

Two New Cauliflorous Species of *Aristolochia* subseries *Anthocaulicae* (Aristolochiaceae) from Southern Central America

José Esteban Jiménez^{1,3,4} and Mario A. Blanco²

¹Research Associate, Herbario Luis A. Fournier Origgi (USJ), Centro de Investigación en Biodiversidad y Ecología Tropical, Universidad de Costa Rica, Apartado 11501-2060, San José, Costa Rica

²Herbario Luis A. Fournier Origgi (USJ), Centro de Investigación en Biodiversidad y Ecología Tropical, and Jardín Botánico Lankester, and Escuela de Biología, Universidad de Costa Rica, Ciudad Universitaria Rodrigo Facio, Apartado 11501–2060, San José, Costa Rica;

³Current address: Florida Museum of Natural History and Department of Biology, University of Florida, Gainesville, Florida 32611, USA

⁴Author for correspondence (jimenezvargas.je@ufl.edu)

Abstract—Two new cauliflorous species of *Aristolochia* subseries *Anthocaulicae* from southern Central America are described and illustrated. *Aristolochia guanacastensis* from northwestern Costa Rica resembles *A. ruiziana*, from which it is distinguished by having glabrous and narrower leaves, larger flowers without a syrxinx, and shorter fruits. *Aristolochia povedae* from the Caribbean slope of Costa Rica and Panama is similar to *A. cordiflora*, but it is distinguished by its smaller, suborbicular and concave perianth limb with a shallower sinus, and slightly larger fruits. Comments about their distribution, habitat, phenology, conservation status, and distinction from related species are provided, and also a key to the species of *Aristolochia* subseries *Anthocaulicae* present in Central America. Evidence that supports the synonymization of *A. cruenta* under *A. goudotii* is presented.

Keywords—Caribbean watershed, Cordillera de Guanacaste, endemic plants, Costa Rica, Panama, taxonomy.

Resumen—Dos nuevas especies caulifloras de *Aristolochia* subserie *Anthocaulicae* del sur de Centroamérica son descritas e ilustradas. *Aristolochia guanacastensis* del noroeste de Costa Rica es parecida a *A. ruiziana*, de la cual se distingue por tener hojas glabras y más estrechas, flores más grandes sin siringe y frutos más cortos. *Aristolochia povedae* de la vertiente Caribe de Costa Rica y Panamá es similar a *A. cordiflora*, pero se distingue por su limbo floral más pequeño, suborbicular y cóncavo, con un seno menos profundo y frutos un poco más grandes. Se proporcionan comentarios sobre su distribución, hábitat, fenología, estado de conservación y distinción de especies relacionadas, así como también una clave de las especies de *Aristolochia* subserie *Anthocaulicae* presentes en Centroamérica. Se presenta evidencia que apoya la sinonimia de *A. cruenta* bajo *A. goudotii*.

Aristolochia L. is the largest genus of Aristolochiaceae (González 1990). It is widely distributed throughout the world, except for Antarctica and New Zealand, with the greatest diversity occurring in the Neotropics. It is composed mainly of twining vines, but also geophytic herbs, and shrubs. They grow in a wide variety of climates and ecosystems, from xerophytic environments to very humid forests (González 1990; González and Stevenson 2002; Wanke et al. 2006).

The circumscription of *Aristolochia* as a genus remains controversial, and different (and often conflicting) subgeneric classifications have been proposed (González 1990; González and Stevenson 2002; Wanke et al. 2006, 2017, and references therein). No modern, comprehensive subgeneric classification has been published, but González (1990) presented a partial subgeneric classification for neotropical species; it remains in general use with some modifications, even if several of its proposed groups appear to be non-monophyletic according to molecular studies (e.g. Wanke et al. 2006, 2017, although with relatively low taxonomic sampling). One of these subgeneric taxa is *Aristolochia* subseries *Anthocaulicae* F.González (placed in *Aristolochia* section *Gymnolobus* Duch., subsection *Hexandrae* Duch., series *Hexandrae* (Duch.) F.González), which includes species that have ramiflorous to cauliflorous racemes with very short internodes, and flowers subtended by reduced bracts (González 1990). It is comprised of ca. 25 species, distributed mainly in the Amazon basin and the Atlantic Forest in Brazil (Freitas et al. 2019, 2020). This subseries was retrieved as monophyletic in a phylogenetic study based on morphological characters only (González and Stevenson 2002). However, neither the monophyly of the group nor its infraspecific relations have been properly tested with molecular data.

Despite a relatively recent revision of *Aristolochia* in Mesoamerica (Barringer 2015) and three taxonomic treatments for Central American countries (González and Pabón-Mora 2018; Jiménez and Blanco 2020; González and Monzón-Sierra 2022), disagreements in species circumscriptions are evident among different authors. The study of *Aristolochia* based exclusively on dry herbarium material can lead to erroneous interpretation of intra- and interspecific variation and consequent lumping of morphologically similar species, due to the obscuring of taxonomically-relevant floral traits after drying. Field documentation of living plants, especially with good descriptions and photographs of flowers, is often necessary to correctly differentiate similar species and to interpret floral character from herbarium specimens (Jiménez and Blanco 2020; Jiménez et al. 2021a, 2021b).

During fieldwork for our research on Aristolochiaceae of Costa Rica (Jiménez and Blanco 2020), two cauliflorous species were found which are distinct from any other known species of *Aristolochia* subseries *Anthocaulicae*. These two species are described here, and they increase the number of known species of *A. subseries Anthocaulicae* in the neotropics to 26.

MATERIALS AND METHODS

This study is based on field work performed during 2013–2016 to study the morphology of the new taxa in situ, and on examination of herbarium specimens. *Aristolochia* specimens (including types) of COL, CR, DUKE, EAP, G, HUA, JAUM, K, LPB, LSCR, M, MEDEL, MO, MOL, P, PMA, QCA, QCNE, SCZ, SINCHI, TEFH, UCH, USJ and USM were examined physically, while those from F, MA, MPU, and US were studied through digital images (JSTOR 2021). Herbarium acronyms follow Thiers (2022). The two new species are illustrated with compound photographic plates that follow the guidelines proposed by Pupulin and

Bogarín (2004), and also with line drawings; these two illustration methods are complementary and emphasize different traits of the structures. Flower measurements and data on color and scent were taken at anthesis.

The distribution map includes the localities of all the specimens examined and was prepared using Adobe Photoshop CS6®, based on a satellite image of the year 2000 from NASA's Jet Propulsion Laboratory, National Imagery and Mapping Agency of the United States. The informal conservation assessments of all species follow the IUCN (2019) Standards and Petitions Committee guidelines, considering the number of locations, criterion B1 (extent of occurrence, EOO), and criterion B2 (area of occupancy, AOO). The values for these criteria were calculated using the GeoCAT tool (Bachman et al. 2011), and the Rapid Least Concern web application (Bachman et al. 2020). Terminology for vegetative and reproductive structures follows González (1990) and Jiménez and Blanco (2020).

TAXONOMIC TREATMENT

Aristolochia guanacastensis J.E.Jiménez and M.A.Blanco, sp. nov. TYPE: COSTA RICA. Guanacaste, Bagaces, La Fortuna, Zona Protectora Volcán Miravalles [Parque Nacional Volcán Miravalles], Cabro Muco, 50 m sobre el camino antes de llegar a la pequeña represa del ICE, 994 m, 12 Sep 2015 (fl, fr), J. E. Jiménez, P. Juárez and A. Retana 3182 (holotype: US)! [3 parts, including flower and fruit in spirit], isotype: CR!).

Similar to *Aristolochia ruiziana* (Klotzsch) Duch. because of its broadly ovate and subpeltate leaves, peduncle plus ovary less than 4.5 cm long at anthesis, and flowers with a broadly ovate and purple limb, but *A. guanacastensis* differs by having glabrous leaf blades, 6.3–8.6 cm wide (vs. villous to puberulous abaxially, 9–23.5 cm), larger flowers with the limb 7.5–12 × 7.2–10.3 cm (vs. 3–6.5 × 3.5–5.5 cm), syrinx absent (vs. present and inequilateral), and fruits 3.5–6.5 cm long (vs. 8–12.5 cm).

