

‘Haricot de Lima’, ‘Haba de Lima’ or ‘Lima bean’:

only a toponym or reflecting an evolutive value?

a name derived from the name of a place, dated ~ 1770: Carter 1949, Webster 2001

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SPECIES
PLANTARUM,
 EXHIBENTES
 PLANTAS RITE COGNITAS.
 AD

1753

innatus.

[pod] moon-shaped

3. PHASEOLUS caule volubili, leguminibus acinaci-
 formibus sublunatis lævibus.

Phaseolus benghalensis scandens, siliqua acinaciformi,
 semine ovato compresso striato. *Berg. viadr. 99.*

Habitat in Benghala. ☉

*Foliola lateralia exteriori latere duplo latiora. Flores mi-
 nimi, virides: alis albis concavis, dein flavescensibus;
 carina spirali.*

inamænis.

[continuously] beautiful

4. PHASEOLUS caule volubili, florum vexillo revo-
 luto, calycibus concolore. *Hort. cliff. 359. **

Habitat in Africa. ☉

HOLMIÆ,
 IMPENSIS LAURENTII SALVII.
 1753.

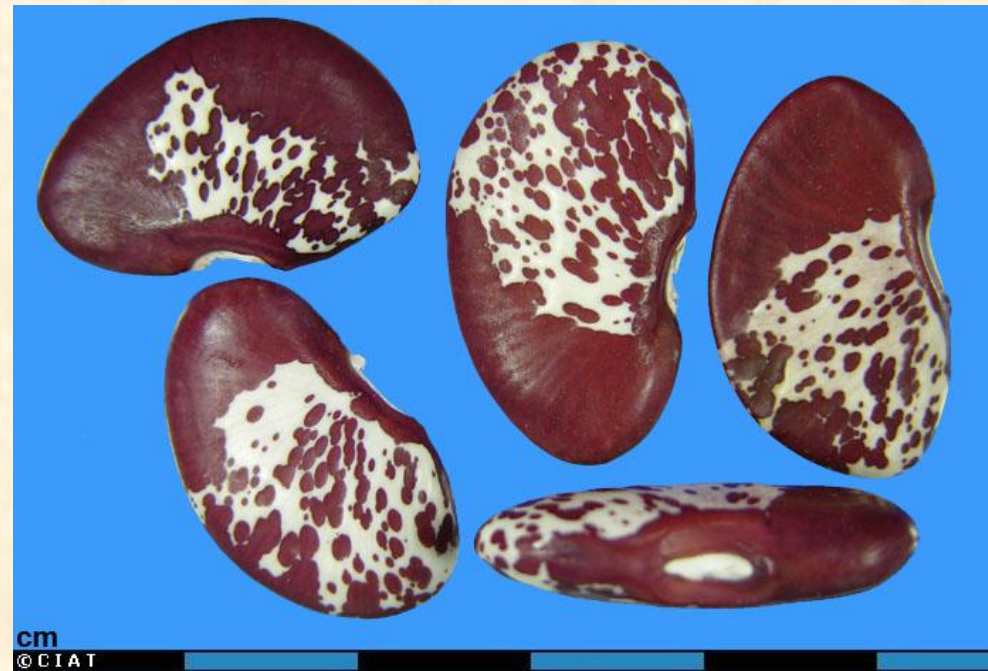
1737

Phaseolus lunatus L.



G27475, from Myanmar

Phaseolus inamoenus L.



