NEW RECORDS OF *PHASEOLUS MICROCARPUS* (LEGUMINOSAE: PHASEOLEAE) FOR COSTA RICA

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ABSTRACT

Evidence is presented about the presence of *Phaseolus microcarpus* in Costa Rica, while it was previously reported northwards in other Central American countries and Mexico. Fourteen populations are currently known, four from the Peninsula of Nicoya, and ten are in the tropical dry forest of the mainland of this country.

RESUMEN

Se presenta evidencia sobre la presencia de *Phaseolus microcarpus* en Costa Rica, que sólo estaba reportado al norte en otros países centroamericanos y México. Se conocen actualmente catorce poblaciones, cuatro en la Península de Nicoya, y diez en el bosque seco tropical de la parte principal de este país.

KEY WORDS: phytogeography, protected areas, tropical dry forest, tropical legumes

INTRODUCTION

On March 16, 2008, Barry Hammel and Isabel Pérez went south from Arado in the Peninsula of Nicoya, Costa Rica, towards the mountainous range of Cerro Brujo and Vista al Mar and collected a little herbaceous legume (*Hammel 24516*) tentatively named *Desmodium* (see in the Discussion below why this identification could make sense). The same year in December, Nelson Zamora identified it as *Phaseolus lunatus* L. In his review of the legume family for the *Flora of Costa Rica*, Zamora (2010:671) wrote "Es factible encontrar *Phaseolus microcarpus* Mart. (Méx. y Guat., El Salv., Nic.) en CR, tal vez en las llanuras de Guanacaste" but without mentioning any specimen, opening up the possibility of finding this species in Costa Rica. One of us (DGD) saw that plant at the Herbarium of Instituto Nacional de Biodiversidad during a visit in March 2013 and identified it as *Phaseolus microcarpus* Mart. Could this species be another of the Crop Wild Relatives (CWRs) of bean for Costa Rica, of which we knew fourteen species at that time? In order to answer that question, more field work was necessary and we headed to Nicoya.

RESULTS

Four exploration trips were carried out in NW Costa Rica in the period 2015–18, and resulted in the disclosure of 13 populations of that taxon (14 in total, including the previous herbarium record) (Table 1; Figs. 1 & 2).

Known Populations of *Phaseolus microcarpus*: **COSTA RICA. Guanacaste:** Cañas, Porozal, 2.3 km NW sobre el camino a Porozal desde el cruce con la ruta 18 (Limonal – Nicoya), GPS: 10°14'27.9"N, 85°11'24.7"W, 109 m, 10 Dec 2018, *N Chaves Barrantes 0015 & R Araya Villalobos* (CR296554, USJ112031); La Cruz, Santa Elena, 7.7 km SW de Cuajiniquil, a partir del cruce de la ruta 914 y el bulevar de entrada a Cuajiniquil, continuando por el camino hacia el Centro de Formación Policial Murciélago, 0.08 km W del final de la pista de aterrizaje en camino hacia entrada del Parque Nacional Santa Rosa sector Murciélago, 10°54'19.3"N, 85°43'18.9"W, 21 m, 11 Dec 2018, *N Chaves Barrantes 0018 & R Araya Villalobos* (CR296559, USJ112032); Santa Cruz, Santa Cruz, poblado Arado, ladera norte del Cerro Brujo, 8 km SW de Arado, 10°10'33.0"N, 85°37'22.8"W, 511 m, 10 Dec 2015, *DG Debouck 3263, R Araya Villalobos & N Chaves Barrantes* (CR281549, NY, USJ111471); La Cruz, Santa Elena, riscos de Bahía Junquillal, 10°57'44.5"N, 85°41'52.1"W, 39 m, 22 Nov 2016, *DG Debouck 3284, R Araya Villalobos & N Chaves Barrantes* (CR282178, USJ111510); Santa Cruz, Arado, 1 km SW de entronque de la terracería de Arado con la pista de entrada al Parque Nacional Diriá, 10°12'01.1"N, 85°36'10.2"W, 293 m, 23 Nov 2016, *DG Debouck 3292, R Araya Villalobos & N Chaves Barrantes* (CR282187, USJ111507); Nicoya, Quebrada Honda, 1 km W de Puerto Moreno, antiguo atracadero occidental sobre el Río Tempisque, 10°12'17.2"N, 85°15'04.0"W, 32 m, 25 Nov 2016, *DG Debouck 3298, R Araya Villalobos & N Chaves Barrantes* (CR282193, USJ111506); Cañas, Porozal, 1–2 km E de Puerto Níspero, antiguo atracadero oriental sobre el Río Tempisque, 10°13'12.2"N, 85°13'12.8"W, 26 m, 25 Nov 2016,