Liana. **Stems** cylindrical and glabrous when young, with corky bark when mature; internodes 9.4–13 cm long; prophylls not atrophied (pseudostipules absent). **Leaves** marcescent, leaving a remnant of the petiole after decomposing; petiole 6.4–12.2 cm long; lamina basifixed to subpeltate, ovate, 10.5–12 × 6.3–8.6 cm, membranous, basally truncate to cordate with the sinus 0–2.2 cm deep, apically acuminate, abaxial and adaxial surfaces glabrous, abaxial surface glaucous, venation palmate to pedate. **Inflorescences** racemose, 3.5–5.2 cm long, with 1–7 flowers, cauliflorous; peduncle 0.4–0.8 cm long; bracts ovate, ca. 0.4 × 0.3 cm, with petiole 1 mm long, glabrous. **Flowers** protogynous; pedicel plus ovary 3.8–4.2 cm long (at anthesis), glabrous; perigone geniculate, bent 75–120° between the utricle and the tube and 170–180° between the tube and the lower part of the limb, outer surface glabrous, cream to pinkish-cream with translucent pinkish-cream veins, scent similar to citronella; utricle obovoid, gibbous, 3.5–3.8 × 2–2.5 cm, inner surface cream, covered by white trichomes with tomentose appearance; syrinx absent; tube infundibuliform, 2.5–3 cm long, 1.8–2 cm of proximal diameter, 2–2.5 cm of distal diameter, inner surface cream covered by white trichomes; fauces rounded, cream with white trichomes; limb unlobed, peltate, broadly ovate, smooth, 7.5–12 × 7.2–10.3 cm, glabrous, apex obtuse-mucronate, lower margin subcordate, with the sinus 0.3–0.5 cm deep, purple with creamy-white veins, with a solid dark-purple blotch above the fauces extending toward the apex and covering most of the upper half of the limb; appendix absent; the apex of the limb pointing upward in natural position; gynostemium coroniform,

shortly stipitate, 0.8–1 × 0.5–0.7 cm, stipe 0.1–0.3 cm long, stigmatic lobes 6, ca. 0.5 cm long, pinkish-cream; anthers 6, linear-oblong, ca. 0.4 × 0.2 cm. **Fruits** capsules; cylindrical, 3.5–6.5 × 1–1.7 cm, apex rounded, glabrescent, with apical, septical dehiscence, with entire septa; seeds obovoid, sticky, not winged, 0.6–0.7 × 0.3–0.4 cm, brown to blackish. Figures 1, 2, 3.

Distribution and Habitat—Endemic to northwestern Costa Rica. It is restricted to both slopes on Cordillera de Guanacaste, between 600–1000 m of elevation (Fig. 4). According to the Holdridge life zone system (Holdridge 1967), it inhabits tropical moist forest and tropical moist forest transition to premontane forest. It occurs in primary and secondary forest, where the vines reach the canopy.

Phenology—Flowering in January, September, and November. Fruiting in May, September, and November.

Etymology—The species is named after the Cordillera de Guanacaste where it is endemic.

Informal Conservation Status—*Aristolochia guanacastensis* is an infrequent species that is known by eight collections from Parque Nacional Guanacaste (Pitilla and Maritza sectors), Parque Nacional Volcán Miravalles (Cabro Muco sector), and Parque Nacional Volcán Tenorio (El Pilón sector). Due to its limited occurrence in less than four locations (EOO: 1819 km²; AOO: 20 km²), and the expansion of agriculture and livestock occurring close to the natural populations in the national parks, *A. guanacastensis* may be preliminarily considered as Endangered according to the IUCN categories and criteria [EN B1ab(iii)+2ab(iii)]. Despite being protected in three different national parks, this species is rarely found in the field (as also observed in most other species of *Aristolochia* subspecies *Anthocaulicae* in Costa Rica, whose populations at a given site consist of a few scattered individuals).

Additional Specimens Examined—Costa Rica. —ALAJUELA: Upala, Bijagua, Parque Nacional Volcán Tenorio, El Pilón, cabeceras del Río Celeste, 700 m, 16 Nov 1987 (fl, fr), G. Herrera 1300 (CR, US). —GUANACASTE: La Cruz, Parque Nacional Guanacaste (Volcán Orosí), 700 m, 11 Nov 1996 (fl), C. Moraga 814 (CR); La Cruz, Parque Nacional Guanacaste (Volcán Orosí), Estación Pitilla, 700 m, 16 Sep 1990 (st), P. Ríos 55 (CR); Liberia, Parque Nacional Guanacaste (Volcán Orosí), Estación Maritza, 600 m, 7 Jan 2000 (fl), B. Hammel 22044 (CR, MO); Liberia, Parque Nacional Guanacaste, Estación Maritza, 6 Jul 1989 (st), INBio II 153 (CR, MO); Bagaces, La Fortuna, Zona Protectora Volcán Miravalles, Cabro Muco, por la represa, 994 m, 6 Jun 2015 (st), J. E. Jiménez and P. Juárez 2792 (CR, USJ); Bagaces, La Fortuna, Zona Protectora Volcán Miravalles, Cabro Muco, 50 m sobre el camino antes de llegar a la pequeña represa del ICE, 994 m, 21 May 2016 (fr), J. E. Jiménez and A. Karremans 3519 (USJ).

Notes—In Costa Rica, *Aristolochia guanacastensis* can be confused with *A. cordiflora* Mutis ex Kunth and *A. povedae* J.E.Jiménez and M.A.Blanco (see below) because they all have ovate leaf blades and flowers with a peltate limb more than 7 cm long. *Aristolochia guanacastensis* is distinguished from both species by having leaves that are abaxially glabrous (vs. puberulent to villous), the utricle 3.5–3.8 cm long (vs. 6.2–10.0 cm), the perianth limb smooth-textured, with an obtuse apex and a sinus up to 0.5 cm deep (vs. with bullate texture, round apex and a sinus 2.5–3.5 cm deep in *A. cordiflora* and 1.5–2.0 cm deep in *A. povedae*), fruits up to 6.5 cm long (vs. 11–12.5 cm long in *A. cordiflora* and 14.0–16.8 cm long in *A. povedae*) and being allopatric (in Costa Rica, *A. cordiflora* occurs at 0–400 m of elevation on the Pacific lowlands and western foothills of the Cordillera de Talamanca, whereas *A. povedae* occurs at 80–500 m on the Caribbean lowlands and eastern foothills of the Cordillera Central and Cordillera de Talamanca; Jiménez and Blanco 2020). An illustration of *Aristolochia grandiflora* Sw. was mistakenly labelled as *A. cordiflora*

