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# *Phaseolus albicarminus* (Leguminosae, Phaseoleae), a new wild bean species from the subhumid forests of southern central Costa Rica

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## Abstract

During a search for populations of wild common bean, namely south of the Central Valley of Costa Rica, a new bean species, *Phaseolus albicarminus*, has been found on the slope of a mountainous range named Cerros Llano Bonito in the western part of Talamanca range, where it appears to be endemic. Its main morphological features are: short pseudoracemes with four small deltoid primary bracts, small early caducous deltoid bracteoles, calyx lobes reduced to two lips, white wings contrasting with carmine purple inner face of standard, and smoothly curved 3–4 seeded pods with prow-shaped beak. The differences with apparently closely related species, *P. hygrophilus* and *P. angucianae*, are: in primary bracts (orbicular versus oval acuminate), larger bracteoles (cordate versus rounded), inner face of standard (pale pink to white versus purple), lower calyx lobes (rounded versus triangular), and pod dorsal suture (straight versus sigmoid), respectively. The fact that to date only three populations of P. albicarminus are known from the same small area of Costa Rica, calls for monitoring its conservation status. This new species is tentatively assigned to the section Brevilegumeni which seems well represented in Costa Rica (with five out of six taxa).

**Keywords:** endemism, montane forests, tropical legumes

## Resumen

Durante la búsqueda de poblaciones de fríjol común silvestre, al sur del Valle Central de Costa Rica, se encontró una nueva especie de fríjol, *Phaseolus albicarminus*, en la vertiente de una fila montañosa llamada Cerros Llano Bonito en la parte occidental de la Cordillera de Talamanca, de donde parece ser endémica. Se describen sus principales características morfológicas, tales como: pseudoracimos cortos con cuatro pequeñas brácteas primarias deltoideas, pequeñas bractéolas deltoideas pronto caedizas, partes terminales de los sépalos formando dos labios, alas blancas contrastantes con la cara interna rojo carmín del estandarte, y las vainas con 3–4 semillas, suturas suavemente curvas y pico en forma de proa. Las diferencias con las especies aparentemente cercanas, *P. hygrophilus* y *P. angucianae*, están en: las brácteas primarias (orbiculares versus ovales acuminadas), las bractéolas de mayor tamaño (cordiformes versus redondas poco acuminadas), la cara interna del estandarte (rosado muy pálido a blanco versus lila), los tres sépalos inferiores (redondos versus triangulares), y la sutura dorsal de la vaina (recta versus sigmoidea), respectivamente. El hecho que a la fecha sólo se conocen tres poblaciones de P. albicarminus, ubicadas en una pequeña área de Costa Rica, indica la necesidad de dar seguimiento a su estado de conservación. Esta nueva especie es tentativamente asignada a la sección Brevilegumeni, la cual parece bien representada en Costa Rica (con cinco de sus seis taxa).

**Palabras clave:** bosques de montaña, endemismo, leguminosas tropicales

## Introduction

The last taxonomic treatment of *Phaseolus* Linnaeus (1753: 723-725) (Leguminosae, Phaseoleae) for Costa Rica by Nelson Zamora (2010: 670-677) considered ten species. Five species were reported as cultivated forms: *P. acutifolius*

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Asa Gray (1850: 43), *P. coccineus* L. (1753: 724), *P. dumosus* Macfadyen (1837: 279), *P. lunatus* L. (1753: 724) and *P. vulgaris* L. (1753: 723). This author rightly noted that cultivation of the former two taxa is nowadays limited in this country of Central America. Tepary bean, *P. acutifolius*, has been reported by a few collections from Guanacaste, the province of Costa Rica that marks the end of its range in Pacific dry subtropical Mesoamerica (Debouck 1992). The scarlet runner, *P. coccineus*, has been cultivated in the central highlands as an ornamental, although its seeds are edible (Pittier 1957). The year-bean, *P. dumosus*, is grown together with maize in the increasingly fewer cases of this crop association in the Central Valley; it is also found as feral (Schmit & Debouck 1991). As noted by Zamora (op. cit. 671), many of the wild purple flowered *P. coccineus* seen by Standley (1937: 551) belong to *P. costaricensis* Freytag & Debouck (1996: 157). While the growing of Lima bean, *P. lunatus*, seems today restricted to indigenous communities in tropical parts of this country (Hazlett 1986), the common bean mentioned in the first historic records (compiled by Patiño 1964 and Solórzano-Fonseca & Quirós-Vargas 2014) continues to be a daily staple (Pittier 1957). Zamora (op. cit. 675 and 676) also rightly observed that for *P. lunatus* and *P. vulgaris* wild forms exist in Costa Rica, confirming previous findings (Debouck *et al.* 1989, Araya-Villalobos *et al.* 2001). These two works also reported the presence of *P. tuerckheimii* Donnell-Smith (1913: 54), bringing the number of known populations of it to seven at that time. During the preparation of field work, in the studies of Herbaria (namely CR and MO; acronyms of Herbaria along *Index Herbariorum,* Thiers 2019), a specimen *Davidse & Herrera 29127* of 1984 stood alone; it was afterwards determined as paratype of *P. talamancensis* Debouck & Torres in Torres-González *et al*. (2001: 280).

The presence of *P. microcarpus* Martius (1831: 18) has been recently confirmed as an annual vine legume of the tropical dry forest of northwestern Costa Rica (Debouck *et al.* 2019). A discovery was that of *P. hygrophilus* Debouck in Salcedo-Castaño *et al*. (2011: 54), found thanks to field work in premontane rain forest, because there were no specimens of it in Herbaria. In contrast, species no. 14, *P. angucianae* Debouck & Araya in Debouck *et al*. (2018: 508) had an unnamed specimen *Michael Grayum 10618* (studied at INB and MO), and additional field work in the Fila Cruces of southeastern Costa Rica was necessary to establish it as a valid species different from *P. talamancensis*. It is noteworthy that with the exception of few records of *P. leptostachyus* Bentham (1837: 72), *P. lunatus*, *P. oligospermus* Piper (1926: 698), and *P. xanthotrichus* Piper (1926: 698), all mentioned in the first flora of Costa Rica by Paul Carpenter Standley (1937), our taxonomic and floristic knowledge about the different *Phaseolus* species growing wild in Costa Rica is recent, and certainly deserves further attention given the potential of that germplasm for bean breeding. In this regard, *P. costaricensis* has been mentioned for its resistance to white mold (Schwartz & Singh 2013), a fungal disease that can cause a 100% loss in bean crop.