Table 1. Some ecological parameters of the fourteen populations known to date. Sources: [1] Bolaños-Montero et al. 2005, where bh-T is tropical moist forest, bh-P is premontane moist forest, bs-T is tropical dry forest, bh-T seco is tropical moist forest dry province transition, bh-P basal is premontane moist forest basal belt transition; [2] Herrera-Soto & Gómez-Pignataro 1993, where 54 is tropical moist with 5–6 dry months, 55 is tropical moist (drier than 54) with 5–6 dry months, 41 is subtropical moist with 5 or 6 dry months, 52 is tropical moist with 5 or 6 dry months. The proximate surrounding is reported from collectors' field notes.

Collection No.	Life zones[1]	Biotic units[2]	Proximate surrounding
15	bh-T	54	road side
18	bh-P	55	road side
3263	bh-T	41	rocky outcrop
3284	bs-T	55	top of cliff
3292	bh-T	41	embankment
3298	bh-T seco	54	rocky outcrop
3299	bh-T seco	54	rocky outcrop
3300	bh-P basal	55	embankment
3321	bh-P basal	55	rocky outcrop
3322	bh-P basal	55	rocky outcrop
3323	bh-P basal	55	behind the beach
3324	bh-P basal	55	road side
3326	bs-T	55	embankment
24516	bh-T	52	unknown

DG Debouck 3299, R Araya Villalobos & N Chaves Barrantes (CR282191, GH, K, MO, USJ111474); Abangares, Colorado, 1 km SE de la planta CEMEX en terracería hacia San Buenaventura, a 4 km desde carretera 18, 10°11'51.4"N, 85°10'59.8"W, 44 m, 25 Nov 2016, *DG Debouck 3300, R Araya Villalobos & N Chaves Barrantes* (CR282192, USJ111499); Liberia, Nacascolo, Parque Nacional Santa Rosa, 6 km WSW de Casona histórica del Parque, en el camino a Playa Naranjo, 10°48'17.1"N, 85°38'26.2"W, 186 m, 24 Jan 2017, *DG Debouck 3321, R Araya Villalobos & N Chaves Barrantes* (CR282214, USJ111483); Liberia, Nacascolo, Parque Nacional Santa Rosa, 7 km WSW de Casona histórica del Parque, en el camino a Playa Naranjo, 10°47'55.1"N, 85°38'35.6"W, 86 m, 24 Jan 2017, *DG Debouck 3322, R Araya Villalobos & N Chaves Barrantes* (CR282215, USJ111482); Liberia, Nacascolo, Parque Nacional Santa Rosa, 1.5–2 km S de Casona de Playa Naranjo por Sendero Carbonal, 10°46'33.9"N, 85°39'33.8"W, 9 m, 24 Jan 2017, *DG Debouck 3323, R Araya Villalobos & N Chaves Barrantes* (USJ111562); Liberia, Nacascolo, Parque Nacional Santa Rosa, 0.8 km NEE de Casona de Playa Naranjo por terracería hacia Casona histórica del Parque, en el cruce de la pista hacia Estación Biológica Nancite, 10°47'59.8"N, 85°38'55.9"W, 21 m, 24 Jan 2017, *DG Debouck 3324, R Araya Villalobos & N Chaves Barrantes* (CR282217, USJ111484); La Cruz, Santa Elena, 1 km NW del cementerio de Junquillal, 10°57'05.5"N, 85°41'45.5"W, 19 m, 25 Jan 2017, *DG Debouck 3326, R Araya Villalobos & N Chaves Barrantes* (CR282219, USJ111509); Santa Cruz. No protegida, Cuenca del Tempisque, Rumbo a Cerros Brujo y Vista al Mar desde Arado, 10:12:29.0000N, 85:35:58.0000W, 200 m, 16 Mar 2008, *B Hammel 24516, I Pérez* (INB4136116).