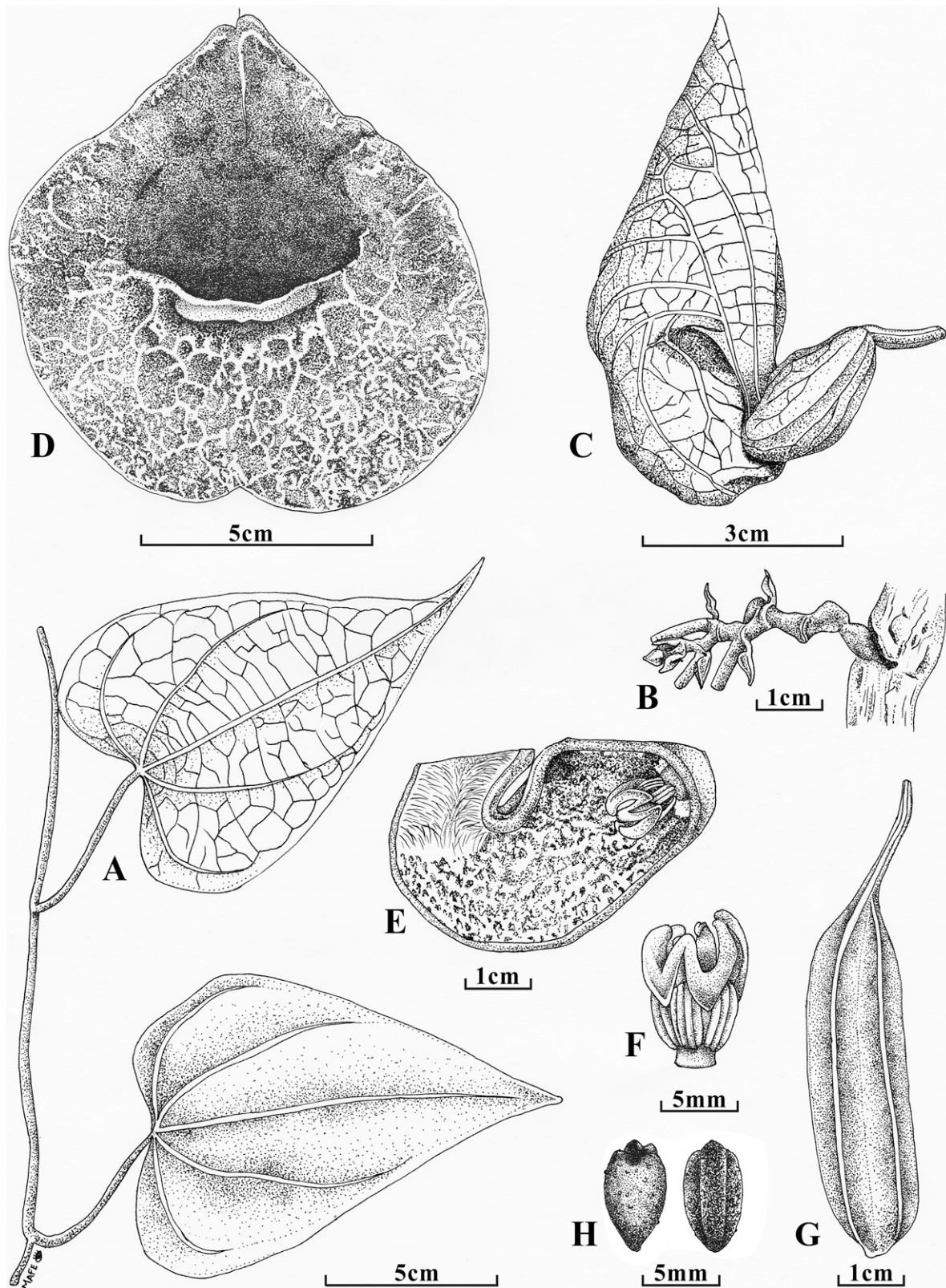


FIG. 1. *Aristolochia guanacastensis*. A. Shoot segment with leaves showing both surfaces of the blade. B. Inflorescence. C. Flower in lateral view. D. Flower limb in frontal view. E. Longitudinal section of the utricle and base of the tube. F. Gynostemium in female phase (with the stigmatic surface exposed and anthers closed). G. Fruit. H. Seeds. Drawings by María Fernanda Cordero Pagoaga based on photographs of the live plant from which the type specimen was prepared (J. E. Jiménez et al. 3182).

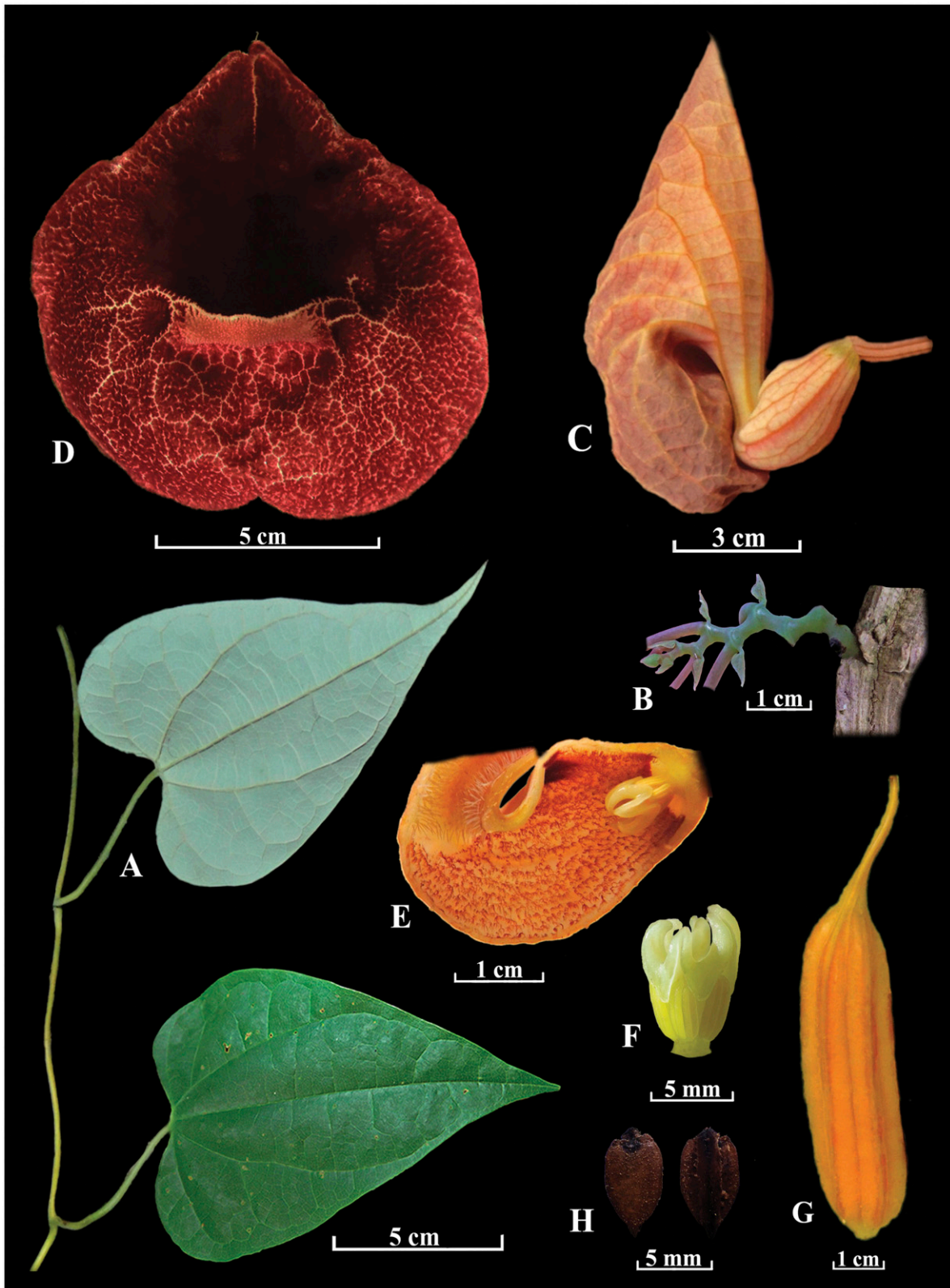


FIG. 2. *Aristolochia guanacastensis*. A. Shoot segment with leaves showing both surfaces of the blade. B. Inflorescence. C. Flower in lateral view. D. Flower limb in frontal view. E. Longitudinal section of the utricle and base of the tube. F. Gynostemium in female phase (with the stigmatic surface exposed and anthers closed). G. Fruit. H. Seeds. (J. E. Jiménez et al. 3182).

