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Original article

A new species of *Mandevilla* (Apocynaceae) from limestone outcrops in Central Brazil with a short note on the occurrence of geophytes in rauvolfioids and apocynoids

J. Francisco Morales[1*], Mary E. Endress[2], Isa Lucia de Morais[3] and Polla Renon[4]

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ABSTRACT

Mandevilla calcicola, endemic to limestone formations in Goiás state, Brazil, is described. A key and photos for all *Mandevilla* species reported in Goiás and Distrito Federal, Brazil, are included. This new species is assessed as Critically Endangered (CR). A short note on the occurrence of geophytes in rauvolfioids and apocynoids (focused on *Mandevilla*) and its taxonomic value is included.

Keywords: apocynoids, geophytes, Mesechiteae, tubers, tuberous roots

Introduction

Brazil is floristically the most diverse country in South America, with ca. 42,850 plant species recorded (Flora e Funga do Brasil 2020). Providing an accurate estimate of the total number of species in the country is a complex task due to the large amount of unidentified material as well as the taxonomic changes proposed every year. As a result of the exploration of remote areas, many new species and genera were described during the second half of the 20th century. At the same time, however, many species have been relegated to synonymy (Brazil Flora Group 2022). Phylogenetic studies provide critical results, which could directly affect the species number in a specific group. The state of Goiás in midwestern Brazil, has a remarkable diversity of habitats dominated by Cerrado with its distinct phytophysiognomic classifications (Ribeiro & Walter 2008; Santos *et al.* 2011; Soares *et al.* 2015). Cerrado occurs predominantly on latosol and quartz sand soils as well on dystrophic and mesotrophic soils (Marimon Junior & Haridasan 2005). Human activities, such as growing field crops (e.g., sugar cane, corn, soy) and cattle ranching, highly threaten this biome. Considerable knowledge has been obtained on Cerrado vegetation in the central region of Goiás, including the Federal District (e.g., Felfili & Fagg 2007; Santos *et al.* 2011; Lenza *et al.* 2011), but many regions in southeastern and southern Goiás remain unexplored.

1 Department of Life Sciences, University of the West Indies, Campus St. Augustine, Trinidad and Tobago; Research Associate, Missouri Botanical Garden, P.O. Box 299, St. Louis, Missouri 63166 U.S.A.
2 Department of Systematic and Evolutionary Botany, University of Zurich, Zollikerstrasse 107, 8008 Zurich, Switzerland.
3 Universidade Estadual de Goiás (UEG), Campus Quirinópolis, Avenida Brasil, 435, Conjunto Hélio Leão, Quirinópolis, 75860-000 Goiás, Brazil.
4 Universidade Federal de Uberlândia, Instituto de Biologia, Uberlândia, 38405-302, Minas Gerais, Brazil.

* Corresponding author: drjfranciscomorales@gmail.com

Apocynaceae comprises 96 genera and ca. 980 species in Brazil. The family is well represented in Goiás (including the Distrito Federal) (Flora e Funga do Brasil 2020). With 43 genera and 143 species recorded, it is the ninth richest Brazilian state in Apocynaceae, with the most diverse genera being *Mandevilla* Lindl. (20 species), *Aspidosperma* Mart. & Zucc. (15 species), *Oxypetalum* R. Br. (13 species), *Ruehssia* H. Karst. (nine species), and *Odontadenia* Benth. (seven species) (Flora e Funga do Brasil 2020). *Mandevilla* (Mesechiteae) is one of the largest genera of Apocynaceae in the New World, with an estimated 200 species (Morales & Morais 2020; Morales & Kollmann 2020a; b; Morales *et al*. 2022), distributed from southern USA and the West Indies to northern Argentina, except in Chile (Morales 2013; Alvarado-Cárdenas & Morales 2014). The genus exhibits a broad range of growth forms, enabling it to thrive in a variety of habitats, from coastal dunes (Restingas) and white-sand formations in the Amazon basin to the Andean forest and campos rupestres in Brazil, as well as dry forest, swamp areas, and savannas (Morales 2007; 2009; 2011). White-sand savannas are rich in endemic plants (Adeney *et al*. 2016).

