



A new species of *Ipomoea* (Convolvulaceae) for the Brazilian Flora discovered in an anthropic habitat

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ABSTRACT

Ipomoea is one of the most diverse genera of Angiosperms, with 700 to 800 species. Several of them are widespread ruderal, often highly polymorphic, making species delimitation a challenge. When collecting Brazilian Convolvulaceae, one specimen from an anthropic Cerrado area in Mato Grosso do Sul state, caught our attention. Morphological, palynological, and anatomical analyses were performed to compare this unidentified species to its closest relatives. *Ipomoea cryptocarpa* Belo & Buril, sp. nov., the new species described here, is similar to *I. bahiensis*, a widespread ruderal plant, due to the shape of the leaves and the presence of an appendage on the sepals. However, they can be distinguished by the shape of the sepals appendage, fruit length, pollen morphology, indument on the leaf blade, petiole, peduncle, and anatomical characters, such as the contour of epidermis, distribution, and types of stomata, the number of laticiferous canals in the petiole, and types of collenchyma observed in the stem. We provide a diagnosis, besides morphological, anatomical, and palynological descriptions, illustrations, and notes on the distribution of the new species. Its informal conservation status is presented as Data Deficient (DD) since only one population is known so far.

Keywords: Brazilian flora, leaf anatomy, morning glory, palynology, species boundaries.

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Introduction

Convolvulaceae Juss. comprises 60 genera and approximately 1,900 species distributed worldwide but most diverse in tropical areas, with few representatives in temperate zones (Staples & Brummitt, 2007; WCSP, 2024). It includes the important crop sweet-potato (*Ipomoea batatas* L.), and other species with pharmacological and ornamental uses (Meira et al., 2012; Wood et al., 2020; Magalhães et al., 2022). Around 430 species are recorded in Brazil (Flora e Funga do Brasil, 2024), of which some were described in the last decade (e.g. Pastore & Simão-Bianchini, 2016; Wood et al., 2016; Belo et al., 2023a; Santos & Buril, 2024).

Ipomoea L. is the most diverse genus of Convolvulaceae, and it is among the most diverse of angiosperms, distributed mainly in the Tropics, comprising between 700 and 800 species, depending on the circumscription (Eserman et al., 2020; Wood et al., 2020). It is characterized by the following features: an entire style, a stigma usually with two globose lobes, echinate and pantoporate pollen grains, and a capsular fruit (Stefanović et al., 2003; Wood et al., 2020). It was the focus of a recent global monograph and molecular phylogenetic inference that led to a proposal to recognize it in a broader sense, including all other echinate-pollen genera within the tribe Ipomoeae Hall. f., such as *Argyreia* Lour., *Astripomoea* A.Meeuse, and *Rivea* Choisy (Muñoz-Rodríguez et al., 2023). As a result of these studies, several new species were combined (Wood et al., 2020; WCSP, 2024).

In Brazil, 160 species of *Ipomoea* are currently known, 40% of which are endemic to the country (Santos et al., 2021; Simão-Bianchini et al., 2024). The greatest diversity is found in the Cerrado (96 spp.) and Caatinga (58 spp.) domains, in areas of open vegetation with high light incidence (Santos et al., 2020a; Simão-Bianchini et al., 2024). Various species of *Ipomoea* are ruderal, being abundant in areas with anthropic influence - such as *I. asarifolia* Roem. & Schult., *I. bahiensis* Willd. ex Roem. & Schult., *I. cairica* (L.) Sweet, *I. nil* (L.) Roth, *I. tricolor* Cav., and *I. triloba* L. Some are rare, and others are considered as threatened, such as *I. cavalcantei* D.F.Austin, *I. lanifolia* D.Santos & Buril, *I. maranhensis* D.Santos & Buril, and *I. pantanalensis* J.R.I.Wood & C.Urbanetz (Wood et al., 2016; Santos et al., 2020b; Wood et al., 2020; Santos et al., 2021).

Its species are often polymorphic, and species delimitation can be a challenge due to morphological characters overlapping in closely related species (Miller et al., 1999; Stefanović et al., 2003; Muñoz-Rodríguez et al., 2019; Wood et al., 2020). Integrative approaches are being used in Convolvulaceae to enlighten species recognition, especially when morphology itself is too variable or difficult to interpret. Thus, recent studies focused on resolving species boundaries are laying on morphometrics - e.g. in *Daustinia* Buril & A.R.Simões (Alencar et al., 2020; 2024), and *Jacquemontia* Choisy (Belo et al., 2024a); molecular - e.g. in *Distimake* Raf. (Pisuttimarn et al., 2023), and

Ipomoea (Muñoz-Rodríguez et al., 2019); palynological - e.g. in *Evolvulus* L., *Ipomoea*, *Jacquemontia*, *Distimake* (Vital et al., 2008; Vasconcelos et al., 2015; Belo et al., 2024b); and anatomical characters - e.g. in *Argyreia* (Traiperm et al., 2017), *Camonea* Raf. (Santos et al., 2024), *Daustinia* (Alencar et al., 2022), *Ipomoea* (Santos et al., 2020a; b), and *Jacquemontia* (Belo et al., 2023b; c).

During field expeditions in Brazilian territory, we collected a morphotype of *Ipomoea* in the Brazilian Cerrado with unusual sepals and fruits, growing in an anthropic area. In the first analysis, we identified it as belonging to the morphological variation of *I. bahiensis*. However, after in-depth and careful analyses, remarkable characters were found, excluding this specimen from the morphological range reported to *I. bahiensis*. The present study provides analyses through morphological, anatomical, and palynological studies at the population level to test the hypothesis that there are morphological reasons to differentiate these two biological entities. Therefore, here we describe this morphotype as a new species.

Material and methods

Macromorphological analyses

Field expeditions were conducted in the Cerrado, Amazon, Pantanal, and Caatinga domains, in the states of Bahia, Mato Grosso do Sul, Pará, Pernambuco, and Piauí, Brazil, between May 2023 and April 2024. Specimens of morphologically close species were analyzed in the following herbaria: ALCB, ASE, CGMS, CEN, EAC, EAN, HUEFS, IAN, INPA, IPA, K, MAC, MBM, MG, NY, P, PEUFR, RB, SP, SPF, UEC, and UFP (Thiers, 2024). We also carefully examined the type material of each possibly related species available at JSTOR (<https://plants.jstor.org/>). The taxonomic description and terminology follow Harris & Harris (2001) and Wood et al. (2020). The phenological period was defined based on the collected specimens. A preliminary conservation status assessment was performed according to the IUCN Red List Categories and Criteria (IUCN, 2012; 2024). The map of occurrence was produced using QGIS Software 3.22 (QGIS.ORG, 2023) (Fig. 1). The geographic coordinates used to prepare the distribution map of the populations used in the micromorphological analyses and of the specimens of *I. bahiensis* can be found in the supplementary material 1. A list of examined specimens that were used for the taxonomic treatment of *I. bahiensis* can be found in supplementary material 2. Dehydrated samples of leaves near the leaf margins and the median portions of petioles and peduncles were prepared for scanning electron microscopy (SEM) analysis by fixing them to aluminum supports (stubs) using double-sided adhesive tape. The samples were then photomicrographed using a Hitachi SEM, model TM4000 Plus. The images were processed using CorelDRAW® 2021 software.