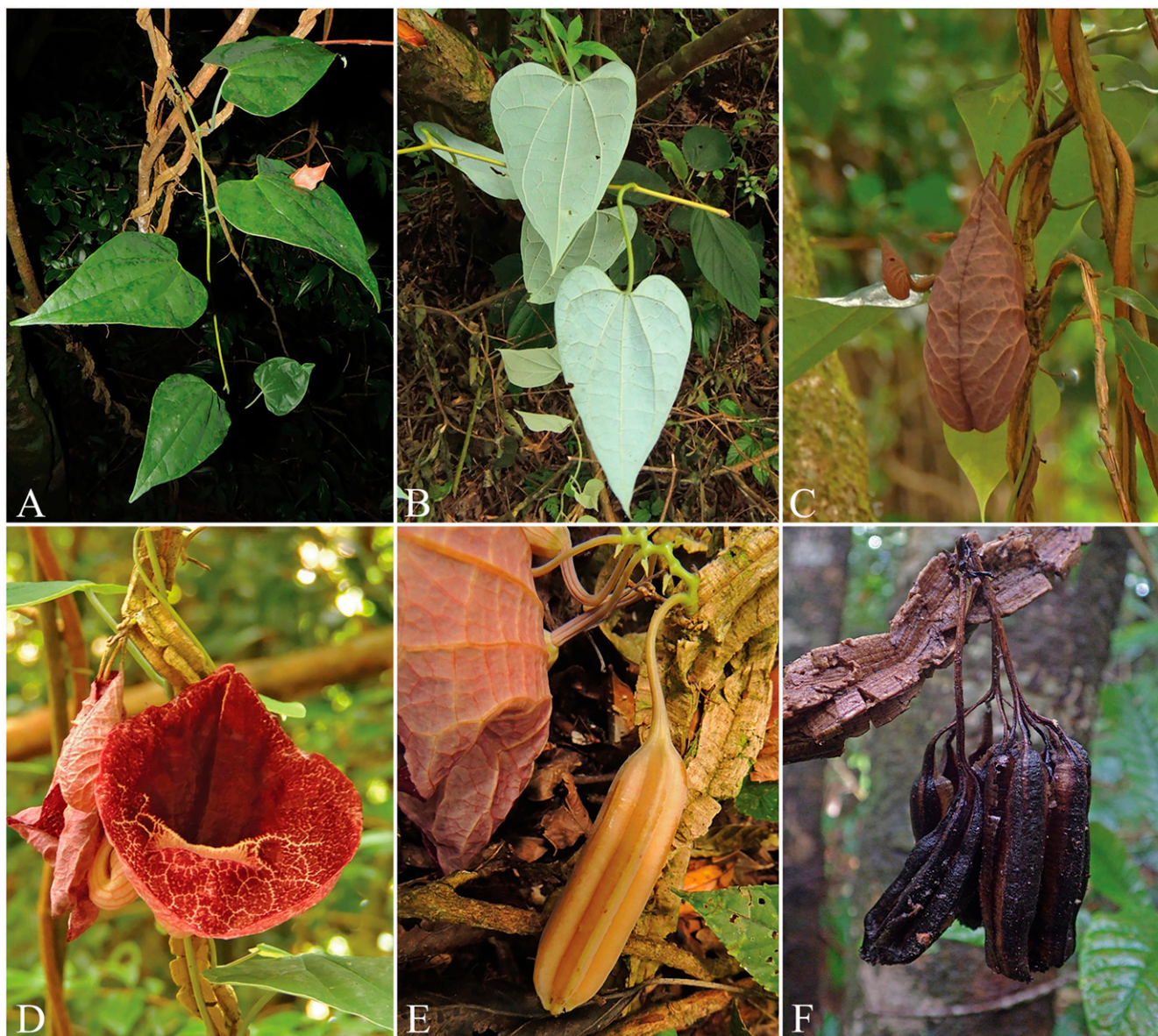


FIG. 3. *Aristolochia guanacastensis*. A. Branch showing upper surface of leaves, and young and mature stems. B. Branch showing lower surface of leaves. C. Floral bud just before anthesis. D. Flower limb in frontal view. E. Detail of corky mature stem, inflorescence, pedicel plus ovary, and immature fruit close to opening. F. Dehiscent fruits. (J. E. Jiménez et al. 3182).

in Jiménez and Blanco (2020). Jiménez (2016) and Jiménez and Blanco (2020) treated *A. guanacastensis* as "*Aristolochia* sp. D".

The flowers of *Aristolochia guanacastensis* have a solid dark purple blotch on the limb just above the entrance of the tube (fauces), that extends toward the apex and covers most of the upper half of the perianth limb. This character can also be useful to separate it from *A. cordiflora* and *A. povedae*, since those species may or may not have a smaller dark purple spot (sub-orbicular in the case of *A. povedae*) located above the fauces, but which does not extend more than 3 cm toward the apex and that covers less than one third of the upper half of the limb.

Due to the shape and dimensions of the perianth, *Aristolochia guanacastensis* can be confused with the Amazonian *A. ruiziana* (for whose circumscription we follow that of González 1990). It differs from the latter species by having glabrous leaf blades 6.3–8.6 cm wide (vs. leaf blades villous to puberulous abaxially, 9–23.5 cm), syrinx absent (vs. present), perianth limb 7.5–12 cm long (vs. 3–6.5 cm), and fruits 3.5–6.5 cm long (vs. 8–12.5 cm).

González (1990) discussed the perianth limb dimensions of *A. ruiziana*, favoring a conservative approach to its circumscription. A few years later, González (1994) published another description of *A. ruiziana* with significantly different and highly variable perianth limb measurements (3–6.5 × 3.5–5.5 cm in González (1990) vs. 3–11 × 3–10 cm in González (1994)). The noticeable variability in perianth shape, size and color shown by various photographs available online of Amazonian plants identified as *A. ruiziana*, suggest that several related but different species may have been lumped under this name by González (1994). A careful study of *A. ruiziana* sensu lato, including in vivo documentation of flowering material from throughout its geographic range, is necessary to clarify their circumscription. A photograph of the type specimen of *A. ruiziana* (Ruiz and Pavón 361, B [destroyed, photo F neg. 4930]) is available online (Field Museum of Natural History 2022), and shows a flower that agrees with the original range of measurements of González (1990).

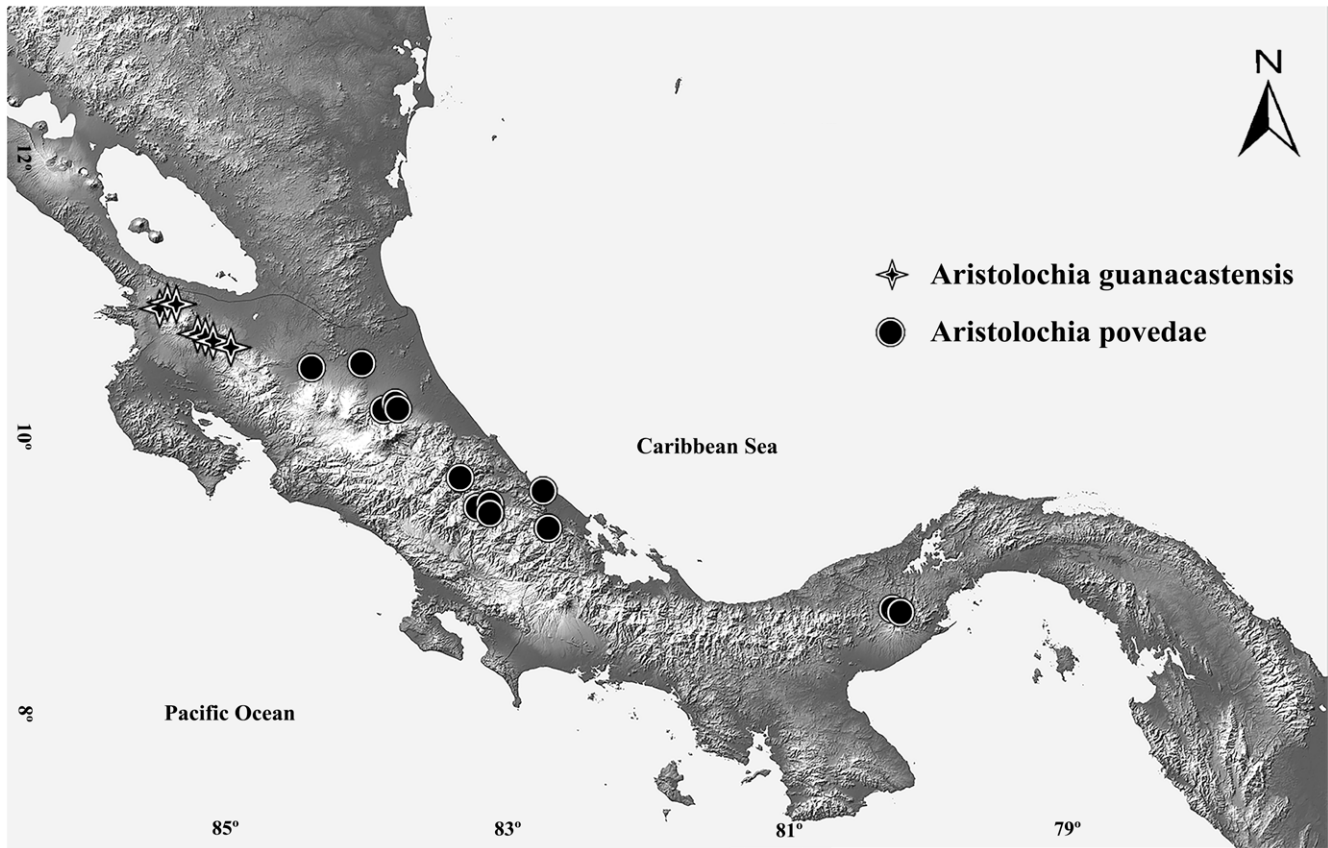


FIG. 4. Geographic distributions of *Aristolochia guanacastensis* and *A. povedae* in Costa Rica and Panama, based on examined herbarium specimens.

