10th conafe
National Dry Bean Research Congress

# Structure of bean genetic resources : its importance and applications

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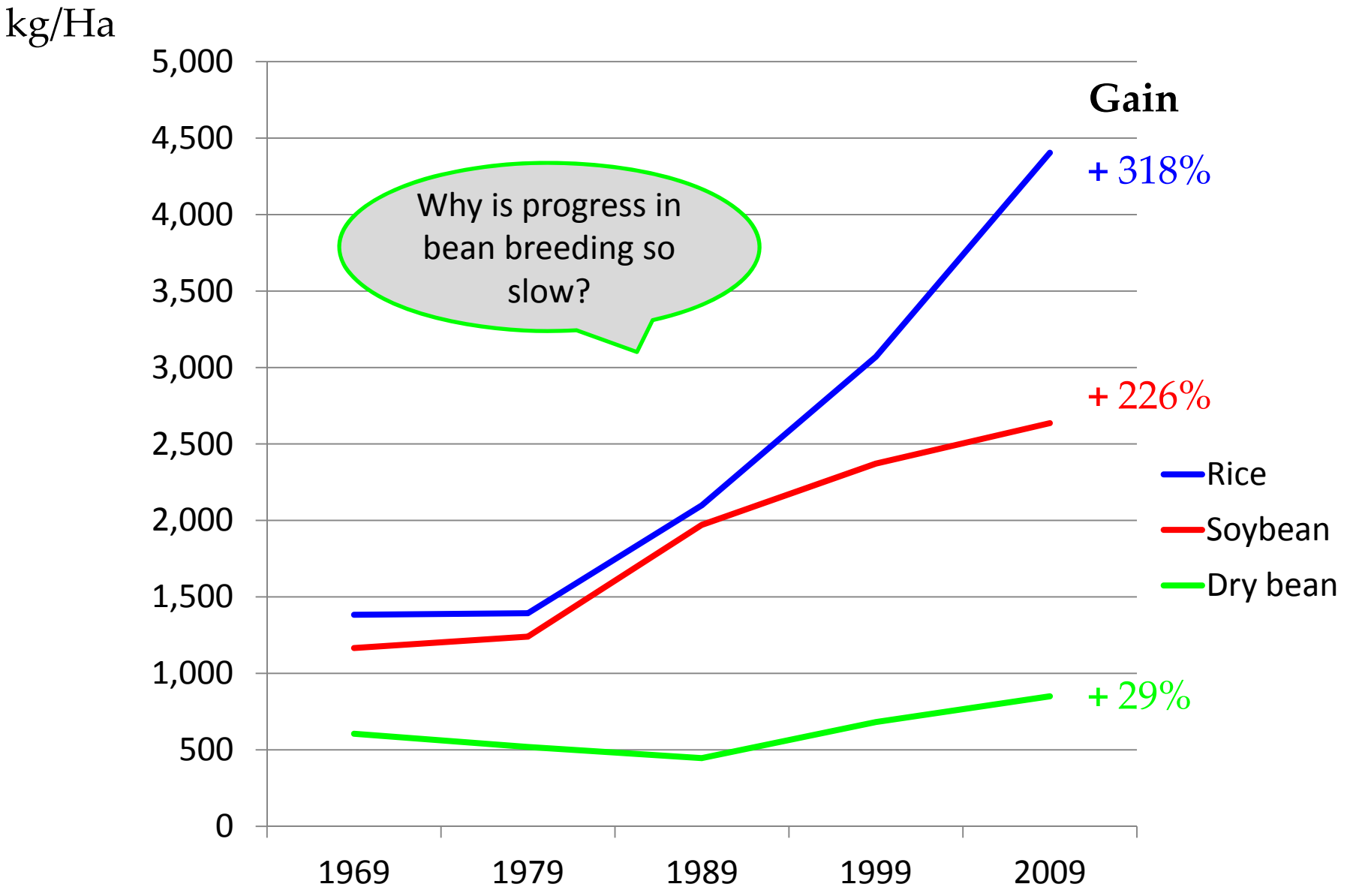
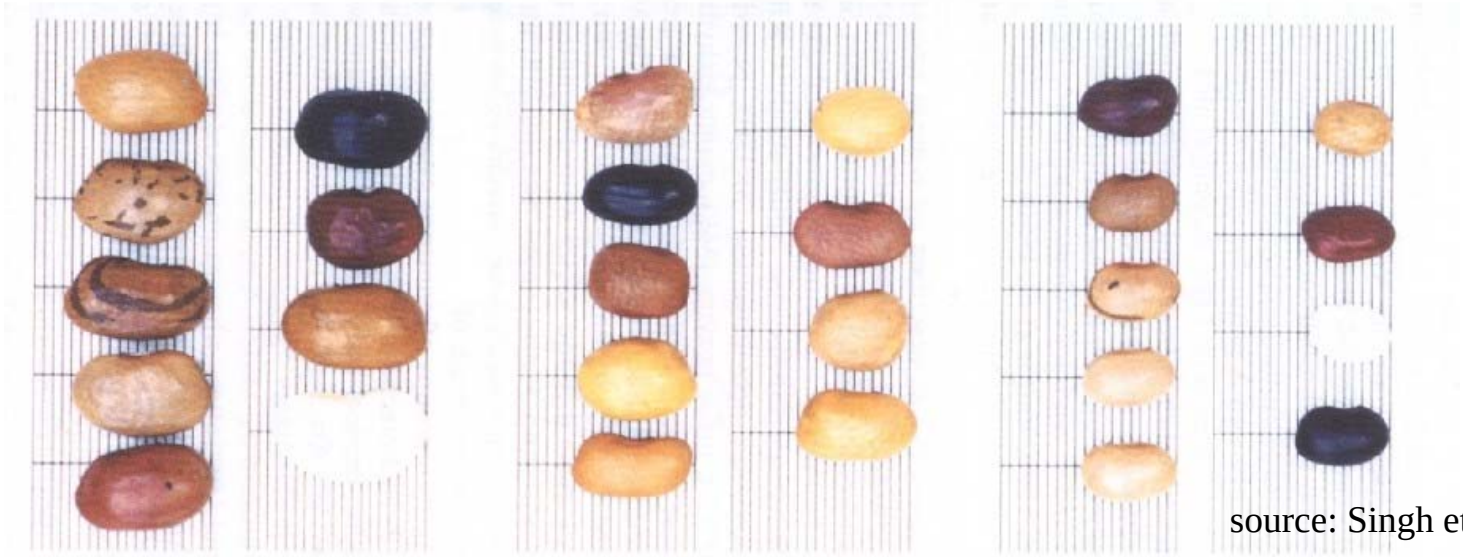
# Comparison of yields of major staple crops in Brazil