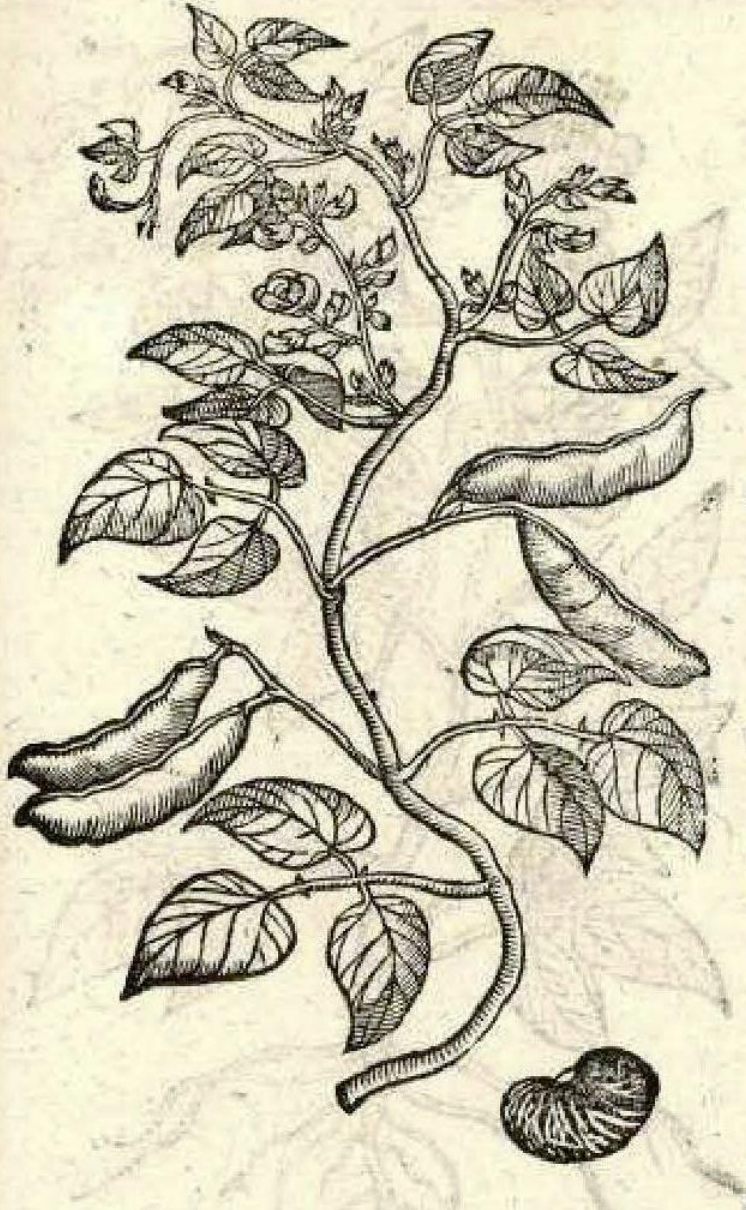
G25694, from Ethiopia

... what Carl von Linné might have seen

- No reference specimens in the LINN and CLI Herbaria (solved by Westphal 1974, Debouck 2021)
- Reports about Old World origin: A.P. de Candolle 1825, Don 1832, Dietrich 1847
- Doubts about Old World origin: Bentham 1859, Al. de Candolle 1883

already described in the pre-Linnean botanical literature

Phaseoli peregrini 1. genus alterum.



from de l'Écluse 1601

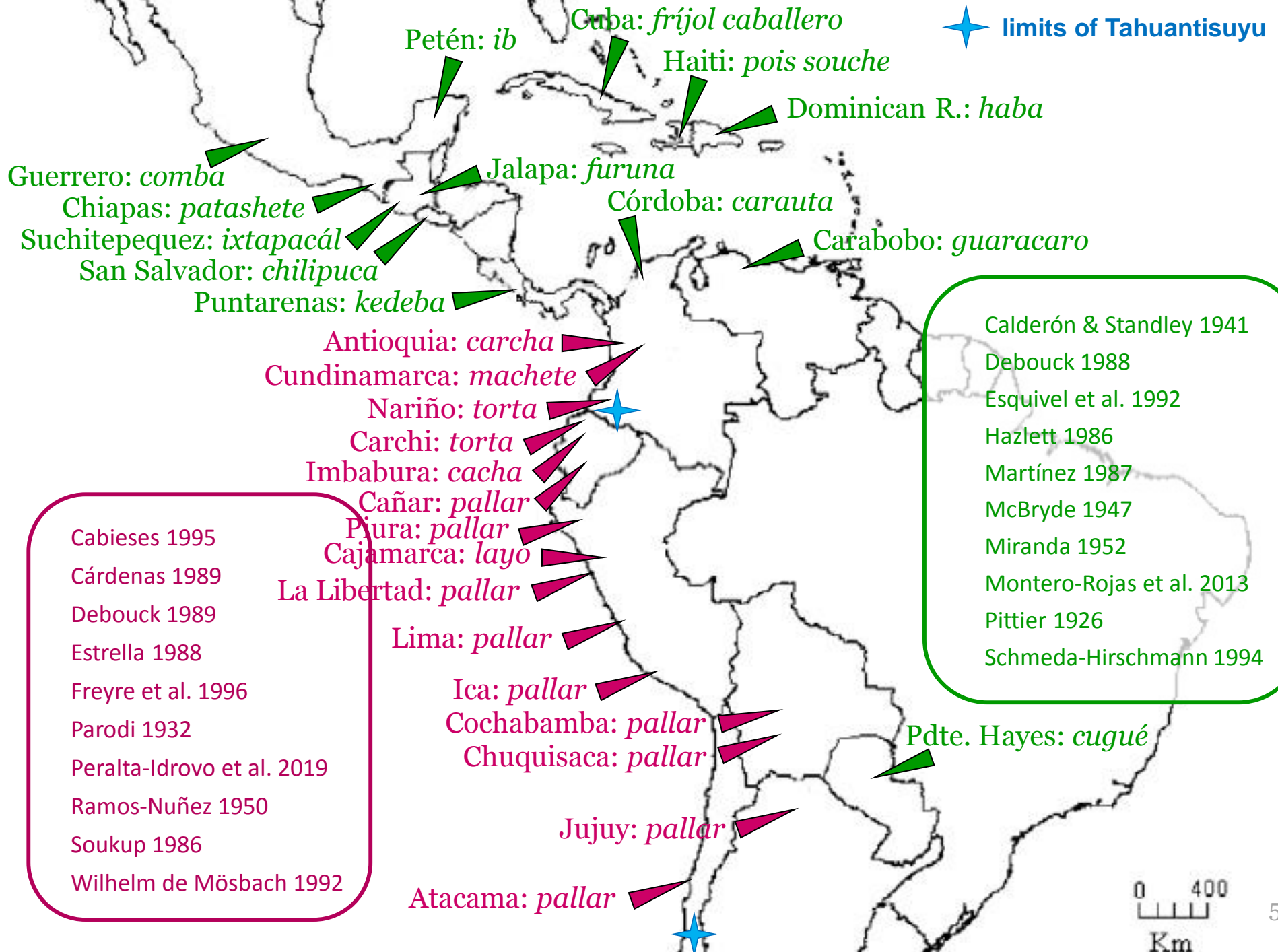
- ✓ Charles de l'Écluse (1601) acknowledged as 'foreign'
- ✓ John Gerarde (1597 [1636]) reported one pair from Brazil
- ✓ J. Bauhin & J.-H. Cherlero (1651) reported several from Brazil