In the dichotomous key for species of *Aristolochia* subseries *Anthocaulicae* published by Freitas et al. (2019), *A. guanacastensis* would key out as *A. cruenta* Barringer (TYPE: COSTA RICA. Heredia, Puerto Viejo, Finca La Selva, OTS Station, Hartshorn trail, 850 m E, 100 m alt., 20 Oct. 1980 [fl], B. Hammel 10242, DUKE, image!), a name that we (Jiménez and Blanco 2020) consider a synonym of *Aristolochia goudotii* Duch. (TYPE: NOUVELLE GRENADE [COLOMBIA], Llano San Martín, 1844 [fl, fr], J. Goudot s.n., P!). González's (1990) illustration of *A. goudotii* (said to be based on the type specimen) shows leaves that match those on the type specimen, but the perianth shape bears little resemblance to that of the flowers on the type. The sheet MPU number 018697 includes a tracing of part of the type specimen of *A. goudotii*, a handwritten description by Duchartre, and detailed pencil drawings of the inflorescence, front view of the flower, and the gynostemium and ovary apex (apparently made from life and used by Duchartre to prepare the original description), all annotated as *Aristolochia goudotii* by Duchartre; thus, even when these drawings were never published and were not attached to the type specimen at P, they constitute original material of *A. goudotii* according to Article 9.4 of the Code (Turland et al. 2018) and are critical for its proper interpretation. Freitas et al.'s (2019) key distinguishes *A. cruenta* from *A. goudotii* by describing the former as having abaxially glabrous leaves (and Costa Rican material indeed has glabrous leaves; Jiménez and Blanco 2020), and the latter with abaxially glabrescent or pubescent leaves. In the protologue, Duchartre (1854) described the leaves of *A. goudotii* as “pagina inferiore glauco-albidus sub lente brevissime praecipueque ad nervos hispidulus” (“lower surface whitish-glaucous, under the magnifying glass very shortly

hispidulous, especially on the veins”). This seems to be the only (and minor) difference between Colombian and Costa Rican populations of *A. goudotii*. The leaves and fruits of *A. guanacastensis* are similar to those of *A. goudotii*, but differ by having flowers 2–3 times larger and by being allopatric (in Costa Rica, *A. goudotii* is known from very few populations, at elevations of 200 m or less).

Aristolochia povedae J.E.Jiménez and M.A.Blanco, sp. nov.
 TYPE: COSTA RICA. Limón, Talamanca, Puerto Viejo, Reserva Indígena Kekoldi, 136 m, 20 Jan 2016 (fl), J. E. Jiménez and C. Jiménez 3475 (holotype: USJ! [4 parts, including flower in spirit]).

Similar to *Aristolochia cordiflora* Mutis ex Kunth because of its broadly ovate, basifixed to subpeltate, abaxially glaucous and villose to puberulent leaf blades, perianth limb greater than 10 cm long with a bullate texture and purple-colored with pale reticulate venation, and fruits 1–1.8 cm wide, but differs in its smaller, suborbicular, and concave perianth limb, 10.4–16.2 × 9.6–15.1 cm, with a sinus 1.5–2.0 cm deep (vs. heart-shaped to broadly ovate limb, 13–35 × 11–23 cm, with a sinus 2.5–3.5 cm deep), and a longer fruit 14–16.8 cm long (vs. 10–12.5 cm long).

Liana. **Stems** cylindrical and puberulous when young, with corky bark when mature, internodes 8.8–12.5 cm long; prophylls not atrophied (pseudostipules absent). **Leaves** marcescent, leaving a remnant of the petiole after decomposing; petiole 5.1–8.5 cm long; lamina basifixed to subpeltate, ovate, 15.5–21.7 × 11.5–15.6 cm, membranous, basally truncate to cordate with the sinus 0–1.0 cm deep, acuminate, abaxial

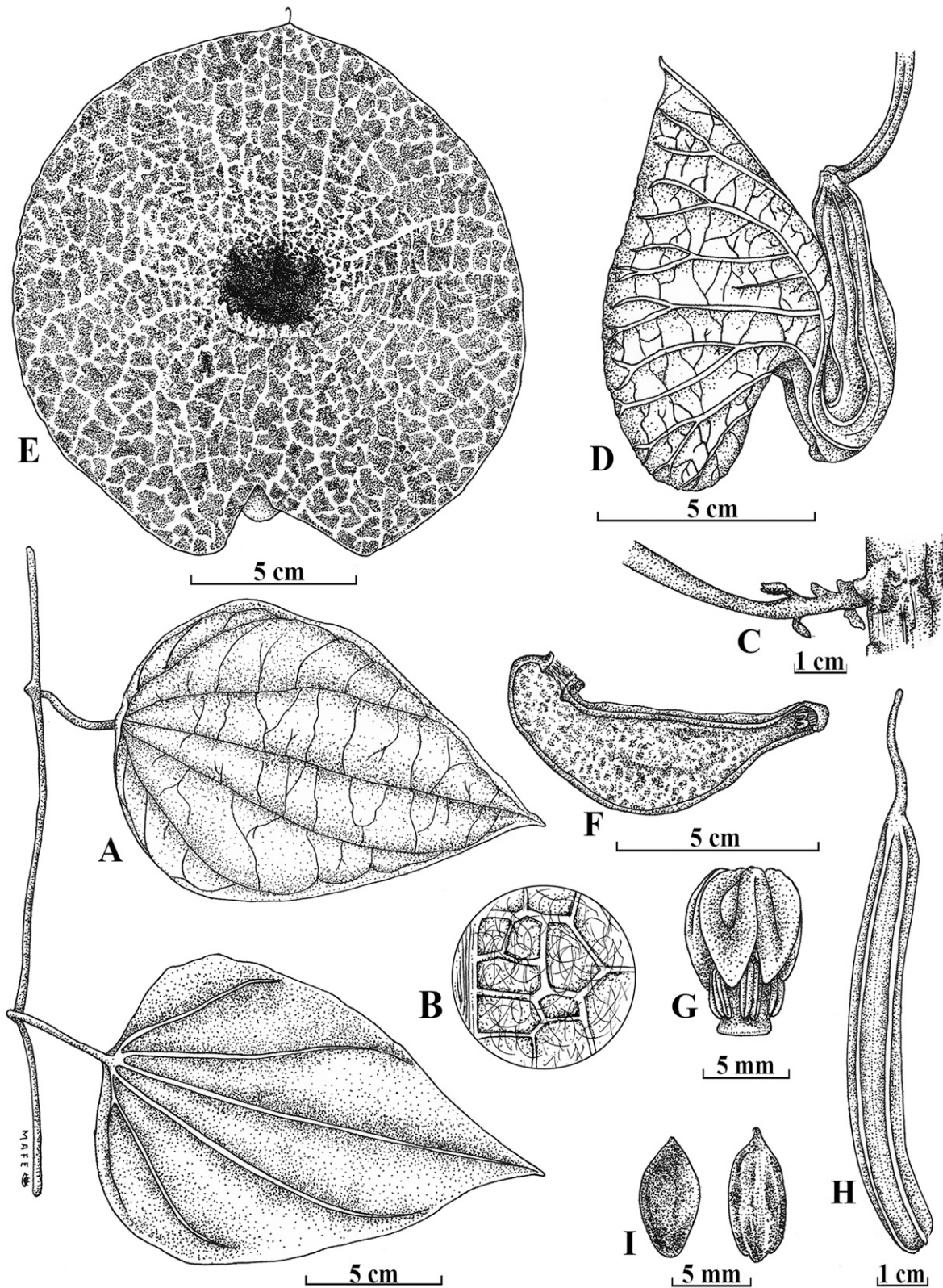


FIG. 5. *Aristolochia povedae*. A. Shoot segment with leaves showing both surfaces of the blade. B. Abaxial surface of leaf showing tomentose indument. C. Inflorescence. D. Flower in lateral view. E. Flower limb in frontal view. F. Longitudinal section of the utricle. G. Gynostemium in female phase (with the stigmatic surface exposed and anthers closed). H. Fruit. I. Seeds. Drawings by María Fernanda Cordero Pagoaga based on photographs of the live plant from which the type specimen was prepared (J. E. Jiménez and C. Jiménez 3475).