Mandevilla is highly diverse in Brazil. Woodson (1933) recorded 36 species for the country, of which 27 were endemic. Since then, the number of species has increased substantially. Sales (1993) recognized 40 species of *Mandevilla* subgenus *Mandevilla* (sensu Woodson 1933). Fifteen new species have been published for Brazil in the last 15 years, almost all of them endemic (Morales 2005a; b; Sales *et al.* 2006; Souza-Silva *et al.* 2010; Morales 2018a; b; Coelho *et al.* 2020; Morales & Kollmann 2020a; b; Morales & Morais 2020; Morales *et al.* 2022). The Flora and Fungi of Brazil recognized 71 species of *Mandevilla* (Flora e Funga do Brasil 2020), 44 of them endemic. However, two species must be excluded as endemic: *Mandevilla alexicaca* (Mart. ex Stadelm.) J.F. Morales & A. Fuentes is present in Peru and Bolivia and *M. illustris* (Vell.) Woodson has been recorded in Peru, Bolivia, and Paraguay (Ezcurra *et al*. 1992; Fuentes & Morales 2014). The current species number for all of Brazil could be around 78 species considering several species described recently (Coelho *et al*. 2020; Morales *et al*. 2022). Taking into consideration the large number of unexplored Inselbergs in Espírito Santo as well as *Mandevilla*'s high diversity and narrow endemism in these formations, this number is likely an under-estimate.

In preparation for a revision on *Mandevilla* reported for Goiás and Distrito Federal, a new species endemic to limestone formations in Ponte de Pedra, Paraúna, Goiás state, was found and is described here. A note regarding geophytic species in traditional Apocynaceae (focused on *Mandevilla*) is provided.

Material and methods

This paper is part of the monograph of *Mandevilla*. Specimens (including types) from the following herbaria were examined: A, AAU, ALCB, AS, ASE, B, BHCB, BM, BOTU, BR, C, CAS, CAY, CEN, CEPEC, CESJ, CGE, CHOCO, CIIDIR, CIMI, CM, COAH, COL, CPUN, CR, CVRD, CUCV, CUZ, DUKE, E, EAP, ECON, ENCB, ESA, ESAL, F, FI, FI-W, FLAS, FLOR, FTG, FUEL, G, G-DC, GA, GFJP, GH, GUA, HAL, HAO, HAS, HB, HBG, HRB, HRCB, HTO, HUA, HUEFS, HUFU, HUQ, IAN, IBGE, ICN, INPA, JAR, JAUM, JPB, K, L, LAGU, LD, LIL, LP, LPB, LV, LZ, M, MA, MBM, MBML, MCNS, MEDEL, MEXU, MICH, MIN, MG, MO, MOL, MVFA, MVJB, NY, O, P, P-HB, P-JU, P-LA, PAMG, PEL, PEUFR, PMA, PR, Q, QCA, QCNE, R, RB, S, SI, SPF, SPFR, SP, TRIN, TULV, U, UC, UB, ULM, UNAH, UPCB, UPS, US, USF, USJ, USM, USZ, UTEP, UVAL, W, WAG, WIS, WU, VALLE, VEN, VIC, Z and ZT. Acronyms cited follow Thiers (2023), continuously updated). Description of the new species was based on herbarium specimens and fresh material. The species concept of Templeton (1989) is followed for the description of the new species, considering the phenotypic variability and habitat restrictions. Typification of species (including homotypic and heterotypic synonyms) reported for Goiás and Distrito Federal is provided in Morales (2022). Morphological terminology follows Radford *et al.* (1974). Pertinent morphological characters are illustrated in Morales (2005c), and definition of parts of the corolla follow Morales and Fuentes (2004). Measurements given in the key are based on an unpublished monograph of *Mandevilla* (Morales, unpub. data) and these can differ with respect to those given in previous papers.

The conservation status was assessed using the IUCN Red List Categories and Criteria, version 3.1 (IUCN 2014). Calculating the extent of occurrence (EOO) or the area of occupancy (AOO) was not made because at least three localities are needed. Population size is poorly understood in neotropical apocynoids (Morales 2018a; Morales & Cornejo 2019), because evaluating this feature is not possible at this time.

Taxonomic treatment

Mandevilla calcicola J. F. Morales, M.E. Endress & I. L. Morais, sp. nov.

Type:—BRAZIL. Paraúna, Goiás: estrada GO-50, c. 30 km após a cidade de Motividiu, estrada para Paraúna, Ponte de Pedra, margens do Ribeirão Corrente, afloramentos de rocha calcárea, 6/I/2020 (fl.), *I.L. de Morais, J.F. Morales 5850* (Holotype JAR!; isotype: HUFU!).

Figs. 1-3, 4C.

Geophytic woody vine or scandent shrub with tuberous roots and milky latex; branchlets cylindrical to subcylindrical, glabrous to glabrescent; interpetiolar colleters inconspicuous, up to 0.3 mm long. **Leaves** opposite, sessile to subsessile, petioles (when present) up to 1.1 mm long; leaf blades 8.8–11.6 × 5.3–7.2 cm, obovate, obovate-elliptic to elliptic, acute to retuse apically, conspicuously cordate basally, with numerous colleters clustered at base of the midrib adaxially, sometimes with a few colleters spread along the secondary and tertiary veins, not bullate,