Here follows another case of a bean plant found during field work with no previous equivalent in the eighty-six Herbaria studied by one of us (DGD) in the period 1978–2019 (see list in Debouck 2019: 11). The first population of it was seen in 2012, and reported tentatively as *P. hygrophilus* in the exploration report (Debouck *et al.* 2012). But during the seed multiplication in Colombia, it became obvious that this plant was very different from *P. hygrophilus* and deserved a new name because it did not match with currently known species. In the meantime another new species, *P. angucianae,* was found in a southeastern mountainous range of Costa Rica (Debouck *et al.* 2018), and considered worth including in the diagnosis. The purpose of this paper is to present the main distinctive features of this new taxon.

## Materials & methods

Looking for populations of wild *P. vulgaris* in the upper Pirrís valley, on December 10, 2012, the authors went southwards from the capital city of San José across the mountainous range named 'Fila Bustamante' at the western end of the Talamanca range. They drove on a dirt road from Monterrey to La Legua and then to San Francisco, in the southern center of the San José province, district of León Cortés. At twilight they found a small population (*Debouck, Araya & Martínez 3242*, see Paratypes below) of a wild bean that they could not name. At the collection site, on hanging vines with mature pods, it was tentatively identified as *P. hygrophilus*. It was an explorer 'best-guess' because the leaflets although similar in size and shape to those of that taxon lacked the typical central variegation (Salcedo-Castaño *et al.* 2011). Two more populations (*Debouck, Araya & Chaves 3342* and *Debouck, Araya & Chaves 3347*) sharing the same morphology were found in 2017 not far from the first collection site, indicating that this plant was unlikely to be an exceptional bean variant, an escape from cultivation or an occasional hybrid.

The following observations were made on plants (of collections #3242, #3342 and #3347, see below) growing in the wild and freely for more than four years in closed greenhouse at CIAT experimental station of Popayán, Cauca,

Colombia (with GPS coordinates: lat. N 02º 31' 02.6"; long. W 76º 38' 04.8"; elev. 1,765 masl, on Andean inceptisol soil) and in growth chambers at CIAT headquarters from original seeds of collection #3242. Because there are no genetic alterations (first generation after original collecting in the wild, closed environment), the materials can be considered under the *Botanical Code* (viz. the Melbourne Code: McNeill *et al.* 2012), not the *Cultivated Plant Code* as aptly explained by Spencer and co-workers (Spencer *et al.* 2007: 58–59). The other materials used in comparative studies were: *P. hygrophilus* (*DG Debouck et al. 3172*, as specimens kept at GH-351974!, INB-4026793!, K!, and NY-1365122!; also as living plants of G40815 in CIAT genebank and cultivated in CIAT growth chambers and experimental station), *P. angucianae* (*DG Debouck et al. 3369*, as specimens kept at CR-286418!, and USJ-111488!), and *P. oligospermus* (*E Hernández-Xolocotzi 16694*, as specimens kept at COL-520054!, IEB-176152!, also as living plants of G40542, cultivated in CIAT growth chambers and experimental station). Maps 'Caraigres 3345-II' and 'Dota 3344-I' at 1:50,000 (1982) and 'Carta aeronaútica' at 1:500,000 (1991) by Instituto Geográfico Nacional of Costa Rica and satellite images (Google Earth 2019, namely to locate the Pirrís dam) were used as sources for Figure 8.

**TABLE 1.** Traits helping to distinguish between some species of section *Brevilegumeni* present in Costa Rica.

| Traits | *P. albicarminus* | *P. angucianae* | *P. hygrophilus* | *P. oligospermus* |
|---|---|---|---|---|
| plant size m | 4–6 | 1–2.5 | 4–6 | 4–8 |
| terminal leaflet base | rounded | truncate | rounded | truncate |
| variegation veins leaflets | absent | often present | always present | often present |
| length of raceme cm | 3–9 | 15–22 | 11–17 | 10–35 |
| no. 1$^{ary}$ bracts; length mm | 2–8; 2.5–4 | 5–9; 2.5–4.5 | 9–18; 5–6 | 5–16; 5–6 |
| shape of primary bracts | deltoid | oval acuminate | orbicular | deltoid lanceolate |
| bracteole shape, length mm | deltoid, 1.5 | rounded, 4 | cordate, 3.5 | lanceolate, 2 |
| free part upper sepal mm | 1 | 1 | 4 | 2.5 |
| color standard & wings | carmine + white | purple + pale lilac | pinkish + white | greenish + lilac |
| lower margin of wings | wrinkled | smooth | smooth | few wrinkles |
| pod length & width mm | 78 × 16 | 66 × 14 | 58 × 11 | 50 × 12 |
| pod beak and length mm | straight, 2–3.5 | stout, 2–4 | straight, 1.5–3 | recurved, 5 |
| shape of dorsal suture | straight | sigmoid | straight | straight |
| seed shape (lateral view) | oval | rounded squarish | circular, lenticular | rounded |
| seed length mm | 12–13 | 16 | 6 | 6.5 |
| 100-seed weight g | 23 | 6.5 | 6.4 | 5.8 |
| life zone* | bmh-P (Premontane wet forest) | bp-MB (Lower montane rain forest) | bp-P (Premontane rain forest) | bh-P (Premontane moist forest) |

* data from Araya-Villalobos *et al.* (2001) and present results, along to the classification of vegetation types defined by Bolaños-Montero & Watson-Céspedes (1993) and Sawyer & Lindsey (1971).