source: FAO Stat, accessed 4 Oct. 2011

# The races initially recognized in common bean for Mesoamerica




source: Singh et al. 1991

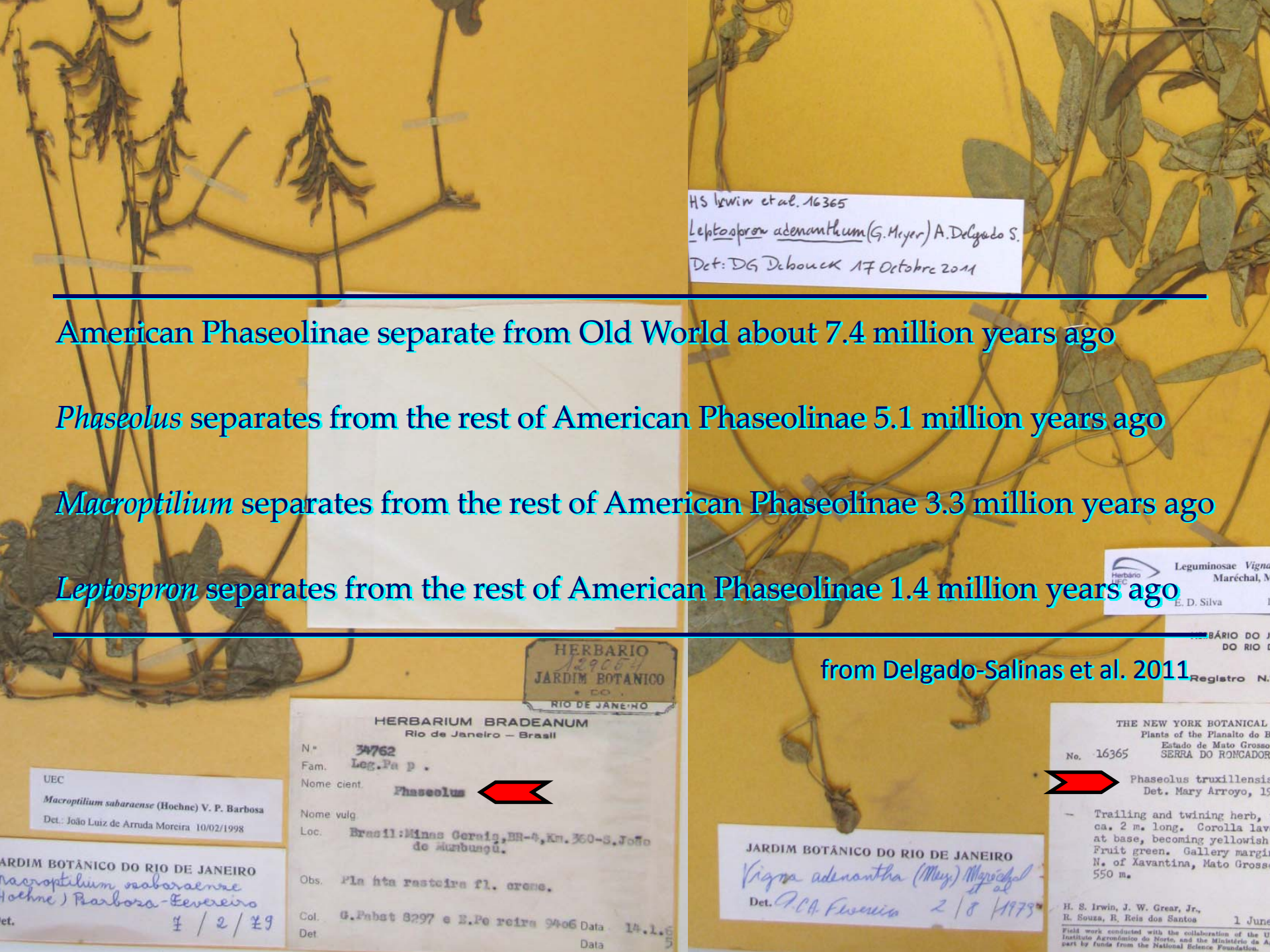
| Countries | Balance (export/ import, ton; 2007) | Race and seed type |
|---|---|---|
| Cuba | - 117,346 | *Mesoamerica*: black |
| Central America | - 100,540 | *Mesoamerica*: red, black |
| Mexico | - 73,360 | *Mesoamerica*: black. Others |
| Brazil | - 65,422 | *Mesoamerica*: mulatinho, carioca |
| Costa Rica | - 38,682 | *Mesoamerica*: black |
| Nicaragua | + 50,608 | *Mesoamerica*: red, black |
| Panama | + 1,950 | *Mesoamerica*: red, black |

[climatic problems: drought, hurricanes]

sources: FAO Stat, acces. Sept. 2010; Singh 1999

# To get **yield**, we need :

| | in *vulgaris* | in other species |
|---|---|---|
| • stem height | 55 cm | 1,200 cm (*costa*) |
| • raceme insertions | 2-6 | over 30 (*tuerc*) |
| • variegation | absent | present (*hygr*) |
| • leaflet width | 10 cm | 0.4 cm (*mont*) |
| • stem diameter | 0.6 cm | 1.2 cm (*cocc*) |
| • root diameter | 0.2 cm | 15 cm (*macu*) |
| • root length | 60 cm | 140 cm (*macu*) |




American Phaseolinae separate from Old World about 7.4 million years ago

*Phaseolus* separates from the rest of American Phaseolinae 5.1 million years ago