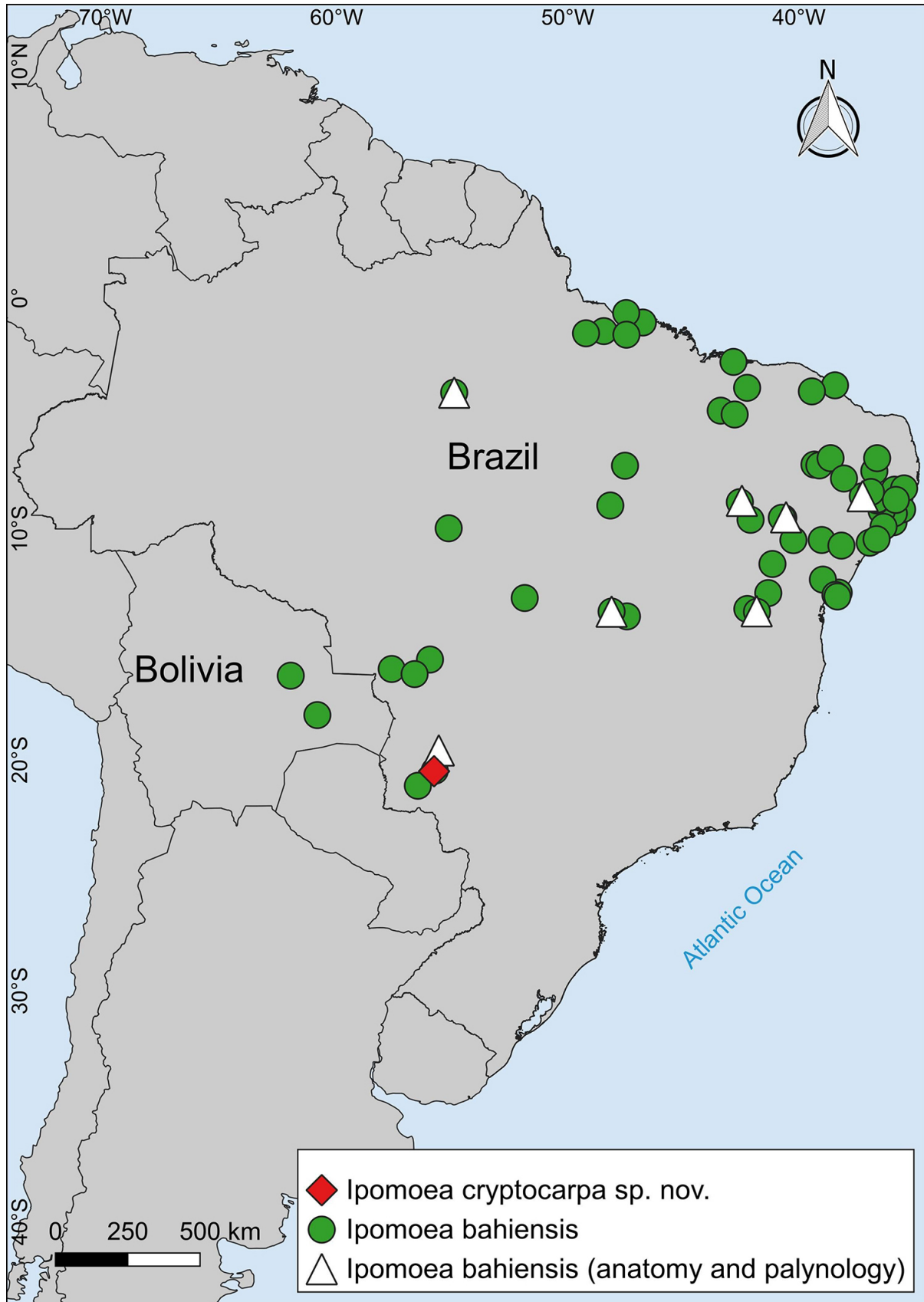


Figure 1. Populations of *Ipomoea bahiensis* Willd. ex Roem. & Schult. (white) and *Ipomoea cryptocarpa* Belo & Buril, sp. nov. (red) analyzed in this study. Specimens of *Ipomoea bahiensis* Willd. ex Roem. & Schult. (green) examined in herbaria.



Anatomical analyses

We proceeded with a comparative anatomical analysis using leaves, sepals, and stems of the new species and its closest relative, *I. bahiensis* (Table 1). Three leaves from the third shoot node, two sepals, and stem samples were obtained from the specimens collected in the field and fixed in FAA 50 (formaldehyde, acetic acid, and 50% ethanol) for 48 hours (Johansen, 1940) and then stored in 70% ethanol. Freehand sections were made in the median region of the leaf blade, petiole, and stem, cleared by 50% sodium hypochlorite treatment, and stained with Safranin-astera blue (Bukatsch, 1972). Slides were prepared according to the protocols of Kraus & Arduin (1997), analyzed under a Leica DM500 microscope, and subsequently deposited in the Integrative Systematics Laboratory at Universidade Federal Rural de Pernambuco, Brazil. The images were processed using CorelDRAW® 2021 software.

Palynological analysis

To describe pollen morphology, at least two unopened flowers were collected from each specimen per population, close to anthesis, to obtain a significant sample of pollen material (Table 1). The pollen grains were acetolyzed according to Erdtman (1960) with the modifications mentioned in Melhem *et al.* (2003). Diameter measurements were taken on 25 pollen grains over one week (Salgado-Labouriau *et al.*, 1965). Other measurements (exine thickness and apertures)

were taken from ten pollen grains. The slides obtained were incorporated into the pollen collection of the Laboratory of Plant Morphology and Palynology - LaMPali/UNESP.

Statistical analyses were performed to obtain the mean ($\bar{x}$) and standard deviation (S_x) of diameters, apertures, spines, the distance between spines, and exine layers of pollen grains (Zar, 2010). The pollen morphology and terminology follow Punt *et al.* (2007) and Halbritter *et al.* (2018). The number of apertures was calculated based on Hoen & Punt (1989), and to calculate the number of spines, we followed what was proposed by Hanks & Fryxell (1979).

Results

Anatomy

In the paradermic section and the frontal view, the leaf blade epidermis of *Ipomoea sp. nov.* comprises cells with sinuous anticline walls on the adaxial and abaxial surfaces, with tector trichomes, and sessile peltate glandular trichomes. The leaf is amphihypostomatic, with anisocytic and paracytic stomata (Fig. 2A–B). In cross-section, the petiole has a concave-convex contour with uniseriate epidermis and absent trichomes (Fig. 2E). Adjacent to the epidermis is found the angular collenchyma with 2–3 layers of cells, arranged continuously along the petiole, followed by the fundamental parenchyma, composed of visually isodiametric cells circular (Fig. 2E).

Table 1. Specimens used in micromorphological analyses.

Taxa	Locality	Voucher	Herbarium	Anatomical analysis	Palynological analysis	Geographic coordinates (latitude, longitude)
<i>Ipomoea cryptocarpa</i> Belo & Buril, sp. nov.	Anastácio, Mato Grosso do Sul state – Brazil	E. Barbier and D. Belo 13	PEUFR	X	X	-20.4977, -55.7875
<i>Ipomoea bahiensis</i>	Aquidauana, Mato Grosso do Sul state – Brazil	A. Pott. 11798	PEUFR	X	–	-19.5933, -55.5833
<i>Ipomoea bahiensis</i>	Catimbau National Park, Pernambuco state – Brazil	D. Belo and E. Barbier 634	PEUFR	X	X	-8.5812, -37.2486
<i>Ipomoea bahiensis</i>	Chapada Diamantina National Park, Bahia state – Brazil	D. Belo <i>et al.</i> 653	PEUFR	X	X	-13.5644, -41.8326
<i>Ipomoea bahiensis</i>	Cavalcante, Goiás state – Brazil	G. Pereira-Silva <i>et al.</i> 4913	MAC	X	–	-13.5833, -48.1075
<i>Ipomoea bahiensis</i>	Juazeiro, Bahia state – Brazil	D. Belo and E. Barbier 621	PEUFR	X	X	-9.4978, -40.5598
<i>Ipomoea bahiensis</i>	Rurópolis, Pará state – Brazil	E. Barbier and D. Belo 25	PEUFR	X	–	-4.1005, -54.9166
<i>Ipomoea bahiensis</i>	Serra da Capivara National Park, Piauí state – Brazil	D. Belo and E. Barbier 628	PEUFR	X	–	-8.7828, -42.4701

