Brazilian Journal of Botany (2023) 46:913–923
https://doi.org/10.1007/s40415-023-00932-6

SYSTEMATICS & PHYLOGENY - ORIGINAL ARTICLE

# *Miconia dianae* (Melastomataceae), a new species from Bahia (Brazil) with notes on leaf and hypanthium surfaces

**Renato Goldenberg[1] · Fabián A. Michelangeli[2] · Juliana K. Ziemmer[3] · André M. Amorim[4]**

Received: 11 May 2023 / Revised: 15 August 2023 / Accepted: 5 September 2023 / Published online: 27 September 2023

## Abstract

*Miconia dianae* is a new species described from four specimens collected in semideciduous forests in the municipality of Ribeirão do Largo, in the state of Bahia, Brazil. According to current data and based on IUCN criteria, this species should be qualified as "data deficient", but we note that it should be actually considered as critically endangered, since the known habitat of *M. dianae* is reduced and subject of constant disturbance, which may perhaps lead to its extinction. The new species can be recognized by the inflorescences of pedunculate triads or seldom pauciflorous racemes with up to five flowers, these on a short pedicel topping an anthopodium 3–8 mm long, early caducous, filiform bracteoles, 5-merous flowers, terete hypanthia with verrucose projections on the abaxial surface, the calyx incompletely closed in bud, rupturing at anthesis in irregular lobes, white stamens with a dorso-basal hump and glandular trichomes on the connective, and a 3-locular, superior ovary with sparse glandular trichomes. The granulose surfaces of stems, leaves, inflorescences and hypanthia in dried specimens are caused by large druses, sometimes measuring half the thickness of the leaf mesophyll, that project themselves into hemispheric domes when the leaves are dried. The verrucose projections on the hypanthium develop from successive divisions of the ground tissue inside it. We were not able to explain its function, since they are not formed by crystals, nor seem to develop as pathogen or animal-induced galls, neither seem to store phenolic compounds nor starch. Since they fade away while the fruits ripen, they probably do not have any function related to dispersal either.

**Keywords** Plant anatomy · Semideciduous forests · South America · Taxonomy · Verrucose projections

## 1 Introduction

With over 1300 species of Melastomataceae, Brazil harbors the largest number of species in this family (Ulloa Ulloa et al. 2022). Within Brazil, the state of Bahia is remarkable for having 332 species, 151 of them endemic (Goldenberg et al. 2020c). This diversity can be partly explained by the variety of habitats and vegetation types within the state that include wet (lowland, montane and sub-montane), semideciduous, transitional and gallery forests, and also inselbergs, campos rupestres, caatinga and restingas. While the flora of the state is relatively well known, the high degree of endemicity, with many narrowly distributed species, means that as new localities are surveyed new species continue to be described (Goldenberg et al. 2020c). Since 2000 at least 85 new species from seven different tribes have been described, and several others newly reported for the state (Baumgratz 2000; Martins 2000; Martins and Woodgyer 2000; Souza 2002; Baumgratz and Souza 2004; Woodgyer and Zappi 2005; Goldenberg and Amorim 2006; Goldenberg and Reginato 2007; Santos et al. 2008; Schulman 2008; Amorim et al. 2009; Goldenberg and Reginato 2009; Woodgyer and Zappi 2009; Baumgratz et al. 2011; Fidanza and Almeda 2011; Almeda and Martins 2012; Freitas et al. 2012; Freitas et al. 2013; Pataro et al. 2013; Reginato et al. 2013; Santos et al. 2013; Amorim et al. 2014; Goldenberg and Chagas 2014; Guimaraes and Freitas 2015; Bacci et al. 2016; Freitas and van den Berg 2016; Goldenberg et al. 2016; Meirelles

---

✉ Renato Goldenberg
rgolden@ufpr.br

[1] Departamento de Botânica, Centro Politécnico, Universidade Federal Do Paraná, Postal Box 19031, Curitiba, Paraná 81531-970, Brazil

[2] The New York Botanical Garden, Institute of Systematic Botany, Bronx, NY 10458-5126, USA

[3] Pós-Graduação em Biologia Vegetal, Universidade Estadual de Campinas, Campinas, São Paulo 13083-862, Brazil

[4] Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilhéus, Bahia 45622-900, Brazil

et al. 2016; Bacci et al. 2018; Jesus et al. 2018; Pacifico and Almeda 2018; Romero and Woodgyer 2018; Freitas et al. 2019; Bisewski et al. 2020; Goldenberg et al. 2020a, b; Pacifico and Almeda 2020a, b; Silva et al. 2021; Gali et al. 2022; Pacifico and Almeda 2022a, b; Pacifico et al. 2022a, b). These have included the description of two new genera, *Physeterostemon* R. Goldenb. & Amorim and *Rupestrea* R.Goldenb., Almeda & Michelang., both endemic to the state, and placed within new tribes erected since their discovery (Goldenberg and Amorim 2006; Goldenberg et al. 2015; Penneys et al. 2020, 2022).

During field work in semideciduous forests, a vegetation type rarely targeted for Melastomataceae, we collected a species of *Miconia* Ruiz & Pav. (tribe Miconieae) with a highly unusual morphology and character combination. After careful comparisons with other species in the tribe, this species is here described as new. Some aspects of leaf and hypanthium morphology in this new species merited further anatomical investigation, since we could not explain some features by their external appearance, even under the stereoscope; we present anatomical descriptions of these structures and provide plausible explanations for these characters.

## 2 Material and methods

The original specimens were collected by one of the co-authors (AMA), who photographed the plants, including leaves, flower buds, flowers and fruits. These were also conserved in ethanol, which in turn were used for descriptions, line drawings and anatomical studies. These procedures “in loco” and a diagnosis of the vegetation where the plants were found also helped us make an accurate assessment of the conservation status for this species (see below). This work was based on literature (mostly Cogniaux 1886, 1891; Wurdack 1973, 1980; Wurdack et al. 1993; Goldenberg 2004, 2009; Rezende et al. 2014; Bacci et al. 2016) and an analysis of specimens of *Miconia* from the herbaria ALCB, CEPEC, HUEFS, NY, RB, UESC, UPCB and US, both “in loco” and through virtual herbaria, such as Reflora (BFG 2022) and SpeciesLink (CRIA 2023). The conservation status was assessed based on IUCN (2022).

Histological investigation of leaves and hypanthia were based on samples fixed in a 2.5% paraformaldehyde solution (PFA) in 0.1 M sodium phosphate buffer, pH 7.2, washed in 0.1 M phosphate buffer and dehydrated in ethanol. The samples were embedded in glycol methacrylate resin (Historesin Leica®), according to the manufacturer's instructions. Sections (5 mm) were obtained in a rotary microtome (Leica Microsystem, RM2145, Germany) and stained with 0.05% toluidine blue at pH 6.8 (O'Brien et al. 1964). Histochemical tests were performed on hypanthium sections with Sudan III (Sass 1951) to detect lipids, lugol for starch (Berlyn and Miksche 1976) and ferric chloride for phenolic compounds. The sections were analyzed with a light microscope (Olympus BX41). The leaf sections were also analyzed under a light microscope adapted with a polarizing filter. For the scanning electron microscopy analyses, hypanthium samples were dehydrated in an ethanol series, critically point dried, mounted on aluminum stubs, coated with gold and examined under a Tescan Vega 3 scanning electron microscope.

## 3 Results

### 3.1 Recognition of the new species

*Miconia dianae* can be recognized by the inflorescences that are pedunculate triads or seldom pauciflorous racemes with up to 5 flowers, these on a short pedicel topping an anthopodium 3–8 mm long and early caducous, filiform bracteoles. Its flowers are 5-merous, with the terete hypanthia covered with verrucose projections on the abaxial surface, and an incompletely closed calyx, with a long tube and short sepals, rupturing below the sinuses during anthesis. The stamens have glandular trichomes at the base of the connective, and long, slender, subulate anthers, and the ovary is covered with sparse glandular trichomes.