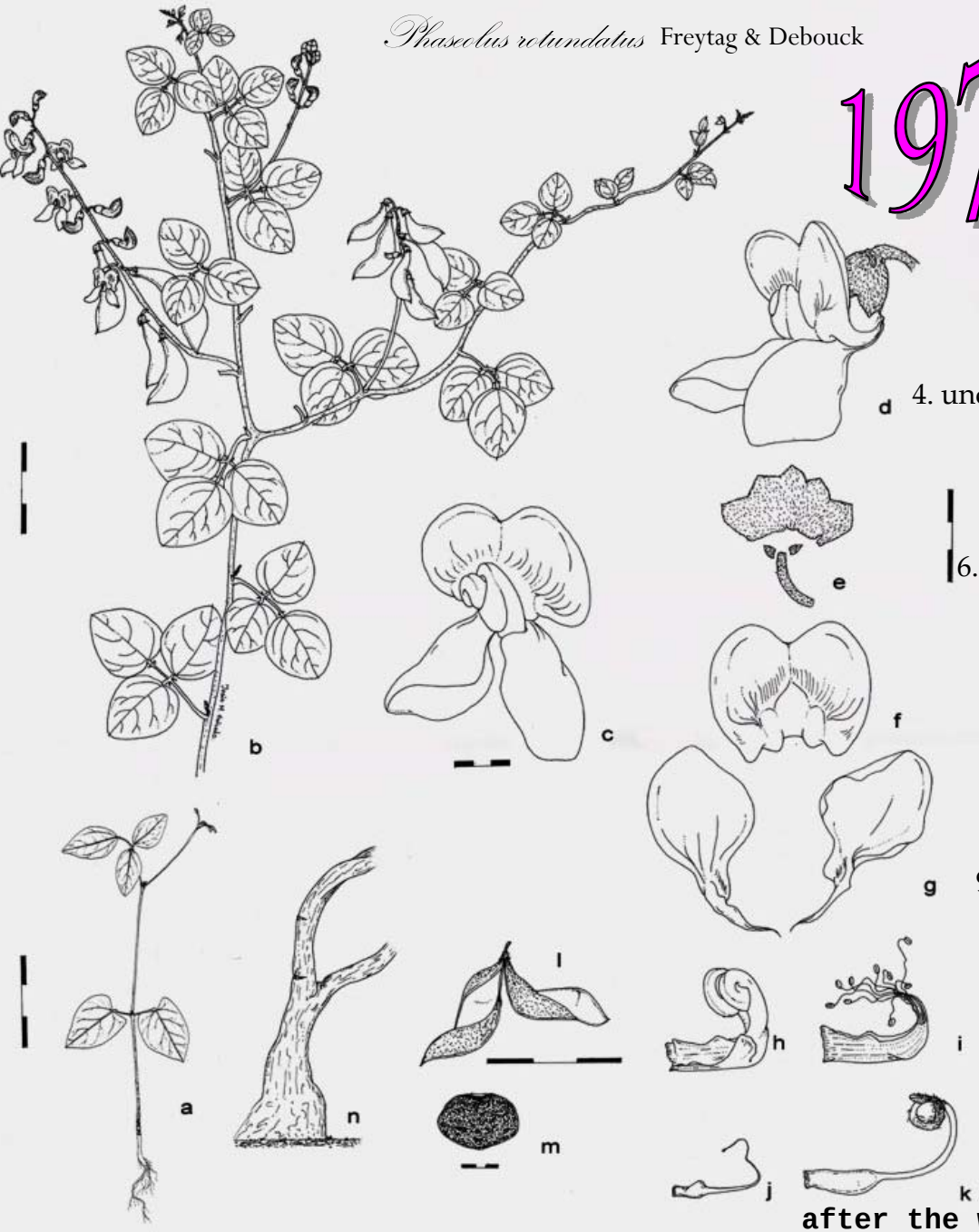
*Macroptilium* separates from the rest of American Phaseolinae 3.3 million years ago

*Leptospron* separates from the rest of American Phaseolinae 1.4 million years ago

from Delgado-Salinas et al. 2011

*Phaseolus rotundatus* Freytag & Debouck

# 1978 what is a bean ?




drawing from Salcedo et al. 2009

1. all Neotropical

2. trifoliolate leaves with stipules and stipels

3. style with inner brush

4. uncinate hairs on all aerial parts (⇔ ***Vigna, Macroptilium***)

5. stipules without extension (⇔ ***Vigna Catiang***)

6. length of pedicel = or > calyx (⇔ ***Vigna, Macroptilium***)

7. primary bracts permanent (⇔ ***Vigna, Macroptilium***)

8. lack of pedicelar glands (⇔ ***Vigna Catiang***)
(present on stipels and bracteoles)

9. style with 1.5-2 closed coils (⇔ ***Vigna, Macroptilium***)

10. style without extension (⇔ ***Vigna***)

11. terminal part of style caducous (⇔ ***Lablab***)