surface glaucous, adaxial surface glabrous, villose to puberulous when mature; venation palmate to pedate. **Inflorescences** racemose, 1.6–2.2 cm long, with 1–7 flowers, cauliflorous; peduncle 0.3–0.6 cm long; bracts ovate, ca. 0.3×0.4 cm, with

petiole ca. 1 mm long, glabrous. **Flowers** protogynous; pedicel plus ovary 6–6.5 cm long (in anthesis), glabrous; perigone geniculate, bent $150\text{--}180^\circ$ between the utricle and the tube and $170\text{--}180^\circ$ between the tube and the lower part of the

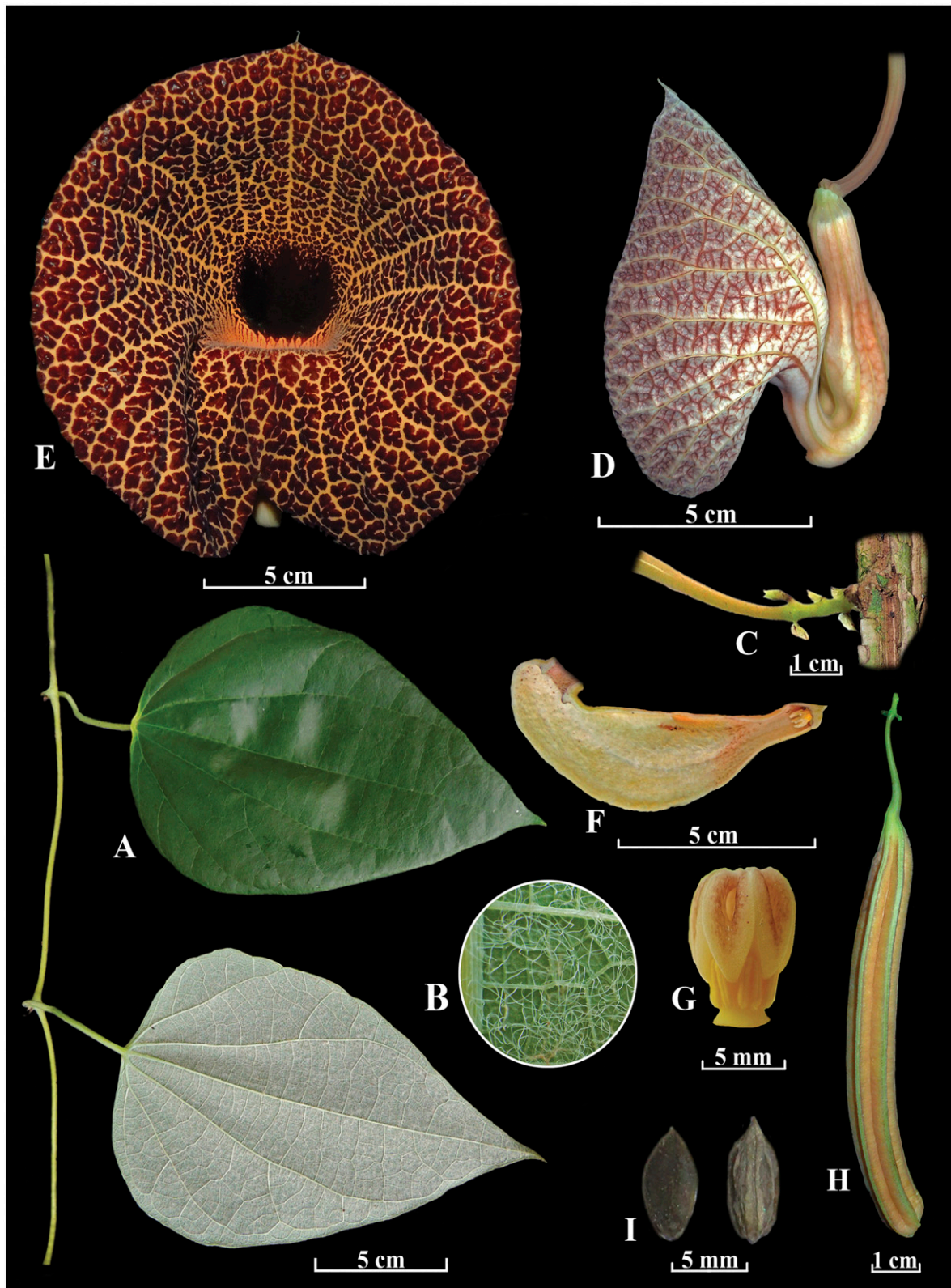


FIG. 6. *Aristolochia povedae*. A. Shoot segment with leaves showing both surfaces of the blade. B. Abaxial surface of leaf showing tomentose indument. C. Inflorescence. D. Flower in lateral view. E. Flower limb in frontal view. F. Longitudinal section of the utricle. G. Gynostemium in female phase (with the stigmatic surface exposed and anthers closed). H. Fruit. I. Seeds. (J. E. Jiménez and C. Jiménez 3475).

limb, outer surface glabrous, cream to purple-cream with translucent cream veins, scent similar to citronella; utricle obovoid, gibbous, 7.1–10.0 × 2.6–3.0 cm, inner surface creamy-white, covered by white trichomes with tomentose appearance; syrx equilateral, extending up to 0.1 cm into the utricle; tube infundibuliform, 3.2–4.6 cm long, 1.2–1.6 cm of proximal diameter, 1.8–2.5 cm of distal diameter, inner surface creamy-white covered by white trichomes; fauces rounded, cream with white trichomes; limb unilobed, peltate, suborbicular, bullate, 10.4–16.2 × 9.6–15.1 cm, glabrous, apex obtuse-mucronate, lower margin cordate with the sinus 1.5–2.0 cm deep, purple with creamy-white veins, with a suborbicular dark-purple spot of 2.5–3 cm diameter above the fauces; appendix absent; the apex of the limb pointing upward in natural position; gynostemium coroniform, shortly stipitate, 0.7–0.8 × 0.5–0.6 cm, stipe 0.1–0.2 cm long, stigmatic lobes 6, ca. 0.3 cm long, pinkish-cream; anthers 6, linear-oblong, ca. 0.4 × 0.1 cm. **Fruits** capsules; cylindrical, 14.0–16.8 × 1.5–1.8 cm, apex

slightly rounded, glabrescent, with apical, septical dehiscence, with entire septa; seeds ovoid, sticky, not winged, 0.6–0.7 × 0.3–0.4 cm, brown to blackish. Figures 5, 6, 7.

Distribution and Habitat—Caribbean watershed of Costa Rica and Panama, in the lowlands and the north and eastern slopes of the Cordillera Central of Costa Rica, Cordillera de Talamanca (Costa Rica and Panama), and Cordillera Central of Panama, between 80–500 (–1000) m of elevation (Fig. 4). According to the Holdridge life zone system (Holdridge 1967), it inhabits Tropical Moist Forest and Tropical Moist Forest transition to Premontane Forest. It occurs in primary and secondary forest, where the vines reach the canopy.