### 3.2 Leaf anatomy

The leaf blade of *Miconia dianae* has a uniseriate epidermis (Fig. 1a), with a thin cuticle and anomocytic stomata present only on the abaxial surface. Epidermal cells on the adaxial face are larger than those on the abaxial face (Fig. 1a). Sparse trichomes may occur on the abaxial surface, and these are either stellate or simple (unbranched) and filamentous. The leaf surface in dried samples has a granular aspect that is probably caused by the presence of druses close to the leaf epidermis, some occupying half the thickness of the mesophyll (Fig. 1a). The mesophyll is dorsiventral and contains one or two layers of palisade parenchyma and five to seven layers of spongy parenchyma (Fig. 1a). The midrib contains some sclereids, druses and three arch-shaped vascular bundles formed by xylem and phloem in adaxial and abaxial positions (Fig. 1b).

### 3.3 Hypanthium anatomy

The hypanthium of *Miconia dianae* has both outer and inner epidermis with small cells (15–20 µm), these polygonal or rectangular. In the outer epidermis there are sparse to moderate stellate and simple (unbranched), filamentose trichomes (Fig. 1c–e). The external surface of the hypanthium has an ornamented cuticle, with parallel striations (Fig. 1e). Ground tissue contains approximately 25 layers of cells of varying

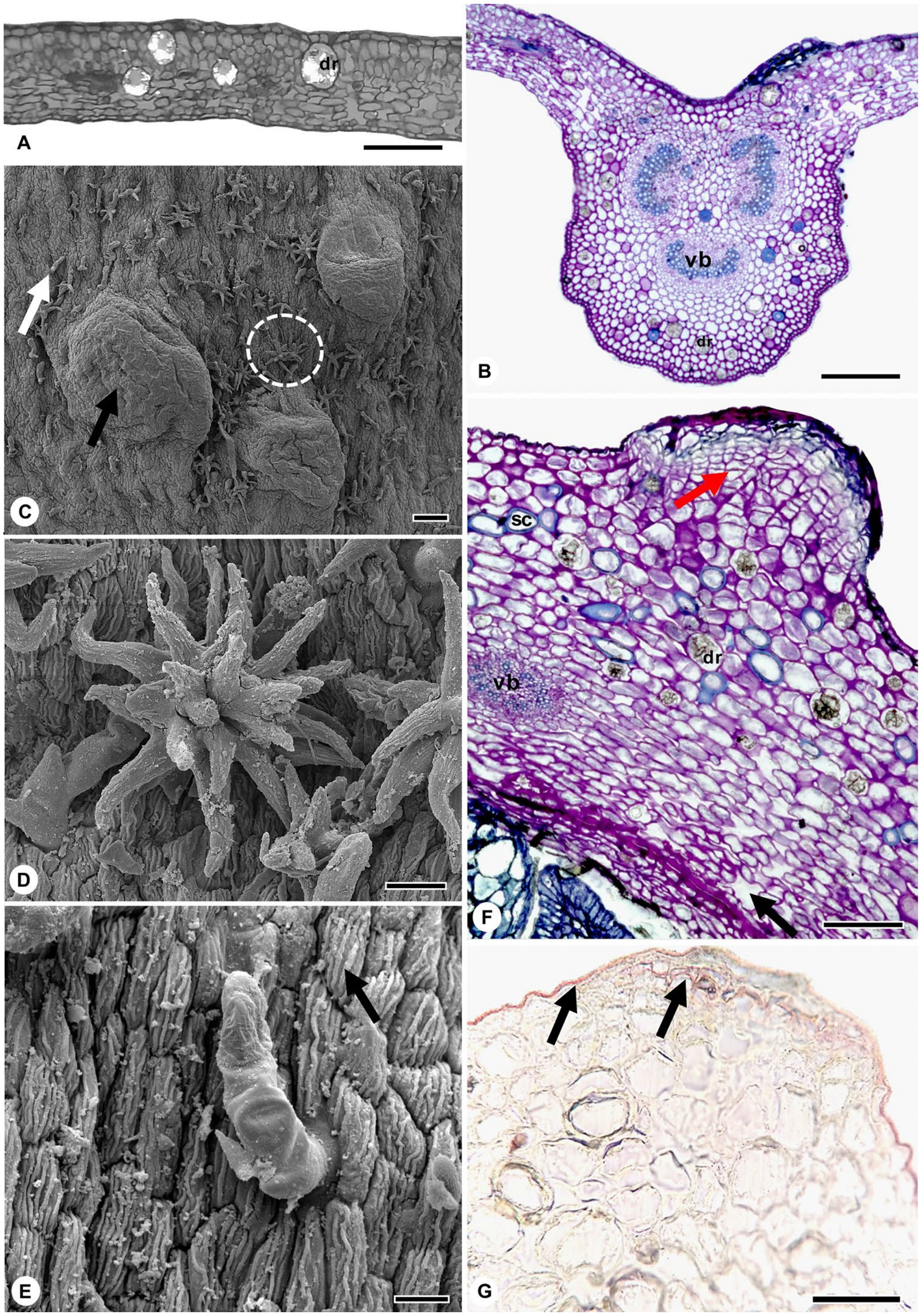

**Fig. 1** Anatomical features of leaves and hypanthia and scanning electron micrographs of the hypanthium abaxial surface of *Miconia dianae*. **a** Cross section of the leaf under polarized light showing druses occupying half of the mesophyll (dr); these druses are apparent as hemispheric projections in dried material. **b** Cross section of the midrib showing the vascular bundles (vb) and druse (dr). **c** SEM of the abaxial surface of the hypanthium showing the verrucose projections (black arrow), the sparse filamentous trichomes (white arrow) and stellate trichomes (dotted circle). **d** SEM with a detail of a stellate trichome; **e** SEM with a detail of a filamentous trichome and cuticle ornamentation with parallel striations (black arrow). **f** Hypanthium cross section showing the successive divisions below the surface of a verrucose projection (red arrow), and the fundamental tissue with druses (dr), sclereids (sc), vascular bundle (vb) and intercellular spaces near the adaxial surface of the hypanthium (black arrow). **g** Lipid compounds in the cuticle and cell walls close to the surface of the verrucose projection. Scale: a, b = 100 µm; c = 100 µm; d = 20 µm; e = 15 µm; f, g = 200 µm

shapes and sizes (Fig. 1f). Druses are sparse, and sclereids are single or in small groups with up to five cells (Fig. 1f). In the ground tissue, large intercellular spaces also occur, especially in the innermost layers of the tissue (Fig. 1f). About eight concentric vascular bundles are immersed in the ground tissue (Fig. 1f). The hypanthium outer surface is also verrucose, i.e., there are small white, wart-like protuberances that develop from successive divisions of the ground tissue (Fig. 1c, f and g). The test with Sudan III showed lipid compounds in the cuticle and in the walls of cells close to the wart surface (Fig. 1g), but tests for starch and phenolic compounds were negative. Apparently, as the cells are exposed on the surface they are compressed and die. These warts apparently fade away during fruit development and completely disappear when the fruits ripen (Fig. 2).