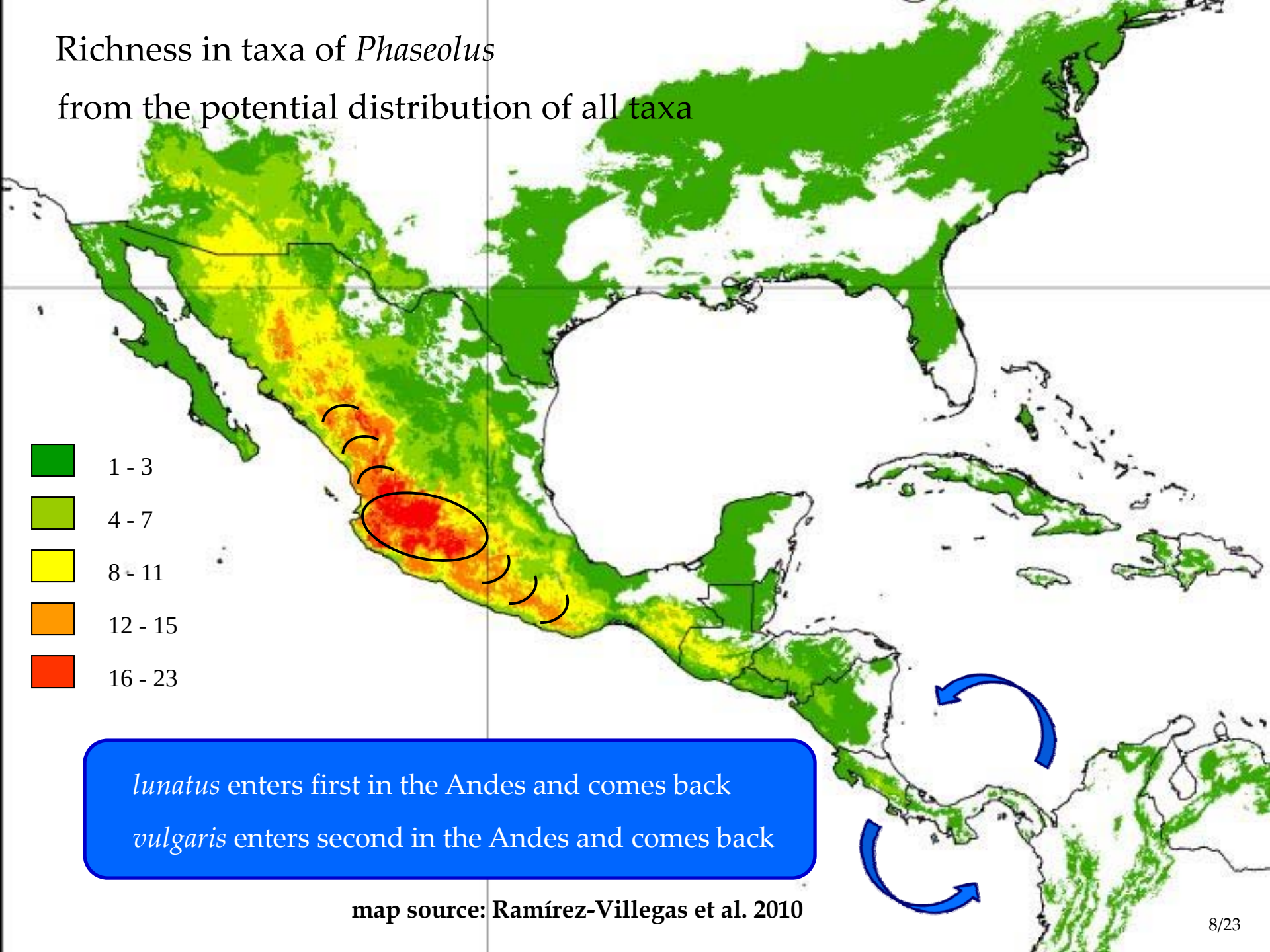
12. pods without internal septa (⇔ ***Strophostyles***)

**after the works by Maréchal et al. 1978; Lackey 1983**

| Sections | Species | total |
|---|---|---|
| Clade A (**8**) | **38** | |
| Not assigned | *glabellus, microcarpus* | 2 |
| *Bracteati* Freytag | *macrolepis, talamancensis* | 2 |
| *Brevilegumeni* Freytag | *campanulatus, hygrophilus, oligospermus, tuerckheimii* | 4 |
| *Chiapasana* (Piper) Delgado | *chiapasanus* | 1 |
| *Digitati* Freytag | *albiflorus, albiviolaceus, altimontanus, neglectus* | 4 |
| *Minkelersia* (Mart. & Gal.) Maréchal,Mascherpa,Stainier | *amabilis, amblyosepalus, anisophyllus, nelsonii, parvulus, pauciflorus, plagiocylix, pluriflorus, tenellus* | 9 |
| *Pedicellati* (Benth.) Freytag | *dasycarpus, esperanzae, grayanus, laxiflorus, oaxacanus, pedicellatus, polymorphus, purpusii, texensis* | 9 |
| *Revoluti* Freytag | *leptophyllus* | 1 |
| *Xanthotricha* Delgado | *esquincensis, gladiolatus, hintonii, magnilobatus, xanthotrichus, zimapanensis* | 6 |
| Clade B (**6**) | **39** | |
| *Acutifolii* Freytag | *acutifolius, montanus* | 2 |
| *Coriacei* Freytag | *maculatus, novoleonensis, reticulatus, ritensis, venosus* | 5 |
| *Falcati* Freytag | *leptostachyus, macvaughii, micranthus* | 3 |
| *Paniculati* Freytag | *albinervus, augusti, jaliscanus, juquilensis, lignosus, lunatus, maculatifolius, marechalii, mollis, nodosus, pachyrrhizoides, polystachyus, rotundatus, salicifolius, scrobiculatifolius, sinuatus, smilacifolius, sonorensis, viridis, xolocotzii* | 20 |
| *Phaseoli* DC | *albescens, coccineus, costaricensis, dumosus, persistentus, vulgaris* | 6 |
| *Rugosi* Freytag | *angustissimus, carteri, filiformis* | 3 |
| Total (no. sections): 14 | | |
| Total (no. species): | sources: Debouck 2011; Delgado-Salinas et al. 2006; Freytag & Debouck 2002 | **77** |

Richness in taxa of *Phaseolus*

from the potential distribution of all taxa




*lunatus* enters first in the Andes and comes back

*vulgaris* enters second in the Andes and comes back

**map source: Ramírez-Villegas et al. 2010**

# Examples of species distribution

| Widespread | | | Intermediate | | | Endemic | | |
|---|---|---|---|---|---|---|---|---|
| 14 | | | 20 | | | 43 | | |
| 13 | 1 | 3 | 19 | 0 | 1 | 41 | 1 | 1 |