## Results

### Taxonomic treatment

***Phaseolus albicarminus*** Debouck & Chaves *sp. nov.* (Figures 1–9).

**Type:**—COSTA RICA. San José: León Cortés, distrito de Llano Bonito, 2 km SW de San Francisco, en terracería que baja a Bajo Moras. GPS: 1,965 m, 9º 40' 48.6"N, 84º 07' 21.4" W, 20 November 2018, *DG Debouck, R Araya Villalobos & N Chaves Barrantes 3347* (holotype here designated: USJ-111997!; isotypes: BRIT!, CR-282240!, F!, GH!, K!, MICH!, MO!, P!, UC!).

**Diagnosis:**—*Haec species Phaseolo hygrophilo Debouck et P. angucianae Debouck & Araya similis, sed differt ab ambobus speciebus racemis brevioribus. Differt a primo foliolis ad centrum non variegatis, bracteis primariis 2 usque 8 lanceolatis 2.5–4 mm longis, bracteolis triangularibus puberulis 1–1.5 mm longis, lobis superis calycis deminutis*

*ad labium 1 mm longis reductis, et vexillo adaxialiter carmino. Atque differt a secundo foliolis terminalibus ad basem rotundatis non truncatis, et bracteis pedicellaribus peranguste lanceolatis 1–2 mm longis, bracteolis triangularibus 1 mm longis, atque seminibus terni levioribus*.

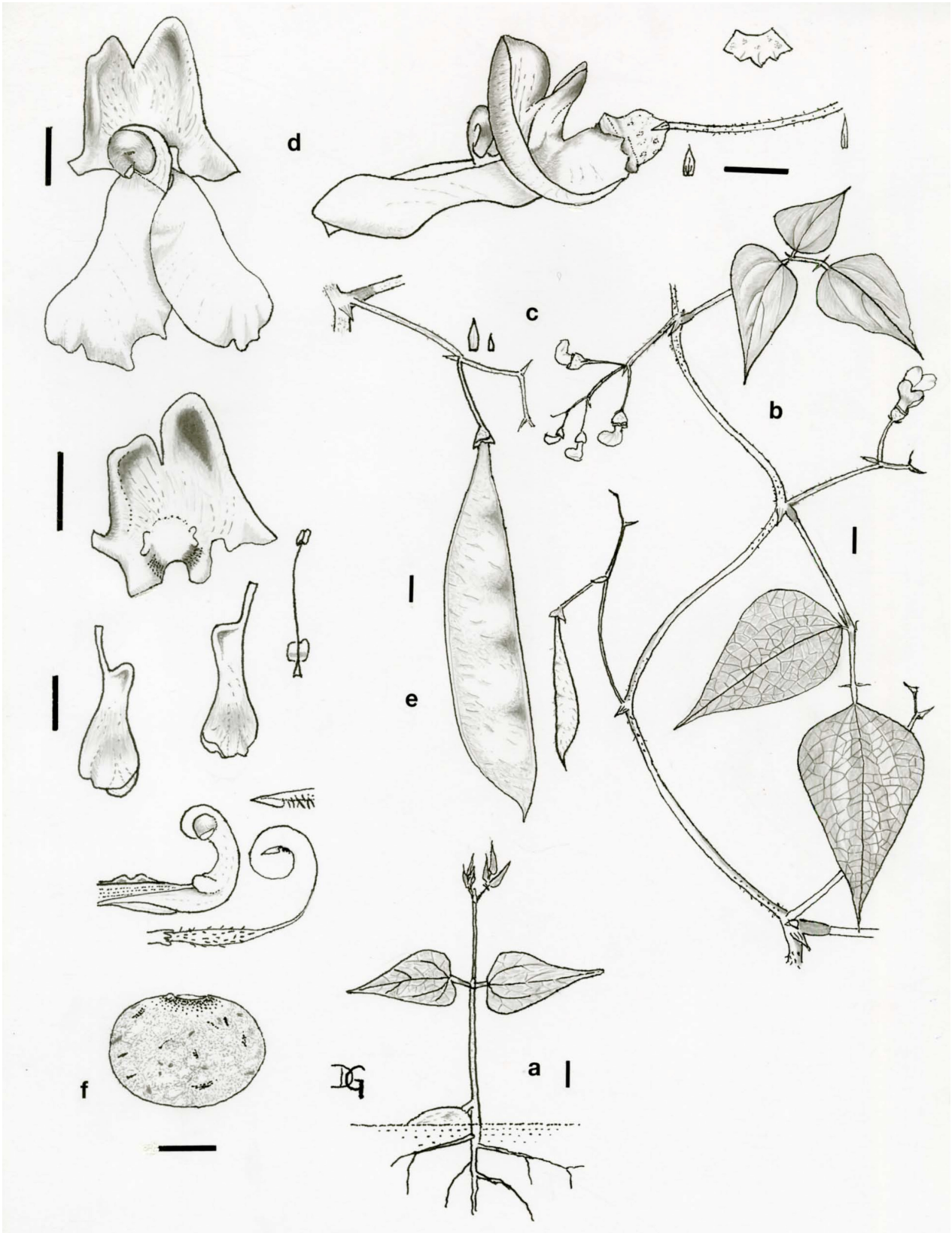


**FIGURE 1.** Drawing of *Phaseolus albicarminus* with all its parts.—a. Seedling.—b. Flowering and fruiting stem.—c. Raceme, with primary and pedicellar bracts in center left.—d. Flower, left front view, right lateral view (facing observer), upper right calyx (at full floral bud development), bracteole, pedicel, and pedicellar bract; lower left standard, wings, vexillar stamen, keel and staminal tube, ovary and style, stigma.—e. Pod near dry maturity.—f. Mature seed (lateral view). Scale bar 5 mm. Drawn by first author.