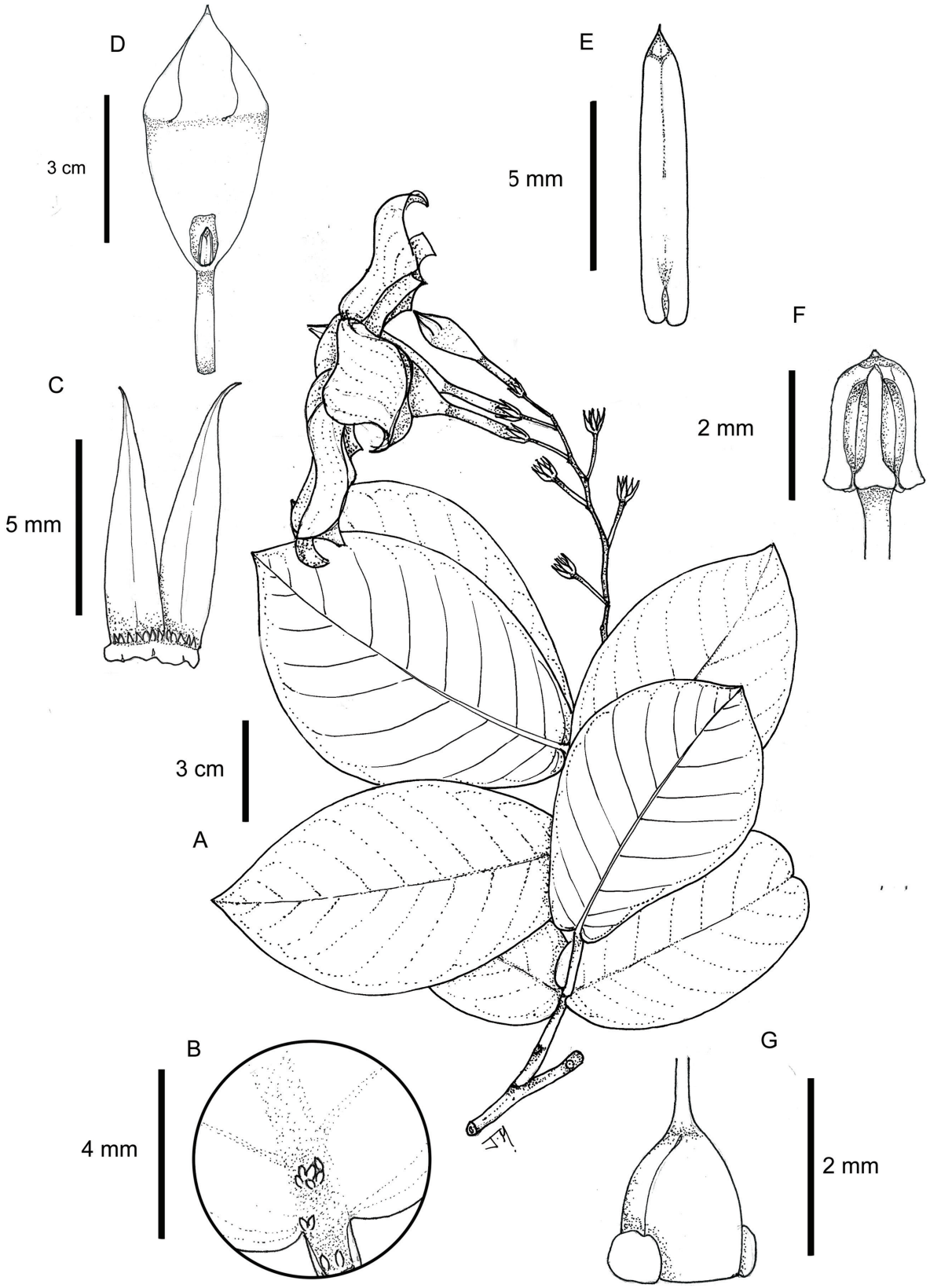

Figure 1. *Mandevilla calcicola*. **A**. flowering branch. **B**. detail of adaxial base of leaf blade and petiole, showing the arrangement of colleters. **C**. adaxial view of two sepals, showing colleters at the base. **D**. corolla tube partially open, showing anthers. **E**. anther, dorsal view. **F**. style-head. **G**. nectaries and ovary (*Fabio de Barros 2196*, HST; drawn by J F Morales).