Phaseolus microcarpus was found inland and close to the Pacific Ocean in the Guanacaste province (Figs. 2 & 3). The populations known to date are distributed in four locations: cliffs of and spots around Junquillal bay, transect Casona—Playa Naranjo in Santa Rosa National Park, transect Arado—Diriá, and rocky outcrops flanking the Tempisque estuary (where three populations #15, #3299 and #3300 enter into the mainland of Costa Rica). The altitude range was from sea level (#3323) to over 500 m (#3263). Field observations (Table 1) indicate that in 9/14 cases the plants were found on top of a cliff or at the bottom of a rocky outcrop (Fig. 4) or a roadside embankment of 2 m or higher, meaning a proximate topography of the collection site where agriculture or cattle ranching would have been difficult (meaning clearing the land by fire was purposeless; see Discussion). Field observations also indicate that *P. microcarpus* is a heliophilous legume thriving in open spaces and not in the shade.

DISCUSSION

First, the presence of *P. microcarpus* is fully confirmed for the flora of Costa Rica (making it species no. 12 for that country; Table 2 in Debouck et al. 2018). The 14 records at different times and in different places of the Peninsula of Nicoya and around it are a clear indication that it is not an accidental weed but a native legume of the Neotropical dry forest. Further, the current distribution in four areas of the Guanacaste province (Figs. 2–4) seems not related to seed distribution by humans, for example along the Inter-American highway or the ways leading to the main towns and villages for cattle sale (a major activity in Guanacaste for four centuries:

Fig. 1. Flower (**left**) and pods (**right**) of population #3263 of *Phaseolus microcarpus*. For scale note that pedicel of first pod to the left is 10 mm long. Yellow arrow to the right indicates the adaxial suture.

Sequeira-Ruíz 1985; Allen 2001). It may suggest instead a relictual distribution before the spread of human induced fires and the introduction of African grasses *Hyparrhenia rufa* (Nees) Stapf, *Brachiaria mutica* (Forssk.) Stapf, and *Panicum maximum* Jacq. (Parsons 1972; Boucher et al. 1983; Sequeira-Ruíz 1985). Being an annual legume with a fibrous root system (Freytag & Debouck 2002), *P. microcarpus* survival is through its seeds only, probably not lasting long under frequent fire. Burning pasture at the end of the dry season has been common practice in Guanacaste to accelerate the sprouting of grasses for cattle feeding (Sequeira-Ruíz 1985). In contrast to pyrophytic African legumes, for example, in *Adenodolichos* Harms, *Vigna* Savi sect. *Liebrechtsia* (De Wild.) Baker, and *Physostigma* Balf. (Maréchal et al. 1978; Schrire 2005), many legume genera of the Neotropical lowlands (e.g., *Calopogonium* Desv., *Centrosema* (DC.) Benth., *Condylostylis* Piper, *Macroptilium* (Benth.) Urban, and *Phaseolus* L.; our field observations in Costa Rica) lack this adaptive trait of survival after recurrent fire.

Second, the records indicate that *P. microcarpus* thrives in 1–2 humid variants of the tropical dry forest in the lowlands of Guanacaste and in the premontane moist forest in the mountainous area of Diriá, respectively. These vegetation types are defined according to Bolaños-Montero et al. (2005), and correspond to four biotic units (41, 52, 54, and 55) of Herrera-Soto & Gómez-Pignataro (1993). In these habitats it seems to be an early species drying off when the dry season arrives and many trees (e.g. *Acacia, Bursera, Pachira,* and *Tabebuia*, found in association with it) become deciduous. Because of its very small flowers and tiny pods (Fig. 1) it may have escaped attention by plant collectors for long.

Third, this case stresses again the importance of checking for specimens of targeted plants in herbaria prior to a germplasm exploration (as recommended by von Bothmer & Seberg 1995). A plant explorer for beans should check whatever legume that could have been considered as a bean, in this case even *Desmodium* Desv. in another tribe, the *Desmodieae* (Benth.) Hutch. (Ohashi 2005)! The one-seeded pod sticks to explorer's clothing (because of the minute uncinate hairs) as does the loment of *Desmodium* (because of the same pubescence; Ohashi et al. 1981). In *P. microcarpus,* the mature pod longitudinally splits along the adaxial suture rather than explosively opens, or falls out the raceme, and thus in contrast to most *Phaseolus* species seed dispersal is by gravity, possibly wind and little superficial water.