Phenology—Flowering in January, February, June, August, September, and November. Fruiting in January, February, March, and June.

Etymology—The species is named after botanist and professor Luis Jorge Poveda Álvarez (born 1945). Since 1969, Poveda has contributed enormously to the documentation

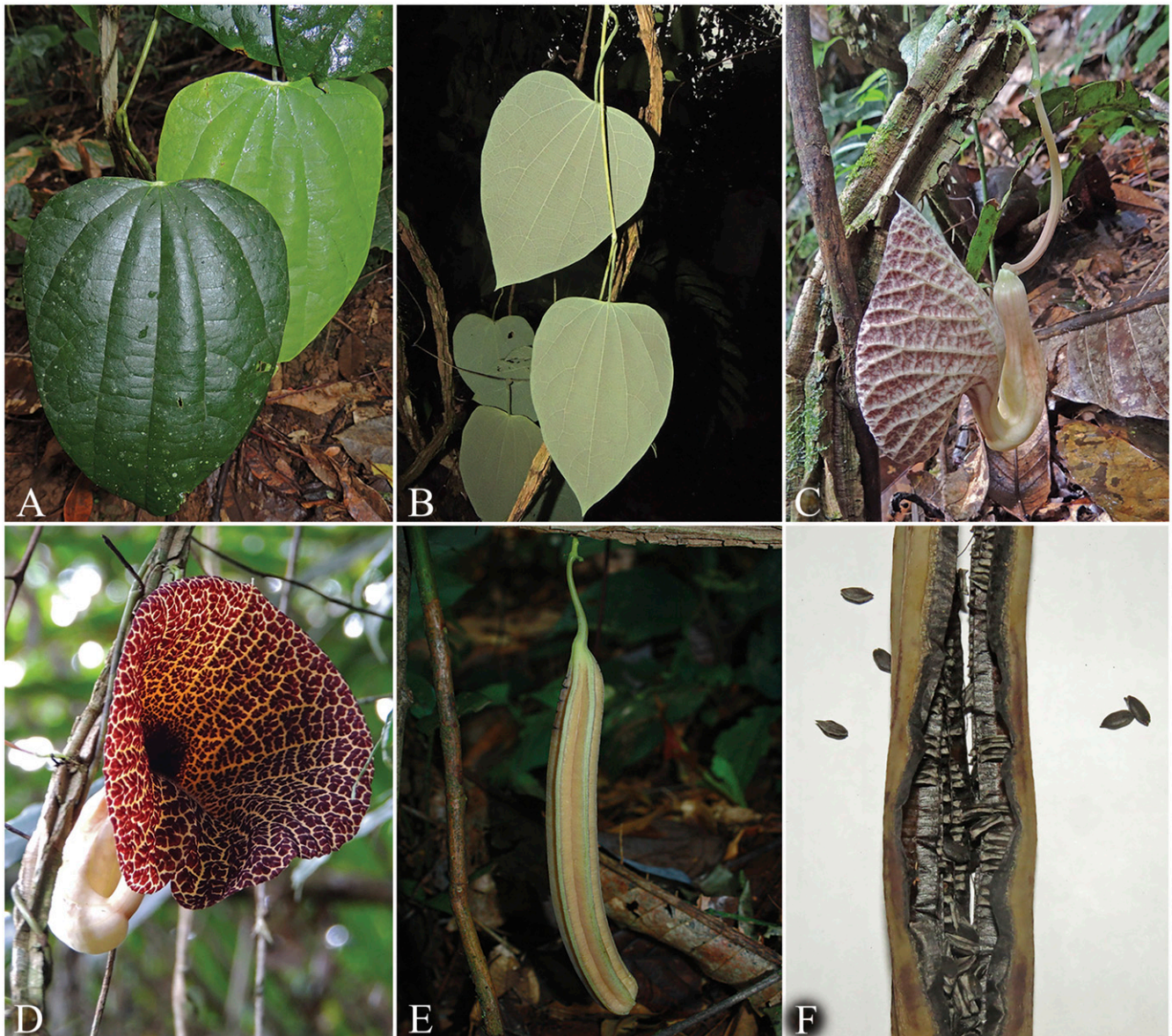


FIG. 7. *Aristolochia povedae*. A. Branch showing upper surface of leaves. B. Branch showing lower surface of leaves and young and mature stems. C. Floral bud just before anthesis. D. Flower in oblique view. E. Fruit close to opening. F. Dehiscent fruit and seeds. (J. E. Jiménez et al. 3475).

and description of the Costa Rican flora, working in the CR, JVR, and USJ herbaria, and teaching botany and dendrology courses at the Universidad Nacional de Costa Rica. He also has mentored numerous botanists in the country.

Informal Conservation Status—*Aristolochia povedae* has been recorded so far by thirteen specimens from ten locations, resulting in an estimated EOO of 17.603 km² and a minimum AOO of 44 km². This species is protected in four of the six locations, namely La Tirimbina Biological Reserve, Selva Bananito Lodge Reserve, and in the indigenous preserves of the Caribbean slope of Talamanca in Costa Rica, and in the Gaital National Park in Antón, Panama. The lands surrounding these protected areas, are highly threatened by high-impact clear cutting for pineapple plantations and livestock grazing. For this reason, it seems prudent preliminarily to include this species in the Vulnerable category [VU B1ab(iii)].

Additional Specimens Examined—**Costa Rica.** —ALAJUELA: San Carlos, Pital, Sahino. Finca privada, 81 m, 10 Nov 2015 (st), J. E. Jiménez and Q. Jiménez 3456 (USJ); [San Carlos, Aguas Zarcas], Forest along San Rafael River near hot spring, Hacienda La Marina, about 14 km S.E. [actually N.E.] of Villa Quesada, 500 m, 18 Feb 1966 (fl), Molina, Williams, Burger and Wallenta 17430 (EAP). —HEREDIA: Sarapiquí, La Virgen, Reserva Biológica Tirimbina, 168 m, 4 Jun 2014 (st), J. E. Jiménez, M. A. Blanco and J. M. Ley 2394 (USJ); Sarapiquí, La Virgen, Estación Biológica Tirimbina, 172 m, 6 Jan 2015 (fl, fr), J. E. Jiménez and J. M. Ley 2538 (USJ [2 parts, flower in spirit]); Sarapiquí, La Virgen, Estación Biológica Tirimbina, sendero Botarrama, 17 Feb 2009 (fl, fr), J. González 10621 (LSCR). —LIMÓN: Limón, Valle La Estrella, Selva Bananito Lodge, márgenes del Río Bananito, 120 m, 22 Nov 2011 (fl), A. Estrada, A. Rodríguez and F. Murillo 5237 (CR); Talamanca, Alto Oro Chico, 7 Apr 1994 (st), S. Ramírez s.n. (USJ-no 52076 [3 parts]); Talamanca, Amubri, Camino entre Amubri y Soki, siguiendo las filas entre Alto Suki y Río Urén, 100 m, 29 Jun 1989 (fl, fr), G. Herrera 3066 (CR, MO); Talamanca, San José Cabecar, Mar 1978 (fr), R. Ocampo and A. Todzia s.n. (CR-no 66097). **Panama.** —BOCAS DEL TORO: Changuinola Valley, 18 Sep 1923 (fl), V. C. Dunlap 247 (US). —COCLÉ: [Antón], inside the crater of El Valle de Antón, on La Mesa below the N rim on forested slopes, ca. 1000 m, 20 Jan 1970 (fl), R. Wilbur, R. E. Weaver and M. Correa 11156 (DUKE); El Valle, on road about 5 miles of town past chicken farms, in swampy sclerophyll forest along road to La Mesa, 2200 feet [670 m], 23 Aug 1983 (fl), B. Hammel and J. Kress 13429 (DUKE).