**Fig. 2** Fruits of *Miconia dianae* in the field. **a–d** Temporal sequence showing old flowers (**a**) to a mature fruit (**d**). Note (1) the verrucose projections fading away, and apparently absent in the mature fruits; (2) the persistent sepals / calyx segments that may be individually broken. From *Amorim* et al. *11,860, 11,862, 18,864* (UPCB). Photos by A.M. Amorim

## 4 Discussion

### 4.1 Taxonomic treatment

#### 4.1.1 *Miconia dianae* R.Goldenb., Michelang. & Amorim, sp. nov.

**4.1.1.1 Type** Brazil: Bahia, Mun. Ribeirão do Largo, ca. 5 km da sede do município m acesso pela BA 634 em direção ao Mun. Itambé, Floresta Estacional Semidecidual 15°26′50″S, 40º46′41″W, 26-I-2022 (bud, fl), AM Amorim, F Cabral and Y Gouvêa 11,810 (Holotype: UPCB! Isotypes: HUEFS!, NY!, RB!, UESC!) (Figs. 2, 3 and 4).

**4.1.1.2 Diagnosis** *Miconia dianae* can be distinguished from *Miconia lasseri* Gleason by the inflorescences that are pedunculate triads or seldom pauciflorous racemes with up to 5 flowers, these on a short pedicel topping an anthopodium 3–8 mm long (vs. subracemiform panicles lacking anthopodia, with glomerulate, sessile flowers, these many more than 5 per inflorescence) and early caducous, filiform bracteoles (vs. late caducous and ovate-triangular); 5-merous flowers (vs. 6-merous); hypanthia with verrucose projections on the abaxial surface (vs. hypanthia lacking these projections); stamens with glandular trichomes at the base of the connective (vs. glabrous); and the ovary covered with sparse glandular trichomes (vs. glabrous).

**4.1.1.3 Description** Shrubs ca. 1.5 m tall. Young branches, petioles, abaxial leaf surfaces, inflorescence axes and hypanthia covered with (a) sparse and caducous stellate trichomes ca 0.1 mm diam., these a bit more dense on the nodes of both vegetative young branches and inflorescences; (b) sparse, minute, sessile, filamentous projections no more than 0.1 mm long; (c) sparse to moderate, more or less hemispheric projections of sub-epidermic druses, these also present and a bit denser on the adaxial leaf surface, resulting in a granular appearance in dry material. Young stems slightly decussately flattened (and slightly sulcate in dried materials), but soon terete, lacking interpetiolar lines, with an indumentum as described above. Leaves isophyllous in each pair, with an indumentum as described above; petiole 4–15 mm long, adaxial surface slightly sulcate, abaxial surface rounded; blade 7–16 × 2.8–6 cm, mostly elliptic or seldom slightly obovate, apex acute or acuminate, base attenuate or acute, margins repand or remotely and shortly denticulate, tenuously hyaline, plane or slightly revolute, eciliate, membranaceous, green on both surfaces but slightly darker on the adaxial surface in both fresh and dried material; the two lateral veins in the single acrodromous pair distinctly suprabasal, the inner pair 3–10 mm distant from the base, frequently asymmetric (the two veins diverging at different distances from the base), on the abaxial surface frequently basally joined to the midrib by a membrane and consequently with pocket domatia, with an additional submarginal very faint pair, main and lateral veins slightly impressed, transversal veins plane and barely visible in dried material, reticulation not perceptible on the adaxial surface, main and lateral veins strongly raised, lateral veins plane but perfectly distinct on the abaxial surface. Inflorescences 1–3.7 cm long, terminal, slightly bent or almost pendulous, usually a triad on a 3–16 mm long peduncle, then each flower on an anthopodium 3–8 mm long, the triad sometimes depauperate, with 2 or only 1 remaining flowers, the inflorescence seldom a very short, racemiform, 3–4.1 mm long, with up to 5 flowers (two lateral and three on the top), each one with its respective anthopodium similar to the ones described above; axes green, with an indumentum as described above; bracts not seen; bracteoles 0.9–1.7 mm long, filiform or linear and slightly applanate, early caducous (i.e. sometimes present at bud stage, but always lacking on flowers at anthesis). Flowers on pedicels 6–9 mm long,

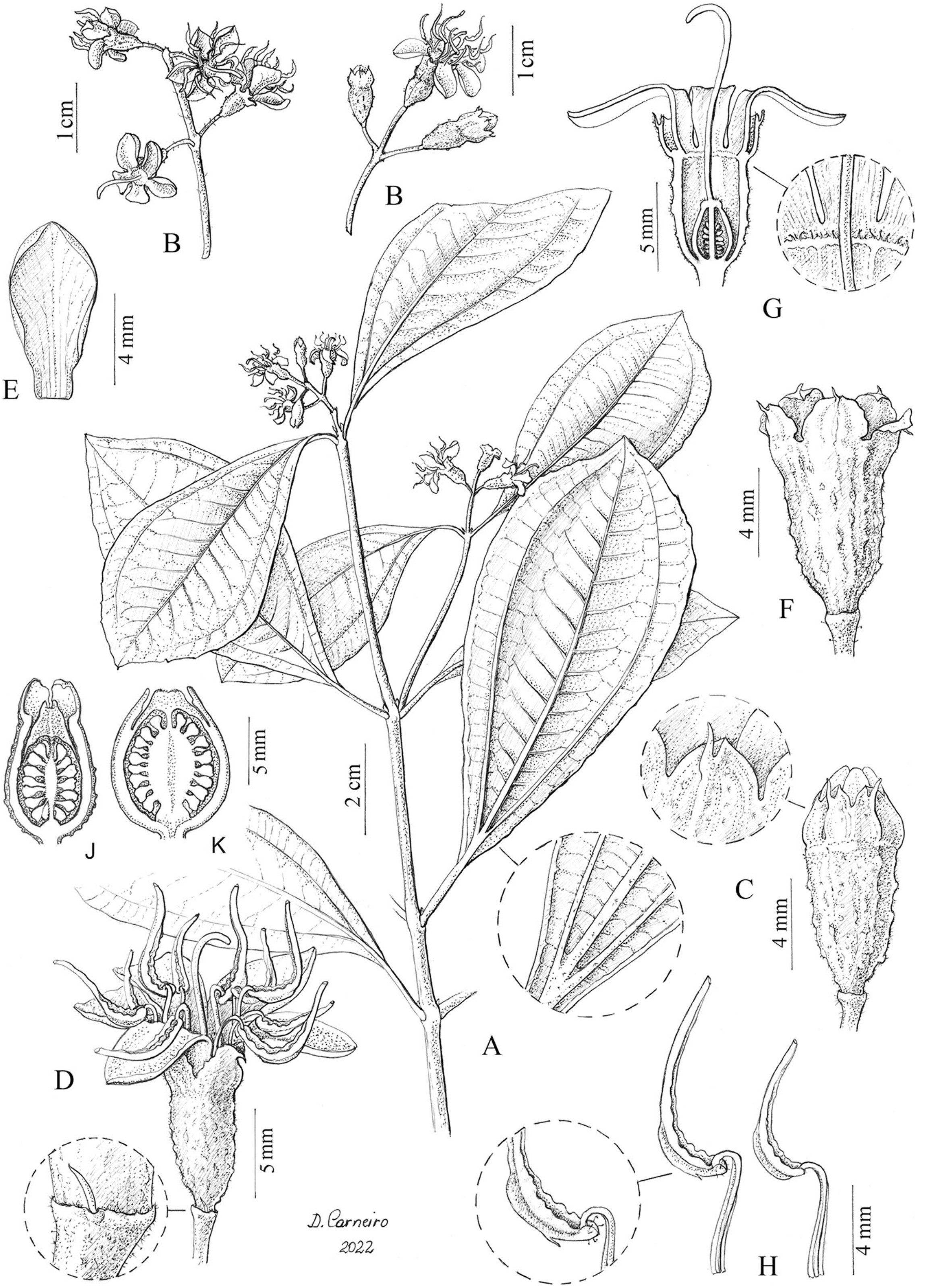

**Fig. 3** General morphology of *Miconia dianae*. **a** Branch with inflorescences, with the detail of the abaxial surface of the leaf base. **b** Details of two inflorescences. **c** Flower bud in pre-anthesis, lateral view, with the detail of the sepals. **d** Flower at anthesis, lateral view, with the detail of one bracteole. **e** Petal, adaxial view. **f** Old flower (post-anthesis), lateral view. **g** Flower at anthesis, longitudinal section, with the detail of the torus at the apex of the hypanthium, and bases of the petals. **h** Stamens in lateral view, antesepalous (left) and antepetalous (right), with the detail of the filament apex and anther/connective base of the antesepalous stamen. **a–h** From the holotype, *Amorim* et al. *11,810* (UPCB). Drawings by Diana Carneiro