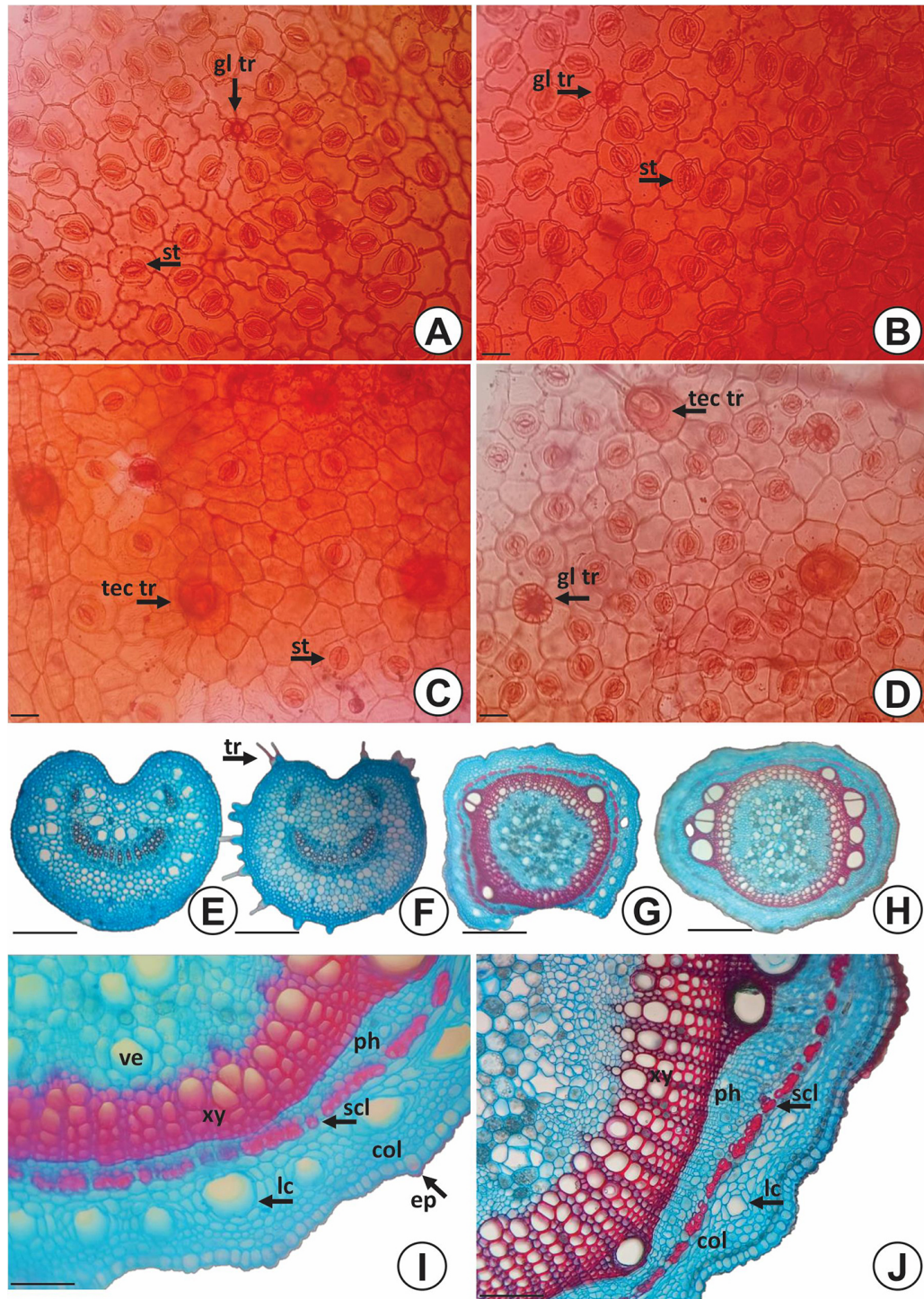


Figure 2. Paradermic and transverse sections of the leaves and stems of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult. **A.** Adaxial epidermis with sinuous cell walls, anisocytic and paracytic stomata in *I. cryptocarpa*: glandular trichome (gl tr), stomata (st). **B.** Abaxial epidermis with sinuous cell walls and paracytic stomata in *I. cryptocarpa*: glandular trichome (gl tr), stomata (st). **C.** Adaxial epidermis with straight to slightly curved walls and paracytic stomata in *I. bahiensis*: tector trichome (tec tr), stomata (st). **D.** Abaxial epidermis with straight to curved walls and paracytic stomata in *I. bahiensis*: glandular trichome (gl tr), tector trichome (tec tr). **E.** Petiole concave-convex with absent trichomes in *I. cryptocarpa*. **F.** Petiole concavo-convex with tector trichomes in *I. bahiensis*: tector trichome (tr). **G.** Stem of *I. cryptocarpa* with few laticiferous canals in the medulla region and xylem. **H.** Stem of *I. bahiensis* with many laticiferous canals in the medulla region and xylem. **I.** Details of the stem of *I. cryptocarpa*: epidermis (ep), collenchyma (col), laticiferous canals (lc), sclerenchyma (scl), phloem (ph), xylem (xy), vessel elements (ve). **J.** Details of the stem of *I. bahiensis*: collenchyma (col), laticiferous canals (lc), sclerenchyma (scl), phloem (ph), xylem (xy). Scale bars: **A–D** = 100 µm; **E–H** = 200 µm; **I–J** = 100 µm. Photographs: Deibson Belo.



The vascular system is bicollateral comprising three bundles, the main one being the arch, located in the central region of the petiole, and two smaller ones positioned on the adaxial surface (Fig. 2E). Laticiferous canals are concentrated in the region above the main vascular bundle of the petiole (Fig. 2E). The secondary stem has a circular shape and uniseriate epidermis (Fig. 2G). The cortical region of the stem is adjacent to the epidermis and composed of 3 layers of lamellar collenchyma, followed by 2–3 layers of parenchyma. Internally to the cortical region, sclerenchyma fibers were observed surrounding the phloem. In the vascular system in a single growth ring, the xylem forms a continuous ring with xylem elements. The central region of the stem is occupied by a medulla composed of fundamental parenchyma with rounded and isodiametric cells, the largest ones in the central region and the smallest close to the xylem, in addition to the phloem (2–3 layers), and idioblasts containing drusen and laticiferous canals in the central region (Fig. 2I).

In the paradermal section, the sepals of *Ipomoea sp. nov.* present straight anticlinal walls on both epidermal surfaces, with the presence of druses on the adaxial surface (Fig. 3C). The stomatal distribution is hypostomatic, with predominantly anomocytic stomata, with anisocytic ones being rare, and occasionally forming stomatal groupings in pairs (Fig. 3D). In cross-section, the sepals have a straight adaxial surface and a prominent abaxial surface, with sharp ends. The epidermis is uniseriate, with glandular trichomes emerging from the surface on both surfaces (Fig. 3F). The mesophyll is homogeneous (Fig. 3F), composed of compact parenchyma cells, without noticeable intercellular spaces, numerous laticiferous canals are present (Fig. 3H), distributed in the central region and along the mesophyll.

In paradermal section, the epidermal cells of the leaf blade of *I. bahiensis* exhibit straight to curved anticlinal walls on both surfaces (adaxial and abaxial) (Figs. 2C–D). The stomatal distribution is amphihypostomatic, and paracytic stomata commonly occur on both surfaces of the leaf blade (Figs. 2C–D). In the transverse section, the mesophyll is dorsiventral, with palisade parenchyma arranged in 2 to 3 layers and spongy parenchyma in 3 to 4 layers. The main midrib displays a biconvex outline, angular collenchyma, and a vascular system consisting of a single central bicollateral bundle in an arch shape. The petiole is concave-convex, with an undulated epidermis and a shallow, closed adaxial concavity (Figs. 2F).

Palynology

The pollen grains of *Ipomoea sp. nov.* are monads, apolar, large size ($\bar{x} = 90.8 \times 90.4 \mu\text{m}$) (Fig. 4A), spheroidal, pantoporate, narrow pores (Fig. 4B), ca. 111 circular pores ($\bar{x} = 2.8 \mu\text{m}$) annulus absent; exine tectate, echinate, and perforate. Bulbous spines ($\bar{x} = 12.2 \mu\text{m}$) (Fig. 4C), ca. 250, rounded apex, wide and polygonal base. Nexine is thicker

than sexine (exine total $\bar{x} = 9.6 \mu\text{m}$; sexine $\bar{x} = 3.9 \mu\text{m}$; nexine $\bar{x} = 5.7 \mu\text{m}$).

In *I. bahiensis*, the pollen grains are monads, apolar, very large ($\bar{x} = 111.7 \times 110.9 \mu\text{m}$) (Fig. 4E), spheroidal, pantoporate, large pores (Fig. 4F), ca. 96 circular pores ($\bar{x} = 9.9 \mu\text{m}$) annulus absent; exine tectate, echinate, perforate. Coniform spines ($\bar{x} = 20.3 \mu\text{m}$) (Fig. 4G), ca. 165, acute apex, wide and rounded base. Sexine is thicker than nexine (exine total $\bar{x} = 10.3 \mu\text{m}$; sexine $\bar{x} = 6.3 \mu\text{m}$; nexine $\bar{x} = 4.1 \mu\text{m}$).

Here we present a taxonomic treatment of the new species and a complete description of *I. bahiensis*, clarifying its morphological boundaries, based on populations studied from its entire distribution range.

Taxonomic Treatment

Ipomoea cryptocarpa Belo & Buril, *sp. nov.* (Figs. 5, 6, 7, 8, 9)

Type: BRAZIL. Mato Grosso do Sul, Anastácio, entrada da cidade, sentido Campo Grande-Anastácio; 20°29'52" S, 55°47'15" W; 171 m; 2 Sep. 2023 (fl., fr.), E. Barbier & D. Belo 13 (Holotype: PEUFR!; Isotype: CGMS!).

Diagnosis: *Ipomoea cryptocarpa* is similar to *I. bahiensis* due to its hastate leaves, with the base hastate to sagittate, and sepals with an appendage at the apex. However, *I. cryptocarpa* bears a glabrous petiole (vs. pubescent in *I. bahiensis*), inflorescence 1–3-flowered (vs. 4–20-flowered), corolla ≤ 30 mm long (vs. > 30 mm long), sepals with a dorsal globose appendage (vs. sepals with a dorsal tooth-like appendage), accrescent, enclosing the capsules (vs. not enclosing the capsules), and seeds lanate (vs. pubescent).

Description: Climbing plants, herbaceous; twining, branches glabrous, striated; internodes 35.6–141.2 mm long. Leaf blades 21.6–45.6 $\times$ 7.3–14.9 mm, hastate to sagittate, margin entire, ciliate, the base hastate to sagittate, the apex caudate, rare mucronate to acute, adaxial surface glabrous to glabrescent with tector trichomes simple or bifid, and sessile peltate glandular trichomes, abaxial surface glabrescent with tector trichomes simple, and sessile peltate glandular trichomes viewed under scanning electron microscopy, venation peninervea, cladodromous type, with eight to ten pairs of secondary veins; petiole 8.8–31.2 mm long, glabrous to glabrescent, sessile peltate glandular trichomes viewed under scanning electron microscopy, striated with protuberances. Inflorescence cymose 1–3-flowers; peduncle 3.3–7.2 mm long, glabrous, striated viewed under stereomicroscope, and sessile peltate glandular trichomes viewed under scanning electron microscopy; bracteoles 3.7–6.6 mm long, lanceolate, the base rounded, the apex acute, glabrous; pedicels 4.5–10.5 mm long, glabrous, striated. Sepals 5, unequal, fleshy, the 2 outer ones 5.4–7 $\times$ 5.5–5.8 mm, ovate, the base rounded to subtruncate, the apex retuse with subtly dorsal globose appendage between 1–1.2 mm long, glabrous, the intermediate one 7–7.6 $\times$ 5.2–5.6 mm,