Fourth, the presence of *P. microcarpus* in Costa Rica may be an indication that wild beans travel over geological times, as it has been shown on wild Lima bean (Serrano-Serrano et al. 2010) or wild common bean

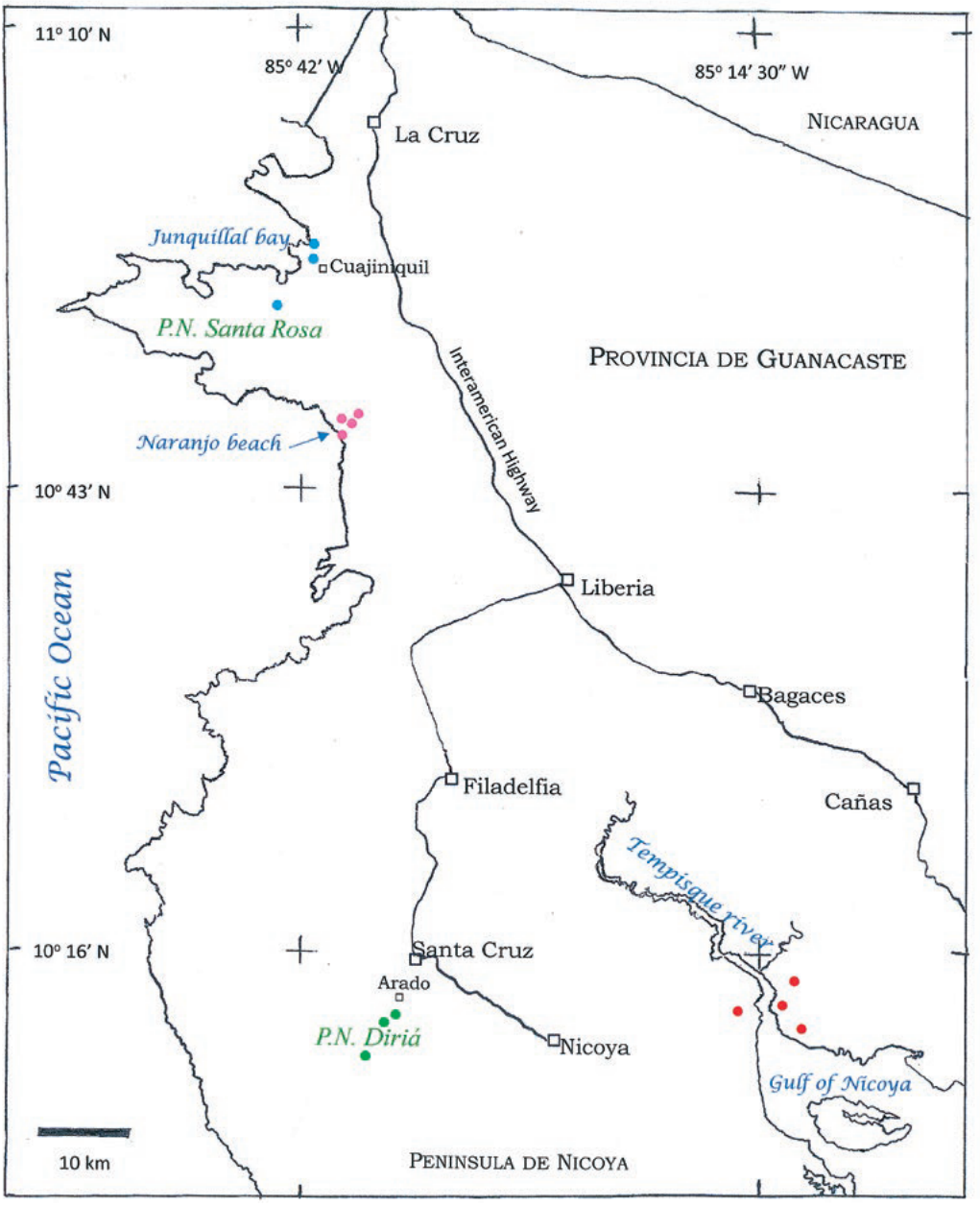

Fig. 2. Distribution map of the populations of *Phaseolus microcarpus* in Costa Rica known to date. **Blue dots:** Junquillal Bay area; **rose dots:** Naranjo sector of Santa Rosa National Park; **green dots:** sector close to Diriá National Park; **dark red dots:** sector of estuary of Tempisque River. Base map after Bolaños-Montero et al. (2005).

Fig. 3. Population #3284 growing on top of a cliff at Junquillal Bay, facing the Pacific Ocean (red arrow points to a couple of trifoliolate leaves of a *Phaseolus microcarpus* vine covering the bush).