from Gerarde 1597 (same woodcut as in de l'Obel 1591?!)

- ➡ already referring to the striae from the seed hilum
- ➡ already reporting the 'willow-leaf' variant
- ➡ mentioned from Africa, Brazil and America

the Amerindian/ folk names (possibly used by 1500!?)



About the name and geographic origin:

- ➔ at contact (1492-1500) in Hispaniola the (Lima) bean was called ‘haba’:
 - its flat seeds remind those of *Vicia faba* L., then grown in the Iberian Peninsula
 - that name persisted in the Dominican R. because of the extinction of Taino people
 - in Cuba the translation of ‘horse bean’ ‘fríjol caballero’ was preferred (same reason?)
- 1520: discovery of the Strait of Magellan; another route to access Peru and Chile
- 1532: end of Inca empire
- 1564: the sea route from Acapulco to Manila was opened by the Spanish galleons
- ➔ the coastal agricultural areas (Brazil, Chile, Peru) were fully exposed to explorers
- ➔ *pallar* was the adopted name in Spanish since 1560 given the Quechuan expansion from the Ancasmayo (Nariño, Colombia) down to the Maule (R. del Maule, Chile)
- ➔ Lima bean was a logical European name for this pulse in 1777 onwards, as it refers to a native bean when Lima was the capital of the viceroyalty (1542-1821)
- ➔ the linguistic argument helped turn down any claim of origin in Old World tropics

The biological origin:

The crop (Lima bean) = the wild ancestor modified by the domestication syndrome

DGD-502, Campeche, Mexico, 1979



photo: Debouck 2008

- reduced pod shattering
- increased seed size
- novel seed colors & patterns
- reduced seed dormancy
- reduced HCN glucosides
- early flowering & monocarpy
- dwarf determinate growth habit
- photoperiod insensitiveness

1859: Bentham reported about 'spontaneous' forms in the Neotropics (but no specimens)

1926: Piper reported wild forms in CUB, PRI, MEX, PNM, CLB, VNZ, BRA, PER (but no specimens)

1943: Macbride reported wild forms for eastern Peru (later on shown with 'M' lectin pattern)

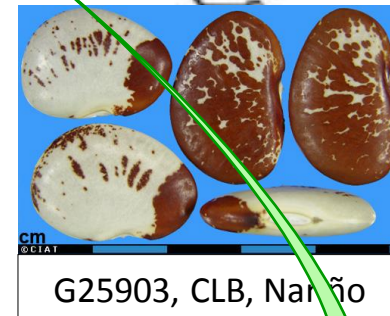
1952: Burkart reported wild forms for Formosa, Jujuy, Salta, Argentina (but no specimens)

additional reading: Debouck 2016, 2021; Erickson 1982; Lewis 1987; Maquet & Baudoin 1997; Montero-Rojas et al. 2013

Smartt 1988

One often repeated story (Mackie 1943):