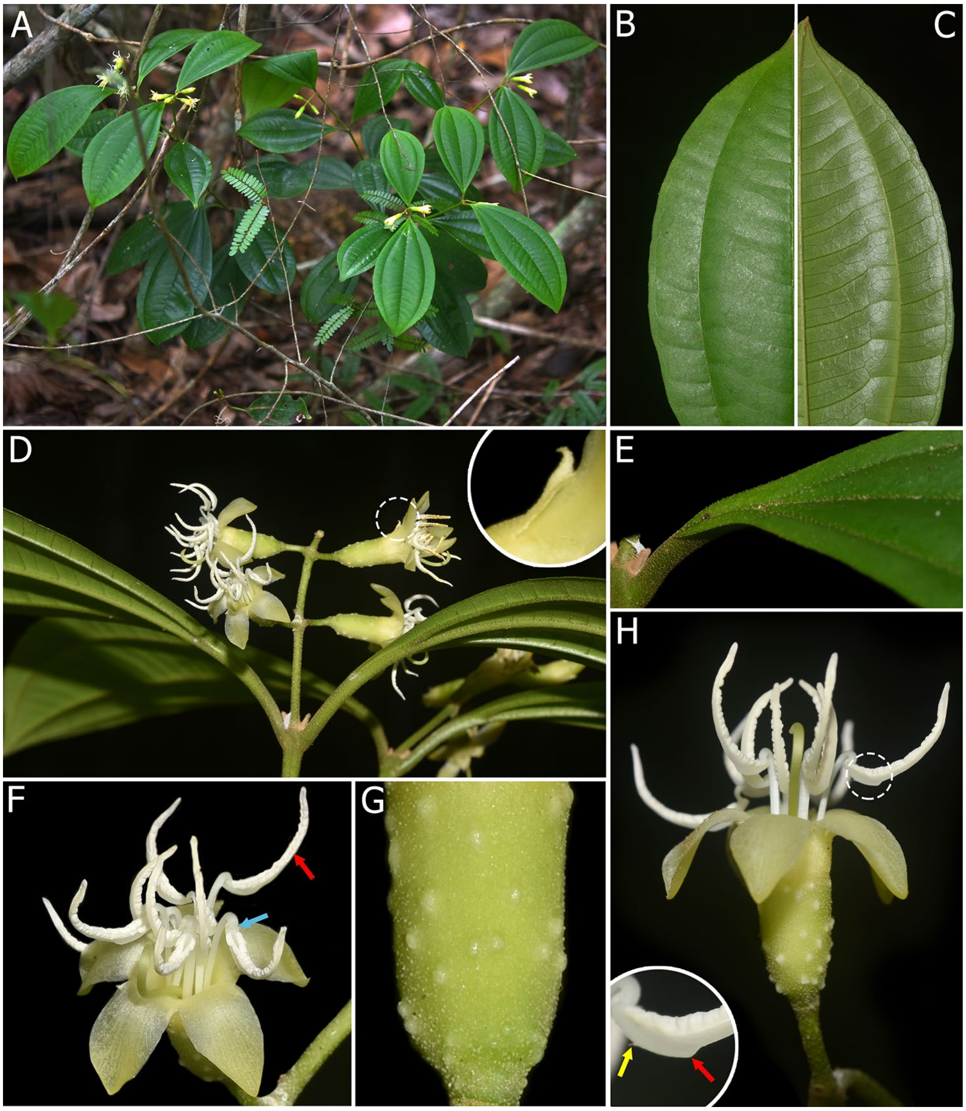

**Fig. 4** *Miconia dianae* in the field. **a** Vegetative and flowering branches. **b** Leaf margin, adaxial surface. **c** Leaf margin, abaxial surface. **d** Inflorescence, with a detail of the external portion of the sepal; **e** Leaf base, adaxial surface. **f** Flower, apical/lateral view, showing the zygomorphic arrangement of the stamens and style; the red arrow indicates one of the longer, antesepalous stamens, and the blue one indicates a glandular trichome on a lateral position of the connective in one of the shorter, antepetalous stamens. **g** Hypanthium lateral view, showing the verrucose projections and the minute, stellate trichomes. **h** Flower, lateral view; the yellow arrow indicates the single, stout glandular trichome bending downward on the connective of an antesepalous stamen, and the red one indicates the connective's dorsal hump on the same stamen. From *Amorim* et al. *11,810* (UPCB). Photos by Y. Gouvêa

5-merous. Hypanthium 5.5–6.7 × 2.5–3.5 mm, light green to green at anthesis (this variation found within the same hypanthium), terete, abaxial surface covered with the trichomes as described above, and with very distinct sparse, whitish, robust, verrucose projections (see anatomical description above), adaxial surface glabrous; torus with sparse, minute, ca. 0.1 mm long, glandular trichomes. Calyx semi-closed in bud, with a truncate tube in young buds, then at pre-anthesis the tube 1.5–1,7 mm long, the sepals with the internal, laminar portion 0.5–0.8 mm long, broadly triangular to semicircular, apex obtuse, margins minutely ciliate and finally at anthesis tearing downward from the sinuses, these ruptures almost reaching the hypanthium in post-anthesis flowers, the calyx persistent, but sometimes with one or more segment individually breaking/caducous after anthesis; sepals with the external, denticulate portion 0.7–1.2 mm long, subulate, projecting above the truncate tube in very young buds or above the laminae at pre-anthesis. Corolla with 5 petals 7.8–9.5 × 2.6–3.8 mm, yellowish green, slightly reflexed at anthesis, spathulate, apex obtuse or rounded (but sometimes the margins are folded near the apex, and then appearing acute), margins entire, eciliate, glabrous. Stamens 10, white, slightly dimorphic, the filaments erect but the anthers slightly bending outward and directed to one side of the flower (usually the same side to which the style bends, too) and consequently zygomorphic; antesepalous stamens with filaments 5.5–6.7 mm long, glabrous, anthers ca. 8–10.5 mm long, subulate, strongly corrugate, ventrally arched, with a minute ventrally inclined pore, connective minutely, 0.1–0.3 mm prolonged below the thecae, basally slightly broadened but unappendaged, and with a dorsal hump on the anther's proximal third part, this thickened portion absent on the other two thirds of the anther; antepetalous stamens with filaments 4.5–6.2 mm long, glabrous, anthers ca. 5.5–8 mm long, subulate, strongly corrugate, ventrally strongly arched (more tightly arched than the antesepalous), with a minute apical pore, connective not prolonged below the thecae, not basally broadened nor appendaged, and with a dorsal hump similar to the antesepalous; the connective in both cycles with minute (up to 0.1 mm long) glandular trichomes on the ventral and lateral surfaces at its base, plus a single, stouter, 0.2–0.3 mm long glandular trichome bending downward in the middle or a bit lower on the dorsal hump, this stouter trichome present in most antesepalous stamens and absent in most antepetalous, but with a few exceptions. Ovary 2.5–3.3 × 1.7–2.3 mm, 3-locular, pluriovulate, superior to 1/5 inferior at anthesis, the apex shortly terete, with sparse, minute, less than 0.1 mm long trichomes; style 10–13 mm long, filiform, sigmoid and strongly curved at the apex, bending to one side of the flower, glabrous; stigma punctiform. Berries 10–12 (except the calyx remains) × 8–9 mm when mature, the actual ovary ca. 9 × 6–7 mm, surrounded by a massive, fleshy hypanthium 1.5–2 mm thick (all measurements from pickled material), slightly oblong, turning from green to red, then purple and finally blackish when ripe, topped with the persistent calyx (but sometimes lacking one or more sepals/calyx segments that may be individually broken), glabrous, the verrucose projections fading during fruit maturation until completely imperceptible in ripe fruits. Seeds 1.5–1.7 × 1–1.2 mm, pyramidate, with one side totally bordered by the convex raphal region, which joins the non-raphal part with a sharp angle, the lateral non-raphal region 2–4-striate, with its flat top not striate: testa smooth.

