A new species of *Phaseolus* (Leguminosae, Papilionoideae) sister to *Phaseolus vulgaris*, the common bean

MARTHA RENDÓN-ANAYA¹, ALFREDO HERRERA-ESTRELLA¹, PAUL GEPTS² & ALFONSO DELGADO-SALINAS³*

¹Laboratorio Nacional de Genómica para la Biodiversidad, Centro de Investigación y de Estudios Avanzados del IPN (Cinvestav), 36821 Irapuato, Guanajuato, México
²Department of Plant Sciences/MS1, Section of Crop & Ecosystem Sciences, University of California, Davis 95616-8780, CA, USA
³Universidad Nacional Autónoma de México, Instituto de Biología, Departamento de Botánica, Cd. Universitaria, Coyoacán, 04510, Ciudad de México, México
*Author for correspondence: adelgado@ib.unam.mx

Abstract

Integrating the information provided by different lines of evidence generated in previous studies, *Phaseolus debouckii*, a new species is described and illustrated. This species occurs only in central-southern Ecuador and north western Peru, mostly in what is known as the Amatope-Huancabamba Depression, and represents a sister species to *Phaseolus vulgaris* L. A comparison table with quantitative and qualitative morphological characters is given, as well as a distribution map and ecological information.

Key words: gene genealogies, nomenclature, phylogeny, taxonomy

Introduction

Morphological and molecular evidence have shown that the New World papilionoid legume genus *Phaseolus* Linnaeus (1753: 723) is monophyletic and comprises ca. 70 species in seven phylogenetic groups (Delgado-Salinas *et al.* 2006). Among these, the *Phaseolus vulgaris* group is composed of seven species, including four cultivated ones with wild counterparts, *P. acutifolius* Gray (1852: 43), *P. coccineus* Linnaeus (1753: 724), *P. dumosus* Macfadyen (1837: 279), and *P. vulgaris* Linnaeus (1753: 723), and three wild, *P. albescens* McVaugh ex Ramírez-Delgadillo & Delgado (1999: 638), *P. costaricensis* Freytag & Debouck (1996: 157), and *P. parvifolius* Freytag in Freytag & Debouck (2002: 302). The cultivars of *Phaseolus vulgaris* are by far the most cultivated throughout the world, and its wild populations occur from southern Chihuahua, Mexico to north-central Argentina. Although the taxonomic literature on *P. vulgaris* is complicated by a plethora of specific and varietal [mostly cultivars] names, the species has been considered by most workers as having only two entities: the cultivar, *P. vulgaris* var. *vulgaris* and the wild Andean South American, *P. vulgaris* var. *aborigineus* (Burkart) C. Baudet (1977: 74), published first as *Phaseolus aborigineus* Burkart (Burkart 1952: 595) (Freytag & Debouck 2002). Variation of other wild populations have been recognized, such as *Phaseolus aborigineus* Burkart var. *hondurensis* Burkart, in Burkart & Brücher (1953: 67); however, it has been considered as an invalid name due that the authors do not accompanied it by a Latin diagnosis or description (Nelson 2002).
Freytag & Debouck (2002), while commenting on the naming of wild *Phaseolus vulgaris*, recognized among others, the wild populations of Ecuador as distinctive for their small-seeded fruits and reproductive isolation (Debouck et al. 1993, Kami et al. 1995). Porch et al. (2013) mentioned that these wild populations not only have a different phaëolin gene structure (encoding globulin seed storage proteins), but also, as suggested by previous studies (i.e., Kami et al. 1995, Chacón et al. 2007), support them as the ancestral population of *P. vulgaris*. However, recent population genetic analyses of nucleotide diversity have suggested a Mesoamerican origin for common bean (Bitocchi et al. 2012), with the state of Jalisco (Kwak et al. 2009) or the Oaxaca valley in Mesoamerica and southern Bolivia and northern Argentina in South America (Rodriguez et al. 2015) as centres of domestication. Hence, these authors concluded that the wild gene pool of Peru–Ecuador still deserved further attention. Recently, the Ecuadoran-northern Peru wild populations have shown to establish symbiotic nitrogen fixation with different strains of *Rhizobium* Frank (1889) other than *R. etli* Segovia et al. (1993) (Ribeiro et al. 2015), a trait consistent with the observation that symbiont preference shifts have accompanied *Phaseolus* diversification (Servín-Garcidueñas et al. 2014).