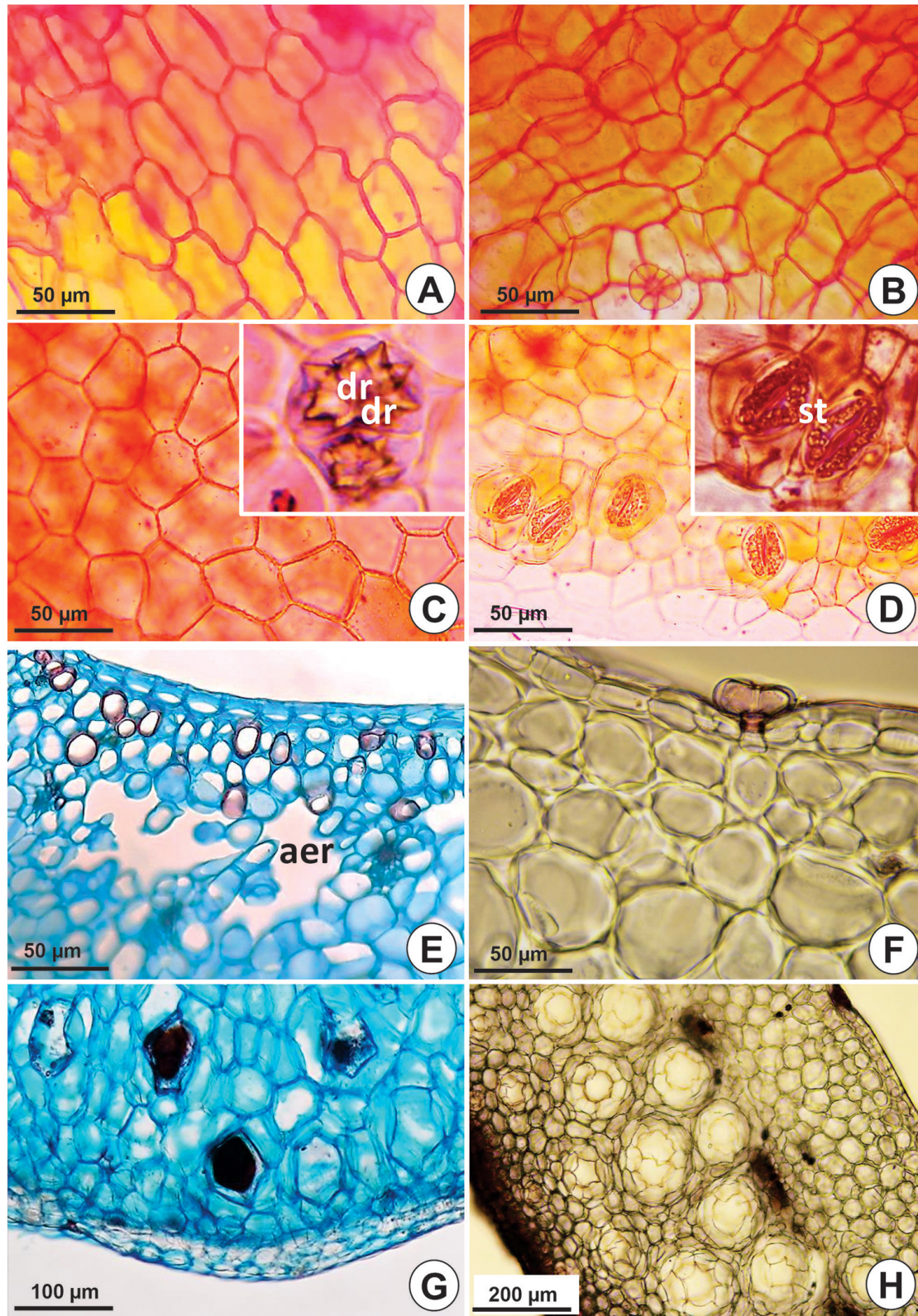


Figure 3. Comparative anatomy of the sepals of *Ipomoea bahiensis* Willd. ex Roem. & Schult. and *Ipomoea cryptocarpa* Belo & Buril. **A.** Adaxial surface of *Ipomoea bahiensis* shows no druses and stomatal clusters. **B.** Abaxial surface of *Ipomoea bahiensis*. **C.** Adaxial surface of *Ipomoea cryptocarpa* showing druses (dr). **D.** Abaxial surface of *Ipomoea cryptocarpa* showing stomatal clusters in pairs (st). **E.** Mesophyll of *Ipomoea bahiensis* showing aerenchyma below the epidermis (aer). **F.** Mesophyll of *Ipomoea cryptocarpa* showing compact homogeneous parenchyma. **G.** Detail of the abaxial region showing few laticiferous canals near the epidermis of *Ipomoea bahiensis*. **H.** Laticiferous canals in the central region of the mesophyll of *Ipomoea cryptocarpa*.



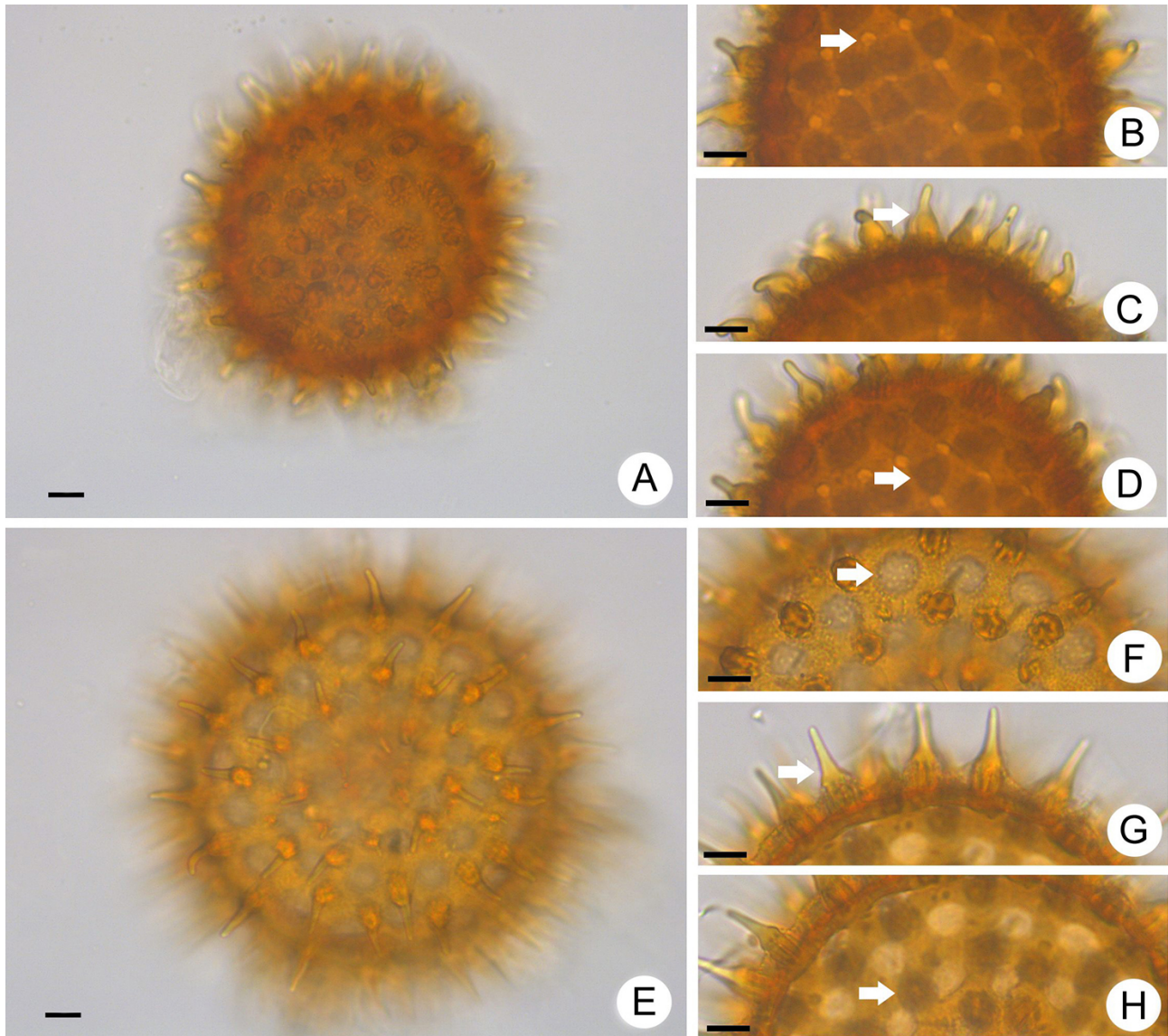


Figure 4. Comparison of the pollen grains of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult. in light micrographs. **A.** General view of *I. cryptocarpa* pollen grains. **B.** Aperture details of *I. cryptocarpa* pollen grains. **C.** Spines details of *I. cryptocarpa* pollen grains. **D.** Base of spines details of *I. cryptocarpa* pollen grains. **E.** General view of *I. bahiensis* pollen grains. **F.** Aperture details of *I. bahiensis* pollen grains. **G.** Spines details of *I. bahiensis* pollen grains. **H.** Base of spines details of *I. bahiensis* pollen grains. Scale bars: 50 µm. Photographs: Eduardo Gasparino.

rotund, the base rounded to truncate, the apex retuse with dorsal globose appendage ca. 1.2 mm long, glabrous, the 2 inner ones 7.1–7.5 × 5.2–5.8 mm, rotund, the base rounded, the apex retuse with subtly dorsal globose appendage between 1–1.2 mm long, glabrous. Corolla 24.1–28.6 mm long, funnellform, pink, glabrous. Filaments 5, emerging from the base of the corolla, 8.1–15.7 mm long, glabrous; anthers usually narrowly oblong 3–3.5 mm long, glabrous. Ovary 1.1–1.3 × 1.8–1.9 mm, globose; style entire, 6–6.2 mm long, stigmatic lobes 2, 0.5–0.6 mm long, oval. Capsules 4-valvar, 8–10 mm long, globose, enclosed by accrescent sepals. Seeds 4.7–5.6 mm long, lanate, golden.

Etymology: The specific epithet is derived from the Greek *crypto-*, covered, hidden, and *-carpos*, fruit; referring to the fruit being hidden by the sepals until maturity, a diagnostic character of the species.

Phenology: *Ipomoea cryptocarpa* was found with flowers and young fruits until early September. Senescent flowers and fruits were also found *in loco*.

Distribution and habitat: This species is known only from Anastácio municipality (state of Mato Grosso do Sul), in the Brazilian Cerrado. It was found near a livestock grazing area in a peri-urban transition zone. *Ipomoea cryptocarpa* is potentially a native plant adapted to anthropic areas.