### 4.1.2 Phenology

*Miconia dianae* was found in flower during January and with fruits in April.

**4.1.2.1 Distribution, habitat and conservation status** *Miconia dianae* has been collected four times, all in the same locality. This is a forest fragment in the municipality of Ribeirão do Largo, state of Bahia, that has no apparent legal protection. The area where the plants were collected was originally covered with semideciduous Atlantic Forest, but it has been subject to selective logging causing habitat loss. The vegetation around Ribeirão do Largo as a whole has been severely disturbed by logging, clearing for agriculture and cattle raising, and also subject to induced fires to clean the soil for coffee and *Eucalyptus* plantations and real estate expansion. The single population of *Miconia dianae* that was found in this study has approximately 20 plants that are randomly dispersed throughout a forest fragment with about 5 km$^2$. Because this species is only known from few collections and in the absence of accurate population information, its conservation status is considered as data deficient [DD] according to IUCN criteria (IUCN 2022). Nonetheless, the known habitat of *M. dianae* is reduced and subject of constant disturbance, which may perhaps lead to its extinction. Maybe our knowledge about it does not fit objective criteria such as IUCN's, but this species is doubtless critically endangered.

**4.1.2.2 Etymology** This epithet honors Prof. Diana Carneiro (1947–; http://www.dianacarneiro.com), a botanical artist born in the municipality of Guanambi (Bahia, Brazil) and now living and actively working at Curitiba (Paraná, Brazil). During an extensive career teaching scientific art, and illustrating hundreds of botanical publications, she has been producing the finest botanical art, always combining an amazing technical precision with her beautifully drawn lines and competent composition. After preparing 63 botanical illustrations for regularly published scientific papers only in Melastomataceae, from which 43 are new species from 14 genera, she came to draw details of melastomes from amazing 25 Brazilian genera. We are sure that very few botanists in the world have analyzed flowers of species from this number of genera in Melastomataceae; we may, therefore, recognize and declare Diana Carneiro as a melastome specialist, such as we are.

**4.1.2.3 Remarks** The relatively big flowers (when compared to other species in *Miconia* s.s.) with terete hypanthia and long, slender, subulate anthers suggest that *Miconia dianae* should belong to either *Miconia* sect. *Jucunda* (Cham.) Triana, *Miconia* sect. *Tamonea* Cogn. or *Miconia* sect. *Laceraria* (Naudin) Triana, according to Cogniaux's (1891) infrageneric classification of *Miconia* s.s. Despite not being monophyletic and not precisely circumscribed (Goldenberg et al. 2008), these sections are still good proxies when one tries to compare one species to others in *Miconia* s.s. (Goldenberg et al. 2013). *Miconia dianae* has some unique features that suggest that it would belong to either one of the three sections mentioned above, or maybe to none of them at all. *Miconia* sect. *Laceraria*, for instance, has flower buds with a completely closed calyx that opens irregularly at anthesis (Cogniaux 1891): *Miconia dianae*, on the other hand, has flower buds with an incompletely closed calyx, with a long tube and short sepals, rupturing below the sinuses during anthesis, and it also has flowers that are larger than usual in *Laceraria*. This calyx is also distinct from all species in sections *Jucunda* and *Tamonea*, but it could be forcibly interpreted as something near the "distinctly lobed, with triangular or subulate lobes" in *Jucunda*, or less so as the "truncate or denticulate calyx" in *Tamonea* (Cogniaux 1891). Cogniaux (1891) complemented the distinction between both with the shape of the petal apex, but this is also of little help since the petals should be subacute in *Jucunda* and obtuse to retuse in *Tamonea*; *Miconia dianae* seems to have petals with an intermediate shape.

In this context, there is a single species, *Miconia lasseri,* that has at least some of features that are also found in *M. dianae*. This similar species is found in Amazonian Venezuela (Bolívar and Amazonas; Wurdack 1973; Berry et al. 2001), Guyana and Surinam (Wurdack et al. 1993), and Northern Brazil (Pará and Roraima; Goldenberg et al. 2020c), and it has been assigned to either *Miconia* sect. *Jucunda* (Wurdack 1973) or *Tamonea* (Gleason in Lasser and Maguire 1954). Its flowers are about the same size of *M. dianae*, with a terete hypanthium and the calyx is also incompletely closed in bud, rupturing at anthesis in irregular lobes; the stamens are also white, with a dorso-basal hump on the connective, and the ovary is 3-locular and superior (fide Gleason in Lasser and Maguire 1954) or only 1/10 inferior (fide Wurdack 1973). In addition to the differences listed in the diagnosis, the petals in *M. dianae* are yellowish green, while those of *M. lasseri* are apparently white, but we do not have a precise description of them. Also, the calyx is not as clearly caducous in *M. dianae* as it is in *M. lasseri*.

**4.1.2.4 Leaf anatomy** All plant surfaces of *Miconia dianae*, including young stems, leaves, inflorescences and hypanthia, have a granular appearance in dry material. This granular surface is more distinct on the adaxial leaf surface, with the granules denser than on the other parts of the plants. The leaf cuts showed no epidermal projections that could explain the granular surfaces. The only explanation for this type of surface would be that the large druses, sometimes measuring half the thickness of the leaf mesophyll, could project themselves into more or less hemispheric domes when the leaves are dried (Judd et al. 2022). Calcium oxalate (CaOx) crystals are quite common in Melastomataceae (Mentink and Baas 1992), and some of them are regarded as important taxonomic/systematics characters, such as the raphids in tribe Henrietteeae (Judd and Penneys 2022). Among the already attributed functions of CaOx crystals in plants are the regulation or sequestration of calcium ions, ionic balance, detoxification of oxalate and/or heavy metals, light reflection and protection of the plant against herbivores (Nakata 2012). However, the calcium reserve does not always seem to be functional, as its mobility to parts of the plant that need calcium supply, such as roots or apical meristems, is limited (Paiva et al. 2019). One possibility is that the plant eliminates the calcium excess through deposition in organs or tissues that will be discarded (Paiva et al. 2019). On the other hand, some plants exploit large crystals of calcium oxalate as dynamic carbon reservoirs, being able to photosynthesize even under extreme conditions using $CO_2$ from the decomposition of crystals instead of the atmosphere (Tooulakou et al. 2016), which in turn may explain the predominance of these structures in plants from dry environments (Karabourniotis et al. 2020).

**4.1.2.5 Hypanthium anatomy** We have no explanation for the function of the verrucose projections on the hypanthium. They are not formed by crystals (see discussion above), nor seem to develop as pathogen or animal-induced flower or fruit galls (Bomfim et al. 2021). They do not seem to store phenolic compounds (Kumar et al. 2020) and do not appear to be related to other plant defense mechanisms. There are no starch or oil bodies, which would be related to secretory activity, i.e. nectar production (Varassin et al. 2008). Considering that the verrucose projections fade away while the fruits ripen (see Fig. 2), they do not seem to have any function related to dispersal either. We also have no indication about what triggers the multiplication of the ground cells of the hypanthium that leads to the development of the warts. The lipid compounds in the walls of cells close to the wart surface may indicate cuticular material, which could reinforce the barrier against water loss and other environmental stresses.