A recent reconstruction of the phylogenetic relationships of *Phaseolus* species, based on genome-wide single nucleotide polymorphisms uncovered that accessions from northern Peru and central-southern Ecuador formed a separate clade derived from Mesoamerican wild subpopulations, sister to all *P. vulgaris* genotypes, Andean and Mesoamerican. This entity represents an isolated surviving lineage that diverged from its sister species *P. vulgaris* some 1 Ma ago, much earlier than the split between the Mesoamerican and central-southern Andean wild populations of *P. vulgaris*, which occurred ca. 200,000 years ago, during the late Pleistocene (Rendón-Anaya et al. 2017). Given the above evidence, we addressed this entity provisionally treated as *pseudovulgaris*, and thus, we formalize here its name as *Phaseolus debouckii*.

### Material and methods

The description is based primarily on herbarium specimens and flower on living material grown from seeds provided by the Centro Internacional de Agricultura Tropical (CIAT), in greenhouse facilities at LANGEBIO-CINVESTAV. Comparative observations were made with NY herbarium specimens on loan at MEXU (Thiers 2011). Micro-morphological observations were made under a Scanning Electron Microscope (SEM, Hitachi SU510) in the Laboratorio de Microscopía y Fotografía de la Diversidad, Instituto de Biología, UNAM. A unified species concept *sensu* de Queiroz (2007) was employed to the recognition of this new species.

### Taxonomic treatment

*Phaseolus debouckii* A. Delgado, *sp. nov.* (Figs. 1, 2, 3).

Type:—ECUADOR. Chimborazo: Municipio Pallatanga, La Florida, 1 km al N de Pallatanga, 1°58’N, 78°07’W, 1610 m elev., 27 June 1990 (fl., fr.), Daniel Debouck et al. 2889 (holotype: MEXU!; isotype: P).

Diagnosis:—It differs from *Phaseolus vulgaris* by the combination of inflorescences with peduncles 1.0–4.0 cm long, rachis reduced to one or two floral nodes, and with two flowers per node; flowers pink, not purple or white, with a more tubular flower shape due to conspicuous wing petals; bracteoles cordate, 8–10 veined, persistent, and with a 100 seed weight of 7.1–12.7 g.

Description:—Herbaceous annual vines, with vigorous stems angulate and striate, up to 3.0 m long, densely to sparsely covered with straight-retrorse and hooked hairs. Stipules triangular to lanceolate, 2.5–5.0 × 1.0–3.0 mm, 5–9 veined, spreading, persistent. Leaves pinnately trifoliolate, with two flowers per node; flowers pink, not purple or white, with a more tubular flower shape due to conspicuous wing petals; bracteoles cordate, striate, 8–10 veined, persistent, and with a 100 seed weight of 7.1–12.7 g.

260 • *Phytotaxa* 313 (3) © 2017 Magnolia Press
the calyx in fresh material, persistent. Calyx campanulate, 3.5–4.0 (5.5) mm long, sparsely covered with antrorse hairs; upper two teeth connate, emarginate; lower and laterals teeth triangular, 1.0–2.0 mm long. Corolla pink, 1.5–1.8 × 0.8 cm; standards oblong to obovate, 0.85–1.0 × 0.6–1.0 cm, recurved at anthesis, glabrous, apex emarginate, thickening at point of reflexion, base biauriculate, with two flap-like appendages, ca. 1.0 mm; tongue-guide broad and smooth, basal claw ca. 3.0 mm long; wings obovate, 1.5–1.8 cm × 6.0–6.5 mm, blades close distally at anthesis, rounded-auriculate on the upper basal portion, claws ca. 4.0 mm long; keel 7.5–9.0 mm long, ca. 6.0 mm high, 1 1/2-coiled, with coils ca. 2.5 mm in diameter, keel transverse pouch ca. 1.0 mm, basal claws ca. 3.0 mm long. Androecium diadelphous, stamens 10, vexillar stamen ca. 1.0 cm long, with a blade-appendage toward the base, staminal tube ca. 1.5 mm, with 4 dorsifixed and 5 basifixed anthers, oblong, ca. 0.5 mm long; pollen triporate, tectate-perforated. Gynoecium at base, with a nectary basal disc, ca. 1.0 mm; ovaries linear, 6.5–7.0 mm, covered with intersparse straight-antrorse and minute hooked hairs; style pollen brush, mostly introrse; stigma introrse with stigmatic pad oblong, ca. 0.6 mm, surrounded by short and straight hairs. Legume linear-straight, slightly falcate, 6.0–7.5 cm × 0.8–0.95 mm, pendent, valves yellowish-brown, with maroon markings, covered with straight-antrorse and minute hooked hairs, slightly expanding over 5–8 seeds, beak 3.5–10.0 mm, strong elastically dehiscent. Seeds oblong-reniform, 6.5–8.0 × 4.5–5.5 mm; testa smooth and shiny, greyish-brown, usually mottled with black, hilum ovate, ca. 1.0–1.8 mm, with epiphilum, halo mottled with black, lens divided. Seedling with epigeal germination.