(Rendón-Anaya et al. 2017). While it seems to be abundant in the states of Oaxaca and Michoacán (from where the type was described in 1831), Mexico, it does extend northwards into the state of Durango, and southwards into the department of Francisco Morazán, Honduras and that of Zacapa, Guatemala (Freytag & Debouck 2002). It has been reported in Ahuachapán and La Unión, El Salvador (Debouck 2018) and in five departments of Nicaragua (Delgado-Salinas 2001; Debouck 2018). The records reported herein may indicate its southern limit.

Fifth, it is positive news that the national parks of Santa Rosa and of Diriá and the Junquillal Bay National Wildlife Refuge harbor several populations of *P. microcarpus* (four, one and one, respectively, because of this research), if fires are controlled within these protected areas. With the outstanding exception of UNESCO biosphere reserve of Manantlán in SE Jalisco, Mexico, established for two relatives of maize and indirectly protecting eight species of bean (Vázquez-García et al. 1995), few protected areas across Latin America have full inventories of the CWRs within their borders.

Finally, finding *P. microcarpus* close to the sea (#3284 is certainly exposed to ocean spray; Fig. 3; and #3323 was found close to a mangrove) raises the question about tolerance to salinity. The few accessions of *P. microcarpus* tested so far have shown to be sensitive to salinity stress, while the few accessions of *P. macvaughii* A. Delgado found on coastal Jalisco, Mexico, were tolerant (Bayuelo-Jiménez et al. 2002). Similar differences in salinity tolerance between populations over short distances have been observed in wild tomatoes (Rick 1979). *Phaseolus microcarpus* seems distant to any bean cultigen for direct gene transfer (Delgado-Salinas et al. 2006; Porch et al. 2013); it might, however, be an interesting model in future salinity studies.

Fig. 4. Overview of population #3299 at the bottom of a rocky outcrop E of the ferry wharf at Puerto Níspero (now abandoned because of the bridge 'Amistad de Taiwan' over the Tempisque River) (red arrows point to individual plants).

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REFERENCES

Allen, W. 2001. Green phoenix: Restoring the tropical forests of Guanacaste, Costa Rica. Oxford Univ. Press, New York, U.S.A.

Bayuelo-Jiménez, J., D.G. Debouck, & J. Lynch. 2002. Salinity tolerance in *Phaseolus* species during early vegetative growth. Crop Sci. 42(6):2184–2192.

Bolaños-Montero, R., V. Watson-Céspedes, & J. Tosi-Olin. 2005. Mapa ecológico de Costa Rica. Centro Científico Tropical. Scale 1:400.000. 1 sheet, San José, Costa Rica.

Boucher, D.H., M. Hansen, S. Risch, & J.H. Vandermeer. 1983. Agriculture – Introduction. In: D.H. Janzen, ed. Costa Rican natural history. The Univ. of Chicago Press, Chicago, Illinois, U.S.A. Pp. 66–73.

Debouck, D.G. 2018. Cahiers de phaséologie: *Phaseolus microcarpus*. Centro Internacional de Agricultura Tropical, Cali, Colombia. Pp. 1–67. https://ciat.cgiar.org/what-we-do/crop-conservation-and-use (under "Publications: Program Files"). Accessed 15 Dec 2018.

Debouck, D.G., R. Araya-Villalobos, & N. Chaves-Barrantes. 2018. *Phaseolus angucianae* (Leguminosae: Phaseoleae), a new bean species from Fila Cruces of southeastern Costa Rica. J. Bot. Res. Inst. Texas 12(2):507–520.

Delgado-Salinas, A.O. 2001. *Phaseolus* L. In: W.D. Stevens, C. Ulloa-Ulloa, A. Pool, & O.M. Montiel, eds. Flora de Nicaragua - Angiospermas (Fabaceae - Oxalidaceae). Missouri Botanical Garden Press, St. Louis, Missouri, U.S.A. Pp. 1042–1046.

Delgado-Salinas, A., R. Bibler, & M. Lavin. 2006. Phylogeny of the genus *Phaseolus* (Leguminosae): a recent diversification in an ancient landscape. Syst. Bot. 31:779–791.

Freytag, G.F. & D.G. Debouck. 2002. Taxonomy, distribution, and ecology of the genus *Phaseolus* (Leguminosae-Papilionoideae) in North America, Mexico and Central America. Botanical Research Institute of Texas Press, Fort Worth, Texas, U.S.A. Sida, Bot. Misc. 23:1–300.