These verrucose projections on the hypanthium are not common in Melastomataceae. Some groups such as *Pternandra* Jack (subf. Kibessioideae; see Maxwell 1981) and *Miconia* sect. *Lima* Majure & Judd and species related to *M. meridensis* Triana (tribe Miconieae; see Wurdack 1973; Majure et al. 2016) may have structures that could be regarded as similar, but they seem to be related to trichomes: the projections are more regularly distributed on the hypanthium surface, and indeed sometimes they are topped with short and wide trichomes. Other groups with verrucose hypanthia are *Merianthera verrucosa* Goldenb et al. (2012) and other species in *Miconia*, such as *M. prominens* Wurdack, *M. glandulistyla* Wurdack and *M. inanis* Gleason (Wurdack 1980), but the former has a rough surface with continuous, irregular masses of tissue, while the latter three have more inconspicuous projections. Wart-like projections that are visually most similar to the ones on *Miconia dianae*'s hypanthium surface can be found in other species of *Miconia*, such as *Miconia conomacrantha* Michelang. (former *Conostegia macranta* Triana), *M. conosetifera* Michelang. (*C. setifera* Standl.) and M. *oerstediana* (Triana) Michelang. (*C. oerstediana* Triana), all from tropical America (Kriebel 2016). They also can be found in some Paleotropical genera in subfamily Astronieae, such as *Astronidium* from New Guinea (Mancera 2017) and *Beccarianthus* Cogn., from Borneo and the Philippines (Cogniaux 1890; photos available at www.phytoimages.siu.org).

**4.1.2.6 Additional specimens examined (paratypes)** Brazil: Bahia, Mun. Ribeirão do Largo, "trilha feita para retirada seletiva de madeira; fragmento ca. 4 km da entrada do município" 15°28′46″S, 40°46′5″W, 14-IV-2022 (fr), AM Amorim and LH Daneu 11,860 (HUEFS, RB, UESC, UPCB); Ibid., AM Amorim and LH Daneu 11,862 (HUEFS, RB, UESC, UPCB); Ibid., AM Amorim and LH Daneu 11,863 (RB, UESC, UPCB).

**Acknowledgements** The authors thank Diana Carneiro for the drawings, Yuri Gouvea for the photos of the plants in the field, Lucas Marinho for helping design the figure plates and Erika Amano for coordinating the "Laboratório de Botânica Estrutural" at UFPR. We also thank the reviewers Frank Almeda, Ana Flávia Versiane and the editor Marcelo Trovó for their suggestions on a previous version of this manuscript.

**Author's contribution** RG prepared the description and, along with FAM, prepared the taxonomical and nomenclatural details. JKZ prepared the material for SEM and anatomical studies, analyzed the slides and prepared the images for Fig. 1. AMA collected material, took photos in the field and prepared Figs. 2 and 4. All authors contributed to the study conception and design, and all took part in manuscript writing. All authors read and approved the final manuscript.

**Funding** This research was supported by the "Conselho Nacional de Desenvolvimento Científico e Tecnológico" (CNPq-Brazil) which awarded Research Productivity grants to AMA (Grant # 309550/2022) and RG (Grant # 310912/2021-0) and "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior"(CAPES-Brazil) for the PhD grant to JKZ (#88887.373597/2019-00). This research was also partially funded by the National Science Foundation (NSF-USA; DEB-2001357).

**Data availability** These specimens belong to herbaria (indicated as acronyms here). All these herbaria are public, and can be freely visited or consulted.

## Declarations

**Conflict of interests** The authors declare that the manuscript does not present any kind of conflict of interests. The purpose and content of the work are original and not previously published.

## References

Almeda F, Martins AB (2012) *Microlicia wurdackiana* (Melastomataceae: Microlicieae), a new species from Bahia, Brazil. Kew Bull 67:467–470. https://doi.org/10.1007/s12225-012-9396-y

Amorim AM, Goldenberg R, Michelangeli FA (2009) A new species of *Physeterostemon* (Melastomataceae) from Bahia, Brazil, with Notes on the Phylogeny of the Genus. Syst Bot 34:324–329. https://doi.org/10.1600/036364409788606389

Amorim AM, Jardim JG, Goldenberg R (2014) *Physeterostemon gomesii* (Melastomataceae): the fourth species of this endemic genus in Bahia, Brazil. Phytotaxa 175:45–49

Bacci LF, Caddah MK, Goldenberg R (2016) The genus Miconia Ruiz & Pav. (Melastomataceae) in Espírito Santo, Brazil. Phytotaxa 271:1–92

Bacci LF, Amorim AM, Michelangeli F, Goldenberg R (2018) Increased sampling in undercollected areas shed new light on the diversity and distribution of an Atlantic Forest endemic genus. Syst Bot 43(3):767–792. https://doi.org/10.1600/036364418X697490

Baumgratz JFA (2000) Two new species of *Huberia* (Melastomataceae: Merianieae) from Brazil. Brittonia 52:24–33. https://doi.org/10.2307/2666491

Baumgratz JFA, Souza MLDR (2004) Two new species of *Miconia* (Melastomataceae) from Bahia, Brazil. Bradea 10:5–33

Baumgratz JFA, Amorim AM, Jardim AB (2011) Two new species of *Bertolonia* (Melastomataceae) from the Brazilian Atlantic Forest. Kew Bull 66:273–279. https://doi.org/10.1007/s12225-011-9281-0

Berlyn GP, Miksche JP (1976) Botanical microtechnique and cytochemistry. Iowa State University Press, Ames

Berry PE, Gröger A, Holst BK, Morley T, Michelangeli FA, Luckana NG, Almeda F, Renner SS, Freire-Fierro A, Robinson OR, Yatskievych K (2001) Melastomataceae. In: Berry PE, Yatskievych K, Holst BK (eds) Flora of the venezuelan guayana, vol 6. Missouri Botanical Garden Press, St. Louis, pp 263–528

Bisewski G, Bacci LF, Amorim AM, Goldenberg R (2020) Novelties in *Bertolonia* (Melastomataceae) from northeastern Brazil. Braz J Bot 43:563–574. https://doi.org/10.1007/s40415-020-00630-7

Bomfim PMS, Kuster VC, Caetano APS, Gonçalves LA, Oliveira DC (2021) Ovule-gall stimulating a large fake fruit on *Miconia chamissois* Naudin (Melastomataceae): a structural overview. Botany 99:115–126. https://doi.org/10.1139/cjb-2020-0112

BFG III—THE BRAZIL FLORA GROUP (2022) Brazilian Flora 2020: leveraging the power of a collaborative scientific network. Taxon 71:178–198https://doi.org/10.1002/tax.12640

Cogniaux AC (1886) Miconieae triana. In: Martius CFP, Eichler AW, Urban I (eds) Flora brasiliensis 14, Part 4. Fleischer, Leipzig, pp 63–558

Cogniaux AC (1890) Beccarianthus. In: Boerlage JG (ed) Flora van Nederlandsch Indie, Part 1 Melastomataceae. E.J Brill, Leiden, p 525

Cogniaux AC (1891) Mélastomacées. In: de Candolle A, de Candolle C (eds) Monographiae phanerogamarum. Masson, Paris, pp 1–1256

CRIA—Centro de Referência e Informação Ambiental) (2023) Specieslink—simple search. Disponível em http://www.https://specieslink.net/search/ (Accessed 27 Mar 2023)