membranaceous, glabrous on both surfaces, not revolute, secondary veins slightly impressed adaxially, conspicuously impressed abaxially, tertiary veins slightly impressed adaxially, inconspicuous abaxially. **Inflorescences** longer than subtending leaves, terminal to subterminal, glabrous, 10–13-flowered, peduncle 40–52 mm long, pedicels 10–13 mm long, bracts 1–1.7 × 0.5–0.8 mm, linear-ovate, scarious; **sepals** 6–7.5 × 1.5–1.7 mm, similar in length, narrowly ovate, acuminate at the apex, the apex slightly reflexed, subfoliaceous, glabrous on the abaxial surface, with numerous colleters irregularly disposed at the base adaxially; **corolla** infundibuliform, pink, the throat yellow within, glabrous, lower part 20–25 × 2.3–3 mm long, upper part 31–33 mm long, campanulate, 24–26 mm diam., apex of the floral bud acuminate; lobes 38–41 × 27–30 mm, obovate, extended; **stamens** inserted at the base of the upper part of the corolla tube, anthers 7.5–8.5 mm long, dorsally glabrous, base auriculate, with auricles rounded; style-head 1.9–2.2 mm long, the main body ca. 1.5 mm long, apical appendages ca. 0.2 mm long; ovary 2–2.5 mm long, glabrous; nectaries two, entire to subentire. **Follicles** unknown.

Distribution and habitat: Endemic to Goiás, where it grows on limestone cliffs in riparian forest at 675–725 m.

Phenology: Flowering in January and February.

Etymology: The name refers to the limestone cliff habitat where it grows.

Conservation status: *Mandevilla calcicola* is only known from limestone cliffs in a small area within a single locality and on a specific substrate (limestone).

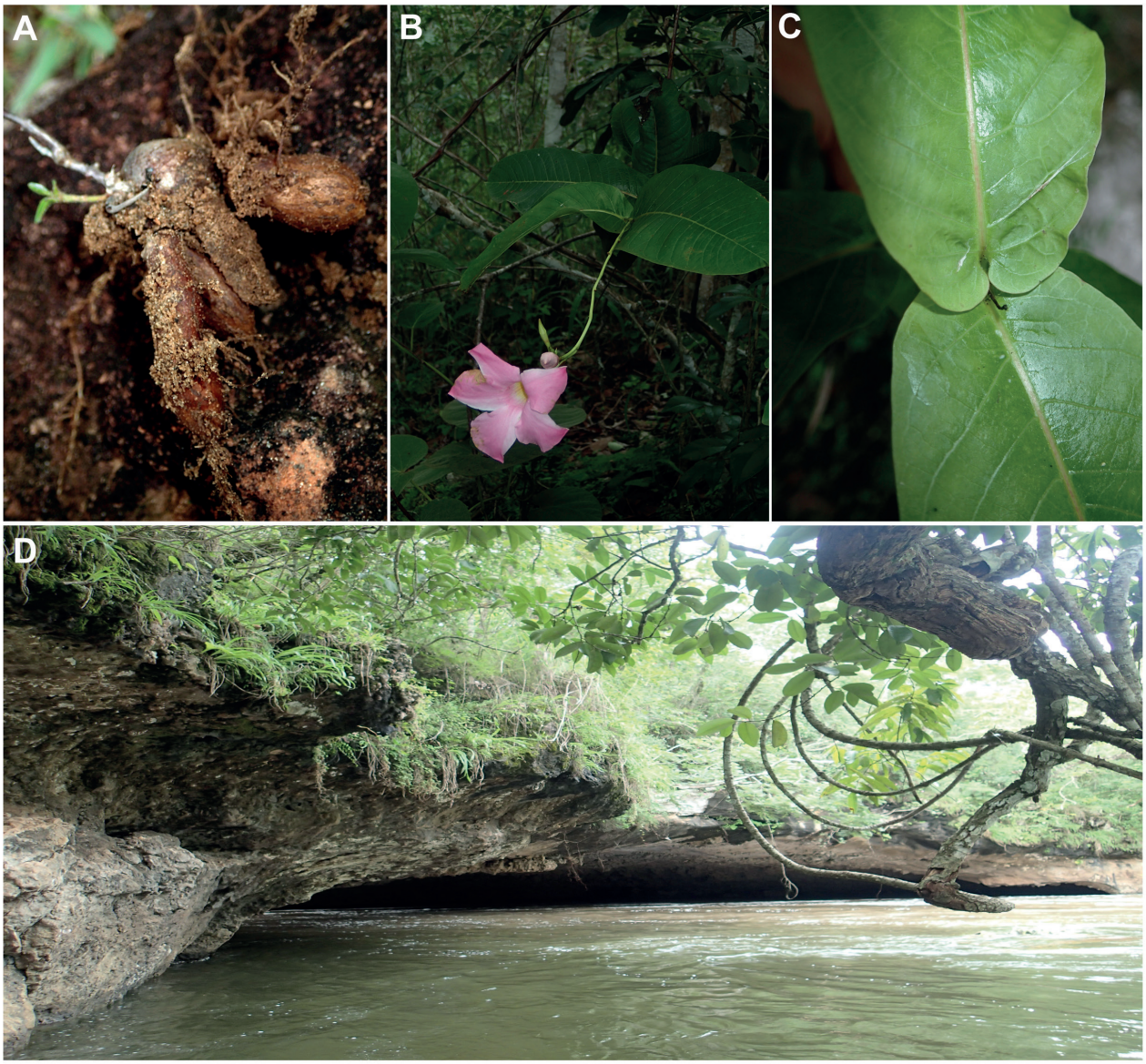

Figure 2. *Mandevilla calcicola* (Ponte de Pedra, Paraúna, Goiás, *I.L. de Morais & J.F. Morales 5850*, JAR). **A**. Tuberous roots. **B**. stem with inflorescence. **C**. detail of leaf base. **D**. habitat.