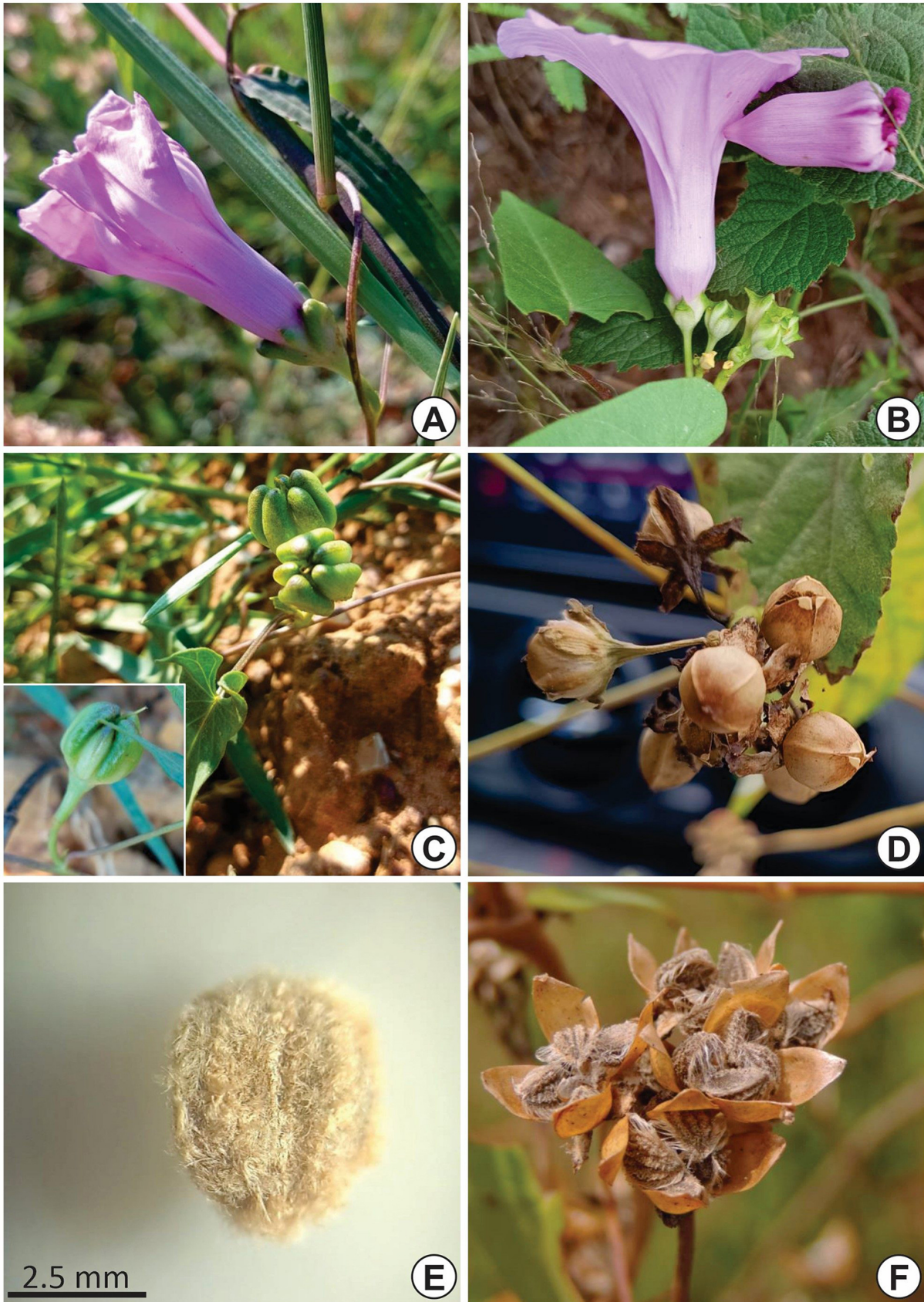


Figure 5. Comparison of the macromorphological structures of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult. **A.** Flower of *I. cryptocarpa*. **B.** Flower of *I. bahiensis*. **C.** Fruits of *I. cryptocarpa*. **D.** Fruits of *I. bahiensis*. **E.** Seed of *I. cryptocarpa*. **F.** Seeds of *I. bahiensis*. Photographs: Eder Barbier (A-E); Diego Gonzaga (F).



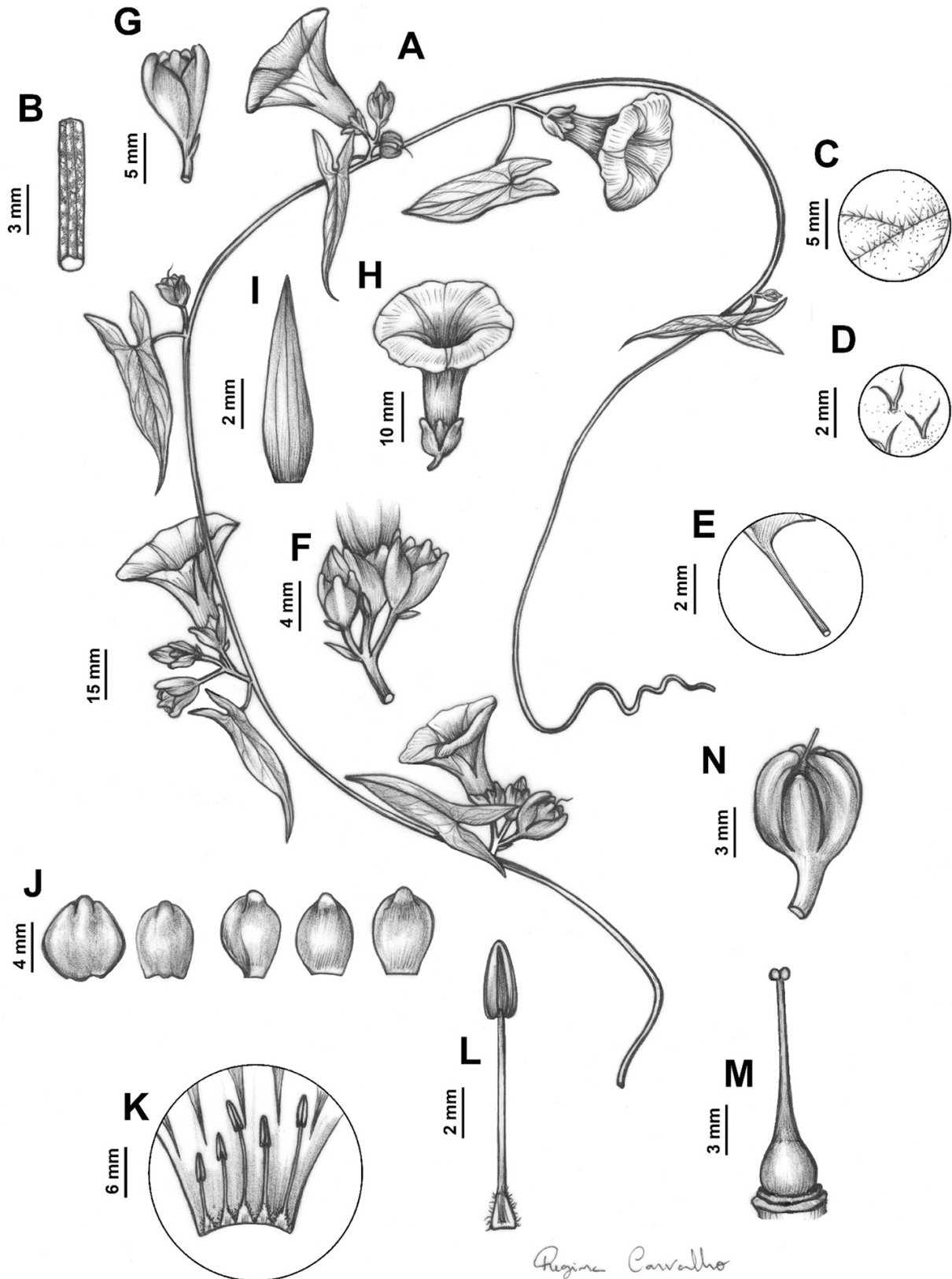


Figure 6. *Ipomoea cryptocarpa* Belo & Buril, sp. nov. **A.** Habit. **B.** Striated stem. **C.** Trichomes on the adaxial leaf surface. **D.** Bifid trichomes. **E.** Striated petiole and glabrous. **F.** Inflorescence. **G.** Floral bud. **H.** Flower. **I.** Bracteole. **J.** Sepals with dorsal globose appendage. **K.** Corolla inner surface. **L.** Stamen. **M.** Gynoecium. **N.** Fruit immature. Illustration of the holotype by Regina Carvalho.