Fidanza K, Almeda F (2011) New species of the Brazilian endemic genus *Cambessedesia* (Melastomataceae). Harvard Pap Bot 16:57–63

Freitas JG, Van Den Berg C (2016) A new species of *Pleroma* (Melastomataceae) endemic to Chapada Diamantina, Bahia Brazil. Phytotaxa. 288:249–257

Freitas JG, Santos AKA, Oliveira RP (2012) *Tibouchina bracteolata* and *T. comosa* (Melastomataceae, Melastomeae): two new species to the Chapada Diamantina, Bahia. Brazil Syst Bot 37:189–196. https://doi.org/10.1600/036364412X616756

Freitas JG, Santos AKA, Oliveira RP (2013) A new and unusual species of *Tibouchina* (Melastomataceae) occurring in Caatinga vegetation in Bahia, Brazil. Syst Bot 38:418–423. https://doi.org/10.1600/036364413X666741

Freitas JG, Santos AKA, Peraza-Flores LN (2019) Reassessment of *Pterolepis parnassiifolia* (Melastomataceae, Melastomeae) and a new combination for the genus. Phytotaxa 427:200–208

Gali L, Pacifico R, Almeda F, Fidanza K (2022) Two new species of *Microlicia* (Melastomataceae) from Chapada Diamantina, Bahia, northeastern Brazil. Phytotaxa 544:52–60

Goldenberg R (2004) O gênero *Miconia* (Melastomataceae) no estado do Paraná. Acta Bot Bras 18(4):927–947. https://doi.org/10.1590/S0102-33062004000400024

Goldenberg R (2009) 18. Miconia Ruiz & Pav. In: Wanderley MGL, Shepherd GJ, Melhem TS, Giulietti AM, Martins SE (eds) Flora Fanerogâmica do Estado de São Paulo, vol 6. São Paulo, FAPESP, pp 73–103

Goldenberg R, Amorim AM (2006) *Physeterostemon* (Melastomataceae): a new genus and two new species from the Bahian Atlantic Forest, Brazil. Taxon 55:965–972. https://doi.org/10.2307/25065690

Goldenberg R, Chagas ECO (2014) *Miconia nordestina* (Melastomataceae), a new species from Brazil. Syst Bot 39:253–259. https://doi.org/10.1600/036364414X678233

Goldenberg R, Reginato M (2007) Three new species of Melastomataceae from the Southeastern Atlantic Forest of Brazil. Brittonia 59:334–342. https://doi.org/10.1663/0007-196X(2007)59[334:TNSOMF]2.0.CO;2

Goldenberg R, Reginato M (2009) New species of *Behuria*, *Miconia* and *Ossaea* (Melastomataceae) from Eastern Brazil. J Torrey Bot Soc 136:293–301. https://doi.org/10.3159/09-RA-019.1

Goldenberg R, Penneys D, Almeda F, Judd WS, Michelangeli FA (2008) Phylogeny of *Miconia* (Melastomataceae): Patterns of stamen diversification in a megadiverse neotropical genus. Int J Pl Sci 169:963–979. https://doi.org/10.1086/589697

Goldenberg R, Fraga CN, Fontana AP, Nicolas A, Michelangeli FA (2012) Taxonomy and phylogeny of *Merianthera* (Melastomataceae). Taxon 65:1040–1056. https://doi.org/10.1002/tax.615010

Goldenberg R, Almeda F, Caddah MK, Martins AB, Meirelles J, Michelangeli FA, Weiss M (2013) Nomenclator Botanicus for the neotropical genus *Miconia* (Melastomataceae). Phytotaxa 106:1–171

Goldenberg R, Almeda F, Sosa K, Ribeiro RC, Michelangeli F (2015) *Rupestrea*: a new Brazilian genus of Melastomataceae, with anomalous seeds and dry indehiscent fruits. Syst Bot 40:561–571. https://doi.org/10.1600/036364415X688862

Goldenberg R, Michelangeli FA, Aona LYS, Amorim AM (2016) Angiosperms and the Linnean shortfall: three new species from three lineages of Melastomataceae at one spot at the Atlantic Forest. PeerJ 1984:1–19. https://doi.org/10.7717/peerj.1824

Goldenberg R, Silva JC, Amorim AM (2020a) *Miconia bahiana* (Melastomataceae, Miconieae), a new species from semideciduous forest in Bahia, Brazil. Pl Ecol Evol 153:152–159. https://doi.org/10.5091/plecevo.2020.1659

Goldenberg R, Michelangeli FA, Amorim AMA (2020b) First Record of *Loricalepis* (Melastomataceae) from the Brazilian Atlantic Forest, with the description of a new species from Bahia. Brittonia 72:308–316. https://doi.org/10.1007/s12228-020-09629-6

Goldenberg R, Baumgratz JFA, Michelangeli FA, Guimarães PJF, Romero R, Versiane AFA, Fidanza K, Völtz RR, Silva DN, Lima LFG, Gonçalves KC, Bacci LF, Fontelas JC, Pacifico R, Brito ES, Rocha MJR, Caddah MK, Meirelles J, Rosa P, Ferreira-Alves R, Santos AKA, Moreira KVC, Reginato M, Oliveira LFA, Freire-Fierro A, Amorim AMA, Martins AB, Koschnitzke C, Almeda

Guimaraes PJF, Freitas JG (2015) Two new species of *Pleroma* (Melastomataceae) from Brazil. Syst Bot 40:553–560

IUCN (2022) Guidelines for using the IUCN Red List Categories and Criteria. Version 13. Prepared by the Standards and Petitions Sub-Committee. Available at https://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf [Accessed 2 Feb 2023]

Jesus JC, Romero R, Roque N (2018) Two new species of *Microlicia* (Melastomataceae) from the Septentrional Espinhaço, Bahia, Brazil. Phytotaxa 343:240–245

Jesus JC, Hinoshita LKR, Kriebel R (2020c) Melastomataceae *in* Flora do Brasil 2020c. Jardim Botânico do Rio de Janeiro. Available at http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB161 [Accessed 4 Jan 2023]

Judd WS, Penneys DS (2022) Systematics of tribe henrietteeae (Melastomataceae). In: Goldenberg R, Michelangeli FA, Almeda F (eds) Systematics, evolution, and ecology of melastomataceae. Springer, Cham, pp 219–234

Judd WS, Majure LC, Michelangeli FA, Goldenberg R, Almeda F, Penneys DS, Stone RD (2022) Morphological variability within the Melastomataceae (Myrtales), including a discussion of the associated terminology. In: Goldenberg R, Michelangeli FA, Almeda F (eds) Systematics, evolution, and ecology of Melastomataceae. Springer, Cham, pp 45–85

Karabourniotis G, Horner HT, Bresta P, Nikolopoulos D, Liakopoulos G (2020) New insights into the functions of carbon–calcium inclusions in plants. New Phytol 228:845–854. https://doi.org/10.1111/nph.16763

Kriebel R (2016) A monograph of *Conostegia* (Melastomataceae, Miconieae). PhytoKeys 67:321–326. https://doi.org/10.3897/phytokeys.67.6703

Kumar S, Abedin MM, Singh AK, Das S (2020) Role of phenolic compounds in plant-defensive mechanisms. In: Lone R, Shuab R, Kamili A (eds) Plant Phenolics in Sustainable Agriculture. Springer, Singapore, pp 517–532

Lasser T, Maguire B (1954) Plantas Notables de nuestra flora, especialmente de la Guayana. Bol Soc Venez Ci Nat 821:97–106

Majure LC, Bécquer ER, Judd WS (2016) Revision of the *Lima* clade (*Miconia* sect. *Lima*, Miconieae, Melastomataceae) of the Greater Antilles. Phytokeys 72:1–99. https://doi.org/10.3897/phytokeys.72.9355

Mancera JP (2017) Morphological phylogenetic analysis of the Astronieae (Melastomataceae). MSc thesis, San Francisco State University.