Carter 1949; Friedberg 1958; Westphal 1974; Baudet 1977



Hopi branch

Carib branch

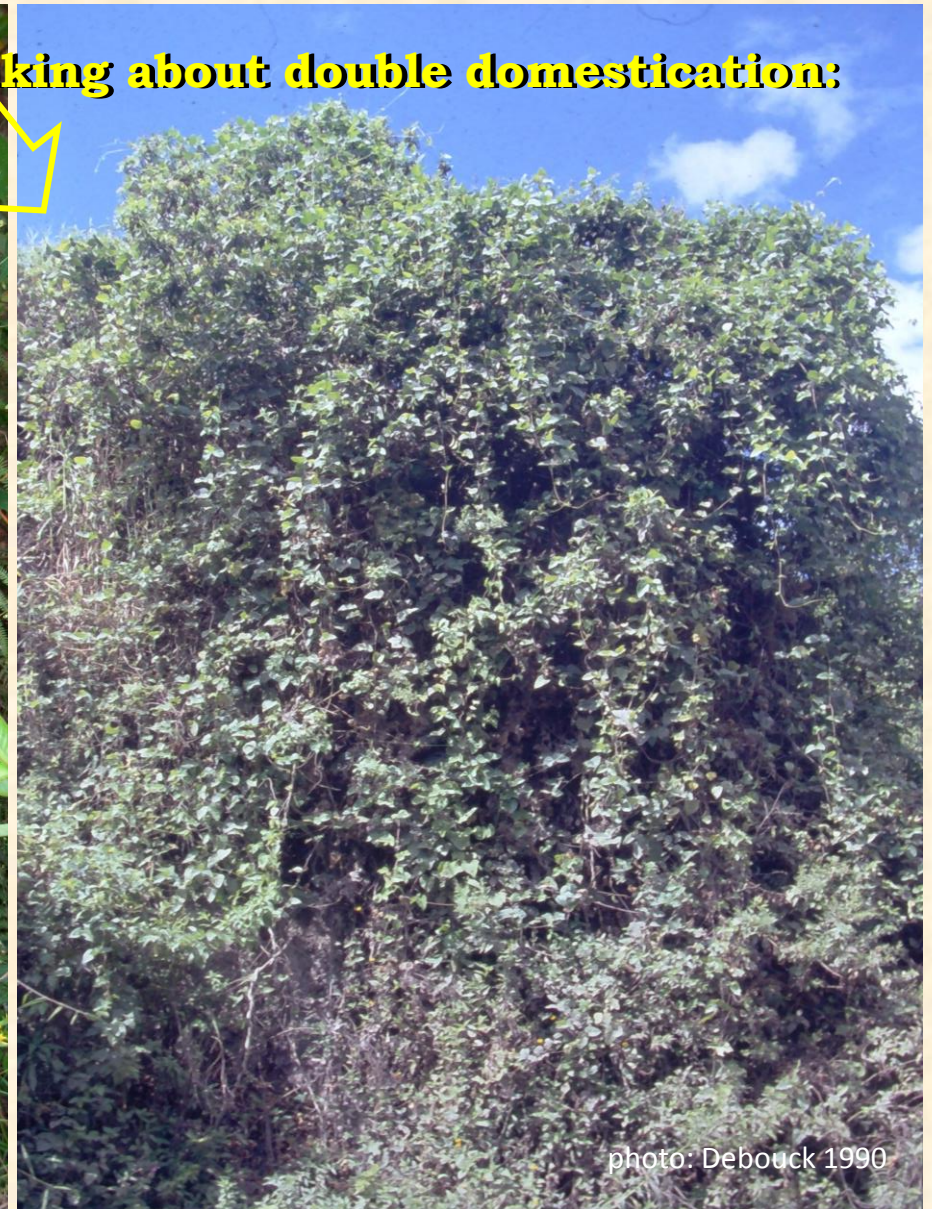
Inca branch

- ✓ weak because of poor and uneven sampling of wild forms
- ✓ infraspecific diversity created by people from a single domestication

although some argued about a double domestication:

Allard 1960; Estrella 1988; Evans 1976; Harlan 1971; Heiser 1965; Kaplan 1965

what brought a change in the thinking about double domestication:



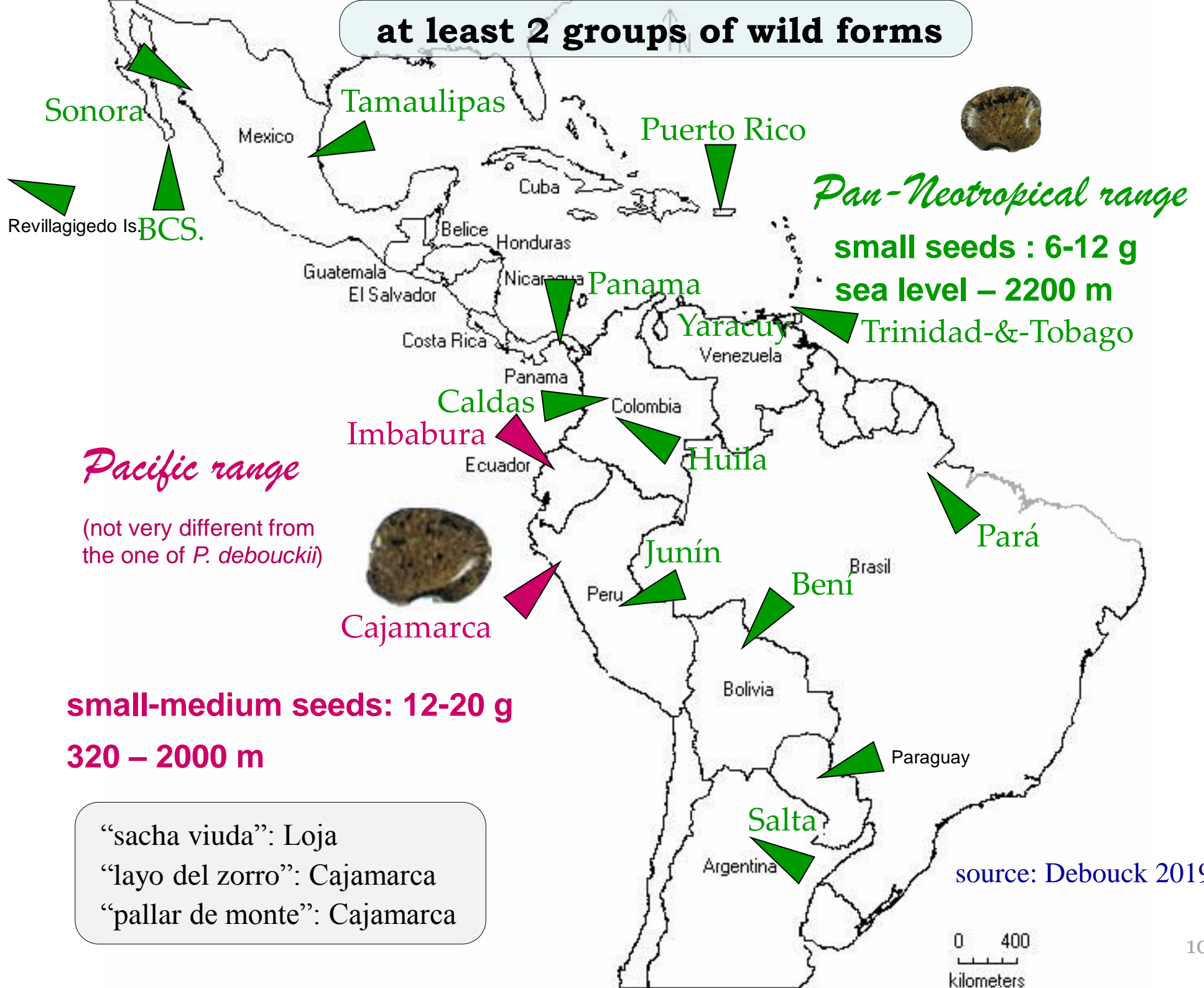
Background: Standley 1937

Explorations (13) in CRI in: 1987 - 2017

Background: Piper 1926

Explorations (2) in ECD in: 1989, 1990

at least 2 groups of wild forms



“sacha viuda”: Loja
 “layo del zorro”: Cajamarca
 “pallar de monte”: Cajamarca

A noteworthy wild Lima bean from Boyacá, Colombia

- found in 1992 NE of Bogotá
- racemes and flowers similar to wild *P. lunatus* of S Ecuador
- 100-seed weight (16.8g) within the range of Andean AI wild forms
- lectin pattern M1, as the ‘Mesoamerican’ but also as in *Phaseolus augusti*
- formed a separate cluster in AFLP analysis
- classified as MII on cpDNA markers
- found close to MII on 4,593 SNPs



Trabajo de Recolección de Germoplasma de *Phaseolus*
patrocinado por el Consejo Internacional de Recursos Fitogenéticos
Misión colaborativa entre el Centro Internacional de Agricultura Tropical (Cali, Colombia) y _____

HERBARIO

Nombre científico: *Phaseolus lunatus* var. *silvester* Baudet
Determinavit: O. Toro Ch. Fecha: 06/II/1992
Nombre vulgar: Frisol de monte
País/Estado/Municipio/Locidad: COLOMBIA, BOYACA, 10 Km W Guateque, Vda. Mihantá
Longitud: 73°31' W Latitud: 05°00' N Altitud: 1600 m
Fecha de Recolección: 06/II/1992

Observaciones: Bosque seco Premontano (transición cálida a bosque húmedo - Montano Bajo. Abundante. En floración y producción. Creciendo con *P. polyanthus* (#142), *Senna bicapsularis*, *Panicum maximum*, *Trypsine* sp., *Vernonia baccharoides*, *Ipomoea* sp., etc.