**FIGURE 2.** Early stages of raceme development in *P. albicarminus* (a, left) and *P. hygrophilus* (b, right). The bigger size of primary bracts in the latter results in a spherical shape of racemes during the first week of development. (photos by first author).

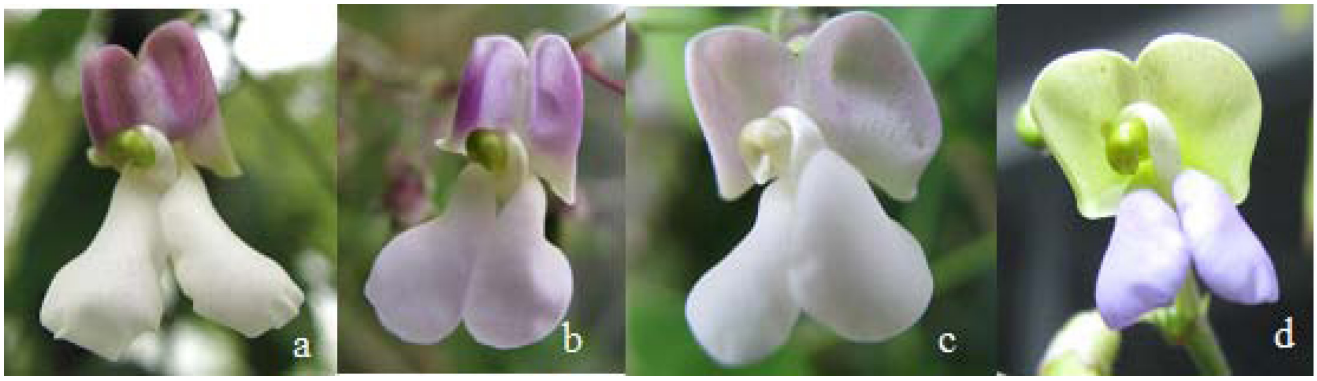


**FIGURE 3.** Front view of flowers facing observer: a—*P. albicarminus*, b—*P. angucianae*, c—*P. hygrophilus*, and d—*P. oligospermus*. Note the development of standard auricles in *P. albicarminus* and *P. angucianae*, and the greening cast of standard inner face in *P. oligospermus*. (photos by first author).

**Description:**—*Plant* a pluriannual (2–4 years) indeterminate vine 4–6 m high with 10–14 lateral inflorescences (Figure 1). *Seedling* total height 90 mm, from hypogeal germination (Fig. 1a), epicotyle 28 mm long brown, eophylls opposite petiolate, the blade triangular deltoid apiculate green no variegation 28–36 × 14–18 mm with cordate base, petiole terete 9 mm long, pulvini green, stipules united purplish 1 mm long. First true leaf trifoliolate. *Root* fibrous turning swollen woody with age below the cotyledonary node, diameter 13–22 mm, branched, 1 m 50 long and more, deep penetrating, epidermis corky tan brown. *Stem* an indeterminate climbing vine (Fig. 1b), the base with diameter 10–22 mm becoming woody with age, with guides twining in upper parts, one or two guides in lower parts trailing