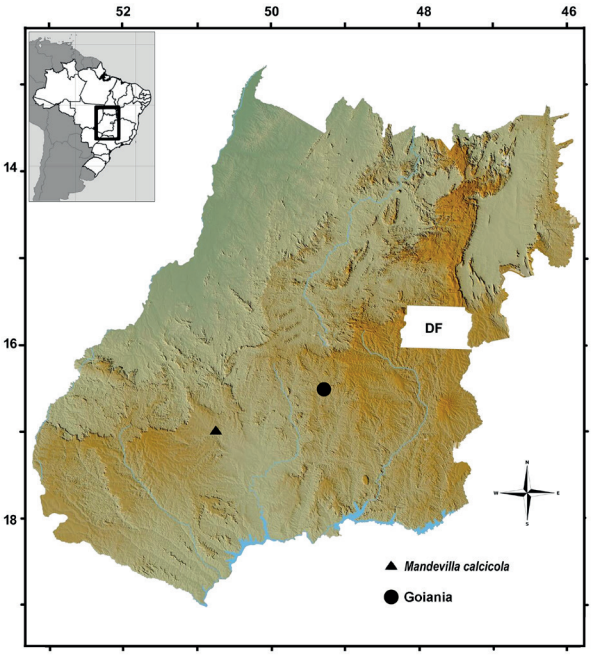

Figure 3. Distribution map of *Mandevilla calcicola*.

Therefore, the extent of occurrence (EOO) and the area of occupancy (AOO) were not calculated. The type locality is an unprotected area surrounded by extensive soy, sugarcane, and corn monoculture. The forest along the river is well preserved but confined along the river margins and under tremendous pressure due to monocultures around.

We assessed this species as Critically Endangered (CR) based on criteria B1ab (iii, iv) + B2ab (iii, iv), considering the number of localities and the severely fragmented and continuing decline of its habitat. Further fieldwork is necessary to discover if there are additional populations along the river or nearby localities with limestone formations.

Observations: Of the species of *Mandevilla* in Brazil, *M. calcicola* shows some similarity to *M. splendens*, which is endemic to inselbergs in Minas Gerais and Rio de Janeiro states, in its subsessile leaves, leaf blade obovate, obovate-elliptic to elliptic, and pink corolla, but can be distinguished by its glabrous leaf blade (vs. tomentulose), sepals 6–7.5 mm long (vs. 9–14 mm), the upper part of the corolla tube campanulate (vs. broadly conic) and corolla lobes 38–41 mm long (vs. 25–34 mm). *Mandevilla calcicola* is the second species described as endemic to Goiás (following *M. myriophyllum* (Taub.) Woodson).

Paratypes: BRAZIL. Paraúna, Goiás: estrada GO-411, ca. 90 km após a cidade de Paraúna, localidade denominada Ponte de Pedra, margens do Ribeirão Corrente, 25/I/1991 (fl), *Fabio de Barros 2196* (CR, HST [HST005584], SP).

Mandevilla grows in a variety of habitats, from dry forest to tropical wet forest, premontane and montane forest, white-sand formations in the Guyana shield and Amazon basin, inselbergs, and Restinga in Brazil. However, this is the first record of an edaphic endemic species of *Mandevilla* specialized on limestone and few Apocynaceae are reported as endemic to this substrate (e.g., *Allamanda* (Souza-Silva & Rapini 2009); *Ceropegia* (Kidyoo 2021); *Hoya* (Rodda & Juhonewe 2012); *Ruehssia* (as *Marsdenia*) Espírito Santo *et al.* (2018); *Wrightia* (Middleton & Santisuk 2001; Middleton 2007)). *Mandevilla calcicola* was known from a single specimen collected 29 years ago, but recent fieldwork has revealed that it is locally common at the type locality, but always restricted to limestone cliffs. Ponte de Pedra is highly deforested and the remnant forests are restricted to strips along the Correntes river surrounded by cane and soy fields.