Colectores: O. Toro Ch. & G.L. Valencia
Nº: 141 Se colectaron semillas bajo el Nº: 141

sources: Caicedo et al. 1999; Chacón-S. & Martínez C. 2017;

Serrano-S. et al. 2010; Toro et al. 1993

Two gene pools in the wild and two domestication events: expected !

| marker | references |
|--------------------------------|--|
| lectin polymorphisms | Debouck et al. 1989; Gutiérrez-S. et al. 1995; Lioi 1996 |
| 20 and 13 isozyme loci | Maquet et al. 1994, 1997 |
| RAPDs on genomic DNA | Nienhuis et al. 1995; Fofana et al. 1997 |
| RFLPs on rRNA | Jacob et al. 1995 |
| 17 isozyme loci, RFLPs on rDNA | Lioi et al. 1998 |
| RFLPs on 6 IGRs of cpDNA | Fofana et al. 1999 |
| SSRs on genomic DNA | Lioi & Galasso 2002 |
| two cpDNA probes | Fofana et al. 2001 |
| sequences of cp and nDNA | Serrano-Serrano et al. 2010 |
| sequences of cpDNA and ITS | Motta-Aldana et al. 2010 |
| ITS of rDNA | Serrano-Serrano et al. 2012 |
| 2 intergenic spacers of cpDNA | Andueza-Noh et al. 2013 |
| 10 microsatellite loci | Martínez-Castillo et al. 2014 |

- ✓ 2 independent domestication events in distant locations (as in common bean)
- ✓ possibly few original populations involved ← high linamarin in wild forms
- ✓ parallel demonstration by use of similar markers of molecular genetics

More gene pools in the wild and a third domestication event: unexpected !

Existence of a 2nd gene pool in the wild Neotropical “small-seeded” Lima bean (MII)

| marker | references |
|----------------------------|---|
| sequences of cp and nDNA | Serrano-Serrano et al. 2010 |
| sequences of cpDNA and ITS | Motta-Aldana et al. 2010 |
| sequences of cpDNA | Andueza-Noh et al. 2013 |
| genome-wide 4,593 SNPs | Chacón-Sánchez & Martínez-Castillo 2017 |

Possibility of a 3rd domestication event from wild forms in MII gene pool !?

| marker | references |
|--------------------|-------------------------|
| sequences of cpDNA | Andueza-Noh et al. 2013 |

- ✓ insufficient sampling of MII in South America to claim a 3rd event ???

