central Jalisco of Mexico	E
63. <i>salicifolius</i> Piper (1926)	Eastern Sinaloa of Mexico	E
64. <i>scrobiculatifolius</i> Freytag (2002)	Western central Veracruz of Mexico	E
65. <i>sinuatus</i> Nuttall (1838)	SE of USA from North Carolina to Florida	I
66. <i>smilacifolius</i> Pollard (1896)	Central Florida of USA	E
67. <i>sonorensis</i> Standley (1940)	SE Sonora and SW Chihuahua of Mexico	E
68. <i>talamancensis</i> Debouck & Torres (2001)	SE of Costa Rica	E
69. <i>tenellus</i> Piper (1926)	Central Neovolcanic axis of Mexico	E
70. <i>texensis</i> Delgado & Carr (2007)	Central Texas of USA	E
71. <i>tuerckheimii</i> Donnell-Smith (1913)	Chiapas of Mexico to western Panamá	I
72. <i>venosus</i> Piper (1926)	E Jalisco, Aguascalientes, SW Zacatecas of Mexico	E
73. <i>viridis</i> Piper (1926)	Veracruz of Mexico to Alta Verapaz of Guatemala	I
74. <i>vulgaris</i> L. (1753)	SW Chihuahua Mexico to NW San Luis Argentina	W
75. <i>xanthotrichus</i> Piper (1926)	Chiapas of Mexico to central Costa Rica	W
76. <i>xolocotzii</i> Delgado-Salinas (2000)	E Sierra Madre del Sur of Mexico	E
77. <i>zimapanensis</i> Delgado-Salinas (2000)	SW Sierra Madre Oriental of Mexico	I



Table 2 – Species and sections as currently recognized (partly based on Delgado-Salinas et al. 2006; Freytag &amp; Debouck 2002).

Sections	Species	total
Clade A (8)	38 (4 widespread; 11 intermediate; 23 endemic)	
Not assigned	<i>glabellus, microcarpus</i>	2
<i>Bracteati</i> Freytag	<i>macrolepis, talamancensis</i>	2
<i>Brevilegumeni</i> Freytag	<i>campanulatus, hygrophilus, oligospermus, tuerckheimii</i>	4
<i>Chiapasana</i> (Piper) Delgado	<i>chiapasanus</i>	1
<i>Digitati</i> Freytag	<i>albiflorus, albiviolaecus, altimontanus, neglectus</i>	4
<i>Minkellersia</i> (Mart. & Gal.) Maréchal, Mascherpa, Stainier	<i>amabilis, amblyosepalus, anisophyllus, nelsonii, parvulus, pauciflorus, plagiocylix, pluriflorus, tenellus</i>	9
<i>Pedicellati</i> (Benth.) Freytag	<i>dasycarpus, esperanzae, grayanus, laxiflorus, oaxacanus, pedicellatus, polymorphus, purpusii, texensis</i>	9
<i>Revoluti</i> Freytag	<i>leptophyllus</i>	1
<i>Xanthotricha</i> Delgado	<i>esquincensis, gladiolatus, hintonii, magnilobatus, xanthotrichus, zimapanensis</i>	6
Clade B (6)	39 (10 widespread; 9 intermediate; 20 endemic)	
<i>Acutifolii</i> Freytag	<i>acutifolius, montanus</i>	2
<i>Coriacei</i> Freytag	<i>maculatus, novoleonensis, reticulatus, ritensis, venosus</i>	5
<i>Falcati</i> Freytag	<i>leptostachyus, macvaughii, micranthus</i>	3
<i>Paniculati</i> Freytag	<i>albinervus, augusti, jaliscanus, juquilensis, lignosus, lunatus, maculatifolius, marechalii, mollis, nodosus, pachyrrhizoides, polystachyus, rotundatus, salicifolius, scrobiculatifolius, sinuatus, smilacifolius, sonorensis, viridis, xolocotzii</i>	20
<i>Phaseoli</i> DC	<i>albescens, coccineus, costaricensis, dumosus, persistentus, vulgaris</i>	6
<i>Rugosi</i> Freytag	<i>angustissimus, carteri, filiformis</i>	3
Total (no. sections): 14		
Total (no. species):		77