FIGURE 1. Distribution, habitat and flower and fruit of *Phaseolus debouckii*. A. Distribution map of *P. debouckii* in Ecuador and Peru based on MEXU herbarium specimens and CIAT seed collections; coloured dots correspond to the georeferenced herbarium and seed collections used in this study. B. Habitat, dry forest in Cajamarca, Peru. C. Flower. D. Pods. E. Plants on shrubs with dehiscent pods. Map by Carlos Gómez Hinostroza; C. photo by Ramón Pelagio Flores; B, D, E photos by Daniel G. Debouck.
Etymology:—The specific epithet honours Daniel G. Debouck, given his scholarly contributions, and extensive and systematic collections of wild and domesticated *Phaseolus* throughout the Americas. He was the first to discover this species during a field expedition in Peru (Debouck 1989, 1990). Seeds from one of these collections (G 21245) were sent to UC Davis, where allozyme analyses provided evidence of their uniqueness, not fitting in either the Andean or wild Mesoamerican *Phaseolus vulgaris*. Based on these results, funding for additional explorations in Ecuador and Colombia, were granted. Further analyses on newly collected materials provided additional evidence from which earlier papers by Debouck et al. (1993) and Kami et al. (1995) evolved.
**Distribution, habitat and phenology:** Known only from an area of 970 km on the mountains of central southern Ecuador and north western Peru, mostly in the region of the Amotape-Huancabamba Depression, from Cantón Pallatanga, Ecuador to the valley of Río Jequetepeque, Peru, at 900–2000 m elevation. It grows in low montane dry tropical forests and shrub lands, on soils derived from andesite (Fig.1). The Amotape-Huancabamba Depression has been recognized as a hot-spot of plant speciation (Weigend 2002, 2004). *Phaseolus debouckii* have been found with flowers in June and with mature fruits in May, June, July, and August.

**Interaction with birds, seed dispersal:** *Phaseolus debouckii* fruits and seeds have been reported to be eaten by human groups, and some animal species after which it has received local names: deer, “frijol venado”, and by pigeons and doves, “frijol de pugro or poroto de paloma” (Debouck et al. 1990). In Ecuador, several species of genera such as *Zenaida, Columba, and Columbina* are called “palomas”. *Zenaida asiatica* and its related species *Z. meloda* are common on SW Ecuador (Ridgely & Greenfields 2001), and their foraging behaviour on the fruits and seeds of *P. debouckii* could be indicative as dispersal agents (DeGraaf & Rappole 1995).

**Conservation status:** This species is not considered to be at risk at this time, due to the lack of an actual estimate of the population size; these statistics together with its occurrence within natural reserves or parks should be documented in the short term.

**Discussion and conclusion**

In contributing to the taxonomic study of the *P. vulgaris* group, we employ a unified species concept *sensu* de Queiroz (2007), in which recently diverged species are acknowledged to be evolving lineages with boundaries that are not only uniquely diagnosed by single morphological traits (Table 1), but by properties such as different distribution and ecological interactions, and where gene genealogies represent powerful evidence of species delimitation. Thus, with this evidence the sister species to the common bean is uncovered and here described.