## Widespread

**North + Mesoamerica**

*polystachyus, vulgaris*

*maculatus, microcarpus*

*xanthotrichus, tuerckheimii*

*parvifolius, filiformis*

**Caribbean**

*lunatus*

**South America**

*augusti*

## Intermediate

**North + Mesoamerica**

*sinuatus, pedicellatus*

*parvulus, acutifolius*

*esperanzae, nelsonii*

*angustissimus, jaliscanus*

**Caribbean**

- - -

**South America**

*pachyrrhizoides*

## Endemic

**North + Mesoamerica**

*macrolepis, texensis*

*talamancensis, nodosus*

*esquicensis, oaxacanus*

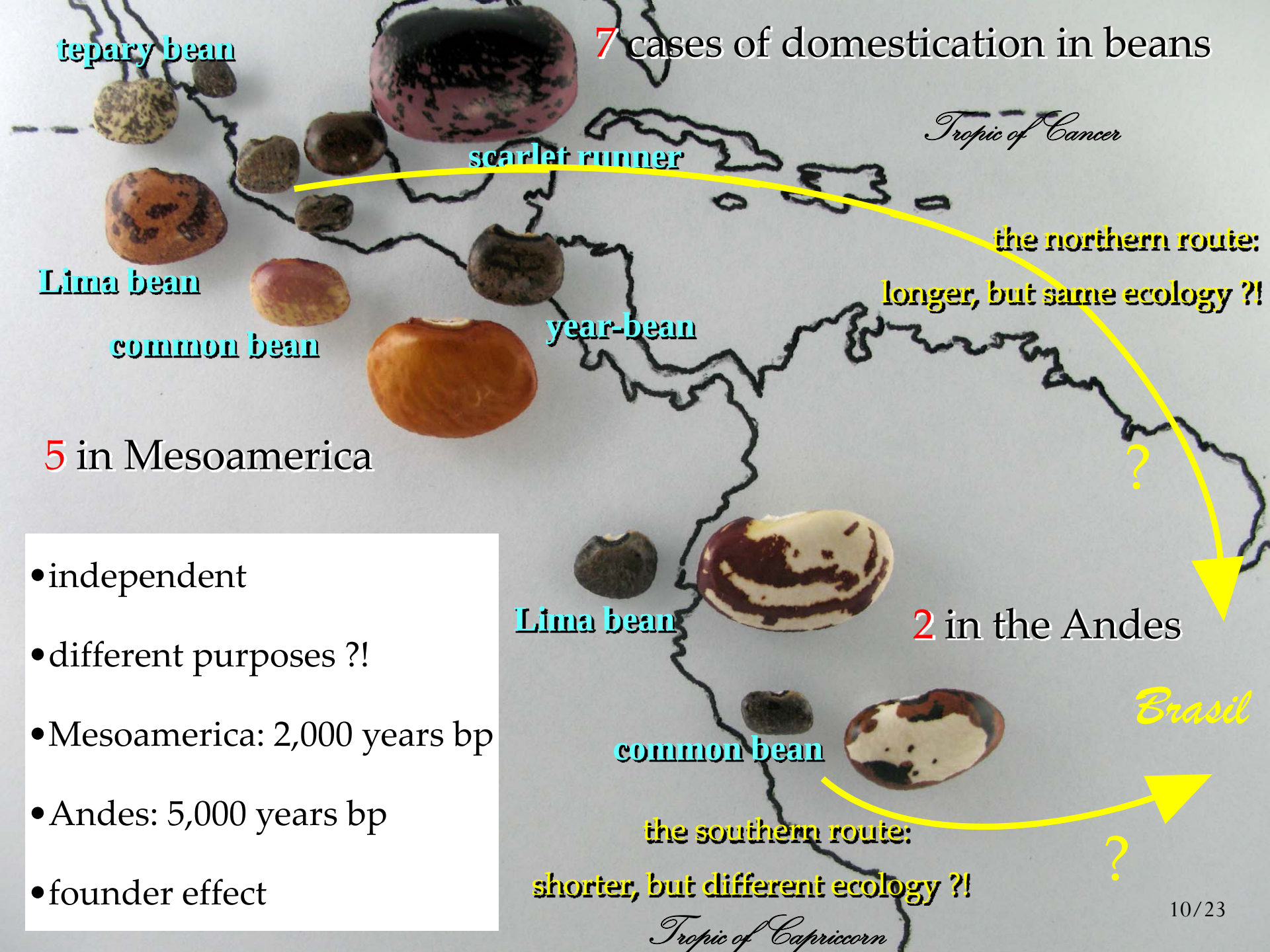
*rotundatus, purpusii*

**Caribbean**

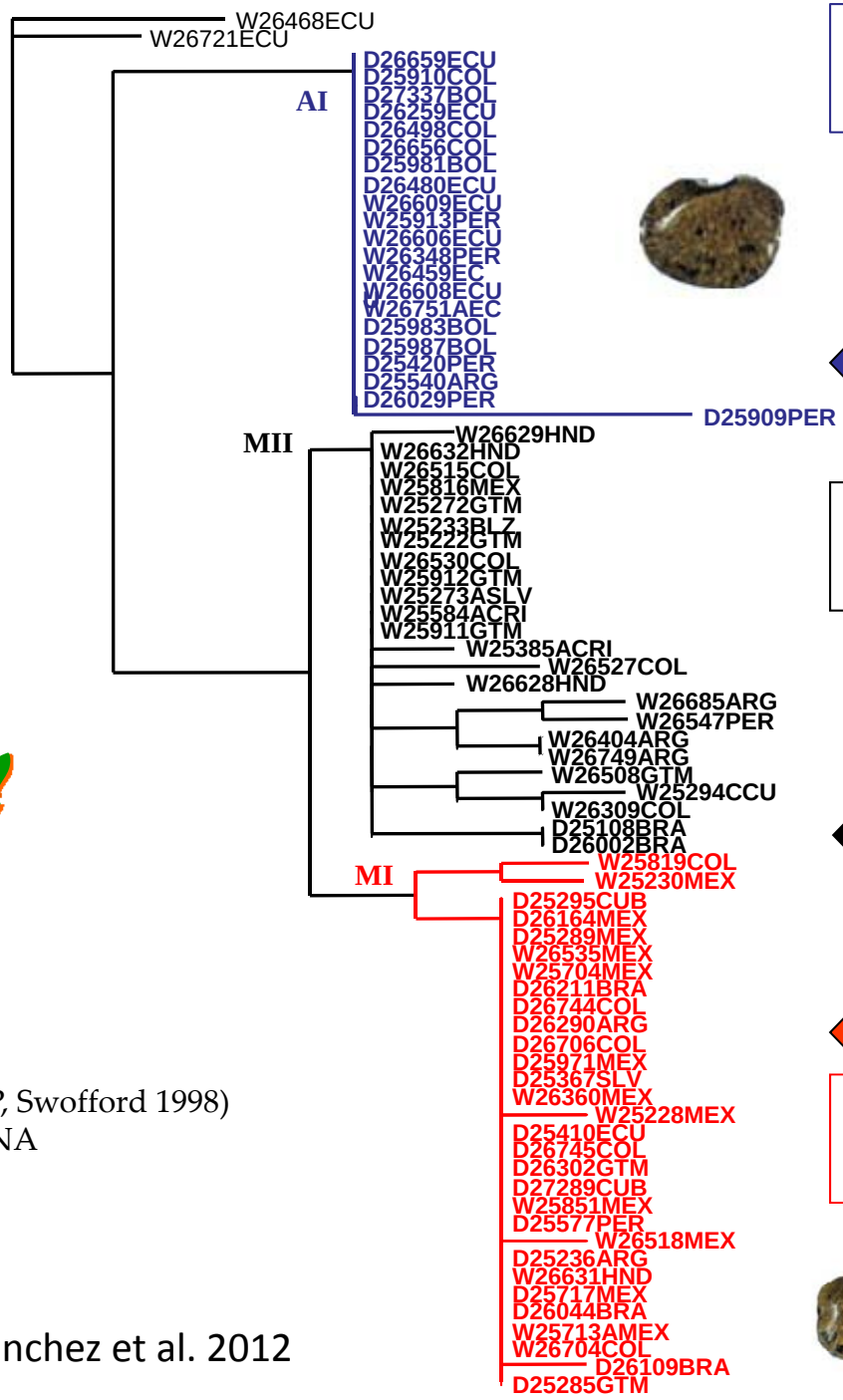
*lignosus*

**South America**

*mollis*




- independent
- different purposes ?!
- Mesoamerica: 2,000 years bp
- Andes: 5,000 years bp
- founder effect




Brazil !

Gene pool AI
(wild+domesticated )



Chuquisaca, Salta

Gene pool MII
(mostly wild)

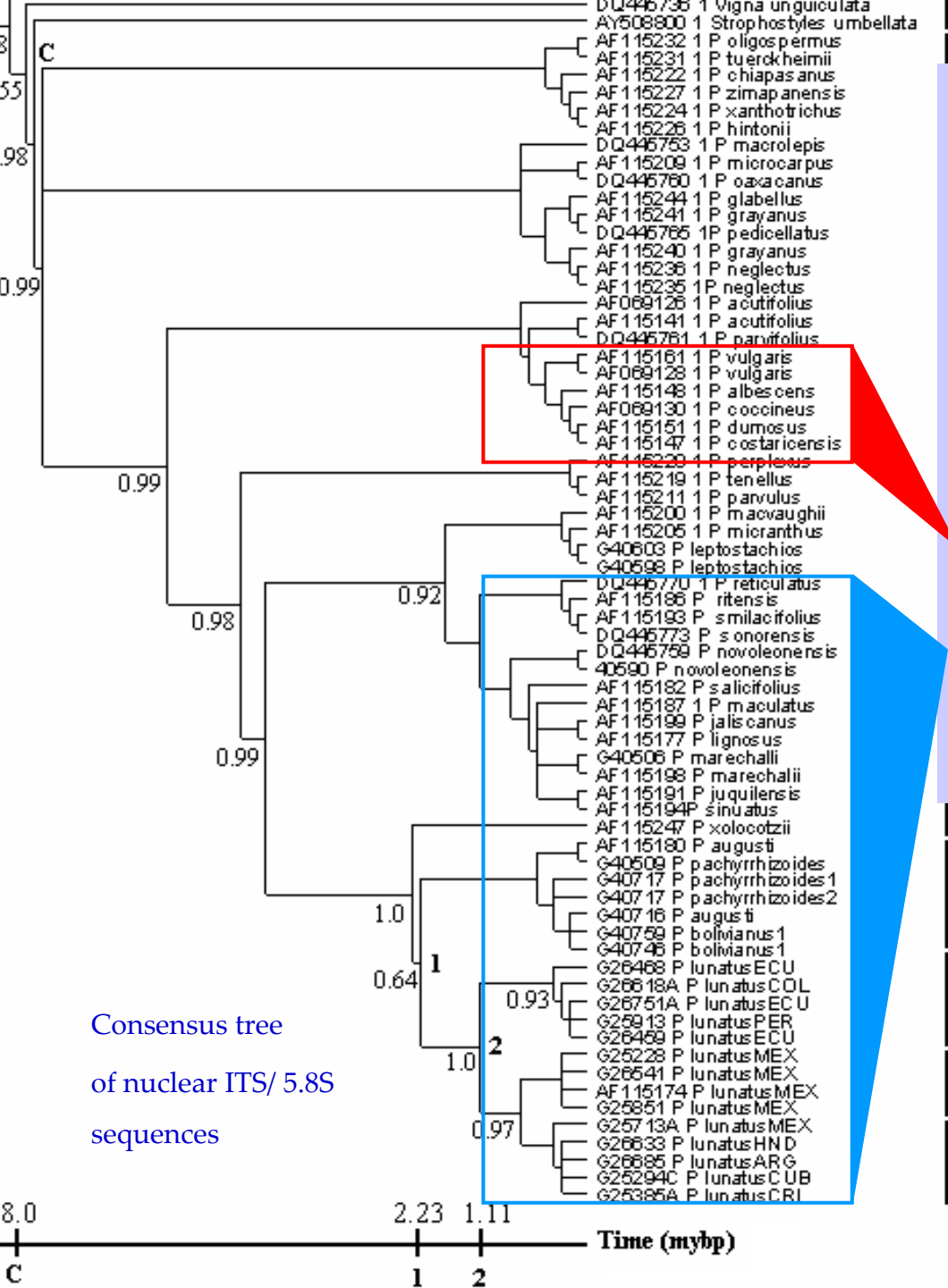
Minas Gerais, Ceará

Formosa, Mato Grosso, Espirito Santo

Gene pool MI
(wild+domesticated)