Notes—*Aristolochia povedae* is morphologically similar to *A. cordiflora* and has been misidentified as such in herbaria. The leaves, fruits, and seeds of the two species are similar,

but their flowers are different. *Aristolochia povedae* has flowers 10.4–16.2 × 9.6–15.1 cm and with a suborbicular, concave limb, a sinus 1.5–2 cm deep, the fauces rounded, and a suborbicular spot just above the tube entrance; whereas the flowers of *A. cordiflora* are 13–35 × 11–23 cm, with a usually more elongate limb (heart-shaped to broadly ovate, rarely suborbicular), a sinus 2.5–3.5 cm deep, and an irregular spot (variable in shape and size, sometimes absent) above the fauces (Fig. 8). The populations of the two species are allopatric, separated by the Cordillera Central of Costa Rica, the Cordillera de Talamanca, and the Cordillera Central of Panama, with *A. povedae* being restricted to the Caribbean slope and *A. cordiflora* to the Pacific slope (Fig. 3). The Costa Rican voucher of *A. cordiflora* cited by Barringer (2015; G. Herrera 3066) is a specimen of *A. povedae*. *Aristolochia povedae* was treated as “*Aristolochia* sp. E” by Jiménez (2016) and Jiménez and Blanco (2020).

An interesting difference between the flowers (at anthesis) of *Aristolochia povedae* and *A. cordiflora* is that the limb of the former is markedly concave, its back slightly pressing against the utricle, without deforming the concavity (as in *A. ruiziana*, see below). In contrast, the limb of *A. cordiflora* is flatter, and its back presses against and partially envelops the tube and utricle, creating a thick, convex ridge on the inner surface of the limb that extends longitudinally both above and below the entrance of the tube (Fig. 8). Our field observations in Costa Rica and Panama indicate that the three-dimensional conformation of the limb described above for both species is consistent and non-overlapping. This is an example of the many taxonomically important differences between similar species of *Aristolochia* that are evident in living plants but that are either lost or obscured in herbarium specimens (Jiménez and Blanco 2020; Jiménez et al. 2021a, 2021b).

Apart from the morphological characters mentioned above and the marked allopatry between the two species, *Aristolochia povedae* flowers have a citronella-like aroma, while those of *A. cordiflora* have a fetid smell similar to decaying meat (both on the first day of anthesis, possibly caused, at least in part, by low and high concentrations of skatol, respectively).

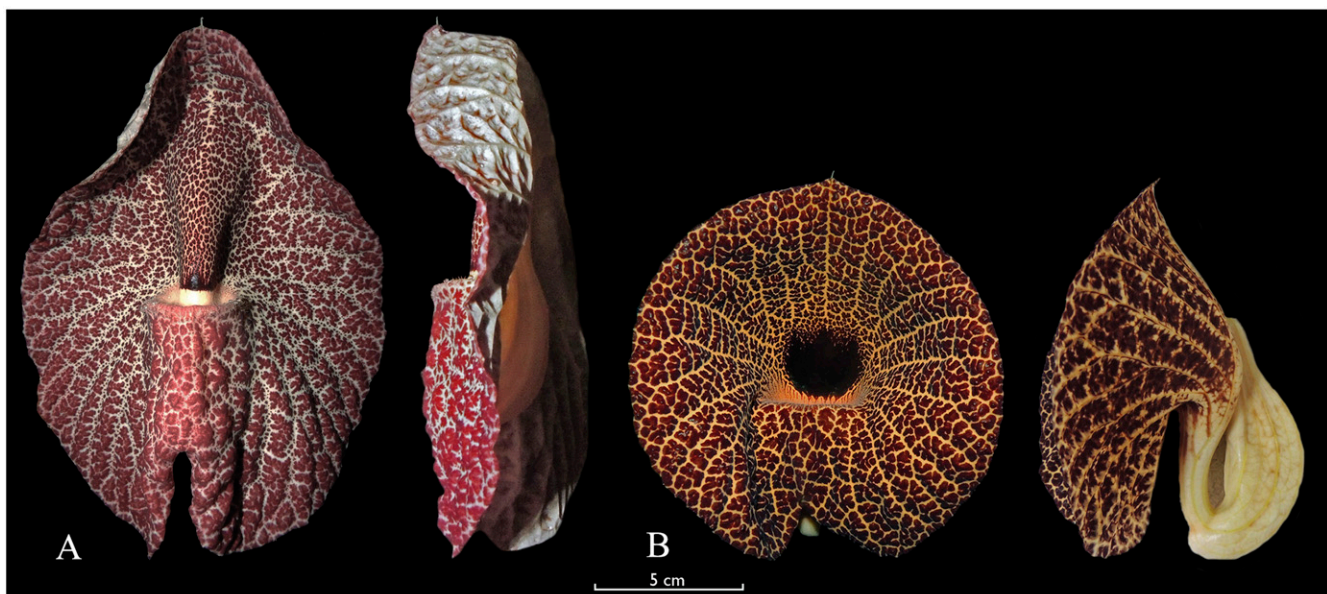


FIG. 8. Comparison of flowers of A. *Aristolochia cordiflora* (J. E. Jiménez 2565, USJ) and B. *Aristolochia povedae* (J. E. Jiménez and C. Jiménez 3475, USJ) in frontal and side view.

The aroma produced by the several *Aristolochia* species is a character infrequently described on herbarium labels and in traditional taxonomic treatments and has not been used taxonomically so far. In various groups of angiosperms, the floral aroma functions as an attraction mechanism for different groups of pollinators and may have implications for reproductive isolation and speciation (Urru et al. 2011).

Aristolochia povedae is also similar to *A. ruiziana* from the Amazon basin, but the latter is differentiated by its proportionally wider leaf blades (length-to-width ratios 1.3–1.4 in *A. povedae* vs 0.9–1.1 in *A. ruiziana*), usually with seven main nerves (vs. five), perianth limb 3.0–6.5 cm long (vs. 10.4–16.2 cm), fruits 8.0–12.5 cm long (vs. 14.0–16.8 cm), and the markedly allopatric distribution.

KEY TO THE SPECIES OF *ARISTOLOCHIA* SUBSERIES *ANTHOCAULICAE* IN CENTRAL AMERICA

1. Leaf blades lustrous adaxially when mature, not glaucous abaxially, cordate, sinus 2.8–5.0 cm deep 2
 2. Leaf blades variegated with yellow around main veins adaxially; perianth limb oblong to oblong-ovate, strongly recurved (the apex almost touching the utricle), internally smooth to slightly granulate, red, dark red to reddish purple with yellow spots to completely yellow; Costa Rica and Panama to Peru *A. leuconeura*
 2. Leaf blade not variegated, uniformly green adaxially; perianth limb lanceolate, slightly recurved (the apex distant from the utricle), internally covered with reddish purple elongate tubercles, cream with reddish purple spots and tubercles; Belize *A. schippii*
1. Leaf blades opaque adaxially when mature, glaucous abaxially, ovate, oblong-ovate, broadly ovate to deltate, rarely cordate, sinus absent to 2.8 cm deep 3
 3. Perianth limb basifixed, 3.5–4.3 cm long; utricle 1.3–2.0 cm long; tube 1.2–2.0 cm long *A. goudotii*
 3. Perianth limb peltate, 7.5–20 cm long; utricle 3.5–10.0 cm long; tube 2.5–4.8 cm long 4
 4. Leaf blade glabrous abaxially; utricle 3.5–3.8 cm long; sinus of limb 0.3–0.5 cm deep; fruits 3.5–6.5 cm long *A. guanacastensis*
 4. Leaf blade puberulent to villose abaxially; utricle 6.2–10.0 cm long; sinus of limb 1.5–3.5 cm deep; fruits 11.0–16.8 cm long 5
 5. Perianth limb heart-shaped to broadly ovate, slightly concave to flat in anthesis, 13–35 × 11–23 cm. with a sinus 2.5–3.5 cm deep; fruits 10–12.5 cm long; Pacific lowlands of Costa Rica to Ecuador *A. cordiflora*
 5. Perianth limb suborbicular, markedly concave in anthesis, 10.4–16.2 × 9.6–15.1 cm, with a sinus 1.5–2.0 cm deep; fruits 14–16.8 cm long; Caribbean lowlands of Costa Rica and Panama *A. povedae*

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AUTHOR CONTRIBUTIONS

The first author performed the fieldwork, took the photographs, and prepared the figures. Both authors designed and implemented the research, wrote the text, made plant identifications, reviewed herbarium material, and reviewed all versions of the manuscript.

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