on ground before climbing up. Lower internodes when young with capacity to produce adventitious roots. Internodes terete twining, 94–147 mm long, diameter 2.5–4 mm, green turning purplish with age or when exposed to light, puberulent with sparsely distributed straight hairs 1–2 mm long and minute uncinate hairs, these being distributed mainly close to the nodes. *Leaves* all trifoliolate (Fig. 1b) with pulvini, petioles and rachis, stipules and stipels, in distichous succession becoming non obvious because of stem torsion. Stipules triangular lanceolate basifix, glabrous, 4–4.5 mm × 2–3 mm, 5–7-nerved, green with base turning purple, covered by a few scattered short white hairs. Petiole terete, 42–67 mm long, green purplish speckled in upper parts of the plant (exposed to direct light), glabrous but with minute uncinate hairs throughout. Foliar rachis terete canaliculate, 17–23 mm long, green purplish speckled in upper parts of the plant (similarly exposed to light), glabrous but with minute uncinate hairs throughout. Pulvinus proximal 6–8 mm long, distal 3–4 mm long, active, green with fine red dots and short straight hairs. Stipels triangular lanceolate, 1.5–2 mm long, green but purplish at base, 2–3 veined, margins finely ciliate. Leaflet blade entire lanceolate apiculate, green (grass-green upper adaxial side, lighter green lower abaxial side, variegation absent), turning yellow when aging, terminal leaflet symmetrical 76–84 × 45–49 mm, lateral leaflets asymmetrical 65–49 × 43–33 mm. *Inflorescence* a short pseudoraceme, usually erect or slightly curved (Figs. 1c, 2a and 5a), with 2–6 axillary simple racemes of ascending flowering (i.e. the basal flowers of the firstly formed raceme bloom first). Peduncle 20–48 mm long, terete, green often purplish at base, covered by a few scattered short hairs and minute uncinate hairs, diameter 1.5 mm at base. Rachis 13–42 mm long, terete, purplish, covered by a few scattered short hairs and minute uncinate hairs, with (2–)4(–8) primary bracts, not straight but variously angled after second primary bract. Primary bracts persistent (Figs. 1c, 2a, 5a), deltoid, glabrous, green with central part purplish, 2.5–4 × 1.5 mm, with 5–7 noticeable veins. Pedicelar bract at the base of each pedicel (Figs. 1d right, 5a), narrowly lanceolate, purplish, 1–2 × 0.7 mm, glabrous with a few scattered hairs on the margin. Pedicel terete, purplish, 10–21 mm long, diameter 1 mm or less, glabrate with a few minute uncinate hairs, straight or slightly curved, often still present once flower has fallen (Fig. 5a top). Floral bud greenish finely purplish veined, purple at bend of standard, 4 mm long to bend 6 mm to tip. *Flower* papilionaceous asymmetrical, bicolor (Figs. 1d, 3a), usually two at each floral node of raceme, with one day difference in anthesis. Bracteoles, two, inserted at the base of calyx (Figs. 1d right, 4a), deltoid, purplish, 1–1.5 × 1 mm, 1/6 to 1/7 calyx length, finely 3-veined, covered with minute short hairs, usually falling shortly after anthesis. Calyx cupped, glabrous, slightly verrucose, purplish, 5.5 × 5 mm (Fig. 1d right, 4a); two upper sepals deep purple, almost united, obtuse, 5 mm long, the free part 1 mm long, forming a prominent lip; three lower sepals green with purple speckle, triangular, 5.5 mm long, the free part of the median sepal 1.5 mm long, almost forming a lip too. Standard asymmetrical (Fig. 1d left), claw 2 mm long; stipe 5 mm long, green turning light green to whitish at anthesis, ending into two earlobe-shaped 1.5 mm callosities (Fig. 1d left middle); outer face of standard from bend purplish glabrous, inner face from bend carmine red purple finely dark purple veined, fading purplish orange one day after anthesis (Fig. 5a), glabrous, narrowly rectangular, 11 × 10 mm, the upper margin with a median sinus 3 mm deep, both upper sides deeply concave, one side often more reflexed backwards, auricles on both sides well developed. Wings pure white (Fig. 4a), turning cadmium yellow one day after anthesis, spreading horizontally, blades obovate, 12–13 × 8 mm, overlapping first and then divergent, lower margin of the blade often slightly undulate, spur angled adhering to the keel, claws linear 8 mm long. Keel white, tubular (Fig. 1d lower part), asymmetrical, 2-coiled counterclockwise, free part of keel petals 5.5 mm, petals then united from the rounded pockets, each pocket adhering to one wing, 3 mm to the first coil, external coil white diameter 2 mm, last coil intense olive green shiny. Stamens diadelphous (9+1); staminal tube white, finely veined, 2.5 mm wide in the basal half, 7.5 mm long to the coil the diameter of which is 5 mm, claws 6.3 mm long, vexillar stamen 14 mm long, claw terete 1.5 mm, knob rounded cupped 1.5 × 1.2 mm, anthers yellow dithecal basifix 0.7 mm long. Ovary laterally compressed, 6.5 × 1.8 mm, light green, covered by a short dense brown pubescence, on a 1 mm white stipitate delicately crowned basis, with 3–4 ovules. Style terete, white, 14 mm long ending into 2 close coils, glabrous but with a brush of short hairs below the 0.8 mm terminal internal stigma (Fig. 1d lower part). *Pod* (Figs. 1e, 6a) laterally compressed prow-shaped, green till maturity then drying dark brown, 47–78 × 12–16 mm, beak 2–3.5 mm long and straight or barely curved, base shortly stipitate, valves obliquely finely striate puberulent, upper (placental) suture linear, lower suture lightly curved and definitely prow-shaped towards pod beak, containing (1)3(4) seeds. *Seed* oval symmetrical, 12–13 × 10 mm, 3–4 mm thick, 100-seed weight 23 g, smooth surface, shiny, cream background finely black speckled denser around the hilum with few black irregular spots (Figs. 1f, 7a).

**Comparisons of *P. albicarminus* with *P. hygrophilus* and *P. angucianae*:**—Among all species of *Phaseolus* sensu stricto reported so far for Costa Rica (Freytag & Debouck 2002, Zamora 2010, Salcedo-Castaño *et al.* 2011, Debouck *et al.* 2018), the diagnosis of *P. albicarminus* should concentrate on differences with the two aforementioned species and *P. oligospermus* (Table 1). If left intact (rural inhabitants in charge of cleaning rural road sides are paid to weed them out!), *P. albicarminus*, *P. hygrophilus* and *P. oligospermus* are much taller plants than *P. angucianae*. Although

the leaflets of *P. albicarminus* are similar in shape and size as those of *P. hygrophilus*, they lack the central variegation present on all leaflets of the latter taxon (Salcedo-Castaño *et al.* 2011). The axillary guides at the lower nodes of main stem in *P. hygrophilus* usually display a prostrate growth habit, while they soon start to climb in *P. albicarminus*. Other important morphological differences between these taxa are summarized in Table 1. Given the number and shape of primary bracts (Fig. 5), there is a sharp contrast in shape of the young developing racemes between the two taxa (Fig. 2). The flowers (facing observer) are shown in Figure 3, where the contrast of inner faces of standards can be seen; both standard auricles are reflexed in *P. albicarminus* and *P. angucianae* while only the left one in *P. hygrophilus*. The differences in calyx lobes can be seen in Figures 4 and 5, almost reduced to two lips in *P. albicarminus*. Bracteoles are almost insignificant in *P. albicarminus*, while developed in the other two taxa (Fig. 5). Pedicelar bracts are more developed in *P. angucianae* as compared to those of *P. albicarminus* (Fig. 5). Both *P. albicarminus* and *P. angucianae* have a greenish gold or olive green final coil of the keel, while this coil is white at anthesis in *P. hygrophilus* (Fig. 3). Pod length and shape differ between the four taxa (Fig. 6). The seed of *P. albicarminus* is a bigger one as compared to those of the other taxa (Fig. 7 and Table 1).