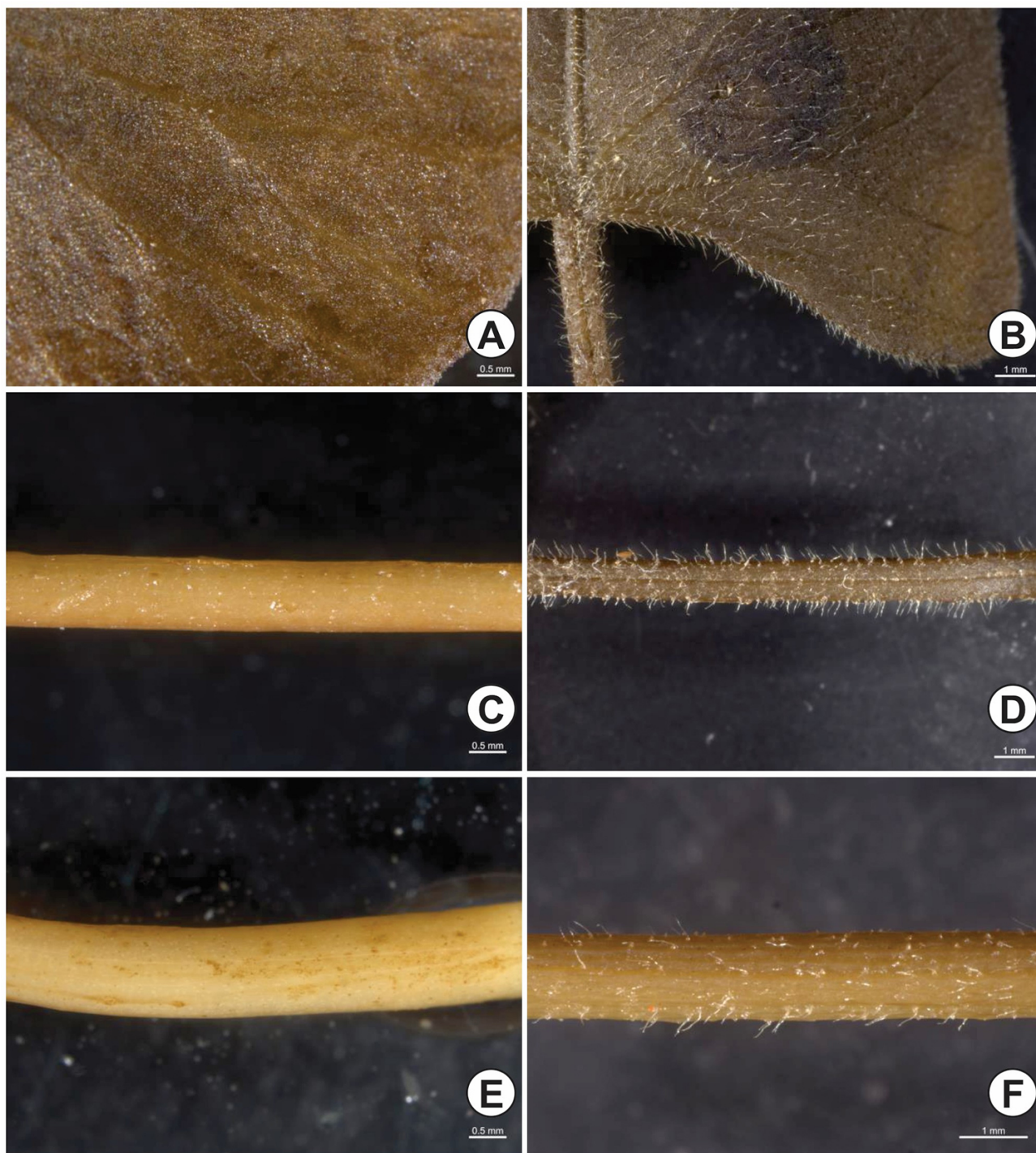


Figure 7. Comparison of the morphological structures of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult. **A.** Adaxial surface glabrous in *I. cryptocarpa*. **B.** Adaxial surface pubescent in *I. bahiensis*. **C.** Petiole glabrous in *I. cryptocarpa*. **D.** Petiole pubescent in *I. bahiensis*. **E.** Peduncle glabrous in *I. cryptocarpa*. **F.** Peduncle pubescent in *I. bahiensis*. Photographs: Deibson Belo.



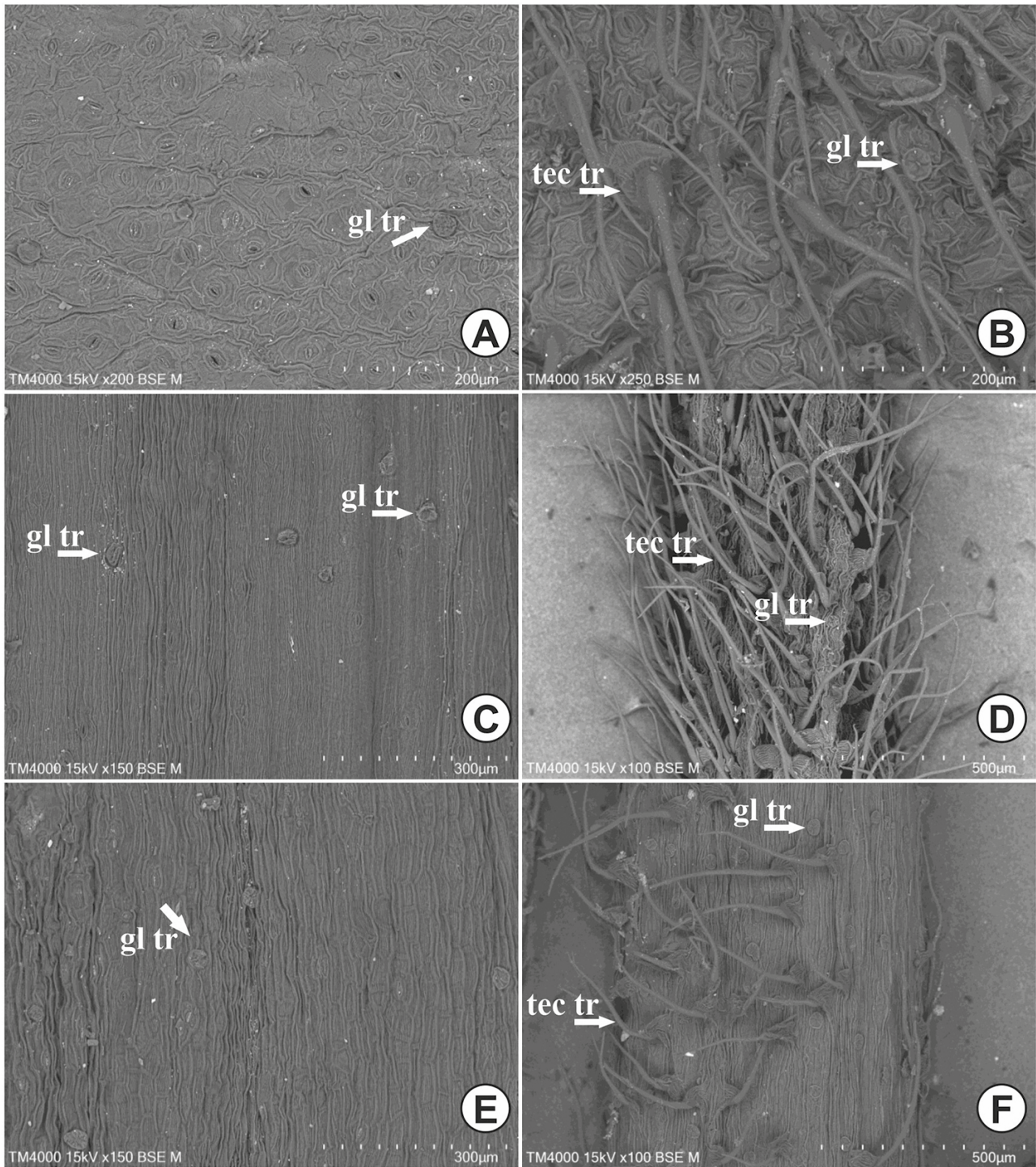


Figure 8. Comparison of the morphological structures of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult. view by scanning electron microscopy. **A.** Adaxial surface with sessile peltate glandular trichomes (gl tr) in *I. cryptocarpa*. **B.** Adaxial surface pubescent with tector trichomes (tec tr) and peltate glandular trichomes (gl tr) in *I. bahiensis*. **C.** Petiole with sessile peltate glandular trichomes (gl tr) in *I. cryptocarpa*. **D.** Petiole pubescent with tector trichomes (tec tr) and peltate glandular trichomes (gl tr) in *I. bahiensis*. **E.** Peduncle with sessile peltate glandular trichomes (gl tr) in *I. cryptocarpa*. **F.** Peduncle pubescent with tector trichomes (tec tr) and peltate glandular trichomes (gl tr) in *I. bahiensis*. Photographs: Hianna Fagundes.



Figure 9. Comparison of the morphological structures of *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis*. **A.** Sepals with dorsal globose appendage in *I. cryptocarpa*. **B.** Sepals with dorsal tooth-like appendage in *I. bahiensis*. **C.** Bracteoles (brac) lanceolate with the apex acute in *I. cryptocarpa*. **D.** Bracteoles (brac) lanceolate with the apex acuminate to caudate in *I. bahiensis*. Photographs: Deibson Belo.

It was observed climbing a species of Poaceae, even though only a few individuals were found in the area.

Preliminary IUCN conservation assessment:

Assessing the conservation status of *I. cryptocarpa*, we considered it as Data Deficient (DD) since it is known only from the type locality. The species was discovered in an anthropic environment, an urban and peri-urban transition zone of the Brazilian Cerrado, near pastures used for domestic animal farming. These areas experience constant human interference, whether from the upkeep of urban roads or the maintenance of crop and livestock management. The Brazilian Cerrado is one of Brazil's biodiversity hotspots and the second-largest phytogeographic domain (Klink & Machado, 2005; Hofmann *et al.*, 2021). The number of vascular plants in this phytogeographic domain exceeds 13,900 known species, of which around 33% are endemic (Flora e Funga do Brasil, 2024). A large part of the Cerrado was transformed into pasture and crop areas (Klink & Machado, 2005), and the destruction of this domain continues, mainly due to human action (Machado *et al.*, 2004). Many biological entities that are still undescribed and inhabit the Cerrado may be threatened, due to the

countless impactful activities that directly or indirectly affect this domain (Fernandes & Pessôa, 2011).

Additional specimens examined (Paratypes): Brazil. Mato Grosso do Sul: Anastácio, 20°29'52"S, 55°47'15"W, 2 Sep. 2023 (fl., fr.), E. Barbier & D. Belo 14 (PEUFR); *ibid.*, 2 Sep. 2023 (fl.), E. Barbier & D. Belo 15 (UFP).

Taxonomic notes: The sagittate and hastate leaves found in the new species are also found in other species of the genus in areas of the Brazilian Cerrado or close to the type locality of *I. cryptocarpa*, such as *I. acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch., *I. aequiloba* J.R.I.Wood & Scotland, *I. aquatica* Forssk., *I. bahiensis*, *I. cryptica* J.R.I.Wood & Scotland, *I. maurandioides* Meisn., *I. mucronatoprodacta* J.R.I.Wood & Scotland, *I. paludicola* J.R.I.Wood & Scotland, and *I. squamosa* Choisy (Wood *et al.*, 2020; Delgado-Junior *et al.*, 2023). Among them, only *I. cryptocarpa* and *I. bahiensis* share the sepals with appendages and possibly are closely related. However, the absence of indument in the branches, in addition to the shape of the sepal appendage, and the capsule enclosed by the sepal when maturing, are relevant macromorphological characters to differentiate them (Figs. 7, 8, 9, Table 2).