Neighbor-Joining (PAUP, Swofford 1998)
topology based on cpDNA

source: Chacón-Sánchez et al. 2012




Consensus tree of nuclear ITS/ 5.8S sequences

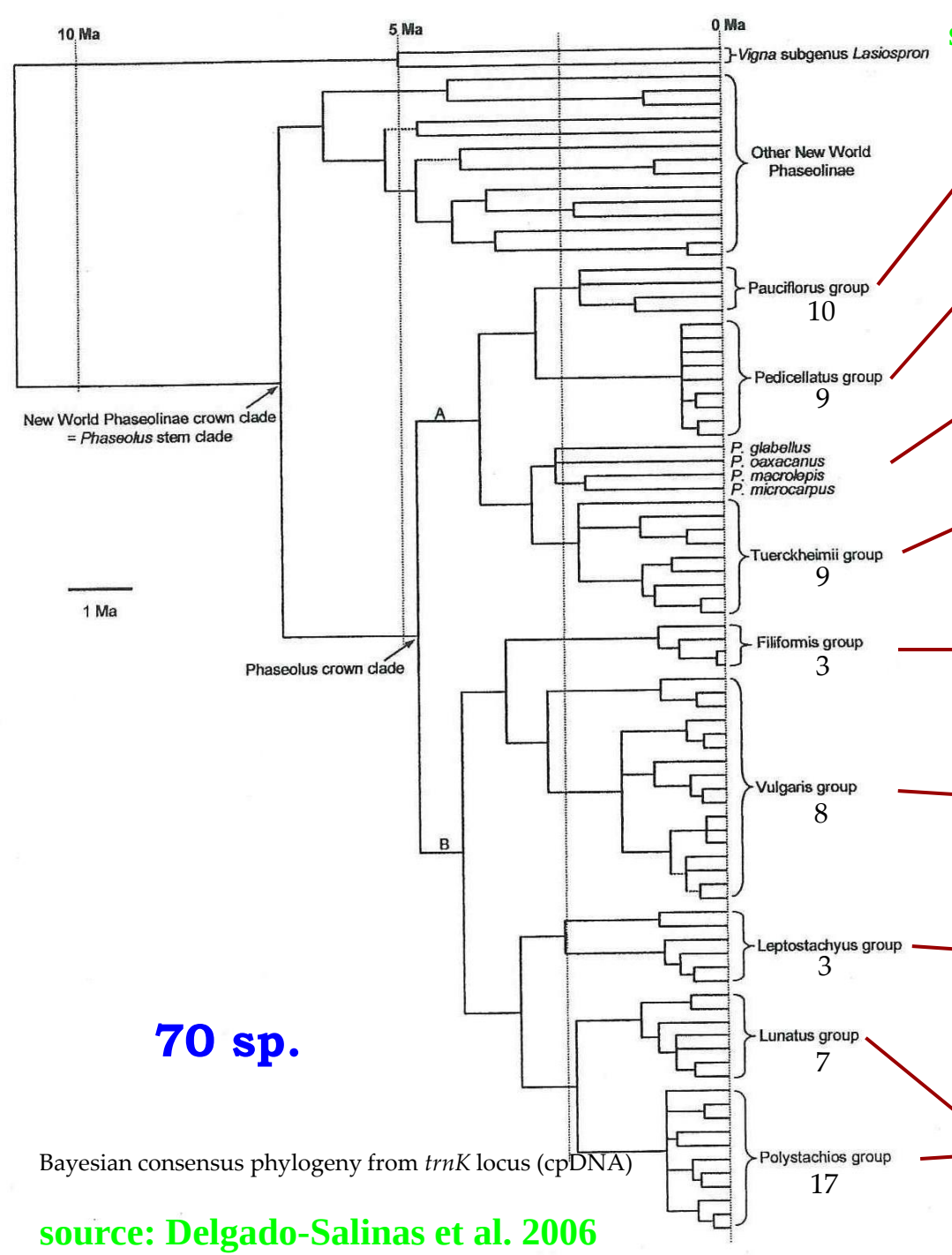
- genus monophyletic (78 sp. !)
- clades (molec) ~ sections (various)
- species ~ 1 my old
- separation *vul-lun* clades 4 mybp
- genepool of *vul*: 4 species
- genepool of *lun*: 24 species
- 15 species described after 2000 !

***Phaseolus***
**Andean species**

**AI Clade**
**MI Clade**
**MII Clade**

***Phaseolus lunatus***

source: after Serrano-Serrano et al. 2010




Bayesian consensus phylogeny from *trnK* locus (cpDNA)

source: Delgado-Salinas et al. 2006

source: Freytag & Debouck 2002

| | |
|---|---|
| *Minkelersia* : 10 | *Minkelersia* : 9 |
| *Revoluti* : 1 | *Revoluti* : 1 |
| *Pedicellati* : 11 | *Pedicellati* : 9 |
| *Digitati* : 5 | *Digitati* : 4 |
| *Bracteati* : 2 | *Bracteati* : 2 |
| *Brevilegumeni* : 3 | *Brevilegumeni* : 5 |
| *Xanthotricha* : 6 | *Xanthotricha* : 6 |
| *Chiapasana* : 1 | *Chiapasana* : 1 |
| *Rugosi* : 3 | *Rugosi* : 3 |
| *Acutifolii* : 2 | *Acutifolii* : 2 |
| *Phaseoli* : 4 | *Phaseoli* : 6 |
| *Coccinei*: 1 | |
| *Falcati* : 5 | *Falcati* : 3 |
| *Paniculati* : 18 | *Paniculati* : 20 |
| *Coriacei* : 4 | *Coriacei* : 5 |
| **70 sp.** | **76 sp.** |

**77 sp.**

source: Debouck 2011

## *founder effect !*

age of the species: 1,000,000 years

998,000

relative durations of evolution: 2,000

as wild and in the wild  as cultivated and in the field

Accelerator Mass Spectrometry data
(years before present)

| | |
|---|---|
| Ocampo, Tamaulipas | 1,285 |
| Tehuacán, Puebla | 2,285 |
| Huitzo, Oaxaca | 2,098 |

source: Kaplan & Lynch 1999


- the extent of genetic load links with the duration of evolution
- 2 genes control pod dehiscence
- 9 genes and their alleles control seed color and color pattern
- the phenotype fools you !