Note on the occurrence of geophytes in rauvolfioids and apocynoids: Geophytes – plants that regrow from buds on underground storage organs, such as rhizomes, tubers, xylopods, bulbs, and corms – are widespread among the land plants (Tribble *et al.* 2021). This adaptive feature allows them to survive during periods of environmental stress such as drought or fire (Howard *et al.* 2019). In Apocynaceae, geophytism is well-documented in some of the derived lineages like Periplocoideae and in Fockeeae, Ceropegieae and diverse Asclepiadeae of Asclepiadoideae (Verhoeven *et al.* 2003; Meve & Liede 2004; Bruyns *et al.* 2015; Brito & Bruyns 2016; Endress *et al.* 2019). In the basal nodes of the family (rauvolfioids and apocynoids), this condition has been less well studied, but in a handful of genera in geophytic species have been reported. In rauvolfioids, most species of the temperate to subtropical genus *Amsonia* die back in winter and resprout from rhizomes in spring (Woodson 1928). Few geophytic species have been known in neotropical rauvolfioids, such as *Rauvolfia anomala* Rapini & I. Koch and *R. weddeliana* Müll. Arg. However, several questions need to be addressed, such as how many genera have geophytic species, why sympatric species of the same genus or different genera in habitats with strong drought seasons do not have underground storage organs or if the presence of geophytes species is restricted to specific clades within a genus.

Among apocynoids, *Apocynum* and *Cycladenia*, which occur mainly in colder regions or higher elevations, are rhizomatous and dormant in the winter (Woodson 1930; Sipes & Tepedino 1996). Most genera of apocynoids with geophytic species, however, occur in habitats where the stress factor is a long-lasting dry season or extreme drought conditions. Most of these has been reported from Brazil, grow in Cerrados, campos rupestres and inselbergs, and have tubers, tuberous roots, or a xylopod. Except for *Rhodocalyx,* most of these have been reported in the genus *Mandevilla* (e.g., Kinoshita *et al.* 2005; Sales *et al.* 2006; Monteiro *et al.* 2017; Morales *et al.* 2022), but specimens (and subsequently descriptions) rarely include or describe these underground parts. The first author has cultivated or studied *in situ* different species of Echiteae (e.g., *Echites*, *Macropharynx*, *Prestonia*, *Temnadenia*), Odontadenieae (e.g., *Odontadenia*, *Pentalinon*, *Secondatia*, *Stipecoma*), and