Table 2. Morphological comparison between *Ipomoea cryptocarpa* Belo & Buril, sp. nov. and *Ipomoea bahiensis* Willd. ex Roem. & Schult.

Character	<i>Ipomoea cryptocarpa</i> Belo & Buril, sp. nov.	<i>Ipomoea bahiensis</i> Willd. ex Roem. & Schult.
Branch indumentum	Glabrous	Glabrescent to pubescent
Indumentum of the adaxial leaf surface	Glabrous to glabrescent, simple or bifid tector trichomes, and sessile peltate glandular trichomes	Pubescent, sericeous to tomentose, simple tector trichomes, and peltate glandular trichomes
Indumentum of the abaxial leaf surface	Glabrescent, simple tector trichomes, and sessile peltate trichomes	Pubescent, sericeous to tomentose, simple tector trichomes, and peltate glandular trichomes
Petiole	Glabrous to glabrescent, sessile peltate glandular trichomes	Pubescent, tomentose to hirsute, tector trichomes simple, and peltate glandular trichomes
Peduncle	Glabrous, striated	Pubescent, tomentose to hirsute, smooth
Bracteoles	Lanceolate	Linear to ensiform
Bracteoles base	Rounded	Truncated
Bracteoles apex	Acute	Acuminate to caudate
Inflorescence	1–3-flowered	4–20-flowered
Apex of outer sepals	Retuse	Acute with mucro
Appendage at the apex of the sepal	Dorsal globose appendage	Dorsal tooth-like appendage
Outer sepals indumentum	Glabrous	Glabrous to glabrescent, with tector trichomes in margin
Pollen size	Large ($\bar{x} = 90.8 \times 90.4 \mu\text{m}$)	Very large ($\bar{x} = 111.7 \times 110.9 \mu\text{m}$)
Pollen aperture	Small pore ($\bar{x} = 2.8 \mu\text{m}$)	Large pore ($\bar{x} = 9.9 \mu\text{m}$)
Pollen spine	Bulbous spines, rounded apex, wide and polygonal base	Coniform spines, acute apex, wide and rounded base
Exine thickness	Nexine thicker than sexine	Sexine thicker than nexine
Ovary	Globose	Ovoid
Seeds indumentum	Lanate	Pubescent
Contour of the epidermal walls of the adaxial and abaxial surfaces of leaves	Sinuuous	Straight to curved
Distribution of stomata	Leaves amphihypostomatic	Leaves amphistomatic
Contour of the epidermal walls of the adaxial surface of the sepals	Straight walls and prominent abaxial surface with absent lobes.	Curvilinear walls, with a prominent abaxial face, presenting three conspicuous lobes.
Type of stomata in the adaxial epidermis of sepals	Anomocytic	Paracytic
Stomatal grouping in the adaxial epidermis of the sepals	Present	Absent



Ipomoea bahiensis Willd. ex Roem. & Schult., Syst. Veg. 4: 769. 1819.

Type: Brazil. T. Hoffmannsegg s.n. (holotype B-W 03753-010).

Ipomoea salzmannii Choisy, Mém. Soc. Phys. Genève 8(1): 59. 1838. Type. Brazil. Bahia, *Salzmann* s.n. (lectotype M0184904, designated by Wood *et al.*, 2020:670).

Ipomoea salzmannii var. *uniflora* Choisy in A.P. de Candolle, Prodr. 9: 379. 1845. Type. BRAZIL. Minas Gerais, Salgado, *Martius* s.n. (holotype M0184905). *Ipomoea bahiensis* var. *uniflora* (Choisy) Meisn. in *Martius et al.*, Fl. Brasil. 7: 269. 1869.

Ipomoea bahiensis var. *sagittifolia* Meisn. in *Martius et al.*, Fl. Brasil. 7: 269. 1869. Type. Brazil. Rio São Francisco, *Gardner* 1359 (lectotype K000944834, designated by Wood *et al.*, 2020:670).

Quamoclit rochai Hoehne, Anexos Mem. Inst. Butantan, Bot. 1, fasc. 6: 79. 1922. Type. Brazil. Ceará, *D. Rocha* 16 (holotype SP).

Description: Climbing plants, herbaceous; twining, branches glabrescent to pubescent, smooth to striated; internodes 10–82 mm long. Leaf blades 12.5–89.18 × 5.79–95.56 mm, cordate, sagittate to hastate, margin entire, the base cordate, subcordate to hastate, the apex acuminate, apiculate with mucro, aristulate with mucro, mucronate to acute, adaxial surface pubescent, sericeous to tomentose, tector trichomes simple, and peltate glandular trichomes, abaxial surface pubescent, sericeous to tomentose, tector trichomes simple, and peltate glandular trichomes, venation peninervea, camptodromous type, with seven to nine pairs of secondary veins; petiole 3.36–63.45 mm long, pubescent, tomentose to hirsute, tector trichomes simple, and peltate glandular trichomes. Inflorescence cymose 4–20-flowers; peduncle 9.97–130.50 mm long, pubescent, tomentose to hirsute; bracteoles 1.73–6.63 mm long, linear to ensiform, the base truncated, the apex acuminate to caudate, glabrescent; pedicels 2–12.56 mm long, glabrous, smooth. Sepals 5, unequal, the 2 outer ones 3.46–7.22 × 2.07–4.1 mm, oval, ovate, obovate, oblong to elliptic, the base subtruncate, cuneate to aequilateral, the apex acute with mucro, subtly tooth-like appendage between 1.3–2.7 mm long, glabrous to glabrescent, with tector trichomes in the margin, the intermediate one 4.17–7.45 × 3.27–6.46 mm, rotund, the base subtruncate, the apex obtuse with mucro, subtly tooth-like appendage between 1.5–2.1 mm long, glabrous to glabrescent, with tector trichomes in the margin, the 2 inner ones 4.79–8.18 × 4.34–8.19 mm, rotund to orbicular, the base cordate to subcordate, rare subtruncate, the apex retuse to obtuse with mucro, with subtly tooth-like appendage between 1.3–2.5 mm long, glabrous. Corolla 30.14–54 mm long, funnelform, pink, glabrous. Filaments 5, emerging from the base of the corolla, 5.93–21.44 mm long, tector trichomes in the base, anthers elliptic 3.1–5.04 mm long, glabrous. Ovary 1–1.98 × 0.8–1.46 mm, ovoid; style entire, 7.36–17.82 mm long,

stigmatic lobes 2, 0.89–1.21 mm long, oval, glabrescent. Capsules 4-valvar, 11–20 mm long, globose; seeds 4.5–5.7 mm long, pubescent, gray to black.

Distribution and habitat: *Ipomoea bahiensis* occurs predominantly in Caatinga areas of northeastern Brazil, mainly on forest edges and disturbed environments. There are also records in other areas of Brazil, such as the Eastern Amazon, Cerrado, Atlantic Forest, and Pantanal (Flora e Funga do Brasil, 2024). It does not occur in the southern region of Brazil. After analyzing specimens in K, we also observed records of *I. bahiensis* in eastern Bolivia (Wood *et al.*, 2015; 2020).

Specimens examined: BOLIVIA – Santa Cruz. Santa Cruz. Nuflo de Chavez, 14 Mar 2019, J.R.I. Wood *et al.* 28973 (K barcode 000544433!). Chiquitos, 18 Apr 2013, J.R.I. Wood *et al.* 27877 (K barcode 001755498!). **BRAZIL – Alagoas:** Marechal Deodoro, 12 Sep 2008, R.P. Lyra-Lemos *et al.* 11512 (MAC barcode 034411!). Murici, margens da Estação Ecológica de Murici, 15 Nov 2023, D. Belo and E. Barbier 638 (PEUFR). **Bahia:** Andaraí, 17 Apr 2024, D. Belo *et al.* 654 (PEUFR). Juazeiro, 21 May 2023, D. Belo and E. Barbier 621 (PEUFR). Morro do Chapéu, 18 Apr 2024, D. Belo *et al.* 656 (PEUFR). **Ceará:** Juazeiro do Norte, 27 May 2023, D. Belo and E. Barbier 630 (PEUFR). Missão Velha, 28 May 2023, D. Belo and E. Barbier 631 (PEUFR). **Goiás:** Cavalcante, 14 Apr 2001, G. Pereira-Silva *et al.* 4913 (CEN barcode 00042107!, MAC 12046!, SP 370075!). **Maranhão:** Carolina, 24 May 1950, J.M. Pires *et al.* 2032 (IAN 58462!). **Mato Grosso:** Cáceres, 21 Jul 1987, W.L. Werneck 64 (CEN barcode 00011380). Novo Mundo Parque Estadual do Rio Cristalino, 9°26'28"S, 55°48'56"W, 1 Jun 2007, D. Sasaki *et al.* 1694 (INPA 222983!). **Mato Grosso do Sul:** Aquidauana, 12 Sep 2004, A. Pott 11798 (CGMS 52986!, PEUFR 53365!). Bonito, 4 Dec 2010, A. Quinet *et al.* 2354 (RB, SP). **Pará:** Belém, 13 May 1997, A. Nitta 17036 (IAN 167912!). Bragança, E.S. Galvão-Júnior 17 (MG barcode 160172!). Rurópolis, 17 May 2024, D. Belo and E. Barbier 25 (PEUFR). **Paraíba:** Cajazeiras, 3 Aug 2023, D. Belo and E. Barbier 636 (PEUFR). **Pernambuco:** Buíque, Parque Nacional do Catimbau, 29 July 2023, D. Belo and E. Barbier 633 (PEUFR). Pesqueira, 30 July 2023, D. Belo and E. Barbier 634 (PEUFR). Triunfo, 28 July 2023, D. Belo and E. Barbier 632 (PEUFR). **Piauí:** São Raimundo Nonato, Parque Nacional Serra da Capivara, 25 May 2023, D. Belo and E. Barbier 628 (PEUFR). **Tocantins:** Pedro Afonso, 28 Apr 1999, K.G. Kissmann s.n. (MBM barcode 248689!).