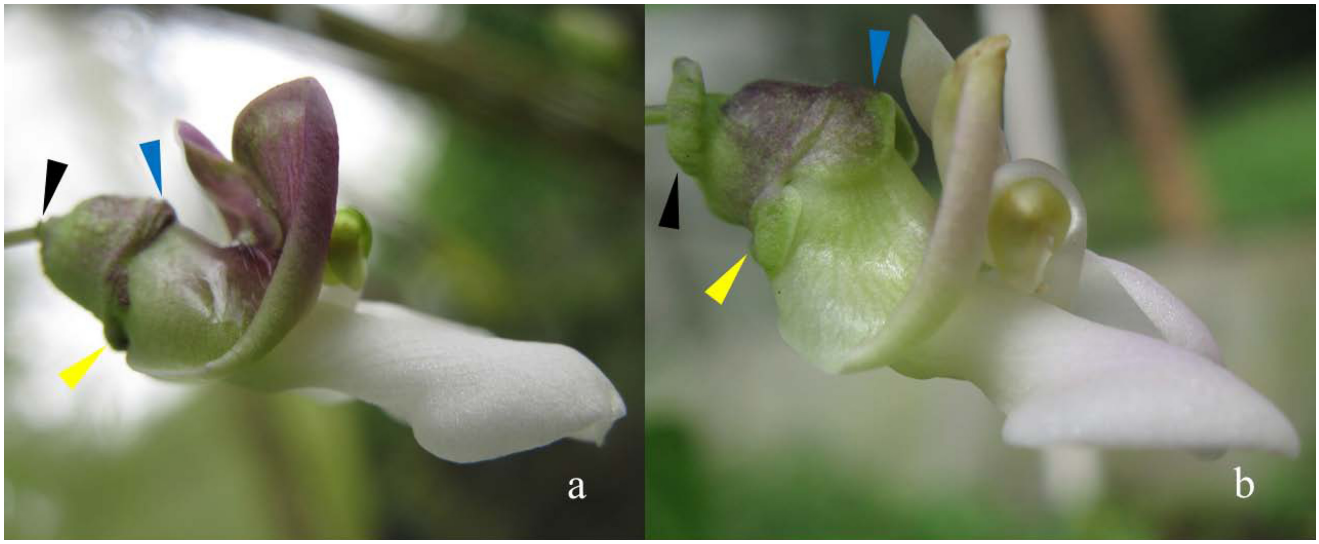


**FIGURE 4.** Lateral views of flowers: a—*P. albicarminus*, and b—*P. hygrophilus*; note size of bracteoles (black arrows), upper sepals (blue arrows) and lower sepals (yellow arrows) (photos by first author).

On the base of data presented in Table 1, the following key distinguishing these taxa can be provided.

1. Base of terminal leaflet of trifoliolate leaves truncate.....2
- Base of terminal leaflet of trifoliolate leaves rounded ..... 3
2. Plants at flowering usually higher than 2.5 m; primary bracts deltoid-lanceolate, 5–6 mm long; inner face of standard greenish; growing outside Fila Cruces..... *P. oligospermus*
- Plants at flowering shorter than 2.5 m; primary bracts elliptical, acuminate, 2.5–4.5 mm long; inner face of standard purple; growing in Fila Cruces ..... *P. angucianae*
3. All leaflets with central variegation; primary bracts rounded, cupped, 5–6 mm long; inner face of standard white pinkish..... ..... *P. hygrophilus*
- All leaflets without central variegation; primary bracts deltoid, 2.5–4 mm long; inner face of standard carmine red..... ..... *P. albicarminus*

**Etymology:**—The epithet was chosen because of the carmine color of the inner face of standard contrasting with the white wings (Fig. 3a). True bicolor flowers with white wings are relatively uncommon in this genus, specially in the wild; they have been reported in cultivated *P. coccineus* (Maréchal *et al.* 1978) and in a rare cultivated common bean variety from France named 'Coco rose d'Eyragues' (Leakey 1988). This color pattern is different from the slightly more frequent situation where the inner face of the standard has the same but darker color than that of the wings (occurring for example in *P. mollis* Hooker f. (1847: 228), an endemic bean from the Galápagos Islands; illustrated by McMullen 1999: 314).

**Geographic distribution, ecology and conservation status:**—With three populations known to date (Fig. 8), in spite of several surveys in Central Costa Rica in the period 1987–2017 (Debouck *et al.* 1989, Araya-Villalobos *et al.* 2001), it is difficult to assess the full range, but the new species seems to be rare, because the study of eighty-six Herbaria has not disclosed any specimen of this taxon. It was found on a slope of Cerros Llano Bonito SE of Cerro

Caraigres, itself part of the mountainous range 'Fila de Bustamante'. The life zone for that part of the slope is given as 'bmh-P' or premontane wet forest (Bolaños-Montero & Watson-Céspedes 1993), that occupies only 5.1% of the land in Costa Rica (Hartshorn 1983). In the upper part of its range (at 1,960 masl), the species is found sympatric with *P. costaricensis* (specimen *DG Debouck et al. 3259* as CR-281548! and specimen *DG Debouck et al. 3343* as CR-282235!), while in the lower part (1,590 masl) it is found together with wild *P. vulgaris* (specimen *DG Debouck et al. 3344* as CR-282237!). Given the deforestation in the area of one of the collections (Fig. 9), the conservation status of the species should be monitored all these years, even though visits to the original site in December 2015, January 2016 and January 2019 have reconfirmed its presence. In the wild, all three populations often displayed many racemes without any pod but just 3–6 small narrowly lanceolate primary bracts (this can be observed on specimen USJ-111443!). This low seed productivity further calls for a conservation assessment according to UICN (2017) criteria.


**FIGURE 5.** View of pseudoraceme terminal parts of: a—*P. albicarminus*, b—*P. hygrophilus* and c—*P. angucianae*, showing size and shape of primary and pedicelar bracts and bracteoles (photos by first author).


**FIGURE 6.** Pods of: a—*P. albicarminus*; b—*P. angucianae*; c—*P. hygrophilus*; and d—*P. oligospermus*. Note the curvature of the placental suture of pods (to the left in all photographs) and shape of pod beaks. The pubescence of pod valves in *P. oligospermus* is noteworthy. (photos by first author).