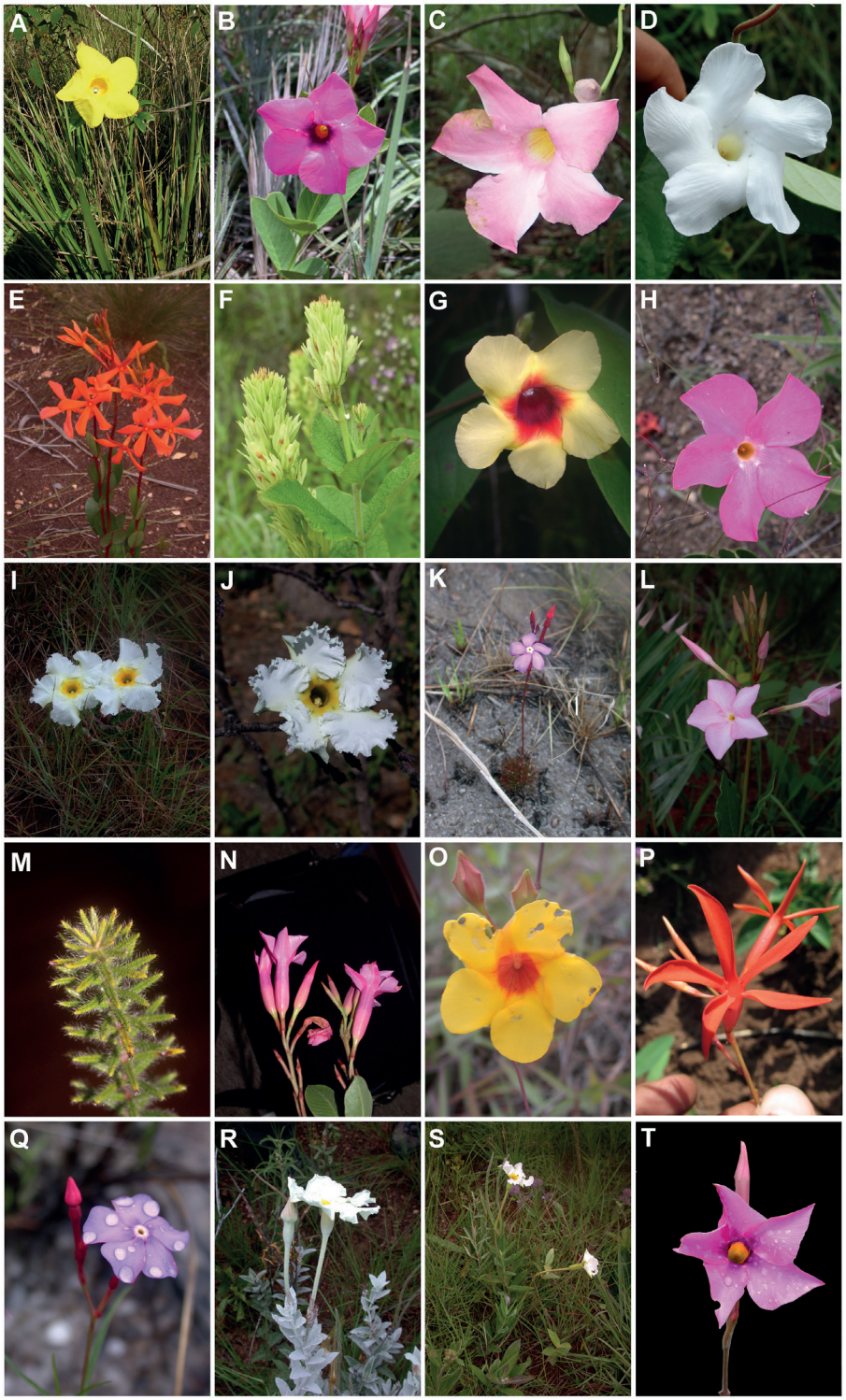

Figure 4. *Mandevilla* in Goiás and Distrito Federal. **A**. *M. abortiva* (Brazil, Bahia, 2019, J F Morales). **B**. *M. alexicaca* (Brazil, Goiás, 2018, J F Morales). **C**. *M. calcicola* (Brazil, Goiás, 2019, J F Morales). **D**. *M. clandestina* (Brazil, Goiás, 2018, I L Morais). **E**. *M. coccinea* (Brazil, Rio Grande do Sul, 2017, J F Morales). **F**. *M. emarginata* (Brazil, Goiás, 2015, J F Morales). **G**. *M. hirsuta* (Brazil, Goiás, 2019, J F Morales). **H**. *M. illustris* (Brazil, Goiás, 2018, I L Morais). **I.** *M. longiflora* (Brazil, Goiás, 2019, J F Morales). **J.** *M. martii* (Brazil, Goiás, 2018, J. F Morales). **K**. *M. myriophyllum* (Brazil, Goiás, 2017, J F Morales). **L**. *M. novocapitalis* (Brazil, Goiás, 2017, J F Morales). **M**. *M. petraea* (showing verticillate leaves) (Brazil, Paraná, 2015, J F Morales). **N**. *M. pohliana* (Brazil, Goiás, 2018, J F Morales). **O**. *M. scabra* (Brazil, Goiás, 2019, J F Morales). **P**. *M. spigeliiflora* (Brazil, Goiás, 2019, I L Morais). **Q**. *M. tenuifolia* (Brazil, Goiás, 2018, J F Morales). **R**. *M. velame* (Brazil, Goiás, 2015, J F Morales). **S**. *M. virescens* (Brazil, Paraná, 2016, J F Morales). **T**. *M. widgrenii* (Brazil, Goiás, 2019, J F Morales).

Rhabdadeniaeae (*Rhabdadenia*) without ever observing the presence of geophytic species. A number of *Mandevilla* species growing on inselbergs have these structures, where geophytism is a common condition (Porembski 2007), as do species from Cerrados or campos rupestres (Appezato-da-Glória & Estelita 2000), but specific studies concerning the characterization of geophyte species in the genus are absent. The few available studies focus on anatomical examinations of a few species (e.g., *M. illustris* (Vell.) Woodson and *M. pohliana* (Stadelm.) A.H. Gentry [Appezato-da-Gloria & Estelita 2000]; *M. tenuifolia* [Costa 2002]; *M. atroviolacea* (Stadelm.) Woodson, [Lopes 2007; Lopes-Mattos *et al*. 2013]).

Mandevilla calcicola has tuberous roots, a common feature of *Mandevilla* species growing on rocks in South America. Following the clades names proposed by Morales *et al*. (2022), almost all the species studied by the first author with tuberous roots, tubers, or xylopods belong to the *Mandevilla* clade, except for a group of species from the *Exothostemon* clade, restricted to granitic or quarzitic outcrops from the Guyana shield in Colombia and Venezuela (e.g., *M. lancifolia* Woodson). However, the presence of this condition in the genus has not been studied in a phylogenetic context, which could provide helpful characters or synapomorphies to characterize clades.