Discussion

Ipomoea cryptocarpa is, to date, known only from its type locality, an anthropic area within the Cerrado domain, in the state of Mato Grosso do Sul. Although we are currently conducting a review of *I. bahiensis*, its most closely related species, we have not detected any specimens that fit its concept in the herbarium collections. However, there may



be other populations that have not been collected due to the morphological similarity to a widespread, very common species.

Several authors have been considering *I. bahiensis* as a morphologically hypervariable species (Simão-Bianchini, 1998; Wood *et al.*, 2020; Delgado-Junior *et al.*, 2023). Thus, proposing new species related to it can be tricky. Starting from the hypothesis that the current concept of *I. bahiensis* is hiding a greater diversity, the ongoing thesis project of the first author aims to evaluate this variability through replicable methods, using different sources of information. After analyzing more than 20 populations and approximately 400 samples, our preliminary results corroborate this hypothesis so far. We can observe discontinuities between morphotypes (Belo & Buriel, unpublished data). The description of *I. cryptocarpa* is the first result of our analysis since many characters support the idea that it does not belong to the typical *I. bahiensis*.

Fifty-two species of *Ipomoea* are found in Mato Grosso do Sul state, but only two of them, *I. cardenasiana* O'Donnell and *I. pantanalensis* J.R.I. Wood & Urbanetz, are endemic to the state (Wood *et al.*, 2020; Simão-Bianchini *et al.*, 2024). As in *I. cryptocarpa*, only four other species of *Ipomoea* that occur in Mato Grosso do Sul have fruits enclosed by accrescent sepals: *I. cardenasiana*, *I. revoluta* J.R.I. Wood & Scotland, *I. rubens* Choisy, and *I. setifera* Poir. (see Wood *et al.*, 2020; Simão-Bianchini *et al.*, 2024).

However, *I. cryptocarpa* has a glabrous stem (vs. glabrescent in *I. cardenasiana*, pubescent in *I. revoluta*, tomentose in *I. rubens*, in hirsute in *I. setifera*), leaves entire, hastate, glabrescent in both surfaces (vs. 3-lobed, glabrous in surface adaxial, pubescent in surface abaxial in *I. cardenasiana*, digitate, 5–7 free leaflets, glabrous in surface adaxial, tomentose in surface abaxial in *I. revoluta*, ovate-deltoid, pubescent in surface adaxial, tomentose in surface abaxial in *I. rubens*, ovate-deltoid, glabrous in both surfaces in *I. setifera*), the base hastate to sagittate (vs. cordate in *I. cardenasiana* and *I. rubens*, tapered in *I. rubens*, cordate to hastate in *I. setifera*), the apex mucronate to acute (vs. acuminate and mucronate in *I. cardenasiana*, mucronate in *I. revoluta*, acute in *I. rubens*, obtuse to mucronate in *I. setifera*).

Comparing the anatomical characters, the angular-type collenchyma and collateral vascular system in the petiole are shared by *I. cryptocarpa* and *I. bahiensis*. However, the sinuous walls on the adaxial and abaxial surfaces in *I. cryptocarpa* differentiate these two species (vs. straight to curved walls on the adaxial and abaxial surfaces in all populations of *I. bahiensis* in this study) (Figs. 2A–D). The distribution of stomata on the leaf blade is different in the two species. In *I. cryptocarpa* the leaves are amphihypostomatic with anisocytic and paracytic stomata (Figs. 2A–B), while in *I. bahiensis* it is amphistomatic with only paracytic stomata (Figs. 2C–D). The unique presence of paracytic stomata in all populations of *I. bahiensis* was also observed by EV Santos (unpubl. res.) when comparing four species of *Ipomoea*.

In *I. cryptocarpa*, the laticiferous canals in the petiole occur in greater quantity and more frequently in the region above the main vascular bundle. We observed a frequency of nine laticiferous canals in the analyzed individuals of *I. cryptocarpa* (Fig. 2E), a characteristic not observed in the *I. bahiensis* populations from this study (Fig. 2F). When we compare the structure of the stem, both species share sclerenchyma fibers surrounding the phloem; however lamellar collenchyma with 3-layers occurs in *I. cryptocarpa* (Figs. 2G, 2I) (vs. angular 2–3-layers in all populations of *I. bahiensis*). Leaf anatomical characters used to support delimitations such as the type of epidermal walls, mesophyll, and shape of the petiole and midrib, in addition to the stem, have also been considered relevant in other studies of Convolvulaceae (Alencar *et al.*, 2022; Belo *et al.*, 2023b; c), as in other families – e.g. in Lamiaceae (Rashid & Parnell, 2017), and Oxalidaceae (Richetti *et al.*, 2023).

When comparing the anatomy of outer sepals, we also observed structural differences between the two species. The adaxial epidermis of *I. cryptocarpa* presents druses (Fig. 3C), predominantly anomocytic stomata, and stomatal groupings in pairs (Fig. 3D), contrasting with *I. bahiensis*, which presents paracytic stomata and does not present druses or stomatal groupings in the epidermis (Figs. 3A–B). In cross-section, the adaxial surface of *I. cryptocarpa* is rectilinear, with a prominent abaxial surface with absent lobes, while *I. bahiensis* has a curvilinear adaxial surface and three conspicuous lobes. In addition, *I. bahiensis* presents aerenchyma in its mesophyll (Fig. 3F), while in *I. cryptocarpa* the mesophyll is homogeneous and compact (Fig. 3E). Besides that laticiferous canals in *I. cryptocarpa* sepals are numerous and are predominantly found in the central region along the mesophyll (Fig. 3H), while in *I. bahiensis*, these canals are restricted to the proximity of the epidermis and in smaller numbers (Fig. 3G).

The pollen grains of *I. cryptocarpa* fit into the characteristic pattern of the genus: echinate and pantoporate pollen grains (Sengupta, 1972; Wood *et al.*, 2020). They are large (Fig. 4A), small pores (Fig. 4B), with bulbous spines (Fig. 4C), rounded apex, wide and polygonal base (Fig. 4D), and nexine thicker than sexine. When we compare *Ipomoea cryptocarpa* with *I. bahiensis*, we observe a variation in pollen and aperture size, the shape of the spines, and the thickness of the exine layers. The pollen results found in *I. bahiensis* in the present study, corroborate the description of *I. bahiensis* provided by Vital *et al.* (2008), and Vasconcelos *et al.* (2015), when studying other populations of this variable species.

Bulbous spines on pollen grains have been previously described in other species of the genus. Sengupta (1972) cites spines as broad and bulbous at the base for the species *I. clausa* Rudolph ex Ledeb & Adlerstam, *I. indica* (Burm.) Merr., gradually tapering towards the apex with a blunt tip and constricted neck, characteristics very similar to the spines observed for *I. cryptocarpa*. Vasconcelos *et al.* (2015) observed pollen grains with bulbous spines, similar to those

described here, for *I. hederifolia* L. and *I. incarnata* Choisy. Tiwari *et al.* (2023) proposed a Type III – wide bulbous base, progressively tapering toward the apex with a blunt tip for the species *I. purpurea* (L.) Roth and *I. triloba*. Bulbous spines were also found by Romeiro *et al.* (2023) for the species *I. cavalcantei* D.F.Austin, *I. decora* Meisn., *I. goyazensis* Gardner, *I. hederifolia*, and *I. marabaensis* D.F.Austin & Secco.

Sengupta (1972) cited this spine morphology as spines broad at the base and gradually tapering towards the apex with more or less rounded tips. Coniform spines such as those observed in *I. bahiensis* were described for *I. procumbens* Mart. ex Choisy, *I. rosea* Choisy, *I. rupestris* Sim.-Bianch. & Pirani, *I. subincana* (Choisy) Meisn., and *I. maurandioides* Meisn. (Vasconcelos *et al.*, 2015). Tiwari *et al.* (2023) described spines wide at the base, progressively tapering toward the apex with a blunt tip (Type II) for the species *I. aitonii* Lindl., *I. carnea* Jacq., *I. eriocarpa* R.Br., *I. hederifolia*, and *I. nil*; Romeiro *et al.* (2023) observed coniform spines in *I. asplundii* O'Donnell, *I. carajasensis* D.F.Austin, *I. procumbens*, and *I. setifera* Poir. pollen grains. Wood *et al.* (2020) indicate that there is continuous variation in pollen morphology with little or no variation that correlates with the phylogeny of *Ipomoea*. However, despite pollen morphology being homogeneous within the genus, our studies indicate that population studies have the potential to differentiate morphologically related specimens.

Species considered ruderal may be hiding a greater diversity of species, and more detailed studies are needed to understand the morphological patterns and species boundaries. Greater collection efforts are needed for verification of the conservation status of *I. cryptocarpa* since current information is still considered data deficient. Many weedy species are studied only locally, which can lead to the common practice of putting all “similar ones” within its taxonomic concept. This can bias the diversity knowledge and hamper conservation policies and bioprospecting. We also emphasize that it is necessary to advance in phylogenetic and population genetic studies to better elucidate the diversity in *Ipomoea*.

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Author's Contribution

DPB conceptualization, investigation, writing– original draft, methodology, validation, data curation, analysis and interpretation of the data, writing – review and editing. ECG conceptualization, methodology, data curation, validation, writing – review and editing, funding acquisition. MTB conceptualization, writing – review, and editing, funding acquisition.

Conflict of interest

The authors declare that there is no conflict of interest.

Supplementary Materials

The following online material is available for this article:

S1 – Geographic coordinates used to prepare the distribution map of the populations.

S2 – List of specimens examined.

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