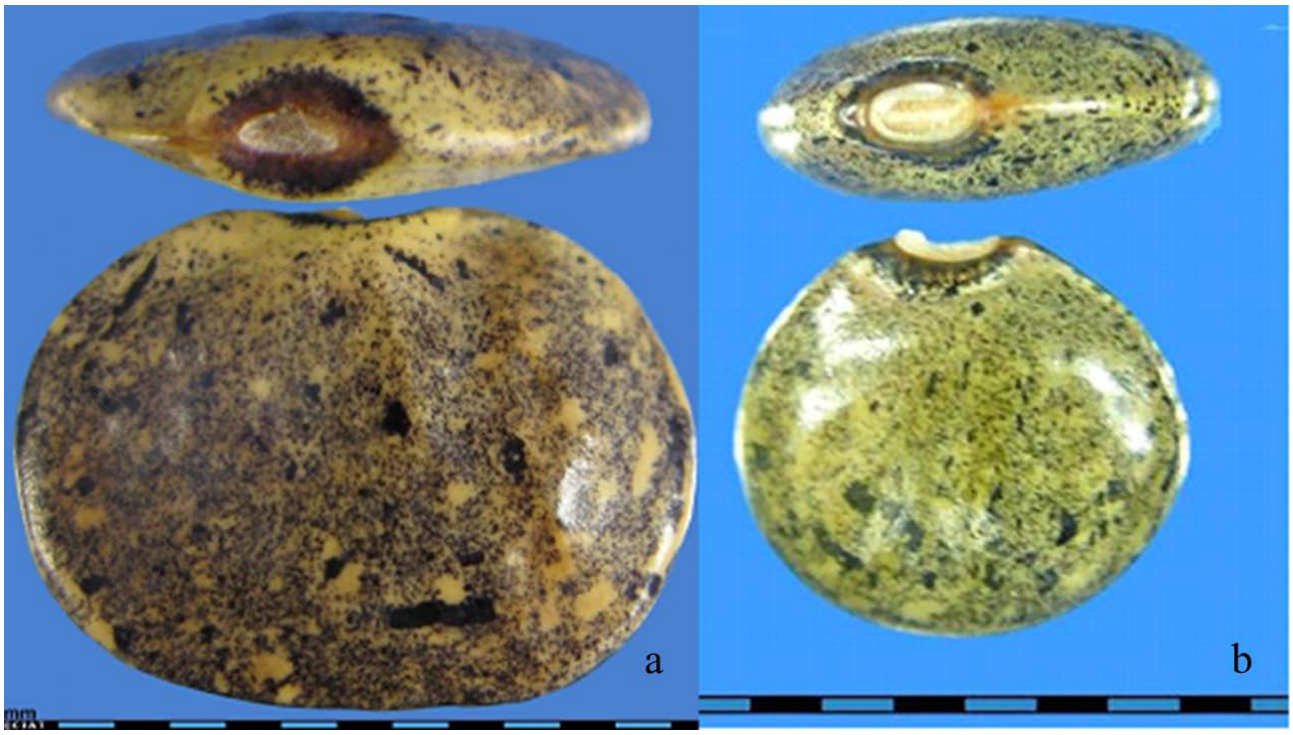


**FIGURE 7.** Seeds of: a—*P. albicarminus*, and b—*P. hygrophilus*; scale bar in mm (photos by Yurany García).

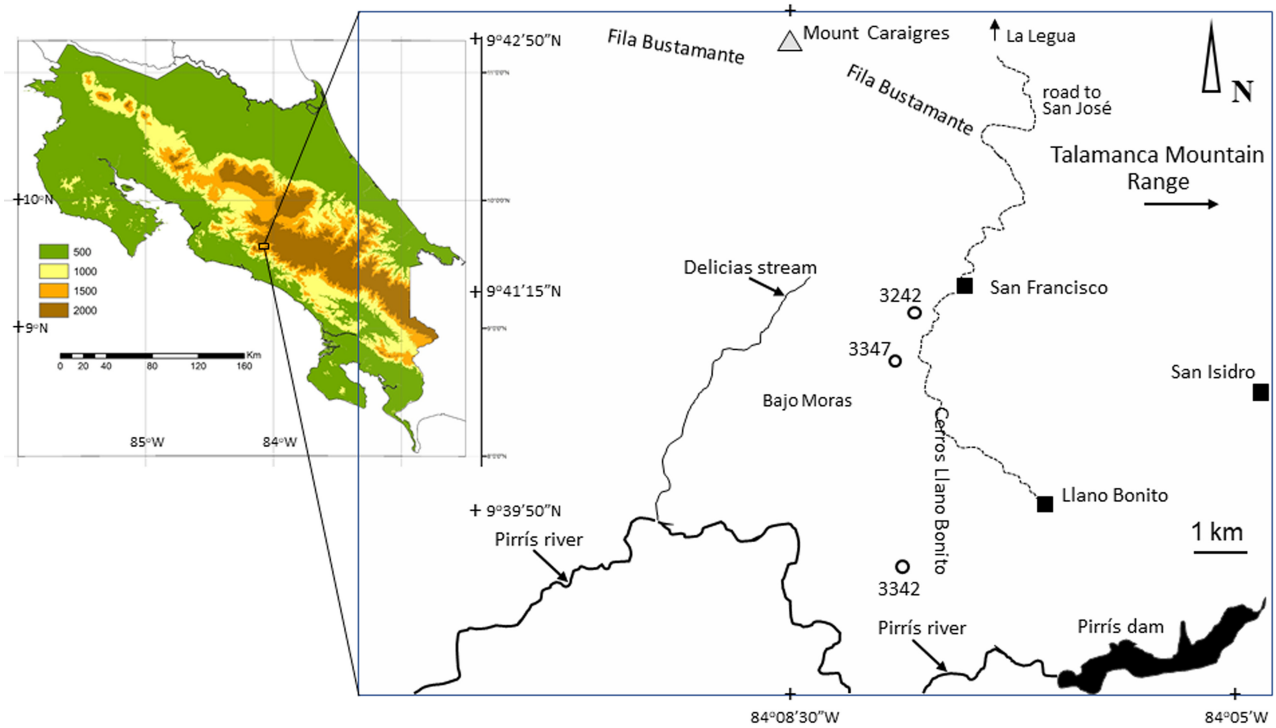


**FIGURE 8.** Geographic distribution of the populations of *P. albicarminus*, known to date. Drawn by first author.

**FIGURE 9.** Proximate surroundings of population #3242 (arrow) of *P. albicarminus*. The upper slope has been deforested to give way to a coffee plantation (photo by first author).