**TABLE 1.** Features that differentiate wild Mesoamerican *Phaseolus vulgaris*, *P. debouckii*, and *P. vulgaris var. aborigineus*.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th><em>P. vulgaris</em> (Mesoamerica)</th>
<th><em>P. debouckii</em></th>
<th><em>P. vulgaris var. aborigineus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of inflorescence peduncle (cm)</td>
<td>4.0–32.0</td>
<td>1.0–4.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Number of floral nodes per infl.</td>
<td>6–10</td>
<td>1 (2)</td>
<td>4–8</td>
</tr>
<tr>
<td>Bracteole shape</td>
<td>ovate</td>
<td>cordate-lanceolate</td>
<td>ovate-lanceolate</td>
</tr>
<tr>
<td>Bracteole number of veins</td>
<td>7–10 (12)</td>
<td>8</td>
<td>5–7</td>
</tr>
<tr>
<td>Bracteole length (mm)</td>
<td>3.5–6.0</td>
<td>5.0</td>
<td>4.0–5.0</td>
</tr>
<tr>
<td>Bracteole width (mm)</td>
<td>2.5–3.5</td>
<td>3.0–3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Flower colour</td>
<td>purple, pink or white</td>
<td>pink</td>
<td>purple, pink, never white</td>
</tr>
<tr>
<td>Fruit width (cm)</td>
<td>0.5–1.0</td>
<td>0.8–0.9</td>
<td>0.6–1.0</td>
</tr>
<tr>
<td>No. of seeds/fruit</td>
<td>8–10</td>
<td>5–8</td>
<td>5–8</td>
</tr>
<tr>
<td>100 seed weight (g)</td>
<td>3.5–6.5</td>
<td>7.1–12.7</td>
<td>11.6–13.9</td>
</tr>
<tr>
<td>Seed length (mm)</td>
<td>5.5–10</td>
<td>6.5–8.0</td>
<td>5.0–10.0</td>
</tr>
<tr>
<td>Hilum length (mm)</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5–1.8</td>
</tr>
</tbody>
</table>


**Seed accessions from CIAT (G = accession number):**—ECUADOR. Chimborro: Azuay. Girón. 2 km SW de Girón, en El Salado, 1900 m elev., 21-06-1989, D.G. Debouck 2762 (G23579); Alausí, Huigra, en Pagma, 1710 m elev., 22-06-1989, D.G. Debouck 2769 (G23582); Capsol, Hacienda Huatagch en vía Sibambe-Capsol, 1870 m elev., 17-06-1990, D.G. Debouck 2865 (G23723); Pallatanga. La Florida, 1 km N de Pallatanga, 1610 m elev., 17-06-1990, 27-06-1990, D.G. Debouck 2889 (G23726); 1.7 km N de Pallatanga, 1640 m elev., 11-05-1993, *E. Neema III* (G51382); 2.2 km N de Pallatanga, 1690 m elev., 20-06-1993, *E. Neema I* (G51383); Sibambe, 13 km de Sibambe, 1740 m elev., 11-05-1993, *E. Neema II* (G51384). Loja: Macará. Eloy Alfaro, Los Cienegos, 8 km N de Macará, 960 m elev., 17-06-1990, 24-06-1990, D.G. Debouck 2881 (G23724); 9.5 km N de Macará, 1040 m elev., 11-05-1993, *E. Neema III* (G51385); Celica. 2 km S de Mullunuma, 1390 m elev., 24-06-1990, D.G. Debouck 2882 (G23725). PERU. Cajamarca: San Pablo. Caserío Sangal. 1 km N de Sangal, 2020 m elev., 13-08-1986, D.G. Debouck 1956 (G21244);
San Miguel. La Capeleña. 6 km al NW de La Conga, 1790 m elev., 15-08-1986, D.G. Debouck 1962 (G21245); Chota: Tocmoche. En Fila de Cashupe, 930 m elev., 15-08-1986, D.G. Debouck 2855 (G23585); 8 km NE de Fila de Cashupe, 1250 m elev., 15-08-1986, 01-08-1989, D.G. Debouck 2858 (G23587); Piura: Huancabamba. Canchaque, 1 km W de Santa Rosa, 920 m elev., 27-07-1989, D.G. Debouck 2788 (G23583); Huarmaca, en Pasayapampa, 1100 m elev., 31-07-1989, D.G. Debouck 2854 (G23584).

Acknowledgments

We wish to thank D.G. Debouck for supplying seed information and photographs of the species and its habitat, the curator of NY for the loan of specimens, and two anonymous reviewers and associate editor Leonardo Borges for helpful comments that improved the manuscript. We also thank Berenit Mendoza Garfias for assistance in SEM work, Albino Luna for the illustration, and Ramón Pelagio Flores, for the flower photograph. Technical assistance was also given by Julio César Montero Rojas and Carlos Gómez Hinostroza with figures. ADS wish to acknowledge Nicholas Turland for his assistance in taxonomic nomenclature and to María del Rosario García Peña for her support with loan materials. Funding for field explorations of *P. debouckii* was provided by IBPGR (now Bioversity) and the USDA NPGS.

References


https://doi.org/10.1073/pnas.1108973109


https://doi.org/10.1007/s00606-007-0536-z


https://doi.org/10.1007/BF02907356

https://doi.org/10.1600/03636406077969560


https://doi.org/10.1080/10635150701710183


https://doi.org/10.2307/3391913