Martins AB (2000) Three new Brazilian species in the genus *Marcetia* (Melastomataceae, Melastomeae). Novon 10:224–229

Martins AB, Woodgyer EM (2000) A new species of *Marcetia* (Melastomataceae) from Brazil. Kew Bull 55:189–193

Maxwell JF (1981) A revision of the genus *Pternandra* (Melastomataceae). Gard Bull Singapore 34:1–90

Meirelles J, Lima DFS, Goldenberg R (2016) *Miconia astrocalyx* (Miconieae, Melastomataceae): a new species from Brazilian Cerrado. Phytotaxa 257:187–192

Mentink H, Baas P (1992) Leaf anatomy of the Melastomataceae, Memecylaceae, and Crypteroniaceae. Blumea 37:189–225

Nakata PA (2012) Plant calcium oxalate crystal formation, function, and its impact on human health. Front Biol 7:254–266. https://doi.org/10.1007/s11515-012-1224-0

O'Brien TP, Feder N, McCully ME (1964) Polychromatic staining of plant cell walls by toluidine blue. Protoplasma 59:368–373. https://doi.org/10.1007/BF01248568

Pacifico R, Almeda A (2018) Two new species of *Microlicia* (Melastomataceae) from the Cadeia do Espinhaço, Brazil. Brittonia 70:445–454. https://doi.org/10.1007/s12228-018-9539-z

Pacifico R, Almeda A (2020a) *Microlicia morrensis* (Melastomataceae): the third species in the genus endemic to Morro do Chapéu, Bahia, Brazil. Phytotaxa 454:137–144

Pacifico R, Almeda A (2020b) A new species of *Microlicia* (Melastomataceae) endemic to restingas in Bahia. Brazil. J Bot Res Inst Texas 14:271–278

Pacifico R, Almeda A (2022a) *Microlicia coronata* (Melastomataceae), a new ericoid species from the Serra das Almas, Bahia, Brazil. Brittonia 74:265–271. https://doi.org/10.1007/s12228-022-09712-0

Pacifico R, Almeda A (2022b) New species of *Marcetia* and *Microlicia* (Melastomataceae) endemic to the *campo rupestre* of Chapada Diamantina, Bahia, Brazil. Phytotaxa 573:39–69

Pacifico R, Almeda F, Gali L, Fidanza K (2022a) Two new narrow endemic species of Microlicia (Melastomataceae, Lavoisiereae) from Serra do Porco Gordo, Bahia, Brazil. Nordic J Bot. https://doi.org/10.1111/njb.03749

Pacifico R, Almeda A, Gali L, Fidanza K (2022b) Novelties in *Microlicia* (Melastomataceae, Lavoisiereae) endemic to the *campo rupestre* of Guiné, Chapada Diamantina, Bahia, Brazil. Phytotaxa 566:290–300

Paiva EAS (2019) Are calcium oxalate crystals a dynamic calcium store in plants? New Phytol 223:1707–1711. https://doi.org/10.1111/nph.15912

Pataro L, Romero R, Roque N (2013) Four new species of *Microlicia* (Melastomataceae) from Chapada Diamantina, Bahia, Brazil. Kew Bull 68:285–293. https://doi.org/10.1007/s12225-013-9448-y

Penneys DS, Almeda F, Michelangeli FA, Goldenberg R, Martins AB (2020) Lithobieae and Eriocnemeae: two new neotropical tribes of Melastomataceae. Phytotaxa 453:157–178

Penneys DS, Almeda F, Reginato M, Michelangeli FA, Goldenberg R, Fritsch PW, Stone RD (2022) A new Melastomataceae classification informed by molecular phylogenetics and morphology. In: Goldenberg R, Michelangeli FA, Almeda F (eds) Systematics, evolution, and ecology of Melastomataceae. Springer, Cham, pp 109–165

Reginato M, Baumgratz JFA, Goldenberg R (2013) A taxonomic revision of *Pleiochiton* (Melastomataceae, Miconieae). Brittonia 65:16–41. https://doi.org/10.1007/s12228-012-9258-9

Rezende A, Romero R, Goldenberg R (2014) Sinopse de *Miconia* seção *Miconia* DC. (Melastomataceae) no estado de Minas Gerais, Brazil. Biosci J 30:273–287

Romero R, Woodgyer EM (2018) Six new species of *Microlicia* (Melastomataceae) from Bahia. Brazil Kew Bull 73:22. https://doi.org/10.1007/s12225-018-9747-4

Santos AKA, Martins AB, Silva TRS (2008) *Marcetia candolleana* (Melastomeae – Melastomataceae), a new species from Bahia (Brazil). Kew Bull 63:315–318. https://doi.org/10.1007/s12225-008-9021-2

Santos AKA, Martins AB, Silva TRS (2013) Two new species of *Marcetia* (Melastomataceae) from the Chapada Diamantina, Bahia, Brazil. Syst Bot 38:714–722. https://doi.org/10.1600/036364413X670377

Sass JE (1951) Botanical microtechnique, 2nd edn. The Iowa State College Press, Ames

Schulman L (2008) *Adelobotrys atlantica* (Melastomataceae: Merianieae): the first species of *Adelobotrys* from Brazil's Mata Atlântica. Kew Bull 63:457–461

Silva DN, Luna BN, Freire TL, Guimarães EF, Guimarães PJF (2021) A new species of *Comolia* (Melastomataceae, Marcetieae) from the sand dunes of Bahia, Brazil, with notes on leaf anatomy. Syst Bot 46:834–843. https://doi.org/10.1600/036364421X16312067913570

Souza MLDR (2002) O gênero *Ossaea* DC. (Melastomataceae) no Brasil: Circunscrição e notas taxonômicas. Insula 31:1–28

Tooulakou G, Giannopoulos A, Nikolopoulos D, Bresta P, Dotsika E, Orkoula MG, Kontoyannis CG, Fasseas C, Liakopoulos G, Klapa MI, Karabourniotis G (2016) Reevaluation of the plant "gemstones": Calcium oxalate crystals sustain photosynthesis under drought conditions. Plant Signal Behav 11:e1215793

Ulloa Ulloa C, Almeda F, Goldenberg R, Kadereit G, Michelangeli FA, Penneys DS, Stone RD, Veranso-Libalah MC (2022) Melastomataceae: Global diversity, distribution, and endemism. In: Goldenberg R, Michelangeli FA, Almeda F (eds) Systematics, evolution, and ecology of melastomataceae. Springer, Cham, pp 3–28

Varassin IG, Penneys DS, Michelangeli FA (2008) Comparative anatomy and morphology of nectar-producing Melastomataceae. Ann Bot 102:899–909. https://doi.org/10.1093/aob/mcn18010.1093/aob/mcn180

Woodgyer EM, Zappi DC (2005) Two new species of *Microlicia* D. Don (Melastomataceae) from Catolés, Bahia. NE Brazil Kew Bull 60:435–440

Woodgyer EM, Zappi DC (2009) Two new species of *Microlicia* D. Don (Melastomataceae) from Bahia. NE Brazil Kew Bull 64:279–284. https://doi.org/10.1007/s12225-009-9121-7

Wurdack JJ (1973) Melastomataceae. In: Lasser T (ed) Flora de Venezuela. Instituto Botánico, Caracas, pp 1–819

Wurdack JJ (1980) Melastomataceae. In: Harling G, Sparre B (eds) Flora of Ecuador. University of Göteborg and Rijksmuseum, Stockholm, pp 1–406

Wurdack JJ, Renner SS, Morley T (1993) Melastomataceae. In: van Rijn ARAG (ed) Flora of the guianas. Koeltz Scientific Books, Koenigstein, pp 1–425