# Resistance to the bean seed bruchids

11,000 landraces evaluated: 0 resistant

190 wild forms evaluated: 30 resistant

globulins ▶

arcelins ▶

*arc-1* *arc-2* *arc-3* *arc-4* *arc-5* *arc-6* *arc-7*

Ica Pijao

various | Colima | Jalisco | Jalisco | Nayarit | Jalisco | Chiapas

source: Acosta et al. 1998

## Progress in evaluation outside cultivated *vulgaris* :

- the evaluation against bruchids is perhaps the most comprehensive to date
  - arcelins found only in (mostly western) Mexico so far
  - arcelin displayed by not all individuals in the original population
  - arcelin seems not to confer a comparative advantage in natural selection
- there has been some evaluation of wild forms/ species in relation to :
  - ✓frost (Balasubramanian et al. 2004): the *Rugosi*
  - ✓nodulation efficiency (Petrônio et al. 2010): wild *vulgaris*
  - ✓photosynthesis (González et al. 1995): wild *vulgaris*
  - ✓salinity (NaCl; Bayuelo et al. 2002, 2003): *filiformis*, *lunatus*, *mcvaughii*
  - ✓white mold (Singh et al. 2007): *coccineus*, *costaricensis*
  - ✓yield (Acosta et al. 2007): wild *vulgaris*

# Diversity of life forms in the genus

| taxa | life cycle (no. of months) | plant height/ length (m) | root |
|---|---|---|---|
| *albescens* | 48-60 | 5-8 | fibrous |
| *costaricensis* | 36-48-60 | 4-8-10 | extensive, fibrous |
| *dumosus* | 48-60 | 6-8-10 | fibrous |
| *persistentus* | unknown | 1-2 | unknown |
| *vulgaris* | 6-12-24 | 2-4 | fibrous |
| *angustissimus* | 12-24 | 2-4 | fibrous, thickened |
| *chiapasanus* | 24-48 | 6-10 | tuberous, globose |
| *filiformis* | 2-5-8 | 0.5-1-2 | fibrous, taproot |
| *hintonii* | 12-36 | 0.7-2.2 | tuberous, barrel-like |
| *lunatus* | 12-36 | 3-6-10 | fibrous |
| *maculatus* | 24-84 | 4-8-12 | tuberous, conical |
| *microcarpus* | 3-9 | 1-2 | fibrous |
| *oligospermus* | 24-36 | 1.5-5 | tuberous, branched |
| *parvulus* | 4-36 | 0.3-0.6 | tuberous, spherical |

# Any prospect for drought tolerance ?

| taxa<br>*Phaseoli* | amount of rainfall (mm/ year) | no. of months of dry season |
|---|---|---|
| *albescens* | 2,000 | 4 |
| *costaricensis* | 2,000 | 4 |
| *dumosus* | 2,500 | 5 |
| *persistentus* | doubtful | doubtful |
| *vulgaris* | 1,000 | 5 |

| taxa<br>*Rugosi* | amount of rainfall (mm/ year) | no. of months of dry season |
|---|---|---|
| *angustissimus* | 150-250 | 3-6 |
| *carteri* | 200-300 | 8-9 |
| *filiformis* | 100-200 | 9 |

| taxa<br>*Acutifolii* | amount of rainfall (mm/ year) | no. of months of dry season |
|---|---|---|
| *acutifolius* | 350-600 | 6-8 |
| *parvifolius* | 300-800 | 4 |

# Possibilities for the canning industry

| Common name, species | Origin | Color/pattern | 100-seed weight |
|---|---|---|---|
| Panamito (*vulgaris*) | Lima, Peru |  | 20.0 |
| Tepary (*acutifolius*) | Arizona, USA |  | 15.8 |
| Jamapa (*vulgaris*) | Veracruz, Mexico |  | 18.0 |
| Xmayum (*acutifolius*) | Campeche, Mexico |  | 16.3 |

# Possibilities for wide crossing with common bean

| cross | source | observations |
|---|---|---|
| *vulgaris* x *acutifolius* | Mejía et al. 1994 | drought tolerance; release in 2012 |
| *vulgaris x parvifolius* | Singh et al. 1998 | resistance to bacterial blight |
| *vulgaris x coccineus* | Singh et al. 2007 | resistance to white mold; ongoing |
| *vulgaris x coccineus* | Freytag et al. 1982 | resistance to root rot; ongoing |
| *vulgaris x costaricensis* | Singh et al. 2007 | resistance to white mold; ongoing |
| *vulgaris x dumosus* | Maréchal 1971 | high Al tolerance; release in 2012 |
| *vulgaris x angustissimus* | Balasubramanian et al. 2005 | frost resistance; no further progress |
| *vulgaris x filiformis* | Balasubramanian et al. 2005 | frost resistance; no further progress |
| *vulgaris x maculatus* | Katanga & Baudoin 1990 | obtained; no further progress |
| *vulgaris x lunatus* | Kuboyama et al. 1991 | obtained; no further progress |

# Composition of *Phaseolus* beans collection kept at CIAT

| | cultivated | wild/ weedy | not assigned | 37 | Falcati | 79 |
|---|---|---|---|---|---|---|
| *acutifolius* | 161 | 165 | Acutifolii | 20 | Minkelersia | 1 |
| *coccineus* | 735 | 205 | Bracteati | 4 | Paniculati | 62 |
| *dumosus* | 455 | 27 | Brevilegum. | 15 | Pedicellati | 16 |
| *vulgaris* | 29,682 | 1,842 | Chiapasana | 3 | Phaseoli | 19 |
| *lunatus* | 2,791 | 274 | Coriacei | 2 | Rugosi | 41 |
| | | | Digitati | 10 | Xanthotricha | 44 |

total cultivated materials: 33,824

total wild materials: 2,866

source: CIAT-GRP, accessed 4 Oct. 2011

# Concluding:

- ✓ the challenge of yield continues to be there; it is more than securing the 1$^{ary}$ productivity
- ✓ increasing the 1$^{ary}$ productivity of common bean is one approach (re-think an ideotype, inter-racial/ -gene pool crosses, inbred backcross with wild forms, F1 hybrid seeds)
- ✓ breeding the other four bean cultigens means as many other approaches, and planning to change ecological behaviour has a cost !
- ✓ seven cases of domestication: 1 in the *Acutifolii*, 2 in the *Paniculati*, 4 in the *Phaseoli*
- ✓ variable founder effects; importance of the wild ancestors, and the 2$^{ary}$ gene pools
- ✓ durations of evolution might be different: between *Phaseoli/ Paniculati*, within *vulgaris*
- ✓ need for other evaluation methods in case of the wild materials
- ✓ need for more germplasm in case of the wild materials (possible exception: *vulgaris* ?!)

*Muito obrigado !*