Existence of a 2nd gene pool in the wild Andean “large-seeded” Lima bean

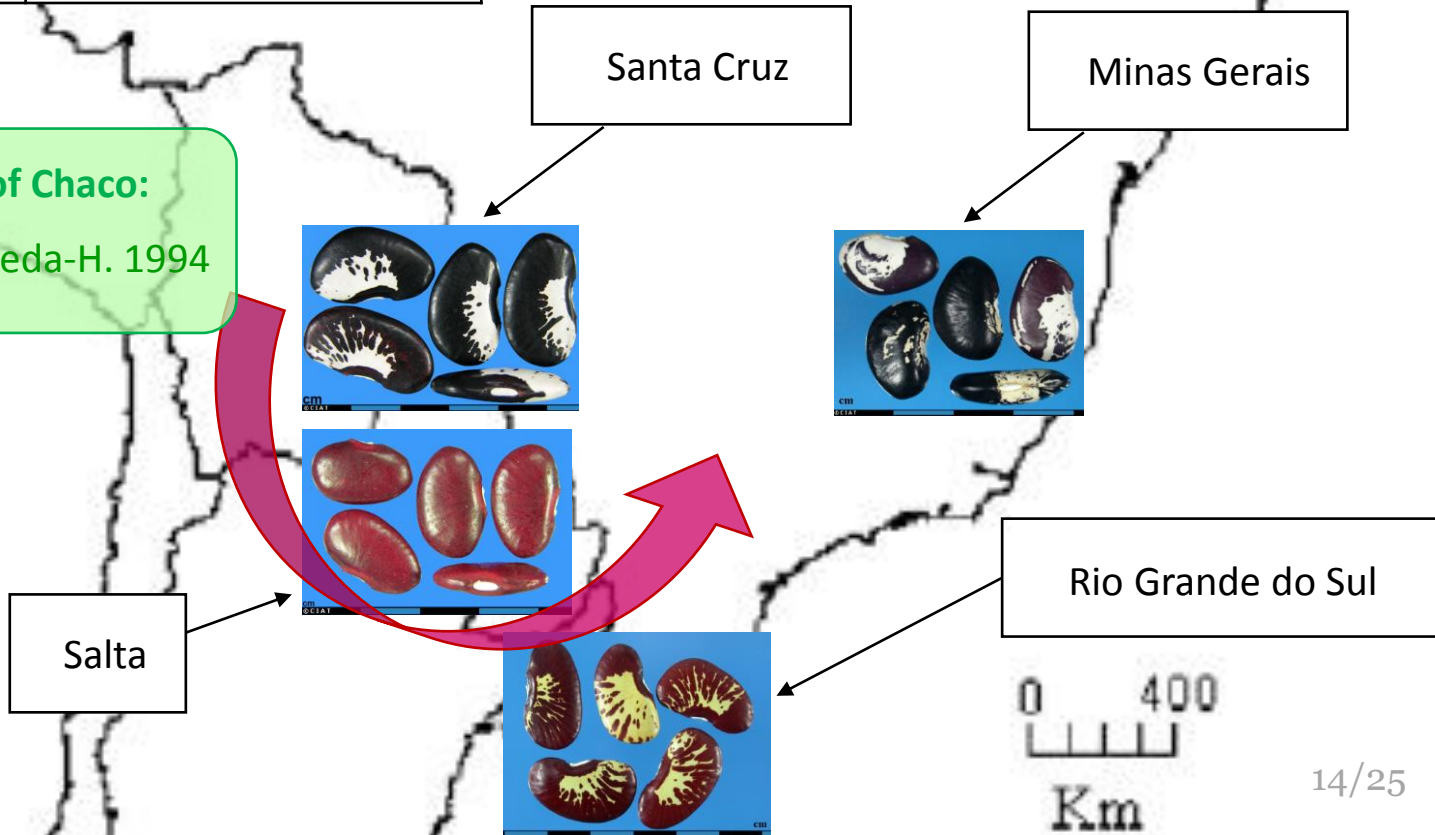
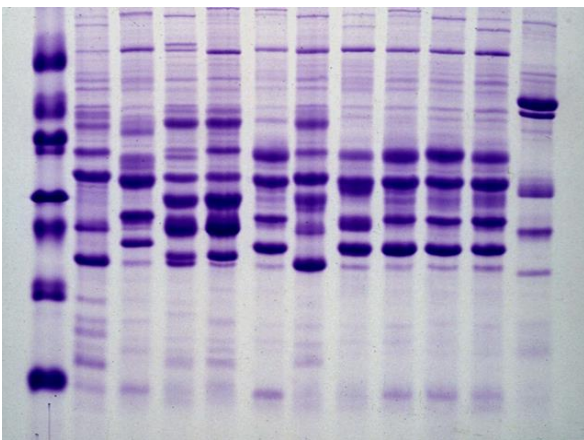
| marker | references |
|---------------------------|---|
| AFLP of genomic DNA | Caicedo et al. 1999 |
| genome-wide 4,593 SNPs | Chacón-Sánchez & Martínez-Castillo 2017 |
| GBS: 12,398 SNVs analyzed | Garcia et al. 2021 |

- ✓ these wild forms from Boyacá-Cundinamarca seem not to be hybrids !