A key to *Mandevilla* in Goiás and Distrito Federal, Brazil is provided here. A total of 20 species are included, with only *M. myriophyllum* and *M. calcicola* being endemic to Goiás (Fig. 4). *Mandevilla antennacea* (= *M. rugellosa* (Rich) Allorge fide Fuentes and Morales (2014)) is reported for Distrito Federal in Flora of Brazil. Five vouchers were cited: *Ferreira 11588* (NY) [Mato Grosso], *Teixeira et al. 510* (F, INPA, K, MG, MO, NY, RB, US) [Rondônia], *Hatschbach 62580* (ESA, MT, NY, UEC) [Mato Grosso], and *Ducke 7636* (RB) [Amazonas]. The specimen *Ducke 7636* is misidentified: its correct identification is *M. scabra*. In Brazil, *Mandevilla rugellosa* has been recorded only in Acre, Mato Grosso, and Rondônia states. Working on a new revision of *Mandevilla*, the first author has never seen a specimen from Goiás or Distrito Federal. Therefore, this species is not included in the key.

Key to species of **Mandevilla** *in Goiás and Distrito Federal, Brazil*

1. Leaf blades with colleters spread along midvein adaxially; corolla tube gibbous at the base 2
2. Floral bracts 11–21 × 1.5–8 mm, foliaceous; sepals 7–12(–15) × 1–3 mm ..... *M. hirsuta*
2. Floral bracts 1–5(–8) × 0.5–1.5(–2) mm, scarious; sepals 1.7–3.5 × 1–2.7 mm 3
3. Leaf blades with tertiary veins not impressed abaxially; erect to suberect herbs or herbaceous vines ..... *M. abortiva*
3. Leaf blades with tertiary veins impressed abaxially; herbaceous to woody vines 4
4. Corolla lobes white; corolla mouth 5–6 mm diam. ..... *M. clandestina*
4. Corolla lobes yellow; corolla mouth 15–24(–27) mm diam. ..... *M. scabra*
1. Leaf blades with colleters grouped at the base of midvein adaxially; corolla tube straight at the base 5
5. Corolla tube 8–18.7 cm long; leaf blades conspicuously white-pubescent abaxially 6
6. Leaf blades white-lanuginose on both surfaces ..... *M. velame*
6. Leaf blades with only the abaxial surface white-lanuginose, adaxial surface green 7
7. Leaves usually verticillate, rarely opposite at some nodes, blades 0.1–1 cm wide..... *M. petraea*
7. Leaves usually opposite, rarely verticillate at some nodes, blades more than 1.4 cm wide 8
8. Inflorescence usually 5–12-flowered ..... . *M. martii*
8. Inflorescence 1–3(4)-flowered 9
9. Lower part of the corolla tube 10.5–15.4 cm long, mouth 15–23 mm diam. ..... *M. longiflora*
9. Lower part of the corolla tube 5.8–7.8 cm long, mouth 6–11 mm diam. ..... *M. virescens*
5. Corolla tube less than 6 cm long; leaf blades glabrous, glabrate abaxially, or if pubescent, then this never white 10
10. Corolla red to orange 11
11. Corolla hypocrateriform, mouth 2.5–3.1 mm diam.; corolla lobes obovate to narrowly obovate ..... *M. coccinea*
11. Corolla narrowly infundibuliform, mouth 3–6 mm diam.; corolla lobes narrowly elliptic to narrowly obovate-elliptic..... *M. spigeliiflora*

10. Corolla pink, lilac, pinkish-white to green or greenish-white 12
12. Corolla hypocrateriform 13
13. Sepals 13–21(–24) mm long, as long as the corolla tube; corolla lobes green to greenish-white ..... *M. emarginata*
13. Sepals 1.5–10 mm long, much shorter than the corolla tube; corolla lobes pink, lilac to pinkish white 14
14. Corolla lobes 17–31 × 11–23 mm; follicles 19–21 cm long ..... *M. novocapitalis*
14. Corolla lobes 6–9 × 4–6 mm; follicles 3.5–6.2 cm long 15
15. Leaf blades 5–15 × 0.2–0.7(–1) mm, filiform ..... *M. myriophyllum*
15. Leaf blades (10–)14—95(–135) × 1.1–90(–160) mm, linear-elliptic, narrowly elliptic, narrowly ovate-elliptic to narrowly obovate ..... *M. tenuifolia*
12. Corolla infundibuliform 16
16. Woody vines; leaf blade conspicuously cordate basally; limestone cliffs (gallery forest) ..... *M. calcicola*
16. Erect plants; leaf blade cuneate, obtuse, rounded to slightly cordate basally; Cerrados and swamp areas 17
17. Leaves opposite to verticillate, blades 2–3 mm wide; swamp areas ..... *M. widgrenii*
17. Leaves opposite, blades 5–95 mm wide; Cerrados 18
18. Upper part of the corolla tube cylindrical to urceolate-cylindrical, 21–48 mm long ..... *M. pohliana*
18. Upper part of the corolla tube conical to narrowly conical, 10–23 mm long 19
19. Corolla mouth 11–19 mm diam.; upper part of corolla tube broadly conical ..... *M. alexicaca*
19. Corolla mouth 4–9 mm diam.; upper part of corolla tube narrowly conical ..... *M. illustris*

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