## Discussion

The aforementioned facts elicit the following points for discussion. The **first** point is the generic affiliation. The legume plant previously described is a *Phaseolus* sensu stricto along the current understanding of the genus (Maréchal *et al.* 1978, Lackey 1983, Schrire 2005, Delgado-Salinas *et al.* 2011), because of the presence of minute uncinate hairs on stems, peduncle and rachis of inflorescences, the trifoliolate leaves with basifix stipules, the rachis of pseudoraceme with persistent primary bracts and no extra-floral nectaries, the pedicel longer than the calyx, and the terminal stigma on a closely 2-coiled style. The very small bracteoles seem to fall early in floral development, but this trait has been observed in several *Phaseolus* sensu stricto species across different sections of the genus, for example *P. jaliscanus* Piper (1926: 697) in section *Paniculati*, *P. macrolepis* Piper (1926: 698) in section *Bracteati*, *P. parvulus* Greene (1881: 217) in section *Minkelersia* and *P. xanthotrichus* in section *Xanthotricha* (Freytag & Debouck 2002). The section of *Phaseolus* species reported for Costa Rica (Araya-Villalobos *et al.* 2001, Zamora 2010, Debouck *et al.* 2018) and across the Neotropics (Porch *et al.* 2013), to which this bean plant could belong, makes a **second** point. The broad (1–)3(–4)-seeded pod (Fig. 1e, Fig. 6) and floral characteristics (primary bract, bracteole, calyx) would indicate a relationship with the section *Brevilegumeni* Freytag (Freytag & Debouck 2002)—of which *P. oligospermus* is the reference species. Under the definition of current sections, no other relationship could be indicated. This brings us to a **third** point: the identity of this bean plant and differences with any of the existing species reported so far (Table 1; Porch *et al.* 2013, Ulloa Ulloa *et al.* 2018 onwards, Dohle *et al.* 2019). In Table 1, the reader will note the absence of other members of the *Brevilegumeni* section, namely *P. campanulatus* Freytag & Debouck (2002: 224) (because of its much longer racemes, 5-ovules pods, and distribution restricted to western Mexico (Debouck 2019) and that of *P. tuerckheimii* (because of its bigger plant size, densely pubescent leaflets, and much longer multi-flowered racemes; Freytag & Debouck 2002).

Although this new taxon shares some traits such as leaflet size and shape with *P. hygrophilus*, the differences summed up in Table 1 and Figs. 2–7, namely in plant size, characteristics of the inflorescence and the calyx, are thought to be strong enough as to warrant a specific rank, not a varietal one. There would be ecological differences too: although the number of populations known to date for these taxa is quite low—three for *P. albicarminus* and four for *P. angucianae* and *P. hygrophilus*—for example, the amount of rainfall (in mm/ year) at the collection sites has been estimated at 2,200 for *P. albicarminus* and over 3,200 for *P. angucianae* and *P. hygrophilus* (Herrera 1985, Bolaños-Montero *et al.* 2005, and Table 1). The former taxon was found in a transition wet forest without tree ferns and with epiphytic mosses, while the latter two were found in rain forests with tree ferns and many epiphytic species in the orchid and bromeliad families (Debouck *et al.* 2018, Salcedo-Castaño *et al.* 2011, respectively). These field observations are in agreement with the distinctions made between these kinds of forest (Holdridge *et al.* 1971, Sawyer & Lindsey 1971, Hartshorn 1983, Zamora *et al.* 2004). Interestingly, each of the different species reported in Table 1 seems to colonize a different life zone in Costa Rica; this seems particularly true for the unique floristic region of Puriscal–Los Santos (Zamora *et al.* 2004) where *P. albicarminus* and *P. hygrophilus* occur but not together. **Fourth**, one should mention that *P. albicarminus* has been first found during a field exploration, apparently with no previous record in Herbaria. It has been found without Geographic Information System (GIS) models that have been useful for disclosing additional populations of other taxa (Jarvis *et al.* 2002, 2005), since there were no data to build the GIS model on. **Finally**, and concluding, although the core of distribution of *Phaseolus* species seems to be in western Mexico (Nabhan 1990, Ramírez-Villegas *et al.* 2010, Delgado-Salinas *et al.* 2011), field work in Costa Rica continues to be rewarding with the addition of a couple of endemic species (*P. angucianae, P. hygrophilus*, *P. talamancensis*; Zamora 2010, and present results). As aptly noted by Ulloa Ulloa and co-workers (2017), with the addition of 744 species on average each year, the flora of the Neotropics is still being disclosed and written!

Paratypes:—COSTA RICA. San José: León Cortés, Llano Bonito, 2 km SW de San Francisco, 3 km NE de Paritilla. GPS: 1,837 m, 9º 41'12.9"N, 84º 07' 12.4"W, 10 December 2012, *DG Debouck, R Araya Villalobos & K Martínez Umaña 3242* (CR-281568!, USJ-111442!). COSTA RICA. San José: León Cortés, Llano Bonito, 6 km SW de Llano Bonito, 1 km N de Santa Juana de León Cortés. GPS: 1,649 m, 9º 39' 18.7"N, 84º 07' 17.7" W, 28 January 2017, *DG Debouck, R Araya Villalobos & N Chaves Barrantes 3342* (CR-282236!, USJ-111444!).

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