**The migration northwards to Antioquia and Cundinamarca:
expected, but towards the Chaco and eastern lowlands !?**

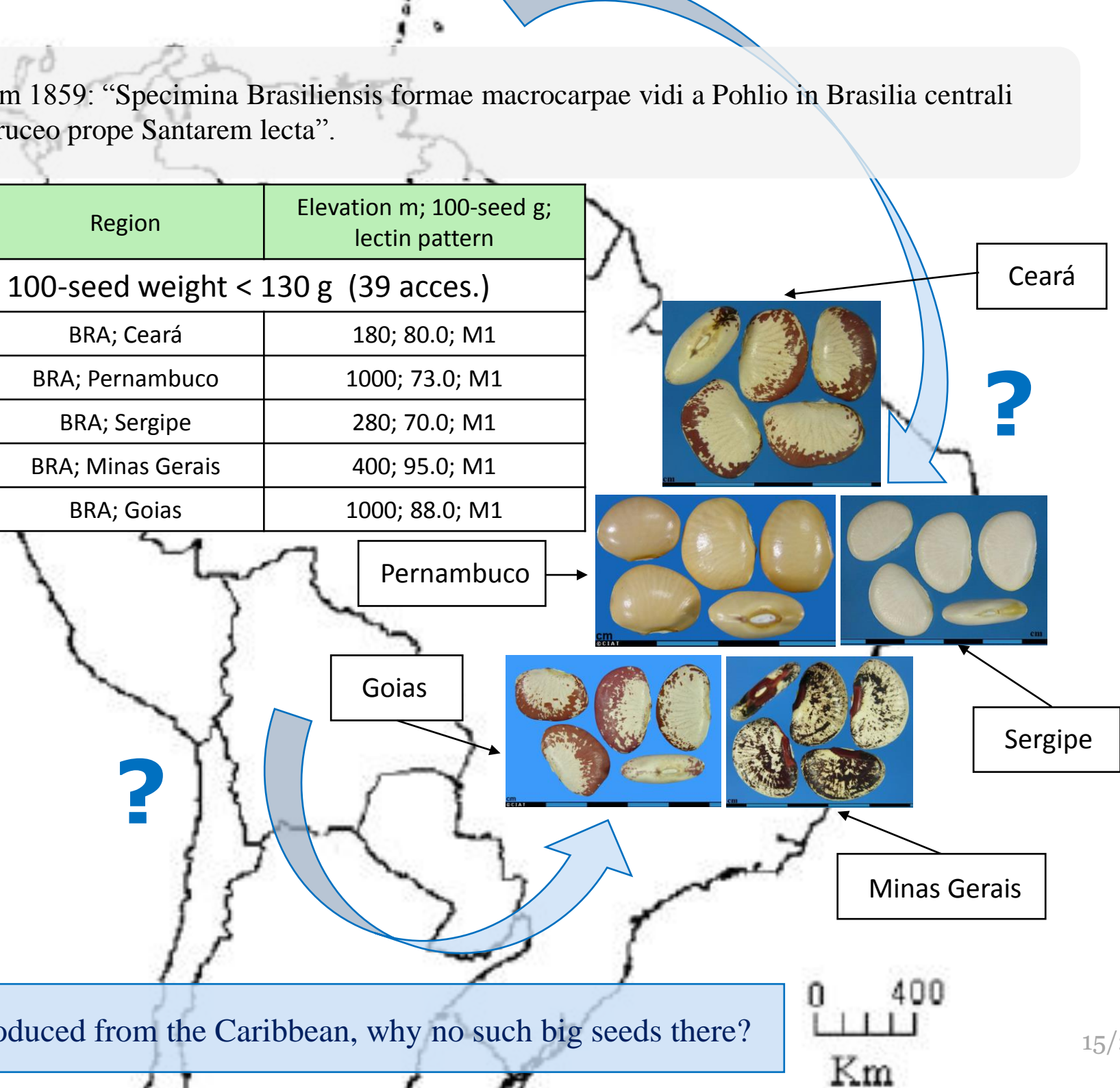
| Materials | Region | Elevation m; 100-seed g; lectin pattern |
|-----------|---------------------|--|
| G25579 | BLV, Sta. Cruz | 450; 111.0; A6 |
| G25540 | ARG, Salta | 1100; 70.0; A3 |
| G26102 | BRA. Rio Grande Sul | 830; 95.4; A3 |
| G26068C | BRA, Minas Gerais | 650; 86.0; A3 |

**Lima bean grown by peoples of Chaco:
the Ayoreo in Paraguay: Schmeda-H. 1994**



Bentham 1859: “Specimina Brasiliensis formae macrocarpae vidi a Pohlio in Brasilia centrali et a Spruceo prope Santarem lecta”.

| Materials | Region | Elevation m; 100-seed g; lectin pattern |
|--|-------------------|---|
| 70 g < 100-seed weight < 130 g (39 acces.) | | |
| G26003A | BRA; Ceará | 180; 80.0; M1 |
| G25997 | BRA; Pernambuco | 1000; 73.0; M1 |
| G26140 | BRA; Sergipe | 280; 70.0; M1 |
| G26034 | BRA; Minas Gerais | 400; 95.0; M1 |
| G26296 | BRA; Goiás | 1000; 88.0; M1 |



if introduced from the Caribbean, why no such big seeds there?

why does the Andean domestication look asymmetrical?

DGD-453; Jalisco



10 g



DGD-1944; Cajamarca



12 g

2250 ppm

increase in seed size and weight



2747 ppm

3-4 x



28 g

43 ppm



131 g

10-14 x

47 ppm

DGD-508; Campeche

DGD-1176; Cajamarca



2 cm

Concluding remarks

- “Lima bean predominates over the frijol in the majority of the American tropics” (Sauer 1950, p. 501)
- in archaeological records (5,600 ybP), it appears fully modern; no transition from the wild in contrast to maize where the transition from the wild can be tracked over 8,000 years
- the reasons to domesticate a lethal legume in absence of pottery (for two millennia) remain unclear, unless it was originally domesticated for non-food purposes
- on the Pacific side, from Cundinamarca to the Atacama desert, into the Chaco and from there into southern Brazil, the gene pool AI had a huge pre-Columbian range
- 3 puzzling facts:
 - this huge colonization of AI = MI, in spite of a narrow range in the wild
 - also puzzling is the colonization of AI in altitude: from sea level up to 3,100 m
 - the increase in seed size in AI: another genetic control as compared to MI?
- field work, rather than methods, in South America, key to solve several pending questions

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