Herrera-Soto, W. & L.D. Gómez-Pignataro. 1993. Mapa de Unidades Bióticas de Costa Rica. Escala 1:685,000. U.S. Fish and Wildlife Service, The Nature Conservancy and Fundación Gómez-Dueñas, San José, Costa Rica, C.A. 1 map.

Maréchal, R., J. Mascherpa, & F. Stainier. 1978. Etude taxonomique d'un groupe complexe d'espèces des genres *Phaseolus* et *Vigna* (Papilionaceae) sur la base de données morphologiques et polliniques, traitées par l'analyse informatique. Boissiera 28:1–273.

Ohashi, H. 2005. Tribe Desmodieae. In: G. Lewis, B. Schrire, B. Mackinder, & M. Lock, eds. Legumes of the world. Royal Botanic Gardens, Kew, England, U.K. Pp. 432–445.

Ohashi, H., R.M. Polhill, & B.G. Schubert. 1981. Tribe 9. Desmodieae (Benth.) Hutch. In: R.M. Polhill & P.H. Raven, eds. Advances in legume systematics, part 1. Royal Botanic Gardens, Kew, England, U.K. Pp. 292–300.

Parsons, J.J. 1972. Spread of African pasture grasses to the American tropics. J. Range Managem. 25(1):12–17.

Porch, T.G., J.S. Beaver, D.G. Debouck, S. Jackson, J.D. Kelly, & H. Dempewolf. 2013. Use of wild relatives and closely related species to adapt common bean to climate change. Agronomy 3:433–461. doi:10.3390/agronomy3020433.

Rendón-Anaya, M., J.M. Montero-Vargas, S. Saburido-Alvarez, A. Vlasova, S. Capella-Gutiérrez, J.J. Ordaz-Ortiz, O.M. Aguilar, R.P. Vianello-Brondani, M. Santalla, L. Delaye, T. Gabaldón, P. Gepts, R. Winkler, R. Guigó, A. Delgado-Salinas, & A. Herrera-Estrella. 2017. Genomic history of the origin and domestication of common bean unveils its closest sister species. Genome Biol. 18(60):1–17. doi:10.1186/s13059-017-1190-6.

Rick, C.M. 1979. Potential improvement of tomatoes by controlled introgression of genes from wild species. Proc. Conf. Broadening Genet. Base Crops, Wageningen, 1978. Pudoc, Wageningen, The Netherlands. Pp. 167–173.

Schrire, B.D. 2005. Tribe Phaseoleae. In: G.P. Lewis, B.D. Schrire, B. Mackinder, & M. Lock, eds. Legumes of the world. Royal Botanic Gardens, Kew, England, U.K. Pp. 393–431.

Sequeira-Ruíz, W.G. 1985. La hacienda ganadera en Guanacaste: Aspectos económicos y sociales 1850–1900. Editorial Universidad Estatal a Distancia, San José, Costa Rica.

Serrano-Serrano, M.L., J. Hernández-Torres, G. Castillo-Villamizar, D.G. Debouck, & M.I. Chacón-Sánchez. 2010. Gene pools in wild Lima beans (*Phaseolus lunatus* L.) from the Americas: Evidences for an Andean origin and past migrations. Molec. Phylogen. Evol. 54(1):76–87.

Vázquez-García, J.A., R. Cuevas-Guzmán, T.S. Cochrane, H.H. Iltis, F.J. Santana-Michel, & L. Guzmán-Hernández. 1995. Flora de Manantlán. Botanical Research Institute of Texas Press, Fort Worth, Texas, U.S.A. Sida, Bot. Misc. 13:1–312.

von Bothmer, R. & O. Seberg. 1995. Strategies for the collecting of wild species. In: L. Guarino, V.R. Rao, & R. Reid, eds. Collecting plant genetic diversity: Technical guidelines. CAB International, Wallingford, U.K. Pp. 93–111.

Zamora, N. 2010. Fabaceae. In: B.E. Hammel, M.H. Grayum, C. Herrera, & N. Zamora, eds. Manual de plantas de Costa Rica. Vol. 5. Dicotiledóneas (Clusiaceae-Gunneraceae). Missouri Botanical Garden Press, St. Louis, Missouri, U.S.A. Pp. 395–775.